TECHNICAL REVIEW AND EVALUATION OF THERMAL EFFECTS STUDIES AND COOLING WATER INTAKE STRUCTURE DEMONSTRATION OF IMPACT FOR THE OYSTER CREEK NUCLEAR GENERATING STATION

REVISED FINAL REPORT

VOLUME I - TEXT

Prepared for

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FOREWORD

This document, "Technical Review and Evaluation of Thermal Effects Studies and Cooling Water Intake Structure Demonstration of Impact for the Oyster Creek Nuclear Generating Station: Revised Final Report" was prepared by Versar, Inc., Ecological Sciences and Analysis Division, of Columbia, MD under the direction of Mr. Richard R. Delgado, Project Manager, Thermal Discharge Program, Division of Water Resources, New Jersey Department of Environmental Protection (NJDEP). The appropriate New Jersey Department of Treasury contract numbers for this work are P21843, P21844, and P42253. This report is a revision of the Final Report dated March 1988. This revision was requested by NJDEP to allow Versar to incorporate a review of critical data collected by GPUN that had not previously been received by Versar (specifically, Addenda C1 and D1).

The purpose of the final report is to summarize the findings and conclusions of Versar's review and evaluation of the Oyster Creek 316 Demonstration and to make recommendations that assist NJDEP in making a §316 decision for the Oyster Creek NGS, including identifying intake technologies for minimizing environmental harm in preparation for a public hearing. In addition, Versar makes recommendations concerning GPUN's request for special water quality standards for Oyster Creek.

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I. INTRODUCTION

A. BACKGROUND

The Oyster Creek Nuclear Generating Station (OCNGS), operated by GPU Nuclear (GPUN) and owned by Jersey Central Power & Light Company (JCP&L, a member of the General Public Utilities System), is located between the South Branch of the Forked River and Oyster Creek, two tributaries of Barnegat Bay, New Jersey (Fig. I-1). The facility consists of a single boiling water reactor rated to produce 670 MWe with once-through cooling water systems (JCP&L 1978). The unit was constructed between December 1964 and September 1969. Thermal discharges and operational testing initiated in August 1969 with commercial operation commencing in December 1969.

Construction of the Oyster Creek NGS resulted in the dredging and widening of both the Forked River and Oyster Creek as well as the construction of man-made canals from these tributaries to the facility. The impacts of water withdrawal and thermal discharges from the Oyster Creek NGS on fishery resources and other aquatic biota in the Oyster Creek/Forked River and Barnegat Bay ecosystems have been a concern to state and federal resource management agencies since the early 1960s when it was first proposed. These concerns are addressed, and station operations are controlled, through the National Pollution Discharge Elimination System (NPDES) permit program and §316(a) and §316(b) of the Federal Water Pollution Control Act of 1972 as amended by the Clean Water Act (CWA) of 1977.

The CWA provides state resource management and regulatory agencies with the authority to administer the NPDES permit program within their jurisdiction(s) under §402. The New Jersey Department of Environmental Protection (NJDEP), Division of Water Resources, accepted delegation of the NPDES permit program from the U.S. EPA in April 1982. As a result, NJDEP presently has the responsibility for issuing final determinations regarding:

- Requests for variances to thermal effluent limitations at Oyster Creek NGS
- Conformance of plant operations and cooling water intake structures at Oyster Creek NGS with the goals of §316(a) and §316(b) of the CWA

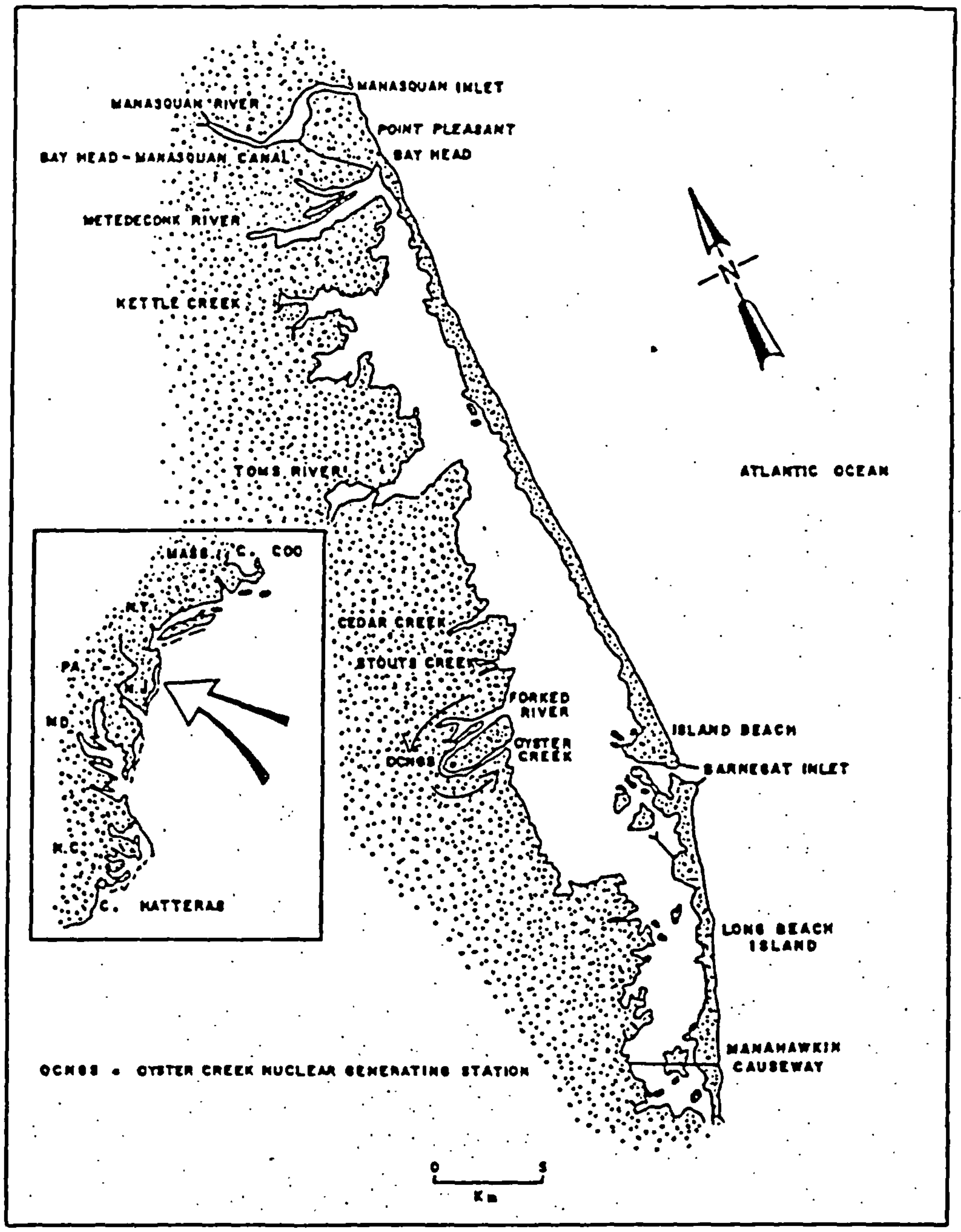


Figure I-1. Map of Barnegat Bay, New Jersey. The inset shows the location of Barnegat Bay in relationship to the state of New Jersey and the Mid-Atlantic Bight (from Chizmadia et al. 1984)

- Review and evaluation of the documents submitted by JCP&L for the Oyster Creek NGS in the context of §316(a) and §316(b) of the CWA.

Section 316(a) of the CWA gives regulatory agencies the authority to allow a thermal discharge to exceed effluent limitations and receiving water quality standards if the owner and/or operator of the discharging facility can demonstrate that the existing limitations are more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is made. Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BAT) for minimizing adverse environmental impact.

At the time the power plant operator applies for a NPDES permit, a determination is made as to whether the facility is in compliance with existing regulations, including thermal limitations and performance standards. If the facility is not in compliance with thermal limitations and the operator/owner has evidence that the existing limitations are more stringent than necessary to protect balanced indigenous populations, then a request can be made for a variance. Requests for a §316 variance must be supported by detailed technical information in the form of a narrative report. This report is called a 316(a) Demonstration. The operator/owner is also required to submit the technical information needed to demonstrate that existing intake structures minimize adverse impacts. The costs of changes in intake structures or plant operations required to reduce adverse impacts associated with intake structures, however, should not be disproportionate with the environmental benefits that result. The information to evaluate impacts associated with intake structures and to identify the "best available technology" for minimizing environmental harm are submitted by owners/operators of power generating facilities in a 316(b) Report. Information in §316(a) and §316(b) documents is used by regulatory agencies to formulate the NPDES permit.

B. THE OYSTER CREEK PROJECT

The Oyster Creek 316 Demonstration submitted to NJDEP by JCP&L is a multivolume, narrative report that details findings of studies designed to assess the impacts of plant operations on receiving waters. A single Demonstration was submitted for 316(a) and 316(b). These studies include qualitative pre-operational/operational comparisons, thermal plume mapping, spatial comparisons of water quality and biotic correlations between areas near the plant and reference locations, estimation

of biotic losses associated with water withdrawal, and evaluation of the consequences of plant related losses to the Barnegat Bay estuary. These studies were conducted over the period 1965-1977 and their results were summarized in the Oyster Creek §316 Demonstration submitted to the U.S. EPA and NJDEP in 1978. Environmental conditions in Oyster Creek and Barnegat Bay have been subsequently evaluated by JCP&L/GPUN from 1978-1986. Reports concerning these findings have been submitted as supporting materials to the original §316 Demonstration. Based on the information in the Oyster Creek 316 Demonstration, JCP&L stated that "since no evidence exists that the RIS [Representative Important Species] populations will be affected by the thermal discharge of the OCNGS ... it is concluded that this discharge will not interfere with the protection and propagation of the balanced, indigenous community of fish and shellfish in Oyster Creek and Barnegat Bay." Although some losses of entrained macrozooplankton and ichthyoplankton have occurred, JCP&L concludes that "it does not appear that the OCNGS operation has either affected the structure of the sand shrimp and blue crab population or reduced the standing crop of juvenile and adult blue crab in the bay" and that "the fish community in the bay has not experienced any variation in species composition or abundance of populations that reproduce in the bay that were not also noted for other southern New Jersey and mid-Atlantic estuaries...therefore, these reductions in Barnegat Bay were attributed to environmental factors...rather than OCNGS entrainment." Finally, JCP&L concludes in the 316 Demonstration that existing intake structures [Ristroph screens] represent the best technology available for reducing entrainment and impingement because "the present intake impact is not significantly affecting the aquatic community of Barnegat Bay and the projected high costs of modifying or replacing the intake structure...are not warranted."

Versar, Inc., ESM Operations was awarded a contract in August 1987 to assist the NJDEP in the technical review and evaluation of the thermal effects and cooling water intake studies conducted for OCNGS by JCP&L, GPUN, and their consultants. The overall objective of this review was to provide a detailed technical evaluation of the Oyster Creek §316 Demonstration and related documents that would assist NJDEP in:

- Defining what constituted unacceptable harm to local and regional environmental resources from operation of the Oyster Creek NGS

- Evaluating the scientific adequacy of the technical material provided by the utility for supporting their conclusions and recommendations and in determining if additional information was required

- Establishing alternate effluent limitations for the Oyster Creek NGS that protect the receiving waters and their biota to the degree required by the CWA

- Determining whether mitigation alternatives selected, or previously installed were the best available for minimizing adverse environmental harm based on the degree and type of impact, engineering feasibility, recent studies of intake technology effectiveness, and costs.

To assist NJDEP in defining evaluation criteria and decision points for making a §316 decision of the Oyster Creek NGS, Versar conducted, in conjunction with Mr. Edward F. Lawson of the law firm Weston, Patrick, Willard, and Redding, a review of relevant litigation involving §316(a) and §316(b) of the CWA. This review is summarized in Appendix B and contains information concerning burden of proof, standard of proof, degree of acceptable harm, environmental factors considered, and cost-benefit considerations as they pertain to §316(a) and §316(b) of CWA.

To assist NJDEP in defining the receiving waterbody, Versar conducted, in conjunction with Dr. William Goldfarb of Cook College of Rutgers University, a litigation review of relevant litigation defining the boundaries of receiving water bodies. The legal brief from Dr. Goldfarb is included in Appendix C. In addition, Versar used the assistance of both Mr. Lawson and Dr. Goldfarb in determining whether JCP&L is entitled to seek both an alternative thermal effluent limitation under §316(a) and a water qualty standards revision under §303(c). This material is presented in Appendices B and C.

GPUN has reviewed and commented on the material in Appendices B and C. Versar's responses to their comments are summarized in Chapter II.

C. POTENTIAL FOR IMPACT OF THE OYSTER CREEK NGS

The magnitude of power plant impacts on aquatic biota is influenced by plant engineering design and operating practices (e.g., the location, design, construction, and capacity of intake structures and intake water velocities), the magnitude of temperature increases across condensers (ΔT), the amount of cooling water use relative to the size of the receiving water body, the amount of "new" water available to dilute plant effluents, the level of power generation, and the duration of exposure of biota to thermal discharges (Clark and Brownwell 1973; U.S. Environmental Protection Agency 1976, 1977a, 1977b; Maryland Department of Natural Resources 1986). Figure I-2 is a schematic representation of cooling water flow through a

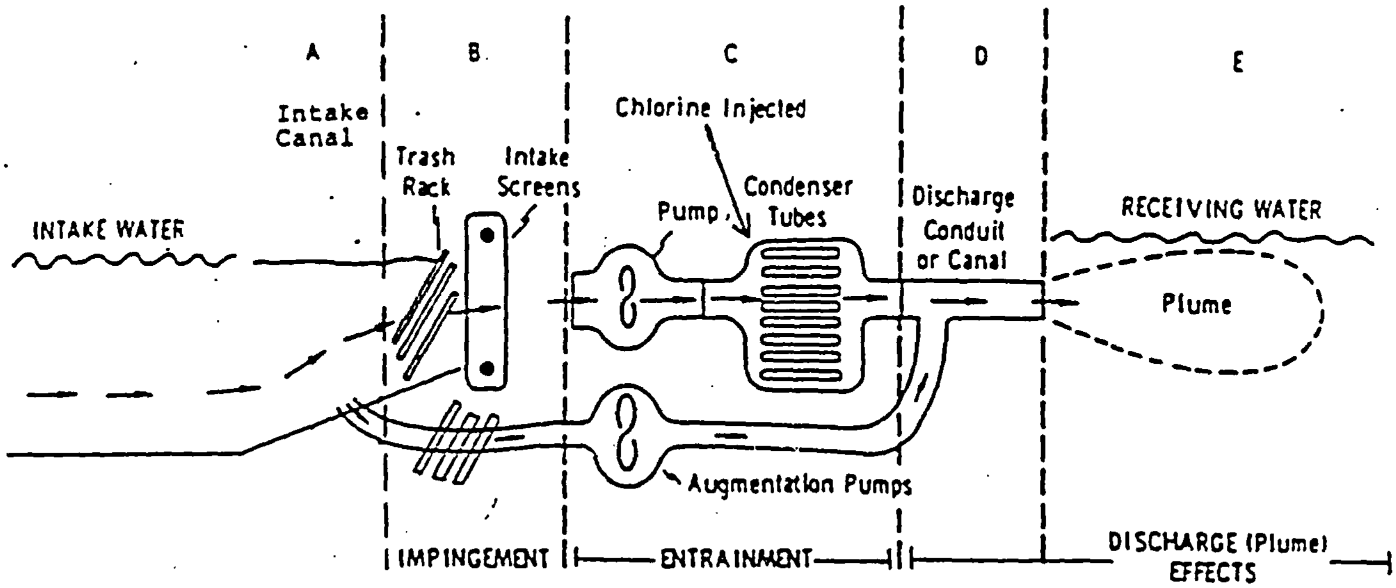


Figure I-2. Schematic path of water flow through a power generating facility showing locations of plant-organisms interactions

A. Fish and crabs may accumulate and become entrapped in the intake canal.

B. Organisms, mainly fish and crabs, too large to pass through the 9.5 mm intake screens or 7.6 cm wide trash racks may become trapped on them (i.e., are impinged). Intake screens are periodically rotated to wash off impinged organisms and return them to receiving water. Trash racks are mechanically cleaned periodically and impinged organisms returned to the receiving water.

C. Organisms small enough to pass through intake screens are drawn through the cooling system (i.e., are entrained). Entrained organisms experience a sudden temperature rise of from 12-13°C, shear and pressure forces, and many contact internal structures. Entrained organisms may also be exposed to lethal levels of chlorine and its residuals during time periods when chlorine is applied. Large organisms (fish and crabs) may also be entrained into unscreened augmentation pumps. During auxiliary pump entrainment fish and crabs experience mechanical damage from contact with internal pump structures.

D. Organisms surviving entrainment and impingement are exposed to continued excess temperatures and possibly to chlorine residuals during the 2-4 hour transit down the discharge conduit and canal enroute back to the receiving body.

E. Organisms in receiving waters may be exposed to elevated temperatures in the discharge plume. Currents associated with the discharge plume may cause habitat modifications through bottom scouring and changes in circulation patterns.

power generating facility similar to the Oyster Creek NGS showing major power plant-biota interactions. These interactions fall into three major categories: (1) impingement, (2) entrainment, and (3) discharge effects. Each of these modes of impact is discussed below.

Impingement

Impingement consists of trapping large organisms on barriers (e.g., trash racks and intake screens) that are used to keep condenser tubes free of blockage (Clark and Brownwell 1973). Impingement often causes immediate mortality by abrasion or by restricting movement of oxygen-bearing water across gills (U.S. Environmental Protection Agency 1977a; 1977b). Latent mortality may also occur because organisms physically damaged during impingement are more susceptible to disease and may be less able to compete when returned to the receiving water body. The methods used to remove impinged organisms and return them to the receiving water body determine, to a large degree, the magnitude of impingement mortality (American Society of Civil Engineers 1982). Impingement is of major concern when losses to juveniles of commercially or recreationally important species are large relative to the stock size of these biota in the receiving water body (Hanson et al. 1977; Barnthouse and Van Winkle 1981).

Entrainment

Entrainment is the transport of biota through the cooling water system; including the condenser, supply water, and dilution pump systems. Entrained biota may experience mortality due to abrasion, rapid velocity changes, shearing flows, rapid temperature increases, and toxic chemicals used to prevent biofouling (Hanson et al. 1977). Entrainment mortality of a large proportion of each year's spawn has the potential to adversely impact regional population size (Boreman et al. 1978; Polgar et al. 1981). Power facilities which use auxiliary dilution pumps to reduce thermal discharge temperatures provide a secondary source of entrainment of both early life stages and larger biota (if auxiliary pumps are not screened). Depending upon the volume of water used for this dilution, entrainment through the augmentation cooling systems can be equivalent to the entrainment observed for condenser cooling systems. The entrainment of early developmental stages is of particular concern when intake structures are located in or near spawning and nursery areas of important species and a large proportion of the regional spawn is entrained (U.S. Environmental Protection Agency 1977a, 1977b).

Discharge Effects

Discharge water from power plants with once-through cooling systems is generally released at temperatures above ambient and may include residues of toxic materials such as copper corroded from the condenser tubes or chlorine injected to reduce biofouling. Biological effects from exposure to thermal effluents depend upon the magnitude of the temperature increase compared with ambient water temperature and the duration of exposure (Barnett and Hardy 1984). Cold shock is of concern when biota attracted to thermal effluents during the winter are suddenly exposed to cold temperatures during plant shutdowns (Hanson et al. 1977; Barnett and Hardy 1984). Chlorine, toxic to most estuarine biota in the ppb to ppm range, is of concern when concentrations in the plant effluents are greater than 0.2 ppm. Chlorine toxicity is greatest at high temperature (Capuzzo 1979).

Exposure to power plant discharges may also have indirect or sublethal effects. Sublethal thermal effects are often as much of a concern as direct thermal mortalities and include alteration of physiological processes (e.g., growth, reproduction), movement of resident biota away from the discharge region, and increases in abundance of nuisance organisms within the thermally impacted region (Coutant 1977; Coutant and Talmadge 1977; Holland and Hiegel 1981). Thermal effluents can also represent thermal barriers blocking migration pathways, particularly of anadromous fish (Coutant and Talmadge 1977).

Site Characteristics

The physical, chemical, and biological characteristics of the water body adjacent to a power generating facility play a role in determining the nature and magnitude of power plant effects as do human uses of the water body. Appendix A summarizes the surrounding ecosystem and the Oyster Creek NGS characteristics which play a major role in determining the magnitude of plant-biota interactions.

D. REPORT ORGANIZATION

The remainder of this document is organized in the following manner:

- Chapter II details the evaluation methodology, evaluation criteria and decision points that were used by Versar in its review of the Oyster Creek 316 Demonstration

- Chapter III describes the selection of RIS (Representative Important Species) and their associated geographic boundaries for the assessment of Oyster Creek NGS impacts on adjacent water bodies

- Chapter IV assesses whether the information presented in the Oyster Creek §316 Demonstration is sufficient to make a §316 determination

- Chapter V critically examines the information available from the Oyster Creek §316 Demonstration to quantify the potential population and ecosystem impacts of the facility

- Chapter VI describes the procedure used to determine whether the Oyster Creek NGS adversely affects balanced indigenous populations and minimizes impacts to the degree required by §316(a) and §316(b) of the CWA by using the the evaluation criteria and decision points developed in Chapter II

- Chapter VII describes the procedure used to determine whether the existing intake structures at the Oyster Creek NGS represent the "best available technology" (BAT) for minimizing environmental harm

- Chapter VIII integrates the findings of the evaluation process into recommendations and conclusions

- Chapter IX - References

- Appendix A - Plant and Ecosystem Characteristics

- Appendix B - Review of Relevant Litigation

- Appendix C - Memorandum Concerning Definition of Receiving Waterbody

- Appendix D - Summary and Evaluation of 316 Evaluation Criteria

- Appendix E - Section 316 Evaluation Criteria from Sources Other Than Litigated Decisions

- Appendix F - Relationship between §316 and Establishment of Water Quality Standards

- Appendix G - Determination of Retrofit Costs at the Oyster Creek Nuclear Generating Station

Appendices H and I - Estimating the Economic Value of Fisheries Resources at the Oyster Creek Nuclear Generating Station.

II. EVALUATION METHODOLOGY

The information described in Appendices B through F and Chapter I are integrated in this chapter into an approach for determining whether:

Operation of the Oyster Creek NGS protects the receiving water body to the degree required by §316(a) of the CWA

- The present intake structures represent the best available technology for minimizing impact as required in §316(b) of the CWA.

The procedure developed by Versar allows for the simultaneous review of the Oyster Creek §316(a) and §316(b) material. However, it calls for the compliance determination required by §316(a) to be made before the determination of the "best technology available" for minimizing adverse impacts required by §316(b) is accomplished. The law does not require a determination as to whether balanced, indigenous populations are protected (§316(a)) before the available technologies are evaluated (§316(b)). However, in this manner, the major sources of power plant impacts (i.e., the problems to be solved) are identified and the causes of impact understood before potential mitigative actions are identified and evaluated. Information presented in Volume II of this report suggests this is a cost-effective and appropriate manner to conduct §316 reviews and evaluations. In the following sections of this chapter, the rationale for this overall approach is discussed, and the specific activities occurring in each step of the evaluation methodology are described.

A. PROBLEMS ASSOCIATED WITH ASSESSING POWER PLANT IMPACTS

It is not feasible or cost-effective to measure power plant effects on all species inhabiting aquatic environments (Limburg et al. 1984). This is because ecological theory has not identified conglomerate measures of system "health" or defined generic system properties that are indicative of overall system status (Summers et al. 1984). In addition, the magnitude of power plant impacts is related to engineering design and site characteristics (see Chapter I). As a result, state and federal regulations governing power plant operations generally do not provide specific criteria to be used to evaluate power plant impacts (e.g., §316 of the CWA). Rather,

regulations generally provide regulatory goals, leaving decision makers, regulators, and the courts with the responsibility for defining specific evaluation criteria.

Some methods discussed in the §316 litigation review (Appendix B) that are appropriate to use for assessing power plant impacts are:

- To focus assessment efforts on target species (often called Representative Important Species) which are indicators of system-wide responses

- To direct the evaluation of plant impacts to a suite of biological processes that cumulatively are indicative of system-wide alterations, including:

  -- Increases in the abundance of nuisance species, which indicate that basic ecosystem processes have been impaired or are in danger of becoming impaired

  -- Change in the biological productivity of the receiving waters, which indicates basic ecosystem processes have been altered

- To focus assessment efforts on adverse change in the beneficial uses of receiving waters, which indicates human uses and values of the water body are threatened and ensures inclusion of organisms that have commercial and recreational value into the evaluation process

- To develop valuation techniques, either ecological (quantification of population, community, and ecosystem losses) or economic (dollar value), on which to base assessments and decisions

- To focus power plant assessments on critical biological activities of target species (e.g., spawning and nursery functions, migration, loss of reproductive population elements) because alterations to these activities are the ones that are most likely to have long-term consequences

- To identify and select cost-effective mitigation alternatives for minimizing losses, including changes in operational practices and structural alterations, assuming that any reductions in losses are beneficial.

B. OVERVIEW OF EVALUATION APPROACH

The steps in the evaluation methodology used by Versar to evaluate the Oyster Creek NGS §316 Demonstration are as follows (Fig. II-1):

- Determine the potential for impact at the Oyster Creek NGS (Step 1)

- Develop evaluation criteria and decision points for assuring the protection of balanced indigenous populations based on the findings of the §316 litigation review and criteria in §316(a) regulations and state/federal guidelines (Step 2)

- Modify evaluation criteria as necessary, to be consistent with litigation for establishment of water quality standards, effluent limitations, mixing zone policies, and anti-degradation policies in the CWA and New Jersey Surface Water Quality Standards, the New Jersey Water Pollution Control Act, and the New Jersey Water Quality Planning Act (Step 2)

- Select RIS and geographical ranges appropriate for assessing power plant impacts at the Oyster Creek NGS (Steps 3 and 4)

- Determine the adequacy of the data in the Oyster Creek §316 Demonstration documents for assessing impacts and making a determination of compliance with decision points in §316(a) and for making a best technology available determination according to §316(b) (Step 5)

- Determine the consequences of missing and/or inadequate data for assessing impacts and making a §316(a) compliance determination and a §316(b) best technology available determination (Step 5)

- Determine the consequences of plant-related losses to regional RIS populations/communities and ecosystem stability (Step 6)

- Determine compliance with decision points developed in Step 2 to identify impacts that must be reduced to protect the maintenance and propagation of balanced indigenous populations (Step 6)

- Determine the consequences of failure to reduce plant-related impacts (Step 6)

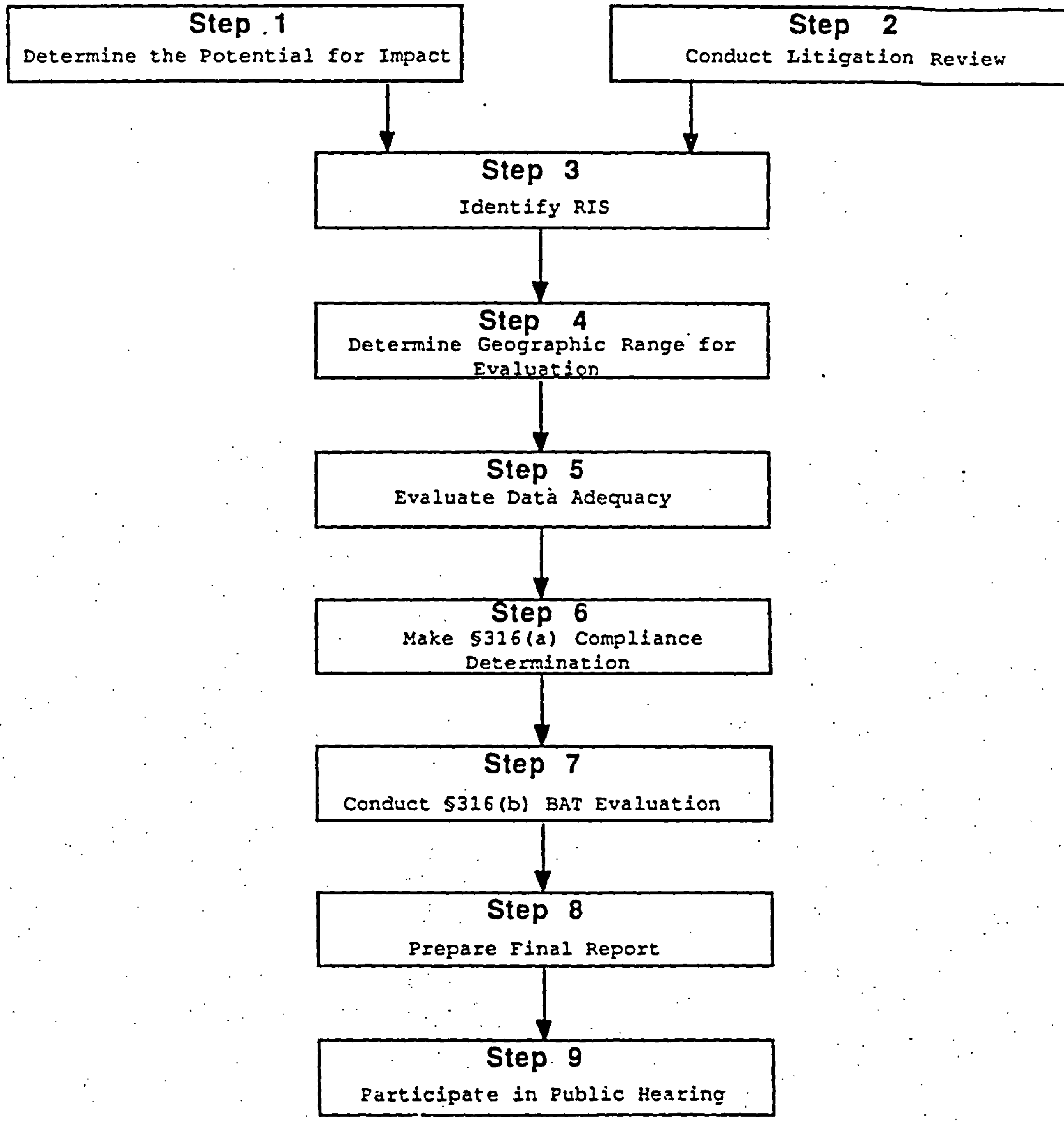


Figure II-1. Versar's assessment methodology

- Identify intake structure technologies and/or modifications to plant operations that represent the best technology available for minimizing impact to environmental resources and attainable uses of receiving waters (Step 7)

- Integrate the findings of Steps 1-7 into conclusions and recommendations that can be used for making §316(a) and §316(b) decisions for the Oyster Creek NGS (Step 8) and for issuing an NPDES permit that is consistent with the New Jersey Water Quality Standards and with criteria described in §316 of the CWA for protecting the nation's waters (Step 8)

- Prepare for and participate in public hearing on the establishment of effluent limitations for the Oyster Creek NGS that protect receiving waters to the degree required by §316 of the CWA and New Jersey Water Quality Standards (Step 9).

The steps in the evaluation methodology were the basic organizational structure for conducting the review and evaluation of the Oyster Creek §316 Demonstration. These steps also provided the basic structure used to organize this report.

C. SPECIFIC ACTIVITIES OCCURRING IN EACH STEP OF THE EVALUATION METHODOLOGY

In Step 1 of the evaluation methodology, information on plant and site characteristics was used to determine whether the potential for biological impacts is high or low. All modes of impact (i.e., entrainment, impingement, discharge effects) were evaluated. This prioritization was used to determine the amount of information that was required to address potential impacts. Less information was required to address impacts with a low potential for occurring than was required to address impacts with a high potential for occurring. Our determination was that the potential for all modes of power plant impact was high at the Oyster Creek NGS. This conclusion was reached because:

- Water use by the Oyster Creek NGS is a relatively large fraction of total freshwater inflow and tidal flushing in Forked River/Oyster Creek as well as Barnegat Bay as a whole

- The ΔT across condensers, discharge temperature, and the volume of discharges are sufficiently large that a substantial portion of the receiving waters could be impacted and the potential for plant operations to cause regional impacts at the population or community level is large

- Velocities through intake screens are sufficiently large to impinge large numbers of indigenous biota
- Impinged organisms are returned to receiving waters via the discharge canal where they are subjected to discharge temperatures that are potentially stressful
- The dead end design of the intake canal and high intake velocities suggest the potential for entrainment and impingement is high.

Step 2 consisted of developing the evaluation criteria in Table II-1. The first three evaluation criteria are intended to indicate whether balanced indigenous populations have been adversely impacted as a result of power plant operations. Criterion four protects important beneficial uses of receiving waters, such as commercial and recreational fisheries. Compliance with criterion five ensures protection of biotic resources that have been determined by their natural abundance levels to be sensitive and stressed by anthropogenic activities. The decision points for each evaluation criterion have been developed in a manner which allows changes (e.g., losses due to plant related mortality) up to the point that those changes begin to threaten the long-term well being and integrity of the receiving water body. They represent an integration of the many decision points identified in Appendices A-F and protect the most important functional system processes. Therefore, failure to comply with the decision points for the evaluation criterion indicate adverse environmental harm. Specific analysis results are then used to define the sources (i.e., cause) of that harm as well as the quantity of its extent.

In most aquatic ecosystems, it is generally possible to identify biota which, because of their abundance, distribution, ecological roles (e.g., food web linkage), or economic importance (e.g., commercially exploited species), are essential to, and/or representative of, the maintenance of balanced, indigenous populations of shellfish, fish, and wildlife. These target species of RIS can be used to focus impact assessment efforts, making the assumption that if populations of these surrogate species are protected, then other populations and the ecosystem as a whole are protected. Because many RIS are near the top of estuarine food webs or are key links in food webs, changes in their abundance or distribution indicate system-wide alterations.

RIS for assessing impacts of the Oyster Creek NGS were selected in Step 3. The RIS resulting from this assessment were compared to the RIS used by GPUN in the Oyster Creek §316 Demonstration. Any discrepancies between the two RIS lists were identified, and the consequences of these differences to

Table II-1. List of evaluation criteria and decision points used for the technical review and evaluation of the Oyster Creek §316 Demonstration and for determining if power plant operations adversely affect the receiving water body

Evaluation Criteria	Decision Point for Non-Compliance with Evaluation Criteria
• No adverse impacts on spawning and nursery functions, including migration to and from spawning grounds	• Plant-related impacts on RIS spawning and nursery activities potentially result in appreciable long-term declines or preclude increases in population abundance or adversely affect the completion of RIS life cycles
• No significant increase in the abundance of nuisance species	• Plant-related impacts result in increases in the population abundance of nuisance organisms, especially those that are associated with declines in indigenous populations
• No adverse changes in the structure of the food web and/or functional properties of the ecosystem	• Plant-related impacts result in changes in the abundance and type of biota occurring at lower trophic levels to the degree that increases are projected to be precluded or declines in the abundance or productivity of higher trophic levels are projected to or actually result
• No adverse impacts on the beneficial uses of the water body	• Plant-related impacts result in or are projected to result in significant declines or preclude increases in boating, swimming, fishing, or other human uses of the receiving water body on a local or regional scale
• No decrease in the abundance of endangered or threatened species	• Plant-related impacts result in an actual or projected decline or preclude increases for a species that is federally or locally recognized as threatened or endangered

making a §316 decision were determined. Versar chose to make an independent selection of RIS rather than use the ones used by GPUN to ensure that plant impacts on potentially important indicator organisms were not overlooked.

Step 4 involved making a determination of the geographic boundaries over which power plant impacts should be assessed. The determination of geographic boundaries for assessing impacts was based primarily on life history attributes of the RIS selected in Step 3 and natural geographic boundaries. Human use patterns of receiving waters were also considered.

In Step 5, an assessment was made as to whether the information presented in the Oyster Creek §316 Demonstration was sufficient to make a §316(a) and §316(b) BAT determination. The litigation review suggests that failure to provide sufficient information can be a basis for disallowing a request for alternate effluent limitations under §316. The first part of Step 5 consists of defining data needs. A determination was made as to whether the data and information in the Oyster Creek §316 Demonstrations were collected, processed, summarized, and analyzed in a manner that was adequate to assess power plant impacts. The consequences of missing or inadequate data and analyses to the review and impact assessment process was evaluated by determining the extent to which the missing data or analyses were likely to alter conclusions. If missing data were critical to the evaluation process, a determination was made as to whether substitute data could be obtained from other sources (e.g., the scientific literature), or whether data could be adjusted in a manner which would make them adequate for making §316(a) and §316(b) decisions. The second part of Step 5 consisted of making a determination of the adequacy of GPUN's conclusions. The adequacy of conclusions was determined by evaluating data inputs, calculation procedures, and assumptions and rationale, as well as by evaluating whether the specific analysis procedures applied were applicable and reasonable. A determination was also made as to whether analysis results were correctly interpreted and supported the conclusions and recommendations.

GPUN did not carry out analyses that rigorously quantified the population, ecosystem, or economic impacts associated with plant-related losses, or to place observed spatial and temporal distribution changes into an ecosystem context. As the first part of Step 6, we determined the consequences of power plant impacts from the Oyster Creek NGS to the receiving waters by applying several impact assessment models that quantified losses (relative and absolute) at the population and ecosystem level as well as estimated losses to fisheries.

GPUN contends these models stop short of addressing the long-term question of maintenance of balanced, indigenous populations. The models do operate within an annual framework

and disregard year-to-year phenomena (e.g., modification of process rates, changes in immigration or emigration). If GPUN wishes to prepare quantitative analyses which incorporate these phenomena, the exercise would surely shed light upon a complex compliance issue. Given the lack of substantive, empirical data concerning the maintenance of balanced, indigenous populations, the impact assessment models provide the best estimate at this time concerning the potential adverse impacts of the Oyster Creek facility.

In the second part of Step 6, the information developed from application of the models in combination with the data and analyses presented by GPUN were used to evaluate whether the Oyster Creek NGS adversely affects balanced, indigenous populations as required by §316(a) of the CWA by determining compliance with evaluation criteria and decision points defined in Step 2. Because the evaluation criteria developed represent an integration of decision points in previous litigation and were consistent with the CWA and New Jersey water quality policies and standards they have legal precedent. The results of the impact assessment analyses and the data adequacy review were the technical basis used to make this determination. As the final part of Step 6, a determination was made of the consequences of missing data to making a §316(a) decision and granting an NPDES permit for the Oyster Creek NGS.

Step 7 involved collecting and integrating the information needed to determine if intake structures at the Oyster Creek NGS represented the best available technology (BAT) for minimizing environmental harm as defined by §316(b) of the CWA. As a part of Step 7, we developed and applied econometric models to determine the costs to ratepayers of requiring effective BAT's. It consisted of seven steps:

- Identification of the adverse impacts to be minimized
- Identification of the available technologies that reduce the identified adverse impacts
- Estimation of the ecological benefit likely to be derived from each applicable technology
- Estimation of costs for each applicable technology
- Optimization of BAT selections based on anticipated benefits and cost-effectiveness
- Determination of the socio-economic consequences of requiring BAT (e.g., costs to rate payers)
- Evaluation of the adverse impacts of requiring BAT.

The proposed methodology calls for a 316(a) determination to be accomplished prior to the BAT evaluation. This will facilitate the most cost-effective BAT evaluation, since the impacts to be minimized will already have been defined. If it is determined in Step 6 that alternate effluent limitations for a facility do not protect the maintenance and propagation of balanced indigeneous populations, then alternate effluent limitations would be denied and the utility must comply with §316(a) (i.e., BIP must be protected). In some cases, compliance with these water quality standards would require certain technologies or operational procedures which would eliminate the usefulness of others. In this manner, it is most cost-effective for NJDEP to make BAT evaluations with as much knowledge as possible (i.e., having made a 316(a) determination).

The next step in the evaluation process (Step 8) was to integrate our findings into recommendations and conclusions to assist NJDEP in:

- Defining alternate effluent limitations for the Oyster Creek NGS and attainable uses for the receiving waters
- Determining effectiveness of tempering pumps
- Defining the BAT for intake structures
- Granting an NPDES permit.

The final step in the study (Step 9), which will occur in the future, will be to assist NJDEP in preparing for a public hearing related to the establishment of alternate effluent limitations for the Oyster Creek NGS.

D. RATIONALE FOR THE APPROACH

The litigation reviews described in Appendices B through F suggest that three different assessment methods have precedential standing for demonstrating compliance with §316 of the CWA including: (1) demonstration of no prior appreciable harm; (2) demonstration of no adverse impact on Representative Important Species (RIS); and (3) submission of biological, engineering, and other data that satisfy §316 requirements. GPUN/JCP&L elected to use a combination of approach 1 and approach 2 in preparing the §316 Demonstration for the Oyster Creek NGS.

The no prior appreciable harm demonstration approach applies only to operating facilities and is based upon the presumption that if no harm can be shown for existing operations then no harm will occur in the future. Existing effluent

limitations then can be presumed to be more stringent than necessary to protect the receiving water body to the degree required by §316 of the CWA, and plant operations should be allowed to continue unaltered. A no prior appreciable harm demonstration is generally based on preoperational/postoperational comparisons of environmental "health" and survey data quantifying spatial changes in biotic distributions attributable to plant operations. The data presented for the no prior harm demonstrations were evaluated (Chapter IV) and were judged to be adequate for phytoplankton, zooplankton, benthic algae, and submerged aquatic vegetation. Data presented for fish suggested significant differences in species number and species composition between preoperational and operational years and were not adequate for making a determination as to the influence of the thermal discharge on fish populations.

A no prior appreciable harm demonstration is also based upon a rebuttable presumption. A rebuttable presumption is a factual inference which may be made in the absence of certainty and which may be rebutted by other evidence. Once the owner/operator of a power plant has provided substantial, creditable evidence for no prior appreciable harm, the burden of proof is on the regulator to either rebut the presumption or to accept it. Rebutting the conclusions of a no prior appreciable harm type §316 Demonstration is difficult unless the regulator has conducted independent studies and/or "new" analyses which allow them to take an affirmative position. In the evaluation methodology used by this study, a series of independant analyses were used to assess the impact of the Oyster Creek NGS on spawning and nursery functions, ecosystem productivity, and beneficial uses (i.e., commercial and recreational fisheries) of the receiving water body. These independent analyses allow NJDEP to take an affirmative position when making §316(a) and §316(b) decisions for the Oyster Creek NGS and provide a means for rebutting the no prior appreciable harm portions of the Oyster Creek §316 Demonstrations should it be necessary to do so.

The evaluation methodology used to determine if operation of the Oyster Creek NGS protected the receiving waters to the degree required by §316(a) and if intake structures represented the best available technology for minimizing environmental harm relies heavily upon identification and selection of RIS and the subsequent evaluation of power plant impacts upon these target species. Not only does this approach have legal precedent but most of the data presented in the Oyster Creek §316 Demonstration documents are applicable to it.

E. GPUN'S COMMENTS ON EVALUATION METHODOLOGY

GPUN provided comments on the evaluation methodology in two different volumes (23 December 1987 and 7 July 1988). In short, their concerns were that the evaluation methodology:

- Combined the §316(a) and §316(b) review and considered impingement and entrainment impacts as a part of the §316(a) review as well as the §316(b) review

- Used impact assessment models to assess the consequences of entrainment losses to regional biological populations and as a result did not rely on the analyses conducted by GPUN and its consultants when determining the consequences of power plant-related losses to regional populations

- Misinterpreted the meaning of "minimize" in the context of §316(b)

- Failed to consider plant-related losses at the population/community level when determining adverse harm

- Considered worst case conditions or assumptions which have little chance of occurring when consideration of extreme conditions which would have a reasonable chance of occurring would have been more appropriate

- Considered adverse impacts on beneficial uses of receiving water under §316 when consideration of impacts on beneficial uses is not specifically required by §316 of the CWA.

In this evaluation methodology we do include impingement and entrainment as a part of our §316(a) evaluation in accordance with our legal reviews (Appendices B and C). The specific wording of §316(a) of the CWA as well as precedents established by previous §316(a) litigation is unclear as to the degree entrainment and impingement losses are considered as a part of §316(a). Clearly §316(a) is mainly directed toward losses due to the "thermal component." Entrainment, however, includes the thermal shock of organisms traversing the condensers and their return to the receiving body via the discharge canal. These thermal effects are a major source of entrainment mortality and interact synergistically with other entrainment stresses to result in an overall entrainment mortality. Impinged organisms are returned to the thermal discharge canal and are also subjected to thermal shock, contributing to impingement mortality. Therefore, it was our judgement that it would be of little value, if not impossible, to separate entrainment good!

and impingement losses due to exposure to the "thermal component' from other stresses. In addition, previous §316(a) litigation indicates "other stress" should be included as part of the §316(a) evaluation. Previous §316 litigation suggests that because all modes of power plant impact are so interrelated that when possible it is preferable to evaluate them simultaneously and jointly. Because joint evaluation was the most cost effective method for conducting the review and evaluation of the Oyster Creek 316 Demonstration, NJDEP and its technical advisors requested that we conduct a joint review.

Versar also used impact models to assess plant-related effects at the population/community level primarily because the analyses provided in the Oyster Creek 316 Demonstration were judged to be insufficient to substantiate the protection of balanced, indigenous populations unless supported by additional information on the impacts to regional populations. The impact models were used to address these shortcomings. It is unclear as to why GPUN commented that the review methodology did not consider the consequences of losses at the population or community level as this is the major purpose of applying the models and the lack of these considerations is the major shortcoming of the 316 documents submitted by GPUN. The evaluation does consider worst case conditions but only those conditions which have some likelihood of happening. We agree with GPUN that consideration of worst case conditions which had little chance of occurring would be of little value. Finally, our evaluation methodology includes beneficial uses, although §316(a) and §316(b) of the CWA do not specifically address beneficial uses. We use beneficial uses to ensure inclusion of important recreational/commercial species (hard clam, winter flounder, blue crab) under the umbrella of balanced, indigenous populations. Previous §316(a) and §316(b) litigation indicate inclusion of adverse impacts on beneficial uses of a water body is appropriate. This inclusion appears to be in agreement with the intent of the CWA. No so!

GPUN felt that the evaluation procedure would require a reduction of losses even if existing operations were not adversely harming balanced, indigenous populations. Therefore, GPUN suggested that Versar had misinterpreted the meaning of the word "minimize" in the §316(b) context. While it is true that the evaluation procedure may require a reduction of plant related losses even if balanced, indigenous populations are not threatened, such a reduction of losses will be achieved by methods whose costs are not wholly disproportionate to the ecological benefits that result. Appendix B indicates this is a reasonable approach. GPUN suggests that if a balanced, indigenous population exists, then there are no ecological benefits to reducing plant related losses. This is inconsistent with §316(b) which requires the minimization of adverse environmental impact not the protection of balanced, indigenous

populations, and may, therefore, be more stringent than §316(a). The major point of disagreement between Versar and GPUN in this context is clearly the determined value of the ecological benefits that result from reducing losses which do not threaten the balanced, indigenous population.

III. SELECTION OF RIS, DETERMINATION OF GEOGRAPHIC BOUNDARIES, AND BOUNDARIES OF RECEIVING WATERBODY FOR ASSESSMENT

GPUN chose to base the Oyster Creek 316 Demonstrations on a combination of the RIS concept and a "no prior harm" demonstration. Therefore, they had to select specific RIS to consider, as well as to decide the geographic boundaries over which Oyster Creek's impact would be evaluated. In this section, we describe the selection criteria used by Versar for making an independent selection of RIS and deciding on geographic boundaries for assessing impacts of the Oyster Creek NGS. We also contrast Versar's RIS with those used by GPUN and discuss the consequences of any differences between the two RIS lists for making a §316 decision and developing final recommendations. The RIS and geographic boundaries used by GPUN have previously been reviewed and commented on by a Technical Advisory Group (TAG) consisting of representatives of concerned state and federal agencies. Versar considered the comments made during these previous reviews when selecting RIS, determining the boundaries of the receiving waterbody for making a §316(a) and §316(b) decisions for the Oyster Creek NGS, and determining whether GPUN should be entitled to seek both an alternative effluent limitation under §316(a) and a water quality standards revision under §303(g).

A. SELECTION OF RIS

The RIS assessment approach is based upon the assumption that species which are essential to, or representative of, the maintenance of balanced, indigenous populations of shellfish, fish, and wildlife in the Oyster Creek/Barnegat Bay ecosystem can be identified. RIS selections for the Oyster Creek §316 Demonstrations should include:

- Species that use the Oyster Creek/Barnegat Bay region as a spawning and/or nursery ground
- Species of commercial and/or recreational value
- Species that are essential to the functioning of the Oyster Creek/Barnegat Bay ecosystem
- Species that are important linkages in the food web of the Oyster Creek/Barnegat Bay ecosystem
- Species recognized as threatened or endangered

- Nuisance species likely to be enhanced by power plant operations

- Species in each of the above categories that are likely to be sensitive to power plant operations

- Species which represent all major trophic categories within the Oyster Creek/Barnegat Bay ecosystem (i.e., primary producers, zooplankton/macroinvertebrates, forage fish, predatory fish, and other vertebrates).

Specific RIS for each of the seven RIS categories were chosen to include at least one species from each trophic level category in the above RIS list. Tables III-1 through III-7 summarize the RIS selected by Versar for each category. These selections were developed from the available scientific literature (e.g., Kennish and Lutz 1984) as well as the Oyster Creek §316 Demonstration documents. Tables III-1 through III-7 describe our rationale for the selection of RIS, and at the bottom of each table a conclusion is reached as to whether the RIS used by GPUN adequately represented each RIS category.

The RIS used by GPUN did not include representatives of habitat formers, threatened or endangered biota, and primary producers (Table III-8). GPUN's failure to use a RIS for the habitat former, primary producer, and threatened and endangered categories did not adversely affect Versar's ability to review and evaluate the Oyster Creek 316 Demonstration. Versar identified eelgrass as a RIS for both the habitat former and primary producer categories. In addition, Versar chose the Atlantic Ridley turtle as a RIS for the threatened and endangered category. Impacts of the Oyster Creek facility on eelgrass are likely to be localized and were evaluated using existing data. There appear to be no adverse interactions between the Oyster Creek NGS and threatened/ endangered biota, but Versar reviewed and evaluated the potential for such interactions.

B. DETERMINATION OF GEOGRAPHIC BOUNDARIES

The four criteria available for the determination of geographic boundaries over which the evaluation could be applied are the use of natural geographic boundaries, regions defined by human use patterns, regions over which the life cycles of RIS are completed, and regions in which critical ecological functions are performed. The litigation review suggested that the evaluation of §316 impacts should be made within natural geographic boundaries unless one of the remaining criteria can be shown to be more reasonable.

Table III-1. Selection of RIS that use Barnegat Bay as a spawning and nursery area

Versar Selections	GPUN Selections
Winter flounder	Winter flounder
Bay anchovy	Bay anchovy
Sand shrimp	Sand shrimp
	Weakfish
	Atlantic menhaden
	Bluefish
	Threespine stickleback

Rationale for Versar's Selections

- A local population of winter flounder use Barnegat Bay as a spawning and nursery area, and their larvae are abundant in entrainment samples.
- Bay anchovy use Barnegat Bay as a spawning and nursery area, and their eggs and larvae are the most abundant ichthyoplankton in entrainment samples. Bay anchovy adults are the most abundant fish in impingement samples.
- Sand shrimp are present in Barnegat Bay for most of the year and early developmental stages are abundant in entrainment samples. Large numbers of sand shrimp are also impinged.

Conclusion: Category is adequately represented by GPUN's selections

Table III-2. Selection of RIS of commercial and recreational value

Versar Selections	GPUN Selections
Hard clam	Hard clam
Blue crab	Blue crab
Winter flounder	Winter flounder
	Bluefish
	Summer flounder
	Weakfish
	Striped bass
	Northern kingfish
	Northern puffer
	Atlantic menhaden

Rationale for Versar's Selections

- Hard clams and blue crabs rank fourth and fifth in commercial landings for Ocean County, respectively. About 30% of the clams and 100% of the blue crabs comprising Ocean County commercial landings are caught in Barnegat Bay.
- Blue crabs are the most abundant organism caught recreationally in Barnegat Bay, and are the second most abundant organism impinged. Large numbers of the early development stages of hard clams are entrained.
- Winter flounder is one of the most sought after recreational species in Barnegat Bay, and their larvae are abundant in entrainment samples.

Conclusion: Category is adequately represented by GPUN's selections

Table III-3. Selection of RIS that are habitat formers

Versar Selections	GPUN Selections
Eelgrass	None

Rationale for Versar's Selection

- Eelgrass is an important primary producer in the Barnegat Bay ecosystem and serves as important habitat for benthos, crabs, and fish. It is a particularly important nursery habitat for juvenile fish and crabs.
- Dredging of the intake and discharge canals and plant operations (i.e., thermal discharges) can potentially adversely affect eelgrass stocks.

Conclusions: Category is not adequately represented by GPUN's selections. The potential for adverse harm of this species warrants evaluation.

Table III-4. Selection of RIS that are important linkages in the food web

Versar Selections	GPUN Selections
Bay anchovy	Bay anchovy
Sand shrimp	Sand shrimp
	Opossum shrimp
	Corophium tuberculatum

Rationale for Versar's Selection

- Bay anchovy and sand shrimp are important forage species in the diets of juvenile and adult fish inhabiting Barnegat Bay.
- Eggs and larvae of bay anchovy are the most abundant ichthyoplankton in entrainment samples, and bay anchovy are the most abundant fish in impingement samples.
- Sand shrimp are the most abundant organism in entrainment samples, and large numbers of them are impinged.

Conclusion: Category is adequately represented by GPUN's selections

Table III-5. Selection of RIS recognized as threatened or endangered

Potential Versar Selections	GPUN Selections
Atlantic Ridley turtle	None

Rationale for Versar's Selection

- The Atlantic Ridley turtle is classified as an endangered species, and it could potentially be impinged on trash racks in front of the auxiliary pumps and the condenser cooling system of the Oyster Creek NGS.

Conclusion: Category is not represented by GPUN's selections, and the potential for adverse harm to this species category warrants evaluation. However, no impingement of sea turtles has been reported from the Oyster Creek NGS. Power plant interactions at the Oyster Creek NGS with threatened and endangered species is likely to be negligible.

Table III-6. Selection of RIS that are nuisance species whose abundance is likely to be enhanced by power plant operations

Versar Selections	GPUN Selections
Shipworms:	Shipworms:
Teredo spp.	*Teredo* spp.
Bankia gouldi	*Bankia gouldi*
	Hydroides dianthus

Rationale for Versar's Selections

- Boring activities of shipworms cause severe damage to submerged wooden structures, and thermal discharges from the Oyster Creek NGS could potentially enhance boring activities, growth rates, and reproductive capacity of naturally occurring shipworm populations.
- The Oyster Creek discharge canal is a potential refuge for subtropical shipworm species that do not naturally occur in Barnegat Bay.

Conclusion: Category is adequately represented by GPUN's selections

Table III-7. Selection of RIS that are sensitive to power plant interactions

Versar Selections	GPUN Selections
Bay anchovy	Bay anchovy
Atlantic menhaden	Atlantic menhaden
Opossum shrimp	Opossum shrimp

Rationale for Versar's Selections

- Bay anchovy are one of the most abundant forage fish in Barnegat Bay and have high mortality rates following entrainment and impingement. Bay anchovy are also sensitive to both the high temperatures and rapid changes in temperature that could be associated with the Oyster Creek discharge canal.
- Menhaden are an abundant planktivorous fish in Barnegat Bay and have been reported to experience heat and cold shock mortalities in the Oyster Creek discharge canal. Menhaden also generally have high impingement and auxiliary pump entrainment mortalities.
- Opossum shrimp is an abundant pelagic macro-invertebrate that is important in the Barnegat Bay food web. They are potentially sensitive to changes in temperature regimes associated with entrainment through the Oyster Creek NGS and through the auxiliary tempering pumps.

Conclusion: Category is adequately represented by GPUN's selections

Table III-8.. Comparison of trophic categories represented by Versar's and GPUN's RIS selections

Trophic Category	Versar's Selection	GPU's Selection
Primary producer	Eelgrass	None
Zooplankton-macroinvertebrate	Opossum shrimp Sand shrimp Shipworms Blue crab Hard clam	Opossum shrimp Sand shrimp Shipworms Hard clam *Corophium tuberculatum* *Hydroides dianthus*
Planktivorous fish	Bay anchovy	Bay anchovy Atlantic menhaden
Piscivorous fish	Winter flounder	Bluefish Winter flounder Weakfish Summer flounder Northern kingfish Northern puffer Striped bass
Other vertebrates	Atlantic ridley turtle	None

For the Oyster Creek NGS, there are three possible choices for the geographic boundaries of concern; namely, Oyster Creek, Barnegat Bay, and the coastal waters of the East Coast of the United States. While the receiving water body should legally be considered Oyster Creek discharge canal (refer to discussions in Section C below), the balanced indigenous populations in Oyster Creek have been irreversibly altered by construction of the facility. Populations that existed prior to the construction of the Oyster Creek NGS in the formerly freshwater portion of Oyster Creek and the formerly terrestrial habitat where the Oyster Creek discharge connects with Forked River have been displaced. Any evaluation of the maintenance of balanced, indigenous populations in these two regions of Oyster Creek would show, of necessity, complete non-compliance. However, it would be inappropriate to base the §316 determination for Oyster Creek NGS on the maintenance of balanced indigenous populations in Oyster Creek alone, since the State of New Jersey approved the construction of Oyster Creek NGS and thus the alteration of Oyster Creek to its present physical form. Given the irreversible alterations made to Oyster Creek, the geographic boundary used for evaluation of plant impacts for all RIS except nuisance species was Barnegat Bay. This selection was made because the Bay represents a natural geographic boundary containing a definable estuarine ecosystem. Barnegat Bay is also a geographic boundary for many human uses of the receiving waters. Examinations of successful completion of life stages of RIS populations could not be evaluated on the geographic scale of Oyster Creek as no RIS species with the possible exception of hard clams and shipworms spawn in Oyster Creek. Protection of RIS on a larger geographic scale than Barnegat Bay would not provide a meaningful basis for NJDEP to make a §316 decision for the Oyster Creek NGS. Oyster Creek was selected as the appropriate geographic boundary for evaluation of enhancement of nuisance species because plant-related enhancements to the RIS nuisance species selected was of greatest concern within Oyster Creek.

C. DEFINITION OF THE RECEIVING WATER BODY

In order to determine compliance of the thermal discharges from the Oyster Creek NGS with New Jersey Surface Water Criteria and designated heat dissipation areas (NJAC 7:9-4.1 et seq.), a determination of what constitutes the receiving water body was required. For this determination one of our legal consultants, Dr. William Goldfarb, J.D. of Pennington, New Jersey, prepared a legal brief defining the receiving water body for the Oyster Creek NGS. The discussions below summarize the findings of Dr. Goldfarb's legal brief (see Appendix C for details).

Three cases have precedent in defining the receiving water body for the Oyster Creek NGS:

- United States v. Holland, 373 F. Supp. 665 (D.C. Fla., 1974)
- Weiszmann v. Corps of Engineers, 526 F. 2d 1302 (5th Cir., 1976)
- Track 12, Inc. v. District Engineer, 618 F. Supp. 448 (D.C. Minn., 1985).

All the above cases conclude that artificial water bodies, like the intake and discharge canal of the Oyster Creek NGS are part of the "waters of the United States" and are regulated under the CWA. In United States v. Holland, the court directly confronted the issue of whether artificial waters are "waters of the United States" by noting:

> The conclusion that Congress intended to reach water bodies such as these canals with the FWPCA is inescapable. The legislative history...manifests a clear intent to break from the limitations of the Rivers and Harbors Act to get at the sources of pollution. Polluting canals that empty into a Bayou arm of Tampa Bay is clearly an activity that Congress sought to regulate. The fact that these canals were man-made makes no difference (373 F. Supp. 665, at p. 673).

Based on the above cases it is clear that the man-made discharge canal of the Oyster Creek NGS, as well as Oyster Creek and Forked River proper, are "waters of the United States." These waters also qualify as "waters of the State" under the New Jersey Water Pollution Control Act and its attendant regulations, which refer specifically to artificial water bodies [NJSA 58:10A-3(t); NJAC 7:14A-1.9)].

Defining the "receiving waters" in a §316 proceeding was also an issue in previous §316 litigation. In In Re Public Service Co. of New Hampshire (1977) (see Appendix B) the EPA Administrator rejected the utility's argument that the receiving waters should be broadly defined by noting:

> One of the underlying questions to be considered in making the decision in this case was what should be considered as the receiving waters. The Hampton-Seabrook area is part of the Gulf of Maine, a much larger body of water, which in turn is part of the Atlantic Ocean. Obviously an impact which created an imbalance in the local indigenous populations might not be felt in the Gulf of Maine or the

> Atlantic Ocean. Put another way, if the Atlantic Ocean (or a part of it as large as the Gulf of Maine) is to be considered as the receiving water, then Section 316 might be a dead letter as to coastal power plants because plants of a size likely to be built probably would not have an effect on such an enormous body of water. Therefore, I think that in order to give effect to Section 316 it is necessary to look at a smaller portion of the coastal waters where human use or enjoyment of the marine resource may be affected. The portion chosen is necessarily arbitrary to some extent where, as in this case, there are no obvious physical boundaries (10 E.R.C. 1257, at page 1265).

The discharge canal of the Oyster Creek NGS possesses physical boundaries and should thus be designated as the receiving water body for thermal discharge. It makes no difference if the canal is unavailable for public recreational use (United States v. Holland). In addition, NJDEP has consistently rejected attempts to ignore tributaries in order to consider larger water bodies as receiving waters when making NPDES decisions.

D. NEED FOR WATER QUALITY STANDARDS MODIFICATION

Under Section 303(g) of the CWA and comparable state law, "water quality standards relating to heat shall be consistent with the requirements of Section 316 of this Act." This provision is clear on its face; a "balanced, indigenous population" is the "bottom line" of acceptable water quality under the CWA. In his remarks supporting the Conference Committee Report on the Clean Water Act Amendments of 1977, Representative Roberts discussed the relationships between Section 316(a) and state water quality standards:

> This act is not intended to change the regulation of thermal discharges. In addition, the conferees must disagree with the interpretation of Section 316(a) expressed by the Senate Committee on Environment and Public Works...that Section 316(a) of the existing law does not preempt State thermal water quality standards.
>
> In adopting Section 316(a) as part of the 1972 amendments to the Federal Water Pollution Control Acts, we clearly intended that the section apply to thermal limitations based on State water quality standards as well as technology-based effluent limitations. Therefore, this committee cannot agree with the present interpretation expressed in the Senate report....We specifically note that EPA correctly interpreted the original intent of the

> effect of Section 316(a) on State water quality standards,... that Section 316(a) operates to affect effluent limitations based on water quality standards relating to heat....The purpose of Section 316(a) -- to provide for site-specific analyses of the impact of thermal discharges -- applies to effluent liitations based on water quality standards, as well as to technology-based effluent limitations. In addition, Section 303(g), which provides that water quality standards related to heat must be consistent with Section 316 of the act, reinforces the intention that the "balanced, indigenous population" standard of Section 316 be the guiding principle in evaluating thermal discharges. This interpretation tends to avoid unnecessary capital expenditure, and thus needless higher costs to the consumer, while assuring adequate protection of the aquatic environment.

Thus, 40 CFR sec.131.10(g) (removing designated uses) has been preempted by Section 316(a) where heat is concerned. EPA recognizes that protecting a balanced, indigenous population is "the minimum requirement for standards relating to temperature."

IV. DATA ADEQUACY

A. INTRODUCTION

Step 5 in the evaluation methodology developed in Chapter II is to identify the information required to make a §316 decision for the Oyster Creek NGS and to determine whether this information is available in the Oyster Creek 316 Demonstration documents. A determination of data adequacy includes an evaluation of the reasonableness of the methods used to collect, summarize, and interpret the data. This chapter discusses data adequacy for each of the major categories of empirical data collected by GPUN and consists of five sections corresponding to the major types of data collected. These sections are:

- Hydrothermal assessment
- Impingement loss estimates
- Entrainment loss estimates
- Discharge effects
- Barnegat Bay population abundance estimates.

Adequate data must be available in all five categories in order for an effective evaluation of the impacts of the Oyster Creek NGS on the Barnegat Bay estuary to be completed.

B. HYDROTHERMAL ASSESSMEMT

The objective of the hydrothermal assessment is to determine if the thermal discharge from the Oyster Creek NGS is in compliance with the New Jersey Thermal Discharge criteria. The primary source of information for this determination is the Oyster Creek 316 Demonstration documents although our evaluation was supplemented by other materials. The receiving water body for thermal discharges has already been determined to be the dredged discharge canal which joins Oyster Creek, which in turns flows into Barnegat Bay. Oyster Creek was widened and deepened (to about 3 meters) to accommodate the combined flows of the condenser discharge (30 m^3/s) and the dilution pumps (33 m^3/s). Barnegat Bay, the secondary receiving

water body, is a wide shallow bay with small annual mean freshwater inflow (< 10 m^3/s) and relatively low-amplitude mean tidal fluctuations (0.15 m) although wind-driven tidal surges can exceed 1 m.

New Jersey Thermal Discharge Regulations 7:9-4.14(C) entitled Surface Water Quality Criteria for SE and SC Waters specify that:

- No thermal alterations causing above-ambient deviations of more than 4° F (2.2° C) can be incurred during the period September through May; and of no more than 1.5° F (0.8° C) from June through August outside the heat dissipation area

- At no time can temperatures exceed 85° F (29.4° C) outside the heat dissipation area [Max. 85°F]

- The heat dissipation area (area characterized by definable power plant altered thermal regimes) cannot extend to more than 25% of the cross-section or not more than 2/3 of the surface radial length from point of discharge to the opposite shore.

GPUN can request and be granted a variance from these thermal requirements when the impacts do not adversely impact the maintenance and propagation of balanced, indigenous populations of fish, shellfish, and other wildlife in or on the receiving water body, especially the thermal component. GPUN contends that Barnegat Bay is the relevant receiving water and proposed a variance to the summer thermal limitations from 1.5° F to 4° F because the thermal plume did not act as a barrier to fish migration. Versar evaluated the compliance of the Oyster Creek NGS thermal discharge based on the exact physical criteria set forth in the New Jersey Thermal Discharge Regulations and considering Oyster Creek as the primary receiving water body for two reasons. First, as discussed in Chapter II and Appendix C, the primary receiving water body is clearly Oyster Creek, although Barnegat Bay may be the secondary receiving waters. As a result, the thermal criteria should be applied to Oyster Creek or to the combination of Oyster Creek and Barnegat Bay. Second, the role of Barnegat Bay as a migratory path for biota is irrelevant at this point because the hydrothermal compliance determination is based solely on physical criteria; namely, the ability of the receiving water to dissipate waste heat. The effect of excess waste heat on the normal movement of biota is secondary to the thermal compliance criteria and can be put forward as a potential source of waiver after a determination has been made as to whether effluent limitations have been exceeded.

GPUN presented results of several hydrothermal studies in the Oyster Creek 316 Demonstration documents upon which our

thermal compliance determination was based. Table IV-1 summarizes the hydrothermal studies conducted in the vicinity of the Oyster Creek NGS. Each of these studies (dye plume mapping, thermal plume mapping, recirculation studies, and hydrothermal modeling) are evaluated below.

Dye Studies

Dye studies were used to define the circulation patterns in Barnegat Bay and to estimate the potential dimensional characteristics of the thermal plume. During the preoperational study conducted by Pritchard-Carpenter Associates, dye was released continuously at the mouth of Oyster Creek for several weeks. The dye distributions in Barnegat Bay were then measured during four separate surveys following release. The preoperational study released dye for a period of time sufficient to allow concentrations to approximate a steady state distribution in Barnegat Bay permitting the accumulation of dye in the Barnegat Bay system that simulated the distribution of waste heat. This information therefore represents the best information that is reasonably available to characterize circulation patterns in mid-Barnegat Bay.

Two important conclusions can be drawn from these studies. The first is that the circulation in Barnegat Bay is wind driven. As a result, the shape and dimensions of the Oyster Creek thermal plume are greatly influenced by the wind. The second is that recirculation of dye (and hence a measure of waste heat) could be large under specific meteorological conditions. Five of the six surveys and predictions showed potential recirculation (i.e., significant dye concentrations at the mouth of Forked River, the plant intake) ranging from 5% to about 50% of the discharge dye concentration. Although recirculation based upon dye concentration would clearly provide an overestimate of the recirculation of waste heat (since dye is more conservative than heat), the present recirculation values based on dye studies provide an estimate of the likelihood of this phenomena. The surface waters in the vicinity of Oyster Creek and Forked River (directly adjacent to shoreline) appear to have a net southward movement toward Barnegat Inlet while the flow in the deeper areas (>1,000 yards offshore) demonstrated a net northerly motion. As dye or waste heat traverse the distance to "deeper waters," a greater likelihood of recirculation occurs. The greatest recirculation occurred when winds were from the south, a condition that prevails during summer. These results suggest that significant excess heat could be recirculated to the plant intake particularly for wind conditions which generally prevail during summer.

Table IV-1. Overview of thermal studies conducted in the vicinity of the Oyster Creek NGS (1969-1976)*

Studies	Study Specifics	Contractor
Dye plume studies	4 dye plumes, preoperational conditions	Pritchard-Carpenter Assoc. for JCP&L
	2 dye plumes, postoperational conditions	GPUN for JCP&L
Thermal plume mapping		
Far field	8 surveys, 5 preoperation	Sandy Hook Marine Lab for USAEC EPA for EPA, NJDEP
Near field	60 surveys	Woodward Clyde for JCP&L Sandy Hook Marine Lab for USAEC
Recirculation study	Continuous temperature monitor for 23 days	Woodward Clyde Consultants for JCP&L
	Radiological inventories of Mn-54 and Co-60	USEPA and NJDEP
Hydrothermal model	2-D steady-state model, with water and heat balance	Lawler, Matusky & Skelly for JCP&L

*Approximately 30 additional surveys have been conducted by JCP&L from 1979-1982. The results of these surveys were not available to Versar at the time of its review.

Thermal Plumes

Two types of studies were used to determine the extent of the Oyster Creek thermal plume from 1969-1976: towed thermistors and IR thermographic overflights with ground truth thermistor profiles. A location northeast of the mouth of Oyster Creek was used for estimating ambient temperature (Fig. IV-1). Versar fully appreciates the difficulty in representing the ambient temperature in Barnegat Bay. It is because of this understanding that Versar feels the location of an ambient temperature station in the mouth of the Forked River will lead to a potentially serious underestimation of the size of the Δ 4°F and Δ 1.5°F thermal plumes. While some variations in temperature probably occur between areas located away from Oyster Creek and the mouth of the discharge canal (i.e., about 1°F), recirculation potential at the mouth of Forked River ensures above ambient temperatures particularly in late summer months. The ambient temperature location selected by Versar is typically far from the influence of the plume, exhibited near average bay temperatures during preoperational surveys, and is not continually modified by the changing temperatures of the seawater entering through Barnegat Inlet. The near-field surveys are of limited use since temperatures were typically recorded only in the vicinity of the discharge, and only to a depth of five feet. For the most part, ambient temperatures cannot be estimated for the nearfield surveys, and hence the true extent of the Δ 1.5° F and Δ 4° F plumes are unknown. The high-altitude flights appear to be the best for determining detailed surface temperatures distributions, and showed the 1.5° F above ambient summer thermal plume extending completely across Barnegat Bay.

Of the thermal survey methods used, the low-altitude overflights used the best method available for collecting information to evaluate compliance with NJDEP thermal regulations. GPUN interpreted these overflights using the Forked River ambient temperature station to evaluate the sizes of the Δ 4°F and the Δ 1.5°F thermal plumes and determined the discharge plumes to be generally in compliance. These overflights demonstrate that the extent of the plume's surface width and cross-section frequently exceeded New Jersey Water Quality criteria when examined using the "new" ambient temperature location selected by Versar. The unspecified altitude flights did not extend far enough from the discharge area to estimate ambient temperature accurately.

Recirculation Study

In order to estimate recirculation of heated water, GPUN monitored the Forked River intake temperature for 23 days and compared the intake temperature time series with a time series

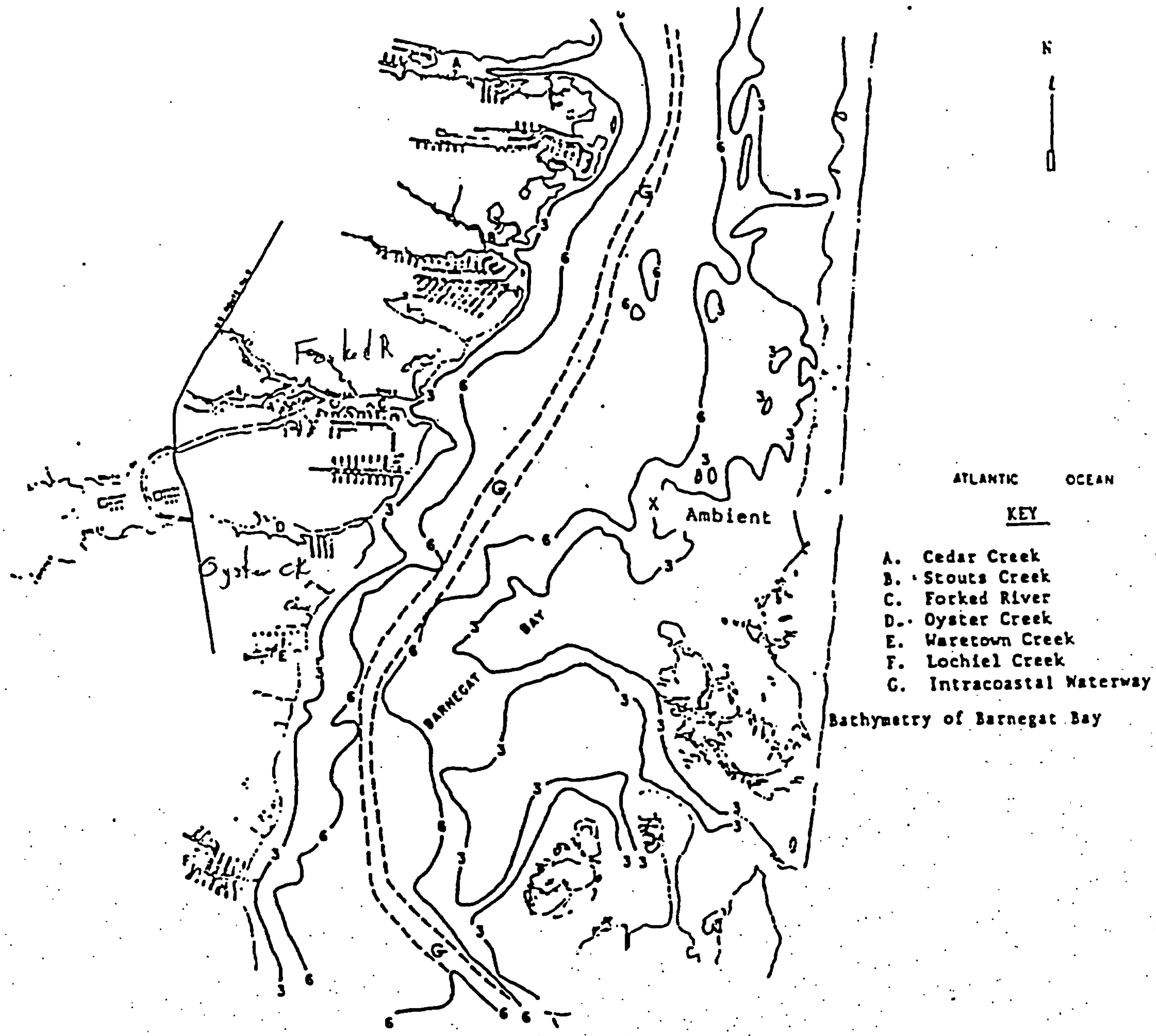


Figure IV-1. Location of region used by Versar to estimate ambient temperatures (modified from JCP&L 1978)

of power production by the Oyster Creek NGS, Newark air temperature, and the southerly wind component. Intake temperature qualitatively tracked air temperature, and based on this finding GPUN concluded that recirculation was small, and that intake temperature was a reasonable estimate of ambient temperature (Figure IV-2). Clearly, this analysis and its interpretation does not reach a reasonable conclusion. A relationship appears to exist between Forked River water temperature, and the interaction of power production of the Oyster Creek NGS and wind condition. Without the raw data used to construct Figure IV-2 this relationship cannot be tested. In addition, this study completely ignored earlier indications of recirculation obtained from the dye studies as well as the thermal plume mapping overflights.

Radiological studies of the distributions of reactor products (Mn-54 and Co-60) in near-field sediments suggest that recirculation occurs at a rate of 18%-22% on an annual average. Given the predominance of southerly flows of the discharge with negligible recirculation in much of the year (Carpenter 1963), the recirculation rates associated with winds from the south must be significantly higher than the annual average of 22%. All of these studies suggested recirculation can be substantial especially during summer when the thermal plume has a northerly orientation for a substantial portion of the time.

Hydrothermal Modeling

GPUN used a hydrothermal model to assess the compliance of the Oyster Creek's discharge with the thermal regulations. The model was formulated as a two-dimensional steady-state mass and heat balance, and was calibrated to dye and thermal survey data. Early attempts at verification indicated that results predicted by the steady-state model for segments upstream (north) of Oyster Creek were significantly different from observed dye results (Carpenter 1963). No reasonable set of parameters would produce steady-state model agreement with the survey results. Modification of the model to a one-dimensional unsteady-state, constant parameter model produced "adequate" verification. Versar contends that the "adequate" verification is minimal and simply confirms that the steady-state model is a poor reflection of the dynamic conditions characterizing Barnegat Bay. The model was tested under assumed wind/tide conditions. Limited information on model inputs or parameters was presented, and the information provided in the 316 Demonstration documents was inadequate to evaluate the model calibration or validation procedures.

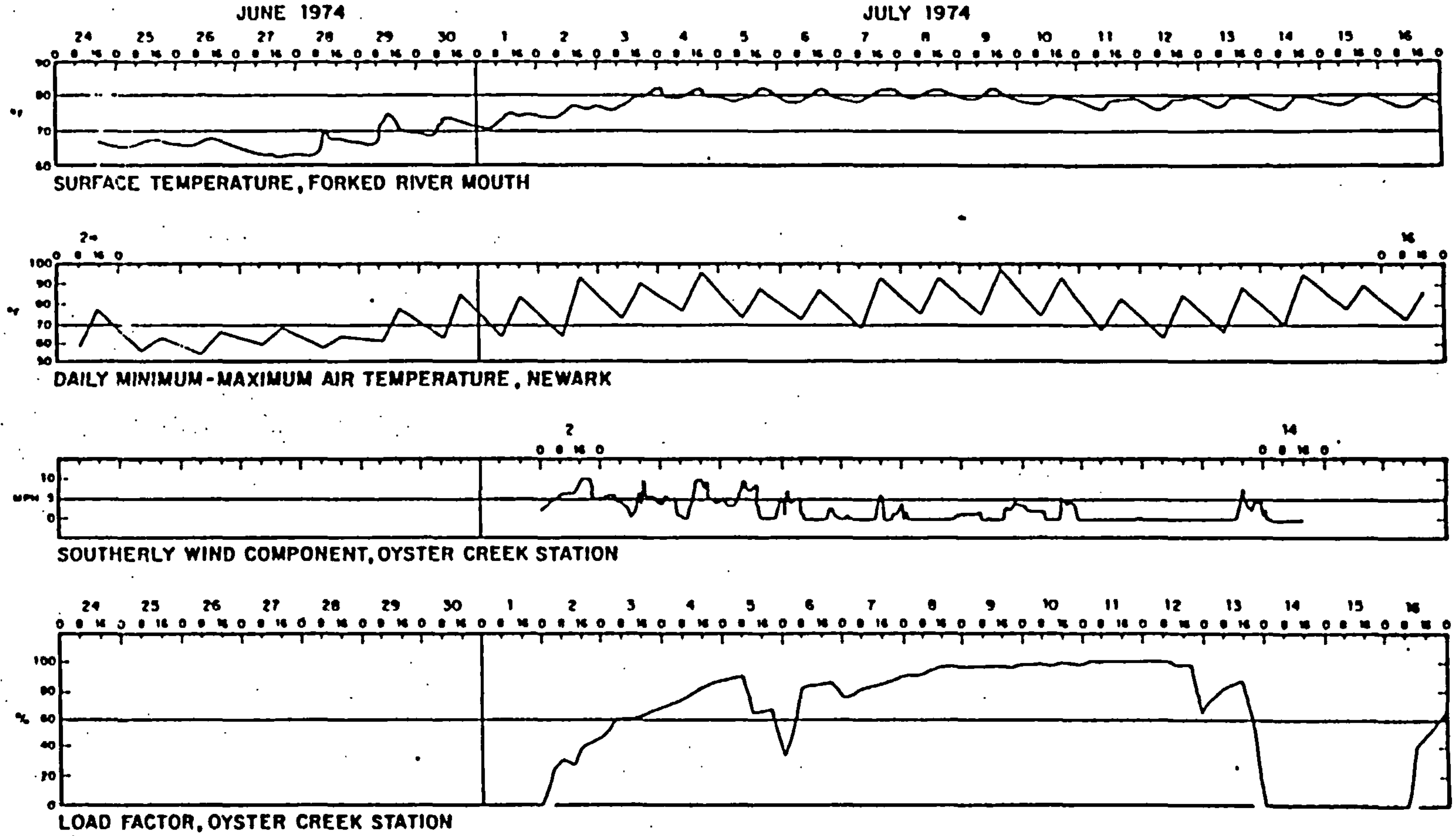


Figure IV-2. Forked River mouth surface temperature and associated environmental data June 24-July 16, 1974 (from JCP&L 1978)

The results of the hydrothermal model are compared by Versar to the New Jersey Water Quality criteria in Table IV-2. The model results indicate that recirculation will raise intake temperatures approximately 2-3° F. The cross-sectional areas of the model plumes are not in compliance (exceed 25%) with the Δ 1.5° F limit during the summer months (Table IV-2). GPUN proposed a modification of the Δ 1.5° F summer limit to a Δ 4° F. However, no model results were presented to demonstrate that existing operations for the Oyster Creek NGS would comply with such a reduction in thermal effluent limitations if it were approved.

In addition, compliance is determined for both cross-sectional area and radial extent based on the distance from the mouth of Oyster Creek to Sedge Island. As discussed in Chapter III, the appropriate receiving water body is Oyster Creek in conjunction with Barnegat Bay. Therefore, the appropriate transect for comparison is from the discharge of OCNGS to Oyster Creek to Sedge Island. This selection modifies the surface width and cross-sectional areas used by GPUN and shown in Table IV-2. Finally, the model used by GPUN estimates the steady-state size and shape of the thermal plume not the actual configurations associated with short-term meteorological events. As a result, GPUN suggested the steady-state model overestimated thermal plume area based on the fact that predicted plume sizes were significantly larger than those based on the thermal surveys. The steady-state model is just as likely to underestimate as overestimate plume size. The bias suggested by GPUN to be inherent in the model predictions is the result of using an inappropriate ambient temperature (Forked River) to determine the Δ-plumes from the hydrothermal survey data.

The thermal plume modeling conducted by GPUN does not represent the best available methods for evaluating plume characteristics. The best method available for simulating dispersion of thermal discharges in shallow bays like Barnegat Bay at the time the Oyster Creek 316 Demonstration documents were prepared would have been a two-dimensional dynamic water and heat balance model capable of accommodating transient events, such as storm tides and winds.

Importance of Recirculation and Ambient Temperature

The accurate estimation of ambient temperature and the amount of recirculation of heated discharge water are essential information for the determination of compliance with the New Jersey Thermal Discharge criteria. GPUN selected the Oyster Creek NGS intake temperature as the best estimate of ambient temperature based on the results of their recirculation study.

Table IV-2. Percent of surface width and cross-sectional area encompassed by Δ 1.5° F isotherm in summer months and Δ 4° F isotherm in non- summer months based on GPUN 2-d hydrodynamic steady state model

Oyster Creek and Forked River Generating Stations

Run No.	Plant Conditions	Wind Conditions	Summer or Non-Summer	% of Surface Width Encompassed by 1.5° F Isotherm	% of Cross-Sectional Area Encompassed by 1.5° F Isotherm	% of Surface Width Encompassed by 4° F Isotherm	% of Cross-Sectional Area Encompassed by 4°F Isotherm
1 (LMST05)	Oyster Creek Forked River	No Wind	Summer	43.8	48.6	--	--
2 (LMST07)	Oyster Creek Forked River	No Wind	Non-summer	--	--	22.0	22.4
3 (LMST12)	Oyster Creek Forked River	West	Summer	42.5	47.0	--	--
4 (LMST17)	Oyster Creek Forked River	West	Non-summer	--	--	22.5	23.1
5 (LMST08)	Oyster Creek Forked River	South	Summer	45.0	50.0	--	--
6 (LMST11)	Oyster Creek Forked River	North	Summer	37.5	41.1	--	--
7 (LMST04)	Oyster Creek Forked River	No wind	Summer	45.1	50.2	--	--
8 (LMST13)	Oyster Creek Forked River	West	Summer	44.4	49.3	--	--
9 (LMST03)	Oyster Creek Forked River	No wind	Summer	44.4	49.3	--	--
10 (LMST15)	Oyster Creek Forked River	West	Summer	42.2	46.7	--	--
11 (LMST19)	Oyster Creek	South	Summer	45.0	50.0	--	--
12 (LMST20)	Oyster Creek	South	Summer	41.7	46.0	--	--

The results of the recirculation study were, however, contradicted by many of GPUN's other hydrothermal studies, which generally showed significant recirculation. For instance, dye studies indicated recirculated water was as much as 50% of intake flow. Similarly, thermal plume surveys (those for which an ambient temperature could be estimated) indicated apparent recirculation in 37 of 52 cases, with 5° F above-ambient temperrature recorded at the mouth of Forked River. Ambient temperatures could not be determined for the remaining surveys. Even the hydrothermal model (shown to underestimate plume sizes) indicated that recirculated water raised intake temperatures approximately 2-3° F above ambient. These results demonstrate that recirculation of heated effluent has a consistent influence on intake temperatures, such that the intake water (Forked River Stations) cannot be used to estimate ambient temperatures.

Assessment of Compliance with Thermal Discharge Criteria

The results of the thermal studies were used by GPUN to support the argument that the Oyster Creek NGS was in compliance with New Jersey Thermal Discharge Criteria. Versar completed a critical examination of all GPUN's hydrothermal data and concluded that the Oyster Creek NGS thermal discharge was not in compliance with New Jersey Thermal Discharge regulations. A summary of the results of GPUN's and Versar's compliance assessment is presented in Table IV-3.

GPUN's Assessment of Thermal Compliance

GPUN suggested that the New Jersey thermal criteria for heat dissipation areas did not apply to the Oyster Creek NGS because thermal discharges were not a barrier to fish migration and the purpose of the criteria is to prevent thermal blockage of migrating fish. In addition, they reported that fish have never migrated through Oyster Creek but did migrate through Barnegat Bay. Hence, the heat dissipation criteria should be applied only to Barnegat Bay as the receiving water body. GPUN stated that the hydrothermal model results indicated that the Δ 4° F plume covered less than 2/3 of the surface width of Barnegat Bay and less than 1/4 of the cross sectional area. Thus, Oyster Creek NGS complied with the criteria for heat dissipation areas. However, GPUN did not provide any specific data that supported this conclusion. In addition, our analysis indicated that the Δ 1.5° F plume covered more than 1/4 of the cross-sectional area of Barnegat Bay (from Oyster Creek to Sedge Island). GPUN finally states that temperatures greater than 85° F occur outside the heat dissipation area occasionally.

Table IV-3. Comparison of thermal compliance assessments by GPUN and Versar

Train of Logic

GPUN Assessment	Versar Assessment
1. Recirculation study: minimal recirculation	1. GPUN recirculation study: inconclusive
2. Ambient temperature assessment: Assuming recirculation is small, Forked River intake temperature = ambient temperature	2. Region for ambient temperature assessment identified from far field and preoperational temperature data; identified bay area NE of mouth of Oyster Creek
3. Δ T values in plume calculated from plant Δ T in an undefined manner, assumed ambient T	3. Δ T values estimated from ambient T (when available) and measured plume temperatures
4. Δ T values and dye results used to calibrate and verify model in an undefined manner	4. Recirculation estimated from: • Dye plumes at Forked River • Δ T values (from 3 above) at Forked River
5. Model test simulations indicate that: • 4° F plume covers < 2/3 width (1.5° F limit argued inapplicable on biological grounds) • 4° F plume covers < 1/4 cross-section (model assumes maximum plume depth of 5 ft; so all subsurface depths are at or near ambient)	5. Model results indicate recirculation to Forked River 6. Plume widths and cross-sections indicate frequent noncompliance
Therefore, OCNGS is in compliance with biologically reasonable limits in NJ Water Quality Criteria	Therefore, best available data (not modeling) indicates OCNGS frequently not in compliance with NJ guidelines

However, GPUN argued that these high temperatures were representative of ambient conditions and the >85° F criteria should be disregarded at Oyster Creek. However, no data were provided to support this position. In summary, GPUN argued that Oyster Creek NGS is in compliance with the biologically reasonable thermal guidelines derived from the New Jersey thermal discharge criteria.

Versar Assessment of Thermal Compliance

Versar examined the available thermal plume maps for compliance with the thermal regulations within three conditions: (1) Oyster Creek, (2) the combined Oyster Creek-Barnegat Bay system, and (3) Barnegat Bay alone. We applied a strict interpretation of the thermal discharge criteria; potential waivers from the regulations on biological grounds were not addressed. All plumes failed the cross-sectional and the surface width criteria when the receiving water body was considered to be Oyster Creek. For the Oyster Creek and Barnegat Bay system, all plumes failed the cross-sectional criterion because approximately 44% of the total cross-sectional area was within Oyster Creek. Forty percent of the thermal plumes fail the 2/3 surface width criterion when the combined Oyster Creek/Barnegat Bay system was considered to be the receiving body (Table IV-4). If Barnegat Bay alone was considered the receiving water body, 48% of the plumes with sufficient data to determine compliance failed the cross sectional criteria and 21% failed the surface width criterion (Table IV-4). There were occasional failures in non-summer months (September-May), meaning that the Δ 4°F isotherm exceeded the allowed heat dissipation area.

When viewed in this context, the steady-state model results (Table IV-2) are likely to fail the thermal criteria based on the combination of Oyster Creek and Barnegat Bay. Without the specific model parameters, estimates are not possible. However, given that 44% of the total cross-sectional area of the transect lies between the OCNGS discharge and the mouth of Oyster Creek, the cross-sectional area of the Δ 4°F or Δ 1.5°F plume likely exceeds 25%.

C. IMPINGEMENT

The major objective of the impingement evaluation was to determine the magnitude of impingement loss associated with normal operation of the Oyster Creek NGS. These estimates were then used to evaluate the impact of the facility on fisheries resources and natural populations. Impingement loss was calculated as the product of species-specific annual impingement

Table IV-4. Number of available thermal plume overflights which comply, do not comply, or for which inadequate data are available to determine compliance with New Jersey thermal discharge criteria

		Summer			Non-Summer			Total		
		Pass	Fail	Inadequate Data	Pass	Fail	Inadequate Data	Pass	Fail	Inadequate Data
Barnegat Bay	1/4 Cross Sectional Area	5	7	24	8	5	12	13	12	36
	2/3 Surface Width	8	3	25	11	2	12	19	5	37
	Overall	5	7	24	8	5	12	13	12	36
Oyster Creek and Barnegat Bay	1/4 Cross Sectional Area	0	36	0	0	25	0	0	61	0
	2/3 Surface Width	5	7	24	10	3	12	15	10	36
	Overall	0	36	0	0	25	0	0	61	0

and species-specific mortality rates (immediate and latent). Annual impingement was estimated using data from an intake screen sampling program after correcting for both screen collection and sampling efficiencies.

We critically examined the methods used to:

- Collect impingement samples
- Determine collection efficiency
- Estimate impingement mortality.

The purpose of this examination was to determine whether best methods reasonably available were employed.

Total Annual Impingement

Impingement studies were conducted annually at Oyster Creek NGS from September 1975 through December 1985. Both similarities and differences exist among the various years of these studies. Similarities include the location of impingement sampling, the sampling gear used, and the techniques used for processing impingement samples. For 9 out of the 10 years of study, samples were collected in an enlarged section of the sluiceway using a device with a 10.7 mm mesh screen. In the last year of impingement sampling (1984-1985), the fish return system was modified so that the screen wash flow could be diverted into a holding pool where a 6.4 mm screen mesh net was used to collect previously impinged biota. The impingement studies provide data on the number of organisms impinged and can be used to estimate annual impingement.

Major differences among years include the type of traveling screens, the mode of screen wash operation, the length of impingement sampling time, the frequency of sampling, and the time of day at which samples were collected. Until 1980, Oyster Creek NGS utilized conventional vertical traveling screens. In 1980, the conventional screens were replaced with Ristroph screens. Both types of screens have a 9.5 mm mesh screen. The screen rotation and wash operation varied from 1975 to 1985 depending upon the magnitude of debris and organisms impinged on the screens. The frequency of sampling and the time of day in which samples were taken changed appreciably over the years. The frequency of sampling ranged from one to four days per week. The sampling period encompassed all times of day, and except for the period September 1977-March 1979, samples were taken both during the day and night.

GPUN used two general equations to estimate annual impingement. Between 1975 and 1979 the following equation was employed:

ESTIMATED ANNUAL IMPINGMENT FOR DAY(NIGHT)	=	DAYS OYSTER CREEK NGS OPERATED	X	NUMBER HOURS IN A DAY(NIGHT)	X	MEAN HOURLY IMPINGEMENT FOR DAY(NIGHT)

Individual impingement samples were used to generate a mean hourly impingement for day (24 hours) and night (12 hours). During the time period when samples were only taken at night (September 1977-May 1979), the equation was modified to reflect total annual impingement only at night.

Between 1980 and 1986, the following equation was used to estimate total annual impingement:

$$\text{ESTIMATED ANNUAL IMPINGEMENT} = \sum_{\text{WEEKS}} \text{7 DAYS/WEEK } i \times \text{MEAN DAILY IMPINGEMENT FOR WEEK } i$$

Mean daily and hourly values are based on actual sampling time for individual samples. GPUN did not provide data for the sampling duration; therefore, we could not directly verify their estimates.

Table IV-5 presents GPUN's estimates for annual impingement between 1975 and 1985. All species collected in impingement samples were identified and counted, however, annual impingement estimates were calculated for only the species indicated in Table IV-5. No species which was impinged in large numbers is missing from this list except grass shrimp which was not selected as an RIS. To consolidate these data we calculated average annual impingement for the major species over the 10 year period (Table IV-6). Considerable variation exists among years as indicated by the large standard errors in Table IV-6. In addition, the highest annual impingement values (extreme years) were more than five times the average values. When average annual impingement was recalculated excluding the values from the years of highest impingement, the standard errors were significantly decreased, indicating that the extreme years account for a large portion of the long-term variability for each species.

Both the conventional and Ristroph intake screens have a 9.5 mm mesh to protect internal plant structures from debris and organisms in intake flows. However, the mesh size of the sampling gear used to collect impingement samples was 10.7 mm from 1975-1984 and 6.4 mm from 1984-1985. For years in which

Table IV-5. Estimated annual impingement (no. of organisms) of selected species and all organisms combined by study year adjusted for differences in sampling effort[a] (EA 1986)

Species Name	SEP 1975 - AUG 1976	SEP 1976 - AUG 1977	SEP 1977 - AUG 1978	SEP 1978 - AUG 1979	SEP 1979 - AUG 1980	SEP 1980 - AUG 1981	SEP 1981 - AUG 1982	SEP 1982 - MAR 1983	NOV 1984 - OCT 1985
Blueback herring	28,120	27,496	42,279	103,498	35,034	29,923	18,181	26,122	52,190
Atlantic menhaden	17,788	94,960	54,460	9,388	3,427	12,005	9,157	6,334	4,654
→ Bay anchovy	1,811,550	147,202	155,858	146,531	85,611	76,994	147,110	25,497	195,867
Atlantic silverside	61,272	35,051	86,687	196,164	153,912	268,961	45,622	117,889	276,943
Northern pipefish	36,066	11,220	21,881	53,700	29,822	92,602	42,808	28,479	107,875
Bluefish	14,086	3,935	3,661	9,658	2,392	9,154	3,278	3,639	4,937
Weakfish	11,790	27,297	20,839	5,272	46,186	37,401	18,936	6,390	11,083
Northern kingfish	16	105	23	20	342	117	21	28	0
Summer flounder	4,266	2,380	1,881	1,308	6,440	8,228	1,012	2,602	3,437
Winter flounder	8,908	18,618	27,600	148,442	16,122	48,511	25,767	37,619	18,205
Northern puffer	3,313	1,516	50,414	272	420	17,179	1,436	655	981
Sand shrimp →	3,342,143	600,278	3,793,355	4,818,977	3,365,975	6,821,222	1,602,897	4,955,771	17,090,788
Blue crab →	5,627,253	230,691	1,167,289	310,873	277,727	1,831,654	248,473	44,248	1,333,894
Other species	519,542	280,647	321,660	877,982	235,526	1,039,660	805,727	424,541	2,866,715
Total	11,486,113	1,481,396	6,043,508	6,682,085	4,258,936	10,293,611	2,910,475	5,679,814	21,967,567

(a) Night samples only were collected for the period from September 1977 through May 1979.

Table IV-6. Mean annual impingement (number of individuals) and observed extreme impingment for selected species at the Oyster Creek NGS

Species	Average Annual Impingement (1975-1985)	Standard Error	Extreme (Year)
Sand shrimp	5,154,601	1,612,004	17,090,788 (1984)
Blue crab	1,230,234	587,275	5,627,253 (1975)
Bay anchovy	310,247	188,443	1,811,550 (1975)
Atlantic silverside	138,060	30,764	276,943 (1984)
Winter flounder	38,866	14,265	148,442 (1978)
Atlantic menhaden	23,575	10,333	94,960 (1976)
Weakfish	20,577	4,699	46,186 (1979)
Bluefish	6,082	1,321	14,086 (1975)
Summer flounder	3,506	810	8,228 (1980)

sampling gear mesh size was larger than the intake screen mesh size (1975-1983), there is a potential to underestimate the magnitude of annual impingement. (GPUN in their comments dated July 1988 indicated that the same mesh was used for impingement samples in 1975-1984 as was used on the screens and that the 1.2 mm mesh difference was due to differences between actual mesh and manufactured specifications.) Annual impingement estimates for later years, when the smaller mesh size impingement sampling gear was used, may not be directly comparable to estimates obtained for earlier years. A gear efficiency study conducted in 1981 indicated that the loss of organisms through the 10.7 mm mesh is probably large (approximately 25%). The lack of direct comparability of impingement estimates pre- and post-1983, resulting from differences in mesh sizes, may be particularly significant for smaller species. In fact, the highest impingement estimates for two of the smaller species (sand shrimp and Atlantic silverside) occurred in 1984-1985 when the sampling gear with smaller mesh size was used. For sand shrimp, annual impingement for 1984-1985 was more than twice that of the year with the next highest impingement estimate (17,100,000 vs. 6,800,000). Thus, it appears that the best sampling methods reasonably available were not used to estimate the magnitude of impingement from 1975-1983. From 1975-1983, sampling gear deficiencies contributed to a significant underestimate of annual impingement. It is not possible for us to adjust these underestimates using the information provided by GPUN (i.e., a correction to make small mesh collections comparable to large mesh screens was not provided) because data to estimate what the magnitude of this correction should be was not provided.

GPUN's calculations of annual impingement were also not corrected for intake screen collection efficiency. Rather, GPUN assumed intake screen collection efficiency was 100%. Intake screen collection efficiency is an important parameter in estimating impingement loss because impinged organisms do not always remain on the screens until they can be collected. Impinged organisms can pass around or under screen panels and become entrained, fall off the screens, swim away, or be eaten while they are on the screens by scavengers. No collection efficiency studies were performed for the conventional vertical traveling screens. Ristroph screen collection efficiency studies were conducted in 1985. For these studies, preserved, fin-clipped Atlantic silversides were released in front of the intake screens and recollected in screen wash samples for 30 minutes. Mean collection efficiency was 90% in May and 53% in November. GPUN suggested that the decrease in collection efficiency between May and November was due to screen deterioration and wear.

A major deficiency of the Ristroph screen collection efficiency study was that GPUN used only one test species. Many previous 316 Demonstrations (e.g., PSE&G 1984) have shown

that intake screen collection efficiencies are species-specific and range from 75% to 92%. Therefore, GPUN did not use best methods reasonably available for estimating screen efficiency. To be protective of the resource, we used the lower intake screen collection efficiency (53%) determined by GPUN for estimating total annual impingement. In addition, because no information on conventional screen collection efficiency was available, we assumed that conventional screen efficiencies were similar to those of Ristroph screens. We consider both of these assumptions to be protective of environmental resources.

Mortality Studies and Impingement Losses

Impingement mortality studies were conducted between 1975 and 1978, and in 1985. Immediate mortality rates were measured between 1975 and 1978 in conjunction with impingement sampling. For these studies, impinged organisms were placed in insulated coolers after they were collected from intake screens and after 5 to 10 minutes the number of live, dead, and damaged were determined. Immediate mortality rates were measured in 1985 in conjunction with the latent mortality tests rather than by the "cooler method." Latent mortality tests were conducted for all years by holding organisms in both ambient and heated water for 96 hours. GPUN did not provide a detailed discussion of the experimental procedures for the latent mortality tests but based on the data provided it appears that over the years the timing of impingement mortality tests encompassed all seasons and 4-7 major RIS.

For the 1975-1978 mortality tests, impingement mortality rates do not appear to have been corrected for holding system mortality. In 1985, holding system mortality was estimated by collecting non-impinged organisms and holding them for 96 hours. Survival was uniformly high (96-100%) for control organisms held in ambient water. Test results from 1975-1978 and 1985 provided mortality estimates for conventional traveling screens and Ristroph screens, respectively.

Estimates of immediate and latent mortality rates were used to calculate total mortality (Table IV-7). Identical species were not tested in all studies; hence, no latent mortality data for Atlantic menhaden and blue crabs impinged on Ristroph screens was provided. For the calculation of impingement loss of these species, we assumed the mortality rate for impingement on Ristroph screens was identical to that determined for conventional screens. The estimates of total impingement mortality rate for bay anchovy and Atlantic menhaden indicated that these species are sensitive to impingement whereas winter flounder is not. Mortality rates for conventional screens and Ristroph screens generally appeared to be similar suggesting

Table IV-7. Total mortality rate estimates (%) determined from immediate and latent mortality studies

	Conventional Screens		Ristroph Screens	
	Ambient (Immediate)	Heated (Latent)	Ambient (Immediate)	Heated (Latent)
Bay anchovy	96	99	81	96
Atlantic silverside	41	48	20	33
Winter flounder	4	4	7	23
Atlantic menhaden	73	86	*	*
Sand shrimp	14	29	5	50
Blue crab	12	13	*	*

*Not available at Oyster Creek NGS, assumed conventional screen mortality rate for Versar calculations

that the Ristroph modification of intake structures did little to protect environmental resources. Bay anchovy and Atlantic silverside showed a slight decrease in mortality rates with the Ristroph screens compared to conventional screens, but winter flounder showed a slight increase in mortality rate. Sand shrimp mortality rate decreased in ambient water with Ristroph screens but increased in heated water.

The major shortcomings of the impingement mortality studies are that mortality estimates were not determined for all RIS and that on some occasions sample sizes were small. Despite these shortcomings we concluded that GPUN used best methods reasonably available to estimate impingement mortality. In lieu of additional data, we assumed 100% mortality for species not included in the mortality tests in our calculations of impingement loss. This assumption is protective of environmental resources.

GPUN calculated impingement loss between 1975 and 1978 for selected species, however, GPUN did not adjust for collection efficiency, underestimating actual loss by approximately 50%. GPUN's calculations therefore did not reflect the best methods reasonably available for estimating impingement loss. Data are available, however, to adjust total impingement rates and to recalculate impingement loss for the Oyster Creek NGS (Table IV-8). These estimates were based on total mortality rates measured in heated water and a screen efficiency of 53%. Mortality rates measured in heated water were used rather than those in ambient water because:

- Until 1977, the terminus of the fish return system was located in the condenser discharge directly exposing previously impinged organisms to the effects of heated water

- Dye and thermal plume studies indicate that the water in the discharge canal is well mixed within several hundred feet of the fish return terminus so that fish returned to the region adjacent to the dilution pump discharge are quickly exposed to heated effluent during their return to Barnegat Bay.

Versar also calculated average annual impingement loss for 1980-1985 (the time period in which Ristroph screens were used) excluding 1982-1983 data because of the extended outage that occurred at that time (Table IV-9). Data for years in which conventional screens were used is not relevant to the present impact assessment or the present conditions at Oyster Creek. The losses incurred under Ristoph screens are appropriate for assessing impingement impact because this is the technology presently employed at Oyster Creek NGS.

Table IV-8. Annual impingement loss at the Oyster Creek NGS based on total mortality rate in heated water for major RIS and 53% screen efficiency (1975-79 conventional screens; 1980-85 Ristroph screens)

Year	Anchovy	Silverside	Winter Flounder	Sand Shrimp	Blue Crab	Menhaden	Total Impingement Loss
75-76	3.383,389	55,492	672	1,828,720	1,380,270	28,864	7,842,383
76-77	247,962	31,744	1,405	328,454	56,585	154,086	1,489,285
77-78	291,131	78,509	2,083	2,075,609	286,316	88,369	4,072,277
78-79	273,709	177,658	11,203	2,636,799	76,252	15,233	5,175,213
79-80	159,915	139,392	1,217	1,841,760	68,122	5,561	2,887,971
80-81	139,461	167,466	21,052	6,435,115	440,954	19,480	9,552,308
81-82	266,463	28,406	11,182	1,512,167	60,946	14,859	3,575,908
82-83[a]	46,183	73,403	16,325	4,675,256	10,853	10,278	5,761,460
84-85	354,778	172,436	7,900	16,123,385	327,182	7,552	22,742,701

[a] September-March only.

Table IV-9. Average annual impingement loss applicable to the Oyster Creek 316 Demonstration review and evaluation based on mortality rate for heated water and 53% screen efficiency

Species	Ristroph Screens 1980-1985 (without 1982-83 data)[a] Mean Loss	Standard Error[b]
Bay anchovy	253,567	62,490
Atlantic silverside	122,769	47,203
Winter flounder	13,378	3,952
Sand shrimp	8,023,556	4,292,019
Blue crab	276,361	112,604
Atlantic menhaden	13,964	3,472
Total impingement loss	11,956,972	5,662,105

[a] 1982-1983 data not included because major outage occurred reducing impingement losses.

[b] Standard error of annual losses.

D. ENTRAINMENT

The major objective of the entrainment studies was to determine the magnitude of entrainment losses associated with normal operation of the Oyster Creek NGS. At the Oyster Creek NGS, entrainment losses include through-plant condenser entrainment and dilution pump entrainment. Organisms entrained through the plant passed through the traveling screens and were defined as entrainable-size. Dilution pumps at Oyster Creek NGS are unscreened and some organisms that would be impinged on intake screens (defined as impingeable-size) as well as entrainable-size individuals pass through these pumps. Total annual entrainment was estimated using data from condenser and dilution pump discharge sampling programs after correcting for collection efficiency. Entrainment loss was calculated as the product of species-specific annual entrainment rates and the species-specific mortality rates associated with each of these sources of entrainment.

Versar critically examined the methods used to collect entrainment samples, to determine collection efficiency, and to estimate entrainment mortality. The purpose of this evaluation was to determine whether best methods reasonably available were employed and to determine whether reasonable estimates of entrainment could be made from data available in GPUN's 316 Demonstration and associated documents.

Annual Entrainment Estimates for Entrainable-Size Organisms

Estimates of annual through-plant entrainment of microzooplankton (<0.5 mm) were made by GPUN in the Oyster Creek 316 Demonstration during 1975-1976. Annual condenser entrainment for macrozooplankton (>0.5 mm) and ichthyoplankton was estimated by species and life stage for 1975-1976 and for 1977-1979. Estimates of condenser and dilution pump entrainment were presented for the 1979-1980 and 1980-1981 for selected macrozooplankton and ichthyoplankton. The sampling frequency and analytical methods for estimating entrainment differed from year to year. However, in 1986, condenser and dilution pump entrainment of entrainable-size organisms was recalculated by GPUN for each year (1975-1981) using the following analytical method:

$$\text{Annual Entrainment} = \sum_{\text{week}} \left(\begin{array}{c}\text{Volume pumped}\\ \text{in week}\end{array} \times \begin{array}{c}\text{Mean entrainment}\\ \text{density for}\\ \text{a week}\end{array} \right)$$

Annual estimates were made for microzooplankton for 1975-1976 (Table IV-10), for selected macrozooplankton for 1975-1981

Table IV-10 Estimated number (x 10^9) of selected microzooplankton passed through the condenser and dilution pumps at Oyster Creek NGS from September 1975 through August 1976 (from EA 1986)

	Condenser	Dilution
Copepod nauplii	18,060.90	17,720.20
Acartia clausi	1,203.43	1,376.50
Acartia tonsa	865.53	934.39
Acartia spp.	3,643.79	3,687.18
Oithona colcarva	23.77	28.02
Oithona spp.	932.25	974.36
Paracalanus crassirostris	1.15	1.21
Rotifers	4,769.21	4,573.78
Bivalve larvae	682.27	632.76
M. mercenaria larvae	63.53	48.80
Mulinia lateralis	140.62	124.25
Barnacle larvae	6.60	6.88
Polychaete larvae	3,792.18	3,227.45
Polydora spp. larvae	5.73	5.82
Gastropod larvae	618.40	547.91

(Table IV-11), and for selected ichthyoplankton for 1975-1981 (Table IV-12). No measure of within year variation was provided for entrainment loss estimates.

GPUN did not use the best methods reasonably available to calculate annual entrainment. Three major limitations existed:

- No correction for gear efficiency (sampling efficiency) was made despite the fact that extrusion and avoidance are likely

- No correction for collection efficiency was made, although most samples were taken from one fixed discharge location

- Dilution pump entrainment estimates were obtained by assuming densities passing through dilution pumps were equal to those passing through the condenser cooling system; however, no data were provided to adequately support this assumption.

Gear efficiency of GPUN's entrainment sampling program is not likely to be 100% for entrainable-size macrozooplankton and ichthyoplankton. Extrusion of some organisms through 505 µm-mesh is likely. Some literature data suggest that as much as 87% of small fish larvae may not be sampled by 505 µm-mesh (McGroddy and Wyman 1977; Houde and Lovdal 1984; O'Gorman 1984; Tomljanovich and Heuer 1986). Larger macrozooplankton and larger fish larvae also avoid sampling nets. Towed-net gear-efficiency for larval and juvenile fish has been estimated to range from 6 to 48% (Murphy and Clutter 1972; Loesch et al. 1976; Kjelson and Johnson 1978; Bowles and Merriner 1978; LMS 1980). In addition, Thayer et al. (1983) found that catches of larval fish (10-25 mm in length) increased by a factor of about five as net tow speed was increased from 2 to 7 m/s. GPUN density estimates were obtained with a fixed net that was not towed at all. Flow through GPUN's net was provided by intake flows which are about 1.0 m/s. For all of the above reasons, GPUN's density estimates clearly were underestimates of actual entrainment density; hence, the associated entrainment estimates were underestimates.

There are two potential collection efficiency problems associated with the entrainment sampling locations used by GPUN. First, only one discharge port was sampled, and no data were provided to demonstrate that densities of entrained organisms were the same at all discharge port sampling locations. Differences among sites are likely due to differences in the operation of circulation pumps. No data were provided, however, to indicate whether these differences in density among discharge ports would result in underestimates or overestimates of entrainment calculated from the selected location. The second potential

Table IV-11. Estimated number (x 10^7) of macrozooplankton passed through the condenser and dilution pumps at Oyster Creek NGS from September 1975 through August 1981 (from EA 1986)

	SEP 1975 - AUG 1976		SEP 1976 - AUG 1977		SEP 1977 - AUG 1978	
	Condenser	Dilution	Condenser	Dilution	Condenser	Dilution
Family Mysidae	1,116.04	1,228.95	1,903.90	1,877.42	898.27	909.28
Neomysis americana	752.12	1,042.77	1,557.64	1,695.03	855.80	876.04
Mysidopsis bigelowi	59.55	77.31	101.30	92.56	53.40	47.52
Crangon zoeae	916.95	678.86	107.43	202.91	873.55	828.43
Crangon undet.	13.25	19.02	8.98	9.28	55.07	58.71
Callinectes sp. zoeae	3.28	3.09	1.26	1.85	1.70	1.87
Callinectes sp. meg.	9.99	8.86	32.18	23.46	10.32	8.33
Cerapus tubularis	2.20	2.13	2.24	3.48	13.93	12.23
Corophium sp.	31.50	29.68	8.59	11.47	98.04	61.99
C. ascherusicum	0	0	0.20	0.22	24.39	18.53
C. tuberculatum	0.29	0.32	0.47	0.52	170.42	107.60
Gammaridae	0.16	0.23	1.36	1.36	1.16	1.17
Ctenophora	47.81	48.49	1.42	1.51	91.47	83.60

Table IV-11. Continued

	SEP 1978 - AUG 1979		SEP 1979 - AUG 1980		SEP 1980 - AUG 1981	
	Condenser	Dilution	Condenser	Dilution	Condenser	Dilution
Family Mysidae	196.11	217.24	1,690.68	1,569.92	1,489.95	1,665.77
Neomysis americana	637.82	657.63	1,382.24	1,296.22	1,431.14	1,338.80
Mysidopsis bigelowi	37.93	42.53	77.22	75.67	72.55	73.75
Crangon zoeae	416.88	363.91	240.52	161.86	377.02	407.74
Crangon undet.	27.28	29.21	6.00	5.63	40.67	43.70
Callinectes sp. zoeae	0.71	0.80	1.65	1.53	0.10	0.01
Callinectes sp. meg.	0.41	0.44	4.94	3.17	3.56	3.26
Cerapus tubularis	0.33	0.32	1.73	1.77	17.11	16.75
Corophium sp.	4.96	4.81	32.05	28.25	89.16	96.69
C. ascherusicum	1.86	1.94	3.18	3.05	8.59	9.28
C. tuberculatum	15.69	15.36	1.78	1.73	2.83	2.95
Gammaridae	2.68	2.74	0.08	0.04	0	0
Ctenophora	74.11	86.85	234.88	188.66	18.28	16.13

Table IV-12. Estimated number (x 10^6) of selected ichthyoplankton passed through the condenser and dilution pumps at Oyster Creek NGS from September 1975 through August 1981 (from EA 1986)

	SEP 1975 - AUG 1976		SEP 1976 - AUG 1977		SEP 1977 - AUG 1978	
	Condenser	Dilution	Condenser	Dilution	Condenser	Dilution
Silverside larvae	15.81	12.15	5.72	3.68	38.28	31.27
Bay anchovy larvae	1,152.09	1,185.82	457.41	297.71	497.35	533.39
Bay anchovy eggs	14,135.76	13,535.11	196.71	179.04	1,994.76	2,158.24
Winter flounder larvae	116.25	140.86	850.84	865.00	597.58	635.09
Sand lance larvae	27.57	36.92	109.77	109.35	142.28	151.69
Goby larvae	614.02	591.79	101.19	84.19	160.19	162.60
Naked goby juveniles	6.71	7.77	0.41	0.21	0.77	0.84
Blenny larvae	11.56	10.54	18.19	12.24	17.38	14.35
Northern pipefish juveniles	54.38	48.42	7.16	5.39	36.53	38.29

Table IV-12. Continued

	SEP 1978 - AUG 1979		SEP 1979 - AUG 1980		SEP 1980 - AUG 1981	
	Condenser	Dilution	Condenser	Dilution	Condenser	Dilution
Silverside larvae	66.50	55.52	5.14	1.71	105.56	98.94
Bay anchovy larvae	1,270.35	1,412.46	144.12	135.26	314.06	318.98
Bay anchovy eggs	3,029.43	3,241.40	475.44	322.38	3,818.59	3,914.51
Winter flounder larvae	1,077.08	808.80	(a)	(a)	126.05	128.36
Sand lance larvae	1,294.87	1,389.67	(a)	(a)	133.67	147.90
Goby larvae	85.64	97.21	188.49	144.17	187.79	202.61
Naked goby juveniles	0.27	0.31	1.82	1.81	1.93	2.91
Blenny larvae	4.01	4.40	8.43	6.26	4.12	4.37
Northern pipefish juveniles	30.69	33.29	17.37	14.48	42.06	39.03

collection efficiency problem is that discharge samples were used to calculate entrainment, and no adjustment was made for mechanical destruction. Mutilation of organisms to a degree that they could not be identified or counted would result in underestimates of entrainment losses. Examinatioon of density at the intake and discharge ports indicated densities were lower, in many cases, at discharge sampling locations than at the intake locations for macrozooplankton and larvae. These data suggested that mechanical destruction may be more of a problem for smaller organisms (e.g., macrozooplankton and fish larvae) than for larger organisms (e.g., juvenile fish). No statistical analyses comparing intake and discharge sample densities were presented by GPUN in the 316 Demonstration documents. However, in their comments on this report, GPUN provided the summary statement based on additional analyses that "a paired T-Test of the mean densities in intake and discharge samples indicated no significant differences." However, the nature of the data used is unclear (e.g., were ichthyoplankton and zooplankton combined? Were all dates used?) and the question of whether some species or some size classes may experience measureable mechanical destruction remains unanswered.

The third major limitation of GPUN's entrainment estimates was that entrainment through the dilution pumps was estimated by assuming that condenser discharge densities were representative of dilution pump entrainment. No studies were conducted to support the assumption. Because the intake structures of the dilution pump system are located on the opposite side of the intake canal and had a different configuration, it was possible that the number and type of organisms entrained through the dilution pumps were different from the condenser system.

The estimates of entrainment provided in the 316 Demonstration should be adjusted for gear efficiency, collection efficiency, and potential differences between condenser and dilution pump densities. Errors due to mechanical destruction are likely to be less than a factor of 2 and do not, therefore, require further consideration. The effect of sampling a single fixed location is unknown in direction (overestimate or underestimate) or magnitude. Eggs and macrozooplankton larvae are generally not capable of avoiding towed nets and thus we assumed gear efficiency to be 100% for all macrozooplankton larvae and fish eggs even though fixed nets were used to sample these organisms. Towed net gear efficiency estimates for fish larvae and juveniles range from 6%-48% depending on conditions (Thayer et al. 1983; Murphy and Clutter 1972). A fixed net sampling design was used to sample larvae and juveniles at the discharge station. As previously noted, fixed nets are more easily avoided by larvae and juveniles than towed nets; thus, an efficiency of 10% was assumed for juvenile and adult invertebrates, and larval and juvenile fish. Revised estimates of annual entrainment for RIS using these correction factors are given in Table IV-13.

Table IV-13. Estimated annual entrainment (millions) of entrainable-size invertebrates and fish at Oyster Creek NGS adjusted for gear efficiency

Year		*Mercenaria* Larvae	Opossum Shrimp Juvenile and Adult	Sand Shrimp Zoeae	Sand Shrimp Juvenile and Adult	Blue Crab Zoeae	Blue Crab Megalopae	Bay Anchovy Egg	Bay Anchovy Larvae	Winter Flounder Larvae
75/76	Condenser	63,530	75,212	9,170	1,325	33	100	14,136	11,521	1,163
	Dilution	48,800	104,277	6,789	1,902	31	89	13,535	11,858	1,409
76/77	Condenser	-*	155,764	1,074	898	13	322	197	4,574	8,508
	Dilution	-	169,503	2,029	928	19	235	179	2,977	8,650
77/78	Condenser	-	85,580	8,736	5,507	17	103	1,995	4,974	5,976
	Dilution	-	87,604	8,284	5,871	19	83	2,158	5,334	6,351
78/79	Condenser	-	63,782	4,169	2,728	7	4	3,029	12,704	10,771
	Dilution	-	65,763	3,639	2,921	8	4	3,241	14,125	8,088
79/80	Condenser	-	138,224	2,405	600	17	49	475	1,441	-
	Dilution	-	129,622	1,619	563	15	32	322	1,353	-
80/81	Condenser	-	143,114	3,770	4,067	1	36	3,819	3,141	1,261
	Dilution	-	133,880	4,077	4,370	0.1	33	3,915	3,190	1,284

*Only 1975-1976 data collected.

Recently, Versar completed field studies to determine the collection efficiency of fixed nets in a discharge canal at a Maryland power plant (Versar 1988). Using dead, dyed fish "injected" into the condenser intake cooling system (i.e., all fish went through the cooling system), collection efficiencies ranged from 0% to 37% using a grid of fixed nets completely covering the discharge canal cross-section. This study suggests the correction factors used were in the appropriate range.

Mortality Studies and Entrainment Losses for Entrainable-Size Organisms

Immediate entrainment mortality by RIS was determined for selected periods from 1975-1985. Organisms were classified as live, stunned, or dead. Mortality rates were based only on dead individuals, and estimates of latent mortality were provided only for bay anchovy and winter flounder in 1985 and only for condenser entrainment but not dilution pump entrainment. Entrainment mortality was incorrectly calculated from 1975-1979 as simply the difference between discharge mortality and intake mortality. Estimates of total condenser entrainment mortality should be calculated as the product of initial and latent mortalities as they were in 1985. In 1986, immediate mortality estimates were recalculated for all previous years to correct this problem.

GPUN did not calculate entrainment loss estimates for microzooplankton. For bay anchovy eggs and larvae and winter flounder larvae, temperature dependent latent mortality was used to calculate losses. No estimates of mortality rates of entrainable-size organisms entrained through dilution pumps were made.

GPUN did not use the best methods reasonably available to calculate annual entrainment losses of microzooplankton, macrozooplankton, and ichthyoplankton from entrainment estimates because:

- Only initial mortality was considered (i.e., stunned individuals were included as live) except for two fish species
- No correction for mortality during chlorination was made and, during these daily periods, mortality of organisms in contact with chlorinated water is likely to approach 100%
- Data on the mortality of organisms entrained through dilution pumps were not provided.

The first two limitations resulted in underestimates of entrainment losses. The third limitation, applying condenser entrainment mortality rates to dilution pump entrainment, was probably protective of the resource since mortality was expected to be less for organisms entrained through dilution pumps than those entrained through the condensers.

Because GPUN did not provide estimates of macrozooplankton entrainment losses for each year, nor estimates of dilution pump entrainment losses for any year, Versar estimated these losses from our adjusted estimates of annual entrainment. For Mercenaria mercenaria, the only RIS microzooplankton, a mortality of 100% was assumed for both condenser and dilution pumps. Mortality rates of 100% were assumed for macrozooplankton entrained through the plant and the dilution pumps since GPUN did not provide adequate estimates of latent mortality for the entrainable-size invertebrates. These adjustments are protective of the resource since mortality is not likely to be 100% for all invertebrates entrained, particularly those entrained through dilution pumps. Adjusted estimates of entrainment losses of ichthyoplankton were calculated as the estimate of annual entrainment times the annual average temperature-dependent mortality for each year which was computed as the estimated number killed in a year divided by the estimated number entrained in that year. The average annual entrainment loss (and standard error) for three years when long-term outages did not occur (1975/1976, 1977/1978, and 1980/1981) are given in Table IV-14.

Annual Dilution Pump Entrainment Estimates for Impingeable-Size Organisms

GPUN did not use the best methods reasonably available to calculate annual entrainment of impingeable-size organisms through the dilution pumps at Oyster Creek NGS. Two major limitations occurred: estimates were made for only one year (1984-85), thereby precluding consideration of year-to-year variability, and no corrections for collection efficiency were made. Several factors influence collection efficiency of the dilution pump sampler:

- Avoidance of the stationary gear set 7.2 m from the dilution pump discharge was likely
- Mechanical destruction was not accounted for since only discharge samples were collected
- Velocity at the mouth of the sampler varied depending on dilution pump operating mode and may have affected the efficiency of the samples

Table IV-14. Versar's estimated mean (and standard error) annual entrainment losses for entrainable-size organisms at Oyster Creek NGS for 1975/1976, 1977/1978, 1980/1981 (millions)

	Condenser	Dilution Pump	Total
Mercenaria larvae	63,530 (-)*	48,800 (-)	112,330
Opossum shrimp Juvenile and adult	101,302 (21,119)	108,587 (13,531)	209,889
Sand shrimp zoeae	7,225 (1,732)	6,383 (1,231)	13,608
Sand shrimp Juvenile and adult	3,633 (1,227)	4,048 (1.157)	7,681
Blue crab zoeae	17 (9)	17 (9)	34
Blue crab megalopae	80 (22)	68 (18)	148
Bay anchovy egg	5,182 (3,299)	5,071 (3,106)	10,253
Bay anchovy larvae	6,545 (2,543)	6,794 (2,607)	13,339
Winter flounder larvae	2,099 (1,588)	2,231 (1,685)	4,330

*Only one year of data.

- Some individuals that were not entrained through the dilution pumps may have entered the sampler

- Only one discharge location was sampled.

Avoidance by a large percentage of organisms surviving dilution pump passage was likely. Mechanical damage to organisms was likely to be relatively small as the dilution pumps at Oyster Creek NGS were designed to minimize damage to organisms. The velocity at the mouth of the sampler varies greatly (0.03 to 1.1 m/s) depending on dilution pump operating mode. Because the dilution pump sampler was not towed, but suspended in a fixed position, sampling efficiency was related to the velocity of the dilution pump discharge which was generally less than 1 m/s. These aspects of gear efficiency are likely to result in severe underestimates of dilution pump entrainment.

In 1986, GPUN proposed that organisms not entrained through dilution pumps may be captured by the dilution pump sampler. This hypothesis was based on the observation that entrainment of impingeable-size organisms was greater for the dilution pumps than was impingement of similar-size organisms on the traveling screens in front of the condensers. A special study was conducted to address this question. Because of the study's many limitations, no conclusions could be drawn. However, if organisms were able to swim into the dilution pump sampler, they would also have been able to avoid it, making the gear used an inappropriate sampling gear for estimating dilution pump entrainment losses.

Given the limitations associated with GPUN's estimate of dilution pump entrainment losses of impingeable-size organisms, and the confounding information concerning collection efficiency, Versar has calculated a range of entrainment estimates for RIS based on collection efficiencies of 1%, 10%, and 100% (Table IV-15).

Mortality Studies and Entrainment Losses for Impingeable-Size Organisms

Initial mortality was recorded for each dilution pump sample taken during 1975-1977 and 1984-1985, and latent mortality studies were conducted during 1975 to 1977. For latent morality studies, organisms were held for 96 hrs at ambient or condenser discharge temperature, or they were allowed to float down the discharge canal in live boxes. Relatively few tests were made on small numbers of fish, and no information or data was provided of how mortalities were adjusted for holding mortality.

Table IV-15. Estimated magnitude of dilution pump entrainment (millions) of impingeable-size RIS at Oyster Creek NGS during 1984-1985, adjusted for different collection efficiencies

	Collection Efficiency		
	100%	10%	1%
Sand shrimp	38.8	387.6	3875.7
Blue crab	3.4	34.3	343.3
Bay anchovy	35.1	350.8	3507.7
Winter flounder	0.07	0.7	7.2
Bluefish	0.3	3.1	30.6
Atlantic menhaden	0.08	0.8	7.9

GPUN did not estimate entrainment losses of impingeable-size organisms through dilution pumps. Therefore, Versar applied mortality estimates to the adjusted estimates of dilution pump entrainment to calculate a range of entrainment losses for RIS through dilution pumps (Table IV-16). Due to the poor design of the mortality studies, Versar used impingement mortality rates to estimate dilution pump mortality for sand shrimp, blue crab, bay anchovy, winter flounder, and Atlantic menhaden.

E. DISCHARGE EFFECTS

To assess the discharge effects of Oyster Creek NGS on balanced, indigenous biota, GPUN provided information from both an RIS and a no prior harm perspective. Using the RIS approach, effects were evaluated by determining:

- The percentage of Barnegat Bay avoided by RIS due to the thermal plume
- The magnitudes of heat shock and cold shock mortalities
- The magnitude of changes in growth, reproduction, mortality, and incidence of parasitism and disease on RIS due to the thermal plume.

Using the no prior harm approach, the distribution of organisms was compared between pre-operational and operational time periods and between thermally affected and unaffected stations. In this section, we describe general conclusions resulting from the 316 Demonstration analyses and make independent assessments of those impacts based on revised thermal mapping data and sensitivity analysis.

Avoidance Temperatures and Thermal Plume Exclusion

GPUN assessed RIS avoidance of the thermal plume by conducting a series of laboratory temperature avoidance studies. The percent area of Barnegat Bay avoided by each species was then estimated by integrating the temperature avoidance results for each species with the isotherms generated by a hydrothermal plume model. High ambient water temperatures in the summer months, particularly in August, resulted in the greatest area of thermal plume exclusion. Avoidance temperatures lower than those determined experimentally were used when field observations indicated a species may have a lower avoidance temperature than indicated by the avoidance experiments (Table IV-17). No avoidance evaluations were conducted for macrozooplankton by GPUN, with the exception of sand shrimp.

Table IV-16. Estimated losses due to dilution pump entrainment losses (millions) for impingeable-size RIS at Oyster Creek NGS during 1984-1985, adjusted for different collection efficiencies and mortality rates

	Collection Efficiency		
	100%	10%	1%
Sand shrimp	19.4	193.8	1937.9
Blue crab	0.5	4.5	44.6
Bay anchovy	33.7	336.7	3367.4
Winter flounder	0.02	0.2	1.7
Atlantic menhaden	0.07	0.7	6.8
Bluefish	0.3	3.1	30.6

Table IV-17. Avoidance temperatures of RIS in Barnegat Bay during August

	Experimental Results (°C)	Used in §316 Demonstration (°C)
Menhaden	33.9	30
Bay anchovy	32	31
Bluefish	33.5	32
Winter flounder	27.8	27.8
Blue crab	37.5	36
Striped bass	33.3	30.5
Weakfish	31	31
Summer flounder	30	30
Opossum shrimp	--	29
Sand shrimp	--	28
Mercenaria		
Adults	--	31
Larvae	--	29

There are deficiencies in GPUN's estimates of the area avoided by Barnegat Bay RIS. First, the area of avoidance was based on a hydrothermal plume model which underestimates the size of the plume and its associated isotherms (see Chapter IV, Section B). In addition, the percent area avoided by RIS was calculated by GPUN based on the area of Barnegat Bay from Good Luck Point to Gulf Point (Cedar Beach to Gulf Point for invertebrates). All of Barnegat Bay, from Bay Head to the Manahawkin Causeway, should be used to calculate area of avoidance, and the avoidance percentage should be based on total volume rather than total area.

Versar recalculated the percent of Barnegat Bay that was avoided due to excessive heat during the month of August (extreme condition) using the avoidance temperatures presented in the 316 Demonstration for all RIS except winter flounder and sand shrimp. Winter flounder and sand shrimp are cool water species and are not abundant in Barnegat Bay during August. Therefore, we calculated the area avoided by winter flounder and sand shrimp in June when these RIS are more abundant. The recalculation of avoidance areas was based on the percent total volume of Barnegat Bay from Bay Head to Manahawkin Causeway and the mean areas and volume associated with the hydrothermal maps presented in the 316 Demonstration. The adjusted estimates (based on % volume) for RIS species are presented in Table IV-18.

Versar conducted a sensitivity analysis on the effect of reductions in the avoidance temperature on the size of the avoidance area (Table IV-19). A 1° C decrease in avoidance temperature generally doubled the avoidance area for all species except bluefish and blue crab (the two most thermally tolerant species). A 2° C decrease in avoidance temperature increased the area of exclusion by approximately a factor of four for all fish except bluefish (threefold increase) and blue crabs (no change). The area of avoidance is sensitive to errors in the determination of the avoidance temperature. Because GPUN often used lower avoidance temperatures in the §316 Demonstration than indicated by their experimental results, the uncertainty associated with the avoidance temperature does not create any difficulties in assessing the effect of normal discharge temperatures on avoidance.

Best methods reasonably available were not employed because avoidance studies were not conducted with opossum shrimp and sand shrimp. Although the best methods reasonably available to assess the percent area of exclusion were not used, the overall exclusionary effect of the plume was localized and small. The exclusion of fish was primarily confined to the discharge canal which comprises about 2-4% of the total volume of Barnegat Bay. The avoidance temperatures used in the 316 Demonstration were the lowest of several available estimates and should be protective of the resource. Finally, the entire thermal plume in August is small relative to the total area of Barnegat Bay (6-10%).

Table IV-18. Percent of Barnegat Bay potentially excluded from selected species during August

	GPUN Estimate (% Area - Gulf Point to Good Point	Versar's Estimate (% Vol - Barnegat Bay)
Menhaden	2.1	2.9
Bay anchovy	2.6	<1.0
Bluefish	2.1	<1.0
Winter flounder[(a)]	7.8	(3.0)
Blue crab	<1.0	<1.0
Weakfish	4.4	<1.0
Summer flounder	1.9	2.9
Opossum shrimp	4.0	5.5
Sand shrimp[(a)]	0.5	(1.6)
Mercenaria		
Adults[(b)]	--	<1.0
Larvae	--	5.2

[(a)] Moves to deeper water in summer -- data in parenthesis are percentages of bottom area avoided in June.
[(b)] Bottom area

Table IV-19. Sensitivity of selected isotherms in Barnegat Bay excluded to selected RIS during August due to OCNGS discharges (Percentage of volume of Barnegat Bay avoided.)

	0°C	-1°C	-2°C
Menhaden	2.9	6.9	15.6
Bay anchovy	<1.0	2.9	6.9
Bluefish	<1.0	<1.0	2.9
Winter flounder[a]	(3.0)	(4.9)	(6.0)
Blue crab	<1.0	<1.0	<1.0
Weakfish	<1.0	2.9	6.9
Summer flounder	2.9	6.9	15.6
Opossum shrimp	5.5	9.5	19.7
Sand shrimp[a]	(1.6)	(2.4)	(2.9)
Mercenaria			
Adults[b]	<1	1.9	3.9
Larvae	5.2	9.3	19.0

(a) % of bottom area; percentage in parenthesis is area avoided in June.
(b) Bottom area.

Cold Shock-Heat Shock Mortalities

Cold shock and heat shock mortalities were assessed by conducting a series of laboratory experiments using specimens acclimated to various ambient temperatures. In general, experimental results showed that fish acclimated to higher temperatures were more resistant to heat shock and that fish acclimated to colder temperatures were more resistant to cold shock. Averaged over all acclimation temperatures and species, mortalities greater than 50% occurred at ΔTs ranging from 7.0 to 19.5° C for heat shock and from -6.5 to -15.0° C for cold shock (Tables IV-20 and IV-21, respectively). Typical winter and summer Δ Ts ranged from 7.9-10° C.

There are deficiencies in the assessment of Oyster Creek NGS heat shock and cold shock mortalities. Although extensive laboratory data were generated, the information was not used to estimate losses due to actual heat and cold shock events at the facility. For example, heat shock occurs when fish are entrained through the augmentation pumps and released into the heated discharge canal. In addition, fish washed from the intake screens are released into the discharge canal and within a short time are subjected to heat shock. Furthermore, estimates of cold shock mortality losses due to winter plant shutdowns could have been estimated using experimental data and density estimates in the discharge canal. No estimates associated with losses from these sources were presented.

Versar evaluated the sensitivity of heat-cold shock mortality under two ΔT regimes, 7.8° C (the long-term average ΔT) and 12° C (a potential extreme Δ T). The incidence of cold shock mortality was not sensitive to the assumption used in the §316 Demonstration of a ΔT of -10° C. In contrast, heat shock was generally sensitive to the assumption of a ΔT of 10° C and significant heat-shock mortality occurred at ΔTs as low as 7.8° C.

Although the best methods reasonably available for evaluating the effects of heat shock and cold shock mortality on the fish populations in Barnegat Bay were not used, the overall effects of heat shock and cold shock are likely small and localized. Heat-cold shock mortalities are generally limited to fish inhabiting Oyster Creek. These losses constitute a small percentage of the fish population of Barnegat Bay. However, losses within Oyster Creek due to cold shock can be potentially high, particularly during winter (when fish are attracted to the discharge canal from many areas within Barnegat Bay).

Table IV-20. General results of heat shock tests: ΔTs which caused greater than 50% mortality

	ΔT (°C)
Atlantic menhaden	10
Bay anchovy	10
Blue fish	10
Weakfish	7
Winter flounder	19.5
Blue crab	18 (from literature)
Opossum shrimp	7.5
Sand shrimp	>14.2

Table IV-21. General results of cold shock tests: ΔTs which caused greater than 50% mortality

	ΔT (°C)
Atlantic menhaden	10
Bay anchovy	6.5
Blue fish	9
Weakfish	10
Winter flounder	No mortality at > -15
Opossum shrimp	No tests
Sand shrimp	No mortality at < -7.7

Population and Community Attributes

GPUN chose to approach the Oyster Creek 316 Demonstration using a combination of the RIS concept and a "no prior harm" concept. In the species distribution portion of the 316 Demonstration, GPUN attempted to show that within the operational years of Oyster Creek NGS, relatively minor changes in abundance, distribution, growth, mortality, parasites, and diseases can be attributed to the facility (RIS concept). In addition, GPUN attempted to show that few community differences between pre-operational and operational time periods could be attributed to operations of the Oyster Creek NGS (no prior harm).

1. RIS Studies

GPUN conducted studies on the possible effects of the Oyster Creek NGS on the distribution, abundance, and growth rates of selected fish species, opossum shrimp, sand shrimp, and hard clam, as well as changes in the mortality of hard clams, in the reproductive potential of fish species, and in the occurrence of parasites and diseases for fish populations in Barnegat Bay. GPUN's methods to determine these effects varied significantly among study years.

a. Fish Studies

The result of GPUN's regression analysis relating fish abundance to 16 independent variables (five of which were related to the operation of Oyster Creek NGS) showed that plant operating conditions accounted for 1-22% of the annual variation in the survey catch data in Barnegat Bay. Statistical analysis on the condition factor (an indicator of the general degree of physiological well being) of menhaden showed that the condition factor was lower for fish in Oyster Creek than Barnegat Bay populations. However, the consequence of this change in condition was of little significance.

The frequency of parasites and diseases found among the fish collected in seining and trawling surveys was very low. Out of thousands of fish collected very few instances of external parasites, diseases, and physical deformities were noted and no increases in these factors were noted in thermally impacted areas.

Observed sex ratios of bay anchovy at thermally affected and unaffected sites were compared to the expected rates of 50/50. Almost 80% of the comparisons resulted in significantly

more females than males, but few differences in sex ratios were found in thermally influenced regions. Gonad condition was determined for Atlantic menhaden. However, the number and percent of specimens in various gonad conditions (immature, mature, enlarged, ripe, and spent) were analyzed by combining thermally influenced and uninfluenced stations. Thus, the effect of thermal effluent on gonad condition could not be evaluated.

GPUN did not use the best methods reasonably available to determine Oyster Creek NGS effects on fish distributions, abundance and composition in Barnegat Bay. However, based on the results presented, plant effects on fish distribution and abundance appeared to be small and localized.

b. Invertebrate Studies

- Hard Clams

Pre-operational and operational distribution studies indicate that densities of hard clams smaller than 66 mm are extremely low in the Oyster Creek region (Campbell 1969). In 1978, over 70% of the population in the vicinity of the Oyster Creek NGS was greater than 66 mm. Densities of small clams (1-5 mm in size) in the vicinity of the Oyster Creek NGS ranged from 20 to 1,580 per square meter in 1978 and from 4 to 80 per square meter in 1979. These young clams were found exclusively in sandy sediments and were noticeably absent from the deeper muddy central portion of the bay where muddy sediments predominate. Few clams, large or small, inhabited areas north and east of Forked River. Clam densities were generally highest in the southern end of Barnegat Bay. The estimated standing crop of hard clams in the central bay amounted to approximately 948 MT of flesh in 1969 and 190 MT in 1978 (Kennish et al. 1984).

Hard clams within a 1.6 km radius of Oyster Creek had a 10-25% reduction in growth rate compared to clams inhabiting other regions of Barnegat Bay (Kennish and Olsson 1975). The effects of thermal discharges on growth were mainly limited to summer months. Experimental studies have generally found that hard clams do not grow at temperatures in excess of 31° C (Calabrese and Davis 1970).

Mortality parameters were examined in natural hard clam populations as well as for clams that were transplanted to a thermally influenced region of Oyster Creek and a

non-thermally influenced reference station (Kennish 1977). Summer and winter were the seasons of highest mortality in natural hard clam populations. It was proposed that stresses associated with reproduction and the increase in predators were the major causes of summer mortalities. The low winter temperatures coupled with reduced levels of food were identified as the major causes of high winter mortality. While the overall mortality rate for hard clams transported to the thermally influenced region of Oyster Creek was not higher than those tranported to control regions not influenced by thermal discharges, a higher proportion of the clams transplanted into the thermally impacted area died at an earlier age.

GPUN did not conduct specific studies to assess clam reproductive condition; however, examination of growth rings in 1973 revealed that no spawning growth breaks occurred in clams collected from a thermally influenced region of Oyster Creek whereas spawning growth breaks were found in clams collected from reference sites that were not affected by thermal discharges.

- Macrozooplankton

Distribution studies of adult sand shrimp were conducted only during the operational period. No sand shrimp distributional data were provided for the preoperational period. The operational data indicated that sand shrimp were attracted to thermally influenced regions of Oyster Creek in the winter. As a result, in winter months, sand shrimp abundances in Oyster Creek were nearly twice those found at thermally unaffected stations. During the summer (typically in July and August) as sand shrimp avoidance temperature (28° C) was approached, they migrated to colder, deeper regions of the Atlantic Continental shelf. Sand shrimp appear to avoid thermally impacted regions of Oyster Creek in the late spring and early fall.

2. No Prior Harm Studies

a. Fish

Fish abundance data presented for the no prior appreciable harm studies were examined by partitioning catches into three functional groups: residents (fish which complete their life

cycle in Barnegat Bay); migrants (fish which complete part of their life cycle in Barnegat Bay after migrating); and visitors (short-term residents which migrate into Barnegat Bay from the Atlantic Ocean to feed). Significant changes in the number of species in each functional group were detected at thermally influenced stations between preoperational and operational years. Similar changes in number of species were also seen at stations which were not affected by thermal discharges. Significant changes in species composition were detected at thermally influenced stations between preoperational and operational years. Similar changes were not detected at thermally unaffected stations. GPUN attributed these changes in distribution mostly to the dredging of Forked River and Oyster Creek and the resulting increased depth and currents rather than thermal discharges. No information was presented, however, to support this hypothesis.

GPUN also compared the median annual catch per unit effort between preoperational and operational years using data collected by their fish survey study. Bay anchovy (Anchoa mitchilli) and Atlantic menhaden (Brevoortia tyrannus) had significant (α = 0.05) reductions in relative abundance after the facility was constructed. This finding is, however, of limited value because of sample design limitations it is not possible to determine if observed differences are due to power plant operations or natural causes.

Results of the fisheries studies conducted in Barnegat Bay were of limited value for assessing power plant effects. Major problems identified were:

- A poor distribution of sampling stations (i.e., the fish community inhabiting the open waters and eastern shore of Barnegat Bay were poorly sampled)

- No detailed data on the influence of the thermal plume on fish avoidance (e.g., trawl surveys evaluating the effects of tidal or wind mediated changes in the thermal plume on fish distributional patterns)

- A poorly designed analysis plan evaluating power plant effects on fish distributional patterns (e.g., Friedman ANOVA could have been used to test for consistent patterns among the station locations that were sampled).

b. Benthos

Most benthic organisms have limited mobility and cannot avoid changes in environmental conditions imposed by perturbations. Therefore, the benthos are particularly appropriate biological indicators for assessing power plant discharge effects under the context of no prior harm.

Benthic surveys were conducted in western Barnegat Bay in the region of Oyster Creek between 1965-1973 to document the abundance and distribution of benthic assemblages prior and subsequent to the operations of Oyster Creek NGS. Data collected between 1965-1968 were considered by GPUN to be of a qualitative nature and were not submitted as part of the 316 Demonstration nor included as a major part of the evaluation of no prior appreciable harm. Benthic data collected between 1969-1973 were submitted as summary tables and figures as a part of the evaluation of no prior appreciable harm.

These studies showed that a significant decrease in benthos density occurred throughout Barnegat Bay (i.e., all stations surveyed and biomass) between 1969 and 1970. This decrease was most severe in thermally impacted regions of Oyster Creek but was clearly not totally due to power plant operations. Benthic densities remained low and relatively constant throughout the remainder of the study. The mean number of benthic species per sample did not vary among stations or years in a manner which indicated power plant mediated changes in distributions.

In 1973-74, an additional benthic study was conducted to assess the local effects of the thermal plume on the benthos in the vicinity of Oyster Creek. Sampling took place during July, August, September, and November 1973 and again a year later in August 1974. This study was designed to evaluate only spatial differences in benthic distributions. Including the 1974 data in analyses makes it impossible to differentiate between spatial and temporal differences. The number of benthic species is significantly greater near the mouth of Oyster Creek than at reference locations located in thermally unaffected areas near Oyster Creek. No significant station differences in total benthic densities or biomass were observed by this study.

The sampling methods used by GPUN to sample benthos (i.e., collection gear, sieve mesh size, replication) limit the usefulness of the data for assessing the impact of plant operations on these biota. First, the collection gear that was used (i.e., ponar grab) is designed for sampling soft mud sediments, not the firmer muddy-sand sediments typical of Barnegat Bay. Although area sampled by the ponar grab is relatively consistent from sample-to-sample regardless of sediment type, the variation in the volume of sediments collected may be great. In sandy sediments, the ponar grab generally takes a shallow sample of sediments, thereby underestimating densities of benthic organisms living more than 1-5 cm deep in the sediments. For example, the following quotation from Loveland et al. (1971) describes this phenomenon. "There is an obvious relationship between the amount of sediment brought up by the ponar and the sediment characteristic: the finer the sediment, the more the ponar brings up per drop. In other words, at Oyster Creek, where the sediments are quite variable, but generally characterized by

having a median grain diameter of 229μ, we must drop the ponar at least seven times in order to obtain a "full" ponar (≡ 7000 mls)." Secondly, benthic samples were washed through a 1.5 mm mesh screen. This mesh size is not small enough to collect juveniles of many dominant benthic species inhabiting Barnegat Bay resulting in a substantial underestimate of the densities of these biota. Finally, although seven grabs were taken at each station, the samples were pooled during sample processing to create one sample per staion. Therefore, the among sample variation cannot be estimated, making it impossible to rigorously evaluate spatial differences within regions. In addition to the sampling limitations, adequate preoperational data were not collected to make a confident comparison between preoperational and operational benthic abundances or distributions. Therefore, best methods reasonably available were not used for the benthic surveys.

c. Phytoplankton

Studies investigating phytoplankton composition, primary production, and biomass were conducted in the Oyster Creek region between 1969 and 1972. Oyster Creek showed 30%, 20%, and 18% lower gross primary productivity, net primary productivity, and phytoplankton standing stock, respectively, than Forked River. A lower phytoplankton species diversity was also observed in Oyster Creek following the initiation of plant operations. In Barnegat Bay; however, no significant change in phytoplankton species composition, abundance, and primary productivity was found between preoperational and operational periods. In addition, no documented algal blooms have occurred within the thermal plume area. Impact of Oyster Creek NGS on the phytoplankton community was confined to the discharge canal and Oyster Creek. A balanced, indigenous phytoplankton community exists in Barnegat Bay and appears to be unaffected by the discharge of Oyster Creek NGS. It appears that best methods reasonably available were used to evaluate power plant impacts on phytoplankton.

d. Zooplankton

A study to investigate the distribution and abundance of zooplankton in western Barnegat Bay was conducted between 1975-1977. The study did not find any differences in holoplankton densities between stations that could be attributed to power plant operations. Generally, no station differences in meroplankton were observed either, except in November, when significantly lower total meroplankton densities were observed at the

thermal plume stations. Significant spatial-temporal interactions in Analysis of Variance (ANOVA) models limited the usefulness of macrozooplankton survey results for evaluating power plant impacts; however, if spatial differences in distribution or abundance due to power plant operations occurred, they were small. Although analyses could have been conducted to compensate for the spatial-temporal interactions, and test directly for spatial differences in macrozooplankton community parameters due to power plant operations (e.g., ANOVA's testing for station differences could have been conducted for each date), it is unlikely the result of such would alter the conclusions drawn. Therefore, best methods reasonably available were used for evaluation of power plant impacts on the zooplankton community. Generally, no spatial differences existed that were attributable to power plant operations.

e. Benthic Algae and Submerged Aquatic Vegetation

Qualitative surveys of benthic algae were conducted between Cedar Creek and the town of Barnegat from 1965-1973. These data indicated that most indigenous algae were unattached, forming an unattached mat along the bottom and were not uniformly distributed. Many algal species were seasonal and were present only during certain times of the year. Several heat sensitive species of Phaeophyta were excluded from thermally impacted regions of Oyster Creek in the summer. A substantial bay-wide increase in the relative abundance of _Codium fragile_ occurred during the study period. This species is generally considered to be a nuisance species along the East Coast (JCP&L 1978). _Codium_ was first observed in Barnegat Bay in 1965 and appeared to be displacing endemic species. By 1969, it ranked fourth in frequency and second in biomass, and by 1972, _Codium_ ranked first in frequency and fourth in biomass. By 1973, however, _Codium_ had declined in relative abundance to fourth in frequency and sixth in biomass, and endemic species appeared to be outcompeting _Codium_. In general, long lasting shifts in dominance or drastic changes in spatial and temporal patterns of benthic algae abundance were not observed.

Information on submerged aquatic vegetation (SAV) was obtained as a part of benthic algae surveys. Eel grass, _Zostera marina_, was the dominant SAV in Barnegat Bay. Widgeon grass, _Ruppia maritima_, also occurred particularly along the eastern shore. _Zostera_ occurred extensively in the estuarine zones of Forked River and Oyster Creek prior to the dredging operations associated with construction of the Oyster Creek NGS (Taylor 1970), but no information exists regarding densities or distributional patterns subsequent to construction. Eel grass was the dominant SAV in Barnegat Bay following construction of the Oyster Creek NGS and has not been affected by the thermal discharge except in the local estuarine zones of Oyster Creek

and Forked River. Best methods reasonably available were used to survey benthic algae but not SAV. Specific surveys to map SAV distribution and abundance during the pre- and post-operational periods should have been conducted. Because plant effects on these biota were limited to the immediate discharge region this deficiency is of no consequence.

f. Nuisance Species

GPUN examined the effects of thermal discharges from the Oyster Creek NGS on nuisance species of shipworms which cause boring damage to piers, pilings, and docks throughout the Barnegat Bay region. Two subtropical (non-native) species of shipworms, *Teredo bartschi* and *T. furcifera*, were found in Barnegat Bay for the first time in 1975. *T. bartschi* was found exclusively in thermally influenced areas by GPUN studies and by non-utility studies (Hoagland 1983). It occurred at six different thermally impacted stations between 1975 and 1982 and was the dominant borer at several thermally impacted stations for three consecutive years. *T. furcifera* was reported in relatively high abundances by GPUN from both thermally influenced stations and a non-thermally influenced station in Manahawkin Bay. Non-utility studies collected *T. furcifera* primarily from thermally influenced stations and did not report this species from Manahawkin Bay (Hoagland 1983).

Two native shipworm species, *Teredo navalis* and *Bankia gouldi*, have been collected in Barnegat Bay every year since 1975. Statistical analyses comparing abundances among stations did not find consistently higher abundances of these species at thermally influenced stations. Statistical tests were also conducted comparing abundances by year to examine the possiblity that years of prolonged outages might cause reduced abundance of shipworms due to cold stress or reduced reproductive capability. These tests did not show a clear correlation between years of outages and years of low shipworm abundance.

Average annual percent destruction to long-term and short-term exposure panels by shipworms was determined for 1975 to 1985 by station. However, no analyses were conducted to determine if differences in the panels existed between thermally influenced and non-influenced stations or between years with and without prolonged outages. Examination of general trends in the data showed that shipworm damage was heavy at both thermally influenced and non-influenced stations and that thermally influenced stations did not exhibit consistently higher destruction rates than non-influenced stations. Additionally, no clear relationship between percent destruction and

outages were evident. These conclusions were limited by the fact that the percent destruction data were not reported by species and no statistical analyses were accomplished. In response to this limitation, GPUN provided statistical analyses on percent destruction by year in their comments dated July 1988. These analyses support the conclusion that there is not a clear relationship between percent destruction and outages.

Shipworms are capable of reproducing all year long in thermal discharges of the Barnegat Bay region (Nair and Saraswathy 1971). Therefore, the thermal discharge from Oyster Creek NGS could lengthen the breeding season and enhance reproductive success of these nuisance species in thermally influenced areas. Thermally influenced stations, however, did not have consistently higher shipworm settlement rates than stations that were not affected by thermal discharges.

Given the large natural variations in shipworm distribution and abundance in Barnegat Bay, detecting the effects of Oyster Creek NGS on shipworm populations is probably best accomplished by making preoperational/operational comparisons. GPUN did not collect any preoperational shipworm data; however, the earliest records of shipworm damage in Barnegat Bay are from the 1880s when destructive borer activity was recorded for railroad bridges at Manahawkin Bay and Toms River. Heavy shipworm destruction was also reported from Barnegat Bay in 1922 (Atwood and Johnson 1924, cited in JCP&L 1978). Although preoperational shipworm activity was recorded in Barnegat Bay, none was recorded in Oyster Creek or Forked River prior to operation of the Oyster Creek NGS. In fact, it is unlikely that shipworms occurred much above the mouths of these tributaries prior to dredging of the intake and discharge canals because the environmental conditions, particularly salinity, were not suitable for inhabitation by shipworms. As stated in the Oyster Creek 316 Demonstration, "Prior to the construction of the OCNGS, the Forked River and Oyster Creek were described as slow-flowing, freshwater creeks" and as stated in the Final Environmental Statement for Oyster Creek NGS (U.S. Atomic Energy Commission 1974), "Oyster Creek, which was freshwater to about 2500 ft downstream of U.S. Route 9 is now saltwater from its entrance into the discharge canal above the highway to its mouth." Construction of the Oyster Creek NGS altered Oyster Creek and the south branch of the Forked River from a freshwater environment which did not support shipworms to an estuarine environment which does.

The methods used by the utility to collect shipworms since 1975 were the best methods reasonably available and have been fairly consistent for all study years allowing direct comparisons of data from year to year. However, the analysis techniques used were not sufficient to clearly evaluate the potential effects of Oyster Creek NGS on shipworm populations, particularly recruitment success.

These limitations notwithstanding, some conclusions can be drawn regarding Oyster Creek NGS's effects on shipworm populations:

- Shipworm activity was limited or non-existent in the upper part of Oyster Creek and Forked River prior to construction and operation of Oyster Creek NGS, while shipworms have been abundant in Oyster Creek and Forked River since operations began

- Operation of Oyster Creek NGS facilitated the establishment of reproducing populations of the subtropical species, Teredo bartschi in the past and the potential for this species to be reintroduced and become established exists as long as prolonged winter outages do not occur

- Operation of Oyster Creek NGS did not extend the settlement period or recruitment potential for native species of shipworms.

3. Fish Kill Monitoring

GPUN's methods for monitoring and quantifying the magnitude of fish kills were not consistent among years. For instance, estimates of the number of fish killed during the 1972-1974 period were determined by counting visible specimens and typically varied greatly among observers. After 1974, GPUN attempted to quantify the magnitude of each kill event by collecting and counting all dead fish. Total catches for these surveys were increased by 25% to account for uncollected dead fish. During some (but not all) kill events, trawl samples were taken in the discharge canal to estimate the abundance of dead non-floating fish. In addition, intensive sampling was conducted during scheduled winter shutdowns, including trawling prior to the shutdown, to assess the species composition in the canal. Visual observations of non-floating kills were made using divers during one scheduled shutdown in December 1982.

During the first six years of plant operation, fish kills in the discharge canal were large. Estimates of cold shock kills ranged as high as 1.2 million menhaden for one event in January 1973 (Table IV-22). Most of the fish kills occurred during colder months and were the result of cold shock impacts on fish overwintering in the discharge canal. Several summer heat shock fish kills were also documented. Summer kills were usually a result of augmentation pump failure, and the subsequent rapid increase in discharge canal water temperatures. Summer heat kills were generally of lesser magnitude than winter cold shock kills (Table IV-22). One chlorine related fish kill was documented (January 1974).

Table IV-22. Estimated number of fish killed by major events recorded in the Oyster Creek discharge canal

	1/72	7/72[a]	1/73	2/73	8/73	1/74[b]	11/74	2/75	11/75
Menhaden	100,000- 1,100,000		18,000- 1,200,000	Several thousand	2,000 4,000	500	9,900- 180,000	100	
Bluefish						100- 3,600		50- 100	
Crevalle Jack									7- 100
Weakfish									
Blue runner									
Atlantic needlefish									
Scup									
Bay anchovy			20						
Oyster toadfish									
Tautog									
Striped bass									

(a) Kills documented, but no numbers provided.
(b) Chlorination system failure.
(c) Actual number, not estimate.
(d) Crevalle jack and blue runner combined.

Table IV-22. Continued

	12/75	4/76[a]	10/77	8/79[b]	1/80	7/80[c]	11/80	12/82	7/87
Menhaden	365-450				5,447				5071
Bluefish	100-200				1,531	161	4,880	5,000	
Crevalle Jack			60-100				17,402[d]	2,655	
Weakfish					62				
Blue runner			60-100					80	
Atlantic needlefish								28	
Scup								9	
Bay anchovy									
Oyster toadfish						110			
Tautog						36			
Striped bass						13			

GPUN instituted operational changes at Oyster Creek NGS in 1974, as required by NJDEP as part of the Oyster Creek NPDES permit. For instance, during a winter-time shutdown the augmentation pumps were immediately shut down to retain residual heat in the discharge canal. Other operational changes included running the augmentation pumps in the fall when bay water temperatures begin to decline to decrease the attractiveness of the discharge canal as overwintering habitat. These changes decreased the number and severity of fish kill events during shutdown events.

There are several limitations of the fish kill monitoring program. The collection techniques used for quantifying the number of fish killed may have favored species that float immediately after death (e.g., menhaden) leaving the number of non-floating fish killed unquantified. In addition, GPUN adjusted the number of dead fish collected for a 25% loss of dead fish to predators by multiplying the total catch by 1.25. GPUN's adjustment is correct if the predators removed 25% of the fish that were collected by GPUN (which is naturally impossible). It is incorrect if the predators removed 25% of the dead fish in the water. To adjust the number of actual fish killed by 25%, the number of observed fish should be multiplied by 1.33 (catch = 0.75 actual)

The best methods reasonably available to assess the effects of fish kills on Barnegat Bay RIS were not used. Estimates of the number of fish killed prior to 1974 were not accurately quantified and were likely severe overestimates. Estimates of the magnitudes of fish kills after 1974 were probably underestimates. However, given the operational changes at Oyster Creek NGS which reduced the severity of fish kills, and the fact that kills were confined to the discharge canal, the overall effect is small relative to the size of fish populations in Barnegat Bay. Any modification to augmentation pump operations to further optimize operations must consider the effects of potential cold-shock kills in winter and heat-shock kills in summer.

4. Beneficial Uses of Oyster Creek NGS

Besides evaluating the discharge effects of Oyster Creek NGS on the biota of Barnegat Bay, Versar reviewed the beneficial uses of Oyster Creek and surrounding areas and examined the potential impact of the power plant on recreational and commercial fisheries. Materials used to conduct this evaluation included the §316 Demonstration and the fisheries chapters in Kennish and Lutz (1984).

a. General Use Patterns

An aerial survey in 1972 of the beneficial uses of the upper Barnegat Bay (Barnegat Inlet to Bay Head) revealed that boat fishing and boating comprised 73% of all uses (Table IV-23). Bathing, bank fishing, sailing, and other uses comprised a much smaller percent of human uses (Halgren 1973). The dominant use of Oyster Creek was bank fishing. Thirty-four percent of all bank fishing in upper Barnegat Bay occurred in Oyster Creek. About 5% of all human uses of upper Barnegat Bay occur in Oyster Creek. The proportion of human usage of the Oyster Creek area (5%) is greater than the proportion of physical shoreline Oyster Creek encompasses of the upper Barnegat Bay region (1%).

b. Recreational Fishery

Recreational bank fishing was the most popular use of Oyster Creek. The months of greatest bank fishing activity in Oyster Creek were July through September. Based on data from 1975-1977, a substantial portion of the western Barnegat Bay recreational landings of summer flounder, winter flounder, bluefish, spot, and blue crab were caught in Oyster Creek (Table IV-24). Oyster Creek was also the most productive fish area censused, yielding the highest catch per individual. Blue crabs comprised 90% of these catches. The thermal discharge of Oyster Creek NGS has extended the recreational fishing season from 8 to 10 months by attracting fish and crabs during the fall and winter.

c. Commercial Fishery

Commercial landings and value of selected finfish and shellfish for Ocean County and Barnegat Bay between 1975-1979 are presented in Table IV-25. During this period, Barnegat Bay commercial landings and their economic values were not recorded separately from Ocean County, but Barnegat Bay's contribution to Ocean County landings was available (EA 1981). Almost all of Ocean County's commercial landings of bluefish, weakfish, and summer flounder were from outside Barnegat Bay, whereas the Ocean County catch of white perch and blue crab were almost entirely composed of Barnegat Bay catches. Hard clams comprised 50% of the Barnegat Bay commercial landings and 81% of the market value. Total value of the Barnegat Bay commercial catch over the five years was under two million dollars, with a mean annual value of about $250,000. There has been no documented detrimental effect of Oyster Creek NGS on the Barnegat Bay commercial fishery although hard clam harvests have been declining. "The standing crop of hard clams in

Table IV-23. Uses of upper Barnegat Bay 1972 (Barnegat Inlet - Bay Head)

	Barnegat Bay Uses (%)	% of Each Use Outside of Oyster Creek	% of Each Use in Oyster Creek
Boat fishing	38	37.2	0.8
Boating	35	34.3	0.7
Bathing	9	8.9	0.1
Bank fishing	8	5.3	2.7
Sailing	6	5.9	0.1
Other	4	3.9	0.1
	TOTAL:	95.5	4.5

Table IV-24. Percent of western Barnegat Bay recreational landings of selected species caught in Oyster Creek (1975-1977)

Species	%
Blue crab	44
Bluefish	60
Spot	57
Winter flounder	65
American eel	17
Summer flounder	85
Weakfish	<1

Table IV-25. Commercial landings (kg) and value ($) of selected finfish and shellfish for Ocean County and Barnegat Bay, New Jersey (from U.S. Department of Commerce 1975-1979)

SPECIES	OCEAN COUNTY CATCH 1975-79	VALUE ($) OF OCEAN COUNTY CATCH 1975-79	% CAUGHT IN BARNEGAT BAY	BARNEGAT BAY CATCH 1975-79	VALUE ($) OF BARNEGAT BAY CATCH 1975-79
BLUEFISH	1,032,951	380,648	< 1	< 10,330	< 3,807
WEAKFISH	670,530	338,648	< 1	< 6,705	< 3,390
SUMMER FLOUNDER	3,144,717	4,113011	< 1	< 31,447	< 41,130
WINTER FLOUNDER	140,375	62,726	30-63	42,113 - 88,436	18,818 - 39,517
AMERICAN EEL	107,826	88,878	46	49,600	40,884
WHITE PERCH	57,251	32,058	98-100	56,106 - 57,251	31,417 - 32,058
BLUE CRAB	259,342	191,493	100	259,342	191,493
HARD CLAM (MEATS)	1,354,802	4,412,333	30-36	406,441 - 487,729	1,323,700 - 1,588,440
TOTAL VALUE		9,620,110			1,624,639 - 1,940,719
MEAN VALUE		1,202,514			206,830 - 242,590

Barnegat Bay has declined since the mid-1960s. Between 1965 and 1978, for example, the standing crop in the central bay decreased approximately 80%. This decline is reflected in commercial landings of the hard clam during the 1970s, which were reduced not only in Barnegat Bay but throughout New Jersey" (Kennish and Lutz 1984).

Conclusions for Discharge Effects

The thermal discharge from Oyster Creek NGS exceeded New Jersey Thermal Discharge criteria, and thus the potential for biological impact was sufficiently large to require detailed evaluation. In many cases, GPUN did not examine the biological impact of Oyster Creek NGS's thermal discharge with best methods reasonably available (see Table IV-26). However, it made little difference to the §316 review process that best methods reasonably available were not used. Based on data available in the Oyster Creek 316 Demonstration and the scientific literature, the potential adverse effects of the thermal discharges on the Barnegat Bay ecosystem were determined and found to be localized and to have few or no regional consequences.

F. POPULATION ABUNDANCE ESTIMATES

Surveys to estimate population abundance of fish, macroinvertebrates, ichthyoplankton, and macrozooplankton were done by GPUN in Barnegat Bay during 1976 and 1977. Four species of fish and macroinvertebrates (bay anchovy, northern pipefish, winter flounder, and blue crab) were sampled in two periods per year. Sand shrimp were sampled once in the trawl survey. Other RIS ichthyoplankton (e.g., bluefish, weakfish) were not sampled due to low abundance.

There are several limitations of the GPUN trawl surveys:

- Several of the target species (bay anchovy, sand shrimp, juvenile flounder and juvenile crab) could easily escape the mesh size used in the surveys (3.8 cm) resulting in underestimates of densities

- Gear collection efficiency was not estimated, and no standard corrections were applied

- The daytime sampling scheme used probably underestimated sand shrimp population abundance which are generally more active and collected at higher abundances at night

- Sampling frequency was not adequate for sand shrimp, which have at least two generations per year

Table IV-26. Versar's evaluation of methods used by GPUN to determine thermal discharge effects

	Best Methods Not Used	Best Methods Used
Avoidance temperatures and thermal plume exclusion	X	
Cold shock -- heat shock mortalities	X	
Population/community attributes		
1) RIS		
Fish	X	
Hard clam		X
Other invertebrates	X	
2) No prior harm		
Fish	X	
Benthos	X	
Phytoplankton		X
Zooplankton		X
Benthic algae		X
Shipworms		X
3) Fish kill monitoring	X	
4) Beneficial uses of Oyster Creek NGS		
Recreational fishery		X
Commercial fishery		X

- Sampling times did not coincide with peak abundances of the fish
- Surveys covered only a portion of Barnegat Bay
- No seasonal or annual abundance estimates were made with the exception of bay anchovy and winter flounder.

Ichthyoplankton and macrozooplankton were sampled with towed ichthyoplankton nets and an epibenthic sled during 1976 and 1977 based on a stratified random sampling scheme. Only the 1977 data were provided in the 316 Demonstration. Limitations of the ichthyo- and macrozooplankton surveys are similar to the fish surveys:

- Daytime sampling probably underestimated demersal and vertically migrating animals such as opossum shrimp (PSE&G 1984)
- Gear efficiency was not tested, and no correction factor was applied
- Sampling frequency was insufficient to characterize seasonal abundances of opossum shrimp, blue crab zoeae and megalopae, and winter flounder larvae because sampling times did not correspond to periods of high seasonal abundance
- The surveys covered generally less than 50% of Barnegat Bay.

Microzooplankton population surveys were carried out twice during 1976. Twelve to fifteen randomly selected quadrats were sampled with a Clarke-Bumpus sampler, and larvae were identified to class. The data are given in the 316 Demonstration working papers, but not in the text. Limitations of this survey were that hard clam larvae were not identified from the samples, and that sampling twice per year was insufficient to estimate total seasonal population of microzooplankton due to their rapid turnover rates.

Since GPUN did not address gear efficiency, Versar estimated gear efficiency to be about 10% for larvae and juveniles based on scientific literature. We assumed the gears used had a 100% gear efficiency for eggs and microzooplankton. These efficiency rates were applied to GPUN's instantaneous population data. Versar's population estimates, as well as seasonal population estimates (adjusted for seasonal turnover rates), are presented in Table IV-27. Seasonal abundance was calculated as the product of mean instantaneous density, the volume of Barnegat Bay, and the turnover rate of the specific life stage population (e.g., daily during the period of availability for bay anchovy

Table IV-27. GPUN population estimates (number of individuals) and Versar adjusted population estimates (number of individuals) for Barnegat Bay RIS

			GPUN	Versar	
			Estimated Instantaneous Mean Population (#)	Corrected Population Size (#)	Corrected Seasonal Population Size (#)
Bay Anchovy	eggs	1977	3.6×10^9[a]	3.6×10^9	2.2×10^{11}
	larvae	1977	2.3×10^8[a]	2.3×10^9	9.2×10^9
	adults	1977	N.A.		
	adults	1976 May Oct.	5.7×10^6 2.6×10^6	5.7×10^7 2.6×10^7	
Winter Flounder	larvae	1977	1.4×10^9[a]	1.4×10^{10}	7.1×10^{10}
	adults	1977	1.1×10^5	1.1×10^6	
	adults	1976	1.9×10^5	1.9×10^6	
Blue Crab	zoea[b]	1977	1.0×10^7	1.0×10^7	2.3×10^7
	megalopae	1977	1.4×10^8	1.4×10^9	1.4×10^{10}
	juv. and adults	1977 East West	6.0×10^5 1.0×10^5	6.0×10^6 1.0×10^6	
	juv. and adults	1976 East West	3.6×10^6 2.6×10^5	3.6×10^7 2.6×10^7	

(a) Calculated as mean from Table 4.3-20 in OCNGS 316 Demonstration.

(b) zoea avoid low salinity, western bay where sampling was done.

Table IV-27. Continued

			GPUN	Versar	
			Estimated Instantaneous Mean Population (#)	Corrected Population Size (#)	Corrected Seasonal Population Size (#)
Sand Shrimp	zoeae	1977	1.4×10^{8}	1.4×10^{8}	2.5×10^{9}
	adults	1977	5.6×10^{4}	5.6×10^{5}	1.2×10^{6}
Opossum Shrimp	juv. and adults	1977	1.8×10^{9}	1.8×10^{10}	5.5×10^{10}

eggs). The gear efficiency adjustments were identical to those used to estimate entrainment losses but the gears used for the population surveys were probably less efficient because of the additional sampling problems described above.

The GPUN population data and hence the population abundance estimates were highly uncertain. The adjustments made by Versar to these estimates in order to be protective of the resource further increased the uncertainty of the population estimates, and the estimates and any assessments made from them must be interpreted with extreme caution.

Entrainment impacts, as percentages of instantaneous population size, were calculated by GPUN (Table IV-28), and were expressed as percent entrained within 12 hours. GPUN's rationale for using 12-hour entrainment losses was that the population surveys represented instantaneous estimates of standing crop taken during approximately a 12-hour period. A comparison of this standing crop estimate for a species to the number entrained during a similar period can give an indication whether or not the form is subjected to losses greater than the average volume of water removed from central Barnegat Bay by OCNGS during a similar period (1.1% of Bay volume in 12 hours). Entrainment loss rates greater than 1.1% would indicate potential concentration near Forked River. The instantaneous rates cannot be used to evaluate seasonal or annual losses at the population level without modification to reflect seasonal or annual abundance of the target species. Table IV-28 shows when extended to a full season, the GPUN instantaneous rates provide ridiculous estimates of overall losses to Barnegat Bay populations. While this is an inappropriate extrapolation of GPUN's instantaneous losses, it is the only way the data could be interpreted and shows that the demonstration does not provide the information necessary to evaluate the impact of total annual condenser and dilution pump entrainment. Clearly, the population abundance values must be put into proper perspective to gauge the potential effects of entrainment losses on the populations of Barnegat Bay.

Given the uncertainty of extrapolating the GPUN population estimates to reflect seasonal abundances, Versar applied a simple model to estimate entrainment losses that does not depend on the population data, but instead estimates entrainment losses as the volume fraction of Barnegat Bay pumped by Oyster Creek NGS each day. The volumetric model assumes a homogeneous distribution of entrainable size organisms in Barnegat Bay, complete remixing of the bay, and no significant water exchange between Barnegat Bay and adjacent water bodies (e.g., Atlantic Ocean). The latter two assumptions are clearly protective of the resources. This model estimated the upper limit of possible entrainment losses. It should not be used as an unbiased estimate of entrainment losses but rather to characterize the maximal limit of entrainment loss.

The volumetric entrainment model was as follows:

$$Me = 1 - e^{-rtm(1-c)}$$

where

Me = mortality due to entrainment during the occurrence of a specific life stage

r = daily entrainment rate, as the volume fraction of the bay entrained per day

t = time in days that the life stage was vulnerable to entrainment

m = the mortality of entrained organisms

c = recirculation rate of discharge water back to the intake canal.

Oyster Creek NGS pumped a maximum of 65.0 m^3/s with the dilution pumps on, and 32.1 m^3/s with the dilution pumps off. Barnegat Bay has a total volume of 2.38×10^8 m^3, which corresponds to Oyster Creek NGS pumping 2% or 1% of the total volume per day with the dilution pumps on or off, respectively. Representative results of the model are given in Tables IV-28 and IV-29, for no recirculation and 30% recirculation, respectively.

Versar is well aware of the inappropriateness of the loss estimates provided in Tables IV-28 and IV-29. These estimates are not intended to describe the impact of OCNGS entrainment upon Barnegat Bay populations. Rather, they serve to exemplify the limited use which can be made of the 12-hour instantaneous population abundances and 12-hour entrainment values provided by GPUN.

The GPUN population surveys did not use the best methods reasonably available. The surveys and the adjusted population estimates have excessive uncertainty, and the estimates can only be used with extreme caution. The volumetric entrainment loss model showed that entrainment losses were potentially high for species with planktonic life stages that were vulnerable to entrainment for periods of 30 days or more. Only more quantitative estimates of the overall impacts of entrainment losses and their relationship to Barnegat Bay seasonal and/or annual populations will more clearly describe the potential (if any) impacts of these losses.

Table IV-28. Percent entrainment of RIS populations in 1977 using GPUN's 12-hr estimates and volume method applied by Versar

		Mean GPUN 12-hr Entrainment (% Entrained/ 12-hr)[a]	Duration of Life Stage (Days)	GPUN 12-hr Entrainment Extrapolated to an Annual Cycle (% Entrained/yr)[b]	Volume Method (% Entrained/ yr)
Bay anchovy	egg	0.5	1.5	1.5	2.2
	larvae	6.4	30	97.8	45.0
Winter flounder	larvae	1.05	15	27.0	20.0
Blue crab	zoeae	11.8	40	99.9	55.0
	megalopae	0.25	7.5	3.7	14.0
Sand shrimp	zoeae	5.1	30	95.3	45.0
	juvenile	NA[c]	90	NA[c]	83.0[d]
Opossum shrimp	juvenile and adult	1.2	120	88.5	91.0

(a) Mean values from Tables 4.3-19 and 4.3-20 in OCNGS 316 Demonstration; assumed mortality 100%.
(b) Annual loss = $1-e^{-2Lt}$, where L is the 12-hr loss rate and t is the duration (in days) of a life stage.
(c) NA - Not applicable.
(d) Since GPUN did not provide an entrainment rate for juvenile sand shrimp, Versar used the percent of water entrained (2%).

Table IV-29. Versar entrainment mortality with 30% recirculation

		Entrainment Mortality	Days Exposed	Net Loss
Bay anchovy	egg	75%	1.5	1.6%
	larvae	100%	30	34%
Winter flounder	larvae	75%	15	15%
Blue crab	zoeae	100%	40	43%
	megalopae	100%	7.5	10%
Sand shrimp	zoeae	100%	30	34%
	juvenile	100%	90	72%
Opossum shrimp	juvenile and adult	100%	120	81%

V. IMPACT ASSESSMENT

The impacts of losses due to operations of the Oyster Creek NGS were examined from two perspectives by GPUN -- no prior harm and Representative Important Species. No prior harm assessments generally require information that characterize the biotic community prior to operation of the facility and afterward. A finding of no change in biotic composition, abundance or population-level attributes (e.g., growth, reproduction, parasitism) between the preoperational and operational periods is then interpreted as the result of the facility having no impact on balanced, indigenous populations. The data presented by GPUN in the §316 Demonstration generally provided data on effects of plant operations on spatial patterns (far-field stations versus thermally influenced stations). Few data were presented by GPUN which included comparison of the preoperational and operational periods. Those that were presented showed significant differences in fish and shellfish community composition and abundance in Oyster Creek and Forked River. Because Oyster Creek was completely dredged and parts of Forked River were also modified in the construction of the facility, it was difficult, if not impossible, to show no prior harm for the Oyster Creek biotic community. Oyster Creek after operation of the facility had very little in common with Oyster Creek prior to construction. Thus, the no prior harm portion of the Oyster Creek 316 Demonstration is of little utility for making a 316 decision if the water body of concern is Oyster Creek. If the Oyster Creek/Barnegat Bay ecosystem represents the water body of concern then overall losses to the ecosystem could be effectively evaluated in a no-prior harm framework, given the proper data were available. These data would require careful analytical screening to extract any locational biases due to the physical/chemical gradients inherent in large estuarine systems. While GPUN has collected and analyzed data scattered over many years of operation, too little care has been exercised to minimize the uncertainties associated with the analytical results. These include:

- Poor sample replicability
- Lack of "true" controls
- Implicit covariates nested within the data sets.

Spatial and temporal patterns are usually defined by contrasting population characteristics between environments (i.e., between thermally affected and unaffected stations). Factors and processes contributing to observed patterns are

then identified by inferential analysis of survey data. Collection of data in estuarine environments comparing and contrasting the effect of a single factor (i.e., temperature) cannot be completed, generally, without confounding the data with the effects of several additional factors corresponding to natural estuarine gradients. These confounding factors make direct comparisons extremely tenuous. Only after the effects of these "extraneous" factors are removed from the data, can the "true" effects of the target factor be determined.

The no prior harm evaluation presented by GPUN is riddled with these types of data inconsistencies which make a direct determination of the level of impact of the operation of OCNGS all but impossible. These data problems can be addressed from two perspectives. Either the data can be reanalyzed, removing the confounding covariates, or the data can be examined from an RIS loss perspective. Versar chose to evaluate the losses due to the operation of OCNGS using three assessment models.

Empirical data collected by GPUN were used to estimate entrainment and impingement losses. Before the consequences of these losses to Barnegat Bay RIS populations can be evaluated, however, the estimates must be put into the context of natural population size, productivity, reproductive success, equivalent adults, and/or mortality due to other sources (e.g., commercial and recreational fish harvests, natural fish kills, or mortality due to other industrial sources). GPUN used only comparisons of 12-hr entrainment losses to instantaneous Barnegat Bay population sizes to evaluate impact (with the exception of bay anchovy and winter flounder). This type of comparison is useful only for populations which would reproduce rapidly (e.g., zooplankton) but not for longer-lived populations. To supplement these data, Versar used three assessment models as screening tools to place entrainment and impingement losses into the context of population-level consequences. Two of the models (production foregone and spawning/nursery area) also were relevant to the assessment of consequences of plant-related losses to the Barnegat Bay ecosystem as a whole.

A. OVERVIEW OF MODELS USED

The three impact assessment models used by Versar are designed to estimate the fractional reduction in RIS populations or population processes that was directly attributable to the Oyster Creek facility. These models were the:

- Equivalent Adult Model (EAM)
- Production Foregone Model (PFM)
- Spawning/Nursery Area of Consequence Model (SNAC)

The PFM and SNAC estimate the fractional reduction in RIS populations (or segment of an RIS population) attributable to the Oyster Creek NGS. The fractional reduction concept is illustrated both graphically and mathematically in Fig. V-1.

All three models have numerous assumptions and data input requirements (Tables V-1 and V-2), including the assumption of no compensation at the population level and the input requirement for the duration of each life stage. SNAC does not require information concerning absolute population size nor entrainment or impingement loss measurements to estimate the fractional reduction attributable to the Oyster Creek NGS (i.e., SNAC results are insensitive to gear efficiencies when a single gear type is used to collect the data).

B. EQUIVALENT ADULT MODEL (EAM)

Purpose and Application for EAM

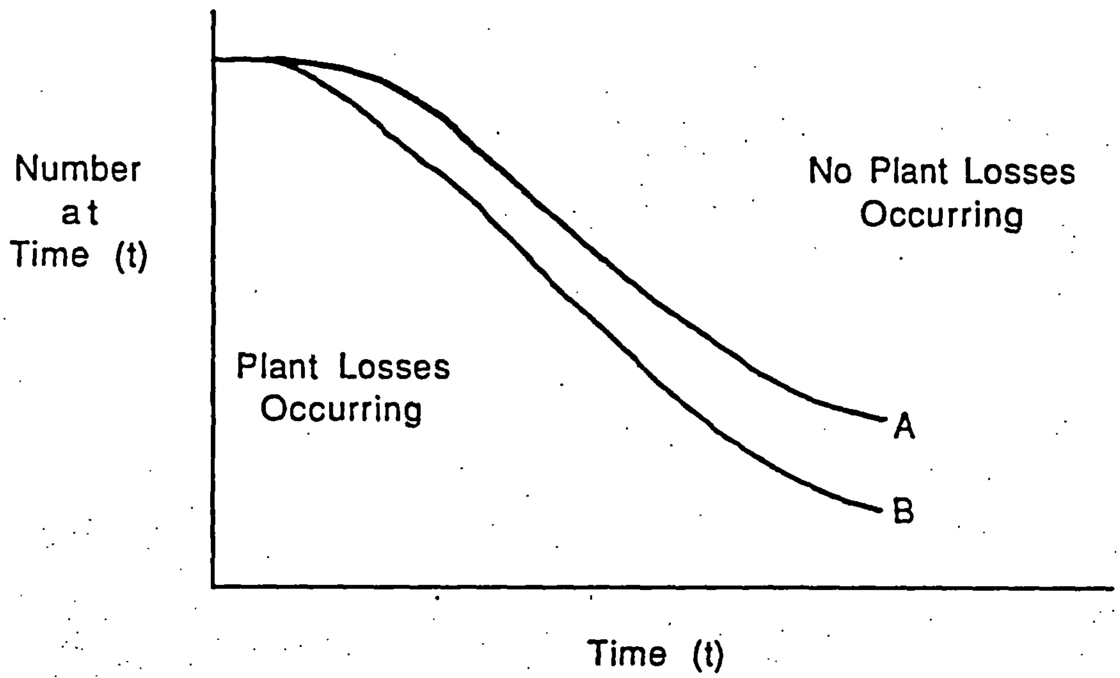
The equivalent adult model (EAM) evaluated the number of RIS which would have survived to adulthood if entrainment or impingement losses had not occurred. The number of equivalent adults is estimated by summing the product of losses of each lifestage and their respective survival rate to adults. Versar applied this model to winter flounder, bay anchovy, opossum shrimp, sand shrimp, hard clam, and blue crab. Our analyses for EAM included both entrainment and impingement losses. The EAM was relatively simple to apply and required little information. However, the data that were required (survivorship rates and absolute entrainment/impingement) were often subject to large variability and were generally difficult to measure.

Assumptions and Data Requirements for EAM

The primary assumption of EAM was that there was no compensatory response by populations to offset plant-induced losses. EAM required absolute estimates of plant-induced losses. It also required the duration of each life stage/age class and instantaneous mortality rates or survivorship rates to maturity. The values of these model inputs are shown in Table V-3.

Implementation and Results for EAM

Table V-4 summarizes equivalent adult losses calculated after adjusting entrainment loss estimates for sampling gear efficiency. These loss estimates included both entrainment and impingement losses. This table also compares the equivalent



A = Population at time (t) with no plant losses

B = Population at time (t) with plant losses

$$\text{Fractional Reduction in Population Due to Plant Losses at Time (t)} = \frac{A - B}{A} = 1 - \frac{B}{A} = \text{Conditional Plant-Related Mortality rate}$$

Figure V-1. Concept of fractional reduction in population size for estimating the consequences of plant related losses

Table V-1. Overview of assumptions of impact assessment models used by Versar to determine the consequences of entrainment and impingement losses to RIS populations

Assumption	Spawning/ Nursery Area Model	Production Foregone Model	Equivalent Adult Model
1. No compensatory response in the population to plant-induced mortality	X	X	X
2. Population is at static equilibrium		X	X
3. Actual (absolute) abundance of population is known		X	
4. Actual (absolute) magnitude of plant-related losses are known		X	X
5. Relative abundance (e.g., catch per unit effort) of the population is known over space and time	X		
6. Mortality is constant within an age class	X	X	X
7. Entire distributional range of RIS is sampled	X	X	
8. Density of RIS in water passing through plant is equal to density at the intake	X		
9. Population comprises a single cohort			X

Table V-2. Data inputs to impact assessment models used by Versar to determine the consequences of entrainment and impingement losses to RIS populations

Input	Spawning/ Nursery Area Model	Production Foregone Model	Equivalent Adult Model
1. Mortality estimates (natural or total)		X	X
2. Initial population size before cohort is subject to plant-induced mortality		X	
3. Absolute impingement/entrainment losses by week and lifestage		X	X
4. Duration of lifestages	X	X	X
5. Duration of cohort (lifespan)	X		
6. Growth rate by lifestage		X	
7. Through-plant mortality rate	X		
8. Size of region containing the population subject to impact	X		
9. Plant water withdrawal rate	X		
10. Entrainment probability by size class	X		
11. Relative abundance of animals over time and space	X		

Table V-3. Parameters used to evaluate equivalent adult losses for the Oyster Creek NGS

Species	Life Stage	Life Stage Survival Rate	Cumulative Survival Rate	Plant-Related Losses (Entrainment and Impingement)	Equivalent Adult Losses
Winter flounder	Eggs	.0347(1)	4.549E-7	--	--
	Larvae	.0215(1)	1.311E-5	4.30E9	5.63E4
	0+	.1500(2)	6.097E-4	2.13E5	1.29E2
	1+	.2500(2)	4.065E-3	--	--
	2+	.3571(3)	1.626E-2	--	--
	3+	.3571(3)	4.553E-2	--	--
	4+	.3571(3)	1.275E-1	--	--
	>4+	.357 (3)	--	--	--
	Total				5.64E4
Bay anchovy	Eggs	.2490(4)	5.229E-5	1.03E10	1.38E7
	Larvae	.0370(4)	2.100E-4	1.33E10	7.21E7
	0+	.1461(4)	5.676E-3	3.51E8	5.13E7
	1+	.1971(4)	3.885E-2	--	--
	>1+	.1971(4)	--	--	--
	Total				1.37E8(0+)

Table V-3. Continued

Species	Life Stage	Life Stage Survival Rate	Cumulative Survival Rate	Plant-Related Losses (Entrainment and Impingement)	Equivalent Adult Losses
Opossum shrimp	0+	.0497[4]	8.210E-3	2.1E11	1.72E9
	>0+	.1652[4]	--	--	--
	Total				1.72E9
Sand shrimp	Larvae	.010[5]	1.60E-4	1.36E10	2.18E6
	0+	.080[5]	1.60E-2	7.68E9	1.23E8
	>0+	.200[5]	--	2.02E8	4.04E7
	Total				1.64E8
Hard clam	Larvae	.0160[6]	3.240E-7	1.12E11	3.63E4
	0+	.0001[7]	2.025E-5	--	--
	1+	.4500[7]	2.025E-1	--	--
	2+	.4500[7]	4.500E-1	--	--
	3+	1.000[7]	--	--	--
	Total				3.63E4

Table V-3. Continued

Species	Life Stage	Life Stage Survival Rate	Cumulative Survival Rate	Plant-Related Losses (Entrainment and Impingement)	Equivalent Adult Losses
Blue crab	Zoeae	.0061[8]	1.701E-7	3.70E7	1.58E1
	Megalopae	.0010[9]	2.788E-5	1.50E8	1.04E4
	0+	.0700[9]	2.788E-2	--	--
	1+	.8850[10]	3.983E-1	--	--
	>1+	.4500[10]	--	--	--
	Total				1.04E4

(1) GPUN 1978
(2) Coates et al. 1970
(3) Howe et al. 1976
(4) PSE&G 1984
(5) Estimated
(6) Carriker 1961
(7) Hibbert 1977
(8) Sandoz and Rogers 1944
(9) Tagatz 1968
(10) Fischler 1965

Table V-4. Comparison of equivalent adult losses at Oyster Creek NGS (corrected for sampling gear efficiency) to Barnegat Bay fisheries. Blanks indicate that bay anchovies, sand shrimp, and opossum shrimp are not harvested in Barnegat Bay

Species	Estimated Loss (#)	Age of Loss (yr)	Estimated Loss (lbs)[a]	Mean Commercial Fishery (1975-1980) (lbs)[b]	Mean Recreational Fishery (1976-1978) (lbs)[b]	% Commercial Fishery	% Recreational Fishery	% Combined Fisheries
Bay anchovy	137,000,000	>0+						
Hard clam	59,100	>3+	8,865	112,565	37,140	8	24	6
Blue crab	10,400	>1+	3,432	114,110	155,850	3	2	1
Winter flounder	56,400	>3+	56,400	46,394	182,439	122	31	25
Opossum shrimp	1,720,000,000	>0+						
Sand shrimp	164,000,000	>0+						

[a] Conversion of loss in numbers to pounds is based on average weight of commercial catch (U.S. DOC 1975-1979)
[b] Sources: Derived from Hillman and Kennish 1984

adult losses to commercial and/or recreational fisheries in Barnegat Bay to obtain a perspective of the magnitude of loss estimates.

Summary and Conclusions for EAM

Based on the above information, we concluded the equivalent adult losses for RIS, with the exception of winter flounder, do not exceed the average commercial fishery for Barnegat Bay for the period 1975-1980. The winter flounder fishery is an under-utilized stock and is generally not a targeted fishery because of the average small size of this species in Barnegat Bay. Barnegat Bay represents a nursery area for winter flounder comprised of young, developing juveniles. Projected equivalent adult losses for bay anchovy, opossum shrimp, and sand shrimp were a significant amount of forage biomass for major commercial fishes, but the production foregone model provided a better means with which to evaluate these losses.

The equivalent adult model requires accurate estimates of plant-induced losses. Because of the large uncertainty associated with the corrected entrainment losses, the results of EAM are also highly uncertain. More reliable estimates of probable adult losses cannot be determined without better estimates of entrainment losses (i.e., without estimates of gear efficiency).

C. PRODUCTION FOREGONE MODEL (PFM)

Purpose and Application for PFM

Versar used the production foregone model (PFM), to estimate the proportional decline in annual net production lost from a population due to entrainment and impingement at the Oyster Creek facility. Net productivity for a species is calculated based on the product of the number of organisms in each life stage and their associated growth rates. The individual life stage net production rates are summed to estimate total net productivity for a species. We computed the annual net productivity of a population as if there were no impingement or entrainment losses (A), and the annual net productivity of that population subjected to entrainment and impingement (B). The fractional loss rate was then calculated as (A-B)/A.

Versar applied the PFM to three species (bay anchovy, opossum shrimp, and sand shrimp) to estimate fractional declines in the productivity of major forage items in Barnegat Bay.

Assumptions and Data Requirements for PFM

The PFM involved two major assumptions which affected interpretation of model results. These assumptions were:

- There was no compensatory response in the populations (e.g., in growth or mortality) due to plant-related losses
- The population was at static equilibrium.

The assumption of no compensatory response by the population was protective since this assumption likely resulted in an overestimate of plant effects. The assumption of equilibrium makes the application of the model to a specific data set pertinent to all years. In reality, bay anchovy, opossum shrimp, and sand shrimp populations are rarely at static equilibrium, and based on limited information, annual changes in recruitment and distribution for these as well as other species in Barnegat Bay and similar estuarine habitats were large. Thus, the assumption of an equilibrium population was only protective if the specific data used in the model represented extreme to average conditions of abundance.

The execution of PFM required data inputs of the abundance of each age class (based on initial population size and age-specific mortality rates), incremental weight gain by age, and estimates of entrainment and impingement losses.

Implementation and Results for PFM

Versar obtained estimates of initial population sizes for RIS from GPUN's bay-wide surveys and sampling at the plant intake. Mortality rates for developmental stages were primarily obtained from the scientific literature (Table V-5). The plant-induced mortality rates were obtained from exploitation rate calculations. Growth rates were obtained from the scientific literature. Plant-induced losses were estimated from the onsite monitoring program and the through-plant mortality studies. Entrainment losses were corrected for gear efficiency.

Versar's application of PFM to bay anchovy, opossum shrimp, and sand shrimp populations resulted in estimated losses in annual net productivity of the Barnegat Bay populations of 12.4% (354,000 lbs), 8.7% (67,000 lbs), and 16.5% (1,650,000 lbs), respectively. Bay anchovy production losses were relatively high (12.4%) mainly from significant losses to the post-larval and juvenile stages hence fewer 1+ anchovies were produced. The natural mortality rate from the juvenile to 1+ age class was

Table V-5. Parameter values for production foregone model as applied to Oyster Creek NGS

Species	Life Stage	Mortality Rate (day^{-1})
Bay anchovy[a]	Egg	1.39
	Prolarvae	.6398
	Postlarvae	.0848
	Juvenile	.0428
	1+	.0045
	2+	.0045
	3+	.0045
	4+	.0045
Sand shrimp[b]	Larvae	.2056
	Juvenile	.0842
	Adult	.0023
Opossum shrimp[a]	Larvae	.128
	Juvenile	.1535
	Adult	.01

[a] Calculated from data provided in Appendix XII, Table 4-31 of the Salem 316(b) Demonstration (PSE&G 1984).

[b] Estimated based on data provided in the Oyster Creek NGS 316 Demonstration (JCP&L 1979).

relatively large; thus a small proportion of juveniles were predicted to reach 1+ age class. In contrast, the juvenile stage was the most productive life stage for anchovy (i.e., largest percentage weight increase). As a result, even though only a small percentage (< 5%) of total abundance were 1+ year old fish, these losses represented a large relative percentage (12.4%) of population-level production from egg to the 1+ age class. The overall production loss due to bay anchovy is only 354,000 lbs. If the bay anchovy biomass that was estimated to be lost by the PFM was converted to predator biomass through one trophic transfer at the rate of 30% assimilation and assuming anchovies comprised only 10% of the predators' diets, then lost anchovy biomass would be projected to be equivalent to about 10,600 lbs of predators.

Relative production losses for opossum shrimp and sand shrimp represent significant losses in net productivity. Similar projected predator production losses for opossum shrimp and sand shrimp assuming a 10% assimilation rate, one trophic transfer, and 50% of predators diets for opossum shrimp and 10% for sand shrimp resulted in the losses of 3,300 and 16,500 pounds of predators, respectively. Almost all the losses for opossum shrimp and sand shrimp resulted from entrainment of juvenile and adult life stages. High natural mortality rates for the early life stages of these organisms combined with high net productivity resulted in moderately high production loss rates for sand shrimp (1,650,000 lbs) and opossum shrimp (67,000 lbs).

Summary and Conclusions for PFM

The PFM required an absolute or relative estimate of population size and plant-related losses. Poor Bay-wide abundance data were presented in the §316 Demonstration resulting in adjusted values for Bay-wide base population levels which were highly uncertain. Based on the above information, we concluded that the relative net production losses for the three RIS represented large portions of forage population production but that the absolute magnitudes of these losses were small (< 355,000 lbs) except for sand shrimp. Production loss resulting from entrainment and impingement losses for sand shrimp were estimated to be about 1,650,000 lbs. A rough estimate of predator losses due to this reduced forage production of sand shrimp was approximately 16,500 lbs. The conversion to predator biomass uses the assumptions previously discussed.

Better production foregone estimates (i.e., with less uncertainty) would have been obtained if better estimates of seasonal population abundances for bay anchovy, sand shrimp,

and opossum shrimp had been available. However, with the exception of sand shrimp, the absolute magnitude of the production losses were too low to have any observable effects upon the net productivity of the forage populations. Regardless, the projected losses to Barnegat Bay predators were only 30,000 pounds or roughly 6% of the combined fisheries for blue crab and winter flounder (major predators of bay anchovy, opossum shrimp and sand shrimp in the Barnegat Bay ecosystem). A better comparison would be to the biomass of the predator populations rather than the combined fisheries. If the fisheries take 10% of the adult biomass of these two species then the estimated forage losses represent less than 1% of the Barnegat Bay predator biomass.

D. SPAWNING/NURSERY AREA OF CONSEQUENCE MODEL (SNAC)

Purpose and Application for SNAC

Versar used the spawning/nursery area of consequence model (SNAC) to estimate the relative population losses from the aquatic communities of Barnegat Bay due to plant-induced losses at the Oyster Creek facility. The approach used empirical field data in the framework of several mathematically simple, conceptual models as a screening tool to evaluate impact. Potential loss of equivalent adults due to entrainment of early life-stages were estimated, and the impact of these losses in terms of an ecologically meaningful measure of consequent loss in ecosystem productivity and in terms of potential value changes in the regional fishery was evaluated. Proportional population losses are calculated as the ratio of specific lifestage power plant-related losses to the size of the base population. The proportional population loss is used to estimate the proportional loss to local fisheries by multiplying the total fisheries dollars in the region attributable to the species of interest by the proportional population loss and then normalizing this to a percent of the total regional fishery. The population loss rate is also used to calculate the proportion of net ecosystem productivity that could be lost due to plant-related losses as the proportion of ecosystem productivity used by a species multiplied by the population loss rate.

Assumptions and Data Requirements for SNAC

The SNAC model was based on four major assumptions which affected the interpretation of model results. These assumptions were:

- There was no compensatory response in the populations due to plant-related losses

- The population was at equilibrium
- The populations did not change prey preferences in relation to plant-induced losses
- There were reasonable estimates of local and regional densities and hydrographic data.

<u>Implementation and Results of SNAC</u>

Versar obtained estimates of local and regional life-stage-specific densities from GPUN's bay-wide surveys and intake monitoring program. Operational and hydrographic data were available from the Oyster Creek 316 Demonstration and entrainment/impingement probabilities were determined from these data. Entrainment/impingement mortality rates were available from mortality studies conducted by GPUN or were assumed to be 100% for entrainment when no data were available.

Versar's application of SNAC to winter flounder, bay anchovy, hard clam, blue crab, sand shrimp, and opossum shrimp populations resulted in potentially significant relative population losses to sand shrimp (Table V-6). Bay-wide densities for all invertebrate RIS, were assumed to be equivalent to the densities determined during the population abundance surveys. The relative population losses portrayed in Table V-6 are our "best-estimate" of population-level losses based on available population abundance data.

Economic losses associated with SNAC population losses were generally small based on the value structure of the Barnegat Bay commercial fishery. The largest contributor to economic losses appeared to be potential hard clam fishery losses which were about 1% of the regional fishery. One percent of the Barnegat Bay clam fishery is equal to approximately $4,000 (dock-side value). The present economic evaluation did not include the economic value of recreational fisheries, equipment or fuel for either commercial or recreational fisheries, or ancillary economic values associated with fishing (e.g., motel, restaurant, or guide costs). Inclusion of these costs would likely reduce the relative impact to the regional economic structure but would increase the total associated dollar value lost (presently $4,760) substantially.

The proposed relative population losses resulted in small relative losses in ecosystem net production (Table V-6). Even the 16.6% population-level loss to sand shrimp results in a very minor impact on the trophic dynamics of Barnegat Bay (<1%).

Table V-6. Results of SNAC model as applied to the Oyster Creek NGS

Species	Population (% of Abundance)	Economic (% of Barnegat Bay Commercial Fishery)	Ecological (% Net Ecosystem Production)
Winter flounder	2.1%	< 0.1%	< 0.1%
Bay anchovy	3.2%	0%	< 0.1%
Hard clam	1.5%	1.2%	0.1%
Blue crab	0.4%	< 0.1%	< 0.1%
Sand shrimp	16.6%	0%	0.3%
Opossum shrimp	2.0%	0%	<0.1%

Summary and Conclusions for SNAC

Based on the above information, we concluded that relative population losses for sand shrimp could conceivably threaten the maintenance of a balanced, indigenous population. This relatively high loss results from the preferential distribution of sand shrimp in regions of the waterbody which are highly at risk to entrainment/impingement (i.e., mouth of Forked River). As a result of this distribution, the length of the life cycle of sand shrimp, and the high rates of condenser entrainment, dilution pump entrainment, and impingement, the projected population losses of sand shrimp are 16.6%. The significance of this level of loss should be evaluated in terms of its potential impact upon local economies (e.g., regional fisheries), ecosystem productivity or energetics, and the capacity for population renewal. Clearly, the SNAC projections suggest no direct economic ramifications of the losses and minimal re-diversion of ecosystem productivity (i.e., 0.3 grams of net production per 100 g produced). This minimal impact results from the minor role sand shrimp play in the Barnegat Bay food web. Sand shrimp mature in a short time period, produce several generations in each year, live a relatively short time, and experience minimal predation pressure. These life history characteristics enable the population to recover quickly from disturbances (i.e., population losses). Unlike longer-lived species which reproduce only once per year (e.g., winter flounder), sand shrimp can withstand relatively large, consistent reductions in population survival (i.e., 10%-20%) without reducing the population's capacity to renew itself. Thus, while direct population losses to sand shrimp may appear substantial (16.6%), this loss rate is unlikely to adversely affect the population abundance of sand shrimp in Barnegat Bay, to affect regional economics, or to reduce system-wide productivity.

The associated economic losses for all species were slight resulting in less than $5,000 direct losses to Barnegat Bay commercial fisheries. The relative contributions of the population losses to loss in net ecosystem production were very small. The overall ecological effect of these species' losses represents less than a 1% decline in net ecosystem production.

VI. COMPLIANCE DETERMINATION

A. OBJECTIVES

In Chapter III, the Oyster Creek NGS was found to be out of compliance with New Jersey Water Quality Standards for thermal discharges. Section 316 of the Federal Clean Water Act provides for a variance from water quality standards and effluent limitations if the owner/operator can demonstrate that the facility does not adversely impact balanced, indigenous populations of the receiving waterbody. The objectives of this chapter are to:

- Use the information on plant-related losses and their impacts presented in Chapters IV and V to develop a recommendation as to whether a §316 variance should be granted for the Oyster Creek NGS

- Make recommendations as to what constitutes appropriate alternative effluent limitations for Oyster Creek.

The evaluation criteria and decision points that were used to determine whether balanced, indigenous populations were adversely impacted and the rationale for their selection were discussed in Chapter II. Recommending a variance be granted requires that all of these criteria be met. Failure to comply with any of the decision points for the evaluation criteria is justification for reaching the conclusion that the potential for long-term harm to balanced, indigenous populations is great and for recommending that GPUN's request for a §316 variance be denied. The burden of proof for demonstrating that balanced, indigenous populations were not adversely impacted lay with GPUN. Data inadequacies that cannot be corrected or that cannot be replaced with information from the scientific literature constitute grounds for recommending that GPUN's request for a variance be denied. Failure to provide the "best information reasonably available" has been considered grounds for noncompliance in previous §316 decisions. Previous §316 litigation also suggests that the information provided by GPUN should allow impacts of plant operations to be projected in both absolute and relative terms and that impacts be estimated with some degree of confidence. If substantial uncertainty exists as to the extent of harm due to insufficient or inadequate information, then we would conclude that GPUN had failed to demonstrate that less stringent thermal standards would protect the biota in the receiving water body (see Appendix B).

B. DEFINITION OF ADVERSE IMPACT

In order to evaluate the acceptability of impacts resulting from the operation of the Oyster Creek NGS, criteria defining an unacceptable level of impact must be determined. Acceptable impact was defined as that level of impact that had a low probability of causing long-term, system-wide harm to Barnegat Bay.

There are no hard and fast rules associated with the determination of an acceptable impact level. It is a function of:

- The type of species affected
- The stresses already placed upon that species by other sources of mortality (e.g., commercial and recreational fishing)
- The importance of the affected species to local ecosystems, economies, and society.

It is not the specific magnitude of power plant-related losses (e.g., the absolute number entrained) that is of relevance when making a §316 decision but rather the incremental increase these losses add to the existing sources of mortality influencing population dynamics. For example, fishing mortality to harvested fish populations can range from 5-50%. Thus, the influence of plant-related losses must be evaluated in the context of already existing sources of losses. In addition, year-to-year variation in recruitment surveys of estuarine biota is frequently very large due to natural fluctuations in climatic conditions and plant-related losses must be considered in the context of natural fluctuations due to climatic events that have a reasonable probability of occurring. The incremental addition to the population mortality rate resulting from plant operations is the critical factor to consider when making a determination as to the magnitude of potential harm likely to result from power plant operations.

Specific life history characteristics also affect the degree to which a given magnitude of loss may have long-term consequences. A short-lived species with a high reproductive rate (e.g., opossum shrimp) can accommodate incremental increases in mortality from power plant operations better than a long-lived population with a lower reproductive rate (e.g., winter flounder). As a result, the acceptable conditional mortality rate from power plant operation may be substantially higher for short-lived, fecund species compared to long-lived species with lower reproductive potential.

No single acceptable impact level (e.g., an allowable proportion of loss) exists because each species is affected by different sources of mortality, has a different position in the trophic structure of the ecosystem, and has different life history characteristics. Thus, determination of the level of acceptable impact is a policy decision that NJDEP must make in conjunction with other state and federal agencies based on the best available technical information and the degree of acceptable harm allowed under §316(a) of the CWA.

For the Oyster Creek NGS review, we set the level of acceptable impact at 10% for RIS populations already under stress from multiple uses (e.g., winter flounder, hard clams) and at 15-20% for short-lived, broadly distributed forage populations (e.g., sand shrimp, bay anchovy). These levels of acceptable impact will in our best professional judgement ensure the long-term protection of balanced, indigenous populations of fish, shellfish and other wildlife in Barnegat Bay given the present uses of Barnegat Bay for commercial and recreational fishing and the dynamics of the individual RIS populations. The levels of acceptable impact were established to be protective of environmental resources.

C. COMPLIANCE WITH EVALUATION CRITERIA

Compliance of the Oyster Creek NGS with evaluation criteria and the basis for compliance are summarized in Table VI-1. The Oyster Creek NGS complied with all five decision points for the evaluation criteria:

- Plant-related losses at Oyster Creek NGS do not adversely impact spawning and nursery functions of the selected RIS
- Plant-related losses at Oyster Creek NGS do not significantly increase the abundance of nuisance species
- Plant-related losses at Oyster Creek NGS do not adversely affect the estuarine food web of Barnegat Bay
- Plant-related losses at Oyster Creek NGS do not adversely impact beneficial uses of Barnegat Bay
- No plant-related losses at Oyster Creek NGS can be attributed to threatened or endangered species.

Of the operational losses that exist at Oyster Creek NGS, entrainment is the major source of plant-related mortalities. Entrainment losses are produced by both condenser entrainment and dilution pump entrainment. Thus, any BAT considerations for the minimization of plant-related effects should focus upon reducing entrainment losses.

Table VI-1. Evaluation of compliance of the Oyster Creek NGS with criteria and decision points in Table II-1

Evaluation Criteria	RIS Used	Compliance Recommendations	Technical Basis for Compliance Recommendations	Consequences of Failure
No adverse impacts on spawning and nursery functions including migration to and from spawning grounds	Hard clam Blue crab Sand shrimp Bay anchovy Winter flounder Opossum shrimp	Pass	The proportional losses due to entrainment for the RIS of concern are small. Hard clams grow slower, reproduce less frequently, and die at an earlier age in the discharge canal or the mouth of Oyster Creek but overall mortality was not greater than in non-thermally influenced areas; fish condition was reduced in the discharge canal as were abundances of some fish. Projected population losses to sand shrimp are 16.6% but will not affect ability of sand shrimp population to maintain a balanced, indigenous population. These effects do not constitute adverse impacts to spawning and nursery functions of Barnegat Bay populations.	Not Applicable
No significant increase in the abundance of nuisance species	Shipworms Fish parasites	Pass	Incidence of shipworms in Oyster Creek has increased post-construction but not due to operation of the facility but instead due to dredging Oyster Creek (not a 316 issue); thermal discharges provided habitat for subtropical species to become established, however, prolonged winter outages eliminated species from the region. Currently not a problem.	Not Applicable

Table VI-1. Continued

Evaluation Criteria	RIS Used	Compliance Recommendations	Technical Basis for Compliance Recommendations	Consequences of Failure
No adverse changes in the structure of the food web and/or functional properties of the ecosystem	Bay anchovy Sand shrimp Opossum shrimp	Pass	The range of productivity losses show some of the estimates could be of concern, namely; • Bay anchovy 12.4% • Sand shrimp 16.5% Although losses of productivity to these populations may be substantial, the effect of these projected losses on the Barnegat Bay food web is inconsequential.	Not applicable
No adverse impacts on the beneficial uses of Oyster Creek/Barnegat Bay	Winter flounder Hard clam Blue crab Shipworms	Pass	Construction of Oyster Creek Discharge Canal created a major recreational resource for fishing (34% of all bank fishing in Barnegat Bay); GPUN's purchase of local marinas and docks along Oyster Creek to preclude difficulties concerning shipworm infestation has reduced some beneficial uses of Oyster Creek	Not applicable
No significant decrease in the abundance of threatened or endangered species	Atlantic Ridley Turtle	Pass	Evaluation of available data show no threatened or endangered species in vicinity of Oyster Creek	Not Applicable

Impingement losses were generally small in magnitude when compared to entrainment losses (even when adjusted for differential survival rates). The losses due to impingement at the Oyster Creek NGS were of no consequence to the compliance determination.

The Oyster Creek NGS thermal discharge was not in compliance with New Jersey Water Quality Standards and effluent limitations. However, the impact of Oyster Creek NGS' discharge was determined to be small and localized. Thermal discharges could exclude some species from Oyster Creek in late summer. Most of these excluded species are generally displaced into Barnegat Bay.

In addition to considering adverse impacts on the Barnegat Bay ecosystem, plant impacts on Oyster Creek were also examined. As discussed in Chapter III, the habitats and environmental conditions of the section of Oyster Creek that connects to Forked River and the section that was formerly a low productivity, freshwater stream were irreversibly altered during construction of Oyster Creek NGS. Near its mouth, Oyster Creek remains a tidally influenced estuary with similar species present today as were present before construction of Oyster Creek NGS. Available data suggest that the primary impact of Oyster Creek NGS on the estuarine portion of Oyster Creek has been to displace some heat-sensitive biota from Oyster Creek. On the other hand, the amount of estuarine habitat, particularily deeper water habitat, has been increased and has been accompanied by increases in fishing activity in the local area.

D. DATA DEFICIENCIES AND CONSEQUENCES TO THE REVIEW PROCESS

In conducting the review and evaluation of the data provided by GPUN in the Oyster Creek §316 Demonstration, numerous data deficiencies were identified. In order to complete the review process, it was necessary for us to use the scientific literature and our best professional judgement to adjust the data provided by GPUN for its most serious deficiencies (e.g., sampling bias). The major data deficiencies identified by Versar during the review of the Oyster Creek 316 Demonstration documents are summarized below.

Because most of the impact assessment analyses (both no prior harm and RIS) presented by GPUN in the Oyster Creek 316 Demonstration were poorly conceived, poorly executed, and not pertinent to a compliance determination, Versar determined the consequences of power plant losses due to Oyster Creek NGS to the receiving waters by applying three impact assessment models.

These independent analyses were necessary because they represented one of the bases for determining compliance with evaluation criteria and decision points. Such analyses were not included as part of GPUN's 316 Demonstration.

In a number of cases, data were not available which were critical to the evaluation of the magnitude of the facility's impact on the Barnegat Bay ecosystem (e.g., mortality rates, growth rates) or Oyster Creek. In these cases, Versar used available information from other sites and from the scientific literature to fill the data gaps. The available data for evaluation of plant impacts on Oyster Creek proper were particularly deficient. Quantitative data with which to assess the extent and magnitude of impacts within Oyster Creek proper were not provided. No preconstruction data on the value and amount of habitat that was irreversibly harmed was provided. In many instances, our compliance determination was not sensitive to the choice of the information used to fill data gaps. The most critical data deficiency in GPUN's demonstration was gear efficiency. GPUN assumed gear efficiencies to be 100% when clearly they are not.

The magnitude of gear efficiency plays a critical role in the evaluation of two decision points; namely, adverse changes in the Barnegat Bay food web and the number of adults lost to balanced, indigenous populations due to entrainment, impingement, and fish kills. The correct absolute magnitude of entrainment losses is necessary to provide a context to evaluate these impact issues. Potential adult losses are determined directly from the magnitude of entrainment losses. The effect of gear efficiency on this decision point is obvious. The impact on the food web was determined from absolute entrainment losses in conjunction with other available data. Since the burden of proof lies with the utility when requesting a variance, it was incumbent on Versar to select from the literature values, a gear efficiency correction factor (i.e., 10%) that is protective of the resource when data were not provided in the Demonstration.

E. APPLICABILITY OF EXISTING TEMPERATURE WATER QUALITY STANDARDS TO THE OYSTER CREEK NGS

The waters of Barnegat Bay are classified as saline estuarine waters (SE). Their designated uses are:

- Shellfish harvesting
- Maintenance, migration, and propagation of natural and established biota

- Primary and secondary recreation
- Other reasonable uses (e.g., industrial water supply).

Existing New Jersey water quality standards for SE waters (7:9-4.14(C)) specify that:

- The heat dissipation area (area characterized by the thermal regimes) cannot extend to more than 25% of the cross-section or not more than 2/3 of the surface radial length from point of discharge to the opposite shore.
- At no time can temperatures exceed 85° F (29.4°C).
- No thermal alterations causing above-ambient deviations of more than 4° F (2.2° C) can be incurred outside of the specified heat dissipation area during the period September through May; and of no more than 1.5°F (0.8°C) from June to August).

The most restrictive designated heat dissipation area that can be defined for the Oyster Creek NGS would be to use Oyster Creek alone. Less restrictive heat dissipation areas (e.g., those that consider Barnegat Bay to be the receiving water body) can also be defined for the Oyster Creek NGS. Thermal discharges of the Oyster Creek NGS exceeded the thermal standards for all reasonable definitions of the allowable heat dissipation area.

GPUN may:

- Achieve compliance by installing the best available technology for reducing thermal loading
- Obtain a variance/waiver under §316(a) of the CWA by demonstrating that balanced indigenous populations of RIS in Barnegat Bay are protected
- Demonstrate to the satisfaction of NJDEP, and the public, that existing temperature water quality standards should be modified (i.e., downgraded) to a condition to which the Oyster Creek NGS will comply.

GPUN has requested on numerous occasions that NJDEP examine the potential for modifying (i.e., downgrading) the water quality standards for temperature in the receiving waters of the Oyster Creek NGS independent of and prior to a §316(a) or §316(b) determination for the Oyster Creek NGS. To date, NJDEP has not convened a proceeding on modification of water quality standards separate from a §316(a) proceeding for the Oyster Creek NGS. NJDEP's position is that both proceedings would

involve similar issues and much of the technical information required to make the decision is contained in the Oyster Creek §316 Demonstration documents. The purpose of the discussion that follows is to determine if the information presented in the Oyster Creek 316 Demonstration provides support for this request.

Designated uses and thermal criteria for receiving waters may only be downgraded if:

- The uses being removed are not existing uses, and

- The uses being removed are not attainable because of natural background, natural physical features of the water body, and/or irretrievable man-induced conditions, or

- Controls more stringent than those required by §301(b) and §306 of the CWA result in substantial and widespread social and economic impact, and

- Reclassification is consistent with §316 of the CWA (N.J.A.C. 7:9-4.10(e); U.S. EPA 1983).

All of the designated uses for the receiving waters of the Oyster Creek NGS are existing uses. Therefore, reclassification and downgrading on the basis that a designated use is not an existing use does not have a basis.

GPUN has claimed that ambient water temperatures in Barnegat Bay preclude the Oyster Creek NGS from complying with water quality standards and is a basis (unattainability) for downgrading. However, the premise of ≥85° F ambient water is incorrect. The average monthly summer temperature for Barnegat Bay in the hottest month is <80° F (Kennish and Lutz 1984), and the majority of Barnegat Bay waters that are not influenced by the Oyster Creek NGS have ambient summer temperatures that are slightly less than 83° F. Intake water temperatures at the Oyster Creek NGS are ≥85° F less than 1% of the time, and then only because of recirculation of waste heat. Solar warming may cause shallow waters with poor circulation to exceed 85° F during the summer. However, these areas constitute less than 1% of the total Barnegat Bay volume and are not a basis for downgrading of water quality standards.

Information presented in the Oyster Creek 316 Demonstration indicate that temperatures greater than the maximum allowed outside of heat dissipation areas (85° F) are likely to adversely affect the behavior and physiology of temperature sensitive RIS. Condition factors of menhaden in the specific heat dissipation area from 1975-1976 were significantly lower than those in Forked River or Barnegat Bay. In addition, hard clams in the

specified heat dissipation areas grew slower, died at an earlier age, and reproduced less frequently than clams in nearby reference areas. Adult hard clams stop growing at 30-31°C (29.4°C) maximum limit. Oyster Creek phytoplankton showed 30%, 20%, and 18% lower gross productivity, net productivity, and standing stock due to thermal discharges, respectively. Some heat sensitive algae were excluded from thermally affected stations. These data indicate that neither the 85° F maximum limit nor the specified heat dissipation area is overly protective. Thus, the existing standards appear to be appropriate for the purpose of protecting aquatic resources and they are surely not overly stringent.

It is clear that economic factors may be considered during a proceeding to modify thermal water quality standards. GPUN must, however, demonstrate more than simple adverse economic impact to attain downgrading of the thermal water quality standards for SE waters. They must show that achieving existing limitations/uses will have a substantial and widespread impact upon the public.

Water quality standards for temperature or any modifications to them may not allow environmental alterations due to the discharge of waste heat that do not comply with the minimum requirements of §316(a) of the CWA (i.e., protection of natural and existing biota). The appropriate and ultimately controlling mechanism for obtaining relief from temperature water quality standards is §316(a) of the CWA.

In summary, we conclude that the existing New Jersey water quality standards for limiting the discharge of waste heat are reasonable standards for ensuring protection of SE waters. Further, the water quality standards that should be applied to Oyster Creek and Barnegat Bay are those applicable to other similarly classified water bodies in New Jersey. If GPUN requires relief from these standards the most appropriate route to obtain that relief is by obtaining a variance under §316(a) of the CWA. However, GPUN may also obtain relief by demonstrating that compliance with the existing standards would cause widespread social and economic impact or by installing "best available technology" for discharge of waste heat. At this time, GPUN has not demonstrated that widespread social and economic impact would be caused by compliance with existing standards.

F. CONCLUSION

In summary, adverse impacts of the Oyster Creek NGS do not indicate unacceptable, substantial long-term population and ecosystem level impacts. Alternate effluent limitations that protect balanced indigenous populations may be granted for Oyster Creek NGS.

VII. IDENTIFICATION OF BEST AVAILABLE TECHNOLOGY FOR INTAKE STRUCTURES

Section 316(b) of the CWA requires that best available technology (BAT) for intake structures be installed at power plants, particularly those that have the potential for adversely affecting balanced indigenous populations (Appendix B). GPUN concluded, in the Oyster Creek 316 Demonstration, that the intake technology of Ristroph screens they presently use represents the BAT for the Oyster Creek NGS. This chapter presents an independent assessment of BAT for the Oyster Creek facility.

A. APPROACH

As noted in Chapter II, we used the steps listed below to develop our BAT recommendations:

- Identification of the problems to be mitigated
- Identification of the technologies that are most applicable to that problem
- Estimation of the ecological benefit that will be derived from each applicable technology
- Estimation of costs for the most applicable technologies
- Optimization of BAT selections based on anticipated benefits and costs.
- Determination of the socio-economic consequences of requiring BAT (e.g., costs to rate payers)
- Evaluation of the adverse environmental impacts of requiring BAT.

As noted in Chapter II, the most cost-effective BAT evaluation will be made if the 316(a) determination is accomplished prior to the BAT evaluation, since the impacts to be minimized will have already been defined. If it was determined that alternate effluent limitations for a facility do not protect the maintenance and propagation of balanced indigeneous populations, alternate effluent limitations should be denied and the utility must comply with §316(a) (i.e., balanced

indigenous populations must be protected), as well as must comply with applicable NJDEP water quality standards. In some cases, compliance with these water quality standards, by necessity, requires certain technologies or operational procedures which would eliminate the usefulness of others. In this manner, it is most cost-effective for NJDEP to make BAT evaluations with as much knowledge as possible (i.e., having all the needed information to make a 316(a) determination).

B. IDENTIFICATION OF THE PROBLEM TO BE MITIGATED

Chapter VI documented that existing operations of the Oyster Creek nuclear generating facility do not adversely impact the balanced indigenous populations of Barnegat Bay. BAT required by §316(b) is the option that reduces impacts to the greatest possible degree where cost is not wholly disproportionate to ecological benefit (Appendix B). Appendix G documents that total losses from the Oyster Creek NGS are approximately $95,000 annually, or a total of five million dollars if adjusted for inflation and an anticipated 25 year operating period. While the test for costs "not wholly disproportionate" with anticipated benefits is not constrained to a monetary comparison (Appendix B), there is no anticipated long-term impact of this facility and these dollar values provide a means by which to screen those technologies whose costs are wholly disproportionate.

The major mode of impact at the Oyster Creek NGS was defined in earlier chapters as entrainment losses to early life stages of RIS, particularly hard clams and sand shrimp. A number of fish and invertebrate species are also impinged; however, the economic value of impingement losses account for less than 10% of the total value of losses from the facility (Table VII-1). Thus mitigation of impingement losses without mitigation of entrainment losses is not feasible within the cost constraints described above. Thermal effects from the Oyster Creek NGS have produced large fish kills, particularly during winter shutdowns. However, the size and frequency of fish kills have been sufficiently reduced since GPUN altered operating procedures of the dilution tempering pumps, such that further reductions in thermal impacts would provide little reduction in the economic value of losses.

C. IDENTIFICATION OF BAT'S THAT ARE MOST APPLICABLE TO THE OYSTER CREEK NGS

Over 30 technologies to reduce impingement and entrainment impacts have been tested or used in power plants (American

Table VII-1. Percentage of equivalent adult losses attributable to impingement, dilution pump entrainment and condenser entrainment

Species	Impingement	Entrainment Dilution	Entrainment Condenser
Winter flounder	< 0.1%	51.2%	48.7%
Bay anchovy	< 0.1%	69.2%	30.7%
Hard clam	0%	43.5%	56.5%
Blue crab	55%	43%	2%
Sand shrimp	1.0%	63.5	35.5%
Opossum shrimp	< 0.1%	51.7%	48.3%

Table VII-2. Categories and examples within each category of available technologies for reducing power plant environmental impacts

- Behavioral barriers
  - light(s)
  - sound(s)
  - air bubbles
  - electrical barriers
  - chemical barriers
  - magnetic barriers
  - louvers
  - velocity caps
  - hanging chains
  - water jets
- Physical barriers
  - traveling screens
  - barrier nets
  - sand filters
  - porous dikes
  - radial well collectors
  - drum screens
  - Passavant screens
  - Beaudrey (Cogenal) screens
  - rotating disc screens
  - fine mesh additions to vertical travelling screens
  - perforated pipes
  - wedgewire screens
- Reductions in water withdrawal
  - closed cycle cooling
    - natural draft towers
    - mechanical draft towers
    - cooling ponds
  - helper towers
  - reduction in intake flows combined with increases in ΔT
  - outages
- Relocation of the intake
  - relocation to deeper offshore water
  - relocation to another water body
- Reductions in approach velocity
  - increase intake size
  - dredging
- Diversion systems
  - angled travelling screens
  - incline plane screens

Society of Civil Engineers 1982). Table VII-2 lists the most prominent of these technologies categorized by their mode of operation. In the following paragraphs we identify the technologies on this list that are most applicable for reducing the impacts of the Oyster Creek NGS and for which cost and ecological benefit should be more closely examined.

Many of the technologies in Table VII-2 were eliminated from further consideration as alternatives for the Oyster Creek NGS because they are effective only at reducing impingement losses. For example, fish collection and removal systems reduce mortality for impinged fish but do not reduce entrainment losses. Behavioral barriers also mainly reduce impingement losses because for these devices to be effective, organisms must have sufficient swimming ability to avoid intake structures (American Society of Civil Engineers 1982). Entrainable life stages generally do not possess this ability. In addition, the effectiveness of behavioral barriers are species-specific and have not been tested on the invertebrate species of concern at Oyster Creek.

Alterations to intake structures that reduce approach velocity are also unlikely to substantially reduce impacts to RIS populations from the Oyster Creek NGS. Velocities adjacent to intake screens presently exceed 2 fps. Impingement losses are generally not substantially reduced until intake velocities fall below 0.5 fps (American Society of Civil Engineers 1982). Reduction of intake velocities through travelling screens from 2-3 fps to 0.5 fps is impractical at Oyster Creek NGS without considerable reconstruction efforts. Additionally, even with low approach velocities, entrainment is likely to remain high because most of the invertebrate larvae entrained at Oyster Creek (e.g., hard clams) are incapable of avoiding even relatively low intake flows (0.5 fps) without bypass currents or fine mesh screening devices.

Diversion systems with angled fine-mesh screens have been suggested as a technology for reducing both impingement and entrainment losses (American Society of Civil Engineers 1982). However, the only studies to examine the efficacy of this technology reported that mortality rates for larval fish in the bypass currents approached mortality from impingement or entrainment (Lawler, Matusky, and Skelly Engineers 1985). This technology has also been criticized as having basic design flaws (Fletcher 1985).

Relocation of the source of intake water is a mitigation strategy that is inapplicable to the Oyster Creek NGS. This technology is a viable alternative only when another water body exists nearby, or when the source of intake water can be moved (e.g., extended to offshore or deeper locations) where the density of vulnerable biota are reduced. No such opportunities exist in Barnegat Bay.

Some physical barrier systems also can be eliminated as inapplicable for reducing impacts at Oyster Creek. For example, barrier nets are effective in reducing impingement losses (Newman et al. 1981; Edwards and Hutchinson 1980; PEPCO 1982), but would not reduce entrainment losses for the species of concern at Oyster Creek because of the large mesh sizes (1.3 - 5.1 cm) used. Similarly, drum screens and rotating disc screens reduce impingement but have never been deployed with the fine-mesh screening required to reduce entrainment losses. Perforated pipes, sand filters, and radial well collectors are all theoretically acceptable technologies for reducing both impingement and entrainment losses, but have never been applied at facilities requiring intake flows > 2 m^3/s (American Society of Civil Engineers 1982). Porous dikes reduce both entrainment and impingement losses (Edwards et al. 1981b; Ketschke 1981a). However, porous dikes are susceptible to fouling and clogging (Ketschke 1981b) and could not be applied in the high detrital, high fouling environment near Oyster Creek NGS without extensive on-site testing and evaluation.

Several physical barriers are potentially applicable for reducing the entrainment and impingement losses at Oyster Creek NGS: 1) existing screens can be retrofit with fine mesh panels, 2) traveling screens with 3/8" mesh can be placed in front of the dilution pumps to reduce entrainment of impingeable size organisms, 3) fine-mesh traveling screens can be placed in front of the dilution pumps, and 4) fine-mesh centerflow screens can be placed in front of dilution pumps. Retrofitting 9.5-mm mesh conventional traveling screens with fine-mesh panels has been tested at a few power plants (Edwards et al. 1981a; Taft et al. 1981a). This technology reduces entrainment losses; however, impingement losses may increase following such retrofits because many organisms that were previously entrained become impinged. The ecological benefit of retrofitting fine-mesh screens on the existing traveling screen system, and likewise placement of screens in front of the dilution pumps, depends on whether the reduction in entrainment losses exceeds the gain in impingement losses that are likely to result.

Wedgewire screening is another technology that uses fine-mesh screening to reduce both impingement and entrainment losses (Otto et al. 1981; Browne et al. 1981; Zeitoun et al. 1981; Hanson 1981; Weisberg et al. 1987). While the primary application of this technology has been for collecting make-up water of closed-cycle cooling water systems, it is currently in use at one power plant that has a once-through cooling water system and has been very successful at minimizing entrainment and impingement losses (Great Lakes Research Division 1982). However, this technology will not be further considered because its capital cost far exceeds that of the 25-year benefit associated with projected impacts.

The final alternative for reducing impingement and entrainment losses is to reduce the volume of cooling water withdrawal. Cooling towers can reduce withdrawal by as much as 95% and would therefore be effective. However, the cost of cooling towers far exceeds the potential economic and ecological benefits that might accrue from such action. Another alternative is to limit withdrawal of water through the dilution pumps. GPUN's current permit for Oyster Creek Generating Station requires that dilution pumps be put into operation when the water temperature in Oyster Creek at Route 9 bridge exceeds 30.6 C and when the water temperature is below 15.6 C. These requirements are intended to reduce heat shock mortality during the summer and cold shock mortality during the winter. However, dilution pumps have historically been run in every month of the year. Because there are ecological costs as well as potential benefits associated with operation of these unscreened dilution pumps, it is possible that altering their operation may reduce total plant-induced losses at Oyster Creek (e.g., ceasing operations when the risk of heat shock and cold shock is low).

In summary, the following section will examine five alternatives for reducing impingement and entrainment losses at Oyster Creek NGS. These alternatives are: 1) retrofitting condenser intake screens with fine mesh, 2) fitting dilution pump intakes with 3/8-in. mesh traveling screens, 3) fitting dilution pump intakes with fine mesh traveling screens 4) fitting dilution pump intakes with Passavant (centerflow) traveling screens, and 5) altering operation of dilution pumps.

D. ESTIMATES OF COST AND BENEFITS FOR APPLICABLE TECHNOLOGIES

Retrofitting Condenser Intake Screens with Fine Mesh

Fine-mesh panels placed on the present traveling screens are unlikely to significantly reduce impacts from the Oyster Creek NGS because they would fail to prevent entrainment of critical life stages for invertebrate RIS and would merely replace entrainment losses with impingement losses for most ichthyoplankton. Installing fine-mesh (0.5-mm mesh) traveling screens on the condenser intake would decrease the open area of the screen and likely double velocities near the screen face relative to those observed with the existing 3/8-in. mesh Ristroph screens. Nearly all previously entrained RIS would be impinged, with the exception of bay anchovy eggs, blue crab zoeae and Mercenaria larvae. The life stages of these three species are the smallest size of the RIS encountered at Oyster Creek NGS. With increased through-screen velocities at the screen face, these species would likely be extruded through the fine mesh screen and entrained.

Table VII-3 presents Versar's estimates of entrainment reductions if fine mesh screening was added to the existing Ristroph screens. No benefit occurs for those small life stages which are still entrained. Small benefits are gained for those which become impinged. Edwards et al, (1981a) and Taft et al. (1981b) have shown that mortality rates for larvae impinged on fine-mesh screens are a function of velocity at the screen face, duration of impingement and duration of exposure to air. At Oyster Creek NGS, impingement velocity is high and duration of impingement is long (> 8 minutes).

Table VII-4 provides cost estimates for retrofitting existing Ristroph screens with fine mesh. The 3/8-in. mesh screen panels can be removed from the screen structures, the fine mesh screen installed on the panels and the panels re-installed on the structures during a normal scheduled outage. Operation and maintenance costs associated with fine mesh screens at the intake should be similar to those for existing 3/8-in. mesh traveling screens. Fine mesh screens require continuous rotation; however, as the existing screens are already rotated continuously, no increase in power usage will result.

Whereas the installation of fine mesh traveling screens is possible, it may not be practical from an engineering standpoint given the existing intake structures. Manufacturers caution that with the existing intake at Oyster Creek NGS velocities resulting from the addition of fine mesh may cause screens to collapse.

3/8-in. Mesh Traveling Screen Addition to Dilution Pump Intakes

Installing traveling screens (3/8-in. mesh) in front of the dilution pumps will cause previously entrained organisms of impingeable size to become impinged. Due to the lack of data concerning the latent mortality of impingeable-size organisms entrained through the dilution pumps (see Entrainment section, Chapter IV), Versar assumed mortality rates to be equal to impingement mortality rates on the condenser traveling screens. Under this assumption, the estimated loss of organisms impinged on dilution pump traveling screens will be equal to that of impingeable-sized organisms passing through the dilution pumps. Therefore, the loss estimates for entrainable-size organisms will not change with the addition of 3/8-in. mesh screens. This alternative cannot be adequately evaluated without additional data.

Table VII-3. Annual impingement and entrainment loss (in millions) at condenser intake with present technology (3/8-in. Mesh Ristroph screens) and fine mesh screens

	Ristroph Screens 3/8-in. Mesh		Ristroph Screens Fine Mesh	
	Impingement	Entrainment	Impingement	Entrainment
Bay Anchovy				
Eggs	0	5182	0	5182
Larvae	0	6545	6545[a]	0
Juvenile and Adults	0.25	0	0.25	0
Winter Flounder				
Larvae	0	2099	1856[a]	0
Juvenile and Adults	0.013	0	0.013	0
Sand Shrimp				
Zoeae	0	7225	3613[b]	0
Juvenile and Adults	8.02	3633	8.02 + 1817[c]	0
Blue Crab				
Zoeae	0	17	0	17
Megalopae	0	80	40[b]	0
Juvenile and Adults	0.28	0	0.28	0
Mercenaria larvae	0	63530	0	63530
Opossum shrimp	0	101302	50651[b]	0

(a) Calculated using literature values of mortality rates for fine mesh (Taft et al. 1981b; Edwards et al. 1981a).
(b) Assumed mortality rate (50%).
(c) The mortality rate of sand shrimp previously entrained but now impinged on fine mesh screens was assumed equal to that on Oyster Creek NGS Ristroph screens (50%).

Table VII-4. Probable project cost of retrofitting condenser intake screens with fine mesh panels

Capital Cost			
Equipment/Installation	Quantity	Unit Cost	Total
Removal of Screen Panels Installation of Fine Mesh Reinstall Screen Panels	6 screens	150 man-hr/screen*	$22,500
Screen Material	270 panels	$200 panel*	54,000
Subtotal (Rounded)			77,000
Contingency (at 20% of equipment and installation)			15,400
Total (Rounded)			$92,000

*Provided by Envirex

Fine Mesh Traveling Screen Addition to Dilution Pump Intakes

Similar to the proposed fine mesh addition at the condenser intake, installation of fine mesh traveling screens at the dilution pumps will result in all previously entrained RIS being impinged, with the exception of bay anchovy eggs, blue crab zoeae, and Mercenaria larvae. Impingement and entrainment losses associated with fine mesh screens were calculated using the same literature values and assumptions mentioned previously (Table VII-5). Because mortality rates of impingeable-size organisms entrained through the dilution pumps were assumed in Chapter IV to be equal to impingement mortality rates on the condenser traveling screens, no difference will be observed between the loss due to entrainment through the dilution pumps and that due to impingement on fine mesh screens in front of the dilution pumps. Sand shrimp zoeae, juveniles and adults, winter flounder larvae, blue crab megalopae, and opossum shrimp show a decrease in losses with fine mesh screens.

The approximate equipment and installation costs for fine mesh traveling screens are shown in Table VII-6. The unit cost per screen includes the spray wash and fish return system immediately surrounding the screen area but does not include the cost of constructing a complete fish return system similar to the present condenser intake fish return system. Annual operation and maintenance estimates are presented in Table VII-7. The unit power cost was assumed to be $0.07 per kilowatt hour. Power usage was based on continuous screen rotation from two other generating stations. Screen assembly removal and inspection costs are based on 25% of initial installation costs.

Passavant (Centerflow) Traveling Screen Addition to Dilution Intake

Passavant (single entry, double-exit) or Beaudrey (double-entry, single-exit) screens are designed to substantially reduce entrainment by providing two screen faces for straining water (Fig. VII-1), rather than the single screen face characteristic of conventional traveling screens. This design reduces intake velocity by almost 50% over that which would occur for conventional screens. Passavant screens are popular in Europe but have been applied at only one facility in the United States (Murray and Jinette 1978).

Impingement mortality rates are not presently available for centerflow screens. Studies indicate that lower velocities at the screen face reduce mortalities (Taft et al. 1981b); however, on centerflow screens, fish may be impinged for a longer period of time (i.e., on both the descending and ascending faces of the screen). The potential benefit of lower through-screen

Table VII-5. Impingement and entrainment losses (in millions) at the dilution pumps with present technology (no screens) and fine mesh screens

	No Screens		Fine Mesh	
	Impingeable-Size	Entrainable Size	Impingement	Entrainment
Bay Anchovy				
Eggs	0	5071	0	5071
Larvae	0	6794	6794[a]	0
Juvenile and Adults	337	0	337	0
Winter Flounder				
Larvae	0	2231	1999[a]	0
Juvenile and Adults	0.2	0	0.2	0
Sand Shrimp				
Zoeae	0	6383	3192[b]	0
Juvenile and Adults	194	4048	194 + 2024[c]	0
Blue Crab				
Zoeae	0	17	0	17
Megalopae	0	68	34[b]	0
Juvenile and Adults	4.5	0	4.5	0
Mercenaria larvae	0	48800	0	48800
Opossum shrimp	0	108587	54294[b]	0

(a) Calculated with literature values of mortality rates for fine mesh screens (Taft et al. 1981b; Edwards et al. 1981a).

(b) Assumed mortality rate (50%).

(c) The mortality rate of sand shrimp previously entrained but now impinged on fine mesh screens was assumed equal to that on Oyster Creek NGS Ristroph screens.

Table VII-6. Probable project cost of dilution pump fine mesh screens

Capital Cost			
Equipment/Installation	Quantity	Unit Cost	Total
Screens (stainless steel) includes Ristroph modifications	6 screens	$150,000/screen[a]	$900,000
Install screens	6 screens	1 wk/screen[b]	30,000
Concrete Structure[c] Modifications			180,000
Subtotal (Rounded)			1,100,000
Contingency (at 20% of equipment and installation)			220,000
Total (Rounded)			$ 1,300,000

(a) Provided by FMC Corp. and Envirex.
(b) Installation of screens estimated on the basis of a five man crew at one week per screen provided by Envirex.
(c) The modifications to the concrete structure were estimated to be 20% of the cost of the screens.

Table VII-7. Probable cost of operation and maintenance fine mesh screens

	Annual Cost
<u>Operation</u>	
Power	$12,000
Labor	18,000
Subtotal (Rounded)	$30,000
<u>Maintenance</u>	
Replacing screens (once every five years)	15,400
Replacing spray nozzles (once every three years)	700
Screen assembly removal and inspection (annual)	7,500
Subtotal (Rounded)	$24,000
Total (Rounded)	$54,000

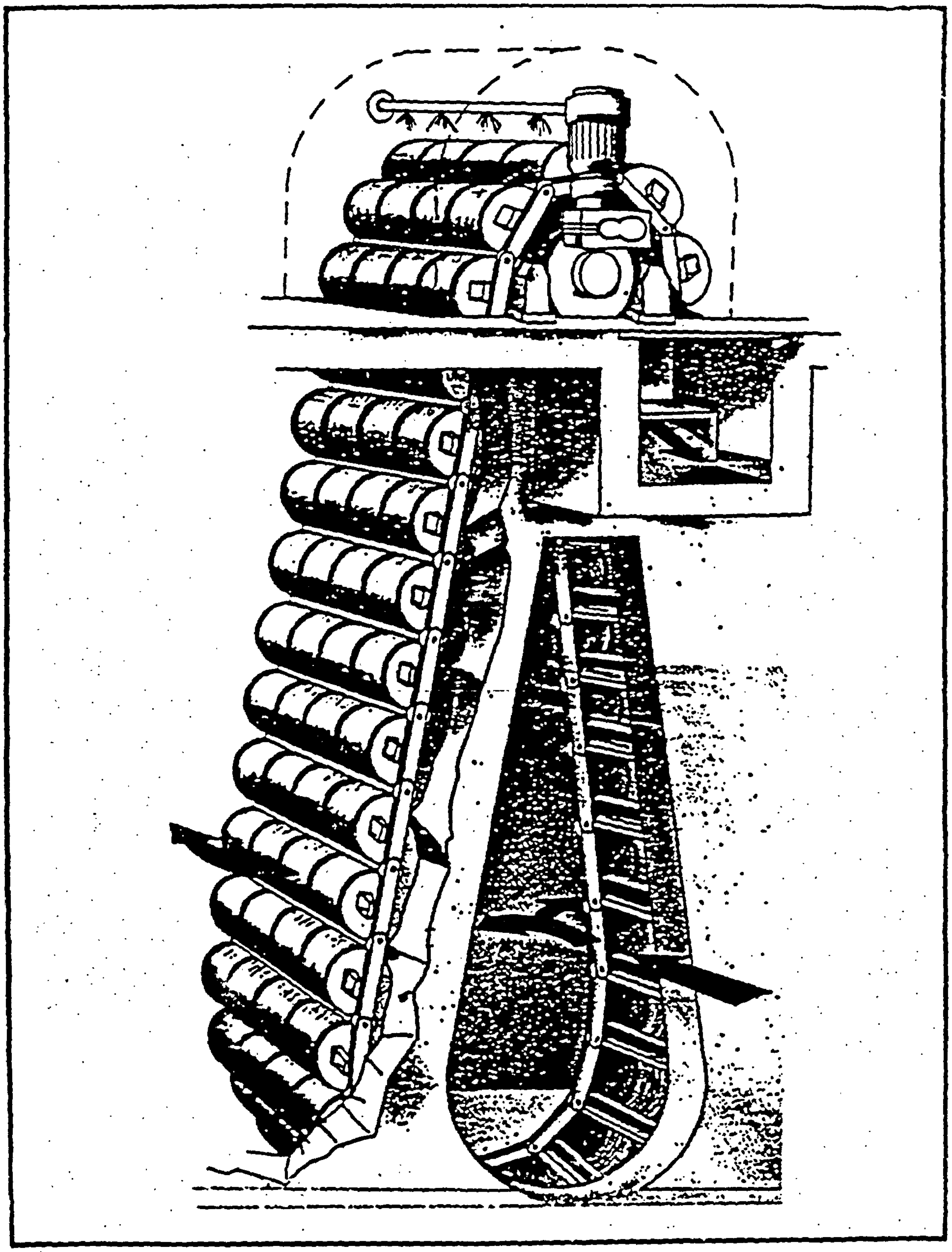


Figure VII-1. Passavant type screen showing single-entry, double exit configuration (from Salem 316 Document)

velocities may be offset by an increase in mortality due to longer duration of impingement. The end result is likely to be that impingement loss on fine mesh centerflow screens is similar to that for conventional traveling fine mesh screens.

The application of centerflow screens in front of the dilution pumps will require some structural modification to the existing dilution intake structure so as to channel the flow to the center of the screens. An estimate of equipment and installation costs are presented in Table VII-8. Annual operation and maintenance estimates are presented in Table VII-9.

Altered Operation of Dilution Pumps

Ideally, optimization of dilution pump operating schedules as a BAT option would be accomplished by comparing total plant-induced losses with and without dilution pump operation for each month of the year. This model would compare the benefits of an altered thermal mortality rate (from the cooling of dilution pumps) with the cost of exposure by entrainment of a great number of RIS. Application of such a model to the Oyster Creek station requires a variety of data inputs, most of which were not available in the 316 demonstration documents. These include:

- Species-specific temperature-dependent mortality rates for entrainment, impingement, and dilution pump entrainment
- Accurate estimates of entrainment, impingement, and dilution pump entrainment by stratum (temperature or time period)
- Discharge temperature distribution data for each operating scenario to be considered (e.g., no dilution pumps operating, one dilution pump operating, two dilution pumps operating)
- Estimates of cold shock losses associated with plant shutdowns for each operating scenario
- Estimates of direct or indirect losses associated with the thermal plume for each operating scenario.

In lieu of an optimization analysis, Versar conducted a simplified analysis designed to determine the likelihood that alteration of dilution pump operation schedules could be used to reduce plant-related losses. Losses with dilution pumps operating were defined as: impingement losses, entrainment losses, and dilution pump entrainment losses. For estimates of

Table VII-8. Probable project cost of dilution pump centerflow screens

Capital Cost			
Equipment/Installation	Quantity	Unit Cost	Total
Screens (stainless steel)	6 screens	$420,000/screen(a)	$2,520,000
Fish return system	6 screens	10,000/screen(a)	60,000
Install screens	6 screens	1 wk/screen(b)	25,000
Concrete structure[a] modifications			756,000
Subtotal (rounded)			3,400,000
Contingency (at 20% of equipment and installation)			680,000
Total (rounded)			$4,100,000

[a] Provided by Passavant, Inc.
[b] Installation of screens estimated on the basis of a four man crew at one week per screen provided by Passavant, Inc.

Table VII-9. Probable project cost of operation and maintenance centerflow screens

	Annual Cost
Operation	
Power (continuous operation of chain drive)	$12,000
Labor	18,000
Power for backwashing	20,000
Subtotal (rounded)	$50,000
Maintenance	
Replace spray nozzles (once every three years)	1,000
Replace screen cloth (once every ten years)	7,500
Screen assembly removal and inspection (annual)	5,000
Subtotal (rounded)	$14,000
Total (rounded)	$64,000

losses when dilution pumps are not operated, losses due to dilution pump entrainment are eliminated and impingement and entrainment losses are altered since entrained and impinged organisms are exposed to different thermal regimes (undiluted discharge water) when dilution pumps are not operated.

This analysis was done on a monthly basis using estimates of numbers entrained and impinged, and annual mortality rates for entrainment and impingement. Monthly estimates of circulating system entrainment losses and entrainable-size dilution pump entrainment losses are based on the three years of data for which only limited plant outages occurred (1975/76, 1977/78, 1980/81). Dilution pump entrainment losses of impingeable-size organisms are taken from 1984/85 data (the only years in which this data were collected) and impingement losses were based on data from years after Ristroph screens were installed. The annual mortality rates used for entrainment, impingement, and dilution pump entrainment are presented in Table VII-10. Mortality rates for entrainment and impingement when dilution pumps are not operated were set to 1.0.

Losses were greater with dilution pumps operating for all species and lifestages of entrainable-size RIS in every month (Table VII-11). This result occurs primarily because mortality rates for circulating system entrainment are believed to be high, which minimizes or eliminates any benefit of dilution pump operation (i.e., reduced thermal mortality rates). Losses of impingeable-size organisms were generally greater with dilution pumps operating (Table VII-11). Losses of some impingeable-sized organisms were greater with pumps off for a few taxa in a few months. However, for a number of these instances, there were no losses recorded for dilution pump entrainment in that month. With no measured dilution pump entrainment, even a small thermal reduction will appear beneficial. However, even in those months when impingeable size organisms were found to benefit from operation of dilution pumps, the benefit was generally small.

This analysis does not consider the potential benefits of dilution pumps in reducing fish kills. Available data on fish kills were summarized in Table IV-22. These data indicate that November through February (cold shock) and July to August (heat shock) may be time periods of high risk for fish kills. Thus, in these months, there are potentially large benefits from dilution pump operation. However, there appear to be many other months particularly in the spring and fall, when the ecological costs of the dilution pumps outweighs the benefit or potential benefit. If more specific data, as described above are made available, a better estimate of the benefits of reducing dilution pump operation can be obtained.

Table VII-10. Mortality rates used in evaluation of dilution pump operations at Oyster Creek NGS

Species	Lifestage	Entrainable-Size Mortality Rates		
		Pumps On		Pumps Off
		Circulating System	Dilution Pump	Circulating System
Opossum shrimp	juvenile	1.0	1.0	1.0
Sand shrimp	zoea	1.0	1.0	1.0
	juvenile	1.0	1.0	1.0
Blue crab	zoea	1.0	1.0	1.0
	megalopae	1.0	1.0	1.0
Bay anchovy	egg	0.71	0.71	1.0
	larvae	1.0	1.0	1.0
Winter flounder	larvae	0.57	0.57	1.0
		Impingeable-Size Mortality Rates		
		Pumps On		Pumps Off
		Circulating System	Dilution Pump	Circulating System
Sand shrimp		0.50	0.50	1.0
Blue crab		0.13	0.13	1.0
Bay anchovy		0.96	0.96	1.0
Winter flounder		0.23	0.23	1.0
Blue fish		0.20	0.20	1.0
Atlantic menhaden		0.86	0.86	1.0

Table VII-11. Differences in entrainment and impingement losses with and without dilution pumps operating (losses with pumps on minus losses with pumps off). Values in parentheses are negative (i.e., losses were greater with pumps off).

Species	Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Entrainable-Size							
Opossum shrimp	juvenile (10^9)	7.8	6.3	14.2	7.6	11.4	10.2	10.4	6.7	11.6	8.8	7.2	6.4
Sand shrimp	zoea (10^6)	6.4	17.0	161.7	2406.4	2104.3	1540.9	57.4	2.1	0	27.7	23.4	25.5
	juvenile (10^6)	448.0	684.1	502.0	546.5	545.1	156.5	152.5	267.2	39.1	9.4	143.0	550.6
Blue crab	zoea (10^6)	0	0	0	0	0	16.7	0	0	0.3	0	0	0
	megalopae (10^6)	0	0	0	0	0	0	0.3	11.2	36.1	16.5	3.7	0.3
Bay anchovy	egg (10^6)	0	0	0	0	121.7	862.0	762.1	352.4	0	0	0	0
	larvae (10^6)	0	0	0	0	72.5	1553.6	2423.2	2411.9	312.5	13.6	4.5	0
Winter flounder	larvae (10^6)	0.1	29.4	277.7	61.9	0	0	0	0	0	0	0	0
						Impingeable-Size							
Sand shrimp	adult (10^6)	34.7	1.7	12.0	27.4	14.2	1.0	0.6	0.1	0.03	0.01	64.3	20.5
Blue crab	juvenile adult (10^3)	1.0	(4.5)	(51.7)	277.3	251.1	681.5	1204.6	299.2	13.6	(23.9)	1.5	(32.9)
Bay anchovy	juvenile adult (10^6)	0.08	0	0.01	70.8	200.0	24.0	10.6	18.1	12.1	10.2	3.6	0.5
Winter flounder	juvenile (10^3)	7.1	2.9	2.6	14.1	7.1	(0.7)	0.1	0.6	(0.003)	(0.03)	80.3	5.4
Bluefish	juvenile (10^3)	0	0	0	0	410.7	104.6	61.3	10.1	9.7	0.2	(0.2)	0
Atlantic menhaden	juvenile (10^3)	36.2	(0.01)	(0.06)	266.5	149.9	70.0	15.4	2.3	1.1	0.7	127.0	12.0

There are no costs associated with reducing operation of the dilution pumps. Dilution pumps require electricity to operate. Thus, any ecological benefits gained from reduced operation is actually enhanced by reduced costs to GPUN.

E. SELECTION OF BAT FOR THE OYSTER CREEK NGS

Three of the candidate technologies, those having to do with placing screens in front of the dilution pumps, can be eliminated as having costs that are disproportionate with anticipated benefits. Levelized annualized costs for each of these options (Appendix H) exceeds the annual value of all lost resources at the facility (Appendix G). Furthermore, none of these screening options reduces losses at the facility by even 50%. While the test for "not wholly disproportionate" costs is not constrained to a dollar value comparison of costs and benefits, the lack of a long-term impact associated with the facility, and the relatively small benefits that would be derived from these technologies make thier implementation inappropriate.

Fine mesh additions to the existing traveling screens is another technology which can be dismissed. Although costs for this technology are only about 15% of total value of lost resources at the facility, less than 10% of the lost resources would be recovered by application of this technology. While this difference may not be large enough to consider the technology "disproportionate," there are concerns that the technology may lead to collapse of the screen. If NJDEP chooses to pursue this option, site-specific studies to address this possibility are recommended.

The only technology that appears to have benefits that exceed monetary costs is altered operation of the dilution pumps. Entrainment through these pumps accounts for more than half of all lost resources at the facility and reduction in their operation would lessen this impact. While this option has no monetary cost, reduced operation does have the potential to increase thermal mortality for organisms living in the discharge canal or increase latent mortality for organisms entrained through the condenser system. It also has the potential to increase thermal shock during cold weather shutdowns.

While the benefits of lower entrainment from reducing dilution pump operation are likely to exceed the associated mortality from a warmer discharge canal, this result will likely be season specific and may depend on the degree to which dilution pump operations are curtailed (e.g., one or two pumps). A modeling analysis that weighs the relative risks of various

seasonal and operating scenarios would provide a basis for determing how operation of dilution pumps should be altered to reduce total plant-related mortality. Since the specific data necessary to conduct this analysis in a scientifically rigorous fashion was unavailable in the 316 Demonstration, Versar recommends that NJDEP collect this data or require that the utility does so. Versar further recommends that prior to the collection of these data, operation of the dilution pumps not be altered because of the risk of increasing total mortality associated with the facility if done inappropriately.

VIII. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The purpose of this chapter is to integrate the information in preceding chapters and Appendices A-H into a summary of findings and conclusions that will assist NJDEP in:

- Making a final determination on GPUN's request for a §316 variance for the Oyster Creek NGS
- Issuing a NPDES permit for the Oyster Creek NGS that establishes alternate effluent limitations protective of Oyster Creek and Barnegat Bay
- Identifying the best available technology for intake structures at the Oyster Creek NGS.

The impacts resulting from power plant operations at Oyster Creek were assessed using evaluation criteria and decision points identified from the review of previous §316 litigation at other power plants. Compliance with the selected criteria assures protection of living resources, important ecological functions, and beneficial uses of Barnegat Bay. Failure to comply with evaluation criteria indicates that the potential for long-term harm is great and that plant impacts should be reduced.

Major findings of Versar's review and evaluation of the Oyster Creek 316 Demonstration and impact assessment for Oyster Creek were:

- Specific information that was necessary to evaluate the consequences of plant-related losses was not available in the Oyster Creek 316 Demonstration and Versar was required to obtain data from other sources or make corrections to the existing data to make it more appropriate
- The Oyster Creek NGS does not comply with NJDEP's Surface Water Quality Standards for thermal discharges. However, present discharge effects are small and localized and have no adverse consequences to Barneget Bay
- GPUN's estimates of entrainment losses were under-estimated due to sampling inadequacies. As a result, these estimates had to be adjusted for deficiencies before the consequences of power

plant impacts could be determined. We adjusted GPUN's estimates of entrainment loss using information from the scientific literature and our professional judgement.

- GPUN inappropriately estimated or did not estimate the seasonal abundances of the Barnegat Bay RIS fish, invertebrate, and plankton populations at risk. As a result, inappropriate estimates provided by GPUN were adjusted for deficiencies and estimates not provided by GPUN were determined by Versar from available data. We adjusted GPUN population estimates using information from the scientific literature and our professional judgement. We estimated abundance of selected RIS populations based on available density data.

- Continued operation of the Oyster Creek NGS at the estimated levels of losses to RIS populations, without modification to intake structures and/or operating practices, does not threaten the protection and propagation of balanced, indigenous populations.

- As a result of physical alterations performed for construction of Oyster Creek NGS the estuarine portion of Oyster Creek was expanded, a portion of the freshwater stream was replaced by estuarine habitat, and a new segment of aquatic habitat was created as a connection to Forked River. These alterations were a result of construction rather than operation of the facility.

- GPUN did not establish, within the §316 Demonstration, any basis for the downgrading of present water quality standards for Barnegat Bay. In fact, information within the §316 Demonstration clearly suggests that present discharge effects in Oyster Creek and Barnegat Bay would not have occurred if the present thermal water quality standards had been met. As a result, there appears to be no reason to downgrade present water quality standards.

- Entrainment losses through the plant and the dilution pumps are the major impact to be minimized at Oyster Creek NGS. The only technology that appears to have costs not wholly disproportionate to anticipated benefits is modifying the operation schedule of the dilution pumps. Modification of the dilution pump schedule will significantly reduce entrainment losses. However, without further studies, the degree of reduction in entrainment resulting from dilution pump operational changes cannot be accurately compared with the potential increases in thermal mortality.

We recommend that:

- GPUN's request for a §316 variance at Oyster Creek be granted.

- GPUN be required to conduct studies that will define optimum operations schedule for dilution pumps. That is, the operating schedule that will reduce entrainment losses the most relative to potential increases in thermal discharge-related losses. Operation of the dilution pumps should not be altered prior to the collection of these data since there is no basis for recommending any alternate schedule at this time.

- Restrictions on planned outages between December and March currently in place should remain unchanged.

To maximize the usefulness of the dilution pump study, GPUN and New Jersey should work together in the planning and conduct of the study. Versar suggests that a study plan be submitted to NJDEP within 60 days after the effective date of the permit modification so that the plan can then be reviewed and revised before field studies are initiated. The study plan should include sampling throughout a full year as well as plans for interim results to be made available to NJDEP before all analyses and reports are completed. If, as a result of these studies, changes to dilution pump operations are implemented, monitoring programs should also be initiated to assess the effectiveness of the changes.

Based on the findings summarized in this report, balanced indigenous populations of Barnegat Bay are protected under Oyster Creek NGS's current operations (maximum BTU/hr of 5.42×10^9). Therefore, if the designated heat dissipation area was increased to the area currently occupied by Oyster Creek NGS's thermal plume, Barnegat Bay populations would continue to be protected. Versar cannot estimate this larger heat dissipation area under all likely operating and hydrological conditions because GPUN did not provide the necessary information in the 316 Demonstration.

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TECHNICAL REVIEW AND EVALUATION OF THERMAL EFFECTS STUDIES AND COOLING WATER INTAKE STRUCTURE DEMONSTRATION OF IMPACT FOR THE OYSTER CREEK NUCLEAR GENERATING STATION

REVISED FINAL REPORT

VOLUME II - APPENDICES

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PLANT AND ECOSYSTEM CHARACTERISTICS

APPENDIX A. PLANT AND ECOSYSTEM CHARACTERISTICS

A. PLANT CHARACTERISTICS

Power plant characteristics play a major role in the degree to which plant-organism interactions affect populations in the receiving water body. This section summarizes the characteristics of the Oyster Creek Nuclear Generating Station as was mainly obtained from the Oyster Creek § 316 Demonstration documents (Jersey Central Power and Light 1978).

Oyster Creek NGS is located between the South Branch of Forked River and Oyster Creek, two tributaries of Barnegat Bay, New Jersey. Construction of Oyster Creek NGS resulted in the dredging and widening of each of these tributaries as well as the construction of man-made canals from the tributaries to the station. The station withdraws water from an intake canal located in the South Branch of Forked River. The canal is approximately 2,621 m (8,600 ft) long, between 67-85 m (220-280 ft) (67-85 m) wide, and 3 m (10 ft) deep. The discharge canal measures approximately 3,505 m (11,500 ft) in length, between 34-305 m (110-1,000 ft) in width, and 3 m (10 ft) in depth. The intake and discharge canals are separated by a dam. Travel time for a particle of water from Barnegat Bay to intake structures and from discharge structures to Barnegat Bay is 2-4 hours depending on the number of circulating and dilution pumps operating.

Oyster Creek NGS utilizes a boiling water reactor designed to operate at a thermal output of 1,930 megawatts and produce 670 megawatts of electrical power for a power production efficiency of about 35%. The maximum temperature differential between the intake and discharge (ΔT) is about 13°C (23°F).

Water Withdrawal

The Oyster Creek NGS maintains two distinct water withdrawal systems: 1) a standard once-through cooling intake structure which withdraws water for the circulating water system (CWS) used to cool the steam produced as part of electrical generation and a service water system (SWS) used to cool the reactor and related equipment, and 2) a dilution water system (DWS) which is used to decrease the absolute temperature of the discharge canal by dilution with ambient water (Fig. A-1). The DWS is located across the intake canal

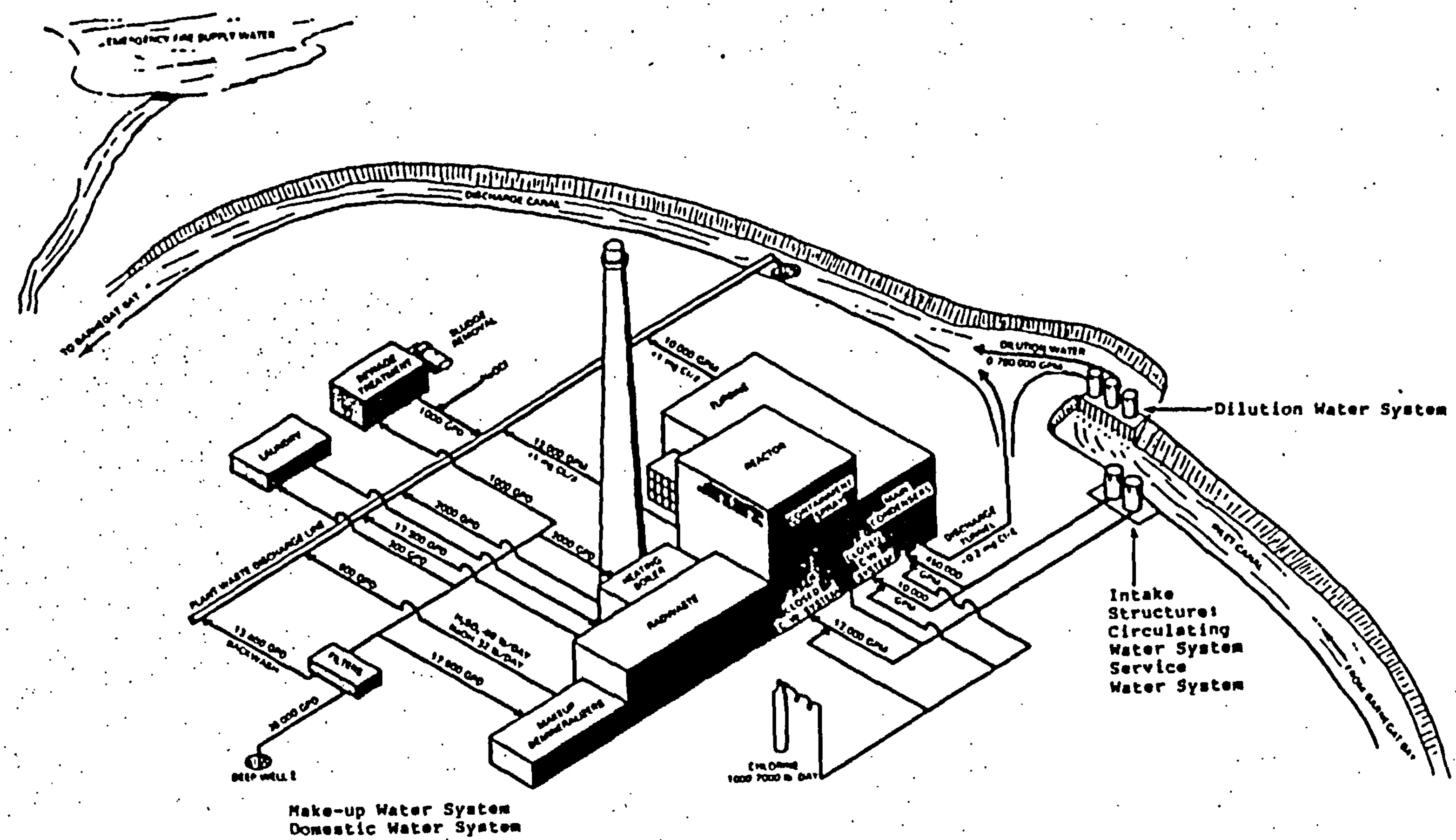

Figure A-1. Oyster Creek NGS water withdrawal systems (from U.S. Atomic Energy Commission 1974)

from the cooling water withdrawal structure. Make-up water for internal plant components (e.g., cooling units) and the domestic water system is drawn from a deep well.

Since the original discharge and intake systems were dredged in 1964-1965, portions of both have been redredged once. In 1979, 53,500-68,808 m^3 (70,000-90.000 yd^3) of sediment were removed from the lower portion of the discharge canal and in 1984 about 22,935 m^3 (30,000 yd^3) of sediment were removed from the lower portions of the intake canal. On both occasions, dredged spoils were placed on property owned by JCP&L.

The cooling water intake structure is divided into two sections or bays, each having two circulating pumps, one large service pump, one small service pump, two emergency service water pumps, and one screen wash pump. Design capacity of each circulating water pump is 7.25 m^3/s [115,000 gpm (Fig. A-2)], and under normal operating conditions the circulating pumps withdraw a total of 29.0 m^3/s (460,000 gpm). Of this total, 28.4 m^3/s (450,000 gpm) is directed to the CWS and 0.6 m^3/s (10,000 gpm) to the SWS. In addition, two large service pumps [design capacity of 0.4 m^3/s (6,000 gpm)] and two smaller service pumps [design capacity of 0.1 m^3/s (2,000 gpm)] also deliver water to the SWS. Two screen wash pumps each with a design capacity of 0.06 m^3/s (900 gpm) are used for washing aquatic life and debris off the traveling screens. Finally, four emergency service water pumps [design capacity of 0.3 m^3/s (4,150 gpm)] are available for emergency operations.

Three dilution pumps [design capacities of 16.4 m^3/s (260,000 gpm) each] provide the water for the DWS. Dilution pumps are low speed (180 rpm) axial flow pumps with 2.1 m (7-ft) diameter impellers to minimize damage to aquatic organisms that are entrained. Under normal operating conditions two pumps are used.

The dam separating the intake and discharge canals forces the flow of the intake canal to pass either through the station condensers or the dilution pumps (see Fig. A-1). The total water withdrawal from the intake canal may be up to 63 m^3/s (about 1,000,000 gpm), depending upon the mode of station operation as outlined in Table A-1. Table A-2 summarizes station water withdrawal characteristics.

The deep well which supplies make-up and domestic water contains one pump [design capacity of 0.03 m^3/s (400 gpm)]. Under normal operation it delivers 37.9-291.5 m^3/day (10,000-77,000 gpd). Of this total, 15.5-53.0 m^3/day (4,100-14,000 gpd) is used for drinking, laundry and other sanitary purposes. The remaining water is used to replenish various plant systems.

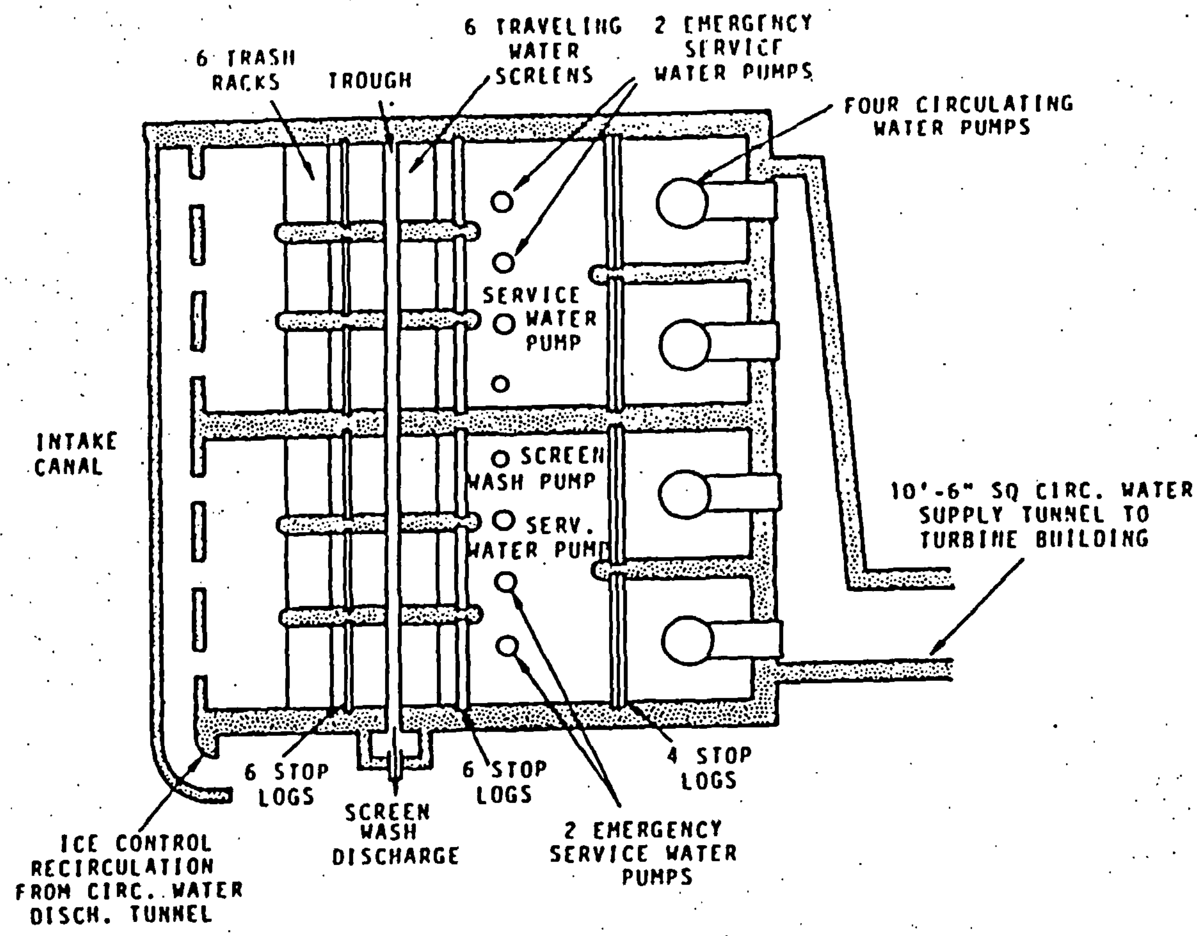

Figure A-2. Oyster Creek NGS intake structure plan (from Jersey Central Power and Light Company 1978)

Table A-1. Intake canal flow rates for various plant operation modes (from Jersey Central Power and Light 1978)

Operating Mode	Intake Canal Flow Rate (m^3/s)	Average Canal Water Velocity (m/s)
1. Oyster Creek NGS operating with two dilution pumps	62.8	0.54
2. Oyster Creek NGS operating with one dilution pump	46.2	0.40
3. Oyster Creek NGS operating with 0 dilution pumps	29.8	0.26

Table A-2. Summary of water use by the Oyster Creek NGS (from Jersey Central Power and Light 1978)

Water Source	Water System	Station Component	Flow Rate
Intake canal	Circulating water system	Main condenser	28.4 m^3/s (450,000 GPM)
	Service water system	Turbine building component cooling	0.6 m^3/s (10,000 GPM)
		Reactor building component cooling	0.8 m^3/s (12,000 GPM)
		Screen wash system	0.1 m^3/s (1,800 GPM)
		Augmented offgas and radwaste component cooling	0.1-0.24 m^3/s (2,000-3,750 GPM)
	Dilution water system	Heat dilution	0-32.8 m^3/s (0-520,000 GPM)
Deep well	Domestic water system	Sanitary use	14.4-17.9 m^3/day (3,800-10,000 GPD)
	Make-up water system	Heating boiler blowdown	0.38 m^3/day (100 GPD)
		Demineralizer rinse	0-37.9 m^3/day (0-10,000 GPD)
		Charcoal filter backwash	0-12/0 m^3/day (0-3,400 GPD)
		Radwaste	0-194.9 m^3/day (0-51,500 GPD)

Ice Barriers and Trash Racks

During winter, water is taken from the discharge tunnel, and released in front of the trash racks to retard icing of intake structures. This flow is about 10% of the main condenser flow, or approximately 3.5 m^3/s (45,000 gpm). Vertical steel bars placed three inches on center are used as trash racks to prevent large organisms and debris from entering the intake structure. Each of the two intake bays are equipped with three trash racks. The dilution water structure also has two trash racks for each of the three pumps. The trash racks are cleaned manually as often as necessary to maintain flow.

Traveling Screens

Between 1969 and 1978, each of the intake bays was equipped with conventional vertical traveling screens with 9.5 mm (3/8 inch) wire mesh screen panels. The screens were automatically rotated every two hours or when the pressure differential across the screen reached a critical level. In 1979, the conventional traveling screens were replaced with Ristroph traveling screens. The Ristroph modification consisted of fitting the base of each screen panel with a water-filled bucket or trough that was 3.8 cm deep (1.5 in) and 5.1 cm wide (2 in) along its base (Fig. A-3). The water filled buckets prevent impinged organisms from falling back into the screen well and becoming reimpinged when screens are rotated and cleaned. The Ristroph screens are rotated at 1.3 cm/s (2.5 fpm) during normal operations. During periods of high impingement the screens may be rotated at 5.1 cm/s (10 fpm). The dilution water system is not equipped with traveling screens.

Water velocities at the cooling water intake structure range between 0.003-0.74 m/s (0.01 and 2.44 ft/s) depending upon location. The average velocity into the plant is about 0.3 m/s (1.0 ft/s) during normal operating conditions (four circulating pumps, two large service water pumps, two screen wash pumps, six screens, and six ports in service).

Screen Wash Return System

Between 1969 and 1978, the conventional traveling screens were rotated and impinged organisms and debris were washed into a sluiceway and released into a thermally impacted region of the discharge canal. In 1977, the fish-return discharge was relocated to an area near the dilution pump that

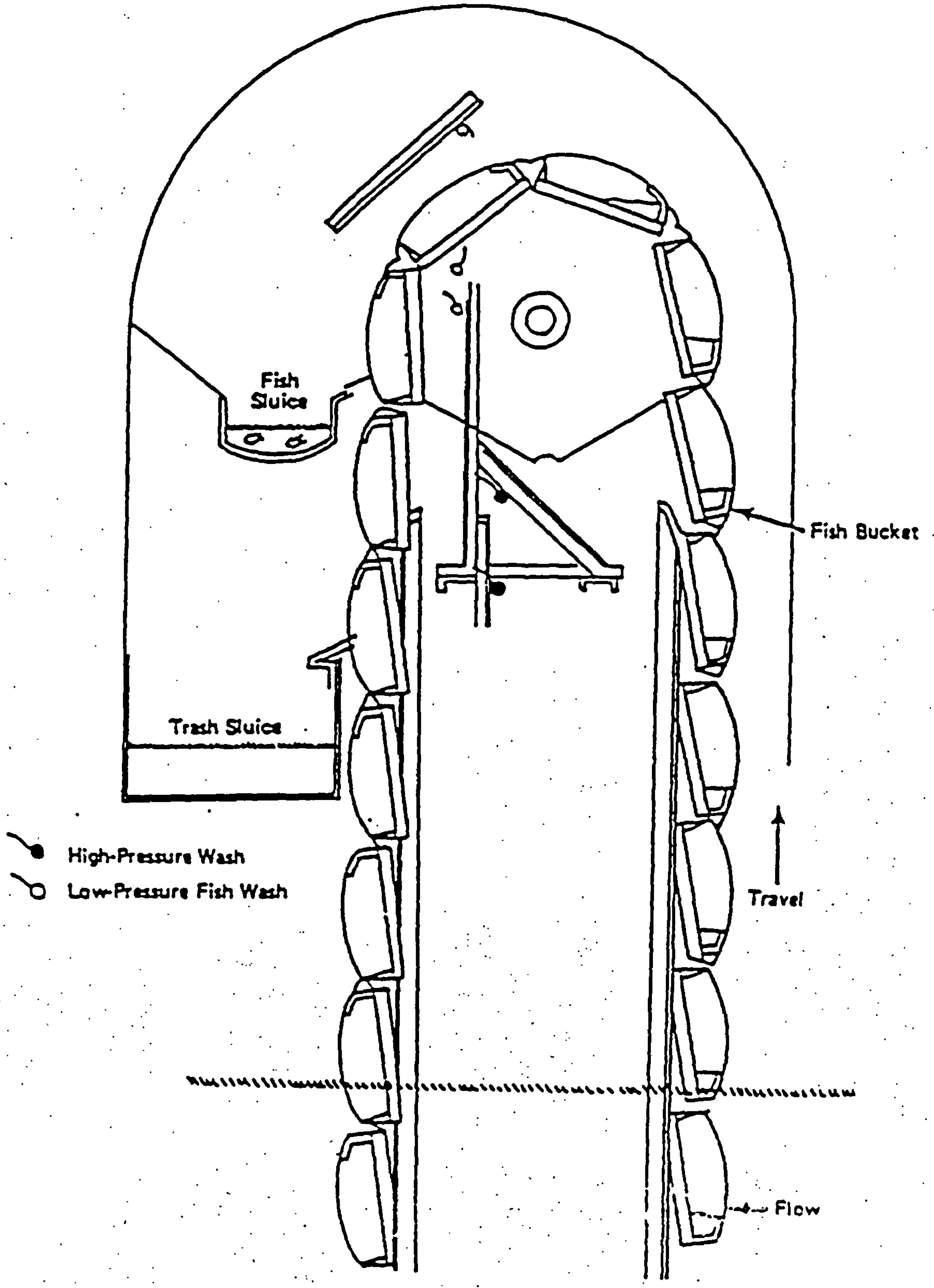

Figure A-3. Schematic of Ristroph type screens used for the circulating water system intake at the Oyster Creek NGS (from Public Services Gas and Electric Company 1984)

is not as impacted by thermal discharges (Fig. A-4). Impinged organisms and debris were washed from the conventional traveling screens by a high pressure spray (70-90 psi). Impinged organisms are washed from the fish buckets of the Ristroph screens by a low pressure (20 psi) spray into an upper sluiceway, and heavier debris is washed from the Ristroph screens into a lower sluiceway by a high pressure (80 psi) spray. The screen wash discharge is a maximum of 0.1 m^3/s (1,800 gpm).

Biofouling Control

Two independent chlorination systems are present at Oyster Creek NGS. Liquid chlorine is injected throughout the year into each of the six circulating water inlet connections to the main condenser and to the service water inlet header six times a day. Each chlorination period is about 20 minutes in duration, and a total of 600-1,200 pounds of chlorine is injected each day. The calculated free available chlorine at the outlet of each condenser section is less than 0.5 mg/l. Chlorine concentration is usually <0.1 mg/l at the point it flows into the canal.

The second chlorination system services the SWS inlet header to the augmented offgas and radioactive waste heat exchangers. This system discharges into the intake canal and is designed to maintain free available chlorine concentration in the system at about 0.2 mg/l. The maximum chlorine concentration in these systems is 0.5 mg/l. The release of chlorine to the intake is limited to two hours per day.

Discharges

There are five discharges from Oyster Creek NGS: the AOG/radioactive waste discharge, the screen wash discharge, the waste water discharge, the dilution water discharge, and the circulating water discharge (Fig. A-5). The AOG/radioactive waste, the screen wash, and the waste water discharges are relatively small, cumulatively amounting to about 1.75 m^3/s (27,743 gpm) or about 3% of the total plant discharge of 63.6 m^3/s (1,075,000 gpm). The AOG/radioactive waste discharge uses a 30.5 cm (12 in) diameter discharge pipe located in the intake canal (approximately 61 m upstream of the intake pump structure) and discharges 0.24 m^3/s (3,750 gpm) of water at maximum discharge temperature of 47.2°C (117°F). The screen wash discharge pipe is 61 cm (24 inches) in diameter, and empties into the discharge canal 9.1 m (30 ft) downstream from the dilution water discharge. Discharge flow from the screen wash discharge is about 0.1 m^3/s (1,800 gpm). The 1.4 m^3/s

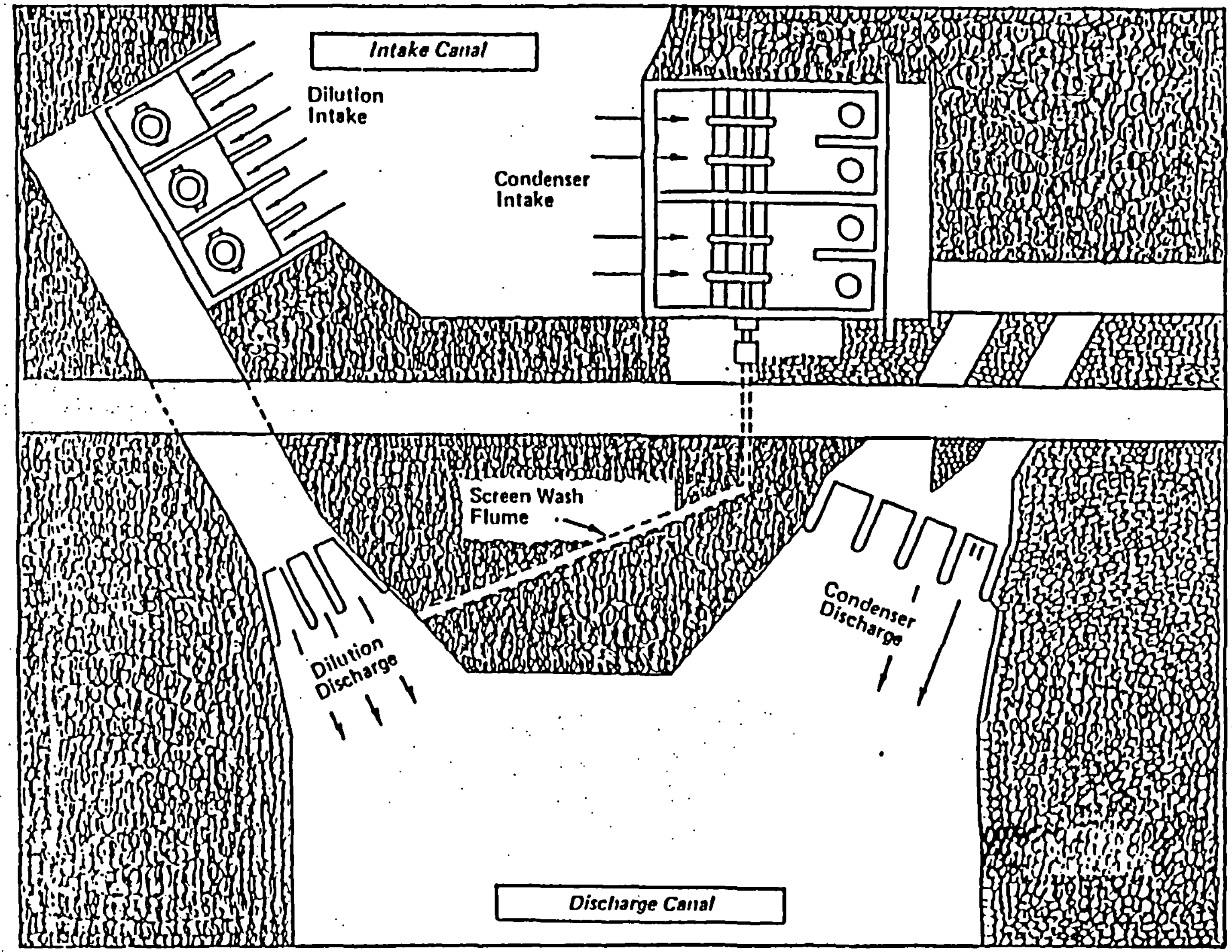

Figure A-4. Location of screen wash discharge after 1977 for the Oyster Creek NGS (from Jersey Central Power and Light Company 1978)

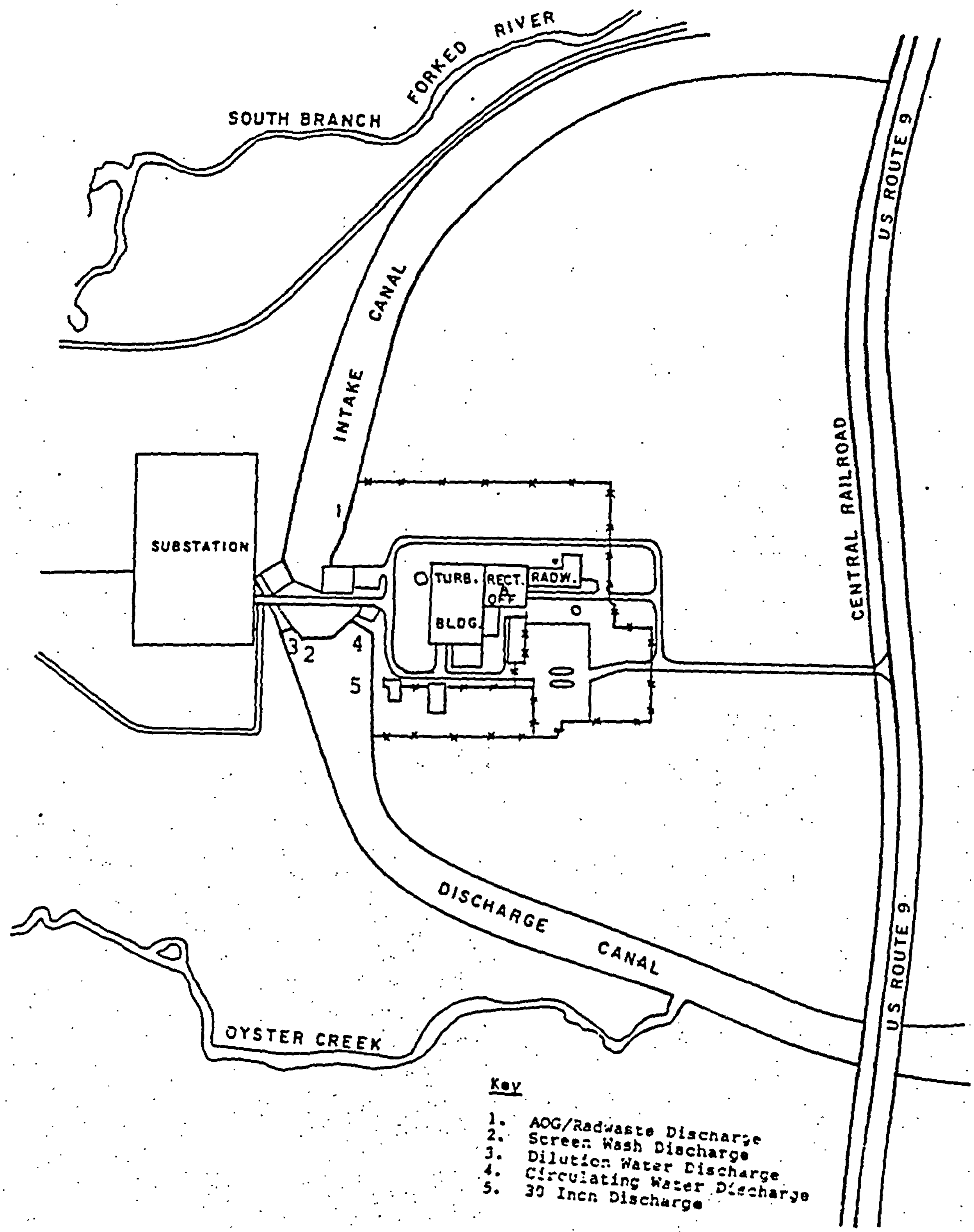

Figure A-5. Locations of discharges for the Oyster Creek NGS (from Jersey Central Power and Light Company 1978)

(22,000 gpm) of waste water discharge consists of cooling water from the reactor and turbine heat exchangers, charcoal filter backwashes, heater boiler blowdown, treated OCNGS sewage (between 1969-1984) and radwastes. It may contain small amounts of sodium, phosphorous, sulfates, chlorides, iron, oil and grease, total suspended solids, and low levels of radioactivity. Prior to discharge, waste water discharges are analyzed to insure that the amount of radioactivity present is within acceptable limits. The wastewater discharge pipe is 76 cm (30 in) in diameter and empties into the discharge canal approximately 76 m downstream of the dilution water discharge. The dilution water discharge is located in the northwest corner of the discharge canal and has a discharge flow rate of up to 32.8 m^3/s (520,000 gpm). The circulating water tunnel is 3.2 m (10.5 ft) in diameter and empties into the northeast corner of the discharge canal. It discharges a maximum of 29.0 m^3/s (460,000 gpm) of heated, chlorinated water.

Station Operation

The single reactor of Oyster Creek NGS began commercial operation in December 1969. Dates of extended outages are presented in Table A-3; net annual power generation between 1978 and 1986 is also included.

B. ECOSYSTEM CHARACTERISTICS OF BARNEGAT BAY

The physical, chemical, and biological characteristics of the water body adjacent to a power generating facility generally play a major role in determining the nature and magnitude of power plant impacts. Human uses of the receiving water body also partly determine the consequences of power plant impacts. The following paragraphs are a summary of important characteristics of the Barnegat Bay estuary that are relevant to assessing the impacts of the Oyster Creek NGS.

Drainage and Basin Morphology

Oyster Creek NGS is located between the South Branch of Forked River and Oyster Creek in Ocean County, New Jersey, approximately 3.2 km (2 miles) inland from Barnegat Bay (Fig. A-6). Barnegat Bay extends roughly north-south, paralleling the mainland, for approximately 48 km (29.8 mi) and ranges from 2 to 6.5 km (1.2-4.0 mi) in width and from 1 to 6 m (3.1-19.7 ft) in depth [average depth is 1.5 m (4.9 ft)]. A narrow

Table A-3. Dates of extended outages at Oyster Creek NGS (1970-1986) and net power generation (1978-1986)

Year	Extended Outage	Net Generation (MWH)
1971	September - November	
1972	May - June	
1973	April - June, September - October	
1974	April - June	
1975	January - May	
1976	January - February	
1977	May - July	
1978	September - December	3,639,771
1979	May - June	4,563,223
1980	January - July	1,942,208
1981	April - May, August - October	2,624,989
1982	January - April	2,002,514
1983/84	February '83 - October '84	205,026 (1983) 277,106 (1984)
1985	February - March, October - November	3,744,664
1986	April - October	1,299,311

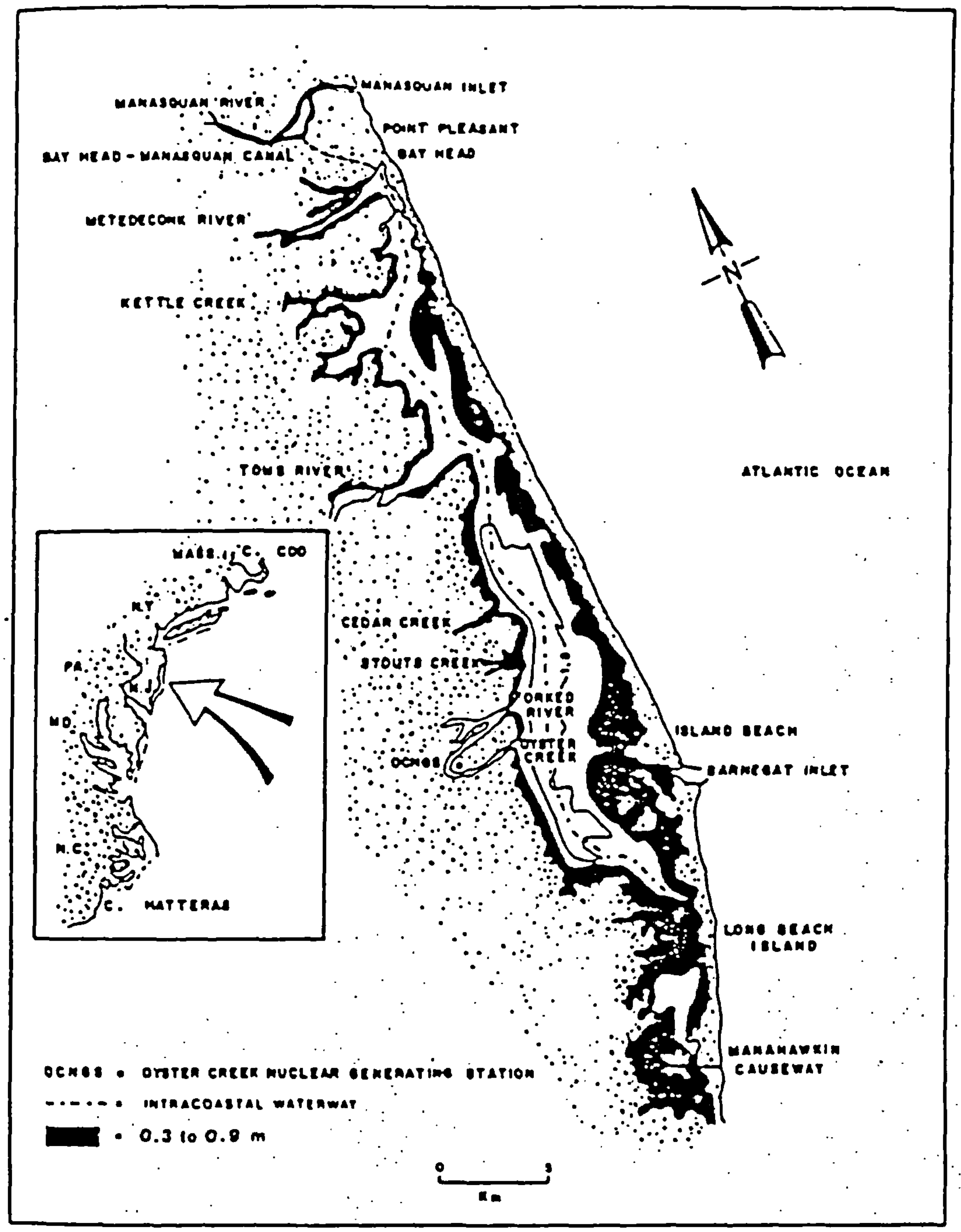

Figure A-6. Bathymetry of Barnegat Bay showing the Intracoastal Water (-•-•-•) (from Chizmadia et al. 1984)

navigational channel (the Intracoastal Waterway) is maintained to a depth of 3-4 m (10-13 ft) for the length of Barnegat Bay by frequent dredging.

Barnegat Bay is a typical lagoon-type estuary associated with a barrier island coastline. It is bordered on the east by Island Beach and Long Beach Island and to the west by the New Jersey mainland. The Island Beach-Long Beach barrier island complex is separated by Barnegat Inlet where the primary exchange between the Atlantic Ocean and Barnegat Bay occurs. The northern reaches of the bay occur at Point Pleasant and Bay Head where Barnegat Bay is connected to the Manasquan River via the Manasquan Canal. To the south, Barnegat Bay ends at the Manahawkin Causeway. The area south of the Manahawkin Causeway is considered to be the northern extension of Little Egg Harbor.

The surface area of Barnegat Bay is estimated to be 1.67 x 10^8 m^2 (1.79 x 10^9 ft^2) and its volume is estimated to be 2.38 x 10^8 m^3 (8.4 x 10^9 ft^3). The estimated exchange rate through Barnegat Inlet is 7% per tide with a net discharge rate of 56.7 m^3/s (898,902 gpm).

Historical Perspective

Prior to the construction of the Oyster Creek NGS the South Branch of the Forked River and Oyster Creek were typical small, spring-fed, cedar-swamp brooks. Oyster Creek was freshwater to at least 762 m (3,500 ft) east of Route 9, and the South Branch of Forked River was tidal freshwater (0.5 ppt) at Route 9. In 1966, the streams were deepened, straightened, and widened by construction of the intake and discharge canals for the Oyster Creek NGS. They have become physical extensions of Barnegat Bay. The intake canal was dredged from the bay along Forked River for about one mile, then up the South Branch to a point just north of the station and east of U.S. Route 9. From that point a man-made canal was extended west and south to the intake structures. The discharge canal was dredged from the bay along Oyster Creek (widening certain areas) to a point approximately 213 m (700 ft) west of U.S. Route 9. From that point a man-made canal was excavated north and west to the discharge structures. The operation of the Oyster Creek facility severely altered the flow of water in the South Branch of Forked River and in Oyster Creek.

A dam was constructed on the South Branch of Forked River west of U.S. Route 9 to prevent intrusion of salt water into the remaining freshwater portions of the river. In addition, Oyster Creek was dammed upstream of the discharge canal to create a pond that could be used to store water for fire fighting purposes.

Freshwater Inflow

The total mean surface water inflow into Barnegat Bay from tributaries draining the New Jersey Pine Barrens is about 10.2 m^3/s. Toms River has the largest freshwater inflow (5.7 m^3/s) and Cedar Creek has the second largest (3.1 m^3/s) (Chizmadia et al. 1984). In combination these two creeks make up about 86% of the net freshwater flow into Barnegat Bay. Oyster Creek and the South Branch of Forked River have flows of 0.7 m^3/sec and 0.1 m^3/s, respectively, or about 8% of the freshwater net flow into Barnegat Bay. The amount of freshwater entering Barnegat Bay from groundwater seepage has not been measured but appears to be a major part of total freshwater inflow as the average bay salinity (25 ppt) is lower than can be expected from the dilution of ocean water by 10 m^3/s of surface water runoff (Chizmadia et al. 1984).

Tidal Flow

Tides in Barnegat Bay are semidiurnal, with a period of 12.7 hours. Tidal flow through Barnegat Inlet is 2.2×10^7 m^3 (7.8×10^8 ft^3). As the tide enters Barnegat Inlet, it is diverted northward to the upper end of the Bay and the southward to Manahawkin Causeway (Chizmadia et al. 1984). The mean tidal range at Barnegat Inlet is 0.95 m (3 ft). The narrowness of Barnegat Inlet and the shallowness of the bay progressively diminish the magnitude of the tide north and south of Barnegat Inlet. At the mouth of Oyster Creek damping has reduced the tidal range to 0.18 m (6.3 in). Tidal range for key locations in Barnegat Bay is shown in Table A-4.

Currents and Circulation Patterns

Circulation patterns throughout Barnegat Bay are dominated by wind velocity and direction. Tidal forces are secondary in importance (Chizmadia et al. 1984). In the summer, wind direction is mainly from the south-southwest causing a general flow of water to the north. In contrast, during the winter, winds are predominately from the west-northwest resulting in an eastward and southward movement of bay water. The circulation pattern for Barnegat Bay is two-layered only in areas deeper than 1.5 m.

Table A-4. Tidal ranges for representative locations in Barnegat Bay (from Jersey Central Power and Light 1978)

	Mean Ranges (meters)
Mantoloking	0.15
Coates Point	0.15
Toms River	0.18
Waretown	0.18
Oyster Creek Channel	0.18
Barnegat Inlet	0.95
Harvey Cedars	0.24

Salinity

Salinity generally ranges from 19 to 30 ppt in the central regions of Barnegat Bay with highest salinities occurring near Barnegat Inlet (Table A-5). A slight increase in salinity occurs north of Toms River as a result of the inflow of high saline water from the Manasquan Canal. Major freshwater inputs occur along the western shore of Barnegat Bay, and result in a mild west-to-east salinity gradient (Chizmadia et al. 1984). Since the operation of Oyster Creek NGS began, salinities in the South Branch of Forked River and Oyster Creek are generally similar to those in the central bay (25 ppt). Salinity distributions in both the South Branch of Forked River and Oyster Creek are vertically homogeneous when the Oyster Creek NGS is pumping water. Bottom salinities in these creeks are, however, slightly higher than surface salinities when the Oyster Creek NGS is not pumping water.

Water Temperature

Because Barnegat Bay is shallow, ambient water temperature responds rapidly to changes in air temperatures. Diurnal fluctuations of 1-2°C (2-4°F) have frequently been observed. Average ambient water temperature ranges from about -1.4°C (29.5°F) in the winter to 28°C (82.4°F) in the summer (Table A-6). Vertical mixing associated with winds prevent vertical temperature stratifications except for the deeper waters of the Intercoastal Waterway.

Dissolved Oxygen Concentration

Barnegat Bay waters are well oxygenated (i.e., they are near saturation levels) throughout the year, and the shallow nature of the Bay results in homogeneous vertical distributions for dissolved oxygen concentration. Between September 1975 and August 1976 dissolved oxygen concentration in the central portion of the Bay ranged from about 6.5 ppm in summer to 12.9 ppm in winter (Table A-7).

Recreational Fisheries

Sport fishing in Barnegat Bay occurs from boats and the shore. Blue crab (*Callinectes sapidus*), bluefish (*Pomatomus saltatrix*), and spot (*Leiostomus xanthurus*) comprise more than 80% of the annual catch (Table A-8). Winter flounder

Table A-5. Mean surface (S) and bottom (B) salinities (ppt) in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976 (from Jersey Central Power and Light Company 1978)

Location (Station No.)		Month: Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of Cedar Creek (1)	S	15.9	16.6	14.5	15.1	12.3	15.4	16.7	17.0	17.1	19.5	23.3	21.4
	B	16.0	17.9	17.3	19.0	17.3	17.8	18.7	18.0	20.0	22.1	25.8	22.6
Mouth of Stouts Creek (2)	S	20.6	20.2	19.1	21.1	19.8	20.7	20.1	21.1	23.2	22.9	27.1	25.1
	B	20.6	21.4	19.2	20.9	20.3	21.0	21.6	21.0	23.4	22.5	27.3	25.7
Barnegat Bay off Forked River (3)	S	23.3	22.0	21.0	22.0	19.0	21.3	22.2	22.2	23.5	24.2	28.2	27.1
	B	24.0	22.0	22.4	22.4	21.3	21.3	22.3	22.2	23.5	23.9	28.1	26.9
Mouth of Forked River (4)	S	22.5	20.6	21.0	21.5	20.1	21.4	21.0	22.3	24.0	24.3	27.7	26.7
	B	22.6	22.0	21.1	22.0	21.9	21.5	21.8	22.5	23.3	24.0	27.6	27.1
Forked River, just east of Rt. 9 bridge (6)	S	20.0	23.0	20.5	21.7	19.9	19.8	21.3	21.8	23.1	23.9	27.2	25.5
	B	21.7	21.2	20.9	21.3	21.2	20.2	22.1	22.0	23.1	23.8	27.2	26.2
Oyster Creek in vicinity of marinas (15)	S	21.1	20.3	20.4	20.1	18.2	19.5	21.5	20.9	22.3	23.4	26.7	26.2
	B	20.6	20.8	20.1	20.8	18.4	19.3	22.3	21.1	22.5	22.9	26.8	26.2
Mouth of Oyster Creek (17)	S	22.0	20.0	20.3	21.8	18.5	20.2	20.2	21.5	23.6	23.3	27.1	26.4
	B	22.0	21.2	20.1	21.7	20.0	21.2	21.0	21.7	23.2	22.6	26.8	25.7
Barnegat Bay off Oyster Creek (19)	S	22.5	22.3	20.8	22.0	18.5	20.6	21.8	21.6	24.0	24.0	27.4	26.0
	B	23.8	22.3	22.0	22.2	18.8	20.9	22.5	22.6	25.1	24.0	27.5	26.5
Barnegat Bay off Waretown (21)	S	24.5	24.3	21.6	22.7	21.0	22.8	24.3	24.3	25.3	25.8	29.0	27.3
	B	25.0	25.1	21.4	23.3	24.0	23.8	24.5	24.5	25.3	24.5	29.0	27.3
Mouth of Double Creek (23)	S	24.0	23.4	22.1	23.5	21.3	23.3	24.6	24.5	24.8	26.8	29.1	27.8
	B	25.0	25.6	21.9	23.1	20.5	23.4	26.4	24.3	25.4	25.8	29.1	28.1
Barnegat Inlet (24)	S	29.5	24.2	27.0	29.3	23.0	22.8	23.3	24.0	25.4	25.6	29.0	26.9
	B	30.0	24.5	27.8	30.0	28.0	24.1	26.0	23.9	25.5	26.3	29.1	27.1

Table A-6. Mean surface (S) and bottom (B) water temperature in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976 (from Jersey Central Power and Light Company 1978)

Location (Station No.)		Month											
		Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of Cedar Creek (1)	S	20.5	16.0	11.8	6.8	1.1	4.9	6.0	12.1	17.5	24.0	24.7	24.3
	B	20.5	16.2	12.0	7.6	1.0	4.3	5.6	11.7	17.0	22.8	24.5	24.3
Mouth of Stouts Creek (2)	S	20.4	15.0	12.3	7.3	0.0	5.1	6.2	12.6	18.2	24.3	24.9	24.8
	B	20.8	15.7	12.2	7.8	0.3	4.3	6.0	11.8	17.3	22.1	24.2	24.6
Barnegat Bay off Forked River (3)	S	20.5	16.5	13.3	8.6	1.0	4.4	7.7	10.4	18.7	23.4	23.6	24.5
	B	20.5	16.7	13.4	8.8	1.0	4.3	7.8	10.7	18.4	21.2	23.6	24.5
Mouth of Forked River (4)	S	19.2	16.7	13.4	6.9	1.2	5.6	8.3	12.3	19.2	24.6	24.1	25.5
	B	20.4	16.3	13.1	6.8	1.3	5.0	7.9	11.7	18.6	21.0	23.9	24.9
Forked River, just east of Rt. 9 bridge (6)	S	20.8	16.5	12.3	8.4	1.3	4.2	5.6	11.4	18.0	22.7	24.3	25.6
	B	20.8	16.7	12.3	8.3	1.1	4.0	5.6	11.7	18.0	20.3	24.1	25.5
Oyster Creek in vicinity of marinas (15)	S	23.4	17.6	15.5	9.5	1.5	4.7	8.5	16.2	23.7	28.7	27.4	29.4
	B	23.4	17.7	15.6	12.5	1.2	4.6	8.4	16.3	23.7	27.7	27.5	29.5
Mouth of Oyster Creek (17)	S	23.0	18.2	16.2	10.2	1.5	5.6	10.4	15.3	23.7	29.3	27.2	29.0
	B	22.1	17.4	16.0	11.3	1.5	5.2	10.3	14.7	23.4	26.5	26.9	29.1
Barnegat Bay off Oyster Creek (19)	S	23.9	16.8	15.4	10.0	1.0	4.8	10.0	12.2	19.8	26.6	25.6	28.0
	B	23.5	16.7	14.1	9.2	1.1	4.8	8.7	12.3	19.6	23.6	25.3	26.8
Barnegat Bay off Waretown (21)	S	21.8	16.1	13.5	7.8	-1.0	4.0	6.8	11.6	18.0	22.9	23.2	25.2
	B	21.1	16.0	13.0	8.0	1.0	3.8	6.9	11.1	17.5	22.9	23.8	25.5
Mouth of Double Creek (23)	S	19.7	17.5	12.7	7.7	1.0	5.5	6.4	13.4	19.0	23.9	25.1	25.6
	B	20.1	16.3	12.6	7.5	1.1	4.7	5.4	12.1	17.4	22.4	25.1	24.4
Barnegat Inlet (24)	S	19.4	15.8	13.9	8.5	1.5	4.1	6.6	9.6	16.1	24.1	22.1	23.6
	B	19.5	15.4	13.8	9.2	1.0	3.7	6.5	10.8	15.9	23.9	22.1	23.5

Table A-7. Mean surface (S) and bottom (B) dissolved oxygen in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976 (from Jersey Central Power and Light Company 1978)

Location (Station No.)		Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
		Month											
Mouth of Cedar Creek (1)	S	8.6	8.6	10.2	10.6	12.9	10.9	10.6	9.1	8.6	8.0	7.9	7.4
	B	9.3	8.6	10.0	10.6	11.8	11.1	10.2	9.3	9.0	7.6	7.5	6.7
Mouth of Stouts Creek (2)	S	8.4	9.1	10.1	10.8	11.0	10.6	10.6	10.0	8.6	7.7	7.8	7.3
	B	8.5	8.8	9.8	10.9	9.7	10.6	10.1	9.7	8.9	7.2	7.2	6.9
Barnegat Bay off Forked River (3)	S	8.8	9.0	10.0	10.3	11.8	11.1	11.1	10.3	8.6	8.8	6.6	7.9
	B	6.8	8.8	9.9	10.0	12.1	11.2	11.1	10.7	8.4	9.2	7.2	7.9
Mouth of Forked River (4)	S	9.3	9.5	9.7	10.1	11.7	11.0	10.9	10.4	8.8	8.4	7.7	7.6
	B	7.6	8.0	9.9	10.3	11.5	11.1	11.0	10.3	8.8	9.2	7.3	7.8
Forked River, just east of Rt. 9 bridge (6)	S	6.8	8.5	9.6	10.4	10.4	11.0	11.4	10.4	8.2	7.3	6.8	7.0
	B	6.5	8.3	9.7	10.2	11.2	11.8	11.2	10.4	8.3	8.3	6.8	6.9
Oyster Creek in vicinity of marinas (15)	S	8.4	8.7	9.6	10.5	11.7	11.1	11.1	10.4	8.6	8.4	7.2	6.7
	B	7.7	8.4	9.7	9.4	11.6	11.2	11.0	10.3	8.4	8.7	7.1	6.5
Mouth of Oyster Creek (17)	S	8.2	8.9	9.5	9.8	12.1	11.1	10.4	9.7	8.5	8.4	7.4	7.5
	B	8.4	8.5	9.7	9.9	11.3	11.2	10.5	9.6	8.3	8.9	6.7	7.3
Barnegat Bay off Oyster Creek (19)	S	7.3	8.7	9.8	10.2	12.1	11.0	10.8	10.5	8.2	8.7	7.0	7.2
	B	7.1	8.5	9.8	10.1	11.9	11.1	11.0	10.0	8.0	9.3	7.0	7.0
Barnegat Bay off Waretown (21)	S	8.9	9.8	9.8	11.2	7.4	9.9	10.5	10.5	8.8	6.7	7.7	7.9
	B	8.4	9.4	9.8	10.9	7.3	10.1	10.4	10.5	8.9	6.6	7.6	7.8
Mouth of Double Creek (23)	S	7.8	9.1	9.9	11.1	11.6	10.2	10.7	8.8	9.2	8.3	8.4	8.1
	B	8.5	9.0	10.0	10.8	9.5	10.1	10.5	9.2	9.5	7.6	7.6	7.8
Barnegat Inlet (24)	S	8.3	10.7	9.6	10.2	10.3	10.2	10.8	10.6	9.3	7.3	7.3	8.4
	B	8.3	10.6	9.5	10.0	10.5	10.6	10.7	10.4	9.3	7.5	7.4	8.1

(Pseudopleuronectes americanus), summer flounder (Paralichthys dentatus), and weakfish (Cynoscion regalis) are also caught but to a lesser extent (Hillman and Kennish 1984). The thermal discharges from Oyster Creek NGS result in the extension of the fishing season in Oyster Creek from 8 months of the year to 10 months, and as a result, shore fishermen can frequently be found along the banks of Oyster Creek. A large portion of the Barnegat Bay recreational fisheries harvest comes from Oyster Creek (Table A-8). The area between Toms River and Barnegat Inlet experiences the greatest activity of boat fishermen, and is a popular fishing ground for weakfish and summer flounder.

Commercial Fisheries

Five species of finfish and shellfish dominate the commercial landings in Barnegat Bay: American eel, winter flounder, white perch, blue crab, and hard clam. Commercial landings data for Ocean County, New Jersey are presented in Table A-9. The relative contribution of Barnegat Bay to the Ocean County landings are: American eel, 46%; winter flounder, 30-63%; white perch, 98-100%; blue crab, 100%; and hard clam, 30-36%. The Ocean County landings of bluefish, weakfish, and summer flounder are mainly taken from areas outside Barnegat Bay. In the early 1980s, there were about 37 fulltime commercial fishermen in Barnegat Bay consisting of three eel potters, five fyke netters, 19 crabbers, and 10 clam wholesalers (Hillman and Kennish 1984).

Table A-8. Recreational landings (numbers of individuals-#) of selected species in western Barnegat Bay, Forked River, and Oyster Creek (after Hillman and Kennish 1984)

Species	Western Barnegat Bay 1975-1976 (No.)	Western Barnegat Bay 1976-1977 (No.)	Forked River 1975-1976 (No.)	Forked River 1976-1977 (No.)	Oyster Creek 1975-1976 (No.)	Oyster Creek 1976-1977 (No.)	Total Catch 1975-1976 (No.)	Total Catch 1976-1977 (No.)
Blue crab	1,989	886	416	207	2,039	699	4,374	1,792
Bluefish	109	112	109	149	425	308	643	569
Spot	38	58	9	-	26	115	73	173
Winter flounder	24	3	5	10	-	79	29	92
American eel	3	12	-	9	-	5	3	26
Summer flounder	-	2	-	-	2	9	2	11
Weakfish	9	-	-	-	-	-	9	-

Table A-9. Commercial landings (kg) and value ($) of finfish and shellfish for Ocean County, New Jersey (from U.S. Department of Commerce 1977-1981)

Species	1977-1978 Weight (kg)	1977-1978 Value ($)	1979-1980 Weight (kg)	1979-1980 Value ($)	1980-1981 Weight (kg)	1980-1981 Value ($)
Bluefish	209,513	82,187	321,834	151,321	245,935	174,882
American eel	15,868	14,230	15,434	20,896	12,409	19,586
Winter flounder	30,122	13,403	23,011	16,713	28,931	16,787
Summer flounder	611,079	945,306	440,332	721,766	417,622	717,799
Weakfish	111,470	61,958	219,787	149,932	231,146	208,649
White perch	4,914	3,311	1,312	932	924	947
Blue crab	14,152	11,960	181,692	160,247	122,223	97,833
Hard clam (meats)	228,396	714,813	257,279	1,145,638	219,274	1,020,020

APPENDIX B

REVIEW OF RELEVANT LITIGATION UNDER § 316 OF THE CWA

APPENDIX B. REVIEW OF RELEVANT LITIGATION UNDER § 316 OF THE CWA

This appendix is a review and summarization of litigation and administrative decisions involving § 316(a) and § 316(b) of the CWA. Three sources of precedents were used: 1) federal court decisions; 2) EPA decisions, several of which are based upon adjudicatory hearings; and 3) EPA Office of General Counsel (OGC) Opinions. The latter were provided in the context of adjudicatory proceedings conducted by EPA. Decisions involving contested issues were used to the maximum extent possible because such decisions generally result in the development of complete administrative records; therefore, they have greater precedential and persuasive value. Determinations which are the result of negotiated settlements provide less reliable guidance because they reflect compromise. Furthermore, uncontested decisions generally treat issues superficially and provide less complete and useful administrative records.

A. SUMMARY OF MAJOR § 316 COURT DECISIONS

1. Appalachian Power Co. v. Train, 545 F.2d 1351 (4th Cir., 1976)

Issue

The issue in this case was whether compliance with "existing water quality standards" demonstrates compliance with § 316(a).

Facts

Appalachian Power Company challenged EPA regulations establishing limitations on the discharge of heat from steam electric generating plants, including EPA's § 316(a) regulations.

Holding

EPA's § 316(a) regulations were upheld. The Court also concluded that compliance with "existing water quality standards" did not automatically satisfy the requirements of § 316(a).

Relevant Discussion

- Water Quality Standards

  The court concluded that compliance with state water quality standards did not in and of itself constitute a showing of compliance with the requirements of § 316(a). Section 316(a) requires consideration of site-specific criteria, while water quality standards are applicable to relatively large segments of waterways.

- Thermal Effluent Limitations

  This decision invalidated EPA's technology-based thermal effluent limitations. Because EPA has never promulgated new regulations, technology-based thermal effluent limitations are established on a case-by-case basis for power generating facilities.

- Existing Pollution

  This case also concluded that EPA may not relax standards for a power generating facility on the basis that the receiving waters are already heavily polluted.

- Monetary Value of Environmental Benefits

  The court rejected industry's contention that, in establishing BAT for thermal discharges under § 301, EPA must quantify the environmental benefits in monetary terms. However, the record must contain a statement of the environmental benefits expected from the technology chosen.

2. U.S. Steel Corp. v. Train, 556 F.2d 822 (7th Cir., 1977)

Issues

The issues in this case were:

- Whether the § 316(a) process is the sole method by which a permittee may obtain relief from thermal limitations
- Whether an NPDES permit may require monitoring of the impacts of the cooling water intake.

Facts

U.S. Steel applied for an NPDES permit for its Gary Works plant. EPA issued a permit. U.S. Steel challenged the conditions imposed in the permit. This action is an appeal from the District Court's dismissal of the company's complaint which was filed while the administrative proceeding was in progress. The company sought review of the Administrative Law Judge's (ALJ) refusal to consider certain issues in the proceeding.

Holding

The major holding in the case was that the question of whether a § 316(a) Demonstration is the appropriate mechanism for obtaining relief from thermal limitations must be addressed by Congress. In addition, the court concluded that the § 316(b) Demonstration is a part of the NPDES permit process, and the Administrator may require the monitoring of intake structures as a condition of NPDES permits.

Relevant Discussion

- Establishment of Thermal Limitations Under § 316(a)

  The Court concluded that it was not within its province to review the appropriateness of § 316(a) as the sole method by which an applicant may seek relief from thermal limitations. Only Congress may address whether the § 316(a) process is appropriate.

- Monitoring Requirements Under § 316(b)

  Section 402(a) implicitly requires the Administrator (or appropriate regulatory authority) to ensure that compliance with § 316(b) exists as one of the NPDES permit conditions. Furthermore, § 402 and § 308 allow the Administrator "broad authority" to require monitoring to assure compliance with NPDES permits. Therefore, the Administrator may require the monitoring of intake structures as a condition of NPDES permits. On this basis, inclusion of thermal limitations in an NPDES permit is acceptable. Even though thermal monitoring required to determine compliance is imprecise, no better alternative exists.

3. Virginia Electric v. Costle, 556 F.2d 446 (4th Cir., 1977)

Issue

The major issue in this case was whether United States District Courts have jurisdiction over challenges to § 316(b) regulations.

Facts

The Virginia Electric Power Company filed a petition for review of EPA regulations implementing § 316(b) in Federal District Court. The District Court held it lacked jurisdiction over such matters pursuant to § 509 of the CWA.

Holding

The major holding of this decision is the review of an Administrator's actions promulgating effluent limitations or "other limitations" under § 316(b) is to be addressed in the Federal Court of Appeals.

Relevant Discussion

Section 509 of the CWA gives the Federal Court of Appeals jurisdiction over certain actions taken by EPA, including the issuance or denial of NPDES permits.

Comment

A NJDEP action modifying a power plant discharge permit would not be reviewable in the Federal Court of Appeals unless EPA vetoes or modifies the actions required by NJDEP. In the absence of a veto by EPA, NJDEP permit actions are reviewed in New Jersey state courts.

4. Appalachian Power Co. v. Train, 566 F.2d 451 (4th Cir., 1977)

Issue

The issue in this decision was whether a document (i.e., federal guidelines) referred to in EPA's § 316(b) regulations could be used in determining best available technology.

Facts

Appalachian Power Company filed an action challenging the requirement in EPA's § 316(b) regulations that information in a document, which had not been adopted as a regulation, must be considered when determining the best available technology for intake structures.

Holding

The § 316(b) regulations were set aside.

Relevant Discussion

EPA's original § 316(b) regulations provided that in order to determine the "best available technology" for intake structures "the information in the Development Document shall be considered." The Court found that this provision violated the federal Administrative Procedure Act (APA) because the Development Document was never incorporated into the Federal Register and, therefore, applicants did not receive legal notice of the requirements and information it contained. Until the Development Document is properly incorporated into the § 316(b) regulations, the regulations are set aside. EPA has never promulgated new § 316(b) regulations and has not incorporated the Development Document into the Federal Register.

5. Weyerhaeuser v. Costle, 590 F.2d 1011 (D.C. Cir., 1978)

Issue

The issue in this case was whether the CWA allows the consideration of receiving water assimilative capacity in establishing effluent limitations.

Facts

Weyerhaeuser challenged effluent limitations imposed by EPA in its NPDES permit and the standards for modifications of requirements for control of pollutants that was required under § 301(c) and § 304.

Holding

Paper mills are point sources and require NPDES permits. As such, they must show that "fundamentally different" factors apply to their plants in order to receive a variance under § 301(c).

Relevant Discussion

This case touches only briefly upon the subject of § 316(a) and thermal discharges. The court did note, however, that only in a § 316(a) determination "is receiving water capacity [for pollutants] to be considered in relaxing standards." In granting a § 301(c) variance, an agency may only consider technology based limitations and may not look to the quality of the receiving waters or receiving water pollution assimilation capacity as the means of controlling pollutant inputs.

6. Seacoast Anti-Pollution League v. Costle, 572 F.2d 872 (1st Cir., 1978)

Issue

The major issue in this decision was whether, following an adjudicatory hearing, EPA may consider evidence which was provided after the conclusion of the hearing in reaching a final decision.

Facts

The utility applied for a § 316(a) variance and a decision under § 316(b). The Administrator (Costle) found that the applicant had "met its burden under § 316." This decision was challenged on the basis that the EPA Administrator had considered extrinsic evidence provided after the adjudicatory hearing was concluded in reaching his decision.

Holding

The decision was remanded to the Administrator for either a hearing on the "new" evidence or a "new" decision independent of evidence which was submitted after conclusion of the hearing.

Relevant Discussion

- Opportunity for a Public Hearing

  Section 316(a) requires an opportunity for a public hearing. The court did not believe that submission of documents constituted a public hearing. In addition, the court concluded that the Administrator may not gather a portion of the evidence at the public hearing and take the rest in written form following the hearing. All major issues should be defined before a public hearing is held; otherwise additional hearings may be required.

- Consideration of Evidence Not in the Record

  In issuing a § 316 decision, the appropriate regulatory authority may rely on testimony from experts presented in the public hearing in coming to a decision. However, these experts may not supply additional evidence separate from the hearing upon which the Administrator bases a portion of his decision. The Administrative Procedure Act 5 U.S.C. § 556(e) limits the record for decision to that created during the hearing process.

- Necessity for an Administrative Record

  The court found "The § 316 determination is reviewable [at the circuit court level] under § 509(b) (1)(D)... "Certainly that is an indication that the agency must be careful to provide some basis [record] for appellate court review." The decision went on to say that if Congress provided for judicial review in the Act, Congress then intended that the judicial review should be based on an accurate and complete record.

B. SUMMARY OF MAJOR § 316 ADMINISTRATIVE DECISIONS

Unless specifically noted below, the following decisions involve determination of whether a utility has demonstrated

that alternate thermal limitations satisfy § 316(a) and whether intake structures reflect the "best technology available for minimizing adverse impacts" under § 316(b).

1. Pilgrim Power Plant, Units 1 and 2, Boston Edison Co., Plymouth, MA (1977)

Facts

The Pilgrim facility uses a once-through cooling system. The applicant requested a variance under § 316(a) and a determination under § 316(b) for best available intake technology for intake structures. This was not a contested decision; however, the administrative record provides a compendium of information on factors (e.g., evaluation criteria and decision points) to be considered for § 316 Demonstration decisions.

Holding

The § 316(a) waiver was granted and the water intake structure was found to be the "best technology available" under § 316(b).

Relevant Discussion

- Information to be Supplied by Applicant

  The Administrator concluded the applicant must provide the "best information reasonably available". He further stated, "Ideally, this information would enable the applicant to project in both absolute and relative terms the species adversely affected so that the impact on the relevant population can be estimated with some degree of confidence." The decision went on to point out that in a § 316(a) Demonstration, the applicant must present all relevant and reasonably obtainable data, account for any significant deficiencies, utilize available predictive methodologies effectively, and provide a reasonable basis for evaluating biological impacts. If "substantial uncertainty" exists as to the extent of harm due to insufficient information, then the applicant failed to demonstrate that less stringent thermal standards would protect the biota in the receiving water body. The decision also indicated that in

the case of a § 316(b) determination, "EPA must assess the level of environmental impact caused by [the] intake structure, estimate its magnitude, identify the best technologies available to minimize the impact, and review the cost of such measures to assure that it is not wholly out of proportion to the protection achieved." Data and information on which EPA bases its decision may (but need not) be provided by the utility for the purposes of demonstrating a less-stringent or less-costly technology applies.

- <u>Factors to be considered for a § 316(a) Determination</u>

  The Administrator concluded an applicant may employ one of three different methods to show that less stringent limitations will meet § 316(a) requirements: 1) absence of prior appreciable harm; 2) demonstration that Representative Important Species (RIS) are protected; and 3) submission of biological, engineering and other data which satisfy § 316(a) requirements. The Administrator indicated that in a § 316(a) determination, the major adverse impacts to be considered include: 1) a decrease in abundance of threatened or endangered species; 2) an increase in abundance of nuisance species; 3) a decrease in abundance of indigenous species; 4) damage to critical aquatic organisms, such as important elements of the food chain or damage to basic ecosystem processes; 5) a change in population composition; and 6) a decrease in commercial or sport fisheries. The decision further indicated all adverse impacts on individual species, including the sublethal and "indirect" impacts of the thermal discharge as well as entrainment and impingement impacts on spawning and nursery areas, must be considered when making a § 316(a) determination. (The degree to which entrainment and impingement are used in the evaluation is not rigorously defined.) "Indirect" effects of the thermal discharge considered by the Administrator included such factors as: adverse impacts on early life stages that can alter the adult population; increases in predator species; cold shock; and gas bubble disease.

- <u>Factors to be considered for a § 316(b) Determination</u>

  The Administrator indicated that a § 316(b) determination requires a look at the six adverse impacts listed above for § 316(a) but only as they are related to entrainment and impingement losses. The decision went on to note that the evidence provided by 316(b) applicants should include: 1) identification of major aquatic species in the source water, including estimates of population

density for each species identified; 2) disclosure of the temporal and spatial distribution of the identified species; 3) data on source water temperature for a full year; 4) documentation of fish swimming capabilities for the species identified under conditions simulating those at the intake; and 5) description of the intake location with respect to the seasonal and diurnal spatial distribution of the identified species.

Cost-Benefit Considerations Under § 316(b)

This Pilgrim case indicates that § 316(b) only requires that adverse impact be minimized, not eliminated. The costs of alternative technology required to minimize entrainment and impingement impacts must be considered to assure they are not "wholly disproportionate" to the environmental impact being reduced.

- Resolution for Pilgrim Units 1 and 2

The Administrator found the impact of Pilgrim to be "minimal in comparison to the species population in the area of impact." The decision concluded that the only species significantly affected was the winter flounder whose population size was projected to drop by about 5.9% over a 40 year period. Although the Administrator found that the negative impact of the intake structure could be minimized, the decision concluded "such minimization would not justify the substantial added cost of the alternatives."

- Subsequent Actions

The Plymouth County Nuclear Information Committee and an individual filed a petition for review of the Administrator's decision in August 1978. This request for a review was denied because "A petition for review is not normally accepted unless the Regional Administrator's Initial Decision is clearly erroneous or involves an exercise of decision or policy which is important and should be reviewed as a discretionary manner."

2. In Re Public Service Co. of New Hampshire, 10 E.R.C. 1257 (1977)

Facts

The Public Service Company of New Hampshire applied for a § 316(a) variance for the proposed Seabrook station, units 1 and 2. EPA made a § 316(a) determination which set less

stringent effluent limitations and allowed once-through cooling. Environmental groups requested an adjudicatory hearing on the decision and challenged the proposed variance as well as the technology and location of the cooling water intake structures. As a result of the challenge, the Administrator revoked the variance and set more stringent effluent limitations that indirectly required closed-cycle cooling. The utility appealed the Administrator's decision. The discussions below detail the result of the utility's appeal of the Administrator's decision.

Holding

The initial determination of EPA was reinstated, and the § 316(a) variance was granted.

Relevant Discussion

- Burden of Proof Under § 316(a)

  This decision indicates that § 316(a) requires that the applicant "demonstrate" entitlement to a variance. Hence, the burden of proof for § 316(a) rests with the applicant.

- Standard of Proof Under § 316(a)

  This decision indicates that in order to reach a § 316(a) decision, the applicant must provide an "interpretive, comprehensive, narrative [original emphasis] summary of the [§ 316(a)] demonstration." The information supplied must be "adequate" to provide "an evidentiary showing needed to make a reasoned decision." The information presented by the applicant, however, does not necessitate data for plant effects on the entire ecosystem. Overall effects on one species can be inferred from studies on selected Representative Important Species (RIS). Data on all RIS need not be supplied if inferences can be drawn about others from the ones studied. Expensive studies that yield only minimal information are not required. The standard for evidence suggested by this decision is "the best information reasonably obtainable".

- Definition of Receiving Waters Under § 316(a)

  This decision indicates that in determining what constitutes receiving waters, "the portion chosen is necessarily arbitrary to some extent...[if] there are

no obvious physical boundaries." It may be necessary to look to that portion of coastal waters "where human use or enjoyment of the marine resources may be affected." This means that if the human use of marine resources is limited to only part of a larger body of water that would be impacted, it is appropriate to determine compliance with § 316(a) in the context of the localized area where human use is important.

- Evaluation of Entrainment and Impingement Impacts Under § 316(a)

  This decision indicates that in reaching a decision regarding whether to grant a variance under § 316(a), it is imperative that the applicant and EPA evaluate "all stresses on the environment" (including entrainment and impingement losses), and not just the harmful effects of thermal effluents. Hence, a § 316(a) determination must take into account entrainment and impingement impacts, even though these impacts are the effects of intake technology specifically addressed under § 316(b). Because of this interrelationship between § 316(a) and § 316(b) it is frequently cost effective and reasonable to make the decisions concurrently.

- Best Technology Available Under § 316(b)

  The determination of "best technology available" does not require a formal cost/benefit analysis. In determining the "best technology available," the cost of the technology should be taken into account to ensure that it is not "wholly disproportionate to the environmental benefit to be gained." This determination is made on a case-by-case basis.

- Requirement of Cooling Towers Under § 316(b)

  The Administrator concluded it was against EPA policy to require cooling towers *per se*; however, EPA may set limitations on intake capacity that would indirectly necessitate cooling towers.

- Capacity Under § 316(b)

  The Administrator concluded that the "capacity" referred to in the language of § 316(b) refers to the volume of intake flows and not to the size (dimensions) of the intake structure.

3. Brunswick Steam Plant, Carolina Power & Light Co., Wilmington, N.C (1977).

Facts

The Brunswick plant is located on the Cape Fear River near Wilmington, N.C. It consists of two boiling water reactor units and uses a once-through cooling system. Considerable concerns were expressed by the public and resource management agencies over the impacts of Brunswick on the biotic resources of the receiving water body. Major concerns were due to the operation of the once-through cooling system on the many "important" species inhabiting the affected waters. The applicant requested an NPDES permit that allowed once-through cooling until closed-cycle units were constructed. The NPDES permit issued by EPA required closed-cycle cooling. The utility requested an adjudicatory hearing to contest the terms of the NPDES permit. A stay was placed on the construction of the cooling towers until the adjudicatory process was completed and its outcome known.

Holding

The Administrator held that any delay in restricting the intake capacity of the Brunswick plant would cause significant harm to the environment. The decision also found that the "best technology available" to minimize the adverse environmental impacts was to restrict the capacity of the intake structure. Finally, the decision concluded that the data available were adequate to make this conclusion and that the hearing would not be reopened at a later date after additional data were collected. The Brunswick decision did not specify a particular technology to limit intake. The Decision of the General Counsel #41 discussed below provides additional detail on the reasons for this conclusion.

Relevant Discussion

- Evaluation of Entrainment and Impingement Effects under § 316(a)

  The Administrator concluded that for a § 316(a) Demonstration the applicant must take into account "all relevant stresses" on the ecosystem including assurance that: 1) all fish populations adversely affected are considered; 2) intake and discharge structures do not

impact on the ecosystems in which they are located; and 3) all elements of the aquatic ecosystem necessary to support a balanced population are not adversely affected. Hence, a § 316(a) determination should take into account adverse effects of impingement and entrainment, even though these impacts are also considered under § 316(b). However, the outcome of a § 316(a) decision should not dictate the result of a § 316(b) determination [e.g., granting a § 316(a) variance does not mean that BAT may not be required under § 316(b)].

- Definition of Adverse Impacts

  "Adverse" was held in the Brunswick decision to the more stringent standard of "harmful" and did not mean "irreversible." Adverse effects are to be minimized under § 316(b).

- Best Technology Available under § 316(b)

  The Brunswick decision suggests two inquiries are relevant in making a § 316(b) determination: 1) is there an adverse impact, and 2) if so, do the existing or proposed modifications to existing control technology reflect the "best available technology" for minimizing the adverse impact? The Administrator also indicated in the Brunswick decision that the "best available technology" contemplates the "best technology currently available at an economically practicable (original emphasis) cost." This, however, does not indicate that the applicant or EPA should or must enter into a cost-benefit analysis. Rather, "practicable" goes to an *ad hoc* consideration of the degree of minimization realized in relation to the financial burden imposed.

Final Resolution

Findings of the Brunswick decision were appealed by the utility and subsequently settled by a negotiated compromise. Under the compromise, the utility was required 1) to reduce intake flows during part of the year, 2) to construct a barrier system to reduce impacts associated with intake structures, and 3) to provide an improved system for returning fish removed from intake screens to the receiving water body. Cooling towers were not constructed.

4. Anclote Plant, Units 1 and 2, Florida Power Corporation (1978).

Facts

The Anclote electric generating station is located immediately north of the Anclote River in southwestern Florida. At the time of the hearing, the facility consisted of one once-through cooling system rated at 515 MWe that used dilution assistance (i.e., reduced the absolute temperature of discharge water by diluting it with pumped water that did not pass through the condensers). A second 515 MWe dilution-assisted generating unit was expected to be ready for commercial use in the future. The NPDES permit application covered both units.

Holding

The § 316(a) variance was denied, and the water intake structure was determined not to represent the "best technology available" under § 316(b). The basis for the denial that was the applicant failed to submit complete and scientifically reliable data.

Relevant Discussion

EPA concluded that projections of impact presented by the applicant were erroneous and founded on "untrue" assumptions. A major omission of the utility's demonstration was that the "vital information" concerning power plant impacts on sea grasses, which were the major primary producers in the area and important habitat formers essential to the maintenance of balanced, indigenous populations in the receiving waters was not included. Similar flaws were found in the discussions of impingement and entrainment effects, thermal discharge data, and information on impacts to animal life. EPA concluded the applicant had "failed to sustain its affirmative burden" to demonstrate that "current operation will assure the protection of a balanced, indigenous population" under § 316(a). EPA used that information supplied by the applicant that was reliable to conclude that a large negative impact occurred. On the basis of their analysis, EPA concluded the effluent limitations proposed were not "more stringent than necessary" to protect the receiving waters, and the water intake structure was not the "best technology available" under § 316(b).

Final Resolution

As a result of the above decision, EPA entered in negotiations with the utility in an attempt to resolve major issues that had been identified. The final resolution required the utility to install supplemental cooling towers at Anclote. In addition, the utility was required to use any of seven operational modes, including auxiliary tempering pumps, to limit discharge temperature to a 5°C rise above ambient, depending upon the likelihood of sensitive biota occurring in the area. Monitoring of discharge temperatures was required for each operational mode.

5. Wabash River and Cayuga Generating Stations, Public Service Co. of Indiana, NPDES Appeal # 78-6 (1979)

Facts

The Public Service Co. of Indiana (PSI) applied for § 316(a) waivers for both the Wabash River and Cayuga generating stations. Each plant employed once-through cooling, although one plant had a "helper tower". The initial NPDES permit issued by EPA required closed-cycle cooling. PSI requested, and was granted, an adjudicatory hearing on the conditions of the permit. At the adjudicatory hearing, the EPA Regional Administrator found both plants were in compliance with § 316(a) "although appreciable harm to the balanced indigenous community of the Wabash River has been caused by the subject discharges of PSI [the utility], those discharges have been demonstrated not to preclude the protection and propagation of the balanced, indigenous population..." This decision was appealed by the EPA Region V, Enforcement Division and the Indiana Stream Pollution Control Board on the basis that the Administrator had misinterpreted the law and had failed to consider important data. The discussions below address the major findings of the appeal process.

Holding

The Regional Administrator's decision was remanded for further proceedings. Since then, Indiana has been delegated responsibility for the § 316 Program. In 1985, permits were issued by Indiana for both facilities. EPA approved the Cayuga permit which incorporated seasonal outages to achieve compliance with thermal effluent limitations. EPA did not approve the Wabash permit issued by Indiana which incorporated a two-mile mixing zone for compliance. The Wabash proceedings remain unresolved.

Relevant Discussion

- Standard of Evidence Showing Appreciable Harm

A major finding of the Wabash and Cayuga proceedings is that if a plant is already in operation and no prior appreciable harm can be shown, then it may be presumed that there will be no appreciable harm in the future. If prior harm is shown, however, there is a presumption that the harm will continue. Both presumptions are rebuttable. A "rebuttable presumption" is a factual inference which may be drawn in the absence of actual certainty and which may be rebutted by other evidence. Once a utility has provided facts establishing no prior appreciable harm, the burden is on the regulator and other opposing parties to rebut the presumption.

- Definitions of Balanced, Indigenous Population and Degree of Acceptable Harm

The Wabash and Cayuga proceedings suggest that in determining what constitutes a "balanced, indigenous population" both individual species and the naturally occurring assemblage of organisms (i.e., the biological community) should be considered. Furthermore, "...[In] attempting to judge whether the effects of a particular thermal discharge are causing the ecosystem to become unbalanced, it is necessary to focus on the magnitude of the changes in the community as a whole and in individual species" and then determine if these changes are "appreciable". The overall number of fish in the receiving waters was unaffected by operations of the Wabash River and Cayuga generating stations. Some fish species were, however, virtually eliminated from the power plant sites. The Administrator found that "such shifts [in the population of individual species] are at war with the notion of 'restoring' and 'maintaining' the biological integrity of the nation's waters" as required by the CWA. The decision went on to note that in determining whether a balanced, indigenous population exists, it is frequently necessary to consider species "whose presence or abundance is attributable to the introduction of thermal pollutants." A minimal reduction in the population of a particular species in a localized area was found to be acceptable, provided that the species continues to flourish in the regional area occupied by its population.

- <u>Investigation of Worst Case Conditions</u>

  The Administrator concluded that the effect of conditions which are less favorable than average must be taken into account in § 316 Demonstrations. For example, the decision required the utility to investigate as a worst case condition impacts associated with the seven day, one in ten year low flows (Q7-10) or about 800-900 cfs with all units operational. The applicant had previously evaluated a low flow of 2640 cfs.

- <u>Economic Factors under § 316(a)</u>

  The Administrator indicated that in coming to a § 316(a) determination, the "consideration of economic factors is only appropriate in setting the original thermal limitations from which the § 316(a) variance is sought on biological grounds. The decision to grant or deny a request for less stringent thermal limitations under § 316(a) hinges solely on proof of the biological effects of the discharges." It, therefore, appears that the Administrator assumed that economic considerations were incorporated into the procedure used to establish the thermal limitation standard.

- <u>Consideration of Intake Structures Under § 316(a)</u>

  Although water intake structures must be considered as part of "all relevant stresses" on the environment under § 316(a), the Administrator concluded the environmental impact of the intake structures need not be independently measured (i.e., direct measurement of entrainment and impingement are not required). It is only necessary for the applicant to evaluate impacts associated with the water intake structures as part of the total stress on the balanced, indigenous populations (i.e., to show that resident populations of important biota have not declined as a consequence of plant operation).

- <u>Flow Reduction Under § 316(b)</u>

  Reduced flows resulting from retrofitting of closed-cycle cooling during critical summer periods were determined sufficient to protect balanced, indigenous populations in the receiving waters and to improve dissolved oxygen conditions to acceptable levels. The thermal discharge of the Cayuga facility was determined to be contributing substantially to sub-standard dissolved oxygen concentrations during low flow periods.

Final Resolution

A final resolution has not been reached for the Wabash or Cayuga stations; however, the present permit requires closed-cycle cooling during critical summer months.

6. Hudson River Settlement (1980)

Facts

Most of the information relevant to the Hudson River facilities comes from a staff document prepared by the EPA Region II Staff. This document is a critique of the methodology and completeness of the Hudson River utilties' § 316(a) and § 316(b) Demonstration documents, and presents the basis for an EPA decision that closed-cycle cooling was the "best technology available" for minimizing the environmental impacts of the Hudson River facilities. The document was presented to Administrative Law Judge Thomas Yost. The major issue in the Hudson River case was ecosystem and population level impacts resulting from entrainment and impingement. Entrainment and impingement impacts on spawning and nursery functions of commercially and recreationally important species, particularly striped bass, were the focus of most of the expert testimony that was provided. The utility consultants estimated that existing plants killed 12% to 14% of the striped bass young-of-the-year annually; government experts estimated losses to be 12% to 22% of the annual spawn.

Relevant Discussion

Based on the technical evidence presented by the utilities, EPA concluded: 1) the subject plants were located in the spawning areas of five important fish species; 2) the estimated annual cropping rate of young-of-the-year for three of these species exceeded 21%, resulting in the reduction of those species to "unacceptable levels" over a 40 year period (this indicates EPA's concern with long-term impacts and regional population level impacts); 3) two facilities impinged and entrained a forage fish, bay anchovy, "such that adverse environmental impact may result" (this indicates EPA concern with forage organisms and food web impacts); 4) all plants impinged clupeids "such that adverse environmental impact may result;" 5) there was entrainment of macrozooplankton (this again indicates EPA's concern with forage organisms and food web impacts);

6) the subject plants "will impact" on one rare and one endangered species indicating concern for power plant impacts on rare and endangered biota; 7) there was no indication that the additional mortality caused by the plants could be absorbed by indigenous populations as no evidence of density-dependent mechanisms was provided (this indicates EPA felt that evidence for compensatory population mechanisms must be supported before they could be used as an argument against reducing entrainment and impingement losses); 8) the reduction of intake flow was determined to be the best technology available for minimizing adverse environmental impact; 9) reductions in flow associated with closed-cycle cooling were projected to reduce plant impacts by 93-94% compared with the present intake systems; 10) only closed-cycle cooling would minimize the adverse impacts resulting from entrainment and impingement (this conclusion is, of course, based upon intake technologies available in 1977); 11) the cost of the installation and operation of closed-cycle cooling was determined not to be "wholly disproportionate" to the environmental benefits derived from application of such technology, and the cost would not "place an impracticable or unbearable burden on the affected utilities or their customers"; and 12) most of the environmental impacts and the additional fuel requirements associated with retrofitting of closed cycle cooling at the Hudson River facilities "will be negligible with the exception of visual-aesthetic impacts, which are subjective." EPA considered the impacts of fogging, icing, noise, salt deposition, and aesthetics, as well as commented on the projected fuel consumption of the cooling structures as a part of their evaluation.

Interim Settlement Agreement

On 19 December 1980, EPA announced a negotiated Settlement Agreement with the six Hudson River utilities as a first step to resolving environmental disputes between power generation on the Hudson River and the protection of the Hudson River biota. Parties to the agreement were:

- U.S. Environmental Protection Agency
- New York State Attorney General
- New York State Department of Environmental Conservation
- Hudson River Fishermen's Association
- Scenic Hudson, Inc.
- Natural Resources Defense Council, Inc.

- Consolidated Edison Company of New York, Inc.
- Orange and Rockland Utilities, Inc.
- Niagara Mohawk Power Corporation
- Central Hudson Gas and Electric Corporation
- Power Authority of the State of New York.

The Settlement Agreement, which is in effect until 1990, called for:

- Abandonment of plans by Consolidated Edison to construct a 2,000 MWe pumped storage hydroelectric project at Cornwall-on-the-Hudson
- Construction and operation by the utilities of a hatchery that released large numbers of striped bass fingerlings annually
- A $12-million endowment provided by the utilities for establishing an environmental research foundation
- A utility-funded $2 million per year monitoring program
- A 25-year ban on construction of new once-through power plants on the Hudson north of the George Washington bridge, applicable for all utilities except Niagara Mohawk
- Periods of reduced flows and partial power production (i.e., outages) during the May-August fin fish spawning and developmental periods at Bowline, Indian Point, and Roseton to reduce perceived adverse impacts on aquatic resources.

The consequences of entraiment losses to the adult striped bass stock and to the overall biological "health" of the Hudson River was not resolved by the Settlement Agreement. Rather, under the agreement the data required to address these issues would be collected and the analysis methods required to use the data developed by 1990.

7. Big Bend Units 1-3, Tampa Electric Company, FL (1981).

Facts

The Tampa Electric Company's (TECO) Big Bend plant is located on Hillsborough Bay in Tampa Bay. Units 1-3 of the plant were designed for once-through cooling with dilution assistance (tempering pumps) to reduce the absolute temperature of discharge flows. The intake flow for the three once-through cooling units was 45.6 m^3/s. Tempering pump flows was 25.2 m^3/s. Total water withdrawal was 70.8 m^3/s. The first § 316 Demonstration document submitted by the utility indicated that operation of units 1, 2, and 3 had a "significant effect" on Hillsborough Bay due to entrainment of large numbers of early life stages of fish and shellfish. The Administrator determined that the station's cooling water intake, including the tempering pump system, did not reflect the "best technology available" for minimizing adverse environmental impact under § 316(b). In response to this decision, the utility proposed to discontinue use of dilution pumps reducing the impact of entrainment but increasing the thermal loading on Hillsborough Bay. EPA allowed TECO to evaluate the effects of the proposed modification using an EPA-approved study plan and made the final § 316 decision for Big Bend units 1-3 based on the findings of the EPA-approved studies.

Holding

The § 316(a) variance was granted and intake structures were determined to be the "best technology available" for minimizing impacts following discontinuing the use of the dilution assistance system.

Relevant Discussion

The findings of the EPA-approved studies indicated that discontinuing the use of dilution pumping reduced entrainment losses without substantially increasing the adverse environmental impacts associated with thermal discharges. Based on these findings, EPA concluded that discontinuing the use of tempering pumps assured the protection of balanced, indigenous populations, and represented the "best technology available" for minimizing adverse impacts from intake structures. As a result of this case, EPA carefully evaluates the environmental consequences of dilution assistance when reviewing § 316 Demonstration documents.

8. Big Bend Unit 4, Tampa Electric Company, FL (1981).

Facts

Tampa Electric Company (TECO) proposed the addition of a fourth once-through cooling unit to its Big Bend station located on Hillsborough Bay near Tampa, Florida. The proposed unit 4 would increase intake flows by about 16 m^3/s. With the addition of Unit 4, total intake flows for the Big Bend facility would be about 61 m^3/s: a water use level near the 70.8 m^3/s which had previously been shown by EPA to adversely impact balanced indigenous populations in Hillsborough Bay. Operation of Unit 4 with once-through cooling was also projected to increase the thermal impact in the discharge area by 33 percent, from 46 to 61 ha. The NPDES permit application by TECO was only for Unit 4; however, EPA considered the combined effects of all operational units (1-4) in reaching a final decision. In an initial holding, the Administrator concluded the conventional intake structures at the Big Ben facility did not represent the "best technology available" under § 316(b). The basis for this decision was data presented in TECO's § 316 Demonstration documents which showed that: "all stages of most species (were) attracted to and (were) concentrated in the intake." In response to the initial holding, TECO constructed and tested a prototype finemesh screening apparatus. On the basis of the findings of its fine-mesh testing, TECO modified the intake design at the Big Ben facility to include fine-mesh screens at Units 3 and 4 and resubmitted its NPDES application.

Holding

The modified intake structure was determined by EPA to represent the "best technology available" to minimize "adverse environmental impacts" under § 316(b), and the increase in thermally impacted area due to the addition of Unit 4 was acceptable (i.e., the § 316(a) variance was granted). A single NPDES permit was granted for Units 1-4. Conditions included:

- Continued monitoring of the performance of the fine-mesh wire screens

- Reassessment of thermal load models of Hillsborough Bay to better define the thermally impacted area.

Relevant Discussion

- Consideration of All Stress in Making 316(a) and 316(b) Decisions

  The Administrator concluded that in order to make a § 316(a) and § 316(b) decision for the proposed Unit 4 existing impacts for Units 1-3 must be considered. This indicates the importance EPA places on considering all power plant impacts on the environment when making § 316 decisions.

- Degree of Minimization Required by § 316(b)

  EPA concluded operation of a fine-mesh screen system on two of the four cooling water intake units represented the "best technology available" under § 316(b). These screens were "approximately 56 percent effective in reducing entrainment losses." EPA did not require elimination of entrainment impacts only the reduction to a level where the costs of the reduction did not exceed the environmental gains realized. In addition, the incremental increase in thermally affected area that resulted from the addition of Unit 4 assured the protection of a balanced, indigenous population in Hillsborough Bay.

9. Indian River Plant, Orlando Utilities Commission, FL (1983) and Cape Canaveral Plant, Florida Power & Light Co., FL (1983).

Facts

The utilities applied for § 316(a) variances and for decisions under § 316(b). Due to the close proximity of the two plants, EPA evaluated the applications jointly and considered the combined effects of the two plants on the receiving water body, Cape Canaveral Pool. This case was not contested, and the resulting decision applied to both plants.

Holding

Section 316(a) variances were granted and the intake structures were found to represent the "best technology available" under § 316(b).

Relevant Discussion

- Considerations under Section 316(a)

  EPA found "significant" adverse biological impacts on a large portion of Cape Canaveral Pool. EPA, however, came to the conclusion that the balanced, indigenous population was not "endangered" when the nature of the body of water, the risks of alternative technologies, and the age of surrounding power plants were considered.

- Considerations Under § 316(b)

  EPA found "substantial losses" in marine organisms due to entrainment and impingement. They, however, concluded that entrainment and impingement impacts could not be reduced without requiring an alternative technology, probably cooling towers. Adverse impacts which would result from the utilization of cooling towers, were determined to be of sufficient severity that "the current intake technology, when compared to the alternatives and viewed in the context of the type and the importance of the biological community in which it is located, minimizes such impacts."

Comment

Discussions in Chapter IV will question the validity of the degree of adverse impact which this decision suggests is acceptable. The presence of the manatee, an endangered species, in the Canaveral Pool possibly influenced EPA to allow such large adverse impacts. The manatees are dependent on the thermal discharges during the winter for their survival. This indicates the importance EPA placed upon protection of endangered species when making § 316 decisions.

10. John Sevier Steam Plant, Tennessee Valley Authority, TN (1986).

Facts

The John Sevier steam station, located on the Holston River near Rogersville, TN is owned and operated by the Tennessee Valley Authority (TVA). Condenser cooling water is withdrawn from water impounded by an overflow retention dam located in the river adjacent to the plant site. Cooling water is

discharged downstream of the retention dam in Cherokee Reservoir. The Cherokee Reservoir fluctuates between being lake-like during high streamflow and stream-like during low streamflow. EPA determined that the retention dam was an integral part of plant intake structure and implicated the dam in impacts on the river biota. EPA further concluded that "all potentially available mitigative measures" were either (1) infeasible, (2) not "available technology" within the meaning of § 316(b), or (3) of such a nature that "costs associated with the mitigation measure were wholly disproportionate to the anticipated benefits." TVA disputed that the dam was part of the intake structure, and contended that it was not subject to an evaluation of "best technology available" under 316(b). In 1976, negotiations between TVA and EPA resulted in EPA granting TVA a temporary permit for the John Sevier facility that required TVA to conduct monitoring and stocking programs in the vicinity of the plant, to perform research on fish passage technology, and to pass a minimum flow of free river water (water that has not crossed the plant condenser system) over the impoundment dam. The required studies were designed to support preparation of a § 316 Demonstration document and the making of a final § 316 decision for the John Sevier facility. In 1979, the § 316 Demonstration document that resulted was submitted to EPA along with an application for a NPDES permit.

Holding

EPA issued a temporary permit which required additional data that would allow a detailed evaluation of the efficacy, effectiveness, legality, and change in conditions resulting from the stocking program and the minimum flow requirement.

Relevant discussion

- Economic Considerations Under § 316(b)

  After evaluation of available information, EPA determined that the costs associated with removal of the impoundment dam for the John Sevier generating station would be "wholly disproportionate to the anticipated benefits" at this time. The Holston River has a history of industrial and municipal pollution that makes it difficult for EPA to determine the role of operations of the John Sevier facility in impairing the "balanced, indigenous community." Benefits to future "balanced, indigenous populations" may, however, be larger than those presently anticipated. If findings of the ongoing monitoring and stocking programs indicate that the

cost of removal of the dam is not "wholly disproportionate" to environmental gains, EPA will modify the permit and require removal of the retention dam.

- Final Resolution

  EPA plans to make a final § 316 determination for the John Sevier facility in 1988.

C. EPA GENERAL COUNSEL OPINIONS RELEVANT TO § 316

1. In Re Inland Steel, Decision of the General Counsel #27 (1975)

Facts

The applicant objected to the inclusion of an intake study as a condition of its permit under § 402 of the CWA. Section 402 requires that the applicant comply with §§ 301, 302, 306, 307, 308 and 403. Section 402 does not specifically require compliance with § 316(b).

Conclusion

The General Counsel concluded § 402 requires the applicant to comply with § 308, which allows the Administrator to require intake studies as a condition of the NPDES permit.

Relevant Discussion

- EPA's authority to require monitoring under § 316(b)

  Section 308 authorizes the Administrator to "require the owner or operator of any point source to...make such reports...install, use and maintain such monitoring equipment or methods...and...provide such other information as he may reasonably require." The only limitations on this authority are that the monitoring is "required to carry out the objective of this Act." Although permits are issued under § 402, and although § 402 does not in itself require monitoring to ensure compliance with § 316(b), the authority vested in the Administrator under § 308 allows him to require reasonable intake studies at power generating facilities as a condition for NPDES permits.

2. In Re Brunswick Steam Plant, Decision of the General Counsel #41 (1976)

Facts

The applicant complained that:

- EPA's definition of "capacity" of intake structures under § 316(b) was incorrect
- The requirement imposed by EPA to retrofit closed-cycle cooling as a condition of the applicant's permit was in violation of existing statutes
- EPA had refused to set specific "performance standards" defining the amount of harm allowed to result from intake structures.

Conclusions

The General Counsel concluded:

- "Capacity" refers to the volume of water taken in rather than the size of the intake structure
- Closed-cycle cooling may not be imposed per se, but the conditions imposed by a NPDES permit may be such that closed-cycle cooling is the only technology available
- An NPDES permit may specify restrictions in the design, location and capacity of intake structures; however, permits need not contain a "performance standard" expressed in terms of the amount of allowable harm for complying with § 316(b).

Relevant Discussion

- Definition of "Capacity" under § 316

  The utility contended that "capacity" referred only to the physical size of the intake structure. The General Counsel indicated that the legislative history of § 316(b) and the dictionary definition of "capacity" clearly indicate that "capacity" refers to volume of water used for cooling purposes. The General Counsel further pointed out "The size of the inlet determines

only the velocity of water withdrawn, not the volume." Moreover, he concluded the intent of capacity restrictions is to prevent entrainment, and the volume of water used is the major factor determining the probability of entrainment, not the size of the intake structure.

- Application of § 316(b) to Cooling Water Systems

The utility argued that § 316(b) did not apply to cooling systems, but only to intake structures; thus, "a closed-cycle cooling system per se cannot be imposed under § 316(b)." The General Counsel's decision supported the utility's argument and noted that § 316(b) authorizes the restriction of the capacity of an intake structure, but "it does not authorize the agency to impose a specific closed-cycle cooling technology." The General Counsel, however, went on to say "while the agency cannot specify abatement technologies to be employed...the use of a particular [cooling] system may be the predictable consequence of the limitation imposed." In summary, § 316(b) is concerned with the withdrawal of cooling water rather than the discharge of heated water. It is also directed toward whether the intake structure represents the "best technology available" rather than whether plant operation causes adverse harm to the environment.

- Definition of "Performance Standards" Under § 316(b)

The applicant wanted EPA to set minimum standards for the amount of environmental harm that intake structures could cause. EPA countered that § 316(b) requires the minimization of adverse impact to the greatest degree possible, not the setting of specific limitations. The opinion stated "The goal of 'best technology available' under § 316(b) is to minimize all adverse environmental impacts -- not to reduce the impact to a predetermined level." "Minimize" was held to mean "reducing to the smallest possible amount." Section 316(b), therefore, does not regulate the use of the intake water, nor does it establish effluent limitations or performance standards. The determination of whether the required minimization has been achieved is made on a case-by-case basis based on an evaluation of whether the costs of the technology are proportionate to the environmental benefits that are anticipated to result. The General Counsel went on to indicate that § 316(b) is different from § 316(a) in this respect. He noted § 316(a) specifies a biological standard which must be achieved -- "a balanced indigenous population".

3. Central Hudson, Decision of the General Counsel #63 (1977)

Facts

The applicant contended:

- Effluent limitations must be established under § 301 and § 316(a) before intake structure conditions under § 316(b) could be considered or developed

- Section 316(b) is limited to new facilities because it applies to "any standard established pursuant to § 301 or § 306..." (emphasis added), a term exclusively applicable to new source performance standards established under § 306

- Permit conditions under § 316(b) may not restrict the capacity of water intake structures to a rate less than that necessary to achieve effluent limitations under § 301 and § 316(a).

Conclusions

The General Counsel concluded:

- Permit conditions may be imposed under § 316(b) independently of any proceeding to modify effluent limitations under § 316(a), although the application of § 316(a) and § 316(b) should generally be coordinated to the fullest extent possible. Permit conditions may be imposed under § 316(b) so long as there is a standard promulgated pursuant to § 401 or § 406 which could be applied to the point source discharger.

- Section 316(b) applies to both new and existing facilities. The reference to "any standard" in § 316(b) refers to the effluent limitations and standards promulgated pursuant to both § 301 (which governs exiting facilities) and § 306 (which governs new facilities).

- Restrictions under § 316(b) may be required independently of effluent limitations established under §§ 301, 304, 306, or 316(a). However, the cost of the modification required under § 316(b) must not be out of proportion to the environmental gains realized.

Relevant Discussion

- Whether Effluent Limitations Under § 301 and § 316(a) Must Be Established Before § 316(b) Conditions Are Considered

  The General Counsel noted that effluent limitations and guidelines are established pursuant to §§ 301, 304, and 306, and "The reference in § 316(b) to § 301 and § 306 clearly indicates that the application of restrictions under § 316(b) is predicated only upon the promulgation of generally applicable national effluent limitations and guidelines. Therefore, it is not necessary to defer a § 316(b) decision until the limitations in a NPDES permit are set pursuant to § 402." He went on to note that "insofar as § 316(a) and § 316(b) address different parts of the same problem -- the environmental impacts associated with the withdrawal and discharge of 'cooling water' -- it is desirable to implement conditions under § 316(a) and § 316(b) in a unified proceeding where possible."

- Application of § 316(b) to Existing Facilities

  The General Counsel clearly pointed out that § 316(b) specifically refers to § 301 as well as § 306. Second, he concluded there is no indication in the legislative history of the CWA nor in the Act's plain wording which would preclude the application of § 316(b) to existing sources. Finally, judicial decisions clearly indicate that § 316(b) "encompasses 'standards' under § 301 as well as § 306." Thus, he concluded that § 316(b) applies to both new and existing point sources.

- Consideration of Entrainment and Impingement under § 316(a)

  The General Counsel pointed out that just because "cooling water could be discharged at a temperature which did not unduly disrupt the aquatic ecosystem does not mean that the withdrawal of the cooling water did not have an adverse environmental impact." He went on to conclude that Congress clearly intended that both the impacts of withdrawal of water and discharge of heated water be considered under § 316(a). In considering a § 316(a) application, EPA, therefore, must take into account the impacts resulting from both withdrawal of cooling water and the discharge of waste heat. "For example, a less stringent effluent limitation might lead to the withdrawal of a greater volume of cooling water and greater mortality to entrained organisms."

- Section 316(b) Conditions Restricting Intake Capacity to a Rate Less than Necessary to Achieve Effluent Limitations Under § 301 and § 316(a)

The General Counsel indicated that intake capacity (i.e., the volume of cooling water withdrawn) may be reduced to a level whereby the power plant cannot, without modification, achieve effluent limitations under § 301 and § 316(a). Therefore, § 316(b) decisions are not dependent upon thermal effluent limitations established under § 301 and § 316(a).

- Burden of Persuasion and Economic Considerations under § 316(a) and § 316(b)

The General Counsel concluded "Under § 316(a) the applicant has the ultimate burden of persuasion, and economic considerations are not appropriate. Under § 316(b) EPA has the ultimate burden of persuasion and economic considerations are appropriate." He went on to note Section 316(a) allows for an adverse environmental impact, provided that the impact does not interfere with the protection and propagation of a balanced aquatic community. Under § 316(b) adverse impact must be minimized, but the cost of the technology to do so should not be "wholly disproportionate to the environmental benefit to be gained."

In the Central Hudson opinion, the General Counsel noted any cooling water intake technology may be imposed under § 316(b), despite a successful § 316(a) Demonstration, as long as the cost of the technology imposed was not "wholly disproportionate" to the environmental gain anticipated. As a practical matter, however, the General Counsel pointed out that it would be difficult for EPA to show that an expensive technology required under § 316(b) was not "wholly disproportionate" to the magnitude of the adverse environmental impact in those cases where the discharger had demonstrated compliance with § 316(a). This appears to be a strong basis for requiring § 316(a) and § 316(b) determinations are conducted in sequence. In addition, it also appears to be a strong argument for considering entrainment and impingement impacts on balanced, indigenous populations under § 316(a).

The General Counsel noted that EPA, in its § 316(b) determination, need not establish a prima facia case (i.e., gather site specific data); however, "EPA...is obligated to give clearly written notice of the factual and legal determinations which underlie the permit conditions at issue," in order to allow the permittee

to comment on the proposed permit conditions. This implies that once EPA has demonstrated a factual basis for requiring a particular technology under § 316(b), the burden of proof shifts to the utility to show that less costly alternatives are preferrable or more desirable.

4. In Re Central Hudson Gas, Decision of the General Counsel #75 (1979)

Facts

The question presented to the General Counsel in this case was whether EPA should consider the § 316(a) and related § 301 and § 304 issues in the context of the pending § 316(b) hearing, or may EPA defer consideration of the § 316(a) and related § 301 and § 304 issues until after a final decision was made on the § 316(b) issues.

Conclusion

The General Counsel concluded that EPA could defer a hearing or consideration of § 316(a) and related § 301 and § 304 issues until after a final decision was made on § 316(b) issues.

Relevant Discussion

This opinion clearly established that § 316(b) determinations are to be made independently of § 301 or § 316(a) determinations. There is, therefore, no legal basis for requiring these issues to be jointly considered in one proceeding. The General Counsel, however, indicated it was desirable to implement conditions under § 316(a) and § 316(b) in a unified manner and regulators have the discretion to determine for each individual case when § 316(a) issues should be deferred pending completion of a § 316(b) determination. The decision to defer may be due to time and/or resource constraints, or may be because the regulator believes closed-cycle cooling can be sustained based solely on § 316(b) issues. These conclusions are supported by the General Counsel decision #63 discussed above.

APPENDIX C

MEMORANDUM CONCERNING DEFINITION OF RECEIVING WATERBODY

By

William Goldfarb

MEMORANDUM

I

THE RECEIVING WATERBODY IS THE MAN-MADE DISCHARGE CANAL

The Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), defines "navigable waters" as "waters of the United States". As far as surface waters are concerned, this phrase includes all waters that Congress is authorized to regulate under the "Commerce Clause" of the United States Constitution. United States v. Holland, 373 F. Supp. 665 (D.C. Fla., 1974). Man-made canals that connect with natural waterbodies are covered by the CWA. Weiszmann v. Corps of Engineers, 526 F. 2d 1302 (5th Cir., 1976); see also Track 12, Inc. v. District Engineer. 618 F.Supp.448 (D.C. Minn, 1985)(artificial wetlands created by man-made connection with a tidal waterway).

In Holland, defendants, without a permit under section 404 of the CWA, discharged dredged and fill material into a man-made mosquito canal emptying into Papy's Bayou on the West Coast of Florida. In affirming Corps jurisdiction over the canal, the court directly confronted the issue of whether artificial waters can be "waters of the United States":

> The conclusion that Congress intended to reach water-bodies such as these canals with the FWPCA is inescapable. The legislative history...manifests a clear intent to break from the limitations of the

> Rivers and Harbors Act to get at the sources of pollution. Polluting canals that empty into a Bayou arm of Tampa Bay is clearly an activity that Congress sought to regulate. The fact that these canals were man-made makes no difference ...(emphasis supplied)(373 F.Supp 665, at p.673).

Clearly, the man-made discharge canal at the Oyster Creek facility is "waters of the United States". It is also "waters of the State" under the New Jersey Water Pollution Control Act and its attendant regulations, which refer specifically to artificial waterbodies (NJSA 58:10A-3(t); NJAC 7:14A-1.9).

Defining the "receiving waters" in a Section 316 proceeding was also an issue in the Seabrook matter. In Re Public Service Co. of New Hampshire, 10 E.R.C. 1257 (1977). There, the EPA Administrator rejected the company's argument that the receiving waters should be broadly defined:

> One of the underlying questions to be considered in making the decision in this case was what should be considered as the receiving waters. The Hampton-Seabrook area is part of the Gulf of Maine, a much larger body of water, which in turn is part of the Atlantic Ocean. Obviously an impact which created an imbalance in the local indigenous populations might not be felt in the Gulf of Maine or the Atlantic Ocean. Put another way, if the Atlantic Ocean (or a part of it as large as the Gulf of Maine) is to be considered as the receiving water, then Section 316 might be a dead letter as to coastal power plants because plants of a size likely to be built probably would not have an effect on such an enormous body of

> water. Therefore I think that in order to give effect to Section 316 it is necessary to look at a smaller portion of the coastal waters where human use or enjoyment of the marine resource may be affected. The portion chosen is necessarily arbitrary to some extent where, as in this case, there are no obvious physical boundaries.(emphasis supplied) (10 E.R.C. 1257, at page 1265).

In the present situation, the discharge canal possesses physical boundaries and should thus be designated as the receiving water. Under the Holland rule, it makes no difference if the canal is unavailable for public recreational use.

The New Jersey Department of Environmental Protection (NJDEP) has consistently rejected attempts to ignore tributaries in order to consider larger waterbodies as receiving waters. Two examples of NJDEP's position on this matter are Morses Creek (Essex County) and Cuckel's Brook (Somerset County).

II

NJDEP SHOULD SET EFFLUENT LIMITATIONS BASED ON BATEA FOR THE OYSTER CREEK NUCLEAR GENERATING STATION

EPA's 1974 effluent limitation regulations for existing steam-electric power plants, based on Best Available Technology Economically Achievable (BATEA), were struck down in Appalachian Power v. Train. 545 F.2d 1351 (4th Cir., 1976). Since EPA has not proumulgated substitute effluent limitation regulations, effluent limitations in NJPDES permits for individual existing

plants must be based on Best Professional Judgment (BPJ). The EPA General Counsel has concluded that BPJ for existing steam-electric power plants must consider those factors listed in Section 304 (b)(2)(B) of the CWA and apply them on a case-by-case basis (see e.g., OGC #63). These factors are the plant's age, the process employed, engineering aspects of applying alternate control technologies, process changes, costs of achieving the reduction in heat discharges, and nonwater quality environmental impact (including energy requirements).

At this point, a determination can be made about whether a cooling tower would be "economically achievable" by JCP&L. However, no balance between control costs and water quality benefits is required under Section 304 (b)(2)(B). Cost is only one factor to be considered in setting BATEA. If a cooling tower is an alternative, aesthetics, noise, other nonwater quality impacts, and energy requirements should also be taken into account.

BATEA must first be established in order to activate Section 316(a), or else in order to establish more stringent water quality-based effluent limitations which would also activate Section 316(a). In Seabrook, the Administrator concluded that unique circumstances merited skipping the

step of evaluating BATEA factors and moving directly to the 316(a) proceeding. Those unique circumstances were that the Fourth Circuit's Appalachian Power decision had come down after the adjudicatory hearing on the discharge permit for the Seabrook facility. This ruling was probably incorrect, but it was harmless since the 316(a) request was granted. In the ordinary situation, BATEA-based effluent limitations must be set before the commencement of a 316(a) proceeding. If a cooling tower is not found to be BATEA, the 316(a) proceeding will, in all likelihood, be unnecessary.

Moreover, if a cooling tower is not found to be BATEA, but is required anyway in order to meet applicable water quality standards, JCP&L may invoke NJSA 58:10A-8. This provision allows a discharger subject to water quality-based effluent limitations requiring installation of "better than BATEA" to secure a modification of the water quality-based effluent limitations by showing that "there is no reasonable relationship between the economic and social costs of compliance and the benefits to be obtained". This section was drafted before the promulgation of federal regulations now codified at 40 CFR 131, and it is arguable that Section 58:10A-8 has been preempted by 40 CFR sec. 131.10(g). It will also be seen that both Section 58:10A-8 and 40 CFR sec. 131.10(g) have probably been preempted by Section 316(a) where heat

dischargers are concerned. Nevertheless, these questions will be academic if a cooling tower is designated as BATEA because both Section 58:10A-8 and 40 CFR sec. 131(g)(6) apply only to "better than BATEA" situations.

III

SECTION 316(a) IS THE EXCLUSIVE MEANS OF MODIFYING THERMAL WATER QUALITY STANDARDS OR EFFLUENT LIMITATIONS.

Under Section 303(g) of the CWA and comparable state law, "water quality standards relating to heat shall be consistent with the requirements of Section 316 of this Act". This provision is clear on its face; a "balanced, indigenous population" is the "bottom line" of acceptable water quality under the CWA. In his remarks supporting the Conference Committee Report on the Clean Water Act Amendments of 1977, Representative Roberts discussed the relationships between Section 316(a) and state water quality standards:

> This act is not intended to change the regulation of thermal discharges. In addition, the conferees must disagree with the interpretation of Section 316(a) expressed by the Senate Committee on Environment and Public Works...that Section 316(a) of the existing law does not preempt State thermal water quality standards.

> In adopting Section 316(a) as part of the 1972 amendments to the Federal Water Pollution Control Act, we clearly intended that the section apply to thermal limitations based on State water quality standards as well as technology-based effluent limitations. Therefore, this committee cannot agree with the present interpretation expressed in the Senate report....We specifically note that EPA correctly interpreted the original intent of the effect of Section 316(a) on State water quality standards,... that Section 316(a) operates to affect effluent limitations based on water quality standards relating to heat....The purpose of Section 316(a)--to provide for site-specific analyses of the impact of thermal discharges--applies to effluent limitations based on water quality standards, as well as to technology-based effluent limitations. <u>In addition, Section 303(g), which provides that water quality standards related to heat must be consistent with Section 316 of the act, reinforces the intention that the "balanced, indigenous population" standard of Section 316 be the guiding principle in evaluating thermal discharges</u>. This interpretation tends to avoid unnecessary capital expenditure, and thus needless higher costs to the consumer, while assuring adequate protection of the aquatic environment. (emphasis supplied)(Congressional Research Service, <u>A Legislative History of the Federal Water Pollution Control Act Amendments of 1977</u>, pp.365-366).

Thus, 40 CFR sec.131.10(g)(removing designated uses) has been preempted by Section 316(a) where heat is concerned. EPA recognizes that protecting a balanced, indigenous population is "the minimum requirement for standards relating to temperature". (EPA Regional Counsel Opinion, Regional VI, issued

March 4, 1977).

IV

JCP&L CANNOT RAISE ECONOMIC FACTORS OUTSIDE OF THE BATEA DETERMINATION

It is well-settled that economic considerations are inappropriate in Section 316(a) proceedings. And since Section 316(a) preempts removal of designated uses, consideration of economic factors in water quality standards removal proceedings is irrelevant to this situation.

However, assuming for the sake of argument that revision or removal of thermal water quality standards independent of Section 316(a) might still be a viable alternative, JCP&L's opportunities to present economic data in those proceedings would be quite limited. Economics may be considered in setting a designated use, but the use must be set at fishable/swimmable unless removed according to 40 CFR sec.131.10(g). Mississippi v. Costle, 625 F.2d 1269 (5th Cir., 1980). Thus, revisions and removals for economic reasons are barred unless "(c)ontrols more stringent than those required by Sections 301(b) and 306...would result in substantial and widespread economic and social impact". (40 CFR sec.131(g)(6). If a cooling tower

is designated as BATEA, economics are irrelevant to revision or removal proceedings. On the other hand, if a cooling tower is not economically achievable, the designated use can only be removed if requiring a cooling tower will cause "substantial and widespread economic and social impact". This once again emphasizes the importance of formally establishing BATEA-based effluent limitations here. Designating a cooling tower as BATEA will obviate both NJSA 58:10A-8 and 41 CFR sec.131.10 (g)(6), or only the latter if it has preempted the former.

This Memorandum does not address the following issues relating to setting BATEA-based effluent limitations:1)whether NJDEP has already fulfilled this responsibility in the process of issuing the NJPDES permit for the Oyster Creek facility; and 2)if not, whether NJDEP should establish such an effluent limitation by rule or through reissuance of the permit.

APPENDIX D

SUMMARY AND EVALUATION OF § 316 EVALUATION CRITERIA

APPENDIX D. SUMMARY AND EVALUATION OF § 316 EVALUATION CRITERIA

The purpose of this appendix is to summarize the information presented in the litigation review to establish the burden of proof, standard of proof, the degree of acceptable harm, environmental factors to be considered, and cost-benefit considerations under § 316(a) and § 316(b) of the CWA. Inconsistencies between the various decisions are also discussed as are general principles of administrative law when such principles are relevant and assist in the resolution of conflicts among the decisions reviewed. Discussion pertaining to § 316(a) and § 316(b) are presented separately and the interrelationship between § 316(a) and § 316(b) is discussed at the end of the chapter.

A. SECTION 316(a)

Burden of Proof

It is clearly established from the litigation review that the burden of establishing entitlement to a § 316(a) variance lies with the applicant (i.e., the owner/operator of the facility). First, the language of § 316(a) requires the owner or operator to "demonstrate to the satisfaction of the Administrator (or, if appropriate, the State)" that thermal limitations are overly stringent. Second, the federal Administrative Procedure Act (APA) provides that in federal rule-making and adjudicatory proceedings "the proponent of a rule or order has the burden of proof" [5 U.S.C. § 556(d)]. The burden of proof has been uniformly applied in the § 316(a) decisions discussed in Appendix B and is addressed by General Counsel Opinion #63.

Summary Statement: The burden of proof is on the applicant under § 316(a).

Standard of Proof

The standard of proof involves determination of how much evidence is required to support an administrative decision. The federal APA requires that a rule of order may not be issued "except on consideration of the whole record or those parts thereof cited by a party and supported by and in accordance with reliable, probative, and substantial evidence" [5 U.S.C.

§ 556(d)]. The APA also provides that in reviewing an administrative action federal courts shall determine whether the action is "supported by substantial evidence" [5 U.S.C. § 706(2)(E)]. Court cases define "substantial evidence " as that which a reasonable mind would accept as sufficient to support a particular conclusion.

In the Anclote Plant decision, the § 316(a) variance was denied in part because of the utility's failure to provide "complete and scientifically reliable data". In Virginia Electric v. Costle, the court held that the agency must provide "some basis" for appellate review. In In Re Public Service Co. of New Hampshire, the Administrator held that the applicant must provide sufficient evidence for a "reasoned decision". It has also been held that the applicant must provide the "best information reasonably available" which "ideally" should allow the determination of impacts "with some degree of confidence." Expensive studies that result in little additional information are not required. Applicants should provide more than just data. The information made available should be presented in an interpretable, comprehensive, narrative summary. In the Wabash River and Cayuga generating stations decision the Administrator required evaluation of worst case conditions as a part of the measures of variation.

Summary Statement: Applicants must supply the best information reasonably available that allows a regulator to reach a reasoned decision. This information should allow the determination to be made with a reasonable degree of confidence and should include consideration of worst case conditions. Expensive studies that result in little additional information should not be required. A § 316(a) variance may be denied because an applicant failed to provide complete and scientifically reliable information. A § 316(a) variance may not be granted on the absence of evidence that there is an impact. Affirmative evidence demonstrating no impact is required.

Degree of Acceptable Harm

Adverse impact is acceptable under § 316(a) as long as the impacts allowed "assure the protection and propagation" of balanced, indigenous populations. EPA's § 316(a) regulations allow existing discharges to satisfy the statute by demonstrating no "appreciable harm" to the receiving water body [40 C.F.R. § 125.73(c)]. This is accomplished on a case-by-case basis.

The cases summarized in this Appendix B approach this issue in a variety of ways and indicate that varying levels of adverse impact are acceptable. In the Indian River Plant and Cape Canaveral Plant decisions, EPA found adverse impacts to be

"significant" but that the balanced indigenous population was not "endangered". This conclusion seems inconsistent with the requirement to "assure the protection" of balanced, indigenous populations. Other decisions have applied more stringent definitions of "appreciable harm." The Wabash River and Cayuga Generating Stations decision found a "minimal reduction" in populations to be acceptable but held that "appreciable" changes in regional populations would be unacceptable. Similarly, in the Anclote Plant decision, the variance was denied because of "significant effects" to important biological populations. In the Brunswick Steam Plant case, EPA held that "significant harm" that occurred to the environment warranted a reduction in intake flows. In all cases evaluations of appreciable harm have been made by considering the long-term consequences of the impacts identified.

Summary Statement: Some impact is acceptable under § 316(a); however, that impact should not result in appreciable harm to biota characteristic of the receiving water body over the long term.

Environmental Factors to be Considered

An applicant may satisfy § 316(a) by: (1) showing the absence of prior appreciable harm; (2) showing that RIS are protected; or (3) submitting other biological and engineering data. Thus, there is more than one way to demonstrate compliance with § 316(a).

The decisions summarized in the previous sections offer a variety of factors to be considered in making a § 316(a) determination, including:

- Adverse effects on those elements of the aquatic ecosystem necessary to support a balanced population
- Impact on Representative Important Species
- Effects of impingement and entrainment
- Indirect effects
- Background stresses and nature of the receiving waters
- Worst case conditions
- Increase or decrease in threatened or endangered species

- Change in the overall composition of aquatic populations
- Adverse effects of withdrawal of greater volumes of cooling water
- The degree of certainty as to the nature and magnitude of impacts including reasonable measures of variation.

The Brunswick Steam Plant decision held that § 316(a) requires consideration of all adversely affected fish populations and any elements of the aquatic ecosystem necessary to support a balanced population. However, in In Re Public Service Co. of New Hampshire, the Administrator held that it may not be necessary to provide data on all species if the species that were studied provided sufficient information on species and ecosystem components not studied to make a decision. These two decisions are not contradictory, but rather indicate that selection of target species should be done in a manner that assures they are representative of the system as a whole.

All decisions reviewed required that § 316(a) studies consider the effects of entrainment and impingement. The degree of acceptable harm from entrainment and impingement was, however, not clearly defined. Some of the decisions suggested that impingement and entrainment be considered as a background stress in the context of which the impact of the thermal discharge is assessed. Other decisions suggest that impingement and entrainment impacts may themselves be the basis for denying a § 316(a) application. In addition, the decision in Pilgrim Power Plant held that indirect effects of thermal effluent (e.g., increases in predator species, cold shock, gas bubble disease) and background stresses must be considered. In addition, in the Wabash River and Cayuga Generating Stations decision the Administrator required consideration of "worst case" conditions.

The capacity of receiving waters to assimilate pollution may be considered under § 316(a) (see Weyerhaeuser v. Costle). This reflects the tolerance of § 316(a) to allow adverse impacts which do not interfere with balanced, indigenous populations. A § 316(a) variance, however, may not be granted on the basis that receiving waters are already polluted (Appalachian Power v. Train).

Summary Statement: A broad range of environmental factors must be considered under § 316(a) including entrainment, impingement, indirect effects, worst case conditions, and the degree of uncertainty as to the nature of impacts. It is not necessary to study all species or aquatic populations as a whole as long as the species selected for study are representative of those not studied.

Cost-Benefit Considerations

The General Counsel Opinion #63 states that economic considerations are not appropriate under § 316(a). This is consistent with the Wabash River and Cayuga Generating Stations decision which holds that consideration of economic factors is appropriate only in establishing "original thermal limitations" and not in determining whether a variance should be granted under § 316(a).

Summary Statement: Alternate effluent limitations that assure the protection and propagation of balanced indigenous populations should be established under § 316(a). The cost of meeting alternate effluent limitations is a secondary consideration.

B. SECTION 316(b)

Burden of Proof

The burden of proof under § 316(b) is discussed only in the Office of General Counsel Opinion #63. That opinion holds that "EPA has the ultimate burden of persuasion." The burden under § 316(b) is different from the burden under § 316(a) because § 316(b) involves "standards" adopted pursuant to § 301 and § 306 of CWA. Because EPA is responsible for adopting the standards, EPA is the proponent of a rule. Once EPA has established the "best technology available" for a particular facilty/situation based upon the regulatory record, the operator of the facility has the burden of going forward if it wishes to utilize some other technology (e.g., one that is less expensive). In other words, if there is a reasonable basis for the regulator's position, the operator/owner has the burden of demonstrating that the existing technology or a more cost-effective alternative is as or more appropriate. Therefore, in order to overcome a regulator's position, the applicant must show that the regulator's position is not based on a "reasoned decision."

Summary Statement: The initial burden of proof under § 316(b) is on the regulator; however, once the regulator has developed a position under § 316(b) and provided the technical basis for that position, the owner/operator must accept the regulator's position or show that the existing technology or a more cost-effective alternative is more appropriate for minimizing environmental impact.

Standard of Proof

The Office of General Counsel Opinion #63, states that EPA must provide "clear written notice of the factual and legal determinations" which provide the basis for discharge permit conditios. The discharge permit conditions must have a reasonable basis, and must be supported by the record.

Summary Statement: The regulator, under § 316(b) is required to establish the record with respect to permit conditions and their reasonableness.

Degree of Acceptable Harm

Section 316(b) requires the use of the "best technology available" for "minimizing adverse" environmental impacts. It does not require elimination of harm. Section 316(b) does not specify the amount of harm which must be avoided, but harm must be minimized to the extent possible without imposing costs wholly disproportionate to the environmental benefits. Adjudicated proceedings suggest harm should be measured in the context of "the species population in the area of impact" and should be measured in terms of absolute damage and percent damage. The degree of acceptable harm should also include consideration of short- and long-term impacts. Minimization of harm may be achieved by means other than alterations to intake structures. Changes in operational modes were required for the Anclote Plant and seasonal outages were evaluted as a part of the Hudson River Settlement Agreement. Within the context of negotiated settlements, stocking programs have been required in the John Sevier Steam Plant decision and the Hudson River Settlement Agreement.

Summary Statement: The objective of § 316(b) is minimization, not elimination, of impact.

Environmental Factors to be Considered

Section 316(b) determinations are made on a case-by-case basis and the factors listed below have been applied to various degrees in the decisions discussed in Appendix B. These factors are included as guidelines, not mandates.

- Whether the location, design, construction, and capacity of the intake structures minimize adverse environmental impacts

- General environmental effects of cooling towers (fogging, icing, noise, salt deposition, and aesthetics) or other alternative cooling technologies that might be required to accommodate a reduction in intake capacity
- Effects of entrainment and impingement including:
  - -- Decrease in abundance of threatened or endangered species
  - -- Increase in abundance of indigenous species
  - -- Decrease in abundance of indigenous species
  - -- Damage to critical aquatic organisms in the food chain
  - -- Change in population composition
  - -- Decrease in abundance of commercial or sport fish
- Temporal and spatial distribution of species
- Fish swimming capabilities
- Intake location with respect to spatial and temporal distribution of aquatic species
- Location of spawning areas in relation to the intake structures
- Ability of aquatic community to absorb the additional mortality caused by the intake structures
- The degree of certainty as to the nature and magnitude of measured or predicted impacts
- Dams and pools associated with intake structures.

It should be noted that because § 316(b) uses the term "cooling water intake structure", it does not authorize the imposition of a specific closed-cycle technology, such as cooling towers. However, § 316(b) authorizes limitations on the withdrawal of cooling water, the practical effect of which may be to require a closed-cycle system. Section 316(b) determinations are not dependent upon thermal limitations imposed under § 301 or § 316(a). An operator may be required to monitor intake structures through an NPDES permit condition.

Summary Statement: All factors that affect the probability of entrainment or impingement are appropriate for consideration under § 316(b) because it is through reductions in entrainment and impingement that the impacts of intake structures are minimized.

Cost/Benefit Considerations

The decision in In Re Public Service Co. of New Hampshire states that "best technology available" means "best technology commercially available at an economically practicable cost." Several decisions held that the costs of the "best technology available" should not be out of proportion to environmental gains that result. EPA recommended closed-cycle systems be required at Hudson River facilities after finding that the cost to consumers was not an "impracticable or unbearable" burden. Cost-benefit considerations are, therefore, appropriate under § 316(b). This does not mean, however, that a formal cost-benefit analysis is required. The cost of the § 316(b) technology which may be required is not limited to the dollar value of environmental benefits which can be shown to result from application of that technology.

Summary Statement: The proponent of an intake technology must demonstrate that the costs for that technology are not wholly disproportionate to the environmental benefits that are anticipated to result. A formal cost-benefit analysis is, however, not required because the environmental gains need not be quantified monetarily or equated to the costs on a dollar-for-dollar basis.

C. INTERRELATIONSHIP BETWEEN § 316(a) AND § 316(b)

Section 316(a) of CWA requires a compliance determination to assure that power plant operations do not adversely impact balanced, indigenous populations of shellfish, fish, and other wildlife in or on receiving water bodies. Entrainment and impingement impacts as well as discharge effects must be considered as a part of this compliance determination. Section 316(b) of CWA requires that entrainment and impingement impacts must be minimized by installation of the best available technology (BAT) for intake structures or modifications in plant operation practices. Under § 316(b) cooling water intake capacity may be restricted to levels lower than necessary to assure protection and propagation of balanced indigenous populations in receiving waters, so long as the resulting costs are not wholly disproportionate to the environmental benefits. The intake technology

required under 316(b) is the available technology that reduces plant impacts to the greatest possible degree where cost is not wholly disproportionate to ecological benefit.

Since the cooling water intake structure and capacity may affect the plant's ability to achieve thermal effluent limitations set under § 316(a), and vice versa, Section 316(a) and 316(b) determinations should be resolved on a consolidated basis whenever possible.

D. CONCLUSION

A review of the litigated decisions, administrative decisions, and Office of General Counsel opinions has resulted in the identification of a substantial number of decision-making criteria which can be applied to the § 316 Demonstration for the Oyster Creek NGS. The review has also identified principles of administrative law which guide the decision-making process. Of all these criteria, the single most important one for the decision-maker is the "substantial evidence" standard. As long as the § 316(a) determination is based upon substantial evidence, it is appropriate and should be upheld.

APPENDIX E

SECTION 316 EVALUATION CRITERIA FROM SOURCES OTHER THAN LITIGATED DECISIONS

APPENDIX E. SECTION 316 EVALUATION CRITERIA FROM SOURCES OTHER THAN LITIGATED DECISIONS

This appendix summarizes the results of a review of state and federal regulations, guidance manuals, and other documents to identify evaluation criteria, decision points, and procedures for making § 316(a) and § 316(b) determinations. This information was integrated with that contained in Appendix D to develop an evaluation methodology for determining the technical adequacy of the Oyster Creek 316 Demonstration and to determine the significance and consequences of plant operation on receiving waters. Most state regulations and/or water quality standards include criteria limiting the extent of thermal discharges (i.e., define an allowable thermal mixing zone). Only a few (e.g., Maryland and Michigan) contain criteria or procedures for determining the consequences of plant effects (i.e., impacts) upon receiving waters. The evaluation criteria, decision points, and review procedures provided in federal guidelines, manuals, and development documents, particularly EPA's § 316(a) and § 316(b) guidance manuals are generally used when making § 316 decisions.

A. SECTION 316(a)

Evaluation Criteria for § 316(a)

The evaluation criteria suggested by state and federal documents for use when making regulatory decisions pertaining to § 316(a) of the CWA are listed below. Specific references for these criteria include U.S. Environmental Protection Agency (1977a), U.S. Fish and Wildlife Service (1978), Maryland Department of Health and Mental Hygiene (1981), and Michigan Water Resources Commission (1975). These criteria require the owner/operator of the facility to demonstrate that:

- A shift toward nuisance phytoplankton or other nuisance biota has not or is not likely to occur
- The discharge has not altered the food web of the indigenous community
- Appreciable harm has not occurred to the balanced, indigenous populations composing the phytoplankton community

- Plant impacts on zooplankton and meroplankton do not result in appreciable harm to fish populations

- The heated discharge has not altered the standing crop or relative abundance of natural zooplankton and meroplankton populations relative to levels typical of natural populations in the receiving water body

- The thermal plume is not a lethal barrier to drifting organisms

- The heated discharge does not result in any deterioration of species that form habitats necessary for persistence of balanced, indigenous populations, including wetlands, submerged aquatic vegetation, macroalgae, shellfish, corals, and sponges

- The heated discharge does not have adverse impact upon threatened or endangered species

- No decline in the shellfish or macroinvertebrate standing crop that would affect higher trophic levels has occurred

- No impact has occurred upon economically important shellfish and macroinvertebrates on their spawning and nursery grounds

- No harm to fish results from cold shock or excess heat

- No reduction in the growth or reproductive success of fish or shellfish occurs as a result of thermal discharges

- No blockage to fish migration occurs

- Fish are not excluded from an excessively large area

- Adverse impact has not occurred to commercial or recreational fisheries

- Adverse impact has not occurred on fish spawning or nursery activities

- Other wildlife do not suffer appreciable harm from thermal discharges

- No adverse harm was found to beneficial uses of the receiving water body

- No adverse harm occurs to the life cycle of a RIS
- No significant change in the biological productivity of the receiving water body has occurred.

The decision criteria listed above appear to overstate the applicable standards under § 316(a), especially in cases where they imply no impact is allowed. Section 316(a) clearly allows impacts as long as they do not affect the maintenance or propagation of balanced, indigenous populations. Otherwise, these criteria appear to be in reasonable agreement with the legal precedents discussed in Appendix D.

Evidence Necessary Under § 316(a)

All of the guidence documents reviewed indicate that the information necessary to support a § 316(a) decision should:

- Represent a logical extension of the available information and be scientifically defendable
- When models are used they should be completely documented and sensitivity analyses should be provided.

In the Interagency § 316(a) Technical Guidance Manual (U.S. Environmental Protection Agency 1977a) a statement is made that a demonstration will be deemed successful if there is "no convincing evidence that there will be damage to the balanced, indigenous community." This statement is erroneous because it would allow a § 316(a) variance without affirmative evidence that the population will not be harmed. As noted earlier, the Administrative Procedure Act requires "substantial evidence" in adjudicatory proceedings. A variance may not be predicated upon the absence of evidence.

B. SECTION 316(b)

Evaluation criteria for § 316(b) decisions are poorly defined in state and federal regulations and guidance documents. The lack of specific evaluation criteria for making § 316(b) decisions is probably a result of the fact that no regulations for § 316(b) have been promulgated by EPA. In addition, § 316(b) has been interpreted to mean the monetary cost of alternate intake control technologies must not be wholly disproportionate to anticipated environmental gains. Making this determination does not, however, require quantification of the monetary value of environmental gains, as long as the nature of the anticipated benefit is clearly described. To date, no

state or federal agency has developed a valuation scheme for lost resources that is applicable to all potential power plant sites and is acceptable to all concerned parties (e.g., scientists, concerned public, natural resource managers, fisheries biologists, economists, industrialists, etc). Because no specific evaluation criteria or quantitative end points exists for § 316(b) decisions, the types of information state and federal agencies, particularly EPA, suggest should be considered in a § 316(b) determination are listed below. Specific references for these criteria include Environmental Protection Agency (1976, 1977b), U.S. Fish and Wildlife Service (1978), Maryland Department of Health and Mental Hygiene (1981), and Michigan Water Resources Commission (1975).

Section § 316(b) determinations should consider:

A detailed description of site characteristics (e.g., a description of the physical and chemical characteristics of the receiving water body), climate, other pollution sources in or on the water body, cooling water intake structures (e.g., water velocity at intake screens), pumps (e.g., rated capacity), biocides (e.g., types and amounts used), thermal exposure (e.g., magnitude and variability of the ΔT), engineering characteristics of internal plant structures (e.g, composition and size of condenser tubes), and plant operational data (e.g., age and expected facility life)

- General information on the biological characteristics of the receiving water body, including a determination of:

  -- The biological value of the zone of influence

  -- The location of spawning/breeding grounds, migratory pathways, and nursery and feeding habitats as they relate to the location of intake structures

  -- Abundance levels of important biota

  -- Critical life-cycle functions characteristic of the area

- Quantitative estimates of the environmental damage based on a number of years of data, including determination of the magnitude of losses. Loss estimates should include:

  -- The numbers of economically important biota, critical biota, and endangered species entrained and impinged under current and alternate technologies

-- The change in percent damage to populations of economically important biota, critical organisms, and endangered species resulting from reduction in entrainment and impingement.

- An assessment of the benefits of reducing indirect effects of entrainment and impingement losses to higher trophic levels

- The rationale and justification for the sampling design and assessment methodologies, including a characterization of the degree of variation and a list of analysis assumptions

- Projections of long-range environmental benefits due to the minimization of adverse environmental impact. This long-range assessment should include:

  -- A determination of source water involvement

  -- Estimates of the probability of entrainment

  -- Estimates of the damage to populations of economically important biota, critical organisms, and endangered species

  -- Determination of community level response patterns.

- Engineering and other information on the ability to reduce losses through changes in plant operating practices, intake flows and/or modifications to intake structures.

C. STEPS IN IMPLEMENTING A SUCCESSFUL § 316 DEMONSTRATION

Several federal and state guidance manuals (e.g., U.S. Fish and Wildlife Service 1978; Environmental Protection Agency 1977a, 1977b; Michigan Water Resources Commission 1975) detail the steps required for completion of a successful § 316 Demonstration (e.g., the granting of an NPDES permit). Based on this information and our experience with the review of § 316 Demonstration documents, we have listed the major steps in the process below:

- Identify major modes of power plant impacts based on site and plant characteristics

- Determine the potential for long-term impacts associated with each mode of impact

- Develop evaluation criteria and decision points to be used for the assessment
- Select and justify assessment methods
- Design and propose studies including definition of objectives, rationale, justification for study methods, and estimation of the probability of measuring change (i.e., power analyses)
- Have study designs and proposed analysis methods reviewed by appropriate state and federal regulatory and resource management agencies
- Modify study designs and proposed analysis methods based upon the comments from the review
- Conduct studies and provide state and federal regulatory and resource management agencies with status reports and results of interim findings
- Prepare a narrative, interpretive § 316 Demonstration document(s) that:

  -- Contain detailed study descriptions

  -- Summarize data including estimates of variation

  -- Characterize data

  -- Measure impacts and identify their causes

  -- Determine precision of impact estimates

  -- Predict the long-term consequences of impacts

  -- Identify modifications to intake structures or operating practices that minimize adverse effects and reduce impacts

  -- Determine and contrast the dollar costs (capital, operational, and other) and environmental benefits associated with each feasible mitigative alternative

  -- Identify intake control technologies that have dollar costs that are not disproportionate with the associated environmental gains likely to be realized

  -- Select the "best technology available" for reducing adverse impacts of intake structure and present the rationale and justification for this selection

-- Prepare a summary that lists the selected evaluation criteria and decision points, determines compliance with each criterion, explains judgements used for the compliance determination, lists major impacts and their long-term consequences, identifies mitigation alternatives for reducing impacts that have costs that are not disproportionate with environmental gains, and recommends alternative effluent limitations that assure the protection of the receiving water body

- Request an operating permit after submitting the above documentary support.

APPENDIX F

RELATIONSHIP BETWEEN § 316 AND ESTABLISHMENT OF WATER QUALITY STANDARDS

APPENDIX F. RELATIONSHIP BETWEEN § 316 AND ESTABLISHMENT OF WATER QUALITY STANDARDS

A. BACKGROUND INFORMATION

GPUN and JCP&L, operator/owner of the Oyster Creek NGS plant, have requested on numerous occasions over the past several decades that NJDEP evaluate the potential for modifying temperature water quality standards and designated uses in Oyster Creek independent of and prior to any action NJDEP may take in making a § 316(a) decision for the Oyster Creek NGS. The utility has stated that the basis for its request is that economic factors may be considered in a proceeding on modification of thermal water quality standards and designated uses for Oyster Creek, whereas economic factors are not a consideration during the § 316(a) decision-making process. The utility's legal staff believes § 316(a) decisions must be based exclusively on biological considerations. It thus appears that GPUN/JCP&L believe that they have a better chance of obtaining approval of once-through cooling system at the Oyster Creek NGS through procedures detailed under § 303(c) of the CWA, that establish and modify water quality standards, than they do under § 316(a) which regulates thermal discharges.

NJDEP has refused to convene a proceeding on modification of water quality standards in Oyster Creek separate from a § 316(a) proceedings for the Oyster Creek NGS. NJDEP's position is that both proceedings would involve similar issues and much of the technical information required to make the decision is contained in the Oyster Creek § 316 Demonstration documents. In addition, NJDEP has noted that holding two proceedings on what they feel is basically the same issue would substantially "complicate, confuse, and significantly delay" any regulatory actions under § 316. NJDEP believes that determination of appropriate water quality standards, designated uses, and effluent limitations for Oyster Creek will be the logical outcome of the review and evaluation process for the Oyster Creek § 316(a) Demonstration. In this chapter we discuss whether there is a legal basis for the utility's and/or NJDEP's positions.

B. THE STATUTORY FRAMEWORK

The CWA authorizes the discharge of pollutants, including thermal discharges, to be regulated pursuant to effluent limitations based on technology and/or water quality standards.

Technology-Based Effluent Limitations

Technology-based effluent limitations are adopted pursuant to §§ 301, 304, and 306 of the CWA. No generic technology-based effluent limitations have been promulgated for steam-electric power plants. Therefore, technology based effluent limitations for steam-electric plants must be developed on a case-by-case basis. The EPA General Counsel has held that in developing individualized NPDES permit conditions, the factors listed in § 304(b) must be considered - including "The age of the equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, nonwater quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate."

Water Quality-Based Effluent Limitations

In addition to technology-based effluent limitations, § 301(b)(1)(C) of the CWA requires compliance with "any more stringent limitation, including those necessary to meet water quality standards...established pursuant to any state law or regulation." Section 510 of the CWA (33 U.S.C. § 1370) provides states with the option of adopting and enforcing standards or effluent limitations which are more stringent than those required by the Act.

Water Quality Standards

Section 303(c) of the CWA requires states to adopt water quality standards. Section 303(c)(2) specifies that such standards shall "consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses. Such standards shall be such as to protect the public health or welfare, enhance the quality of water and shall be established use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation." EPA has promulgated regulations governing the adoption of water quality standards and criteria (40 CFR Part 131).

Section 303(d)(1)(B) requires states to identify those waters for which the technology-based controls on thermal discharges required by § 301 are not stringent enough to assure

"protection and propagation of a balanced indigenous population of shellfish, fish and wildlife." Section 303(d)(1)(D) then requires states to develop the total maximum daily thermal load required for protecting balanced, indigenous populations. In addition, § 303(g) specifies that: "Water quality standards relating to heat shall be consistent with the requirments of Section 316 of this Act." Similar language appears in NJDEP's water pollution control regulations [N.J.A.C. 7:9-4.10(g)].

Thermal Discharge Variances

As noted in discussions in previous appendices, § 316(a) of the CWA allows the owner/operator of facilities discharging heat an opportunity to demonstrate that "any effluent limitation proposed for the control of the thermal component...will require effluent limitations more stringent than necessary to assure the protection of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made...." The phrase "any effluent limitation" has been construed to include both technology and water quality-based effluent limitations [e.g., see the preamble to EPA's § 316(a) regulations, 39 Federal Register 36176 et set. at 36178 (October 8, 1974)].

C. ROLE OF ECONOMIC FACTORS IN ESTABLISHMENT AND REVISION OF THERMAL EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

Consideration of Economic Factors Under § 316(a)

Economic factors are a secondary, and minor, consideration in the § 316(a) variance process (refer to discussions in Appendices B and D). For example, the decision of EPA's General Counsel # 63 held that "economic considerations are not appropriate" under § 316(a). In addition, in the Wabash River and Cayuga Generating Stations decisions (NPDES Appeal #78-6, 1979) the Administrator noted "consideration of economic factors is only appropriate in setting the original thermal limitations from which the § 316(a) variance is sought on biological grounds."

Consideration of Economic Factors Under § 303

Section 303(c)(2) of the CWA states that the "use and value" of waters for water supply, fish, wildlife, recreation, agriculture, industry, and navigation should be considered in

setting and revising water quality standards. This language is sufficient to allow consideration of economics in the establishment of water quality standards and designated uses even though § 303 does not expressly authorize consideration of economics as a part of the process. The use, however, must be set at the fishable/swimmable standard unless removed according to 40 CFR § 131.10(g) [Mississippi v. Costle, 625 f. 2d 1269 (5th Cir., 1980)]. In addition, the regulations adopted by EPA to accomplish the goals of § 303 allow a designated use for a water body which is not an existing use to be removed, if attaining the designated use is not feasible because controls more stringent than those required by § 301(b) and § 305 would result in "substantial and widespread economic and social impact" [40 CFR § 131.10(g)]. NJDEP water quality regulations that define procedures for reclassifying segments of water bodies for less restrictive uses [N.J.A.C. 7:9-4.10(c)(7)] contains language identical to that in 40 CFR § 131.10(g). The economic effects to be considered as part of a demonstration of "substantial and widespread economic and social impact" are those which result incrementally from the imposition of effluent limitations more stringent than the technology-based limitations required by § 301(b). In other words, the issue of economics does not arise in establishing or revising water quality standards and designated uses unless the resulting standards require effluent limitations which are more restrictive than would be the case with technology-based effluent limitations. As previously noted, there are no generic § 301(b) effluent limitations for steam-electric plants. Therefore, the appropriate technology-based limitations for the Oyster Creek NGS will have to be established individually based on site-specific information (see page 2-11 of the Water Quality Standards Handbook; U.S. Environmental Protection Agency 1983).

It should be noted that states are allowed to incorporate variance procedures in their water quality standards (40 CFR § 131.13). Furthermore, EPA has approved variances in the past when the "substantial and widespread economic and social impact" standard was met (U.S. Environmental Protection Agency 1983).

Summary Statement

The extent to which economic factors may be considered in establishing or revising water quality standards under the "substantial and widespread economic impact" standard is limited because this standard requires much more than a simple demonstration of adverse economic impact (see page 1-8 of EPA's

Water Quality Standards Handbook; U.S. Environmental Protection Agency 1983). NJDEP and/or GPUN must demonstrate that achieving the designated use will have a substantial and widespread economic impact upon the community served by the utility causing such effects as closure of other industries and regional unemployment.

D. RELATIONSHIP BETWEEN § 316(a) AND OTHER SECTIONS OF THE CWA AS THEY RELATE TO THE ESTABLISHMENT OF WATER QUALITY STANDARDS

Language in § 303(g) of the CWA provides that: "Water quality standards relating to heat shall be consistent with the requirement of section 316 of this Act." Similar language appears in N.J.A.C. 7:9-4.10(g). This language may be construed in only one way; water quality standards may not allow thermal discharges which do not assure the protection of balanced, indigenous populations required under § 316(a). The rationale behind § 303(g) is to protect the integrity of the § 316(a) baseline and to preclude the establishment or revision of water quality standards which are inconsistent with § 316(a) and the protection of balanced, indigenous populations.

That § 316(a) is controlling for thermal discharges is further supported by an EPA Regional Counsel Opinion (Region VI) issued March 4, 1977. This opinion addresses a proposal by the State of Texas to revise water quality criteria for temperature in order to accommodate the construction of a power plant. The issue involving § 316(a) was stated as follows: "Can the State of Texas justify its proposed temperature downgrading on the basis of the effects of the proposed point source?" The Regional Counsel concluded that protecting a balanced, indigenous population was "the minimum requirement for standards relating to temperature." He further noted that § 316, rather than revision of water quality standards, is the "appropriate vehicle" for relief from thermal limitations.

E. CONCLUSION

Based on the above, we conclude that economic factors may be considered in revising water quality standards but may not be considered in evaluating a request for a § 316(a) variance. The burden of demonstrating that water quality standards should be revised because of economic factors is a substantial one, however, because "substantial and widespread adverse social and economic impact" must be shown to be the logical result of not revising water quality standards before such revisions can

be adopted. Most importantly, however, any water quality standard established for thermal discharges must be consistent with § 316(a). Revision of thermal water quality standards is not the appropriate vehicle for obtaining relief from thermal limitations, and the operation of the Oyster Creek NGS must provide for a balanced, indigenous population of shellfish, fish, and wildlife. NJDEP has, therefore, taken the appropriate position by refusing to convene proceedings on modifications of the thermal water quality standards for Oyster Creek separate from a § 316 proceeding for the Oyster Creek NGS. No support was found in the existing regulations and guidelines for the utility's request for convening a public hearing on water quality standards independent of the § 316(a) process. The question of whether operation of the Oyster Creek NGS protects the receiving water body to the degree required by the CWA will be resolved when NJDEP makes a § 316 decision for the Oyster Creek NGS and should be the logical result of applying the evaluation methodology discussed in Chapter II.

APPENDIX G

DETERMINATION OF RETROFIT COSTS AT THE OYSTER CREEK NUCLEAR GENERATING STATION

DETERMINATION OF RETROFIT COSTS
AT THE OYSTER CREEK NUCLEAR
GENERATING STATION

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Determination of Retrofit Costs
At the Oyster Creek Nuclear Generating Station

A. Introduction

This study evaluates the cost to utility ratepayers of seven retrofits to the Oyster Creek Nuclear Generating Station (OCNGS) plant. The engineering costs (i.e., costs of construction, installation and maintenance) were obtained from an earlier General Public Utilities Nuclear (GPUN) study or were supplied to us by Versar. These cost elements were then translated into changes in total company revenue requirements and electric rates. The implicit assumption is that all costs (i.e., revenue requirements) are fully recovered from ratepayers with no impact on shareholders.

The retrofits considered fall into two general categories -- those that modify water intake into the plant, and those that affect cooling water discharge. The latter are relatively expensive measures, while the former are much less costly. The cooling water modifications analyzed in this report are the four different approaches identified by GPUN as being the "preferred systems" out of 16 considered. These include a natural draft cooling tower, fan-assisted natural draft cooling towers, round mechanical draft cooling towers and an artificial discharge canal to Barnegat Bay. The three intake modifications, selected by Versar, are fine-mesh additions to existing intake screens; fine-mesh screens in front

.... pumps, and dual-flow screens in front of dilution pumps.

A separate cost impact analysis was undertaken for each of the seven retrofits. That is, for costing purposes, each was treated on a stand-alone basis as if it is the only modification to the plant. If more than one modification is made, for example, construction of a cooling tower along with fine-mesh intake screens, the separate cost impacts should be additive.

B. Description of the Costing Analysis

In order to conduct the analysis, cost impacts were placed into the following categories: (a) rate base; (b) power replacement costs; and (c) other operations and maintenance (O&M) expenses. Annual review requirements values are computed in each category, and the total annual revenue requirement (for a given retrofit) is simply the sum of these three components. It is assumed that each retrofit will enter service in 1990 and will remain in service until the retirement of OCNGS, currently planned by GPUN as 2004. This is a 15-year time period. Recent trends in the electric utility industry have been to extend plant lives beyond planned retirement dates. To incorporate that possibility, a second retirement date of 2014 has been assumed, which results in a 25-year service life for the retrofits (i.e., 1990-2014).

The most complex part of the analysis involves revenue requirement impacts related to changes in rate base. The rate base consists of construction and installation expenditures plus any interest accruals during the construction period (referred to as allowance for funds used during construction, or AFUDC). Although these figures were supplied to us either from the earlier GPUN report or Versar, it was necessary to use inflation adjustment factors to reflect a 1990 in-service date. The GPUN report provided direct costs in 1976 dollars and indirect costs in (estimated) 1984 dollars. We escalated both to end-of-year 1986 dollars using the actually experienced GNP implicit price deflator. The figures were then further inflated to 1990 using an assumed 5 percent per year escalation factor. According to the GPUN report, the indirect cost estimates are inclusive of any AFUDC, so no separate analysis of that factor is needed.

The Versar construction cost data for the intake modifications are in 1987 dollars, which we escalated to 1990 using the 5 percent per year escalation rate. It was assumed that installation could be accomplished in a relatively short amount of time, and therefore no AFUDC would be applied. In other words, the rate base value is equal to the construction expenditure.

These calculations produced the following initial rate base values for 1990, in millions of dollars:

<u>Discharge/Cooling Measures</u>

(1)	Discharge Canal to Bay	$40.4 million
(2)	Fan-Assisted Cooling Towers	70.6
(3)	Mechanical Draft Round Cooling Towers	68.6
(4)	Natural Draft Cooling Towers	74.0

<u>Intake Measures</u>

(1)	Fine-mesh additions	0.107
(2)	Fine-mesh screens for dilution pumps	1.505
(3)	Dual-flow screens for dilution pumps	4.75

As this shows, the discharge/cooling measures result in a larger initial rate base by at least an order of magnitude.

Given the initial rate base, a series of complex accounting calculations must be performed to determine the year-by-year revenue requirements which enable the Company to recover its investment and earn a return on the unrecovered portion of the investment. For this purpose, a computerized accounting model, developed in-house by Exeter, was employed. This model is the Utility Cost Analysis Model (UCAM). The model takes as input the initial year rate base (or stream of capital expenditures), along with a series of financial parameters, and calculates the year-by-year and total life time revenue requirements.

In order to run the model, it is necessary to specify some key ratemaking and financial assumptions. These assumptions were either supplied to us by GPUN in response to a data request* or determined by judgement (or both). The principal assumptions are listed on Table 1 below.

With regard to rate of return, capitalization data were extracted from the Jersey Central Power & Light Company's (JCP&L) latest rate order from the New Jersey Board of Public Utilities (NJBPU) dated May 30, 1986. However, the capital costs from that rate order were not used for two reasons. First, those costs are "embedded" rather than "incremental" as this analysis requires. Second, they are out of date. Cost rates more representative of current capital market conditions resulted in an overall incremental rate of return of 11.29 percent.

For convenience, this figure was also used as the consumer discount rate, although arguments could certainly be made for using alternative figures. It is important to note that the consumer discount rate need not equal the utility's incremental cost of capital. It may be either be higher or lower depending upon a number of judgemental factors considered.

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*Response accompanying letter to Mr. Richard R. Delgado (N.J. Department of Environmental Protection from Mr. Michael B. Roche (GPU Nuclear Corporation), January 15, 1988.

Financial Assumptions Employed in Modeling Rate Base-Related Revenue Requirements

Rate of Return

Type	Balance	% of Total	Cost	Weighted Cost
Long Term Debt	$775,832	43.02%	10.00%	4.30%
Preferred Stock	191,250	10.60	9.00	0.95
Common Stock	836,465	46.38	13.00	6.03
Total	$1,803,547	100.00	–	11.29%

Taxes

Federal Income	34%
State Income	0
Property tax (of rate base)	1
Gross receipts and add-on taxes	0

Depreciation

Book - straight line 15 or 25 years

Tax - 15-year MACRS method

Other

Insurance assumed to equal 1% of rate base

Discount rate equals 11.29%

AFUDC accounting

receipts and franchise taxes are omitted. The Company estimates this to be 13.16 percent of 1987 revenue. In our judgement, this should be excluded from the analysis for two reasons. First, no such taxes have been included on the benefit side of the analysis, so its exclusion here is merely one of consistency. Second, these taxes are not a "cost" to New Jersey as a whole. They are merely transfer payments from ratepayers to taxpayers. That is, the state and local governments also have "revenue requirements". If ratepayers pay more taxes through a gross receipts tax, then presumably they pay dollar-for-dollar less in other forms of taxes. The ultimate effect is neutral. However, the reader may easily incorporate these taxes if he so chooses by multiplying any revenue impact figure presented in this report by 1.1316.

The second category of costs involves replacement power. This cost is incurred because the retrofit reduces plant efficiency and therefore power output must be replaced. It is assumed that only the four discharge/cooling retrofits affect plant efficiency, and therefore this category of costs was ignored for the intake measures.*

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*This assumption is not strictly true, but the replacement power cost for the intake retrofits is very small and for convenience is simply included in the other O&M category.

energy and capa-

city, with the penalties shown below as estimated by GPUN:

	Capacity (MW)	Demand Energy (thousands MWh)
(1) Discharge Canal to Bay	1.6	8.4
(2) Fan-Assisted Cooling Tower	23.3	120.9
(3) Round Mechanical Draft Cooling Tower	20.4	107.2
(4) Natural Draft Cooling Cooling Tower	21.3	112.0

For the discharge canal, the penalty is very small, but for the three cooling tower options, it is a significant cost.

The energy penalty was estimated for initial year 1990 using Jersey Central's latest projection of its avoided energy cost, $31.60 per MWh. After 1990, Jersey Central projects extremely rapid rates of increase, nearly 10 percent per year. Instead of using those projections, which depend upon some very speculative fuel cost assumptions, it was assumed that the avoided cost per MWh would increase by 7.0 percent per year after 1990.

On the capacity side, a combustion turbine was used as the lowest cost method of replacing the lost capacity. In a separate analysis, the levelized cost of a combustion turbine entering service in 1990 was found to be $60 per kW per year. Since this is a levelized figure, no escalation is needed. The analysis also assumes that Jersey Central actually needs capacity in 1990.

a plant shut down for installation. Any installation can be handled during a refueling or other scheduled outage. If this is not the case, then significant additional costs will be incurred. GPUN's own study also assumed that no additional plant down time would result from installation.

The final category of costs, other than O&M, is a relatively small one. It includes any on-going periodic labor, water purchases, chemicals and other expenses. GPUN's earlier report contained estimates of annual O&M costs for the discharge/cooling options, and Versar provided the costs for the intake measures. The data provided were escalated to 1990 using the same escalation procedure as used for rate base. After 1990, a 5 percent per year escalation factor was used. Shown below are the estimated 1990 O&M costs for the seven items, in millions of dollars:

Discharge/Cooling	
(1) Discharge Canal to Bay	$ 0.6
(2) Fan Assisted Natural Draft Cooling Towers	1.1
(3) Round Mechanical Draft Cooling Towers	1.1
(4) Natural Draft Cooling Towers	0.9
Intake	
(1) Fine-mesh additions	0.0
(2) Fine-mesh screens in front of dilution pumps	0.063
(3) Dual flow screens in front of dilution pumps	0.074

Once again, the costs associated with the in-take measures are substantially smaller than those related to discharge/cooling systems.

C. The Cost Results

The three categories of costs are computed, as described above, for each of the seven retrofits. In each case, two scenarios were used, a 15-year and a 25-year service life. In the appendix to this chapter, separate tables are provided which list in year-by-year fashion the capital (i.e., rate base) related charges, replacement capacity and energy and other O&M. These columns are summed together in the total revenue requirements column and then divided by Jersey Central's total sales projections for each year to obtain the impact on a per kWh basis. Both the total and per kWh impacts are discounted using the 11.29 percent rate of return to obtain discounted present values (with 1990 being "the present"). Finally, both lifetime total and average annual impacts are presented at the bottom of each table.

The information contained in the 14 tables is summarized for convenience on Tables 2 and 3, for the 15- and 25-year service lives, respectively. As both tables demonstrate, there is a dramatic difference between the cost impacts of the intake modification measures versus those of the discharge/cooling measures. For 15 years, the lifetime revenue requirements for the intake measures ranges from $234,000

Table 2

Summary of the Rate Impacts of
OCNGS Retrofits - 15-Year Service Life
(Thousands dollar)

Retrofit	Lifetime Revenue Requirements		Ave. Annual Revenue Requirement		Average Rate Impact (¢/KWh)	
	Actual	Discounted	Actual	Discounted	Actual	Discounted
Discharge/Cooling						
(1) Discharge Canal	$109,533	$ 62,913	$ 7,302	$ 4,194	0.04¢	0.024¢
(2) Fan-Assisted Cooling Towers	295,354	158,968	19,690	10,598	0.107	0.059
(3) Round Mech. Draft Cooling Towers	277,455	149,959	18,497	9,997	0.100	0.056
(4) Natural Draft Cooling Towers	289,587	157,149	19,306	10,477	0.105	0.059
Intake						
(1) Fine-Mesh Additions	234	140	16	9	0.0001	0.0001
(2) Fine-Mesh for dilution pumps	4,655	2,620	310	175	0.002	0.001
(3) Dual Flow screens for dilution pumps	11,999	6,983	800	466	0.004	0.003

Table 3

Summary of the Rate Impacts of
OCNGS Retrofits - 25-Year Service Life
(Thousands dollar)

Retrofit	Lifetime Revenue Requirements		Ave. Annual Revenue Requirement		Average Rate Impact (¢/KWh)	
	Actual	Discounted	Actual	Discounted	Actual	Discounted
Discharge/Cooling						
(1) Discharge Canal	$157,673	$ 66,147	$ 6,307	$ 2,646	0.032¢	0.015¢
(2) Fan-Assisted Cooling Towers	521,100	182,086	20,253	7,283	0.103	0.039
(3) Round Mech. Draft Cooling Towers	483,881	170,829	19,355	6,833	0.096	0.037
(4) Natural Draft Cooling Towers	499,961	178,135	19,998	7,125	0.099	0.039
Intake						
(1) Fine-Mesh Additions	291	140	12	6	0.0001	0.000
(2) Fine-Mesh for dilution pumps	7,099	2,822	284	113	0.0014	0.0006
(3) Dual Flow screens for dilution pumps	16,447	7,214	658	289	0.0034	0.0016

$295 million for the discharge/cooling modifications, a dramatic difference.

It is also useful to note the effects of these retrofits on Jersey Central's electric rates. The overall average rate increase would be 0.0001 cents per kWh to 0.004 cents for the intake modifications to 0.04 to 0.107 cents per kWh for the discharge/cooling measures. By way of comparison, Jersey Central's rates to its retail and wholesale customers averaged 9.5 cents per kWh in 1985, according to its Annual Report (Form 1) filed with the Federal Energy Regulatory Commission (FERC). To put this in perspective, for a typical residential customer consuming 10,000 kWh per year (i.e., 833 kWh per month), the intake measures increase the average monthly bill by 0.08 cents to 3.3 cents for the intake measures and 33.3 cents to 89.2 cents for the discharge/cooling measures. (This assumes that these costs would be allocated among customer classes on the basis of energy usage.) These figures indicate that the most expensive retrofit (fan-assisted cooling towers) would increase electric rates by about 1.1 percent.

The total lifetime cost impacts increase substantially using the 25-year life. This is because the depreciation period is longer and thus additional carrying costs related to the investment would be incurred. Also, the O&M and replacement power costs extend (and are escalated) over the

cost impact increases as the service life increases, the cost per KWh does not. In fact, it decreases slightly.

Tables 2 and 3 also provide the cost impacts on a present value discounted basis. These results are particularly useful for making comparisons among the retrofit alternatives and for comparing costs with benefits. This is because discounting corrects for timing differences. That is, the "actuals" are the estimated impacts that ratepayers actually observe, but the discounted present values should be used for making cost versus benefit comparisons.

The reader is referred to the appendix to this chapter for year-by-year results and the details of each cost component.

APPENDIX

Detailed Cost Impact Results

TABLE A-1(a)

REVENUE REQUIREMENT OF DISCHARGE CANAL TO BAY - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 8968.8	$ 96	$ 600.00	$ 265.44	$ 9930.24	16311	0.061 ¢	$ 9930.24	0.061 ¢
1991	8524.4	96	630.00	284.02	9534.42	16590	0.057	8567.19	0.052
1992	8039.6	96	661.50	303.90	9101.00	16967	0.054	7348.13	0.043
1993	7554.8	96	694.58	325.18	8670.55	17326	0.050	6290.40	0.036
1994	7110.4	96	729.30	347.94	8283.64	17693	0.047	5400.04	0.031
1995	6706.4	96	765.77	372.29	7940.46	18037	0.044	4651.20	0.026
1996	6262.0	96	804.06	398.35	7560.41	18381	0.041	3979.32	0.022
1997	5858.0	96	844.26	426.24	7224.50	18713	0.039	3416.76	0.018
1998	5454.0	96	886.47	456.08	6892.55	19006	0.036	2929.08	0.015
1999	5050.0	96	930.80	488.00	6564.80	19325	0.034	2506.78	0.013
2000	4605.6	96	977.34	522.16	6201.10	19634	0.032	2127.68	0.011
2001	4201.6	96	1026.20	558.71	5882.52	19940	0.030	1813.62	0.009
2002	3797.6	96	1077.51	597.82	5568.94	20249	0.028	1542.76	0.008
2003	3393.6	96	1131.39	639.67	5260.66	20560	0.026	1309.51	0.006
2004	2949.2	96	1187.96	684.45	4917.61	20873	0.024	1099.94	0.005
TOTALS	88476.0	1440	12947.14	6670.25	109533.39	279605	0.040	62912.64	0.024
AVERAGE	5898.4	96	863.14	444.68	7302.23	18640.33	0.040	4194.18	0.024

TABLE A-1(b)

REVENUE REQUIREMENT OF DISCHARGE CANAL TO BAY - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 7918.4	$ 96	$ 600.00	$ 265.44	$ 8879.84	16311	0.054 ¢	$ 8879.84	0.054 ¢
1991	7595.2	96	630.00	284.02	8605.22	16590	0.052	7732.25	0.047
1992	7231.6	96	661.50	303.90	8293.00	16967	0.049	6695.75	0.039
1993	6908.4	96	694.58	325.18	8024.15	17326	0.046	5821.44	0.034
1994	6544.8	96	729.30	347.94	7718.04	17693	0.044	5031.33	0.028
1995	6262.0	96	765.77	372.29	7496.06	18037	0.042	4390.89	0.024
1996	5938.8	96	804.06	398.35	7237.21	18381	0.039	3809.21	0.021
1997	5656.0	96	844.26	426.24	7022.50	18713	0.038	3321.23	0.018
1998	5332.8	96	886.47	456.08	6771.35	19006	0.036	2877.57	0.015
1999	5050.0	96	930.80	488.00	6564.80	19325	0.034	2506.78	0.013
2000	4726.8	96	977.34	522.16	6322.30	19634	0.032	2169.27	0.011
2001	4444.0	96	1026.20	558.71	6124.92	19940	0.031	1888.35	0.009
2002	4120.8	96	1077.51	597.82	5892.14	20249	0.029	1632.30	0.008
2003	3838.0	96	1131.39	639.67	5705.06	20560	0.028	1420.14	0.007
2004	3555.2	96	1187.96	684.45	5523.61	20873	0.026	1235.48	0.006
2005	3272.4	96	1247.36	732.36	5348.11	21188	0.025	1074.88	0.005
2006	3070.4	96	1309.72	783.62	5259.75	21508	0.024	949.88	0.004
2007	2908.8	96	1375.21	838.48	5218.49	21829	0.024	846.82	0.004
2008	2706.8	96	1443.97	897.17	5143.94	22155	0.023	750.04	0.003
2009	2545.2	96	1516.17	959.97	5117.34	22485	0.023	670.47	0.003
2010	2383.6	96	1591.98	1027.17	5098.75	22821	0.022	600.26	0.003
2011	2222.0	96	1671.58	1099.07	5088.65	23162	0.022	538.30	0.002
2012	2060.4	96	1755.16	1176.01	5087.56	23507	0.022	483.59	0.002
2013	1858.4	96	1842.91	1258.33	5055.64	23858	0.021	431.80	0.002
2014	1696.8	96	1935.06	1346.41	5074.27	24214	0.021	389.43	0.002
TOTALS	109847.6	2400	28636.26	16788.82	157672.68	506332	0.032	66147.28	0.015
AVERAGE	4393.9	96	1145.45	671.55	6306.91	20253.28	0.032	2645.89	0.015

TABLE A-2(a)

REVENUE REQUIREMENT OF FAN-ASSISTED NATURAL DRAFT COOLING TOWER - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 15673.2	$ 1400	$ 1100.00	$ 3820.44	$ 21993.64	16311	0.135 ¢	$ 21993.64	0.135 ¢
1991	14896.6	1400	1155.00	4087.87	21539.47	16590	0.130	19354.36	0.117
1992	14049.4	1400	1212.75	4374.02	21036.17	16967	0.124	16984.56	0.100
1993	13202.2	1400	1273.39	4680.20	20555.79	17326	0.119	14913.03	0.086
1994	12425.6	1400	1337.06	5007.82	20170.47	17693	0.114	13148.96	0.074
1995	11719.6	1400	1403.91	5358.36	19881.87	18037	0.110	11646.00	0.065
1996	10943.0	1400	1474.11	5733.45	19550.56	18381	0.106	10290.16	0.056
1997	10237.0	1400	1547.81	6134.79	19319.60	18713	0.103	9137.03	0.049
1998	9531.0	1400	1625.20	6564.23	19120.43	19006	0.101	8125.47	0.043
1999	8825.0	1400	1706.46	7023.72	18955.18	19325	0.098	7238.07	0.037
2000	8048.4	1400	1791.78	7515.38	18755.57	19634	0.096	6435.30	0.033
2001	7342.4	1400	1881.37	8041.46	18665.23	19940	0.094	5754.61	0.029
2002	6636.4	1400	1975.44	8604.36	18616.20	20249	0.092	5157.24	0.025
2003	5930.4	1400	2074.21	9206.67	18611.28	20560	0.091	4632.83	0.023
2004	5153.8	1400	2177.92	9851.14	18582.86	20873	0.089	4156.49	0.020
TOTAL	154614.0	21000	23736.42	96003.92	295354.34	279605	0.107	158967.76	0.059
AVERAGE	10307.6	1400	1582.43	6400.26	19690.29	18640.33	0.107	10597.85	0.059

TABLE A-2(b)

REVENUE REQUIREMENT OF FAN-ASSISTED NATURAL DRAFT COOLING TOWER - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 13837.6	$ 1400	$ 1100.00	$ 3820.44	$ 20158.04	16311	0.124 ¢	$ 20158.04	0.124 ¢
1991	13272.8	1400	1155.00	4087.87	19915.67	16590	0.120	17895.29	0.108
1992	12637.4	1400	1212.75	4374.02	19624.17	16967	0.116	15844.52	0.093
1993	12072.6	1400	1273.39	4680.20	19426.19	17326	0.112	14093.51	0.081
1994	11437.2	1400	1337.06	5007.82	19182.07	17693	0.108	12504.63	0.071
1995	10943.0	1400	1403.91	5358.36	19105.27	18037	0.106	11191.09	0.062
1996	10378.2	1400	1474.11	5733.45	18985.76	18381	0.103	9992.89	0.054
1997	9884.0	1400	1547.81	6134.79	18966.60	18713	0.101	8970.08	0.048
1998	9319.2	1400	1625.20	6564.23	18908.63	19006	0.099	8035.46	0.042
1999	8825.0	1400	1706.46	7023.72	18955.18	19325	0.098	7238.07	0.037
2000	8260.2	1400	1791.78	7515.38	18967.37	19634	0.097	6507.97	0.033
2001	7766.0	1400	1881.37	8041.46	19088.83	19940	0.096	5885.21	0.030
2002	7201.2	1400	1975.44	8604.36	19181.00	20249	0.095	5313.71	0.026
2003	6707.0	1400	2074.21	9206.67	19387.88	20560	0.094	4826.15	0.023
2004	6212.8	1400	2177.92	9851.14	19641.86	20873	0.094	4393.36	0.021
2005	5718.6	1400	2286.82	10540.71	19946.14	21188	0.094	4008.82	0.019
2006	5365.6	1400	2401.16	11278.56	20445.33	21508	0.095	3692.29	0.017
2007	5083.2	1400	2521.22	12068.06	21072.48	21829	0.097	3419.49	0.016
2008	4730.2	1400	2647.28	12912.83	21690.31	22155	0.098	3162.68	0.014
2009	4447.8	1400	2779.65	13816.73	22444.17	22485	0.100	2940.61	0.013
2010	4165.4	1400	2918.63	14783.90	23267.92	22821	0.102	2739.27	0.012
2011	3883.0	1400	3064.56	15818.77	24166.33	23162	0.104	2556.42	0.011
2012	3600.6	1400	3217.79	16926.08	25144.47	23507	0.107	2390.05	0.010
2013	3247.6	1400	3378.68	18110.91	26137.19	23858	0.110	2232.38	0.009
2014	2965.2	1400	3547.61	19378.67	27291.48	24214	0.113	2094.59	0.009
TOTAL	191961.4	35000	52499.81	241639.15	521100.36	506332.0	0.103	182086.49	0.039
AVERAGE	7678.5	1400	2099.99	9665.57	20844.01	20253.28	0.103	7283.46	0.039

TABLE A-3(a)

REVENUE REQUIREMENT OF ROUND MECHANICAL DRAFT COOLING TOWER - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 15229.2	$ 1224	$ 1100.00	$ 3387.52	$ 20940.72	16311	0.128 ¢	$ 20940.72	0.128 ¢
1991	14474.6	1224	1155.00	3624.65	20478.25	16590	0.123	18400.80	0.111
1992	13651.4	1224	1212.75	3878.37	19966.52	16967	0.118	16120.93	0.095
1993	12828.2	1224	1273.39	4149.86	19475.45	17326	0.112	14129.25	0.082
1994	12073.6	1224	1337.06	4440.35	19075.00	17693	0.108	12434.84	0.070
1995	11387.6	1224	1403.91	4751.17	18766.68	18037	0.104	10992.76	0.061
1996	10633.0	1224	1474.11	5083.75	18414.86	18381	0.100	9692.40	0.053
1997	9947.0	1224	1547.81	5439.62	18158.43	18713	0.097	8587.87	0.046
1998	9261.0	1224	1625.20	5820.39	17930.59	19006	0.094	7619.83	0.040
1999	8575.0	1224	1706.46	6227.82	17733.28	19325	0.092	6771.48	0.035
2000	7820.4	1224	1791.78	6663.76	17499.95	19634	0.089	6004.48	0.031
2001	7134.4	1224	1881.37	7130.23	17370.00	19940	0.087	5355.28	0.027
2002	6448.4	1224	1975.44	7629.34	17277.18	20249	0.085	4786.29	0.024
2003	5762.4	1224	2074.21	8163.40	17224.01	20560	0.084	4287.50	0.021
2004	5007.8	1224	2177.92	8734.84	17144.56	20873	0.082	3834.78	0.018
TOTALS	150234.0	18360	23736.42	85125.06	277455.48	279605	0.100	149959.21	0.056
AVERAGE	10015.6	1224	1582.43	5675.00	18497.03	18640.33	0.100	9997.28	0.056

TABLE A-3(b)

REVENUE REQUIREMENT OF ROUND MECHANICAL DRAFT COOLING TOWER - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 13445.6	$ 1224	$ 1100.00	$ 3387.52	$ 19157.12	16311	0.117 ¢	$ 19157.12	0.117 ¢
1991	12896.8	1224	1155.00	3624.65	18900.45	16590	0.114	16983.06	0.102
1992	12279.4	1224	1212.75	3878.37	18594.52	16967	0.110	15013.18	0.088
1993	11730.6	1224	1273.39	4149.86	18377.85	17326	0.106	13332.95	0.077
1994	11113.2	1224	1337.06	4440.35	18114.60	17693	0.102	11808.76	0.067
1995	10633.0	1224	1403.91	4751.17	18012.08	18037	0.100	10550.75	0.058
1996	10084.2	1224	1474.11	5083.75	17866.06	18381	0.097	9403.55	0.051
1997	9604.0	1224	1547.81	5439.62	17815.43	18713	0.095	8425.65	0.045
1998	9055.2	1224	1625.20	5820.39	17724.79	19006	0.093	7532.38	0.040
1999	8575.0	1224	1706.46	6227.82	17733.28	19325	0.092	6771.48	0.035
2000	8026.2	1224	1791.78	6663.76	17705.75	19634	0.090	6075.09	0.031
2001	7546.0	1224	1881.37	7130.23	17781.60	19940	0.089	5482.18	0.027
2002	6997.2	1224	1975.44	7629.34	17825.99	20249	0.088	4938.33	0.024
2003	6517.0	1224	2074.21	8163.40	17978.61	20560	0.087	4475.34	0.022
2004	6036.8	1224	2177.92	8734.84	18173.56	20873	0.087	4064.94	0.019
2005	5556.6	1224	2286.82	9346.27	18413.70	21188	0.087	3700.83	0.017
2006	5213.6	1224	2401.16	10000.51	18839.28	21508	0.088	3402.25	0.016
2007	4939.2	1224	2521.22	10700.55	19384.97	21829	0.089	3145.65	0.014
2008	4596.2	1224	2647.28	11449.59	19917.07	22155	0.090	2904.12	0.013
2009	4321.8	1224	2779.65	12251.06	20576.50	22485	0.092	2695.91	0.012
2010	4047.4	1224	2918.63	13108.63	21298.66	22821	0.093	2507.43	0.011
2011	3773.0	1224	3064.56	14026.24	22087.80	23162	0.095	2336.54	0.010
2012	3498.6	1224	3217.79	15008.07	22948.46	23507	0.098	2181.32	0.009
2013	3155.6	1224	3378.68	16258.64	23816.92	23858	0.100	2034.20	0.009
2014	2881.2	1224	3547.61	17182.74	24835.55	24214	0.013	1906.02	0.008
TOTAL	186523.4	30600	52499.81	214257.38	483880.59	506332	0.096	170829.02	0.037
AVERAGE	7460.9	1224	2099.99	8570.30	19355.22	20253.28	0.096	6833.16	0.037

TABLE A-4(a)

REVENUE REQUIREMENT OF NATURAL DRAFT COOLING TOWER - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 16428.0	$ 1278	$ 900.00	$ 3539.20	$ 22145.20	16311	0.136 ¢	$ 22145.20	0.136 ¢
1991	15614.0	1278	945.00	3786.94	21623.94	16590	0.130	19430.27	0.117
1992	14726.0	1278	992.25	4052.03	21048.28	16967	0.124	16994.34	0.100
1993	13838.0	1278	1041.86	4335.67	20493.53	17326	0.118	14867.86	0.086
1994	13024.0	1278	1093.96	4639.17	20035.12	17693	0.113	13060.73	0.074
1995	12284.0	1278	1148.65	4963.91	19674.56	18037	0.109	11524.56	0.064
1996	11470.0	1278	1206.09	5311.38	19265.47	18381	0.105	10140.11	0.055
1997	10730.0	1278	1266.39	5683.18	18957.57	18713	0.101	8965.81	0.048
1998	9990.0	1278	1329.71	6081.00	18678.71	19006	0.098	7937.76	0.042
1999	9250.0	1278	1396.20	6506.67	18430.87	19325	0.095	7037.86	0.036
2000	8436.0	1278	1466.01	6962.14	18142.15	19634	0.092	6224.83	0.032
2001	7696.0	1278	1539.31	7449.49	17962.80	19940	0.090	5538.04	0.028
2002	6956.0	1278	1616.27	7970.96	17821.23	20249	0.088	4937.01	0.024
2003	6216.0	1278	1697.08	8528.92	17720.01	20560	0.086	4410.97	0.021
2004	5402.0	1278	1781.94	9125.95	17587.89	20873	0.084	3933.94	0.019
TOTAL	162060.0	19170	19420.71	88536.63	289587.34	279605	0.105	157149.29	0.059
AVERAGE	10804.0	1278	1294.71	5929.11	19305.82	18640.33	0.105	10476.62	0.059

TABLE A-4(b)

REVENUE REQUIREMENT OF NATURAL DRAFT COOLING TOWER - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	REPLACEMENT CAPACITY COSTS	OPERATION & MAINTENANCE COSTS	REPLACEMENT ENERGY COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 14504.0	$ 1278	$ 900.00	$ 3539.20	$ 20221.20	16311	0.124 ¢	$ 20221.20	0.124 ¢
1991	13912.0	1278	945.00	3786.94	19921.94	16590	0.120	17900.93	0.108
1992	13246.0	1278	992.25	4052.03	19568.28	16967	0.115	15799.39	0.093
1993	12654.0	1278	1041.86	4335.67	19309.53	17326	0.111	14008.88	0.081
1994	11988.0	1278	1093.96	4639.17	18999.12	17693	0.107	12385.37	0.070
1995	11470.0	1278	1148.65	4963.91	18860.56	18037	0.105	11047.75	0.061
1996	10878.0	1278	1206.09	5311.38	18673.47	18381	0.102	9828.52	0.053
97	10360.0	1278	1266.39	5683.18	18587.57	18713	0.099	8790.83	0.047
98	9768.0	1278	1329.71	6081.00	18456.71	19006	0.097	7843.42	0.041
99	9250.0	1278	1396.20	6506.67	18430.87	19325	0.095	7037.86	0.036
2000	8658.0	1278	1466.01	6962.14	18364.15	19634	0.094	6301.00	0.032
2001	8140.0	1278	1539.31	7449.49	18406.80	19940	0.092	5674.93	0.028
2002	7548.0	1278	1616.27	7970.96	18413.23	20249	0.091	5101.01	0.025
2003	7030.0	1278	1697.08	8528.92	18534.01	20560	0.090	4613.60	0.022
2004	6512.0	1278	1781.94	9125.95	18697.89	20873	0.090	4182.22	0.020
2005	5994.0	1278	1871.04	9764.76	18907.80	21188	0.089	3800.13	0.018
2006	5624.0	1278	1964.59	10448.30	19314.89	21508	0.090	3488.14	0.016
2007	5328.0	1278	2062.82	11179.68	19848.50	21829	0.091	3220.87	0.015
2008	4958.0	1278	2165.96	11962.26	20364.21	22155	0.092	2969.32	0.013
2009	4662.0	1278	2274.26	12799.61	21013.87	22485	0.093	2753.21	0.012
2010	4366.0	1278	2387.97	13695.59	21727.56	22821	0.095	2557.93	0.011
2011	4070.0	1278	2507.37	14654.28	22509.64	23162	0.097	2381.17	0.010
2012	3774.0	1278	2632.73	15680.08	23364.81	23507	0.099	2220.89	0.009
2013	3404.0	1278	2764.37	16777.68	24224.05	23858	0.102	2068.58	0.009
2014	[illegible]	1278	2910.39	17352.12	[illegible]	24214	0.104	1937.11	0.008
TOTAL	201206.0	31950	42954.39	223850.99	499961.38	506332.00	0.099	178134.64	0.039
AVERAGE	8048.2	1278	1718.18	8954.04	19998.46	20253.28	0.099	7125.39	0.039

TABLE A-5(a)

REVENUE REQUIREMENT OF FINE MESH ADDITIONS TO EXISTNG SCREENS - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 23.8	$ 0.00	$ 23.75	16311	0.00015 ¢	$ 23.75	0.00015 ¢
1991	22.6	0.00	22.58	16590	0.00014	20.29	0.00012
1992	21.3	0.00	21.29	16967	0.00013	17.19	0.00010
1993	20.0	0.00	20.01	17326	0.00012	14.52	0.00008
'94	18.8	0.00	18.83	17693	0.00011	12.28	0.00007
95	17.8	0.00	17.76	18037	0.00010	10.40	0.00006
1996	16.6	0.00	16.59	18381	0.00009	8.73	0.00005
1997	15.5	0.00	15.52	18713	0.00008	7.34	0.00004
1998	14.4	0.00	14.45	19006	0.00008	6.14	0.00003
1999	13.4	0.00	13.38	19325	0.00007	5.11	0.00003
2000	12.2	0.00	12.20	19634	0.00006	4.19	0.00002
2001	11.1	0.00	11.13	19940	0.00006	3.43	0.00002
2002	10.1	0.00	10.06	20249	0.00005	2.79	0.00001
2003	9.0	0.00	8.99	20560	0.00004	2.24	0.00001
2004	7.8	0.00	7.81	20873	0.00004	1.75	0.00001
TOTAL	234.3	0.00	234.23	279605	0.00009	140.13	0.00005
AVERAGE	15.6	0.00	15.62	18640.33	0.00009	9.34	0.00005

TABLE A-5(b)

REVENUE REQUIREMENT OF FINE MESH ADDITIONS TO EXISTNG SCREENS - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 21.0	$ 0.00	$ 20.97	16311	0.00013 ¢	$ 20.97	0.00013 ¢
1991	20.1	0.00	20.12	16590	0.00012	18.08	0.00011
1992	19.2	0.00	19.15	16967	0.00011	15.46	0.00009
1993	18.3	0.00	18.30	17326	0.00011	13.27	0.00008
1994	17.3	0.00	17.33	17693	0.00010	11.30	0.00006
1995	16.6	0.00	16.59	18037	0.00009	9.71	0.00005
1996	15.7	0.00	15.73	18381	0.00009	8.28	0.00005
1997	15.0	0.00	14.98	18713	0.00008	7.08	0.00004
1998	14.1	0.00	14.12	19006	0.00007	6.00	0.00003
1999	13.4	0.00	13.38	19325	0.00007	5.11	0.00003
2000	12.5	0.00	12.52	19634	0.00006	4.30	0.00002
2001	11.8	0.00	11.77	19940	0.00006	3.63	0.00002
2002	10.9	0.00	10.91	20249	0.00005	3.02	0.00001
2003	10.2	0.00	10.17	20560	0.00005	2.53	0.00001
2004	9.4	0.00	9.42	20873	0.00005	2.11	0.00001
2005	8.7	0.00	8.67	21188	0.00004	1.74	0.00001
2006	8.1	0.00	8.13	21508	0.00004	1.47	0.00001
2007	7.7	0.00	7.70	21829	0.00004	1.25	0.00001
2008	7.2	0.00	7.17	22155	0.00003	1.05	0.00000
2009	6.7	0.00	6.74	22485	0.00003	0.88	0.00000
2010	6.3	0.00	6.31	22821	0.00003	0.74	0.00000
2011	5.9	0.00	5.89	23162	0.00003	0.62	0.00000
2012	5.5	0.00	5.46	23507	0.00002	0.52	0.00000
2013	4.9	0.00	4.92	23858	0.00002	0.42	0.00000
2014	4.5	0.00	4.45	24214	0.00002	0.34	0.00000
TOTAL	290.9	0.00	290.93	506332	0.00006	139.90	0.00003
AVERAGE	11.6	0.00	11.64	20253.28	0.00006	5.60	0.00003

TABLE A-6(a)

REVENUE REQUIREMENT OF FINE MESH SCREENS IN FRONT OF DILUTION PUMPS - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 334.1	$ 63.00	$ 397.11	16311	0.0024 ¢	$ 397.11	0.0024 ¢
1991	317.6	66.15	383.71	16590	0.0023	344.78	0.0021
1992	299.5	69.46	368.95	16967	0.0022	297.89	0.0018
1993	281.4	72.93	354.37	17326	0.0020	257.09	0.0015
394	264.9	76.58	341.46	17693	0.0019	222.59	0.0013
395	249.8	80.41	330.24	18037	0.0018	193.44	0.0011
1996	233.3	84.43	317.70	18381	0.0017	167.22	0.0009
1997	218.2	88.65	306.87	18713	0.0016	145.13	0.0008
1998	203.2	93.08	296.25	19006	0.0016	125.90	0.0007
1999	188.1	97.73	285.86	19325	0.0015	109.16	0.0006
2000	171.6	102.62	274.19	19634	0.0014	94.08	0.0005
2001	156.5	107.75	264.27	19940	0.0013	81.48	0.0004
2002	141.5	113.14	254.61	20249	0.0013	70.53	0.0003
2003	126.4	118.80	245.22	20560	0.0012	61.04	0.0003
2004	109.9	124.74	234.69	20873	0.0011	52.47	0.0003
TOTAL	[illegible]	1359.45	4655.40	[illegible]	0.0017	2619.91	0.0010
AVERAGE	219.7	90.63	310.36	18640.33	0.0017	174.66	0.0010

TABLE A-6(b)

REVENUE REQUIREMENT OF FINE MESH SCREENS IN FRONT OF DILUTION PUMPS - 25 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 295.0	$ 63.00	$ 357.98	$ 16311	0.0022 ¢	$ 357.98	0.0022 ¢
1991	282.9	66.15	349.09	16590	0.0021	313.68	0.0019
1992	269.4	69.46	338.85	16967	0.0020	273.59	0.0016
1993	257.4	72.93	330.29	17326	0.0019	239.62	0.0014
1994	243.8	76.58	320.39	17693	0.0018	208.86	0.0012
1995	233.3	80.41	313.68	18037	0.0017	183.74	0.0010
1996	221.2	84.43	305.66	18381	0.0017	160.88	0.0009
1997	210.7	88.65	299.35	18713	0.0016	141.57	0.0008
1998	198.7	93.08	291.74	19006	0.0015	123.98	0.0007
1999	188.1	97.73	285.86	19325	0.0015	109.16	0.0006
2000	176.1	102.62	278.71	19634	0.0014	95.63	0.0005
2001	165.5	107.75	273.30	19940	0.0014	84.26	0.0004
2002	153.5	113.14	266.65	20249	0.0013	73.87	0.0004
2003	143.0	118.80	261.77	20560	0.0013	65.16	0.0003
2004	132.4	124.74	257.18	20873	0.0012	57.52	0.0003
2005	121.9	130.97	252.88	21188	0.0012	50.82	0.0002
2006	114.4	137.52	251.90	21508	0.0012	45.49	0.0002
2007	108.4	144.40	252.76	21829	0.0012	41.02	0.0002
2008	100.8	151.62	252.45	22155	0.0011	36.81	0.0002
2009	94.8	159.20	254.01	22485	0.0011	33.28	0.0001
2010	88.8	167.16	255.95	22821	0.0011	30.13	0.0001
2011	82.8	175.52	258.29	23162	0.0011	27.32	0.0001
2012	76.8	184.29	261.05	23507	0.0011	24.81	0.0001
2013	69.2	193.51	262.74	23858	0.0011	22.44	0.0001
2014	63.2	203.18	266.39	24214	0.0011	20.44	0.0001
total	4092.1	3006.81	7098.90	506332	0.0014	2822.07	0.0006
average	163.7	120.27	283.96	20253.28	0.0014	112.88	0.0006

TABLE A-7(a)

REVENUE REQUIREMENT OF DUAL FLOW SCREENS IN FRONT OF DILUTION PUMPS - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 1054.5	$ 74.00	$ 1128.50	16311	0.0069 ¢	$ 1128.50	0.0069 ¢
1991	1002.3	77.70	1079.95	16590	0.0065	970.39	0.0058
1992	945.3	81.59	1026.84	16967	0.0061	829.06	0.0049
1993	888.3	85.66	973.91	17326	0.0056	706.57	0.0041
1994	836.0	89.95	925.95	17693	0.0052	603.62	0.0034
1995	788.5	94.44	882.94	18037	0.0049	517.19	0.0029
1996	736.3	99.17	835.42	18381	0.0045	439.71	0.0024
1997	688.8	104.13	792.88	18713	0.0042	374.98	0.0020
1998	641.3	109.33	750.58	19006	0.0039	318.97	0.0017
1999	593.8	114.80	708.55	19325	0.0037	270.56	0.0014
2000	541.5	120.54	662.04	19634	0.0034	227.15	0.0012
2001	494.0	126.57	620.57	19940	0.0031	191.32	0.0010
2002	446.5	132.89	579.39	20249	0.0029	160.51	0.0008
2003	399.0	139.54	538.54	20560	0.0026	134.06	0.0007
2004	346.8	146.51	493.26	20873	0.0024	110.33	0.0005
TOTAL	10402.5	1596.81	11999.31	279605	0.0024	6982.93	0.0026
AVERAGE	693.5	106.45	799.95	18640.33	0.0044	465.53	0.0026

TABLE A-7(b)

REVENUE REQUIREMENT OF DUAL FLOW SCREENS IN FRONT OF DILUTION PUMPS - 15 YEAR LIFE
(thousands of dollars)

YEAR	CAPITAL RELATED COSTS	OPERATION & MAINTENANCE COSTS	TOTAL REVENUE REQUIREMENTS	FORECAST SALES (GWH)	REVENUE REQUIREMENT (CENTS/KWH)	DISCOUNTED TOTAL REVENUE REQUIREMENT	DISCOUNTED REVENUE REQUIREMENT (CENTS/KWH)
1990	$ 931.0	$ 74.00	$ 1005.00	16311	0.0062 ¢	$ 1005.00	0.0062 ¢
1991	893.0	77.70	970.70	16590	0.0059	872.23	0.0053
1992	850.3	81.59	931.84	16967	0.0055	752.36	0.0044
1993	812.3	85.66	897.91	17326	0.0052	651.43	0.0038
1994	769.5	89.95	859.45	17693	0.0049	560.27	0.0032
1995	736.3	94.44	830.69	18037	0.0046	486.59	0.0027
1996	698.3	99.17	797.42	18381	0.0043	419.71	0.0023
1997	665.0	104.13	769.13	18713	0.0041	363.75	0.0019
1998	627.0	109.33	736.33	19006	0.0039	312.91	0.0016
1999	593.8	114.80	708.55	19325	0.0037	270.56	0.0014
2000	555.8	120.54	676.29	19634	0.0034	232.04	0.0012
2001	522.5	126.57	649.07	19940	0.0033	200.11	0.0010
2002	484.5	132.89	617.39	20249	0.0030	171.04	0.0008
2003	451.3	139.54	590.79	20560	0.0029	147.06	0.0007
2004	418.0	146.51	564.51	20873	0.0027	126.27	0.0006
2005	384.8	153.84	538.59	21188	0.0025	108.25	0.0005
2006	361.0	161.53	522.53	21508	0.0024	94.37	0.0004
2007	342.0	169.61	511.61	21829	0.0023	83.02	0.0004
2008	318.3	178.09	496.34	22155	0.0022	72.37	0.0003
2009	299.3	186.99	486.24	22485	0.0022	63.71	0.0003
2010	280.3	196.34	476.59	22821	0.0021	56.11	0.0002
2011	261.3	206.16	467.41	23162	0.0020	49.44	0.0002
2012	242.3	216.47	458.72	23507	0.0020	43.60	0.0002
2013	218.5	227.29	445.79	23858	0.0019	38.08	0.0007
2014	199.5	238.65	438.16	24214	0.0018	33.53	0.0002
TOTAL	12915.3	3531.81	16447.06	506332	0.0034	7213.89	0.0016
AVERAGE	516.6	141.27	657.88	20253.28	0.0034	288.56	0.0016

APPENDIX H

ESTIMATING THE ECONOMIC VALUE OF FISHERIES RESOURCES AT THE OYSTER CREEK NUCLEAR GENERATING STATION

Revision 1

ESTIMATING THE ECONOMIC VALUE OF FISHERIES RESOURCES AT THE OYSTER CREEK NUCLEAR GENERATING STATION

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OCTOBER 1988

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ESTIMATING THE ECONOMIC VALUE OF FISHERIES RESOURCES AT THE OYSTER CREEK NUCLEAR GENERATING STATION

A. Introduction and Overview

This report estimates the economic value of the damages to recreational and commercial fishing resources in Barnegat Bay, New Jersey, caused by the operation of the Oyster Creek Nuclear Generating Station (OCNGS). These damages are almost exclusively the result of entrainment of marine organisms by the once-through cooling system in operation at the plant. The populations of economically valuable species are, thereby, reduced; and those population reductions can, under appropriate assumptions, be converted into economic damage estimates. The estimates are based on a "with and without" analysis, comparing aquatic population estimates assuming the operation of the OCNGS with its current once-through cooling system to estimates assuming no plant at all (or assuming the plant could be modified so that it causes no population damages).

As is often the case when estimating the benefits resulting from environmental improvements, the available data are sparse and, in many important instances, not very recent. In addition, the data required for estimates of some parameters have apparently not been collected for geographic aggregations of which Barnegat Bay is a part, such as the entire New Jersey coast and

Ocean County. For some parameters, no data at all have been found for Barnegat Bay; these are based on studies of environmental damages to other marine ecosystems, notably the Chesapeake Bay. It was also necessary to make judgmental assumptions for certain key parameters. Accordingly, care has been taken to provide damage estimates in parametric form, so that these estimates can easily be adapted to alternative assumptions or parameter values or updated as better information becomes available.

In performing this study, analyses were conducted separately for the commercial and recreational benefits. The first step was to quantify the annual benefits in 1986 dollars, since the latest available data were for that year. The initial year benefits were then extrapolated over the time periods 1990 to 2004 and 1990 to 2014, and computed on both an actual dollar and present value basis. This was done in order to be consistent with the companion report on the cost of retrofits at OCNGS. Specifically, retrofits at the plant (which would provide the fisheries benefits) are assumed installed in 1990 and remain in-service through 2004 (the planned OCNGS retirement date). The second time period is based on the assumption that General Public Utilities Nuclear (GPUN) extends the life of OCNGS ten years beyond the planned retirement date. Consistent with the cost study, a 5.0 percent annual inflation factor is used, and a discount rate of 11.29 percent is used to calculate the discounted present values.

The remainder of this report describes the analysis, calculation procedures and results. The economic theory which underlies the analysis and the development of the models is not included in the body of the report and is, instead, provided in an appendix. The next two sections describe the commercial and recreational benefits analysis. Next is a summary of the cumulative benefit results over the two assumed service lives of the OCNGS plant. The last section is a brief review of the benefits analysis undertaken by GPUN.

B. Commercial Benefits Estimates

Two methods have been used to estimate the commercial benefits, and they provide a range of results. The first method is an analysis based upon the economic theory which is normally applicable to commercial fishing -- the theory of an "open access" resource. This is a complex analysis which requires parameters which are not available specifically for Barnegat Bay. The second method is not directly based upon the open access resource model but is much more straightforward and does not require as much information as the first method. The second method is the basis for the commercial benefits estimates reported in this study, and the first method is included only for comparison purposes.

Method 1

This method is based upon the theory of an open access resource. A complete and technical description of that model may

be found in the Appendix to that report, and that discussion need not be repeated here. Before applying this model, it is first necessary to develop several key inputs applicable to commercial fishing in Barnegat Bay. These include:

- the effect of the operation of OCNGS (as presently operated) on species populations;
- initial or currently prevailing prices of and quantities for commercially important species;
- the price elasticity of demand for each species;
- the price elasticity of supply for each species; and
- the relationship between species population and commercial catch rate.

The development of these values is described below.

Versar, Inc. has prepared estimates of population losses for key species in Barnegat Bay, resulting from OCNGS operation based on the SNAC model (Spawning/Natural Areas of Consequence). The estimated population losses for these species in the Bay are as follows:

(1)	Winter flounder	2.1%
(2)	Bay anchovy	3.2
(3)	Hard clam	1.0
(4)	Blue crab	0.3
(5)	Sand shrimp	16.6
(6)	Opossum shrimp	2.0

These percentages refer to the ratios $\Delta N/N$ in the Appendix.

Of these six species, only hard clams and blue crabs are both commercially important and are affected by the plant. Two forage species, sand shrimp and opossum shrimp, are also affected and the loss of these two species could conceivably affect commercially valuable predators. However, such effects are not

believed to be large for commercial fishing. The commercial analysis is limited to hard clams and blue crabs, although forage species have been included in the recreational benefits analysis.

The change in species populations resulting from plant operation will have an effect on commercial catch. The question is how much? For purposes of this study, we define the variable, Θ, as the percentage increase in catch for a percentage change in population. Unfortunately, historical data series on species population in Barnegat Bay and catch rates which could be used to estimate Θ are not available. In the absence of such data, one possibility is to assume that the percentage change in catch rate is the same as the percentage change in population. An alternative which is used for this study is to consider research results conducted elsewhere and for other species. Kahn and Kemp (1985) constructed a supply model of striped bass fishing in the Chesapeake Bay, in which catch is related to population estimates. The study yielded an estimate for Θ of 0.75, and that value is adopted for both the commercial and recreational analyses. To clarify, $\Theta = 0.75$ means that a ten percent increase in population results in a 7.5 percent increase in catch, assuming no change in the amount of fishing resources (i.e., same number of boats, fishermen, etc.).

The commercial analysis requires data on initial levels of commercial fishing prices and quantities. Data on landings of blue crabs and hard clams in Ocean County were collected from the National Marine Fisheries Service office in Toms River, New

Jersey, and are presented on Table 1. According to Danila, Milstein and Associates (1979), Barnegat Bay accounts for all of the blue crab taken in Ocean County and about 30 percent of the hard crabs. The initial catch or output level is taken as the average annual catch over this six-year period -- 213,000 pounds of blue crabs and 174,000 pounds of hard clams (30 percent of the county total of 580,000). The initial prices are simply the actual 1986 prices of $0.48 per pound for blue crabs and $3.28 per pound for hard clams.

Finally, one of the two methods employed requires an estimate of price elasticities for blue crabs and hard clams ($\mathcal{E}_D$). The price elasticity of demand is defined as the percentage change in quantity demanded of the product resulting from a percentage change in the price of that product. Several commercial fish price elasticity studies were reviewed including Huang (1985), Kahn and Kemp (1985) and Wang (1986). These studies provided a wide range of results. For the present study, a demand elasticity $\mathcal{E}_D$ = -5.0 is used, a figure in the middle of the range of the values reported in the above studies. This means that 5 percent increase in price will cause a 25 percent reduction in the quantity (pounds) of fish purchased.

A price elasticity of demand of -5.0 may appear to be a very high figure. However, the crab and clam fishermen in Barnegat

Table 1

Annual Landings of Blue Crabs and Hard Clams
Ocean County, N.J.

Blue Crabs

Year	Shell Weight lbs.	Value	Average Price ($/lb.)
1980	287,200	$111,429	$0.388
1981	185,500	63,670	.343
1982	133,700	57,130	.427
1983	174,100	79,871	.459
1984	293,600	123,534	.421
1985	199,200	103,531	.520
1986	219,800	105,539	.480
Average	213,000	$92,000	--

Hard Clams

Year	Meat Weight lbs.	Value	Average Price ($/lb.)
1980	486,700	$ 974,810	$2.00
1981	498,900	1,087,734	2.18
1982	549,900	1,357,554	2.47
1983	668,500	1,643,956	2.46
1984	699,600	2,120,636	3.03
1985	533,300	1,658,046	3.11
1986	620,800	2,034,369	3.28
Average	580,000	$1,554,000	--

Source: National Marine Fisheries Service, Toms River, N. J.

Bay must compete with suppliers from other regions. Thus, they may face a highly elastic demand curve.

Using the data in Table 1, a supply elasticity ($\mathcal{E}_S$) is estimated using ordinary least squares regression. The supply elasticity measures how much more producers will supply (in percentage terms) for a given percentage increase in price. Annual landings were regressed on average price (lagged one year and deflated by the food manufacturers' price index), producing the following model:

$$\ln\text{(pounds of crab)} = \underset{(0.51)}{13.28} + \underset{(0.60)}{1.29} \ln \text{price}$$

$$R^2 = 0.54 \quad N = 6$$

This provides a price elasticity of supply of 1.29 for blue crabs, meaning that, as price increases by 10 percent, producers will increase output of blue crabs by 12.9 percent. Unfortunately, the regression analysis did not provide any meaningful results for hard clams and, thus, an $\mathcal{E}_S = 0$ is assumed for that species.

Table 2 summarizes the various data and parameter values needed to calculate the commercial sector benefits using both methods.

With the key input parameters specified in Table 4, the model may now be applied. Using equations (1) and (2) from the Appendix, new price and quantity levels are calculated for blue crabs and hard clams. Equation (3) may now be used to calculate the benefits. The calculations are summarized as follows:

Table 2

Parameters Employed in Calculating Commercial Benefits

Parameter	Blue Crab	Hard Clams
Population loss ($\Delta N/N$)	0.259	0.245
Average Output (Q_o)	213,000 lbs./yr.	174,000 lbs./yr.
Initial price (p_o)	\$0.48	\$3.28
Output Loss Elasticity (θ)	0.75	0.75
Demand Elasticity (ε_D)	-5.0	-5.0
Supply Elasticity (ε_S)	1.29	0.0

Blue Crabs

Initial price (p_o) = \$0.48 Final price (p_1) = \$0.4798

Initial catch (Q_o) = 213,000 Final catch (Q_1) = 213,381

Net benefits = \$43 per year in 1986 dollars

Hard Clams

Initial price (p_o) = \$3.28 Final price (p_1) = \$3.2751

Initial catch (Q_o) = 174,000 Final catch (Q_1) = 175,037

Net benefits = \$855 per year in 1986 dollars

As this indicates, the net annual benefits (in 1986 dollars) are \$43 for blue crabs and \$855 for hard clams, for a total \$898.

There are several problems with this analysis. First, it views Barnegat Bay as if it were a single market area for hard clams and blue crabs. In point of fact, these products are part of regional markets. Changes in production at Barnegat Bay may not have the impacts on market prices that this analysis portrays. Second, the analysis is based on supply and demand elasticity estimates that may not be reliable. In particular, no acceptable supply elasticity for hard clams could be obtained, and the value was, therefore, set equal to zero.

Method 2

As a result of the practical difficulties in applying Method 1, a simpler, more straightforward method is employed as an alternative. This method does not require supply or demand elasticities nor does it assume that Barnegat Bay is a single, self-contained market.

This method is based on the notion of productivity. A higher population of commercial fish species will improve the productivity of commercial fishing. That improved productivity is assumed to have no effect on market prices since it is a small increment to the total market. The production increase is, therefore, the measure of benefits. Once again, using the data in Table 2, this is calculated as: population increase ($\Delta N/N$) times catch elasticity (θ) times output (Q_o) times price (p_o). This is shown below, in 1986 dollars, for hard clams and blue crabs.

Hard clams = 1.0% x 0.75 x 174,000 x $3.28 = $4,280

Blue crabs = 0.3% x 0.75 x 213,000 x $0.48 = $ 230

This is substantially greater than the benefit estimate obtained from Method 1. It should be noted that the Method 1 estimates consist entirely of consumer surplus gains with producer surplus assumed competed away immediately in the "open access" fishery. In contrast, Method 2 benefits consist entirely of producer surplus.

We believe the Method 2 analysis provides a more reliable estimate of benefits than the Method 1 analysis because it does not depend on the elasticity assumptions needed to implement Method 1. Moreover, it does not make the assumption that Barnegat Bay is a self-contained market. For this reason, this study relies on the Method 2 results, and the Method 1 estimates are only provided for comparison purposes.

C. Recreational Benefits Estimates

The recreational benefits analysis uses the travel cost method to estimate a demand curve for fishing trips (i.e., the relationship between the number of fishing trips demanded and the cost of a fishing trip). Consumer surplus, which is derived from that demand curve, is the measure of benefits. Consumer surplus is a net benefit concept and measures how much value the consumer receives from a product over and above the price paid for the product. The "price" that recreational fishermen pay is assumed to be the cost of travel to Barnegat Bay. All else equal, the further a fisherman must travel from his home, the fewer fishing trips he will take. The basic model and theory used to derive the recreational fishing benefits is developed in the second part of the Appendix to this report.

Implementing the methodology requires the following steps:

(1) Determine the relationship between number of trips taken by fishermen to Barnegat Bay and the distance they must travel.

(2) Convert distance traveled into monetary terms so that it can be used as a measure of the cost or price of a fishing trip.

(3) Using available information on number of fishermen in the region who might fish at Barnegat Bay, along with the information developed in steps (1) and (2), estimate a market demand curve for recreational fishing.

(4) Use this demand curve to calculate consumer surplus. This last step requires knowledge of how fishermen will react to improved fishing conditions (i.e., more fish).

Step 1: The Trip Demand Model

To estimate the trip demand function for Barnegat Bay, an extract of the 1980 Survey of Fishing, Hunting and Wildlife-Related Recreation was used, consisting of all survey respondents in New York, New Jersey and Pennsylvania reporting salt water fishing in Wildlife Management Zone 348. This zone consists of the coastal strip of Ocean, Atlantic and Cape May Counties of New Jersey. There were 61 respondents in these states who reported some salt water fishing in this zone, 77 percent of whom were residents of New Jersey. For these respondents, the number of trips to zone 348 for salt water fishing was regressed against the reported trip distance, plus a number of socioeconomic variables, including income, age, education and race. Only trip distance was statistically significant, and so the other independent variables were discarded. Linear, semilog and log linear specifications were examined, and the log linear specification was chosen for further analysis. The estimated equation is as follows:

$$\ln(\text{trips}) = \underset{(.74)}{3.843} - \underset{(.176)}{0.556} \ln(\text{distance in miles})$$

$$R^2 = .15 \quad N = 61$$

The trip demand curve above was truncated at a distance of 100 miles, on the assumption that fishermen traveling greater distances were very likely visiting more than one site, or were engaging in more than one recreation activity. In either case,

it would not be proper to ascribe the entire value of a trip to salt water fishing.

Fishermen, of course, incur other costs when engaging in recreational fishing other than travel (e.g., equipment, boat rentals, meals, and so forth). However, unlike travel costs, these other costs may be assumed to be either constant or randomly distributed across fishermen and, therefore, would not affect the calculation of consumer surplus. This is why it is appropriate to employ travel cost as a price measure for purposes of estimating consumer surplus.

Step 2: Determining the Cost of Travel

The cost of driving to Barnegat Bay is the "price" of fishing, and it is, therefore, necessary to calculate that price. Travel cost has two components -- (1) the cost of foregone time that could be spent either working or in some other leisure activity; and (2) the out-of-pocket expense of driving.

The calculations are shown on Table 3. The value of time is based on 50 percent of the average hourly (after-tax) rate of pay in New Jersey. The 50 percent factor is based on a study (Briezelius 1979) that finds that the value of lost time is 30 percent or 70 percent of the individual's after-tax wage rate, depending upon whether the time is spent commuting (30 percent) or waiting in line (70 percent). Assuming travel to Barnegat Bay at an average speed of 35 mph, the value of the foregone time is $0.1381 per mile. Assuming out-of-pocket expense of $0.20 per mile and 2-1/2 persons per vehicle, the total of expense plus

Table 3

Estimating the Per Mile Cost of Travel

A. The Value of Time

(1) Average hourly rate of pay in New Jersey = $12.53/hr. (1986$)
(2) After-tax = $9.67 (using 22.8% tax rate)
(3) Value of travel time = 50% of pay = $4.835 per hour
(4) Average speed traveling assumed = 35 mph
(5) Cost of time = $4.835 hr./35 mph = $0.1381 per mile

B. Transportation Expense

(1) Out-of-pocket cost of driving = $0.20 per mile
(2) 2-1/2 persons assumed in each car
(3) Cost per person per mile = $0.20/2.5 = $0.08 per mile

C. Total Cost

(1) Per mile cost of time plus expenses = $0.1381 + $0.08 = $0.2181
(2) Round-trip cost = 2 x $0.2181 = $0.436

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(1) Hourly pay developed from U.S. Statistical Abstract (U.S. GPO 1986), p. 418.

(2) The 50 percent discount for value of time developed from Briezelius (1979). That study finds the value of time lost in commuting equals 30 percent of the wage, while time waiting in queues is 70 percent of the wage.

lost time is $0.2181 per mile. On a round-trip basis, this is $0.436 per mile distance from the Bay, or $4.36 for each ten miles.

Step 3: Construct a Market Demand Curve for Fishing Trips

In order to construct a market demand curve, it is first necessary to determine the size of the market. Table 4 shows the population and number of fishermen (who fish in the eastern New Jersey region) by population zones, with the zones defined as distance from Barnegat Bay.

The total population figures (by distance zone) were obtained from county population figures assigning each county in New Jersey, southern New York and eastern Pennsylvania to a zone. The third column on the table is the number of individuals who fish in the coastal New Jersey area. Based on data in the 1980 Fish and Wildlife Survey, the percent of the population who fish in that region was determined to be 5.6 percent in New Jersey, 4.0 percent for eastern Pennsylvania and 1.3 percent for southern New York. For example, in the first zone (0 to 10 miles) the population is 349,000, and 5.6 percent or 19,540 individuals in that zone fish in the New Jersey coast region.

The last column, number of fishing trips per year for each individual in column (3), is computed from the econometric model that relates trips to distance. Distance is measured as the midpoint of the zone. For example, for zone 2 (11 to 20 miles), the midpoint of 15 miles is inserted into the model as:

Table 4

Determination of Number of Fishing Trips per Year

(1) Zone Distance to the Bay (miles)	(2) Population in each Zone (thousands) NJ	NY	PA	(3) Number of Persons Fishing in Ocean, Atlantic or Cape May Counties	(4) Fishing Trips per year per person
0-10	349	0	0	19,540	19.07
11-20	519	0	0	29,060	10.35
21-30	519	0	0	29,060	7.79
31-40	1,538	0	0	86,130	6.46
41-50	273	0	0	15,290	5.62
51-60	772	0	0	43,230	5.03
61-70	1,495	0	0	83,720	4.58
71-80	408	0	1,768	93,570	4.23
81-90	448	1,880	1,179	96,690	3.95
91-100	200	2,040	1,026	78,760	3.21

(1) Population in each zone are estimates based on county level population data.

(2) Number of persons in each zone who fish in the designated counties is calculated from 1980 Fish and Wildlife Survey. The percentages are 5.6 percent in New Jersey, 4.0 percent for eastern Pennsylvania and 1.3 percent for southern New York.

(3) Fishing trips per year in each zone are calculated from the econometric equation:

$$\ln(\text{trips per year}) = 3.843 - 0.556 \ln(\text{distance in miles})$$

Distance is based on the mid-point of each zone.