Chalk Point include Cadman (1988), Wendling and Holland (1989), PEPCO (1989), Loos and Perry (1989), and Versar (1989a).

Six plants (Brandon Shores, BRESCO, Gould Street, Riverside, Wagner, and Westport) are located in Baltimore Harbor, where salinities are generally in the low mesohaline range for most of the year and the oligohaline range in the spring. The results of studies there were summarized in CEIR-6.

- Entrainment

Phytoplankton and zooplankton entrainment losses at Calvert Cliffs and Morgantown were generally variable, were greatest in the summer, and did not cause population depletions near either facility. This was probably because plankton populations recovered rapidly from plant-related stresses, and only a small proportion of the water available was withdrawn into the facilities. Such losses at BRESCO and Brandon Shores are similarly projected to have no adverse impact upon Harbor populations, because both of these facilities withdraw relatively small volumes of water.

Chalk Point, during partial power operations, has been observed to reduce phytoplankton biomass by an average of 20 percent and zooplankton by a range of 30 to 80 percent (particularly during periods of chlorination); these reductions were measured between the plant intake and the end of the plant discharge canal. Again, these losses caused no observable consequences on regional phytoplankton or zooplankton populations. Of all Maryland power plants in the mesohaline zone, Chalk Point is considered to have the greatest potential for entrainment impacts on life forms.

Potential declines in regional fish populations due to ichthyoplankton entrainment at Calvert Cliffs, Morgantown, Chalk Point, and Wagner were modeled to assess potential impacts of plant operations on spawning and nursery areas of RIS (PPRP 1986). Based on conservative assumptions, entrainment losses estimated by models caused little change in projected net system productivity at Calvert Cliffs and Morgantown, but some projected losses (8 percent) at Chalk Point (PPRP 1986). Regional ichthyoplankton populations of several RIS may be adversely affected at Chalk Point (Edinger and Buchak 1985; Turner and Heimbuch 1986; Versar 1989a). Forage species (e.g., naked goby, silversides, bay anchovy) were determined to be particularly vulnerable to entrainment, and impacts on these populations may be significant. Model estimates of losses of bay anchovy in the Patuxent ranged from 21 to 75 percent annually (Turner and Heimbuch 1986). Field survey data tend to support the findings of entrainment modeling, except that ichthyoplankton entrainment losses at Calvert Cliffs and Morgantown did not result in the predicted significant depletions in local ichthyoplankton populations.

Empirical studies of entrainment at Chalk Point have indicated the potential for significant losses of forage species (bay anchovy, naked goby, silversides) in the Patuxent River. Such losses can inhibit the successful completion of the life cycles of other important species that use the Patuxent as a spawning and nursery area (MMES 1985a). By comparison to the model results cited above (21 to 75 percent losses), observations indicated that losses of bay anchovy in the Patuxent River due to entrainment of larvae at Chalk Point are approximately 8 percent to 56 percent (most probably 10 to 20 percent) annually (Loos and Perry 1989; Versar 1989a). These estimates were based on field measurements of population size in the Patuxent and entrainment by Chalk Point (Loos and Perry 1989), and took into account measured sampling efficiency in the Chalk Point discharge canal (Cadman 1988; Versar 1989a). When assumptions of the model studies were made to agree with empirical studies (area of impact and volume pumped by the plant), then estimates ranged from 22 percent to 56 percent annual loss, which agreed well with the model estimates of 21 to 35 percent loss (Versar 1989a; Turner and Heimbuch 1986).

Augmentation pumps used at Chalk Point to temper thermal and chemical effects in the discharge canal and nearby were an additional source of entrainment until 1986 (see Figure 4-1). As recent studies have shown, the unscreened tempering pumps did not substantially reduce adverse thermal and chemical impacts, but did substantially increase the entrainment mortality of fish and crabs (Wendling and Holland 1989). In response to a PPRP recommendation, their use was discontinued, which also helped to reduce the utility's financial liability for impingement losses.

The cumulative impacts of all six power plants on the lower Patapsco ecosystem (Baltimore Harbor) may be substantial, but have not been assessed. Technical approaches for addressing the cumulative impact requirement of the new MDE thermal discharge regulations as they pertain to the Harbor power plants will be developed by PPER over the next six months. There are still some outstanding permit issues at several of the Harbor power plants, the studies for which could contribute to the evaluation of cumulative impacts. The plants are not located in a spawning area for harvested species; the major spawners are forage species. Ichthyoplankton entrainment losses at most plants were low, but were greater at Riverside and Wagner (PPRP 1988). Entrainment impacts on spawning and nursery areas of consequence for forage species may be significant at Wagner; but BG&E has not assessed their consequences (Shaughnessy *et al.* 1990). Further studies may be needed to assess the status of the Harbor as a spawning and nursery area, and to assess the impacts of entrainment on this area. These studies would be especially important in light of improvements in water quality and bottom-dwelling biotic resources in the outer Harbor area (Shaughnessy *et al.* 1990). Studies of ichthyoplankton abundances are currently being conducted at the BRESCO facility to establish population levels within Baltimore Harbor. Based on population estimates and operating regimes, cumulative entrainment impacts are potentially substantial, even though losses due to individual power plants may be low (Holland *et al.* 1988b).

- Impingement

Impingement at mesohaline facilities was discussed in previous CEIRs. This information, along with 1986-1989 data for Chalk Point and Calvert Cliffs and 1978-88 data for BRESCO, is summarized below.

At Calvert Cliffs, bay anchovy, spot, menhaden, hogchoker, and blue crabs have generally dominated impingement counts during the season of their occurrence. Species composition and total numbers impinged fluctuated widely from 1982 to 1985, probably reflecting regional variation in abundances of the impinged species (PPRP 1988).

Impingement of fish and crabs at Chalk Point has declined substantially since PEPCO installed a dual barrier net system. Two sets of nets were installed in 1981 and 1985, and other improvements were made in 1985. Total impingement in 1984-1985 was one-tenth that of 1976-1977 (PPRP 1988). Atlantic menhaden remained the dominant fish in impingement samples. The utility continues to monitor impingement at Chalk Point.

Estimates of impingement were made at the BRESCO facility for July 1985 through June 1986 as required by the Maryland State Discharge Permit. Estimated total impingement was 80,178 fish and shellfish over that period. Based on valuations prescribed by regulations and a realistic assumed mortality rate of 12 percent for blue crabs, the dollar value of impingement losses was estimated to be $2,746 (Holland *et al.* 1988b).

Mortality rates of impinged fish varied from species to species and from facility to facility. Post-impingement mortality rates at the Chalk Point plant were estimated to be high during summer. During other seasons and at other Maryland power plants, about 90 percent of the hardy species (e.g., spot, hogchoker) survive impingement, whereas only about 25 percent of the sensitive species (e.g., menhaden, other clupeids) survive. Blue crabs had essentially no post-impingement mortality at facilities other than Chalk Point.

Impingement losses to dominant species at all mesohaline plants are small compared to commercial harvests and are only a small percentage of the forage required for major predatory fish populations (ANSP 1977, 1983a; MMEC 1980). Thus impingement losses are not expected to affect commercial or recreational landings of fish and crabs from mesohaline habitats.

- Discharge Effects and Habitat Modification

Thermal plume dimensions for power plants in the mesohaline zone were discussed in previous CEIRs. In all cases, the distribution and size of the plumes vary with season, tidal stage, wind velocity and direction, and plant operating level. This section summarizes the thermal and physical discharge effects; toxic discharges are covered in Section G.

Of the mesohaline power plants, Chalk Point has the greatest potential for causing discharge effects: the receiving water body is shallow, and plant water use exceeds the amount of flow available for dilution. Thus a relatively large region of the Patuxent River is affected by the plant's thermal discharge. Because Chalk Point failed to comply with any of the mixing zone specifications in state thermal regulations, studies were performed to assess and limit the impact of its thermal discharge.

These studies showed that changes in biotic distributions resulting from Chalk Point's thermal effluents were localized: increases in the abundance of heat-tolerant benthic species and mortalities to heat-sensitive benthic species and zooplankton (Holland *et al.* 1989). No effect on the abundance of clams was observed (Wendling and Holland 1989). Fish and crabs were attracted to or excluded from the discharge region, depending upon season; some sport fish were attracted during winter. Fish migration routes were not blocked, and thermal effluents did not adversely affect the growth and reproduction of fish or other biota.

No consistent discharge effects on phytoplankton, zooplankton, or fish were measured at Morgantown or Calvert Cliffs. However, high-velocity discharge systems modified habitat characteristics at both sites, scouring away natural sands and muds in the immediate vicinity. This affected the abundance and makeup of benthic biota nearby. Plant-related increases and decreases in benthic abundance, growth, and productivity away from the scoured areas were measured; increases in these areas far outweighed decreases. Many of the species that increased in abundance were heat-tolerant organisms.

The effects of the Wagner plant on benthic populations are difficult to separate from those of a variety of other industries located in the Harbor (Holland *et al.* 1989). The Brandon Shores and BRESCO facilities in the Harbor area probably cause no additional adverse environmental impact on mesohaline habitats. Empirical data on the extent of the thermal plume at BRESCO collected in 1985 indicate that the facility complies with applicable thermal discharge compliance criteria, except that the discharge flow exceeds 20 percent of the annual average net flow past the point of discharge. Consequently, existing data were analyzed to determine compliance with biological criteria in COMAR. This analysis found that the BRESCO facility passed or probably passed all of the evaluation criteria (Holland *et al.* 1988b). However, if improvements in environmental quality in Baltimore Harbor lead to increased importance of RIS spawning and nursery functions near the facility, future reevaluation may be required. When BRESCO's NPDES permit is renewed, biological studies will be required to: 1) identify the resources at risk and provide a baseline for estimating entrainment losses; and 2) characterize the status and trends of RIS fish resources that use the BRESCO region as a nursery area.

- Conclusions for Mesohaline Power Plants

When the results of studies at all mesohaline plants are considered collectively, a picture emerges that indicates a low probability of cumulative impact on mesohaline habitats. Although large phytoplankton and zooplankton entrainment losses have been frequently measured, no consistent population depletions have been found. This is probably due to the rapid recovery of most plankton from entrainment stress. Since no important commercial or recreational species spawn in the mesohaline zone, there are limited economic losses. Forage fish species spawn in this zone, and large numbers of their ichthyoplankton are entrained. The only mesohaline facility that may impact riverwide spawning and nursery areas of forage species is Chalk Point. In general, research has shown that large numbers of juvenile fish and crabs are impinged at mesohaline power plants, but that impingement losses do not cause measurable population depletions. Discharge effects in mesohaline habitats are generally localized. Fish and crabs may be either attracted to or repelled from plant discharges; but fish migration, spawning, and growth are not adversely affected. Benthic abundance and productivity are generally higher in thermally affected areas; however, increases in secondary productivity do not impact local or regional food web dynamics.

Tidal Fresh-Oligohaline Power Plants

The eight plants located in waters that are oligohaline in the spring (Table 4-4) -- Chalk Point, Morgantown, and the Baltimore Harbor area plants -- are on waters that are mesohaline during the summer and fall. These were discussed in the preceding section.

The Vienna and C.P. Crane plants are in waters that are tidal fresh in the winter and spring, and oligohaline in the summer and fall. Possum Point in Virginia, on the Potomac River, although it is not located in Maryland, is also included in this discussion because it impacts Maryland waters. Vienna, on the Nanticoke River, and Possum Point are both in major striped bass spawning areas. Crane, though located on tidal fresh/oligohaline waters, does not impact a striped bass spawning area. The Perryman site, the likely location for BG&E's next generating station, is also located on waters that are tidal fresh in the spring and oligohaline in the summer and fall. This section briefly summarizes information presented in greater detail in previous CEIRs, with some additional information on BG&E's plans for Perryman.

- Entrainment

At Crane, entrainment enhanced phytoplankton productivity at low temperatures and inhibited it at high temperatures. Zooplankton entrainment generally did not result in population depletions except during summer. Although ichthyoplankton entrainment losses were large in the receiving water body adjacent to Crane, the potential for regional impact from these losses was small.

Entrainment of phytoplankton and zooplankton at Vienna was estimated to be low. Although the Vienna facility is located in a striped bass spawning area, entrainment of striped bass and other ichthyoplankton RIS is probably also low.

Although no entrainment studies have been conducted at Possum Point, no local depletions of phytoplankton or zooplankton have been found during surveys. However, Possum Point's entrainment losses in spawning populations of fish are high relative to Maryland power plants. Entrainment losses at Possum Point represent about 3.3 percent of the annual value of the Potomac fishery, corresponding to a loss in ecosystem productivity of 0.44 percent.

- Impingement

Impingement of juvenile and adult fish at Vienna is negligible. At Possum Point it is also suspected to be small, since water use is not high. At Crane, a significant number of menhaden, white perch, and blue crabs are impinged, but at lower rates than for mesohaline facilities. Although impingement rates at Crane fluctuated considerably from one sampling date to another, the general trend was for impingement to be highest in summer and fall and lowest in late winter.

- Discharge Effects and Habitat Modification

The thermal plume at Vienna is small, and discharge effects are negligible. No discharge effects from Possum Point were found in the Potomac River, probably because the point of discharge release is located on Quantico Creek. Only small changes in biotic distributions in the creek were attributed to effluents from Possum Point. Fish avoided the thermal effluents during summer and were attracted to them during winter, but fish migration and spawning and nursery activities of RIS were not adversely affected.

The thermal plume at Crane affects about 40 percent of the volume of the receiving creek system. Crane effluents also slightly increased local salinity, but did not affect dissolved oxygen. Thermal effluents from Crane inhibited local phytoplankton productivity (during summer) and submerged aquatic vegetation growth. Plant effects on zooplankton community composition and abundance were relatively small. Thermal effluents at Crane affected benthic populations by reducing winter mortality of cold-sensitive forms, increasing summer mortalities of heat-sensitive species, and enhancing growth and development of heat-tolerant species.

As with the mesohaline power plants, fish were attracted to or avoided the Crane discharge region depending upon season. However, fish migration routes were not impeded, and discharge effects on local fish movements did not adversely impact regional populations. Power plant operations did not adversely impact nursery or spawning activities of white perch and yellow perch.

BG&E is currently planning expansion of its generating capabilities by developing new facilities at its Perryman site on the Bush River in Harford County. The Perryman project is planned to consist of two 400 MW combined cycle units (BG&E 1989). Because of limited sources of water for once-through cooling, such a plant would employ cooling towers and discharge only blowdown water from the closed-cycle system into the Bush River. The primary source proposed for the makeup water would be Conowingo Reservoir on the Susquehanna River, with the water being conveyed to Perryman by the City of Baltimore's emergency water supply pipeline. Susquehanna River water is relatively rich in nitrogen and phosphorus, raising the possibility that a closed-cycle system would increase the concentrations of these nutrients in the blowdown water by a factor of as much as five. However, studies have indicated that the relatively high concentrations of algae currently found in the estuary do not result in oxygen depletion, and that there is little likelihood of encountering large increases in algal biomass due to the combined effects of the proposed power plant and Harford County's publicly owned treatment works (POTW) expansion at the adjacent Sod Run facility (Rose *et al.* 1986).

Analysis of the cooling water alternatives for the Perryman site showed that the use of cooling towers for a plant as large as 1,200 MW would produce a discharge well within the mixing zone criteria. The addition of high nitrate levels from the Baltimore City water supply pipeline would add less than 0.2 milligrams per liter (mg/l) in nitrate concentrations to river levels in the vicinity of the discharge under conditions of poorest water quality in the Bush River. BG&E (1989) has conducted further evaluations of existing modeling studies and updated field water quality data in the Bush River. These studies and supplemental biological studies have been conducted to provide a baseline for evaluation and impact analysis for the Perryman licensing application presently before the Maryland PSC (Case No. 8241).

- Conclusions for Tidal Fresh-Oligohaline Power Plants

Entrainment losses at Crane do not affect regional RIS populations. At Possum Point and Vienna, entrainment losses affect striped bass and other harvested fish populations, but the losses are small. The consequences of impingement at oligohaline plants are similar to those at mesohaline plants: many organisms survive impingement, and the major species impinged are ubiquitous and abundant throughout Maryland's tidal waters.

Impingement losses appear too small to have a detectable effect on regional finfish populations. Power plant operations at Crane measurably affect the salinity and temperature of the receiving water body, especially in summer when high temperatures, low freshwater flows, and high generating loads occur. Local plant-related thermal effects were frequently detected under these conditions. Discharge effects at Possum Point are similar to those at Crane, but apparently do not impact Maryland waters. Discharge effects at Vienna are negligible. Therefore, the operations of power plants in the tidal fresh-oligohaline zone do not significantly affect biotic resources in this habitat zone.

Effects on the Bush River estuary of the discharge of cooling tower blowdown water from a power plant at Perryman likely would be small, even when combined with the effects of the increased discharge of an adjacent POTW currently undergoing expansion. Even if the plant draws nutrient-rich makeup water from the Susquehanna River and discharges it into the estuary, the discharge is unlikely to cause significant increases in algal biomass over levels observed at present. Further, any reduction of the now-adequate DO concentrations observed there is unlikely.

Nontidal Freshwater Power Plants

Two steam electric stations are located on riverine waters: R.P. Smith and Dickerson, both on the Potomac River (Table 4-4). Each facility uses, at times, a substantial portion of river flow for cooling purposes. These plants are relatively old, of low-to-medium generating capacity, and located in areas inhabited by typical warm water riverine biota.

- Entrainment

Entrainment of phytoplankton and zooplankton is not a major concern at these steam generating stations because of the minor role of these biota in biological productivity and system dynamics of nontidal fresh water habitats. Ichthyoplankton entrained at R.P. Smith and Dickerson are mostly forage species. Economic and ecological losses due to this entrainment have been projected to be small and unlikely to have regional consequences.

- Impingement

Impingement at R.P. Smith was projected to have negligible effects on regional fish populations, the monetary loss being estimated at less than $500 annually. Impingement at Dickerson was negligible, although sporadic high-impingement episodes have occurred. The losses associated with these occasional episodes have little economic consequence.

- Discharge Effects and Habitat Modification

Plant-related changes in the number of benthic taxa, in density and biomass of some invertebrates, and in life history characteristics (i.e., growth rate and timing of emergence) of some insects have been measured within regions thermally affected by R.P. Smith and Dickerson. Fish were attracted to or repelled from the plants' thermal plumes depending upon the season. Feeding habits and the physiological condition of fish collected in thermally influenced areas also differed slightly from those of fish collected from nearby reference areas, but not by enough to suggest that the plant had changed the structure of the Potomac food web. Changes in biota from the long-term degradation of water quality of the Potomac far exceeded the measured power plant effects. Differences in catches between thermally impacted and control sites for some fish species continued to be observed in some collecting months in 1987 (PEPCO 1987). PEPCO plans to examine these differences in relation to long-term distributions over the period 1985 to 1990.

- Conclusions for Nontidal Freshwater Power Plants

In general, entrainment and impingement impacts are small at freshwater facilities, and discharge effects are localized. No long-term cumulative impacts of the operation of these facilities have been identified.

F. Aquatic Impact Assessment for Hydroelectric Facilities

Status of Assessment Studies for Conowingo Dam

Conowingo Dam on the Susquehanna River is the largest hydroelectric generating station in Maryland. Significant stocks of resident and anadromous fish species (e.g., channel catfish, white perch, striped bass, river herring) occur downstream of the dam; historically, large spawning runs of anadromous species were found upstream of it (Mansueti and Kolb 1953). Sport fisherman regularly visit the region, and surveys suggest that in past years the area has been one of the most intensively fished locations in Maryland (Pavol and Davis 1982).

In 1976, when the Conowingo hydroelectric facility applied to FERC for license renewal, a number of interested parties (including Maryland DNR) became involved in the licensing procedure as intervenors. The interveners wanted the Philadelphia Electric Company (PECO), operator of the facility, to restore anadromous fish runs upstream of the dam and to implement actions that would alleviate environmental problems downstream, which were associated with water level fluctuations. These included low DO concentrations in dam discharges and virtual cessation of flow when turbines were shut down (Philipp and Klose 1981; Weisberg and Janicki 1985).

In 1980, when FERC issued new operating licenses for Conowingo and for three hydroelectric dams upstream in Pennsylvania, the agency required that the licensees undertake detailed studies of the causes of oxygen depletion in their reservoirs and in downstream river reaches, the effects of project operations on downstream water quality and habitat, and the feasibility of means to improve the oxygen concentration of the discharge enough to maintain the State discharge standards for DO. The studies for the upstream dams were completed and approved by FERC from 1983 to 1985.

In early 1988, the State of Maryland and PECO came to an agreement on the three broad areas of water flow and downstream habitat, water quality, and anadromous fish restoration. A preliminary agreement was signed in February 1988, and was ratified by FERC and the other intervenors. By the summer of 1988, implementation of major portions of the agreement was well underway.

The following sections discuss the background, the findings of technical studies and other evidence serving as a basis for the agreement, and the details of the agreement regarding each of the three major areas.

- Water Flow and Downstream Habitat

Until 1982, Conowingo Dam operated in a peaking mode throughout the year. To alleviate habitat modifications downstream of the dam, FERC ordered that, beginning in 1982, a minimum flow of 5,000 cubic feet per second (cfs) be maintained from 15 April through 15 September, while PECO carried out field studies designed to aid in the selection of a permanent minimum flow. A study evaluating the responses of benthic invertebrates and fish to this minimum flow found that benthic abundance was dramatically higher, fish feeding rates were greater, and the condition of fish better, during the interim minimum flow period than during sporadic water release (Weisberg and Janicki 1985). Through 1986, the latest year sampled, growth rate, condition factor, and the variety and number of prey items in fish stomachs all appeared to be enhanced by the increased flow. By providing more food and available habitat, the minimum flow apparently has helped the fish populations below the dam to become healthier, which will likely increase overall productivity in the lower Susquehanna River (Weisberg *et al.* 1989).

As a result of these studies, PECO agreed to provide minimum flows all year beginning in March 1988. The amount of flow is seasonal, varying from a high of 10,000 cfs in the spring down to 3,500 cfs in the winter. The agreement represents a significant cost to the utility, because it requires shifting some power generation to times (nights and weekends) when the economic payback is significantly lower. The resource agencies have agreed to allow temporary reductions in flow below the agreed levels during periods of extremely high demand for electricity. Continuous flows during the winter months (December through February) are being studied by DNR to determine if the biological resources at risk during those months require continuous flows (Versar 1989b).

- Water Quality

PECO and PPER have funded modeling and field studies to identify factors affecting water quality in aquatic habitats downstream of Conowingo Dam and in Conowingo Pond. A simulation model of the DO dynamics in aquatic habitats downstream indicated that the downstream DO concentration was controlled by that of the water released through the turbines (Dwyer and Turner 1982). Results of modeling studies indicated that, due to the strong vertical stratification and near-anoxic bottom water in Conowingo Pond during summer, the dissolved oxygen concentration in discharge flows (and thus downstream) could not be increased substantially by continuous minimum flow release schedules (Summers 1984). The only feasible methods of increasing the DO concentrations downstream during minimum flow releases were adding oxygen to the water (either in the impoundment or in the turbines), or reducing the amount of oxygen-consuming material entering the impoundment from upstream sources (Dwyer and Turner 1986). In 1987, PECO submitted a plan to FERC to utilize turbine venting and other methods to add oxygen to the water being discharged.

As a part of the 1988 settlement agreement, PECO agreed to test the effectiveness of turbine venting by retrofitting one turbine immediately. PPER conducted a study in cooperation with PECO to evaluate the most appropriate DO monitoring locations below the dam (Wendling 1989); its results were incorporated into PECO's procedures to ensure that the dam's releases meet Maryland's dissolved oxygen standard (PECO 1989a). Results of turbine venting tests indicated that it is an effective aeration technique under certain conditions (specifically, low tailrace elevations with only a few units running) (PECO 1989b). To ensure compliance with the DO standard and to alleviate the potential problem of nitrogen gas supersaturation, alternative aeration methods are also being evaluated. These methods include intake air injection, oxygen injection, operation of some of the turbines inefficiently (so as to bubble air into the discharge), and spilling water over the dam (bypassing the turbines entirely). The latter two alternatives result in the utility foregoing some power generation revenue.

In 1989, two additional units were retrofitted for turbine venting with an improved design over the first unit. Preliminary test results showed even greater effectiveness of this technique as compared with the first test conducted in 1988. However, the high flow conditions which prevailed during the summer of 1989 prevented evaluating the effectiveness of turbine venting alone or in combination with intake aeration under low DO conditions. Two additional turbines are scheduled to be retrofitted in 1990 and 1991; tests of turbine venting and other aeration techniques are expected to continue then.

- Anadromous Fish Restoration

FERC's hearings on the restoration of anadromous fish runs upstream of Conowingo Dam concluded with final briefs in early 1983. The intervenors and three utilities that operate dams upstream of Conowingo agreed on a settlement that included an extensive program for releasing hatchery-reared juvenile shad and prespawned adults from other rivers into the upstream tributaries of the Susquehanna River. It was hoped that a subsequent return of large numbers of adults to Conowingo (the furthest downstream migratory barrier) would demonstrate the feasibility of a full-scale restoration program. In 1989, PECO collected over 8,000 adult shad at its experimental fish lift at Conowingo Dam, compared with an annual return of a few hundred fish in the late 1970s (see Figure 4-5). Most of the shad were transported by truck to upstream spawning grounds.

In negotiations with PECO, the intervenors had maintained that the existing Conowingo fish lift, built in the early 1970s as an experimental sampling device, was too inefficient to support an adequate demonstration.

At first ordered by FERC to build a new demonstration facility under the 1988 agreement, PECO agreed to defer the construction and to investigate immediately the feasibility of constructing permanent full-scale fish passage facilities. A general design for the permanent facility was supplied by the resource agencies of Maryland and Pennsylvania and the U.S. Fish and Wildlife Service; in December

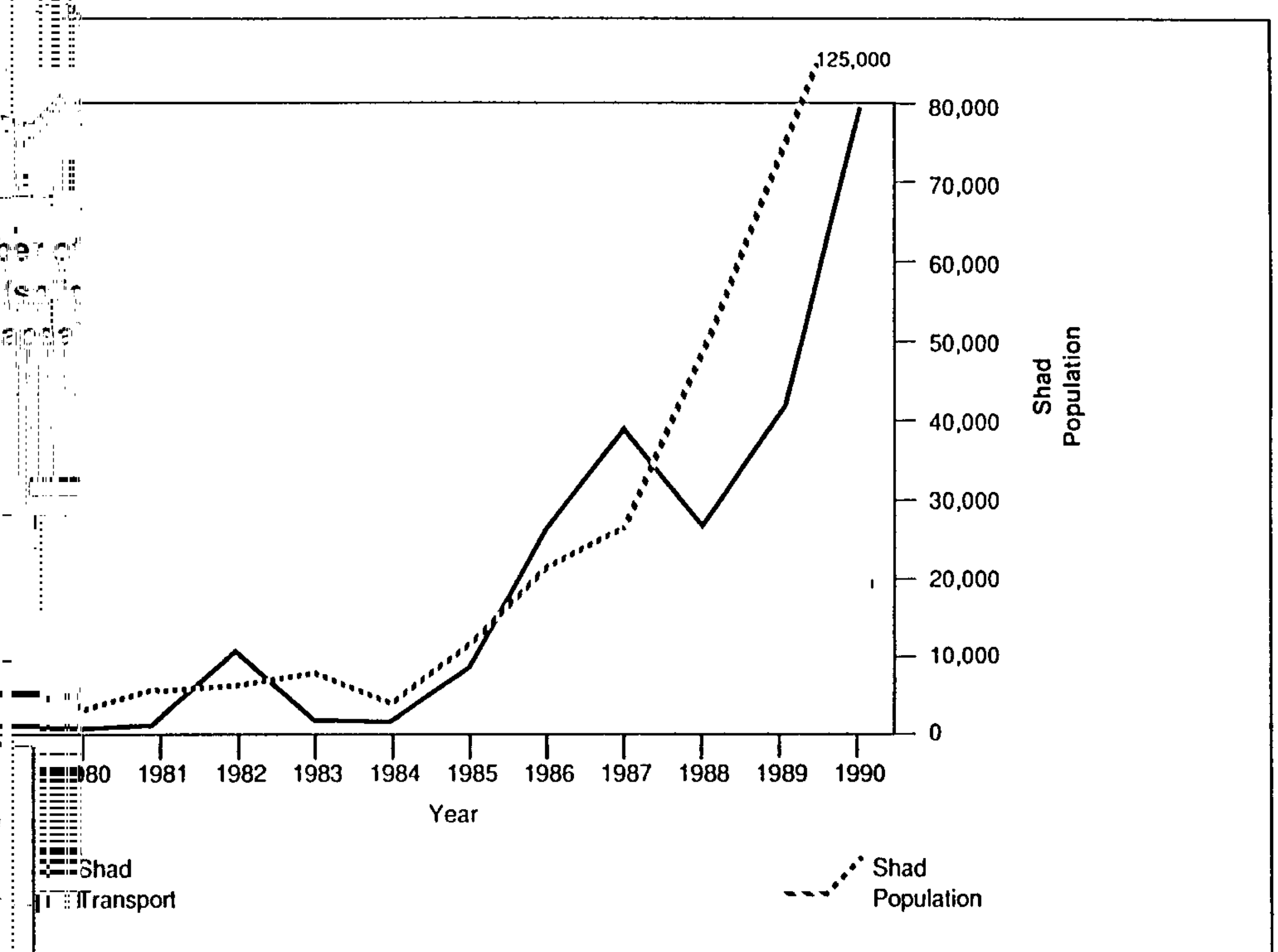

Figure 4-5.

American Shad caught at the experimental fish lift at Conowingo Dam 1980 -
line) as compared with American Shad population estimates in the upper
ke Bay (dashed line)

Source: SRAFRC 1990

15415 71

1988, PECO and the agencies reached agreement on the construction of permanent fish passage facilities at Conowingo.

The fish passage agreement includes the following elements:

- design and construction of a permanent passage facility that will lift fish over the east side of the dam for release into Conowingo Pond;
- an initial capacity of 750,000 American shad and 5,000,000 river herring;
- capability for doubling capacity in the future;
- the construction of trucking and sorting facilities, if funding is provided from non-PECO sources;
- shutdown of Units 1 and 2 when river flow is less than 65,000 cfs to enhance effectiveness of the existing fish lift; and
- future determination by the Susquehanna River Technical Committee of need for phased construction of a new west-side fish passage facility, when the capacity of the currently planned lift is approached.

Final design plans for the new east-side fish lift were subsequently approved by all parties, and construction began in 1990. Completion is anticipated in spring of 1991, if possible before the 1991 run of American shad.

With final resolution of the fish passage issue at Conowingo, the focus of attention passes to the upstream licensees. Upstream utilities include BG&E, PP&L, and GPU. One of the outstanding issues in early 1990 is the other, non-PECO participation in construction of sorting and trucking facilities at the new lift at Conowingo Dam. These are required because the new fish lift will not pass fish above the dam, no suitable shad spawning habitat exists in Conowingo Pond, and no passage facilities are present at the three upstream dams.

Until passage can be provided at the upstream dams, the fish captured in the Conowingo lifts must be sorted and trucked upstream above the dams. Issues under discussion between the intervenors and the upstream utilities include the option of immediate construction of passage facilities at all of the upstream dams and various alternative sources of funding for the trucking and sorting facilities at Conowingo Dam. Studies continue to investigate the movement patterns of adult fish through the four impoundments, behavior of downstream migrating juveniles moving out of the river system in the fall, and means of passing these juveniles out of the system with minimal mortality.

- Conclusions

A settlement agreement between PECO and the State instituted a minimum flow at Conowingo for the period March through December. By providing more food and available habitat, the minimum flow has helped fish populations below the dam to become healthier and more productive. Flows during the winter months are being studied to determine if the biological resources at risk during those months require continuous flows on a permanent basis. Physical modification of the dam is underway to improve dissolved oxygen downstream; preliminary results indicate that turbine venting is an effective aeration technique and should permit compliance with the state DO standard. Studies are underway to evaluate the effectiveness of turbine venting and other techniques to add oxygen to the turbine discharge. Final design plans for a permanent fish lift facility were approved and construction began in 1990. Completion is anticipated in spring 1991 and is expected to precede the 1991 run of American shad. Until fish passage can be provided around the upstream dams, fish still must be sorted and trucked upstream. Studies are continuing to investigate the movement patterns of adult fish through the lower four impoundments and the behavior and success of out-migrating juveniles.

Status of License Renewal and Assessment Studies for the Deep Creek Hydroelectric Facility

In January 1994, the Pennsylvania Electric Company's (Penelec) license to operate the hydroelectric facility at Deep Creek will expire. In late 1988, Penelec filed a notice of intent to relicense with FERC. Penelec is expected to file a draft license application in early 1991. The following section contains a summary of the project and a preliminary list of project concerns identified by the State.

The Deep Creek hydroelectric project is located in Garrett County, about 1.75 miles above the confluence of Deep Creek with the Youghiogheny River. The watershed above the 3,600-acre impoundment is relatively small, encompassing approximately 65 square miles. The reservoir is irregular in shape, with a shoreline length of approximately 65 miles. The Deep Creek dam was designed and constructed for hydroelectric generation. Water is supplied from a single intake port to a surge tank and penstock, which feeds two turbines. Essentially all the water received by the reservoir is passed through the facility and is discharged to a 435 ft long tailrace, which bypasses Deep Creek and empties into the Youghiogheny River 1.5 miles downstream of Deep Creek, near Hoyes Run. Prior to construction of the dam, natural drainage to the river occurred via Deep Creek; since the dam became operational, water has been discharged to Deep Creek itself only twice during flood conditions. Hydroelectric generation is accomplished at the power house with two variable speed, vertically mounted Francis turbines, each rated from 9.6 MW at 600 cfs with 400 ft of head. Yearly power production at the facility has averaged approximately 30,000 MWH. Power is generated in a peaking mode. During low demand periods, e.g., nights and weekends, power is usually not generated and no releases occur.

Although there are no requirements for reservoir drawdown in the existing license, Penelec attempts to maintain reservoir levels at or above an existing rule curve that was developed for the project in the 1920s. It is used to assure a full pool in summer and provide water for year-round operation of the hydro facility. Under the rule curve, summer drawdowns are limited to less than four feet, with a maximum drawdown of 11 feet during late fall. Special weekend or holiday releases are made infrequently (several times per year) to accommodate the requests of commercial whitewater boating companies.

PPER has identified the following issues of potential concern to the State that should be addressed during Deep Creek relicensing proceedings:

- Water released from the hydroelectric facility does not meet state water quality standards for dissolved oxygen, particularly during August and September. DO levels less than 1 ppm have been recorded.

- Rapid changes in mainstem water temperature due to hydroelectric operations may affect downstream biota, including endangered species and trout populations. Discharges of approximately 16°C may occur into the river, where ambient temperature is greater than 24°C, during low-flow periods on hot summer afternoons.

- Short-term fluctuations in mainstem flows of 20 times or more may affect biota. These short-term fluctuations may also affect the wild and recreational character of the upper Youghiogheny River.

- There is no formal requirement at present to maintain reservoir volume at levels compatible with recreational use of the lake.

- Public access to the Youghiogheny River near the Deep Creek power plant and to Deep Creek Lake is limited and could be improved.

These issues are of particular concern because of the presence of a large native trout population in the Youghiogheny River and because the Maryland Heritage Program believes that several endangered species inhabit the area. PPER is currently evaluating Penelec's plans to address these issues.

Status of Assessments for Other Small-Scale Facilities

Sixteen small-scale projects (including Deep Creek, discussed above) have been reviewed by the State as of September 1989. Nine of these facilities are now in operation (Table 4-7); four have environmental issues still pending and one is still under construction (Table 4-8). Six additional projects for which permit applications were submitted have been abandoned by the developers (Table 4-9). A number of environmental issues have been raised repeatedly in the review of these projects.

The first issue, modification of river flow, is complicated because of its importance to both developers and resource agencies. Without alterations in river flow, some projects will be economically infeasible. However, numerous studies (Hildebrand *et al.* 1980; Loar and Sale 1981; Weisberg *et al.* 1985) have shown that the potential negative effects of unmitigated flow alterations on biota are large.

Table 4-7
Operational small-scale hydro projects
October 1990

Project	Project Capacity (kW)	River/Location	FERC Docket No.	Developer	License Type	Issued	Expires	Status
Gilpin Falls	396	Northeast Creek/Pleasant Hill, Cecil County	3705	American Hydropower Company	License exemption	1982	-	Operational since 1984
Wilson Mill	23	Deer Creek/ Darlington, Harford County	-	A. Thadani	None	-	-	Operational since 1983
Gores Mill	10	Little Falls/ Baltimore County	-	C. Lintz	None	-	-	Operational since 1950s
Parker Pond	40	Beaver Dam Creek/ Wicomico County	-	W.H. Hinman	None	-	-	Operational since 1950s
Potomac Dam #5	1,120	Potomac River/ Clear Spring, Washington County	2517	Potomac Edison	Major license	1976	2003	Operational since 1919
Potomac Dam #3	600	Potomac River/ Harpers Ferry, WV	2515	Potomac Edison	Major license	1962	1993	Operational since 1922
Potomac Dam #4	1,000	Potomac River/ Shepherdstown, WV	2516	Potomac Edison	Major license	1965	2003	Operational since 1909
Deep Creek	20,000	Youghiogheny/ Garrett County	2370	PECO	Major license	1968	2003	Operational since 1925
Brighton	400	Patuxent River/ Clarksville, Montgomery County	3633	Alternate Energy Associates Limited Partnership	Minor license	1984	2024	Operational since 1986

Table 4-8
SSH projects with issues pending
June 1990

Project	License Type	Status	Actions Taken by Developer in Previous Six Months	Actions by Developer Anticipated in the Next Six Months	Actions Taken by The State in Previous Six Months	Next Action Item Required of the State
Potomac Dam #4 (Shepherdstown) 1,000 Kw Docket 2516	Major license issued 1965; Ammendment issued May 1984 expires 2003.	Third unit installed--operational during Spring 1990 but malfunctions again forced shut down. Third unit is again being repaired.	Operated third turbine, but unit not on line at present due to equipment failures.	Complete repairs on third turbine. Inform FERC when third turbine is fully operational and submit revised schedule for required studies. Initiate additional studies of dissolved oxygen and turbine mortality as required by FERC.	Reviewed final results of recreational studies.	Review results of field studies conducted under three turbine operations.
Jennings Randolph 13,000 Kw	Preliminary permit application	Previous developer abandoned project. Two competing developers, Synergics and the Town of Westernport filed applications for preliminary permit. A third party, Allegany County, may also be filing a competing application.	Submitted preliminary permit application to FERC.	Investigate project feasibility; begin to develop detailed project plans and draft license application.	None.	Review and comment on proposed project. Identify studies to be conducted by developer if licensing is pursued.
Potomac Dam #3 (Harpers Ferry) 600 Kw Docket 2515	Major license issued 1966; expires 1993.	Submitted initial information package regarding relicensing in September 1989. Submitted plan for environmental studies in June 1990.	Prepared study plan to address environmental concerns about the project.	Respond to agency comments and revise necessary study elements. Conduct environmental studies and prepare draft license application.	Reviewed and commented on studies proposed by the developer as part of relicensing.	Review results of environmental studies. Review and comment on draft license application.
Deep Creek 20,000 Kw Docket 2370	Major license issued 1968; expires 1993.	Initiated relicensing consultation process in January 1989. Conducting environmental studies in support of relicensing. Investigating means to correct low dissolved oxygen in discharge water.	Initiated entrainment studies. Evaluating mitigation alternatives for dissolved oxygen.	Continue water quality field studies. Conduct temperature modeling of river below tailrace. Prepare draft license application.	Reviewed developers proposals for 1990 field studies.	Review water quality, fisheries and recreational study results collected by developer in 1990. Construct temperature model for Youghiogheny River. Review and comment on draft license application.
Brighton 400 Kw Docket 3633	Minor license issued 1984; expires 2024.	Operational December 1985. Compliance with license conditions challenged by the State.	Attended FERC dam inspection to discuss silt valve operation and responsibility.	Collect water quality data during silt valve operations or provide notice of such operation to the State.	Submitted a letter to FERC expressing the continuing concern over water quality during silt valve operations.	Review or collect water quality data during silt valve operations. Complete analysis of previously collected benthic data. Work with WSSC and developer to develop silt valve release strategy that minimize adverse environmental impacts.

Table 4-9
Abandoned SSH Projects
October 1990

Project	Project Capacity (kw)	FERC Docket No.	License Type	Issued	Expires	Status
Atkisson, Winters Run	176	8384	Preliminary permit	December 1984	June 1986	Preliminary permit expired, developer dropped plans for the project due to liability concerns of the landowner (U.S. Army) and excessive siltation of the reservoir.
Daniels, Patapsco River	281	7752	Preliminary permit	April 1984	October 1985	Preliminary permit expired, developer has abandoned project.
Dickey, Patapsco River Parker Pond	600	4380	Preliminary permit	August 1981	February 1983	Developer abandoned the project in a letter to FERC (1/9/87) due to economic infeasibility of addressing environmental concerns expressed by the State.
Little Falls, Potomac River near Washington D.C.	11,500	9989	Preliminary permit	March 1986	Surrendered permit March 1986	Surrendered preliminary permit, developer has dropped plans for the project due to opposition by the Department of Interior (landowner).
Savage River	3,200	10087	License Exemption	April 1987 (Applied)	December 1988	Dismissed by FERC because Reed Hydroelectric was unable to obtain a use agreement with the State.
Savage River	2,000	9697	Preliminary permit	November 1988	July 1989	Surrendered preliminary permit, developer has dropped plans for the project due to infeasibility of construction and operation.
Rocky Gorge, Patuxent River	125	6596	License exemption	December 1982	Exemption surrendered	Developer dropped plans for the project based on economic infeasibility of further dam safety analyses required by FERC.
Bloomington (Jennings Randolph) N. Branch Potomac River	13,846	4506	Major license	1983	December 1989	Developer unable to resolve conflicts with Army Corps; Memorandum of Understanding for final construction approval not granted and license extension period expired.

As a result of such concerns, the Gilpin Falls and Brighton Dam turbine designs were modified to minimize water level and flow fluctuations downstream (Bowman and Weisberg 1985). Results of a field study are currently being analyzed to assess the effects of the Brighton Dam project on downstream biota. Both the Gilpin Falls and W.J. Dickey projects, as originally proposed, included diversion of a large fraction of streamflow from behind a dam to a generating facility some distance downstream. This would have partially dewatered the diverted stream reaches, leading to possible biotic impacts. This issue was successfully resolved at Gilpin Falls; the W.J. Dickey project was abandoned by the developer while still under FERC review.

Fish passage is an issue at projects located in areas that might support migratory fish populations. A requirement that "fish passage facilities will be established if anadromous fish are restored to the base of the dam" has been repeatedly included as a license condition in the State's comments to FERC on proposed projects. However, no projects with the potential for anadromous fish passage have been licensed to date.

A final issue is that of turbine-related fish mortality. The sources of fish mortality associated with passage through hydroelectric turbines are not well understood, but may be due to mechanical injury (e.g., impact with a solid object within a turbine system), pressure effects (sudden change to subatmospheric pressure during turbine passage), and shear effects (effect of two adjacent high-velocity water flows). Although the type of turbine has an influence on turbine mortality, site-specific factors such as head, efficiency, and blade tip clearance also play a major role.

In Maryland, two general concerns about fish passage through hydroelectric facilities exist: movement of anadromous fish (primarily herrings and temperate basses) associated with reproduction, and losses incurred by resident populations. Studies to date have only been conducted at facilities where resident fish were of concern; these studies have suggested that turbine-related mortality of resident populations is unlikely to have a major population-level impact. However, the magnitude of turbine-related mortality tends to be site-specific, suggesting the need for at least some degree of evaluation at each project. In addition, turbine-related mortality may not be sufficient to cause a population-level response, but may be great enough to have a measurable impact on the recreational fishery.

Conclusions

Hydroelectric facilities can affect aquatic life forms in a number of significant ways. Dam operations at Conowingo control water level and flow in downstream aquatic habitats, thereby directly affecting the abundance and type of food organisms important for fish growth and survival. Water quality is also affected: in summer, low DO concentrations from the impoundment released in the discharge water can cause poor water quality downstream of the dam. The physical presence of the dam can deny anadromous fish access to spawning areas upstream.

For smaller-scale hydroelectric projects in Maryland, the review process mandating early state resource agency participation has allowed PPER to work with developers in mitigating potential project impacts prior to plant construction or operation. Where potential impacts could not be fully addressed prior to construction, monitoring programs to measure the degree of impact have been required of the developer or conducted by the State. Field work and modeling studies are being conducted by the State and Penelec to assess the impact of current operation of the Deep Creek hydroelectric facility and to determine measures that could be taken to minimize those impacts. Field work is also being performed at the Brighton Dam and Potomac Dam No. 4 projects, both small-scale hydroelectric facilities currently operating.

G. Toxic Impacts

This section summarizes studies and regulatory activities concerning the effects of toxic substances associated with power plant operations. In previous reports, this information was distributed among a number of sections. In addition to projects completed since the previous CEIR, several older studies are included in order to provide comprehensive coverage.

Impacts from Atmospheric Emissions

Steam generating power plants emit a number of pollutants from the combustion of fossil fuels. These include oxides of sulfur, nitrogen, and carbon; polynuclear aromatic hydrocarbons (PAHs); metals; dioxins; and furans (Majumdar *et al.* 1987). Depending on particle size, contaminants are subject to both long- and short-range atmospheric transport. Long-range transport of oxides of nitrogen and sulfur results in acidic deposition, which is discussed in Chapter 8. Some potential local impacts of power plant emissions are discussed below.

Toxic metal and organic pollutants tend to concentrate in the microlayer within approximately 50 microns of the water surface (Hardy *et al.* 1985), which is an important habitat for the eggs and larvae of many commercially important fish and shellfish (Shanks 1983). Concentrations of metals and organics in the surface microlayer at 12 stations in the Chesapeake and its tributaries were measured in a PPRP-sponsored study (Hardy *et al.* 1987). A bulk water sample was collected in the area of the Chesapeake Bay Bridge for comparison. This study also attempted to determine the importance of power plant emissions as a source of contaminants in the microlayer. The ratios of concentrations of various metals in the microlayer were compared with these ratios in fly ash.

Concentrations of total particulate metals, alkanes, and PAHs were higher in the microlayer by factors of 4.1, 33.5, and 9.3, respectively, than in the rest of the water column. The study identified a variety of sources, including coal and gasoline combustion and uncombusted petroleum hydrocarbons. The identity and concentrations of chemicals measured in the microlayer at stations located near the two power plants (Chalk Point and Vienna) did not implicate those plants as dominant sources of microlayer contaminants.

Impacts of Coal Piles and Ash Disposal Sites

- Chemical Characterization of Coal Leachates

Laboratory experiments were conducted to identify the mechanisms of leaching and to characterize leachates under controlled conditions (Tuttle *et al.* 1989). The major inorganic elements in the coal were sulfur and iron, with aluminum, calcium, magnesium, sodium, potassium, beryllium, manganese, copper, arsenic, and cadmium also at high abundances. Leachates were typically in the pH 2 to 3 range. The dominant process was iron pyrite oxidation. Leachates are typically concentrated acid iron sulfate solutions that contain environmentally hazardous concentrations of several metals (e.g., aluminum and copper). Metal and PAH concentrations in laboratory leachates were near the upper limit of concentrations measured in leachates near coal storage piles, indicating that the experiments adequately simulated field conditions. Addition of limestone to the coal eliminated acidity and reduced concentrations of the hazardous metals investigated to below detection limits (Helz *et al.* 1987).

Leaching of organic compounds seems to pose a lesser potential environmental threat than that of inorganic substances because of the low quantity of organics found in leachate; however, it was emphasized that polar organics had not been considered in the analysis (Tuttle *et al.* 1989). The organics measured in leachates included complex mixtures of aliphatic and aromatic hydrocarbons, including alkyl-substituted and unsubstituted PAHs (Fendinger *et al.* 1989). These were mainly associated with suspended particles rather than being dissolved.

A number of techniques are available for minimizing the environmental impact of coal pile storage. The practice of storing leachates in containment ponds and neutralizing them with carbonates should facilitate precipitation of most metals (Tuttle *et al.* 1989). Other possible methods include: 1) increasing the height of piles; 2) storing coal in larger pieces to decrease surface area for leaching; and 3) attempting to retard the development of pyrite-oxidizing bacteria by "sealing" stored coal to prevent oxygen from entering the pile or by applying inhibiting substances to the surface of the pile. Coal storage may also have a beneficial environmental impact: the sulfur content of coal can be decreased by as much as 50 percent after 100 days of leaching.

- Effects of Coal Leachates on Fish Spermatogenesis

In order to evaluate the possible effects of coal leachates on fish reproduction, Cochran (1987) examined sperm production in the mummichog (*Fundulus heteroclitus*) in a series of laboratory and field studies. Fish were collected weekly from April to August from waters adjacent to the Brandon Shores, Chalk Point, and Morgantown plants, from control sites two miles upstream of these plants, and from a reference site (Parrish Creek) away from the plants. A sperm index was calculated to account for size differences in fish and testes. The total sperm production over the season was not significantly different between the plant and the reference stations. However, production was significantly higher at the

Parrish Creek site. These differences may be the result of genetic, nutritional, ecological, or toxicological factors.

Laboratory experiments were conducted with Parrish Creek fish exposed for six weeks to leachates prepared from coals collected from these three plants. Leachate pH was adjusted to 7.8. Relative to unexposed controls, the sperm index was lowered by exposure to Chalk Point coal leachate but not by leachate from the other plants' coals. In another experiment, fish were exposed to leachates prepared from various coals that had been mined in Kentucky, Maryland, and Pennsylvania. There were significant reductions in sperm index in fish exposed to the Maryland and Pennsylvania coal leachates, with a concentration-response apparent for the Maryland coal. In some cases, photoinsensitive fish (i.e., those that do not ordinarily go into breeding condition from photoperiod stimulation) could be stimulated to go into breeding condition when exposed to diluted coal leachates. The large difference in sperm index between the populations near and far from some plants and the differences in responses to various leachates indicate an area for further examination.

- Acute and Chronic Effects of Arsenic and Selenium on Early Life Stages of Striped Bass

The effects of arsenic and selenium on early life stages of striped bass (*Morone saxatilis*) were examined in a series of laboratory bioassays (Klauda 1986). These metals may enter aquatic systems as airborne fly ash particles or in run-off from coal and coal-waste disposal piles. Eggs, larvae, and juvenile fish were exposed to these metals singly and jointly in acute (96-hour) and chronic (60-day) exposures. Experiments were performed in estuarine creek water with salinities ranging from 3.5 to 7.5 ppt. Ninety-six hour LC50 values (median lethal concentrations) were in the 7 to 19 mg/l range for arsenic and the 10 to 86 mg/l range for selenium for larval and juvenile fish. The hatching success of eggs was not affected by either metal at concentrations as high as 1,000 mg/l. The concentrations of arsenic and selenium required to produce acute toxic effects on striped bass are unlikely to occur in nature.

Chronic exposures were also conducted in which larvae and juveniles were exposed to fractions of the LC50 levels for arsenic and selenium (singly and jointly) until they were between 60 and 66 days old. Selenium was accumulated with a concentration factor of 3.0, while arsenic was not accumulated. An increased incidence of lower jaw deformities was observed in 12 to 30 day old larvae that had been continuously exposed to selenium at 0.09 to 0.99 mg/l. These individuals weighed less and were less robust than individuals that were not deformed. However, no statistically significant changes in length, weight, or condition were reported in larvae and juveniles exposed to either or both metals for 60 days. Typical arsenic and selenium levels in fresh and estuarine waters were less than 0.2 mg/l. Klauda (1986) stated that selenium concentrations approaching 1.0 mg/l may occur in areas near discharges or from contaminated sediments. Potential toxic effects from exposure to these (or possibly lower) concentrations could include the development of skeletal abnormalities, slowed growth, and reduced survival.

- Larval Yellow Perch Survival Study near the Faulkner Ash Disposal Site

Ash generated from the operation of the Morgantown SES is stored at the Faulkner Ash Storage facility located in Charles County. The ash storage site is also located in the Zekiah Watershed, and is upgradient from Zekiah Swamp Run. Although yellow perch (*Perca flavescens*) populations have decreased statewide, the possibility existed that leachate from the ash storage site could be contaminating the surface waters and affecting reproductive success within Zekiah Swamp Run. In spring 1989 and 1990, a series of *in situ* bioassays were conducted with larval yellow perch to examine survival in Zekiah Swamp Run (Burton *et al.* 1990). In 1989, tests were performed at three stations: in Zekiah Swamp Run less than one mile downstream of the site, in Zekiah Swamp Run approximately three miles upstream of the site, and at a reference station in nearby Mattawoman Creek. The Mattawoman site was chosen because high larval survival had been reported there in previous *in situ* bioassays. All of these stations are in non-tidal reaches. In 1990, a fourth station located in the tidal portion of Allen's Fresh was tested to examine survival of larvae carried downstream from spawning areas in Zekiah Swamp Run. During both years, water quality parameters were monitored and a limited number of samples were analyzed for organic and inorganic chemical contaminants.

In 1989, mortality averaged from all the bioassays was 94 percent at the Upper Zekiah station, 91 percent at the Lower Zekiah station, and 51 percent at the Mattawoman station. In 1990, mortality averaged 99 percent at the Upper Zekiah station, 93 percent at the Lower Zekiah station, 79 percent at the Mattawoman station, and 66 percent at the Allen's Fresh station. Statistical analysis indicated that there was significantly higher mortality in the Zekiah stations relative to reference stations in both years; however, water quality parameters and contaminant concentrations were similar at all stations and did not implicate specific causes for the elevated mortality within Zekiah Swamp.

Results to date indicate that poor larval survival in the *in situ* stations from non-tidal areas of Zekiah Swamp Run results from a system-wide phenomenon. In contrast, significantly better survival was observed in the downstream tidal area. Specific factors responsible for the poor survival are unknown, however, the similarity in responses at the potentially site-impacted Lower Zekiah station and the upstream Zekiah station strongly indicate that at the present time, the ash storage site does not appear to be a contributing factor.

In 1990, an egg strand survey was conducted to determine if yellow perch spawning still occurred within Zekiah Swamp and to create a data base to assist in monitoring future spawning activity. The results of the survey revealed that over 1,500 females spawned in Zekiah Swamp Run just above the fall line in 1990, suggesting that system was an active spawning area.

- Impact Assessment Studies at the Vienna Fly Ash Disposal Site

The Vienna Fly Ash Disposal Site, located in wetlands across the Nanticoke River from the Vienna Power Plant, received ash from 1966 to 1972. PPSP-sponsored studies were conducted from 1981 to 1983 and were summarized by Klose (1984). In the first study, potentially elevated concentrations of aluminum, arsenic, and selenium were measured in tissues of mummichogs collected at the site relative to a reference site. However, this finding was not corroborated in a follow-up study. The follow-up study also reported that concentrations of these metals were not elevated in tissues of white catfish, channel catfish, eel, and white perch collected near the site. According to Klose, there was no consistent indication of contamination in fish tissues.

Impacts of Cooling Water Discharges

Cooling water discharges may have toxic impacts on aquatic biota if toxicants are introduced into the discharge water. The use of chlorine as a biocide (and its combined effects with elevated temperature) (Cairns *et al.* 1978), as well as the leaching of metals from condenser tubes, are major areas of concern.

- Biotic Effects of Chlorine Use

Because chlorine is injected into cooling water just after plant entry, it adds a chemical stress to entrainment (Brungs 1976; Bongers *et al.* 1977). Studies at Morgantown and Chalk Point indicate that entrainment mortality was higher during periods of chlorination than at other times (Morgan 1968; Bongers *et al.* 1975; MMES 1985a; ANSP 1983a). Laboratory biotoxicity studies further demonstrate that early life stages of fish and shellfish are adversely affected by chlorine and its decay residuals at very low concentrations (ppb range) (Roberts *et al.* 1975; Liden *et al.* 1980). The allowable chlorine discharge limit at Maryland power plants is 0.2 ppm.

Laboratory studies indicate that early life stages of benthic organisms are also adversely affected by chlorine at very low concentrations (Brungs 1976; Liden *et al.* 1980). However, no depletions of benthic populations have been observed in the vicinity of power plant discharges following extended periods of chlorine use (MMES 1985a), and the concentrations of the most toxic forms of chlorine in power plant discharges are within acceptable limits (Sugam and Helz 1977; Helz 1981). This is because chlorine decays rapidly to relatively nontoxic forms in estuarine waters.

- Metal Discharges

In the past, copper released from the copper-nickel condenser tubes (recently replaced with nontoxic titanium tubes) at Chalk Point was of concern because the copper bioconcentrated in oysters near the discharge (Roosenburg 1969; Eaton and Chamberlin 1982; ANSP 1983a, 1983b). Bioconcentration of copper, however, did not adversely affect oyster growth or survival (ANSP 1983b). The affected region is not prime oyster habitat, and oysters are not commercially harvested there

(MMES 1985a). High tissue burdens of copper have only rarely been reported in oysters from commercial oyster beds located downstream (ANSP 1983a; MMES 1985a). Also, a monitoring program conducted by the utility (PEPCO 1985) found no abnormal tissue burdens of copper in oysters near the Chalk Point discharge. The minimal effects of copper discharge at Chalk Point have recently been eliminated completely with the installation of titanium condenser tubes.

Oysters in the vicinity of Calvert Cliffs and Morgantown also bioaccumulated copper; however, oyster densities in the affected areas were too low to support a fishery (Phelps 1979; MMEC 1980). No copper uptake by other benthic biota in the nearfield areas of these plants has been observed (ANSP 1977; MMEC 1980; Holland *et al.* 1985a). No above-ambient levels of copper were found in sediments or biota near Crane or any other tidal fresh-oligohaline zone power plant (EA 1979a; DP&L 1982).

State Biomonitoring Program

Under authority of the Clean Water Act Amendments of 1987, Maryland has included effluent toxicity testing in its discharge permit and biomonitoring programs. Quarterly whole-effluent toxicity test requirements are now included in the permits issued for the Brandon Shores and Vienna plants. Effluent toxicity test results are available for 10 power plants tested either under permit requirements or for compliance sampling inspections (MDE 1989a). For all tests listed in the MDE data base, EC50 (median effective concentration) or LC50 values were reported as greater than 100 percent effluent. This means that, while there may be some mortality in animals exposed to the effluent, there was not enough effluent to allow calculation of an EC50 or LC50. Two chronic toxicity tests were performed with effluent from the R.P. Smith plant. In a test with fathead minnows, no toxic effects were observed in fish exposed to 100 percent effluent. In *Ceriodaphnia dubia*, no toxic effects were observed at 32 percent effluent; the lowest concentration where an effect was observed was 56 percent effluent.

Power Plants on Maryland 304(l) List

Under section 304(l) of the Clean Water Act as amended in 1987, states are required every two years to compile lists (called C lists) of all waters impaired by toxic effluents, and to identify the point sources and the amounts of pollutants discharged that cause toxic impacts. Facilities may be listed as toxic dischargers if effluent concentrations exceed acute (short-term) or chronic (long-term) ambient water quality criteria.

The Brandon Shores and Vienna power plants are included in MDE's final C list. Brandon Shores was listed because its average effluent copper concentration (from two samplings conducted in 1988) was 46.8 micrograms per liter (µg/l), which exceeded the Maryland estuarine copper standard of 6.3 µg/l. Vienna was listed because its average effluent copper concentration of 170 µg/l exceeded the Maryland acute and chronic freshwater standards of 18 and 12 µg/l, respectively (at 100 mg/l hardness). The final 304(l) list developed by EPA Region III (EPA 1990) included these two plants because of these copper concentrations.