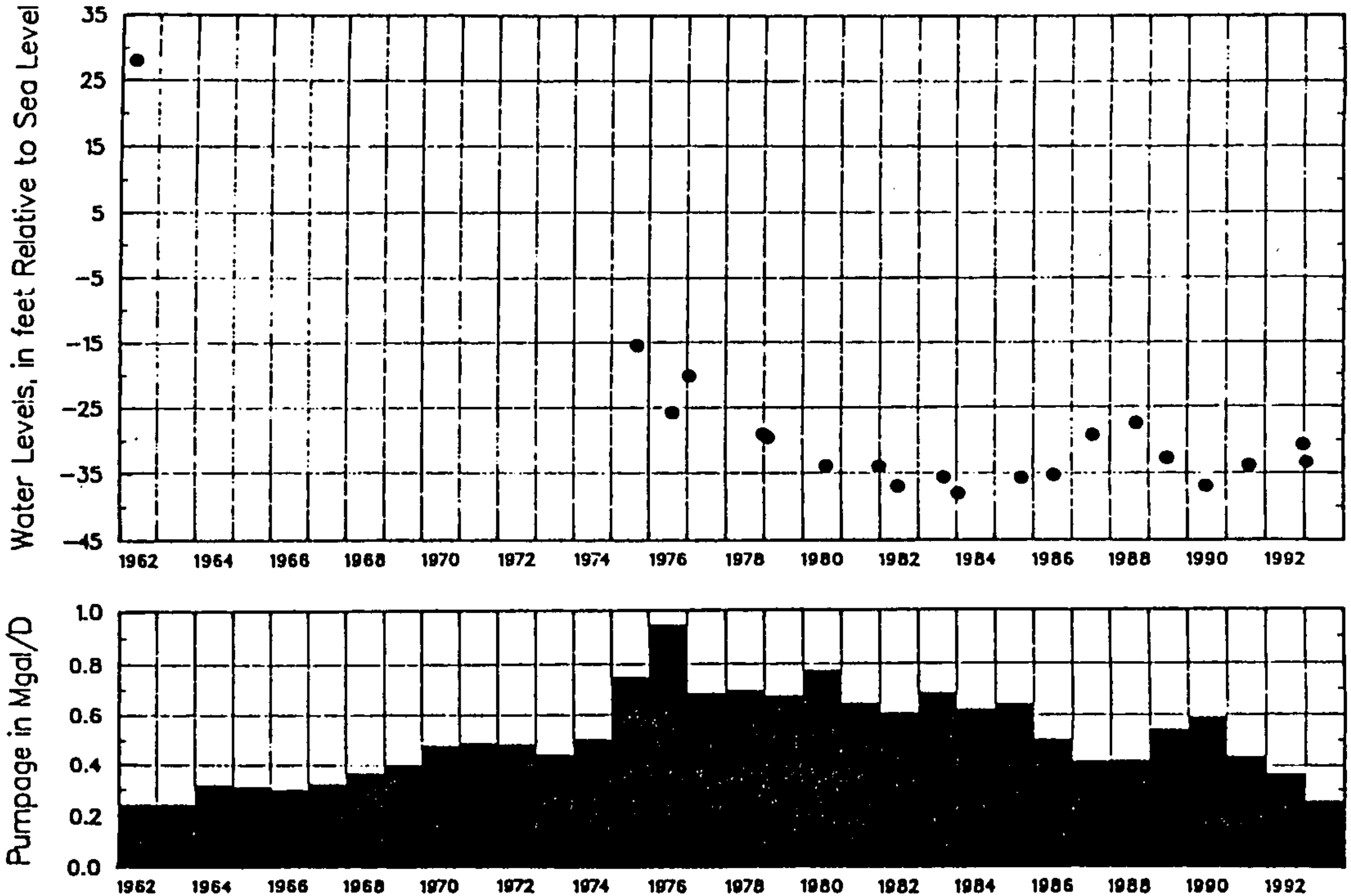
Figure 3-25
Annual Low Water Levels and the Average Ground Water Withdrawal for the Magothy Aquifer and Chalk Point, 1962-1992



Source: U.S. Geological Survey

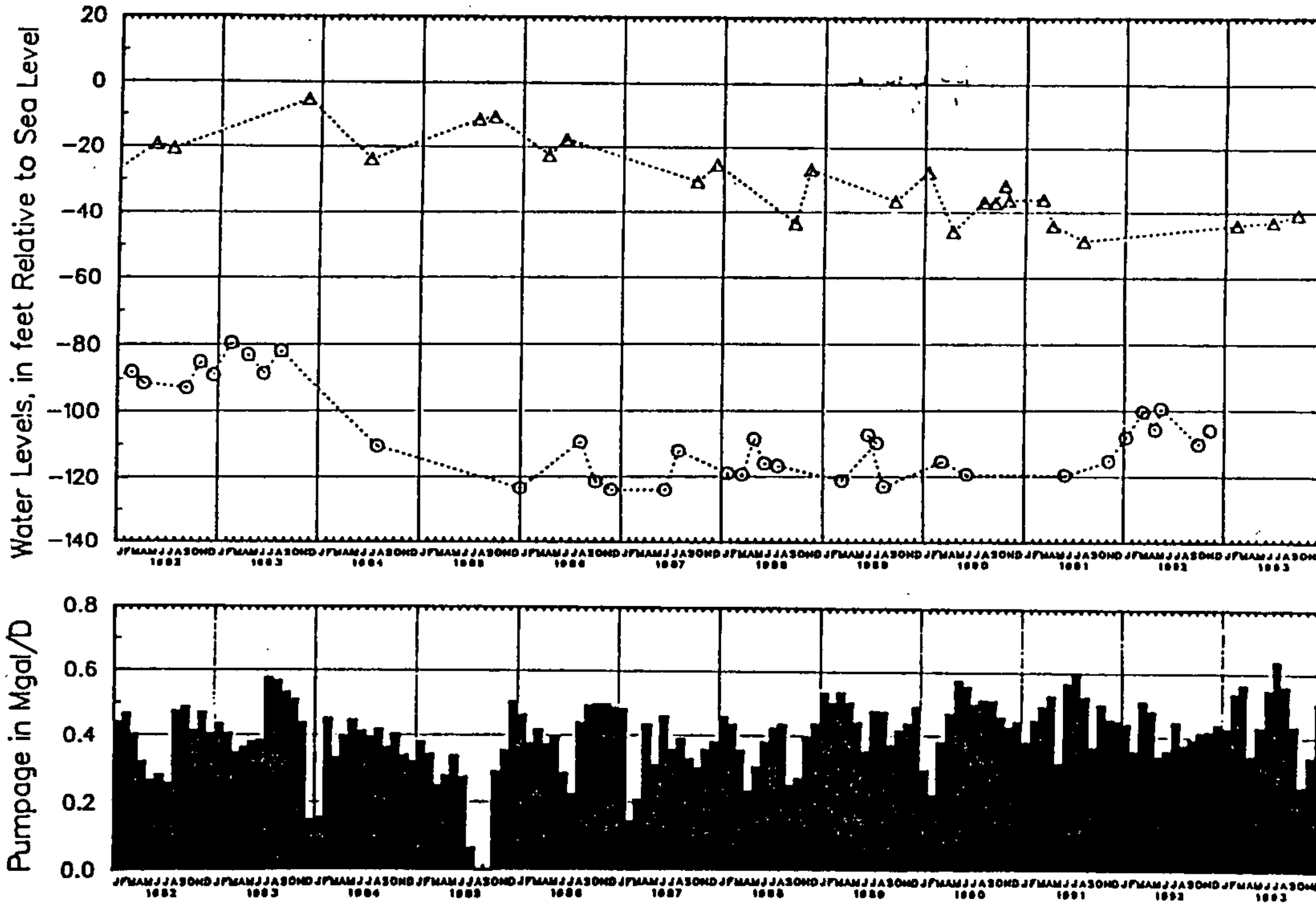
Figure 3-26 presents monthly pumping rates and random water levels for PEPCO's Patapsco Aquifer production well (PG-Hf 38) for the period 1982 through 1993. Random water level measurements made in the production well during both "pump on" and "pump off" cycles indicate a general downward trend in the Patapsco water level between 1982 and 1989. This trend appears to have leveled off between 1989 and 1993, and the figure indicates a slight rise in the water levels from approximately mid-1991 through 1993. The slight water level rise correlates to a decrease in withdrawal rates from the Patapsco Aquifer at Chalk Point during 1992.

Figure 3-27 shows the potentiometric surface of the Magothy Aquifer in 1993, as determined from 89 wells. The potentiometric surface slopes towards the southeast with local gradients directed toward three pumping centers located in Annapolis, Waldorf, and Chalk Point. Ground water levels were more than 50 feet below sea level in the Waldorf area, more than 40 feet below sea level at Chalk Point, and approximately 10 to 15 feet below sea level in the Annapolis area. The areal extent of the cones of depression in each of these areas has remained relatively constant since 1984. This suggests that potentiometric levels in the aquifer have stabilized with pumping.

Figure 3-28 illustrates the difference between the potentiometric surfaces of the Magothy Aquifer between 1975 and 1993. The potentiometric surface of the Magothy Aquifer has declined approximately 20 feet at the Chalk Point facility, and as much as 60 feet in the Waldorf area. The potentiometric surface at Waldorf has declined by almost five feet since 1990. These decreases in the potentiometric head are small, however, compared to the approximately 500 feet of drawdown available in the Magothy Aquifer in the vicinity of Chalk Point. PEPCO plans to continue to decrease pumping from the Magothy Aquifer. The decrease in withdrawals should result in some recovery of the potentiometric surface in the Magothy at Chalk Point.

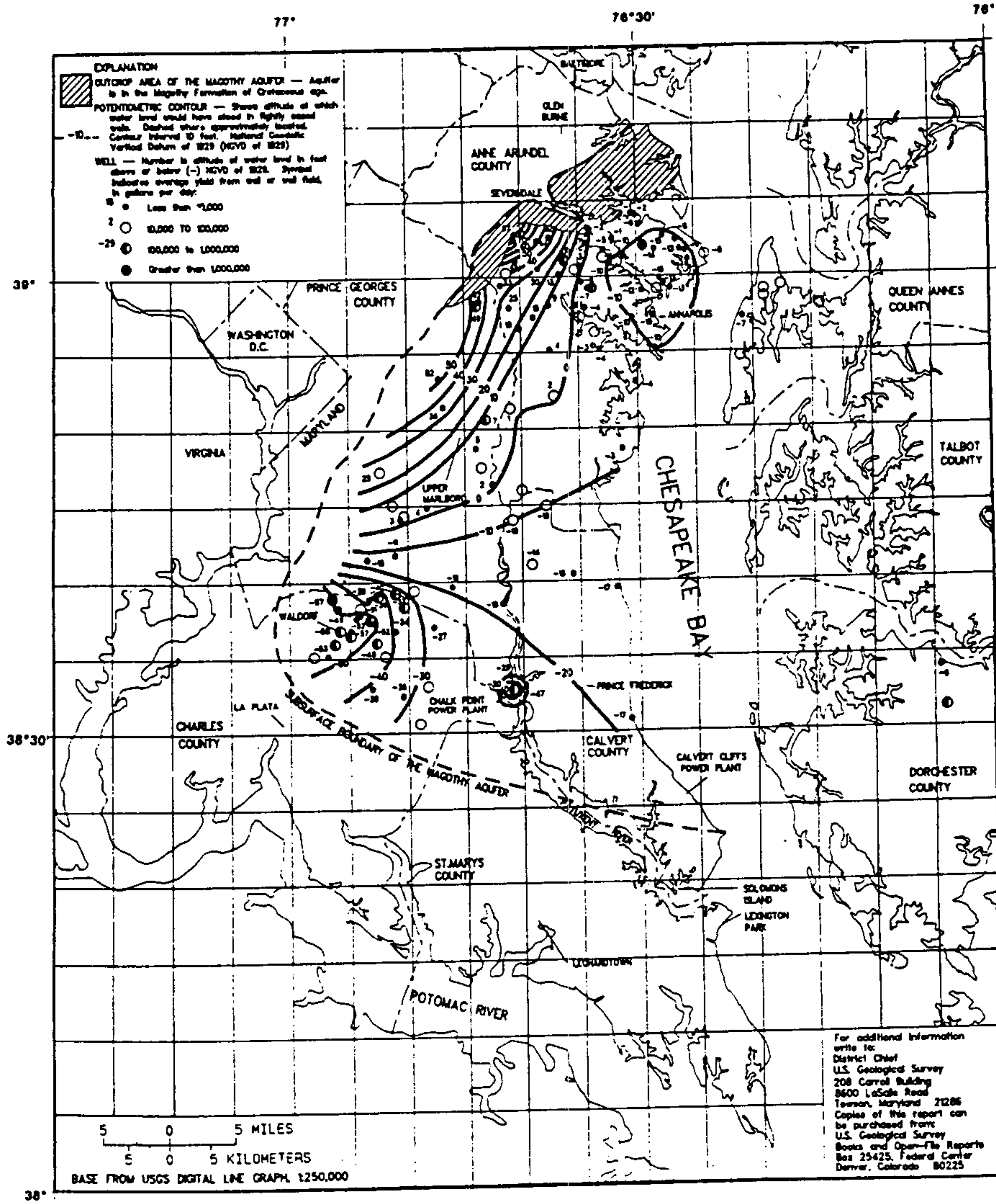
Figure 3-29 illustrates the potentiometric surface of the Upper Patapsco Aquifer in 1993, and is based on data from 45 wells clustered in northern Anne Arundel County near Annapolis, and in northern Charles and southern Prince George's Counties near Waldorf and Chalk Point. Ground water in the Upper Patapsco Aquifer flows to the south and southeast toward pumping centers in the Annapolis, Waldorf, and Chalk Point areas. A cone of depression, albeit poorly defined due to the limited number of wells in the Patapsco monitoring network, has developed in the Waldorf area. This depression is related to withdrawals for public supply in the Waldorf area and is not related to the withdrawals at Chalk Point. A comparison of the 1993 map with the 1990 map (presented in PPRP 1993) indicates that the potentiometric surface in the Waldorf area

Figure 3-26
Monthly Ground Water Pumpage and Random Water Levels Measured in Production Well PG-Hf for the Patapsco Aquifer at the Chalk Point Power Plant, 1982-1993



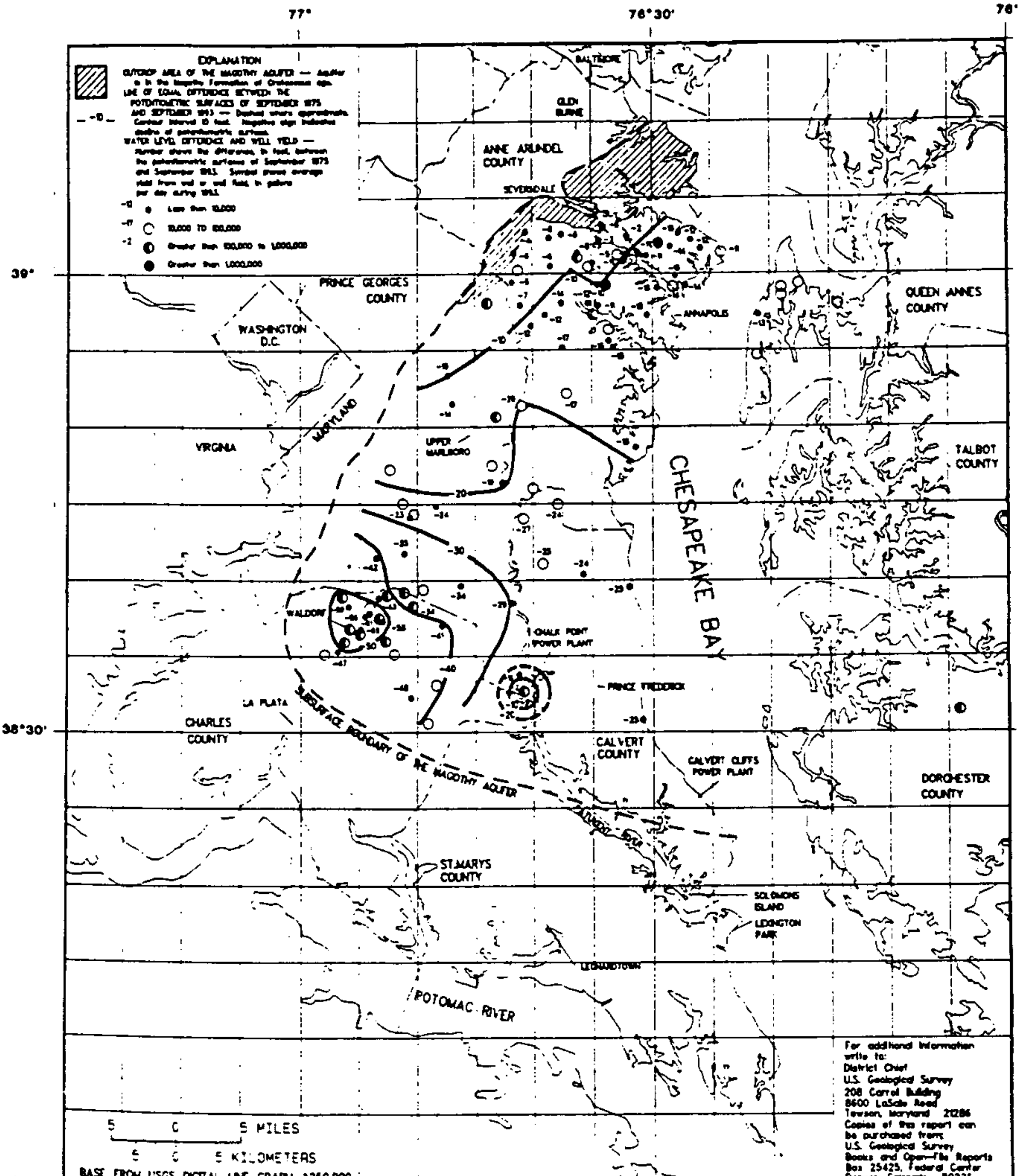
Source: U.S. Geological Survey

Figure 3-27
Potentiometric Surface of the Magothy Aquifer in Southern Maryland, September 1993



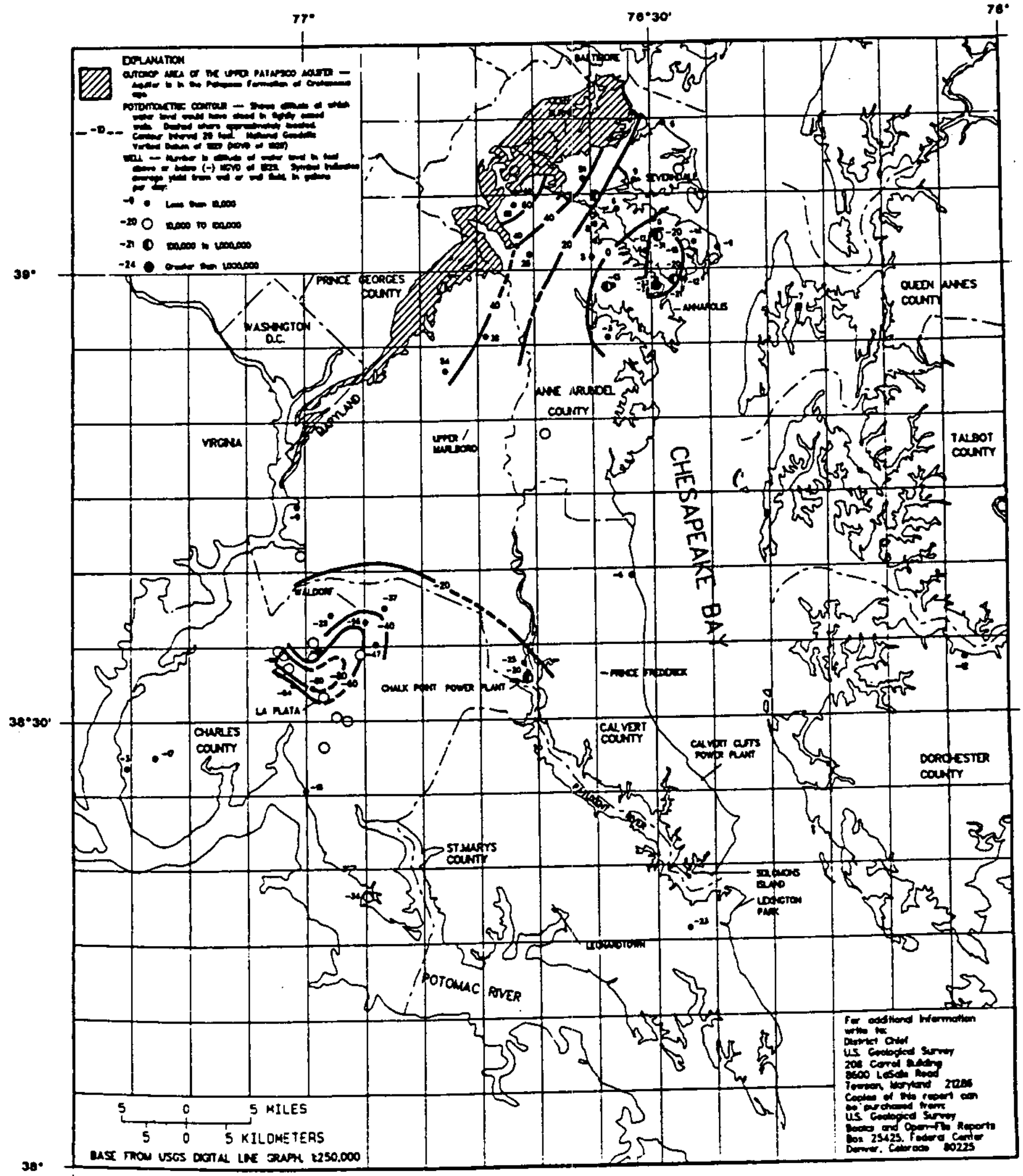
Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-391

Figure 3-28
The Difference Between the Potentiometric Surfaces of the Magothy Aquifer of September 1975 and September 1993 in Southern Maryland



Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-394

Figure 3-29
Potentiometric Surface of the Upper Patapsco Aquifer in Southern Maryland, September 1993



Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-392

has declined approximately 40 feet in three years. The cone of depression at Chalk Point has remained relatively constant since 1990.

Potentiometric levels in observation well PG-Hf 40, which is screened in the Upper Patapsco Aquifer, have decreased 27 feet from 1975 to 1986 (Mack 1988), and an additional 10 feet from 1986 to 1993 (PPRP 1993). Well PG-Hf 40 is located approximately 1.5 miles from the single production well in the Patapsco that PEPCO was using at Chalk Point prior to 1991. The 37 feet of drawdown is considered minimal compared to the approximately 740 feet of drawdown remaining in the aquifer near Waldorf and La Plata.

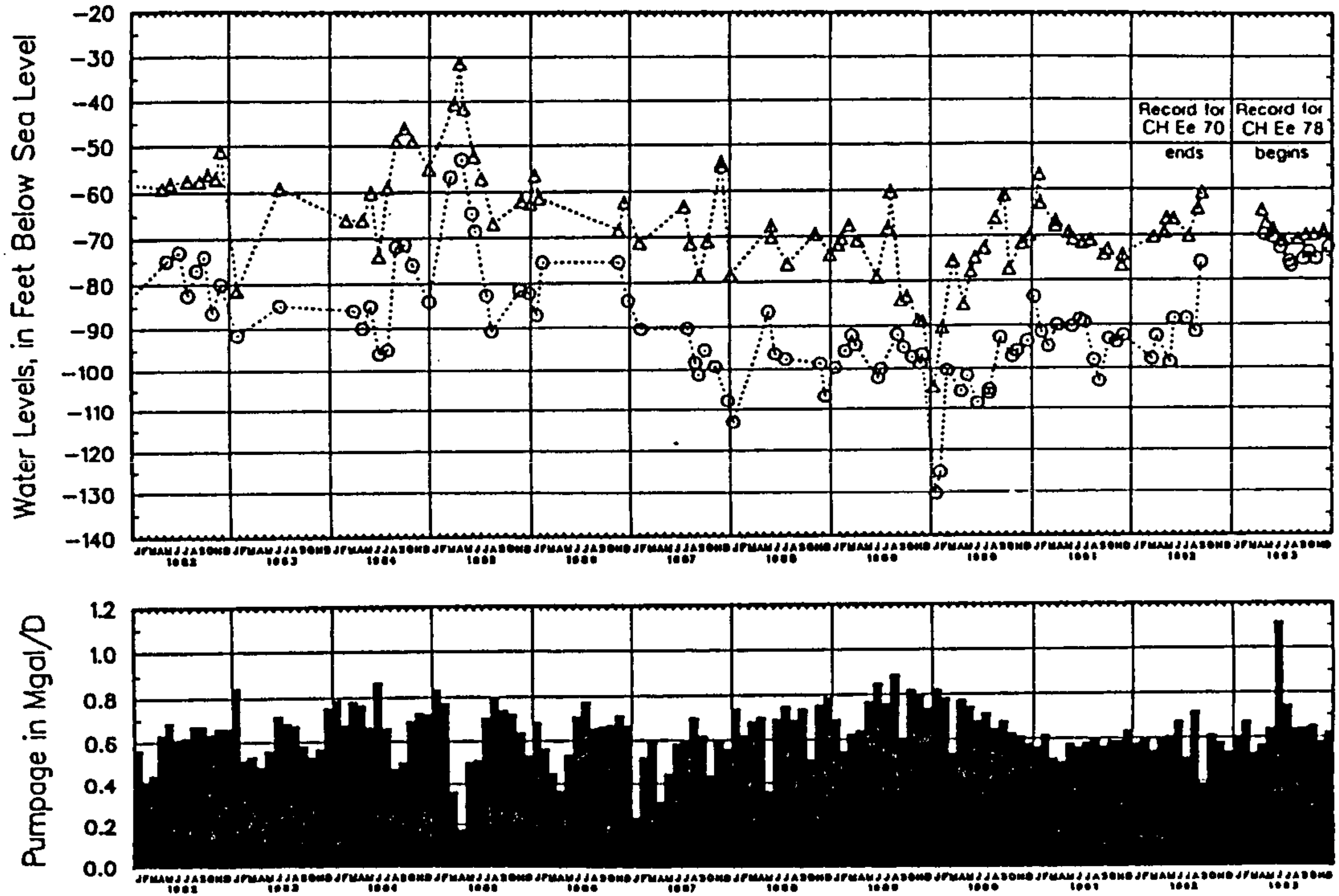
Morgantown Power Plant

Morgantown withdraws ground water from four production wells in the Lower Patapsco Aquifer at depths ranging from 1,050 to 1,095 feet below sea level (Table 3-9). Average daily withdrawal rates at Morgantown in 1992 and 1993 were 0.58 and 0.67 mgd, respectively (Table 3-8).

Figure 3-30 depicts periodic monthly high and low water levels in observation well CH-Ee 70 and CH-Ee 78 compared with monthly pumpage rates at the Morgantown power plant from 1982 to 1993. Water levels appear to correlate roughly with plant withdrawals; however, other factors apparently influence the Lower Patapsco Aquifer in this area as well. For instance, there was a sharp decline in water levels measured in January 1990, but no corresponding increase in monthly pumping rates. The downward trend in Patapsco water levels observed near Morgantown, as illustrated in Figure 3-29, is probably related to withdrawals by distant large municipal supply users in areas such as Waldorf, La Plata, St. Charles, and Indian Head.

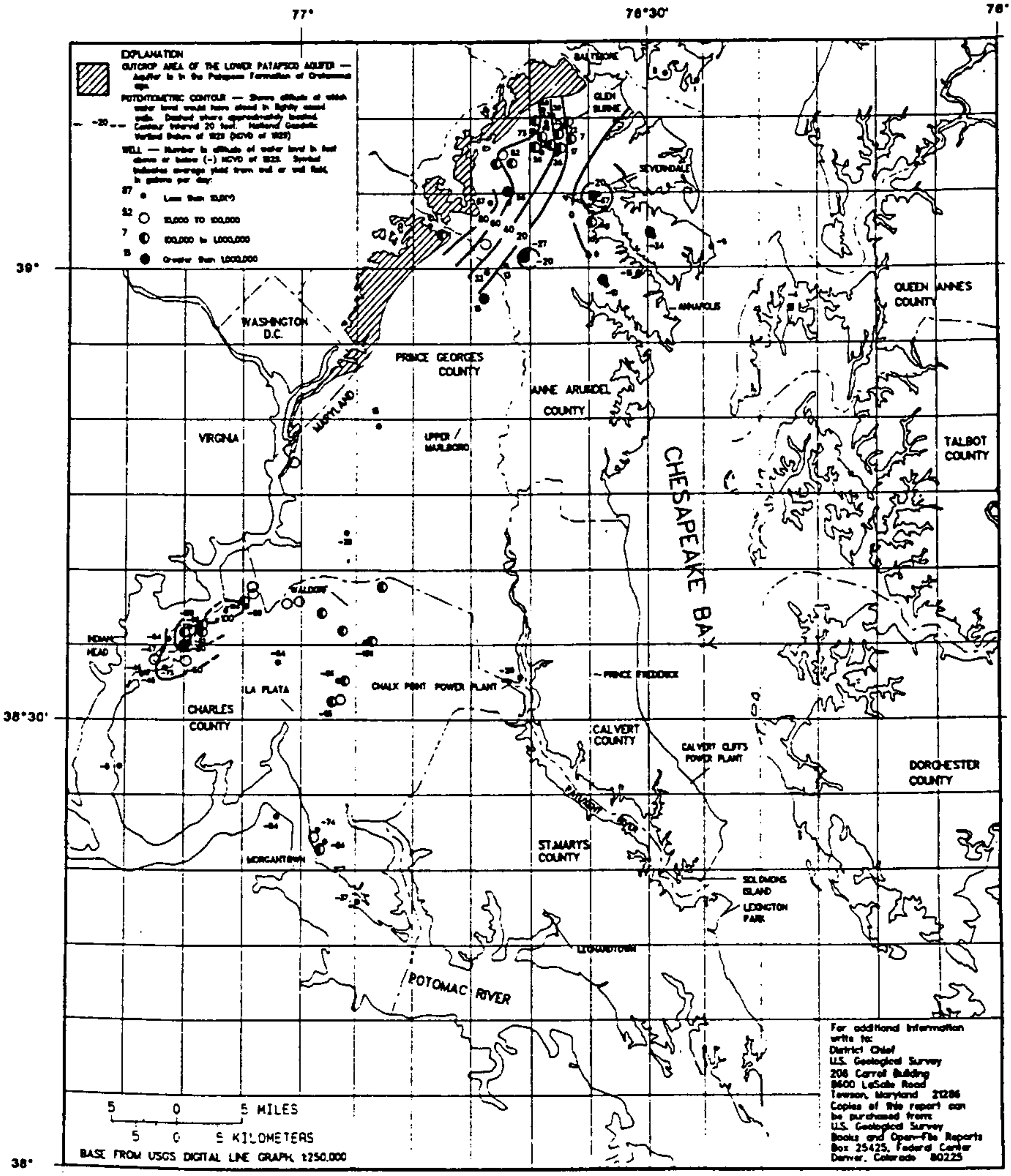
Figure 3-31 shows the potentiometric surface of the Lower Patapsco Aquifer in 1993. Based on water level measurements from 53 wells, the potentiometric surface of the Lower Patapsco generally trends to the south and southeast with localized flow toward pumping centers at Severndale, Annapolis, Waldorf, La Plata, Indian Head, and Morgantown. The water levels observed in 1993 in the two observation wells at Morgantown differ by 10 feet, suggesting a steep gradient toward the center of pumping. The potentiometric surface of the Lower Patapsco Aquifer has declined approximately 5 feet from 1990 to 1993 in the vicinity of Morgantown (PPRP 1993). There is approximately 1,400 feet of available drawdown remaining in the Lower Patapsco Aquifer in the Waldorf and La Plata areas.

Figure 3-30
Monthly Ground Water Pumpage and Water Levels in Observation Wells Ch-Ee 70 and 78 at the Morgantown Power Plant from 1982 through 1993



Source: U.S. Geological Survey

Figure 3-31
Potentiometric Surface of the Lower Patapsco Aquifer in Southern Maryland, September 1993



Source: U.S. Departmentof the Interior, U.S. Geological Survey
Prepared in cooperation with Maryland Geological Survey and Maryland Tidewater Administration
Prepared by Stephen E. Curtin, Frederick K. Mack, and David C. Andreasen
Open-file Report 94-393

Vienna Power Plant

The Vienna power plant withdraws ground water from one production well in the Columbia Group Aquifer. This production well is shallow and is screened from 26 to 46 feet below sea level (Table 3-9). The average daily ground water withdrawal rates from this well were 0.04 and 0.03 mgd for 1992 and 1993, respectively (Table 3-8). Delmarva Power has been withdrawing ground water from the Columbia Group Aquifer at approximately the same rate since 1980.

Figure 3-32 shows the relation between water levels in nearby observation well DO-Dh 27 and pumping rates at the Vienna power plant. Monitoring of this observation well began in mid-1990; therefore, the long-term effect of pumping cannot yet be determined. Figure 3-32 shows that the water level in the monitoring well is barely affected by pumpage at the plant. Given that the rate of ground water withdrawal at the Vienna plant is relatively low, the impact to ground water quantity in the Columbia Aquifer is anticipated to be negligible.

SMECO Combustion Turbine at Chalk Point

SMECO initiated ground water withdrawals from two production wells completed in the Upper Patapsco Aquifer in 1990 to serve the water needs of an 84-MW combustion turbine brought on line in the same year. The wells are screened at depths ranging from 803 to 847 feet below sea level. The average daily withdrawal rate from these wells totaled 0.01 mgd for 1992 and 1993.

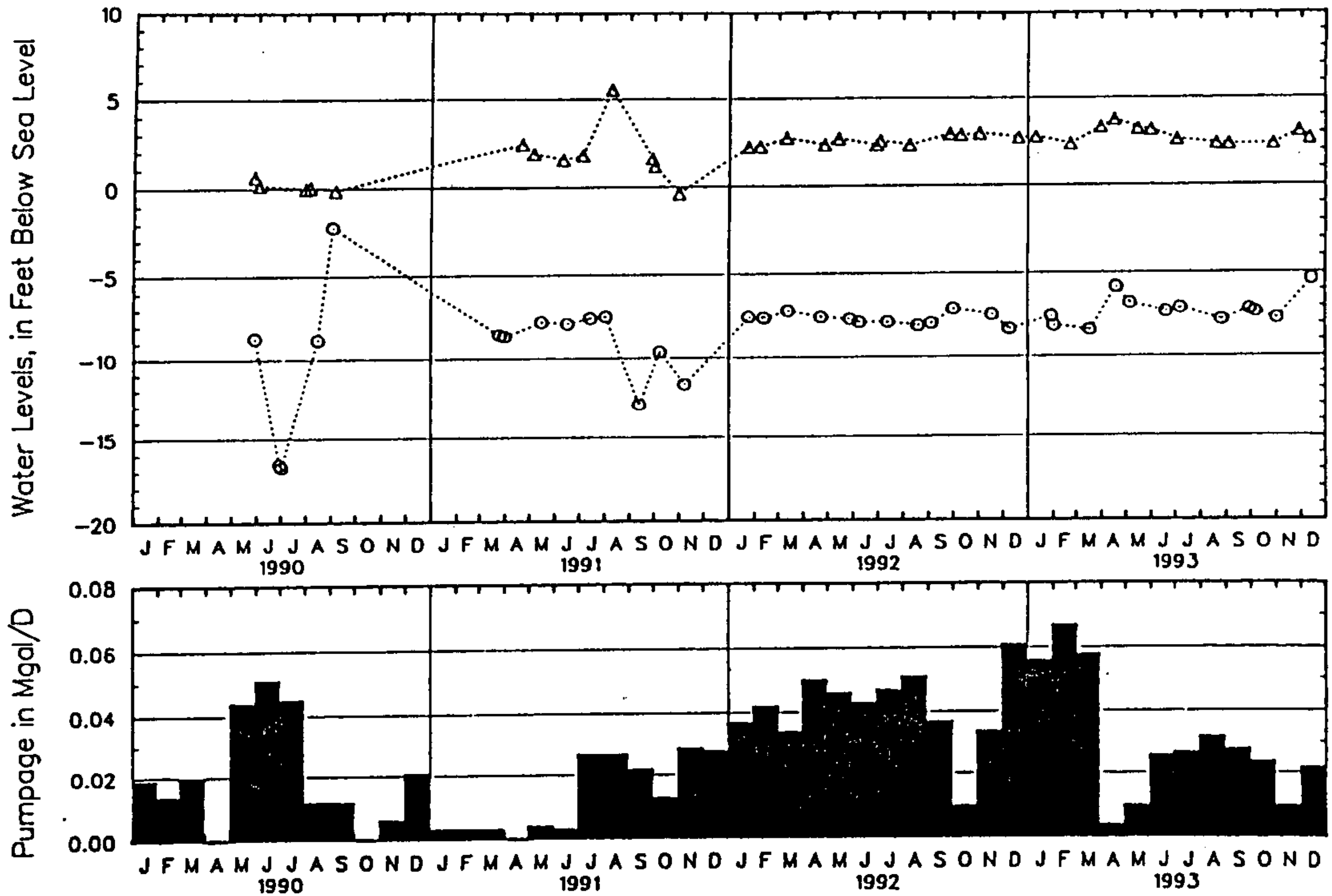
The impacts from ground water withdrawals at Chalk Point on water levels in the Upper Patapsco Aquifer were discussed earlier. The withdrawal rate of 0.01 mgd from the SMECO production well is small compared to PEPCO's withdrawals at Chalk Point (0.46 mgd in 1993). Therefore, the impact on the ground water levels of the Upper Patapsco Aquifer from the SMECO production wells is likely insignificant compared to the impact associated with the PEPCO production wells.

3.3.2.2 *Ground Water Quality Impacts*

In addition to affecting ground water quantity, power plants can potentially impact the quality of ground water. The three primary sources of potential ground water quality impacts are:

- Coal pile leachate,
- Coal combustion by-product leachate, and
- Liquid petroleum leaks and spills.

Figure 3-32
Monthly Ground Water Pumpage and Water Levels in Observation Well DO-Dh 27 at the Vienna Power Plant from 1990 through 1993



Source: U.S. Geological Survey

The potential impacts to ground water associated with each of these sources are summarized below.

Coal Pile Leachate

PPRP assessed the potential for coal piles to impact ground water quality at Maryland's seven coal-fired power plants (Keating 1990). Coal piles placed on the ground surface are uncovered and exposed to precipitation. As water infiltrates through the piles, acidic runoff (**leachate**) is produced. The leachate contains constituents such as trace metals, iron, and sulfate that can degrade ground water quality in the vicinity of the coal pile.

All seven of Maryland's coal-fired power plants collect coal pile leachate. In 1990, all but one, PE's R.P. Smith plant, also treated the leachate. Since the time of PPRP's investigation, R.P. Smith has upgraded its facility to collect and treat coal pile leachate prior to discharge.

At PEPCO's Chalk Point and Dickerson facilities, and the three BGE plants (C.P. Crane, H.A. Wagner, and Brandon Shores), the potential for degradation of ground water quality from the coal pile was determined to be low in view of the leachate collection and treatment systems. At PEPCO's Morgantown plant, the coal pile leachate is collected and treated; however, there is no clay liner beneath the coal pile and leachate collection basin, which would further protect ground water quality.

Coal Combustion By-product Leachate

In the past, PPRP has conducted several field investigations at active and former landfill sites to evaluate the impacts of landfilling coal combustion by-products. In general, these studies indicate that ground water quality can be degraded as constituents are leached from the landfills; however, degradation is localized and does not appear to affect ground water users. The results of a few recent studies are summarized below.

- *Faulkner Fly Ash Landfill* - PEPCO's Faulkner Fly Ash Landfill, located near Zekiah Swamp Run in southern Charles County (Figure 3-19), has been in operation since 1970 to handle the large quantities of fly ash generated at the Morgantown power plant. Water quality data obtained during several studies conducted at Faulkner indicate that acidic leachate with elevated concentrations of metals, iron, and sulfate is migrating to the ground water (Simek *et al.* 1983; Klose and Potera 1984; Price and Keating 1991). The extent of ground water affected by the leachate is limited to an area within 1,500 feet of the landfill. The leachate does not appear to have affected surface water quality in Zekiah Swamp Run or nearby ground water users.

- *Brandon Woods Coal Ash Structural Fill* - The Brandon Woods Coal Ash Structural Fill is operated by BGE. Coal combustion ash generated at the Brandon Shores and H.A. Wagner power plants is used as structural fill for the Brandon Woods Energy Business Park. Since 1982, when placement of the ash started, quarterly data from ground water monitoring wells at Brandon Woods have shown no adverse impact of the facility on ground water quality (Keating and Price 1994). The absence of ground water quality degradation downgradient of the coal ash fill indicates that the placement technique used at the site, coupled with site-specific hydrogeologic conditions, minimize potential adverse environmental impacts from the ash.

Liquid Petroleum Leaks and Spills

In addition to coal pile and ash landfill leachate, spills and leaks of fuels stored and used at power plants also pose a risk to ground water quality. Petroleum fuels generally do not dissolve in water; however, some organic compounds contained in the fuels, such as benzene, are slightly soluble in water and can dissolve in the ground water.

A petroleum leak impacted ground water quality at BGE's Perryman combustion turbine facility in Harford County. Fuel oil was released to the subsurface when an underground pipeline connecting the fuel oil tanks to a combustion turbine failed. BGE discovered the release in 1991, but it is not known when the underground pipeline began leaking. Investigations conducted by BGE indicate that some oil is present on the water table surface, and contamination of the ground water covers an area of approximately five acres. Because the surface aquifer is not used for water supply downgradient of the Perryman site, the release is not expected to affect any ground water users. BGE is currently remediating the spill. BGE has also reported an underground fuel oil leak at its C.P. Crane Plant; however, the environmental impact from this release has not been determined.

3.3.2.3 *Summary of Ground Water Impacts*

Currently, five power plants withdraw ground water from four major Coastal Plain aquifers: the Columbia Group, the Aquia, the Magothy, and the Patapsco. Total withdrawals from these five power plants were slightly lower in 1992 and 1993 relative to the two previous years, and remain below appropriations limits set by permit. Specific changes in ground water withdrawals by the power plants in the last two years are summarized below:

- Ground water usage rates at Calvert Cliffs in 1992 and 1993 were similar to the 1991 pumping rate, but remained below the withdrawal rates prior to the 1989 shutdown;
- PEPCO's withdrawals from the Magothy Aquifer at Chalk Point for 1992 and 1993 continue to decrease from previous years;
- PEPCO has generally increased its withdrawals from the Patapsco Aquifer at Chalk Point over the last three years to make up for reduced withdrawals from the Magothy Aquifer and to supply water for four new combustion turbines that began service in 1991 and 1992. A slight decrease in the ground water withdrawal from the Patapsco Aquifer at Chalk Point was observed for 1992; and
- PEPCO's withdrawals from the Patapsco Aquifer at Morgantown in 1992 and 1993 remained similar to withdrawal rates from previous years.

Long-term monitoring of water levels in the Aquia, Magothy, and Patapsco Aquifers indicate a decline in water levels in the Aquia Aquifer at Calvert Cliffs, in the Magothy Aquifer at Chalk Point, and in the Upper Patapsco Aquifer at Chalk Point. These impacts are considered negligible compared to the available drawdown in these aquifers. Water quantity impacts to each of these aquifers are summarized below:

- In the Aquia Aquifer at Calvert Cliffs, water levels declined 30 feet over 11 years. The water level measured in observation well CA-Ed 47 in the Aquia has declined approximately 20 feet from 1990 to 1993. The recent acceleration in water level declines is due to withdrawals from well fields at Lexington Park and southern Calvert County. The impacts of the water level declines are considered negligible compared to the approximately 270 feet of drawdown available in the Aquia Aquifer.
- Water levels in the Magothy Aquifer at Chalk Point have declined by 16 feet from 1975 to 1993, and approximately three feet from 1990 to 1993. Water levels in the Magothy Aquifer are expected to recover to some extent with decreased pumping by PEPCO at Chalk Point.
- A decline of approximately six feet in the potentiometric surface of the Upper Patapsco Aquifer has been observed at Chalk Point from 1990 to 1993. Declines are expected to continue with increased withdrawal from this aquifer by both PEPCO and SMECO. However, these declines are not expected to significantly reduce the approximately 740 feet of water available in the Upper Patapsco Aquifer.

Power plants can potentially impact the quality of ground water from three sources: coal pile leachate; coal combustion by-product leachate; and liquid petroleum leaks and spills. Monitoring at coal pile and combustion by-product landfill sites indicates a potential for acidic leachate with high concentrations of metals, iron, and sulfate to impact ground water. Furthermore, the petroleum leak at the Perryman combustion turbine facility demonstrates that the transport and storage of petroleum fuels at power plants pose a risk to ground water quality. However, when ground water degradation does occur, it generally is localized, and does not impact ground water users.

3.4 *TERRESTRIAL IMPACTS*

3.4.1 *Introduction*

Maryland possesses a wide variety of wildlife that inhabit its **terrestrial** (or land) ecosystems. Some components of natural terrestrial ecosystems in Maryland include forests, wetlands, and non-aquatic wildlife. Components created by humans that have replaced Maryland's natural terrestrial ecosystems include agricultural land, residential development, and commercial development.

The construction and operation of power plants affect terrestrial ecosystems both directly and indirectly. Direct impacts result from the construction of power plants and their related **linear facilities** (transmission line rights-of-way, gas pipelines, water pipelines, access roads, etc.). For example, the creation of rights-of-way for transmission line towers often modifies portions of existing ecosystems. Indirect impacts of plant construction and operation are often much harder to quantify or to distinguish from the effects of other factors, and are usually related to plant operations. Modes of indirect impact relate to pollution of air, water, and soil by power plants and their related facilities.

3.4.2 *Direct Impacts*

Terrestrial resources are affected by the construction and operation of power plants through physical modification or elimination of existing habitats, disturbance and displacement of wildlife, deposition of particulate matter or gaseous emissions to the atmosphere, and inadvertent spills and permitted releases of toxic materials. Permanent modification of existing terrestrial habitat occurs with the construction of transmission line corridors or when forested habitats are converted to **scrub/shrub** habitat or **herbaceous habitat**. Construction of underground facilities, such as gas pipelines or water pipelines, causes temporary disturbances to terrestrial habitat. If the right-of-way was previously forested, maintenance of the right-of-way in herbaceous or scrub/shrub communities also results in permanent habitat modification.

Direct impacts often adversely affect both nontidal and tidal wetlands. In the 1780s, Maryland possessed about 1,650,000 acres of wetlands (24.4% of its surface area); as of about 1989, Maryland possessed only about 440,000 acres of wetlands (6.5% of its surface area). These figures represent a 73% loss of wetlands in the state (Dahl 1990). The state is concerned with such losses, and now protects these resources. Through regulations developed under Maryland's 1991 Nontidal Wetlands Protection Act (COMAR 08.05.04.01), many activities in nontidal wetlands are regulated under a policy of **no net loss**. Similarly, activities in tidal wetlands in Maryland are regulated under the 1994 Tidal Wetlands Regulations (COMAR 08.05.05).

Compared to residential and other types of commercial construction, power plant construction has caused minimal direct wetlands impacts since the implementation of Maryland's nontidal wetlands law. Further, compared to the total amount of wetlands resources in the state, only relatively small losses of wetlands are associated with recently licensed Maryland power plant facilities (Perryman, Dorchester, and Panda-Brandywine). Wetlands losses were minimized through the stringent CPCN process, requirements of the Nontidal Wetlands Protection Act, and cooperation from the utilities. To counter wetlands losses for the state's no net loss goal, mitigation is being required for these projects.

Forest resources are also adversely impacted by the development of power plants and their linear facilities. Maryland's forest resources are now protected under the 1991 Forest Conservation Act (FCA). New developments of 40,000 square feet or more[1] are regulated in the state under the FCA. According to the FCA, tree conservation, replanting, and other environmental parameters must be considered prior to disturbance of forest resources. One important factor concerning the FCA is the exemption for rights-of-way (i.e., linear facilities) and land for construction of electric generating facilities constructed by investor-owned utilities, municipals, or cooperatives, provided that CPCNs have been issued. Non-utility generating projects are not exempt from the FCA. Exemption status is lost if the developer of a proposed generating site or its linear facilities cannot demonstrate that cutting or clearing of forest will be minimized.

1 As the FCA is implemented at the county level, certain requirements of the FCA vary. For example, in Anne Arundel County, new developments of 15,000 square feet or larger (as opposed to 40,000 square feet or larger in other counties) are regulated.

3.4.2.1 *Steam Electric Power Plants*

There are 14 steam electric power plants in Maryland greater than 100-MW capacity; nine are located in rural areas and five are in urban, developed areas. The total area of all rural sites is approximately 5,500 acres, the majority of which lies within the Coastal Plain province (Figure 3-19). This acreage amounts to less than 0.1 percent of Maryland's total land area (over six million acres). Facilities located in urban areas generally do not impact native vegetation or wildlife, and thus have little direct impact on Maryland's terrestrial ecosystems.

Depending on the location of the facility and its design, the project footprint (buildings, structures, roads, etc.) may compose only a small portion of the total acreage of a plant site. From surveys of land utilization patterns at the 14 steam electric facilities, PPRP found that the footprints (of all of the sites combined) average about 54% of the total acreage of the sites, with a range of about 7% at Calvert Cliffs to 100% at Westport. The remaining land at the facilities comprises forests, wetlands, grassland/oldfield, and agricultural land. The proposed footprints of two recently licensed facilities in Maryland, Dorchester and Panda-Brandywine, are approximately 31% and 67% of the total site acreages, respectively.

As new power plants are sited and constructed in Maryland, it is likely that the footprint acres/total site acres ratio will become larger than in the past (i.e., footprints will be a larger proportion of smaller sites). This can be attributed in part to more stringent environmental regulations such as the Nontidal Wetlands Protection Act and the FCA that limit the number of suitable large sites, the lack of availability of suitable large tracts, and the rising costs of land.

3.4.2.2 *Hydroelectric Facilities*

Nine hydroelectric facilities are currently active in Maryland (See Table 3-6). Terrestrial habitats that are typically displaced by the impoundments created by dams are nontidal wetlands and riverine forests, which are known to support a diverse and valuable group of flora and fauna. The impoundment areas associated with the nine facilities (not including Conowingo Pond, which is partially located in Pennsylvania) total around 7,000 acres, representing approximately 0.1% of the total land area of Maryland. The loss of existing terrestrial habitats by inundation has been mitigated to some degree by the formation of new habitat along the peripheries of the impoundments. Open water habitats, suitable for a variety of wildlife, including waterfowl, have also been provided by the impoundments.

The impoundments created by the hydroelectric facilities have not eliminated a significant portion of Maryland's total **riparian habitat**, which is on the order of half a million acres (Dahl 1990). Unaltered rivers, however, are becoming increasingly more valuable for recreational and educational purposes. Electricity is generated by peaking operations at three of the nine hydroelectric facilities in Maryland, and by **run-of-river** operations at the other six facilities. Peaking refers to the storage and subsequent release of water from the impoundment to the turbines at a hydroelectric facility. Peaking operations involve rapid fluctuation of impoundment and river water levels which may have adverse effects on wetlands vegetation and wildlife. These rapid water level fluctuations can expose and freeze plant roots in the winter, strand bird hatchlings on mudflats (making them more prone to predation), and increase streambank and impoundment edge erosion. Run-of-river operations are generally less ecologically harmful than peaking operations, in that they simulate natural river flow by passing a minimum flow through the project at all times, and do not involve rapid, severe changes in water levels.

3.4.2.3 *Combustion By-Product (Ash) Landfills*

There are five active coal-fired power plant ash landfill sites occupying about 1,000 acres, and over 30 inactive or smaller sites in Maryland. These landfill sites are typically 50 to 100 acres in size, but vary depending on the type of coal used and the generation facility. The capacity of some of these sites may be 20 years; others may possess only a 5- to 10-year capacity. Over the next 40 years, Maryland's coal-fired plants could require between 1,100 and 2,300 acres for ash disposal (PPER 1991). With several landfill sites near their capacities, additional landfill space must be identified. Several candidate landfill sites adjacent to the existing sites are being considered as potential new landfill areas.

A number of adverse environmental impacts are associated with the development and operation of combustion by-product landfills and related facilities. Clearing, grubbing, and fill placement to create landfill sites destroys vegetation and wetlands; eliminates forested habitats of rare, threatened, and endangered species; and displaces wildlife. Operation of landfills generates leachate that is either acidic or alkaline in nature, depending on the type of combustion process and air pollution controls employed at a particular generating facility. Although leachate generation is usually limited through design of the landfills and coal piles to minimize the amount of water that percolates through them, terrestrial resources can be affected by even small releases. Inadvertent releases of leachate from these facilities can damage vegetation and kill fauna in carrying streams. Such damage to flora and fauna due specifically to by-product landfill sites is not well documented, however. A PPRP study

COAL ASH UTILIZATION

The amount of coal ash and flue gas desulfurization (FGD) by-products that are placed in landfills can be significantly reduced through utilization programs. Coal ash can be used in a variety of construction applications. A few examples of utilization of coal ash include additives for cement, structural fill for road base, cinder for ice control, soil stabilization agent, coal mine reclamation material, and raw material for production of bricks or grout. FGD sludge can be used in the manufacture of wallboard, land reclamation, and construction of artificial reefs.

Currently, only one-fourth of the fly ash and almost none of the FGD by-products generated in the United States are being utilized. The paucity of coal ash utilization is due primarily to: 1) the physical and chemical characteristics of the by-products versus other raw materials, and 2) the economics of using coal ash versus other raw materials. The physical and chemical properties of a particular ash may make the material less than ideal when compared to raw materials. For example, if a by-product has a particularly high free lime content, it may heat too rapidly during the production of concrete, reducing the strength of the material. From an economic standpoint, the relative cost of using by-product versus traditional raw materials depends largely on local availability of raw materials and transportation costs.

Coal ash is used for a variety of purposes in Maryland. BGE places coal ash from the Wagner and Brandon Shores power plants into the Brandon Woods Business Park Site as structural fill at a rate of approximately 400,000 tons per year. The site is being developed as an industrial park with buildings placed over top of the ash. Also, PEPCO and BGE sell coarser grained bottom ash for use in snow and ice control. The proposed AES Warrior Run facility plans to use 100 percent of its by-product for reclamation of the surface coal mines where the feed coal is extracted (see Section 2.3.1.3). PPRP is currently investigating the use of by-products in reclamation of abandoned deep mines as well. The amount of coal ash utilized will likely increase over time, as it becomes increasingly more difficult to construct and operate landfills due to regulatory and public opinion constraints.

found higher levels of arsenic and manganese (typical constituents of fly ash) in trees immediately adjacent to the Faulkner ash landfill site compared with control sites, but these concentrations were still within the naturally occurring range for these elements (Klose and Potera 1984).

Terrestrial impacts of ash landfills are prolonged by the fact that landfills are rarely managed for habitat restoration purposes after closure. Little compensatory mitigation for these sites is required by state regulations. These sites are designed to be dry and elevated above the water table. Owing to the operation of the landfills, the fly ash and other materials are usually highly compacted, which tends to inhibit deep root growth; this precludes establishment and survival of woody vegetation. One closed landfill site in Anne Arundel County has been partially developed into a business park and has been landscaped, but this is an exception to the rule.

3.4.2.4 *Transmission Line Rights-of-Way*

Electric transmission line rights-of-way are distributed throughout the state. Transmission line corridors typically require 12 to 24 acres per mile and cross over 3,000 miles of land in Maryland (DeMuro *et al.* 1987). Utilities may either hold title to the lands or hold easements granting them rights of access to the lines constructed within them.

Both temporary and permanent impacts can occur due to transmission line and linear facilities construction and maintenance. To construct these corridors, land must first be cleared of vegetation, and sometimes graded. Once the linear facilities have been installed, the rights-of-way must be maintained in herbaceous or shrubby vegetation, resulting in permanent impacts primarily to forest, wildlife, and wetlands resources.

With appropriate planning and construction techniques under ideal conditions, it has been shown that nontidal wetlands (excluding forested systems) can recover from linear facilities construction in as little as two years (Grigal 1985; Thibodeau and Nickerson 1986). Recent investigation by PPRP has indicated that construction of electric transmission line rights-of-way has had relatively little impact on nontidal wetlands in Maryland. Transmission line construction accounted for only 1 of the 92 wetlands permits and about 7 of the 682 Letters of Authorization approved by DNR from January 1991 (when State nontidal wetlands permitting activities began) to May 1994.[2] In the same period, the construction of new transmission line rights-of-way has permanently

[2] All nontidal wetlands impact information was derived from unpublished data provided by the DNR Nontidal Wetlands Division.

impacted only about one acre of nontidal wetlands and temporarily impacted about eight acres. Many of these transmission line impacts represent the conversion of one type of vegetation to another; for example, in some cases, forest is converted to scrub/shrub habitat. To put these numbers into context, permanent nontidal wetlands impacts for all projects in Maryland that were authorized from January 1991 through December 1993 totaled 76.9 acres. Temporary impacts authorized during that time period totaled 93.6 acres.

Under Maryland's nontidal wetlands regulations, permanent impacts to nontidal wetlands must be mitigated (i.e., new wetlands created, other disturbed wetlands restored, or payment made to the Wetlands Compensation Fund) at ratios of 3:1, 2:1, or 1:1, depending on the type of wetlands affected. A ratio of 3:1 is applied to scrub/shrub and forested wetlands of special state concern, a 2:1 ratio to scrub/shrub and forested wetlands and herbaceous wetlands of special state concern, and 1:1 for emergent wetlands. Mitigation ratio requirements are similar for state tidal wetlands. Temporary impacts and impacts to wetlands buffers do not usually have to be mitigated. According to Maryland's nontidal and tidal wetlands regulations, monetary contributions to the Wetlands Compensation Fund are the least preferred method of mitigation for licensed wetlands impacts. In many cases, the State will only accept monetary compensation if it determines that creation, restoration, or enhancement of wetlands are not feasible alternatives.

Considerable edge habitat (grasslands/shrublands) is created when transmission line rights-of-way are created in forested areas. While there is often an increase in the total number of species in a newly created edge habitat, some forest-dwelling species decrease in number. Often, new species of animals that have an affinity for brushy or oldfield habitats colonize the area and account for the increased total number of species. This positive benefit is offset by fragmentation of forests into smaller and smaller areas, however, which can result in population declines of migrant birds and other species that require large tracts of forest.

Biodiversity is the variety and variability among living organisms and the ecological complexes in which they occur (Fiedler and Jain 1992). Forest fragmentation caused by construction and maintenance of right-of-way corridors can lead to a loss in biodiversity of a region through bisection and isolation of forest tracts. In general, large blocks of undisturbed habitat are better for conserving biodiversity than smaller ones (CEQ 1993).

3.4.2.5 *Right-of-Way Maintenance: Herbicides vs. Mowing*

Growth of woody vegetation on transmission line and other rights-of-way (such as natural gas pipelines) can present public safety hazards. Trees that grow too close to power lines ("danger trees") could fall on the lines in a storm event; deep roots from trees or other woody plants could jeopardize the integrity of underground pipes. Utilities most often manage vegetation through a combination of mechanical mowing and chemical herbicide application. State regulations permit the utilities to use only U.S. EPA-approved herbicides. These herbicides have been reported to pose little danger to the terrestrial environment if properly applied (DeMuro *et al.* 1987).

The herbicides that are most commonly used by the Maryland utilities, such as those with glyphosate as the active ingredient, persist in the environment for less than two months, and are generally not toxic to wildlife when they are applied appropriately.[3] Improper use of chemical herbicides, however, can result in excessive amounts being carried by runoff and by wind transport into areas outside the right-of-way, and may damage untargeted vegetation and wildlife.

Several of Maryland's electric utilities have initiated maintenance programs to improve wildlife habitat in rights-of-way. Under these programs, stable oldfield (i.e., weedy, shrubby) habitats are established with few tree species that have the potential for becoming "danger trees." This is typically accomplished by only spot treating potentially undesirable trees with glyphosate herbicide every three to five years, instead of the more typical mowing every two to three years or broadcast spraying of herbicides. Preliminary results provided by the utilities indicate that such selective programs have created better, more stable habitats for wildlife, and have saved millions of dollars in maintenance costs.

Mechanical cutting of vegetation in rights-of-way is not necessarily benign; it can disturb and kill wildlife, and has the potential for polluting surface waters, depending on the type of equipment used (GNP 1992). Right-of-way management, whether it is accomplished by mowing or by herbicides, often affects wildlife by altering the original vegetative community. Most Maryland utilities indicate that they use a combination of selective herbicide application and mechanical cutting rather than exclusively one or the other. It has been generally observed that spraying

[3] However, the U.S. EPA announced in May 1994 that glyphosate is eligible for the agency's re-registration process. Uses of this product could be more limited under a new U.S. EPA registration.

and cutting of entire corridors is more harmful to wildlife than selective cutting, selective application of herbicides, or a combination of both.

3.4.3 *Indirect Impacts*

Power plants affect terrestrial ecosystems through the deposition of airborne pollutants. These compounds can be in either gaseous or particulate form, and are emitted from stacks, coal and solid by-product handling activities, and ash landfill operations. As airborne pollutants from power plants are dispersed, some are deposited on land and surface waters. These pollutants can contribute to acidification of soils and waters. Aquatic biota can absorb pollutants through surface waters, and may incorporate these pollutants into the food chain of terrestrial wildlife. Pollutants deposited onto land can also be incorporated into terrestrial food chains when pollutants are taken up by crops and farm animals. No long-term studies are available on actual damage to plants and animals from existing emissions in Maryland.

Cooling towers are another source of air emissions that can affect terrestrial resources. Evaporative aerosols released by the towers carry some of the chlorides and other solids that were dissolved in the liquid water. Deposition of these solids may impact terrestrial ecosystems by directly contacting plant tissue, and by elevating levels of chlorides and other salts in soils. Studies at Chalk Point indicate that emissions from the large natural draft cooling tower may cause measurable effects on plant tissue and possibly soil chloride concentrations, but that adverse impacts to vegetation are unlikely (Mulchi *et al.* 1977).

SO_2 and NO_x are also emitted by power plant stacks. Power plants in Maryland do not emit NO_x in quantities great enough to cause either acute or chronic injury to vegetation (FWS 1978). SO_2 is known to cause acute injury to sensitive plant species; however, direct evidence of such damage in ecological systems in Maryland is unavailable. Direct effects of sulfur or nitrogen oxides on animals in Maryland are unlikely to be significant at the present levels of emission (PPER 1991).

3.4.4 *Summary*

Terrestrial ecosystems are affected by the construction and operation of power plants due to habitat alterations and by air emissions that are later deposited on land or water. Direct impacts due to the construction and maintenance of power plants and their linear facilities relate to permanent modification of forested habitats, permanent and temporary impacts to wetlands, and impacts to vegetation and wildlife from inadvertent releases of toxic materials. Indirect impacts on terrestrial ecosystems, such as the effects of emissions of particulate or gaseous contaminants, have not been subject to long-term study in Maryland; there are no existing data to prove that such impacts have occurred in the state. Indirect impacts resulting from direct habitat alteration, such as gradual changes to vegetational structures along edges of cleared power plant sites or transmission line rights-of-way, are also potentially ecologically important effects. However, such impacts are difficult to document and quantify, and have not been studied in Maryland.

Many of the direct impacts from new construction of power plants, landfills, rights-of-way, or hydroelectric dams can be avoided by careful site selection and planning. Of particular concern, due to the paucity of information, are the potential cumulative impacts of landscape fragmentation due to construction of transmission line corridors and the resulting loss of biodiversity.

3.5 *RADIOLOGICAL IMPACTS*

This section provides information about the cumulative radiological effects of nuclear power production in Maryland and discusses PPRP's assessment of the radiological effects of the Calvert Cliffs and Peach Bottom nuclear power stations. This evaluation is based on environmental research and monitoring programs conducted by PPRP, MDE, and the utilities. The radioactive discharges of each power plant, the nuclear waste generated during power production, and the dispersion of radionuclides into the environment are discussed. This section also lists estimated radiation doses to humans attributable to plant-related releases. When appropriate, estimated doses are compared with natural background doses, operating license requirements and restrictions, and concentrations of radionuclides in the environment measured during previous years.

3.5.1 *Background*

Various sorts of radiation, including radiowaves, infrared radiation, visible light, ultraviolet light, x-rays, and gamma-rays, are found throughout the environment. Only the radiation having sufficient energy to cause the **ionization** of matter is of specific relevance to the assessment of **radioecological effects** of nuclear power plants.

Ionizing radiation originates from both natural and human sources. Natural sources of radiation have been present since the origin of the universe and result in the majority of the radioactive dose received by the general population. Sources of radiation resulting from human activities have been present for approximately 100 years and include diagnostic x-rays and various radiotherapies used in medicine, consumer products (for example, smoke detectors, gas lantern mantels), and the nuclear power industry. Both natural radiation and that resulting from human activities lead to varying degrees of human exposure. The average human exposure, or the **effective radiation dose equivalents**, to individuals in the United States is approximately 360 millirems (mrem) per year (NCRPM 1988). Approximately 300 mrem per year is from natural sources, including 200 mrem per year from radon and its decay products (Table 3-10). About 65 mrem is from human sources, of which 3 mrem is attributed to the operation of nuclear power plants. This dose of 3 mrem is approximately equivalent to the radiation dose received during two transatlantic trips in a commercial airliner. These data indicate that nuclear power plants are minor contributors to radiation exposure in the United States.

Table 3-10 Average Radiation Exposure to Humans in the United States

Source	Average Annual Effective Dose Equivalent (mrem)
Resulting from Natural Sources (82%)	
Radon	200
Cosmic Rays	29
Terrestrial	29
Internal	39
Resulting from Human Activities (18%)	
Medical X-rays	39
Nuclear Medicine	14
Consumer Products	10
Nuclear Power	3
Rounded Total	**360**

Source: NCRPM 1988

Most of the radiation dose attributed to the operation of nuclear power plants is due to the direct, controlled release of radionuclides into the environment. Production of nuclear power in the United States is licensed, monitored, and regulated by the U. S. Nuclear Regulatory Commission (NRC). Provisions in the operating licenses of each plant allow utilities to discharge low levels of radioactive material to the environment. The kind and quantity of releases are strictly regulated and must fall within limits defined in federal law. The NRC regulates power plants according to the principle that releases be kept "as low as reasonably achievable" (ALARA). Annual total body doses to the general public cannot exceed 3 mrem per reactor for the aqueous pathway and 5 mrem per reactor for the atmospheric pathway (Table 3-11).

Table 3-11 Nuclear Regulatory Guidelines

Dose Pathway	Design Objectives[a]
I. Liquid effluents	
a. Dose to total body from all pathways	3 mrem/yr/unit
b. Dose to any organ from all pathways	10 mrem/yr/unit
II. Gaseous effluents	
a. Gamma dose in air	10 mrad/yr/unit
b. Beta dose in air	20 mrad/yr/unit
c. Dose to total body of an individual	5 mrem/yr/unit
d. Dose to skin of an individual	15 mrem/yr/unit
e. Dose to any organ from all pathways	15 mrem/yr/unit

(a) Evaluated for a maximally exposed individual. The rad is the unit used to quantify the amount of energy deposited in a given material, such as tissue. One rad is the amount of radiation that will deposit 100 ergs of energy per gram of material. The rem is a unit of energy used to quantify potential biological effects of exposure. The rem (Roentgen Equivalent Man), when multiplied by a quality factor (which varies for different types of radiation), equals the dose equivalent (GPC 1994).

Source: USNRC 1977.

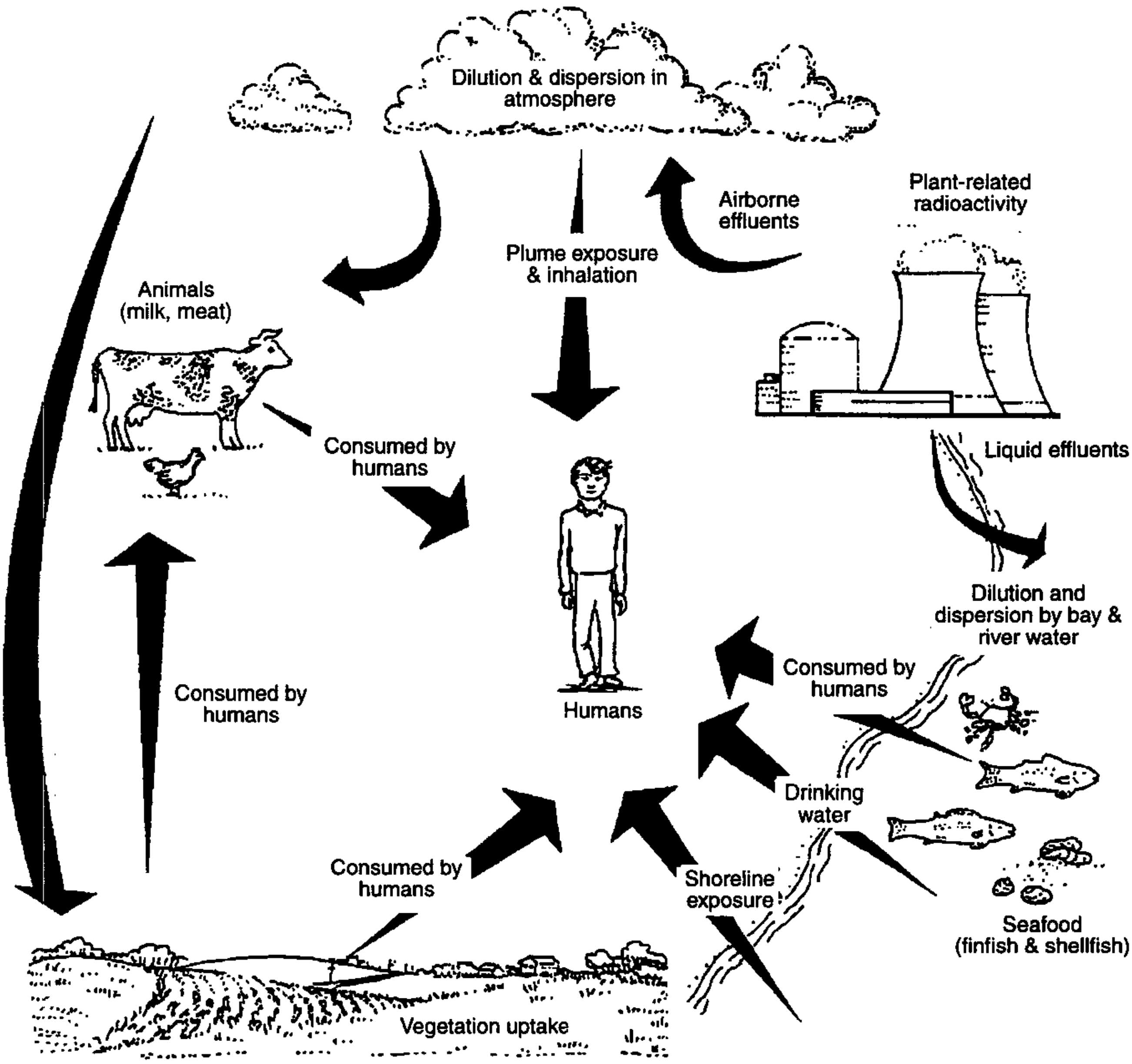
Pathways of exposure to radioactive material in the environment are illustrated in Figure 3-33. An aqueous pathway dose (water dose) is received by ingesting radioactive water and seafood and by exposure to contaminated sediments and water. An atmospheric pathway dose results from external exposure to or inhalation of radioactive gas or airborne particles or ingestion of radionuclides that have been deposited on or assimilated by terrestrial vegetation and animals.

Two nuclear power stations release radionuclides into Maryland's environment: the Calvert Cliffs Nuclear Power Plant (CCNPP), which is the only nuclear power facility in Maryland; and the Peach Bottom Atomic Power Station on the Susquehanna River, north of the Pennsylvania/Maryland border (Figure 3-34). The next closest nuclear power plant to Maryland, Three Mile Island Atomic Power Station, is on the Susquehanna River approximately 12 miles south of Harrisburg, Pennsylvania. Radiation released during routine operation of the Three Mile Island plant was not detected in Maryland during 1992 and 1993 or previously (GPUN 1993, 1994; PPRP 1993).

BGE, PPRP, and MDE conduct environmental monitoring programs in the vicinity of Calvert Cliffs, and PECO, PPRP, and MDE conduct programs in the vicinity of Peach Bottom. These monitoring programs are used to assess the radiological effects on the environment attributable to each of the nuclear power plants.

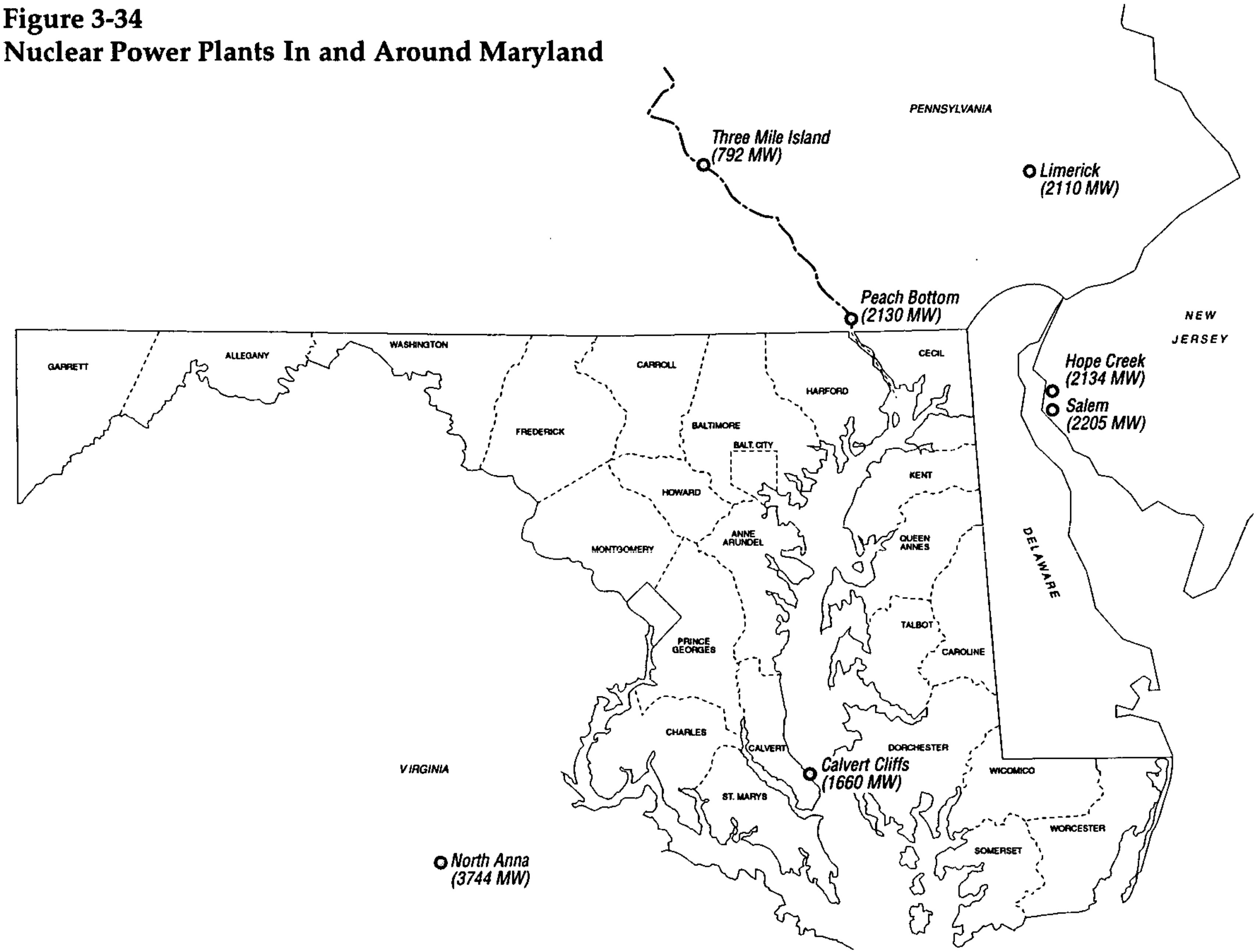
These programs are designed to conform to the NRC operating license requirements for each plant. MDE provides an external program for assurance monitoring to confirm the results of the utilities' programs

Figure 3-33
Exposure Pathways for Radioactivity Introduced into the Environment Which May Contribute to a Human Radiation Dose



Source: GPUN 1989; Eisenbud 1987.

Figure 3-34
Nuclear Power Plants In and Around Maryland



independently. PPRP's monitoring program focuses on radiological effects within the Chesapeake Bay ecosystem and is designed to provide information concerning both the environmental and human health effects of exposure to radioactive material released via the aqueous pathway. Detailed descriptions of individual environmental monitoring programs may be found elsewhere (BGE 1994a; PECO 1994a; Fletcher and Abell 1994; Stanek *et al.* 1995a, 1995b).

3.5.2 *Calvert Cliffs Nuclear Power Plant*

BGE owns and operates Calvert Cliffs, which is in Calvert County, Maryland, on the western shoreline of the Chesapeake Bay (Figure 3-34). Each of its two units is a pressurized water reactor with a capacity of 830 MW. The units began service on 8 May 1975 and 1 April 1977.

3.5.2.1 *Radioactivity Released*

CCNPP releases between 900 and 7,600 Curies of radioactivity annually in the form of radioactive gaseous and liquid effluents into the atmosphere and the Chesapeake Bay. The level of radioactivity of these effluents at any given time depends on factors including plant operating conditions, conditions of the nuclear fuel, and operating efficiency of the radioactive waste processing systems. Since Calvert Cliffs has been in operation, releases of radioactivity to the environment have been well within the regulatory limits.

Atmospheric Releases

Table 3-12 summarizes CCNPP's releases of radionuclides to the atmosphere for 1992 and 1993, as reported by BGE. Radioactive **noble gases**, primarily xenon (Xe-131m, Xe-133, Xe-133m, Xe-135), krypton (Kr-85, Kr-85m), and argon (Ar-41), constitute the great majority of radioactive material released to the atmosphere from Calvert Cliffs. Noble gases are chemically inert, are not readily incorporated into biological tissues, and are not bioconcentrated. They are readily dispersed in the atmosphere, and most have short half-lives decaying rapidly to stable forms; therefore, the noble gases do not represent a significant threat to human or ecological health. Table 3-13 summarizes radioactive half-lives for the dominant radionuclides released from the Calvert Cliffs plant.

Table 3-12 Total Quantities (Curies) of Radionuclides Released to the Atmosphere by CCNPP: 1992 and 1993

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Tritium	9.78800	0.17%	24.58000	10.29%
Noble Gases				
Ar-41	0.01903		0.01781	
Kr-85	39.30400		9.89500	
Kr-85m	5.93333		0.65888	
Kr-87	0.00001		ND	
Kr-88	ND		ND	
Xe-131m	63.75640		1.72974	
Xe-133	5629.36700		178.40659	
Xe-133m	50.79900		0.60914	
Xe-135	81.08665		22.81277	
Xe-135m	ND		ND	
Xe-138	ND		ND	
Total	**5870.26542**	**99.83%**	**214.12993**	**89.69%**
Iodines				
I-131	0.01672		0.01395	
I-133	0.02034		0.02474	
I-135	ND		ND	
Total	**0.03706**	**0.00%**	**0.03869**	**<0.02%**
Particulates				
Co-58	ND		ND	
Co-60	ND		0.00001	
Zn-65	ND		ND	
Sr-89	ND		ND	
Sr-90	<0.00000		ND	
Sr-91	ND		ND	
Cs-134	<0.00000		0.00340	
Cs-137	0.00005		0.00420	
Cs-138	ND		ND	
Ce-144	ND		ND	
Ba-139	ND		ND	
Ba-140	ND		ND	
Y-91m	ND		ND	
Mo-99	ND		ND	
Te-132	ND		ND	
La-140	ND		ND	
Zr-97	ND		ND	
Tc-99m	ND		ND	
Cd-109	ND		ND	
Total:	**0.00005**	**0.00%**	**0.00762**	**0.00%**
Total Curies:	**5880.09055**		**238.75623**	

Source: BGE 1993b, 1994b

ND = No data

Table 3-13 Half-Lives for Dominant Radionuclides Released

Radionuclide	Half-Life
H-3 (tritium)	12.28 years
Ar-41	1.83 hours
Kr-85	10.72 years
Xe-131m	11.84 days
Xe-133	5.25 days
Xe-133m	2.19 days
Xe-135	9.11 hours
Co-58	70.80 days
Cs-134	2.06 years
Cs-137	30.17 years
Cr-51	27.70 days
Ag-110m	249.85 days
Fe-55	2.7 years

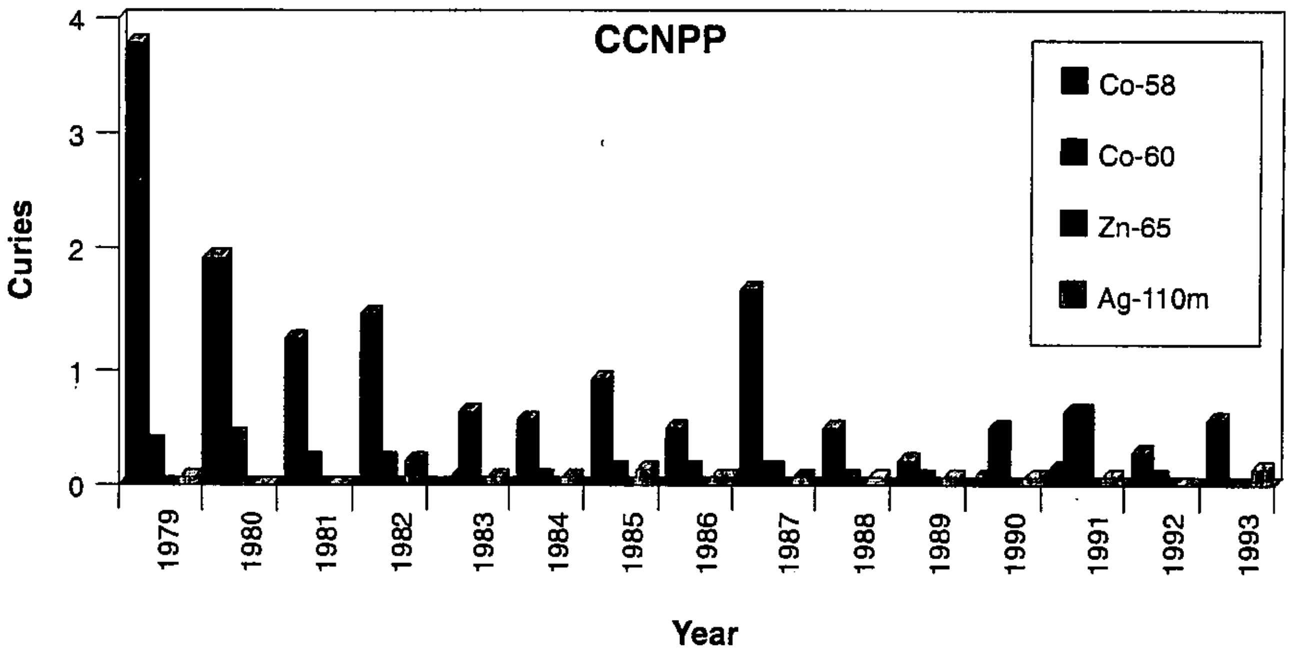
Other notable radionuclides in the plant's atmospheric releases were tritium (H-3), radioiodine (I-131 and I-133), and radiocesium (Cs-134 and Cs-137). Even though these radionuclides were reportedly released, concentrations of radioiodine or other fission or activation products were not detected in atmospheric environmental samples during 1992 and 1993 (BGE 1993a, 1994a).

Aqueous Releases

Table 3-14 presents CCNPP's releases of radionuclides to the Chesapeake Bay for 1992 and 1993, as reported by BGE. Radioactive tritium constitutes more than 99% of all radionuclides released to the Chesapeake Bay by Calvert Cliffs. The other 1% of radionuclides released includes forms of radioactive cesium, cobalt (Co), and silver (Ag). These radionuclides are notable because biota, such as oysters, accumulate them readily. They also can be trapped in sediments at the bottom of the Bay. Through the food chain, these radionuclides in sediments may ultimately contribute a radiation dose to human populations. For this reason, the aqueous pathway is considered to have the greatest potential for affecting the environment.

Figure 3-35 depicts the historical trends in the quantities of aqueous releases of environmentally significant radionuclides from CCNPP (and from Peach Bottom; see Section 3.5.3). The annual release of Co-58 in recent years is significantly lower than releases measured for the period 1979 through 1982; however, there has been a steady increase in the release of Co-58 during the period 1990 through 1993. Annual release rates for Co-60, zinc-65 (Zn-65), and Ag-110m are more variable and show no significant intra-annual patterns.

Figure 3-35
Aqueous Release Totals (Curies) from CCNPP and PBAPS of Environmentally Significant Radionuclides: 1979-1993



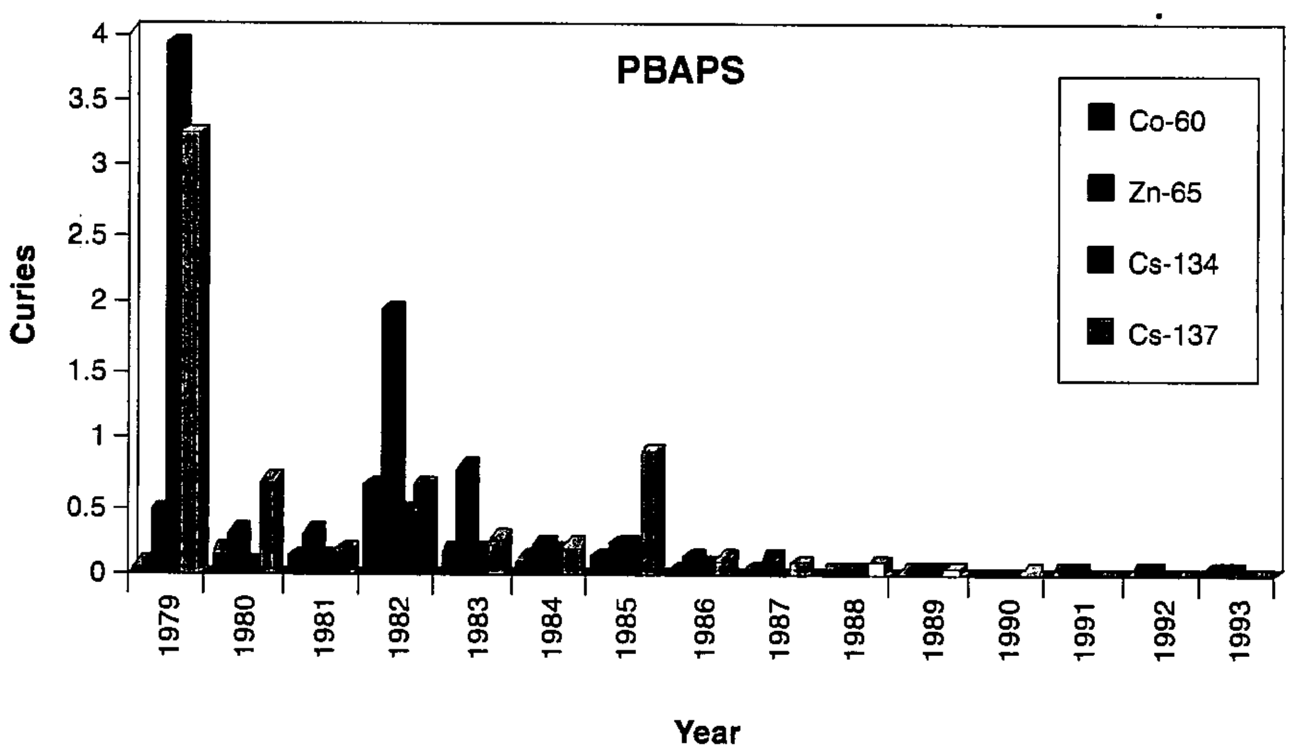


Table 3-14 Total Quantities (Curies) of Radionuclides Released to the Chesapeake Bay by CCNPP via the Aqueous Pathway: 1992 and 1993

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Tritium	1772.00000	99.87%	636.00000	99.71%
Dissolved Noble Gases				
Kr-85	0.06585		ND	
Kr-85m	0.00000		ND	
Xe-131m	0.00367		0.00031	
Xe-133	0.74700		0.08845	
Xe-133m	0.00366		ND	
Xe-135	0.00834		0.00232	
Xe-135m	0.00014		ND	
Total	**0.82996**	**0.05%**	**0.09108**	**0.01%**
Iodines				
I-131	0.04147		0.03785	
I-132	0.00011		ND	
I-133	0.04715		0.00611	
I-135	0.00167		ND	
Total	**0.09039**	**0.01%**	**0.04396**	**0.01%**
Particulates				
Na-24	0.00125		0.00034	
Cr-51	0.04665		0.25660	
Mn-54	0.01147		0.00377	
Co-57	0.00008		0.00069	
Co-58	0.26630		0.57592	
Co-60	0.06601		0.01669	
Zn-65	0.00006		0.00182	
Sr-89	0.00151		0.00083	
Sr-90	0.00053		0.00037	
Sr-92	0.00030		ND	
Zr-95	0.02766		0.00365	
Nb-95	0.05476		0.00778	
Nb-97	0.00600		ND	
Mo-99	0.00008		ND	
Tc-99m	0.00165		0.00028	
Ru-103	0.00389		0.00239	
Ru-106	0.00937		ND	
Ag-110m	0.01661		0.15423	
Sn-113	0.00665		0.00158	
Sb-122	0.00161		0.00013	
Sb-124	0.00091		0.01752	
Sb-125	0.01141		0.10588	
Te-132	0.00002		ND	