CHAPTER 6

GROUND WATER IMPACT

A. Introduction

The impacts associated with the siting, operation, and expansion of power plants on Maryland's ground water resources continue to be a prominent issue, particularly in view of increasing public awareness of the importance of ground water as both a natural and an economic resource. Significant ground water resources are available for development in Maryland, especially in the Coastal Plain; but long-term protection must be provided to ensure their availability for users. The purpose of this chapter is to update information on the cumulative impacts of Maryland power plants on ground water quantity and quality in the state, as part of the State's effort to manage and protect valuable ground water resources.

The information used to evaluate cumulative ground water quantity impacts is obtained through a cooperative program between PPER and the Maryland Geological Survey (MGS). Under this program, observation wells near Maryland power plants that withdraw ground water have been incorporated into the statewide U.S. Geological Survey (USGS)/MGS ground water monitoring network. The statewide monitoring network provides data for in-depth studies of Maryland aquifers. The PPER/MGS/USGS effort, begun in 1975, has produced a significant data base for documenting changes in aquifer water levels near power plants. PPER uses this data to evaluate local and regional withdrawal impacts from power plants and to report the impacts in the CEIR volumes.

PPER has collected information on ground water quality impacts over the past eight years as part of its ongoing efforts to monitor the environmental impacts of Maryland power plants. A number of site-specific studies have been conducted to evaluate the impacts of particular plants on ground water quality. Utilities are also required to monitor ground water quality at some facilities, specifically fly ash landfills, and to report the data to the Maryland Department of the Environment (MDE).

This discussion of ground water impact begins with an overview of Maryland's approach to managing ground water resources and how that approach affects Maryland power plants. Next it focuses on local and regional ground water withdrawal by power plants during 1987 and 1988, and summarizes its cumulative impact on Maryland's ground water resources. Finally, the impact of power plant operations on ground water quality is presented by briefly summarizing those power plant sources with the potential to degrade ground water quality, followed by an overview of the results of several site-specific PPER studies.

Previous CEIRs provided background information on the ground water resources of Maryland and the ground water impacts of power plant operations. CEIR-5 presents a discussion of the geology and occurrence of ground water in Maryland. CEIR-6 discusses potential impacts from ground water withdrawal and ground water quality degradation at power plants. These previous discussions provide a framework for evaluating the cumulative ground water impact of Maryland power plants, and the reader is referred to these documents to gain a more complete understanding of these subjects.

B. Ground Water Management

Ground water is recognized as a renewable natural resource that requires careful development and protection to ensure a long-term water supply of adequate quantity and quality. Essentially, the purpose of ground water management is to maximize utilization of available resources for beneficial uses while simultaneously minimizing adverse impacts that may limit both current and future ground water use. This objective requires balancing the quantity and quality requirements of domestic, municipal, agricultural, commercial, and industrial users with the limitations of available ground water resources.

Power plants have their greatest impact on ground water in the Coastal Plain of southern Maryland, where large quantities are available for development. Yields of aquifers in other portions of Maryland are significantly less and are generally suitable only for low-volume users. Consequently, this chapter focuses on the impact to ground water resources of southern Maryland. Since BG&E is proposing to use ground water at its Perryman facility in Harford County, which is projected to begin operation in 1994, future CEIRs will evaluate withdrawal impacts in the northern Maryland Coastal Plain as well.

Constraints on the Development of Maryland's Ground Water

The importance of ground water management is best understood by examining the constraints on ground water development, with particular reference to southern Maryland's Coastal Plain. Two concepts basic to an understanding of ground water resource management are basin yield and overdraft. Basin yield is defined as the maximum withdrawal rate that can be supported by a hydrologic system without creating unacceptable changes in it (Freeze and Cherry 1979). Basin yield can be examined from two perspectives: safe yield and optimal yield. Safe yield is defined as the annual quantity of ground water that can be withdrawn from a basin without causing adverse impacts (Todd 1959). These adverse impacts include:

- depletion of the quantity of ground water available for withdrawal;
- intrusion of water with poor quality relative to the ambient water quality and intended use of the ground water (e.g., salt water intrusion);
- violation of existing water rights;
- the costs of developing new ground water supply;

- reduction of streamflow by induced infiltration of ground water as a result of overpumping; and

- land subsidence associated with heavy ground water withdrawal.

Optimal yield is determined by the ground water management approach that best suits the socioeconomic requirements of the ground water user, and is dependent upon both hydrogeologic and socioeconomic conditions in the area. Optimal yield may range from withdrawals approaching resource depletion at one extreme to careful conservation of ground water at the other extreme, but is usually found between the two (Freeze and Cherry 1979).

Overdraft of a ground water basin refers to ground water withdrawal that exceeds its safe yield. It creates declining water levels that do not stabilize because withdrawals exceed the rate of ground water recharge to the hydrogeologic system. Under some circumstances it is possible that the hydrogeologic system may not be able to recover, and overdraft may cause irreparable damage to the resource even after it is discontinued.

Constraints on the development of ground water resources in southern Maryland include both the quantity and quality of ground water available from aquifers. The yield of aquifers suitable for development ultimately restricts the quantity of ground water available for withdrawal. Often, an aquifer is capable of providing significant quantities of water to wells, but of less than desirable quality for the intended use. Naturally occurring high concentrations of many inorganic constituents, specifically cations (e.g., iron, manganese, calcium, and magnesium), anions (e.g., chloride and sulfate), and suspended, colloidal or dissolved solids, can be reduced to acceptable levels by water treatment. In some circumstances, treatment may be technically feasible but can significantly increase costs of ground water development, especially for low-volume users. Such costs may make the use of ground water uneconomical.

Ground water quality may also be degraded as a result of human activities. When contaminants from point and non-point sources infiltrate through the unsaturated zone into ground water, natural water quality is affected and may be degraded to a degree that prevents use of the water for human consumption. Relatively small quantities of contaminants can adversely affect the quality of an entire aquifer. Furthermore, remediation of contaminated aquifers is costly and in some circumstances technically infeasible.

Economic constraints also significantly limit ground water development in southern Maryland. In areas of heavy ground water usage, aquifer water levels decline, and new wells must be installed to greater depths to obtain water. As depth increases, drilling, design, and construction costs increase significantly. Deeper wells are also more expensive to operate and maintain.

The increase in cost with well depth is especially critical to low-volume users, which typically include individual households, small communities, and small businesses. Low-volume users pay significantly more per gallon for ground water supply than high-volume users (Driscoll 1986), in spite of the higher design and construction costs of high-volume wells. Low-volume users are also less likely to have the financial resources to obtain water from deep aquifers. Consequently, they must have access to suitable quantity and quality ground water from shallow aquifers, which are less expensive to develop.

On a regional scale, the available quantity and quality of ground water can significantly influence the entire economy of a region that depends primarily on it for water supply. If suitable water supply is unavailable or uneconomical to develop, economic growth can be inhibited, especially if alternative surface water supplies are not available. Consequently, protection and management of Maryland's ground water resources are essential from an economic as well as an environmental standpoint.

In summary, the important objectives of ground water management to Maryland users are:

- to prevent overdraft;
- to prevent adverse impacts associated with overdraft;
- to protect ground water resources for all users; and
- to avoid adverse economic impacts to ground water users.

Maryland's approach to ground water management, discussed below, is designed to achieve these objectives.

Maryland's Ground Water Management Programs

Formal state management of ground water in Maryland originated with legislation passed by the General Assembly during the 1930s (WRA 1982). Today, the quantity and quality of ground water resources are managed through the coordinated efforts of three state agencies. The Maryland Department of Natural Resources Water Resources Administration (WRA) has primary responsibility for permitting the use of ground water within the state while still protecting this resource from overuse. USGS/MGS provides technical support by generating a ground water data base and investigating ground water resources to provide information for WRA management decisions. MDE has the task of managing and protecting the quality of ground water resources.

WRA's ground water supply program grants appropriations of ground water to users through the issuance of permits. The permit program provides for both allocation of resources and monitoring of ground water use, enabling WRA both to conduct long-term ground water supply planning and to prevent and mitigate excessive withdrawal. Ground water users must submit an application to WRA requesting an appropriation permit for all ground water withdrawals other than those for domestic use. WRA uses the information provided in the permit application to determine the conditions or limitations of the permit. Permits are issued for a specified period of time and are periodically reviewed while in effect. The permits also require semi-annual reporting of average daily ground water withdrawals to WRA.

Some of the information used by WRA is provided through data collection programs and investigations conducted by MGS in cooperation with USGS. The statewide ground water observation well network maintained by USGS and MGS provides important information on changes in ground water levels of aquifers used for water supply. This information, in conjunction with ground water withdrawal data collected by WRA through its permit program, is used to monitor changes in aquifer hydraulic conditions. MGS and USGS also conduct detailed investigations to define and better understand the complex hydrogeologic systems serving as sources of water supply, and perform predictive modeling studies to provide insight into future long-term withdrawal impacts on ground water resources.

MDE conducts regulatory programs to ensure that drinking water of suitable quality can be obtained from ground water, and to prevent and mitigate contamination of ground water by human activities. Well construction regulations are implemented to minimize degradation of ground water quality from poor or improper construction of wells. A permit must be obtained prior to drilling any type of well, and a well completion report must be submitted to document the well location and construction. Abandoned wells must be permanently sealed in accordance with MDE regulations and a well abandonment report filed. MDE also uses enforcement programs to remediate existing ground water contamination problems.

Maryland's abundance of ground water resources, coupled with prudent management, have prevented the severe ground water supply problems experienced by some other eastern states (WRA 1982). The coordinated management approach implemented by WRA, MGS, and MDE to develop and protect ground water resources is effective for providing the quantity and quality of ground water resources necessary for development by users throughout the state.

Ground Water Management and Maryland Power Plants

Since power plants withdraw large volumes of ground water, and handle fuels and combustion by-products that can degrade ground water quality, it is necessary to manage power plant operations with an eye to ground water quantity. Like other ground water users, power plants must plan and operate within the constraints and guidelines established by the state agencies responsible for ground water management. These constraints generally include:

- restrictions on further development of specific aquifers that are heavily used;
- restrictions on total drawdown of water levels in any aquifer;

- permit appropriations placing overall limits on withdrawal rates by each ground water user;
- ongoing efforts to prevent future withdrawal impacts from current heavy use of specific aquifers; and
- measures to prevent or minimize ground water quality degradation from current and future activities.

The impacts of utilities' ground water withdrawals are monitored and evaluated through a joint program of USGS/MGS and PPER. Since four power plants in Maryland -- Calvert Cliffs, Chalk Point, Morgantown, and Vienna -- are major users of ground water, USGS/MGS has incorporated observation wells at those plants into its statewide monitoring network, through a cooperative effort with PPER that began in 1975. This monitoring program has expanded the USGS/MGS monitoring network while simultaneously providing important data for PPER to monitor and evaluate the long-term impact of ground water withdrawal by power plants. Table 6-1 summarizes information for both production and observation wells at each of the four power plants.

MDE maintains files of ground water quality data reported by utilities with operations potentially affecting ground water quality, such as fly ash landfills, where the utilities are required to conduct routine ground water monitoring. MDE uses the data to ensure compliance with applicable ground water quality standards. In addition, data gathered by MDE are used in conjunction with data collected by PPER during site-specific studies of proposed and existing facilities to evaluate potential and actual ground water quality impacts associated with power plant operations.

Public awareness and sensitivity to ground water supply and quality issues are likely to increase as more demands are placed upon available ground water resources in southern Maryland. This increased awareness can produce changes in state and federal ground water regulations. Although no significant adverse impacts to ground water quantity and quality from Maryland power plants have been identified, and impacts that have been identified are generally localized, power plants will have to comply with any future changes in regulations designed to protect ground water quality.

C. Ground Water Withdrawal

Ground Water Withdrawal Impacts at Maryland Power Plants

Four power plants (Calvert Cliffs, Chalk Point, Morgantown, and Vienna) withdraw significant quantities of ground water from four Maryland aquifers (see Figure 6-1 for locations): the Columbia, the Aquia, the Magothy, and the Patapsco. The total quantity of ground water collectively withdrawn by these four power plants during 1987 and 1988 averaged approximately 1.3 million gallons per day (mgd) -- significantly lower than the approximately 1.8 mgd withdrawn by these power plants in 1985 and 1986.

Table 6-1
Selected production and observation wells for Maryland power plants using ground water

Power Plant	USGS Well Number	Maryland Permit No.	Well Type	Elevation of Land Surface (feet)	Screen Position Below Sea Level (feet)	Total Depth Drilled (feet)	Aquifer
BG&E - Calvert Cliffs	CA-Ed 23	72-0041	Production	80	403-527	607	Aquia
	CA-Ed 24	72-0063	Production	100	420-537	640	Aquia
	CA-Ed 25	69-0035	Production	60	445-563	638	Aquia
	CA-Ed 27	69-0037	Observation	62	489-499	585	Aquia
	CA-Ed 47	81-0754	Observation	10	467-513	565	Aquia
PEPCO - Chalk Point	PG-Hf 23	47061	Observation	7	601-606	675	Magothy
	PG-Hf 24	47129	Observation	8	404-409	454	Aquia
	PG-Hf 25	47062	Observation	14	351-357	454	Aquia
	PG-Hf 26	49920	Production	14	591-621	638	Magothy
	PG-Hf 27	49921	Production	16	581-617	650	Magothy
	PG-Hf 28	51271	Production	7	587-616	640	Magothy
	PG-Hf 30	72-0047	Production	55	340-371	426	Aquia
	PG-Hf 32	73-0065	Observation	11	1514-1519	1545	Patapsco - 1500 foot sand
	PG-Hf 33	73-0065	Production	11	585-628	639	Magothy
	PG-Hf 35	72-0086	Observation	11	388-419	430	Aquia
	PG-Hf 36	73-0140	Production	12	593-622	634	Magothy
	PG-Hf 38	73-0172	Production	12	952-1054	1066	Patapsco - 1000 foot sand
	PG-Hf 40	73-0298	Observation	28	832-842	1095	Patapsco - 850 foot sand
	PG-Hf 41	73-0297	Observation	28	616-626	675	Magothy
	PG-Hf 42	73-0294	Observation	28	336-346	395	Aquia
	PG-Hf 44	73-0065	Observation	11	1014-1019	1545	Patapsco - 1000 foot sand
PEPCO - Morgantown	Ch-Ee 68	67-0080	Observation	22	1067-1092	1132	Lower Patapsco
	Ch-Ee 69	69-0089	Production	22	1051-1082	1152	Lower Patapsco
	Ch-Ee 70	67-0081	Observation	23	1050-1086	1130	Lower Patapsco
	Ch-Ee 71	69-0090	Production	22	1059-1095	1117	Lower Patapsco
	Ch-Ee 72	69-0087	Production	22	1057-1092	1114	Lower Patapsco
	Ch-Ee 73	69-0088	Production	22	1057-1077	1152	Lower Patapsco
DP&L - Vienna	DO-Dh 27	71-0001	Observation	9	24-54	152	Columbia
	DO-Dh 28	71-0013	Production	10	26-46	67	Columbia

Sources: Drummond 1984; Mack 1988; Curtin 1989

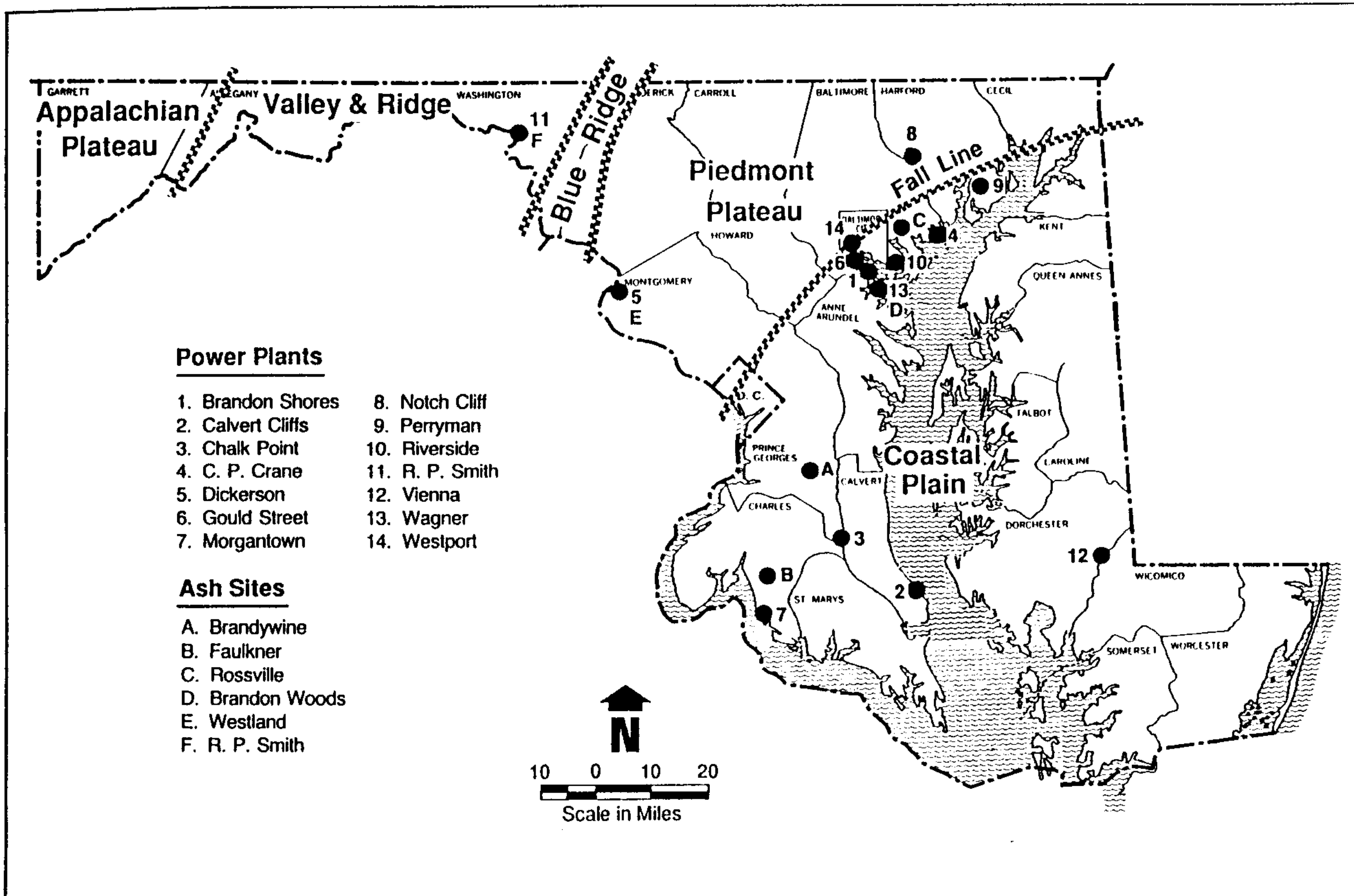


Figure 6-1. Locations of existing Maryland power plants and ash sites in relation to physiographic provinces

Ground water withdrawals by each of the four plants and their impact on Maryland's ground water resources are discussed below.

- Calvert Cliffs Nuclear Power Plant (BG&E)

The Calvert Cliffs Nuclear Power Plant withdraws ground water from three production wells screened in the Aquia aquifer at depths of 483 to 637 feet below the land surface (Table 6-1). Daily ground water withdrawal by the plant averaged approximately 0.31 mgd during 1987 and 1988. This volume was slightly greater than the 0.26 mgd pumped from the Aquia in 1985 and 1986, but was significantly less than the plant's WRA-approved appropriation of 0.45 mgd (Curtin 1989).

Figure 6-2 provides a summary of high and low water level measurements from observation well CA-Ed 47 and daily pumping rates from the Aquia aquifer at the Calvert Cliffs plant during 1987 and 1988. The lost record for ground water pumpage from January through June 1987 was due to an inoperative meter. Monthly withdrawal rates ranged between 0.15 and 0.43 mgd during the two-year period (Curtin 1989). Monthly high and low water levels in the aquifer near the plant fluctuated in response to the withdrawals: when pumpage increased, water levels showed a corresponding decline; when water levels rose, it was due to decreases in withdrawal rates. The higher water levels for the period January through June 1987 suggest that monthly ground water withdrawal rates during the period of lost pumpage data were lower than in the remainder of the two-year period. The response of water levels in the Aquia to changes in the withdrawal rate at Calvert Cliffs clearly indicates that aquifer water levels in the vicinity of the plant are directly influenced by pumping patterns at the plant.

Figure 6-3 presents monthly high and low water levels and pumpage rates at Calvert Cliffs for the longer period 1984 through 1988. Water level fluctuations also correlated with changes in withdrawal rates during this period. Withdrawal rates remained relatively constant, with the largest withdrawals occurring during late 1987 and early 1988. After taking into consideration variations in withdrawal rates, water levels in the Aquia near Calvert Cliffs remained relatively stable during this five-year period, with monthly low water levels ranging from 41 to 58 feet below mean sea level.

Figure 6-4 presents the potentiometric surface of the Aquia aquifer in southern Maryland in the fall of 1988. Water levels in the Aquia at Lexington Park and Solomons Island ranged from 73 to 104 feet below sea level in the fall of 1988. Comparison to the fall of 1986 (PPRP 1988) shows that the cone of depression created by large ground water withdrawals at Lexington Park and Solomons Island expanded northward to encompass Calvert Cliffs, as indicated by the shift in the location of the minus 40 foot potentiometric contour. In addition, the minus 20 foot potentiometric contour moved toward the northwest into Charles County relative to its position in the fall of 1986. These changes in the potentiometric surface are significant and indicate that water levels in the Aquia aquifer throughout southern Maryland continue to decline regionally.

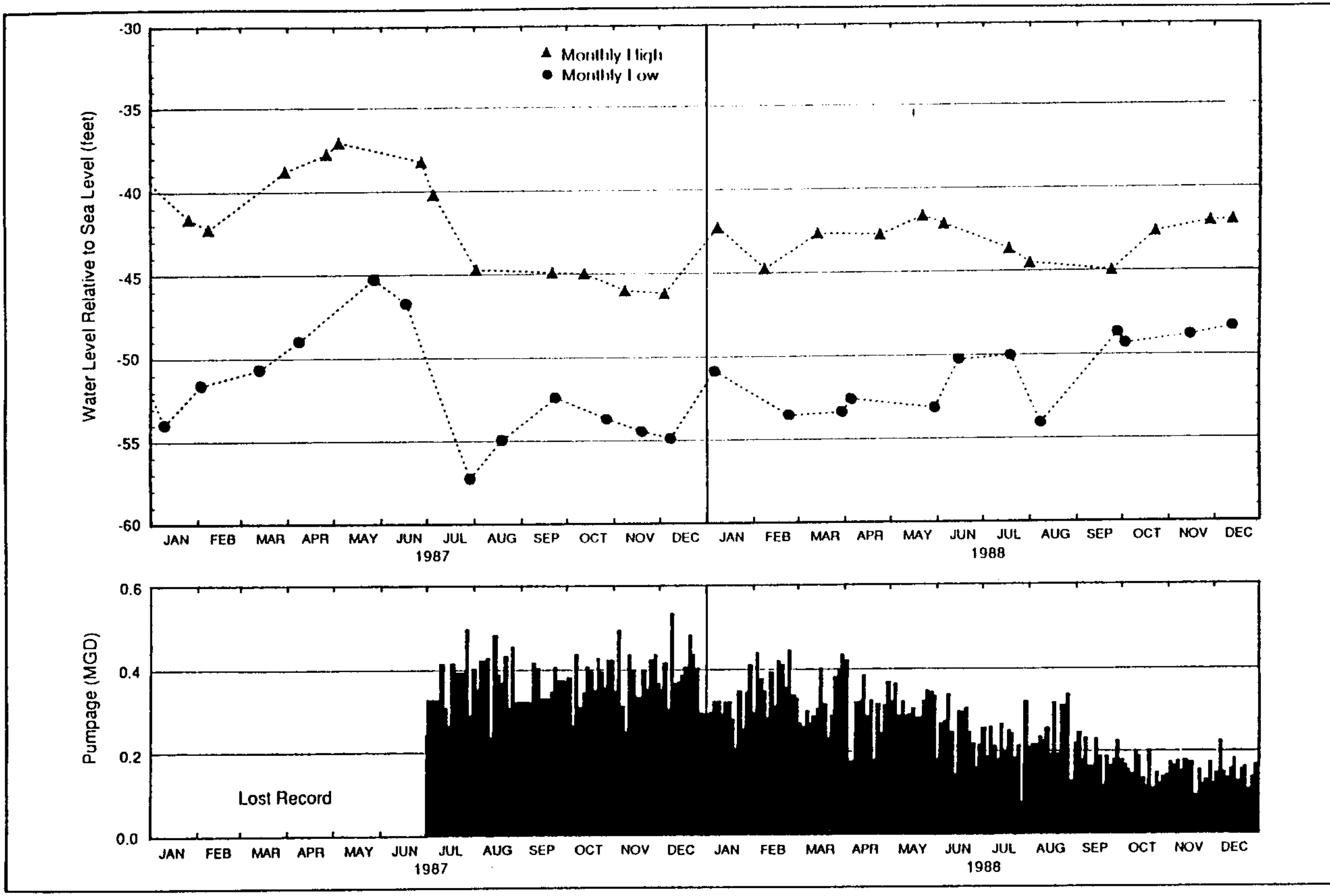


Figure 6-2. Daily ground water pumpage and monthly ground water levels for observation well CA-Ed 47 at the Calvert Cliffs Nuclear Power Plant (January 1987 - December 1988)

Source: Curtin 1989

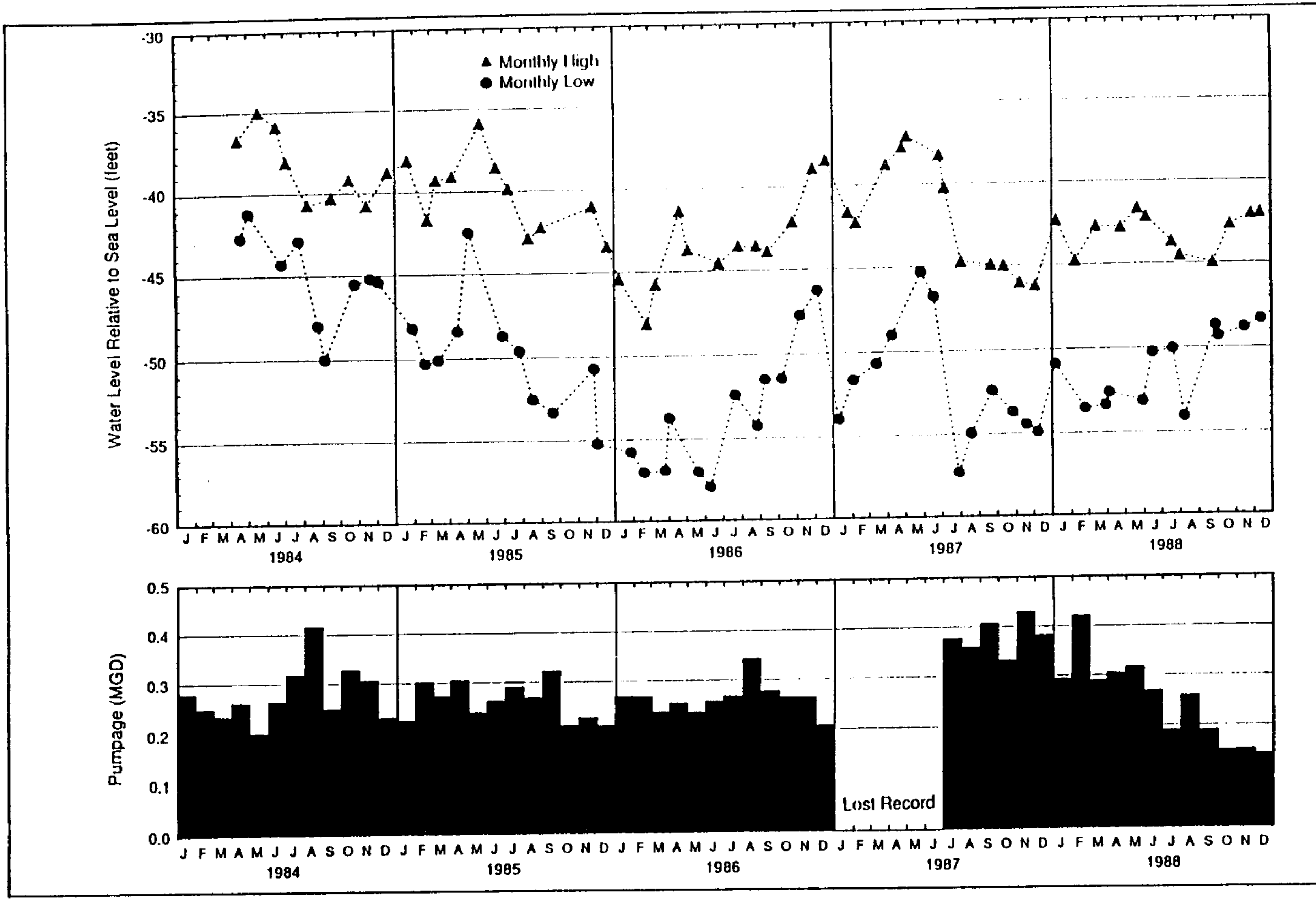


Figure 6-3. Monthly ground water pumpage and water levels in observation well CA-Ed 47 at the Calvert Cliffs Nuclear Power Plant from 1984 through 1988

Source: Curtin 1989

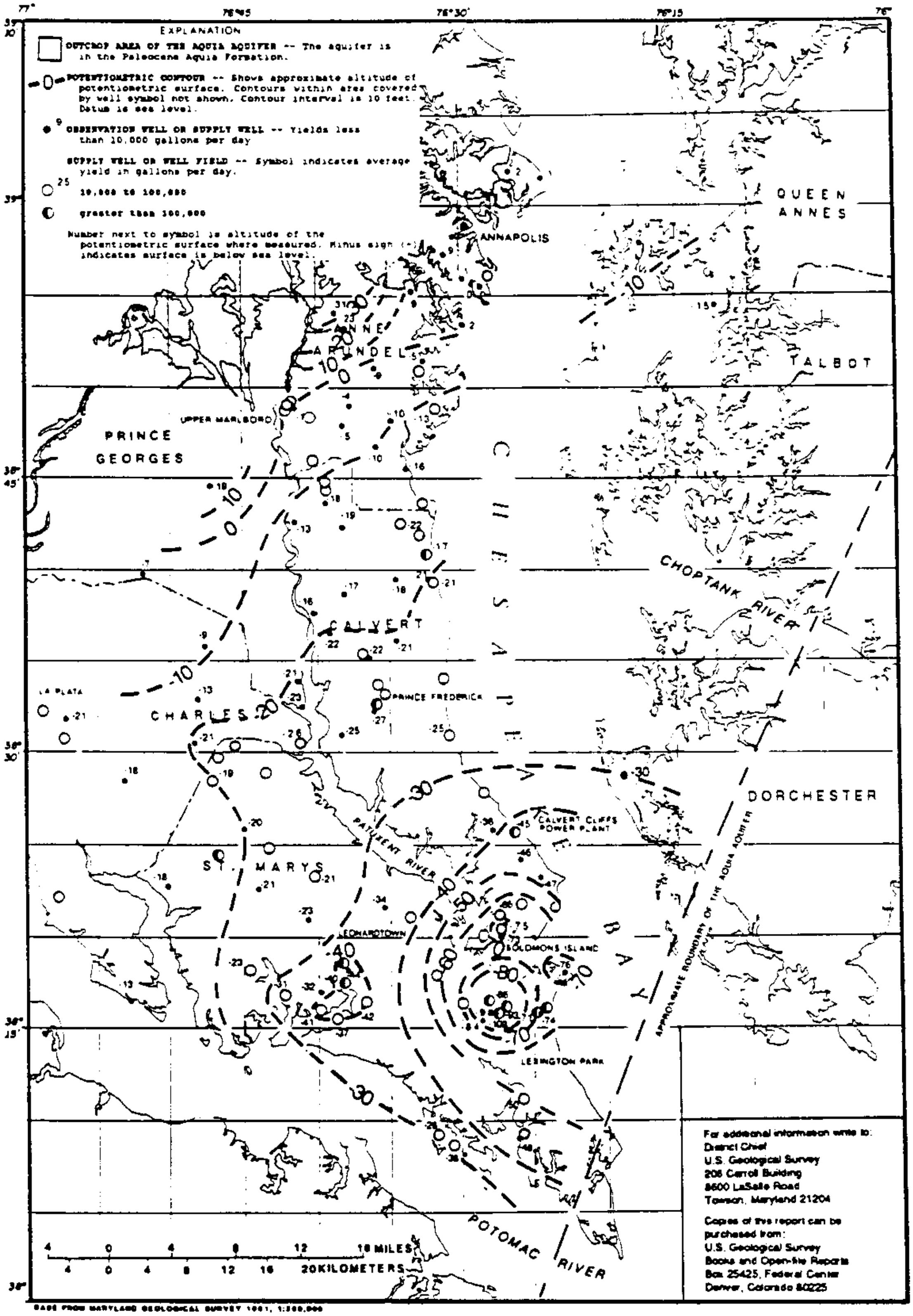


Figure 6-4. Potentiometric surface of the Aquia aquifer in southern Maryland during September 1988

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler

In Cooperation with: Maryland Geological Survey, Maryland Tidewater Administration and United States Department of the Interior Geological Survey
Water Resources Investigation Report 90-4037

Figure 6-5 shows the difference between the potentiometric surfaces of the Aquia aquifer in the fall of 1986 and the fall of 1988. This map indicates that ground water withdrawal from the Lexington Park and Solomons Island area has caused the Aquia potentiometric surface to decline 13 to 24 feet in two years: quite significant compared to its 13 to 20 foot decline over the seven-year period from the spring of 1979 to the fall of 1986 (PPRP 1988). The decline in the Solomons Island and Lexington Park area indicates a significant increase in ground water withdrawal during the two-year period.

At the Calvert Cliffs power plant, the potentiometric surface declined only one foot from 1986 to 1988, but has declined approximately 21 feet since the spring of 1979 (PPRP 1988). While the cumulative decline is significant, it is small compared to the approximately 400 feet of hydraulic head remaining in the Aquia aquifer. Ground water withdrawal at Calvert Cliffs continues to contribute to overall declines in Aquia aquifer water levels, but the plant's withdrawal impact is minor compared to the drawdown occurring in the Lexington Park and Solomons Island area. Based upon the area influenced by the cone of depression, ground water withdrawals at Lexington Park and Solomons Island have had the most significant impact on the Aquia aquifer in southern Maryland.

- Chalk Point Power Plant (PEPCO)

The Chalk Point Power Plant obtains ground water from five production wells in the Magothy aquifer and one production well in the Patapsco (Figure 6-6). Wells in the Magothy are screened at depths of 594 to 639 feet below the land surface, and the Patapsco well is screened from 964 to 1,066 feet (Table 6-1).

Figure 6-7 presents monthly pumpage data for both aquifers during 1987 and 1988. In 1987, an average of 0.42 mgd was pumped from the Magothy aquifer and 0.35 mgd from the Patapsco, for a total average of 0.77 mgd. In 1988, withdrawals rates for the Magothy and the Patapsco were 0.42 and 0.37 mgd, respectively, for a combined total withdrawal rate averaging 0.79 mgd. The withdrawal rates from the Magothy have decreased considerably from the average 1985 and 1986 rates of 0.64 and 0.50 mgd respectively (PPRP 1988).

Some of the decrease in Magothy pumping rates was offset by withdrawal from the Patapsco aquifer, but the Patapsco withdrawal rates in 1987 and 1988 nonetheless remained below the 1986 rate of 0.41 mgd. The combined withdrawal rates for both aquifers in 1987 (0.77 mgd) and 1988 (0.79 mgd) were thus significantly less than the 0.91 mgd combined withdrawal rate for 1986. The current WRA appropriation limits for average daily withdrawals at Chalk Point are 0.83 mgd from the Magothy and 0.83 mgd from the Patapsco aquifer (Curtin 1989).

Water level measurements for the observation wells (see Figure 6-6 for well locations) in the Magothy, Patapsco, and Aquia aquifers at Chalk Point are shown in Figure 6-7. Water levels measured in well PG-Hf 41 in the Magothy aquifer during 1987 and 1988 continued to fluctuate, by amounts of less than 10 feet, in response to increases and decreases in aquifer pumping rates. Figure 6-8 shows

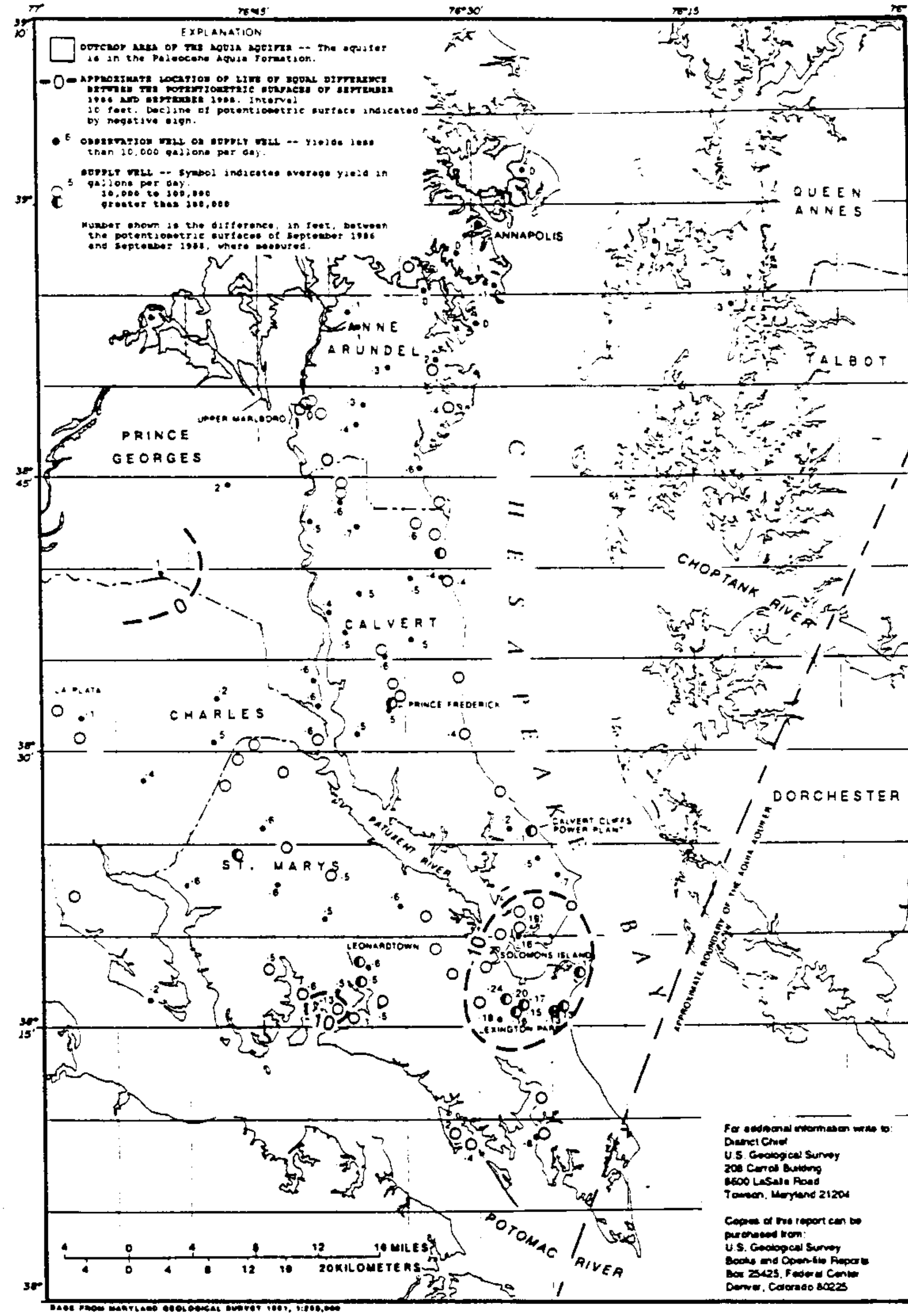


Figure 6-5. Difference between the potentiometric surfaces of the Aquia aquifer in September 1986 and September 1988 in southern Maryland

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler
In Cooperation with: Maryland Geological Survey, Maryland Tidewater Administration and United States Department of the Interior Geological Survey
Water Resources Investigation Report 90-4039

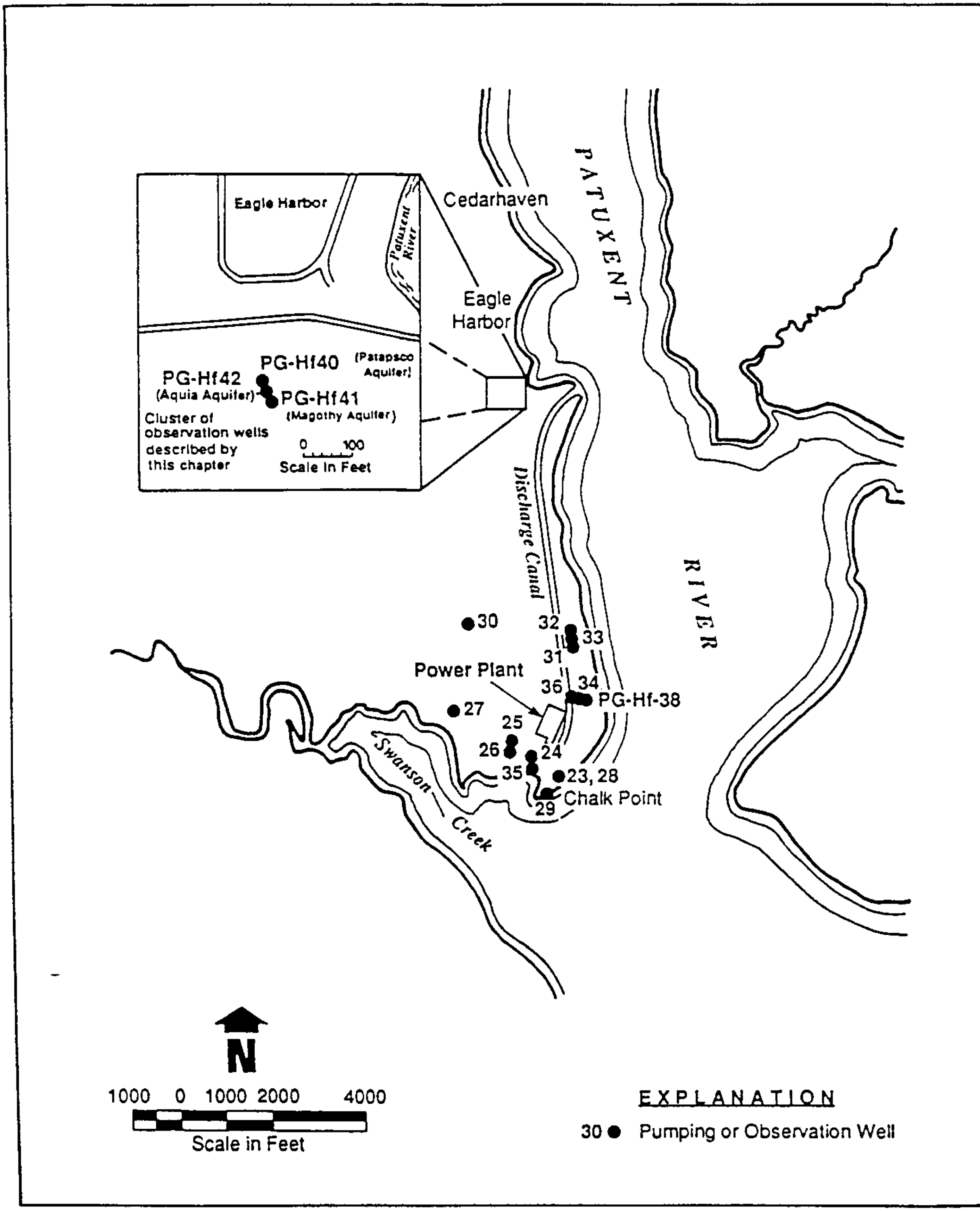


Figure 6-6. Location of wells surrounding PEPCO's Chalk Point Power Plant

Source: Mack 1976

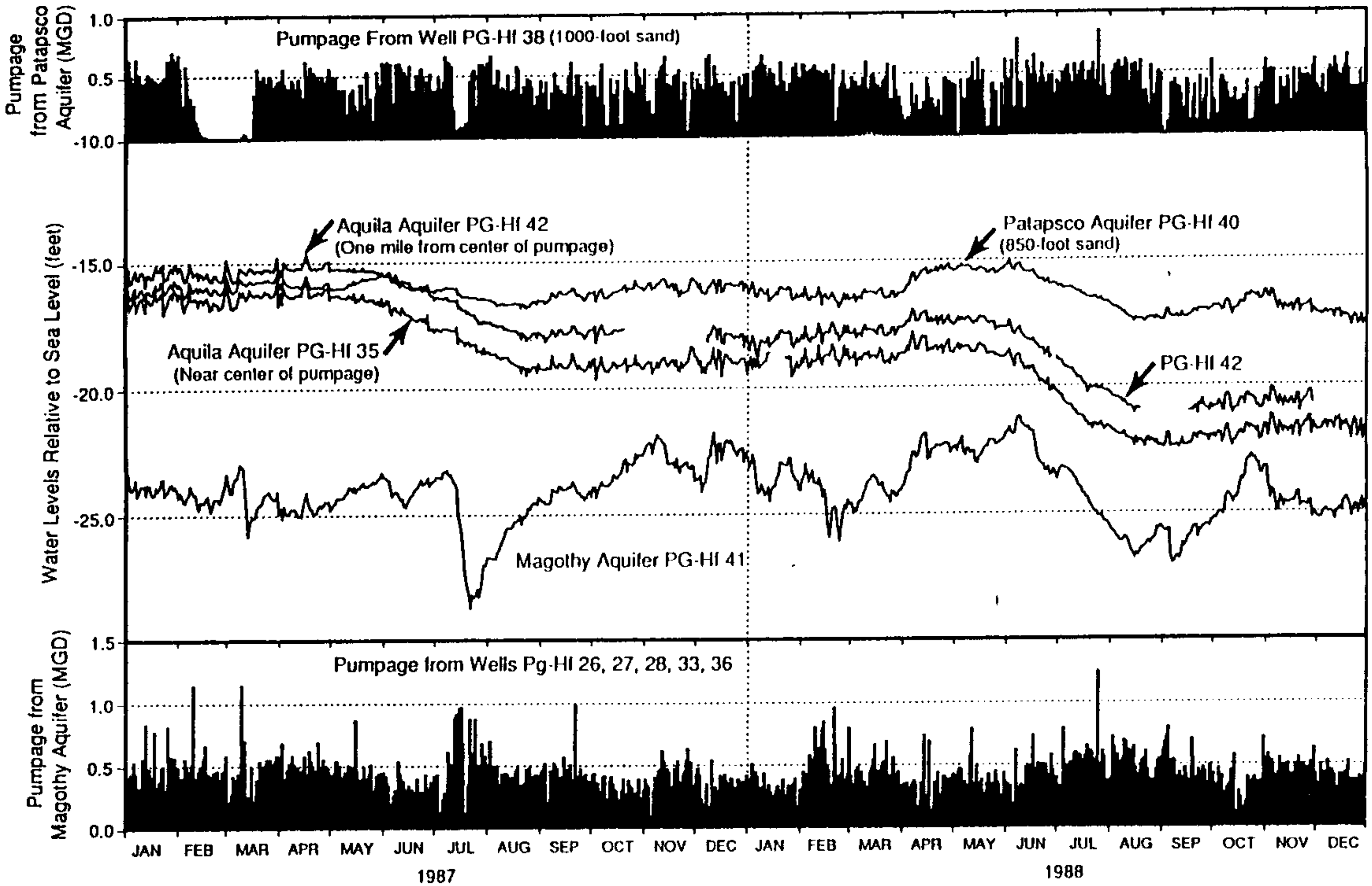


Figure 6-7. Daily ground water pumpage and water levels for Chalk Point Power Plant (January 1987 - December 1988)

Source: Curtin 1989

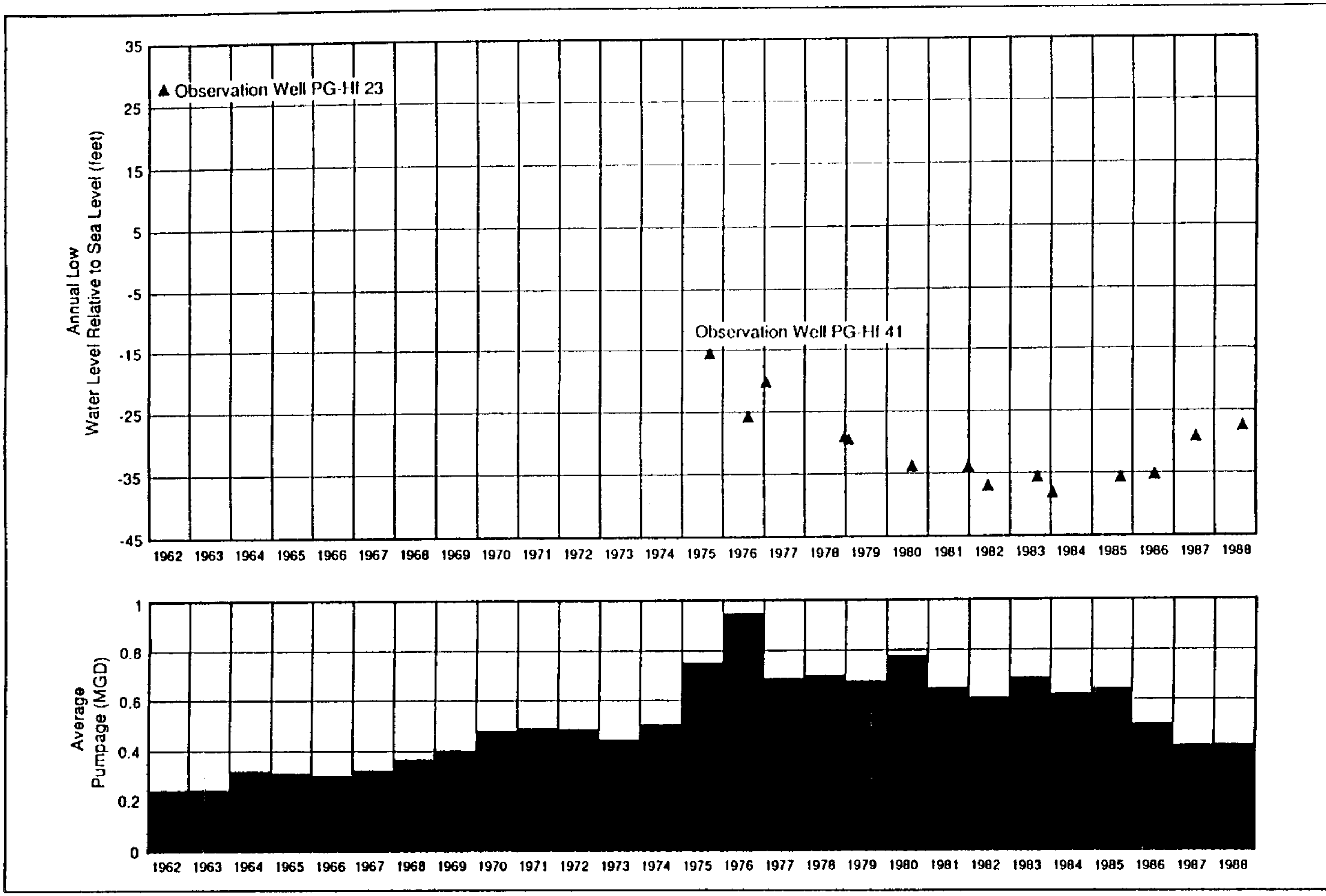


Figure 6-8. **Relationship between annual low water levels and average annual ground water pumpage for the Magothy aquifer at the Chalk Point Power Plant (1962 - 1988)**

Source: Curtin 1989

that, after a period of steady decline from 1962 through 1984, annual low water levels in the Magothy aquifer at Chalk Point have risen since 1985, indicating recovery of water levels in response to an overall decrease in withdrawal rates.

Figure 6-9 shows monthly pumping rates and random water levels for PEPCO's Patapsco aquifer production well (PG-Hf 38) for the period 1980 through 1988. Random water level measurements made in the production well during both "pump on" and "pump off" cycles indicate a downward trend in the Patapsco water level. Due to the irregularity of water level measurements and the influence of well pumping cycles, such water level measurements do not provide as true an indication of the overall response of the aquifer to pumping as is obtained from observation wells equipped with continuous water level recorders. However, in spite of this limitation, it is possible to conclude from the "pump off" data that there has been a decline in the "pump off" water level from minus 10 feet to minus 30 feet since 1980. Since there has been relatively little change in the average annual ground water withdrawal at Chalk Point, it is not clear why the decline has occurred.

While each of the Magothy and Aquia aquifers consists of a continuous layer of sand, the thicker Patapsco is composed of several sandy units separated by low-permeability units (aquitards). Figure 6-7 shows water level measurements from observation well PG-Hf 40, which is completed at a depth of 860 to 870 feet below the land surface in a thin sand layer of the Patapsco aquifer referred to as the "850-foot" sand. Well PG-Hf 40 is located approximately one and a half miles north of the Patapsco production well (PG-Hf 38), which is completed in a sand layer in the Patapsco referred to as the "1,000-foot" sand, at a depth of 964 to 1,066 feet below the land surface.

Water levels in PG-Hf 40 declined approximately two feet from January 1987 through December 1988. This decline continues a downward trend that began in 1986 when PEPCO increased the withdrawal rate from the Patapsco (PPRP 1988). The response of water levels in the 850-foot sand to pumping from the 1,000-foot sand indicates both that there is hydraulic interconnection between the two levels and that Chalk Point pumping has a large cone of influence in the Patapsco -- especially considering that the observation well is located more than a mile from the pumping. The Patapsco aquifer is targeted for supplying ground water for the planned expansion at the Chalk Point site. The aquifer should be able to provide the additional water without adverse impacts since approximately 500 feet of hydraulic head remains in the Patapsco aquifer. Based upon water level fluctuations observed in the Magothy aquifer observation well PG-Hf 42 (Figure 6-7), pumping of the Patapsco production well does not appear to affect water levels in wells screened in the Magothy.

Water level data from Aquia aquifer observation wells (PG-Hf 35 and PG-Hf 42) are also presented in Figure 6-7. While Chalk Point withdraws no water from the Aquia, the aquifer is monitored to detect any effects of ground water withdrawal from the underlying Magothy and Patapsco aquifers. Figure 6-7 shows that the water level in the Aquia aquifer declined approximately five feet in both wells during 1987 and 1988. Although the magnitude of this decline is similar to the

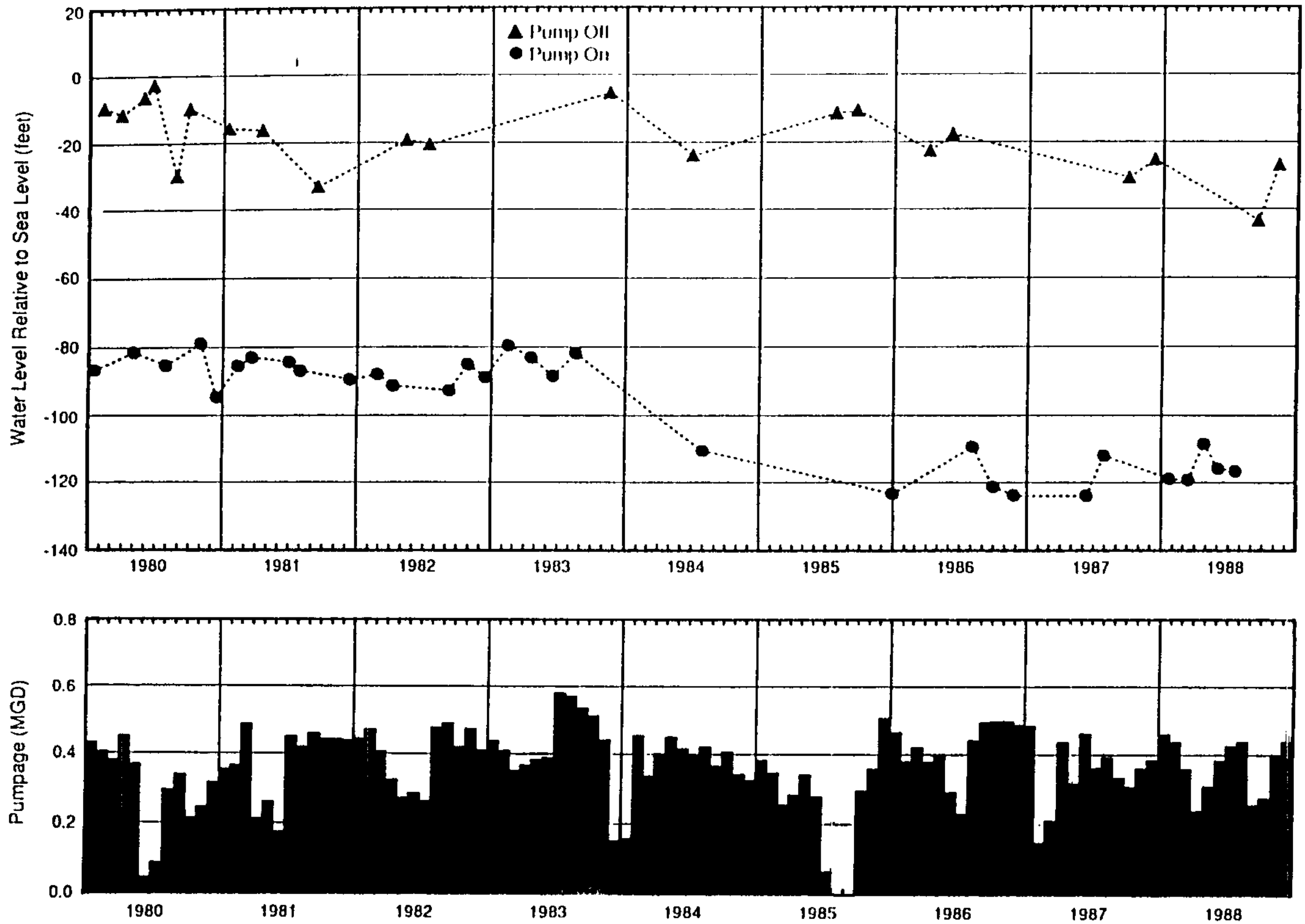


Figure 6-9. **Ground water pumpage and random water levels measured in production well PG-Hf 38 for the Patapsco aquifer at the Chalk Point Power Plant**

Source: Curtin 1989

decline observed from 1983 through 1986 (PPRP 1986, 1988), it does not correlate with fluctuations in pumpage from the underlying Magothy and Patapsco aquifers. This lack of correlation, together with the lack of interconnections between the Aquia and the other two underlying aquifers (Mack 1976), indicates that Chalk Point withdrawals do not influence water levels in the Aquia aquifer. The decline observed at these two observation wells correlates with the regional decline of the potentiometric surface of the Aquia aquifer in southern Maryland (see Figure 6-5). Thus, the domestic wells in the vicinity of Eagle Harbor that tap the Aquia or other shallow aquifers will not be affected by ground water withdrawals at Chalk Point.

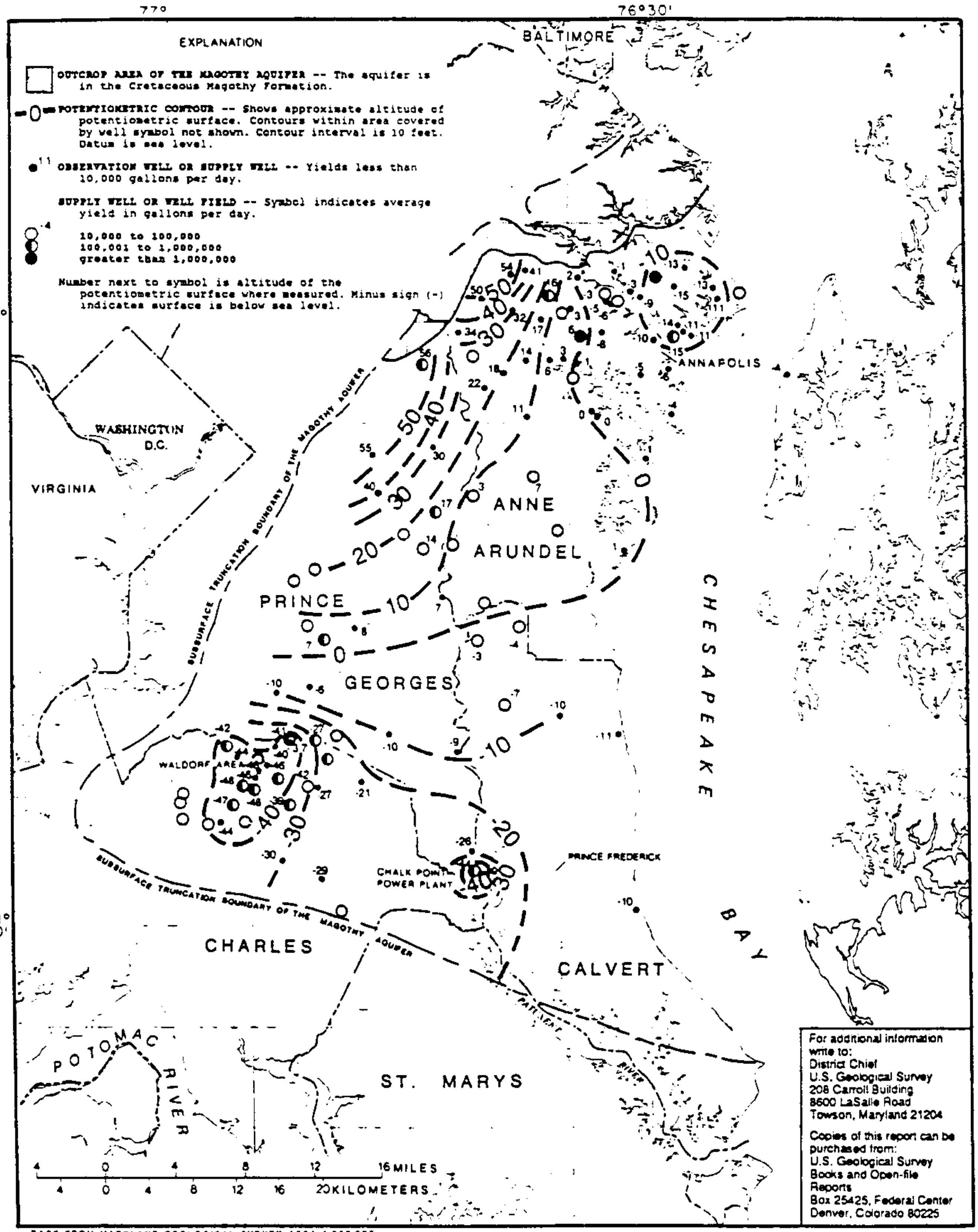
The potentiometric surface of the Magothy aquifer near Chalk Point (Figure 6-10) is quite similar to those for 1984 (PPRP 1986) and 1986 (PPRP 1988). The similarity in the potentiometric surfaces indicates that, as indicated earlier in this section, water levels resulting from pumping the Magothy at Chalk Point have stabilized. In the Waldorf area, where large volumes of water are withdrawn from the Magothy primarily for domestic use, the cone of depression is extensive; however, water level contours in that area have remained relatively stable during the two-year period.

The map presented in Figure 6-11 shows the difference between the potentiometric surfaces of the Magothy aquifer in the fall of 1986 and the fall of 1988. At Chalk Point, there was no change in water levels during this period, which is a further indication that PEPCO's reduction of its ground water withdrawal from the Magothy has stabilized formerly declining aquifer water levels in the immediate vicinity of Chalk Point. In the northern part of the Waldorf area, water level contours declined approximately 10 feet during the two-year interval, as a result of pumping from a new public water supply well. However, water levels in the Magothy at Chalk Point are not considered to be critical levels since approximately 400 feet of hydraulic head remains available in the aquifer for drawdown.

- Morgantown Power Plant (PEPCO)

The Morgantown Power Plant withdraws ground water from four production wells screened in the Patapsco aquifer at depths ranging from 1,073 to 1,117 feet below the land surface (Table 6-1). Figure 6-12 presents daily pumping rates for the Morgantown production wells and water levels from observation well Ch-Ee 70 during 1987 and 1988. Although there are significant data gaps in the water level data, it is evident that water level fluctuations are related to pumping rates. Withdrawal rates from the Patapsco averaged 0.52 mgd in 1987 and 0.67 mgd in 1988, in comparison to 0.61 mgd in 1985 and 0.62 mgd in 1986. The WRA appropriation limit for average daily withdrawal for Morgantown is 0.82 mgd (Curtin 1989).

Figure 6-13 shows periodic monthly high and low water levels and monthly pumpage for the Morgantown Power Plant from 1979 through 1988. Again, water level fluctuations correspond to changes in withdrawal rates. Pumping fluctuated between 1985 and 1988, when the rate of withdrawal stabilized



BASE FROM MARYLAND GEOLOGICAL SURVEY 1961, 1:250,000

Figure 6-10. Potentiometric surface of the Magothy aquifer in southern Maryland during September 1988

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler
In Cooperation with: Maryland Geological Survey, Maryland Tidewater Administration and
United States Department of the Interior Geological Survey
Water Resources Investigation Report 90-4040

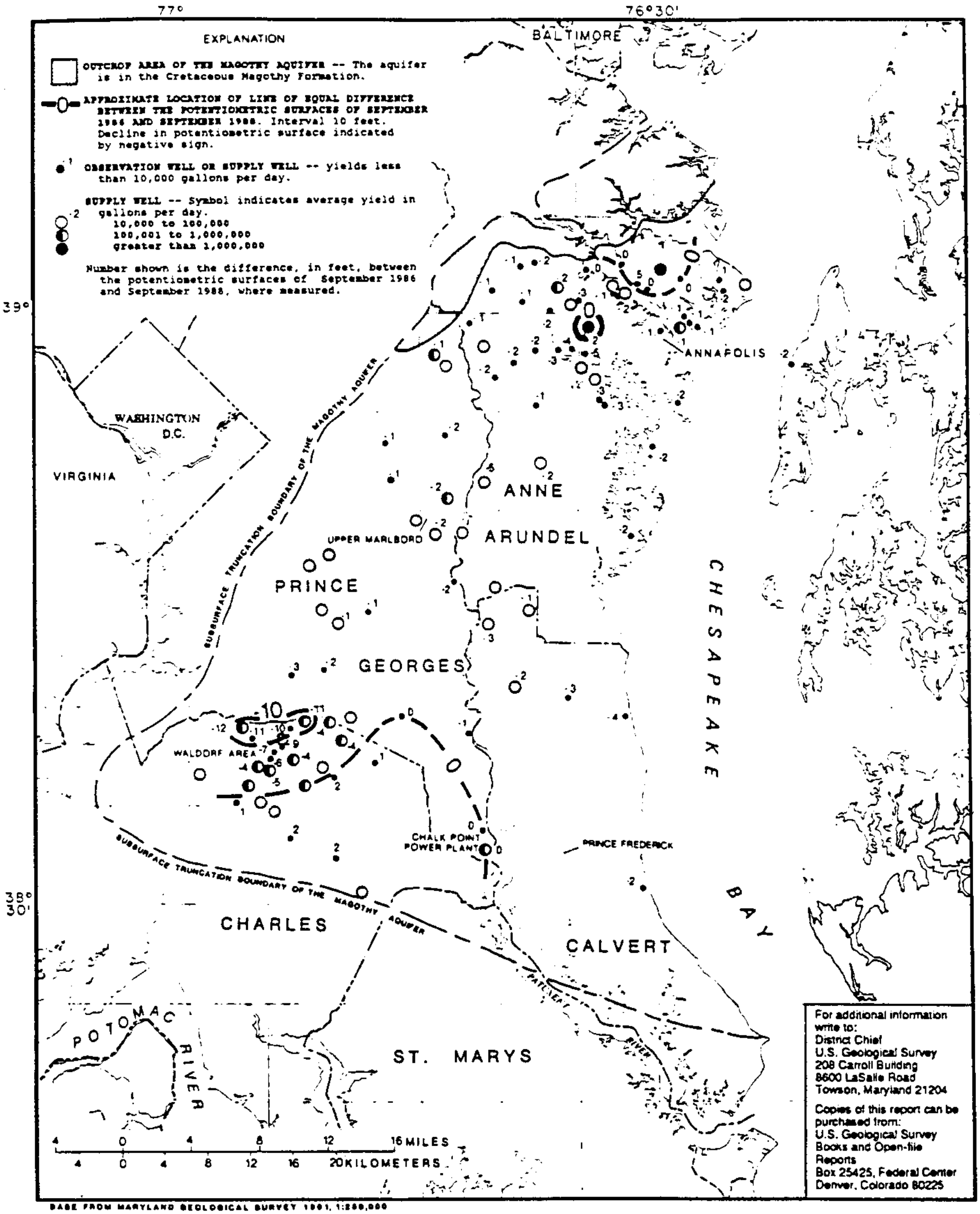


Figure 6-11. Difference between the potentiometric surfaces of the Magothy aquifer in September 1986 and September 1988 in southern Maryland

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler
In Cooperation with: Maryland Geological Survey, Maryland Tidewater Administration and United States Department of the Interior Geological Survey
Water Resources Investigation Report 90-4038

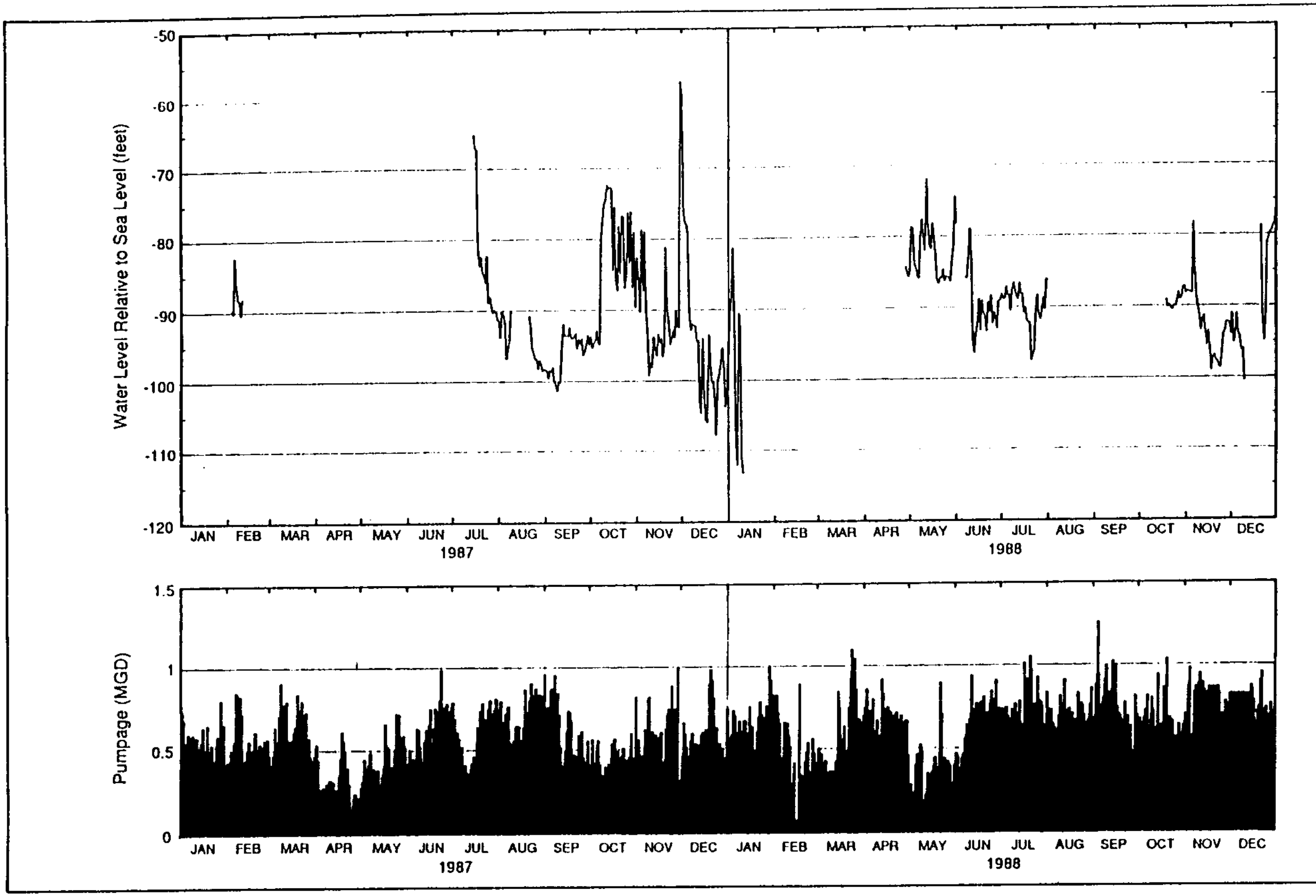


Figure 6-12. Daily ground water pumpage and low water levels in observation well Ch-Ee 70 at the Morgantown Power Plant (January 1987 - December 1988)

Source: Curtin 1989

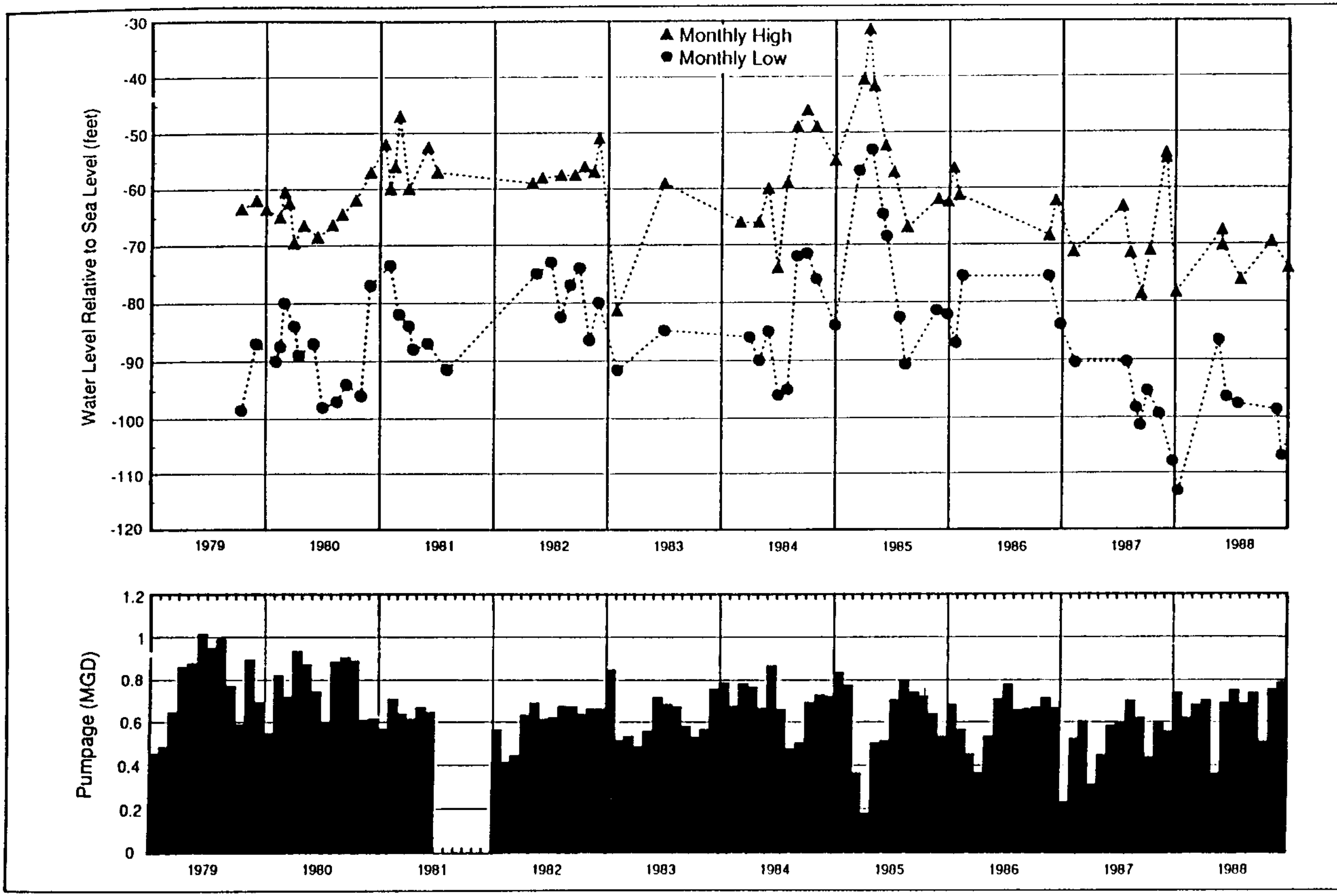


Figure 6-13. Monthly ground water pumpage and water levels in observation well Ch-Ee 70 at the Morgantown Power Plant from 1979 through 1988

Source: Curtin 1989

somewhat. Both high and low water levels have generally declined during the same period. The downward trend in Patapsco water levels observed near Morgantown is probably related to withdrawals by large municipal supply users (>0.1 mgd) in areas such as Waldorf, La Plata, St. Charles, and Indian Head, and commercial users throughout Charles County that rely on the Patapsco aquifer for water supply (PPRP 1988). However, the WRA management policy limiting aquifer drawdown to a maximum of 80 percent of the available drawdown, coupled with the approximately 800 feet of total drawdown available in the Patapsco aquifer, should allow the continued use of the Patapsco aquifer without unacceptable impact on it.

- Vienna Power Plant (DP&L)

The Vienna Power Plant (see Figure 6-1 for location) currently withdraws ground water from the unconfined Pleistocene-Age Columbia Group aquifer. Prior to 1979, ground water was also obtained from a deeper confined aquifer in the Miocene-Age Chesapeake Group. The current production well is screened in a sand layer at a depth of 36 to 56 feet below the land surface (Table 6-1).

Figure 6-14 shows monthly ground water withdrawal rates by the Vienna plant from both aquifers for the period 1975 through 1988. The significant reduction in pumping during 1980 reflects reduced water supply needs resulting from the retirement of Units 5 through 7. The Vienna plant withdrew an average of 0.033 mgd in 1987 and 0.030 in 1988, up from 0.028 mgd and 0.023 mgd in 1985 and 1986, respectively. The WRA appropriation limit for the Vienna plant is 0.05 mgd (Curtin 1989).

The Vienna plant's ground water withdrawal rate is relatively low, and its impacts on nearby wells and on regional water levels within the aquifer are believed to be negligible. However, no data exist on the actual effect of Vienna's withdrawals from the Columbia on aquifer water levels. PPER and MGS/USGS are in the process of establishing an observation well to fill this data gap. Initially, USGS will collect continuous water level data to establish a baseline. After evaluating the initial water level data, USGS will begin long-term monitoring of water levels in the Columbia aquifer at the Vienna plant that will provide PPER with data to evaluate the withdrawal impact.

Summary of Cumulative Ground Water Withdrawal Impacts

The Aquia, Magothy, Columbia, and Patapsco aquifers continue to serve as sources of ground water for the Calvert Cliffs, Chalk Point, Morgantown, and Vienna power plants. During 1987 and 1988, these four facilities combined withdrew an average of approximately 1.3 mgd, which was 0.5 mgd less, on average, than in 1985 and 1986.

Power plant withdrawals continue to contribute to long-term regional water level declines of some heavily used Coastal Plain aquifers, specifically the Aquia and Magothy. However, maps of the potentiometric surfaces of these two aquifers indicate that the hydraulic head in each aquifer remains adequate to maintain

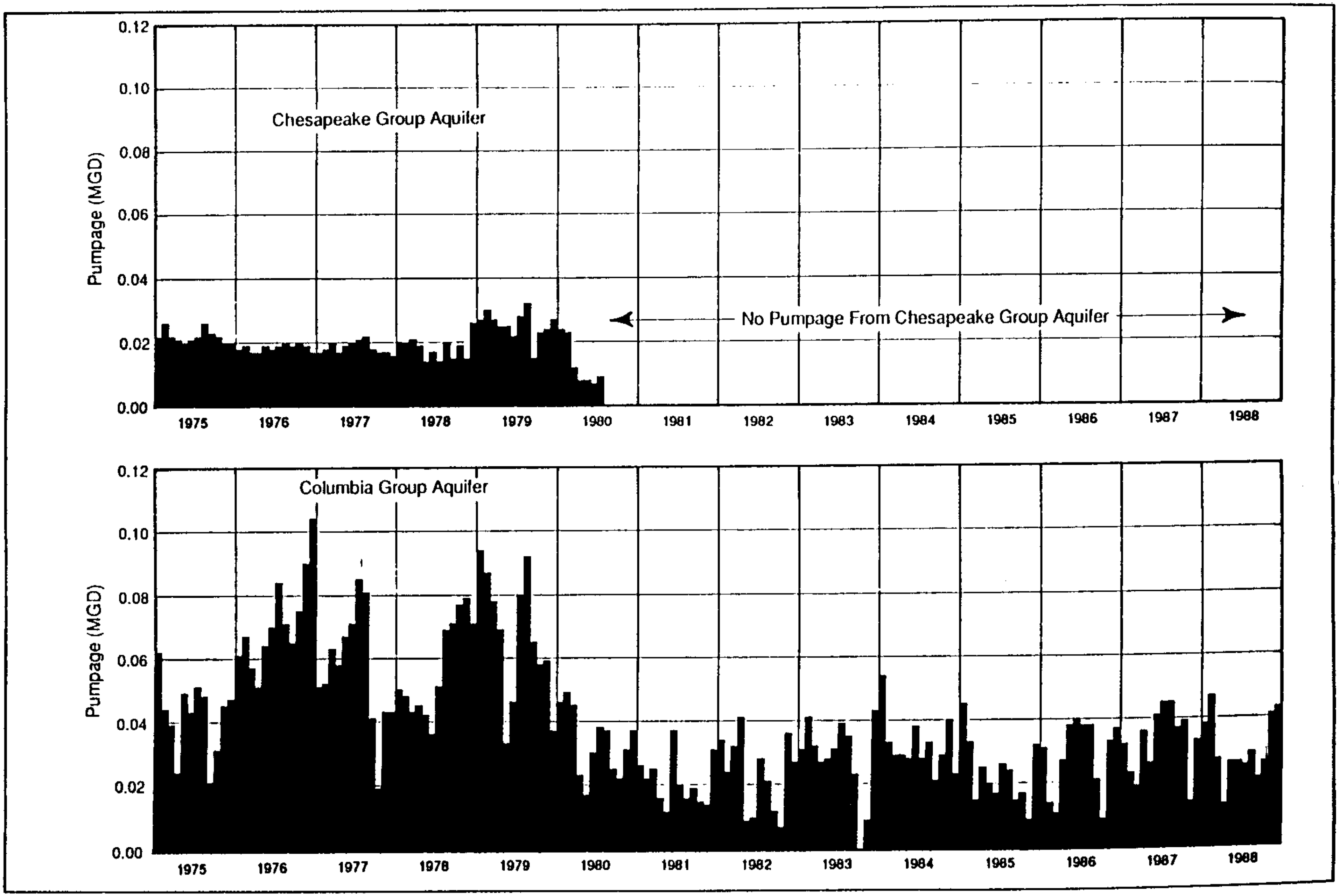


Figure 6-14. Monthly ground water pumpage at the Vienna Power Plant from 1975 through 1988

Source: Curtin 1989

current withdrawal rates for many years. Water level declines in the Aquia and Magothy aquifers are significantly less than declines observed near other areas of high-volume ground water withdrawals, specifically the Waldorf, Anne Arundel County, Lexington Park, and Solomons Island areas.

WRA has addressed the problem of water level declines in the Aquia and Magothy aquifers by limiting commercial and industrial use in those aquifers, encouraging such users to further develop the Patapsco aquifer for their water needs (Miller 1987). PEPCO's Chalk Point power plant is an example of the application of this ground water management approach. Chalk Point began reducing withdrawals from the Magothy in 1986, making up the difference with increased withdrawals from the Patapsco. Water level data from Chalk Point observation wells clearly indicate recovery of water levels in the Magothy aquifer as a result of reduced pumpage. Water levels have subsequently declined in the Patapsco; however, the Patapsco is not as heavily developed as the Magothy, and the observed water level declines do not indicate an adverse impact on the aquifer.

The major impact of Maryland power plants on the ground water resources of southern Maryland is their continuing contribution to the overall water level declines observed in the Aquia, Magothy, and Patapsco aquifers. However, available data indicate that past and current power plant withdrawals have not created adverse impacts to other ground water users. Furthermore, current ground water management practices implemented by the State appear to minimize the impact of power plant ground water withdrawals.

D. Ground Water Quality Degradation

Summary of Power Plant Sources of Ground Water Quality Degradation

Coal storage pile and combustion by-product leachates, and petroleum hydrocarbon products pose the greatest risk to ground water quality from power plants. These potential sources and the associated constituents that can impact ground water quality are summarized below:

- Coal Pile Leachate

Acidic leachates are formed by chemical reactions from the infiltration of precipitation and run-off water through coal storage piles. Pyrite in the coal oxidizes to form iron sulfate, thus lowering pH. Trace metals in the coal, including arsenic, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, selenium, and zinc, are also mobilized and transported by water moving through the coal pile. Solutes dissolved by the water may infiltrate into the unsaturated zone and eventually enter ground water unless the leachates are collected and treated. Since coal is the primary fuel for Maryland power plants, coal pile leachates are common and pose a risk to ground water quality in the state.

- Coal Combustion By-products

Leachates from landfilled combustion by-products also pose a threat to ground water quality. The by-products of coal combustion include fly ash, bottom ash, and slag. The solutes mobilized by infiltrating water include major ions such as iron, manganese, chloride, sulfate, and nitrate, and numerous trace metals contained in the coal and concentrated in by-products by combustion. Leachates containing these solutes can infiltrate through the unsaturated zone into ground water. Degradation of ground water quality can be minimized by engineering controls during landfill construction and the collection and treatment of leachates. Due to the volume generated, coupled with the lack of leachate collection and treatment, the impacts of landfilling coal combustion by-products are a concern in Maryland. Several studies have been conducted documenting the fact that ground water quality degradation from these facilities is localized.

- Oil Ash

As oil ash is a relatively low-volume by-product of oil-fired boilers, it does not pose a significant threat to ground water quality. However, its composition is quite variable. Its primary components include salts and oxides of cadmium, nickel, vanadium, zinc, and iron. Oil ash also contains organometallic compounds and soot containing carbon, which is a potential source of hydrocarbon compounds. Other components may include sulfuric acid and trace concentrations of arsenic, barium, chromium, cadmium, lead, mercury, selenium, and silver. Methods of disposal vary, but the low volumes of oil ash are not expected to create a significant risk to ground water quality (PPRP 1988).

- Petroleum Hydrocarbon Products

Spillage and leaks during transport or storage of petroleum products such as fuel oil, lubricating oil, transformer oil, and gasoline also pose a risk for ground water quality. Petroleum hydrocarbons, which do not dissolve in water, can migrate through the unsaturated zone to ground water where they will float on the water table as a separate phase. However, some organic compounds contained in petroleum products (e.g., benzene) are slightly soluble in water, and can form a dissolved contaminant plume in an aquifer. The potential threat to ground water from petroleum hydrocarbons can be minimized by employing proper management practices during transport and storage.

Contaminants from all these sources can impair the quality of ground water available to other users. Prevention of ground water quality degradation by proper management of these sources provides the best approach.

Low-volume waste streams from coal-, oil-, and natural gas-fired boilers can also degrade ground water quality. These waste streams include the following:

- waterside washwater;
- fireside washwater;

- wastewater treatment liquids and sludges;
- cooling tower basin sludges;
- demineralizer regenerant; and
- pyrite rejects.

However, because relatively small volumes of these wastes are generated, the risk to ground water quality from them is relatively low.

Site-Specific Evaluations of Power Plant Ground Water Quality Impacts

- Coal Pile Run-off

PPER recently assessed the potential for run-off from coal storage piles at Maryland's seven coal-fired power plants to impact ground water quality. Coal piles placed on the ground surface are uncovered and exposed to precipitation. Water infiltrates the piles and acidic run-off is produced by oxidation of pyrite contained in the coal. The acidic run-off, or leachate, is enriched in both major and trace elements, especially iron and sulfate, and therefore has the potential to degrade ground water quality in the vicinity of the piles. Data for the evaluation consisted of information on storage pile management practices gathered during site visits, along with site-specific topographic and hydrogeologic information. This information was used to determine whether there was high, medium, or low potential for ground water quality degradation at the sites.

The assessment indicated that all seven plants collect run-off and six of the seven, with Potomac Edison's R.P. Smith being the exception, also treat the run-off. R.P. Smith is upgrading to begin treatment by the end of 1990. Although coal pile run-off at PEPCO's Morgantown plant is collected and treated, the run-off may have some potential to degrade ground water since no clay liners are used beneath either the pile or collection basins, and there are no monitoring wells in place to detect a release of leachate constituents to ground water. At PEPCO's Chalk Point and Dickerson facilities, and three BG&E plants (C.P. Crane, H.A. Wagner, and Brandon Shores), the potential for degradation of ground water quality from coal pile run-off was determined to be low in view of the run-off collection and treatment systems in place.

- Coal Combustion By-products

PPER has evaluated the impacts associated with landfilling coal combustion by-products through several field investigations of both currently operating and former by-product landfills. In general, these studies by PPER indicate that ground water quality degradation from coal combustion by-product facilities can occur, but that this degradation when it does occur, is localized, minimal, and does not appear to affect ground water users. The ground water quality impacts identified by each of the studies of combustion by-products landfills are summarized below.

Brandywine Ash Landfill

The Brandywine Ash Landfill, located in Prince Georges County, is operated by PEPCO for storage of fly ash generated by the Chalk Point Power Plant. In 1984 PPSP assessed the potential impacts of the 300-acre storage facility on the environment, including ground water (PPSP 1984). The facility is designed and operated to stabilize the ash under saturated conditions and to minimize contact with water (i.e., precipitation and run-off).

The landfill is constructed on Pleistocene- and Quaternary-Age deposits underlain by the Calvert Formation, which is a confining unit to underlying aquifers. Ground water in the vicinity of the site is used for drinking water, most of which is obtained at depths in excess of 300 feet. At the time the study was conducted, no wells identified within a one-mile radius of the facility obtained water from the shallow water-bearing sediments overlying the Calvert Formation.

Ground water monitoring data indicated localized degradation of natural ground water quality in the shallow ground water system. This was not considered an adverse impact, since the shallow aquifer is not used for drinking water supply in the immediate vicinity of the site. It was also concluded that downward migration of leachate constituents into deeper aquifers is prevented by the relatively impermeable sediments of the Calvert Formation underlying the shallow aquifer.

Brandon Woods Coal Ash Structural Landfill

The Brandon Woods Coal Ash Structural Fill is located in Anne Arundel County. Coal combustion ash generated at BG&E's Brandon Shores and H.A. Wagner power plants is managed at the Brandon Woods site. The site is actively being developed as an industrial park, with the coal ash serving as structural fill. PPER is completing an evaluation of the impacts of this facility on ground water quality, focusing on the environmental aspects of using coal ash as structural fill (Keating *et al.* 1989). The key design feature of the structural fill is the placement of the coal ash in compacted lifts with a total thickness of two to 20 feet. Compaction of each lift during placement ensures structural stability and minimizes the infiltration of precipitation and surface run-off into the fill. A low permeability clay cover and topsoil is placed over the horizontal surfaces and slopes of the coal ash. After a four to five acre area is filled, the area is stabilized with vegetation prior to development.

The landfill is constructed on unconsolidated sediments consisting primarily of sand, sandy silt, sandy clay, and silty clay. Ground water beneath the site occurs under water table conditions in a perched saturated zone within a surficial sand unit, and under semi-confined to confined conditions in a lower saturated zone