Aquatic Radionuclide Distributions

As indicated in Table V-10, radionuclides released to the Susquehanna River by PBAPS were detected at relatively low levels in a variety of aquatic biota and Table sediments (PECO 1986, 1987; McLean and Domotor 1988b). Zn-65, Cs-134 and Cs-137 were consistently detected.

- Aquatic Biota

Finfish collected during 1985 and 1986 contained radionuclides attributed to PBAPS, including Zn-65 and Cs-134 and Cs-137 (some fraction of Cs-137 is fallout-related). Co-60 was also detected in 1985 in forage finfish collected in the plant discharge vicinity. As in prior years, concentrations of all these radionuclides were highest in finfish collected from the Conowingo Pond and the dam tailrace. Concentrations were detectable at much-reduced levels on occasion in finfish from the Susquehanna Flats and were not detected upstream of the plant influence (Holtwood Reservoir). All edible finfish species collected in the Conowingo Pond or dam tailrace contained PBAPS radionuclides. Included are channel catfish, carp, walleye, white perch, smallmouth and largemouth bass and hybrid (White x Striped) bass. Levels of all radionuclides recorded during 1985-1986 were similar to those observed before 1983 and substantially lower than during the 1983-1984 reporting period.

Submerged aquatic vegetation (SAV) collected in 1986 in Conowingo Pond just below the plant discharge contained plant-related Co-60, Cs-134 and Cs-137. Collections from the Susquehanna Flats and Upper Chesapeake Bay have also previously contained Cs-134 and Zn-65 from PBAPS, but with the exception of a trace of Cs-134, plant-related radioactivity was not detected during 1985 and 1986. SAV collections from the Susquehanna River and Susquehanna Flats have also consistently contained low levels of I-131. The principal source of I-131 is assumed to be the Hershey Medical Facility because this nuclide was, and continues to be, detected at nearly comparable concentrations throughout the river, above and below Three Mile Island in river water and SAV (GPUN 1986, 1987; McLean and Domotor 1988a).

Table V-10

Maximum Concentrations of radionuclides attributed to Peach Bottom Atomic Power Station in various aquatic biota for the period 1985-1986

Sample Type Collected	Collection Location	Year	Radionuclide Concentration (pCi/wet kg)) Cobalt-60	Cesium-134	Cesium-137 [a]	Zinc-65
Edible Finfish Flesh	Holtwood Reservoir	1985	< 10	< 10	< 12	< 15
		1986	< 94	< 84	4+-9	< 206
	Conowingo Pond	1985	< 73	11+-6	35+-22	< 151
		1986	< 102	17+-4	47+-6	2+-12
	Conowingo Dam Tailrace	1985	< 122	19+-9	71+-13	< 297
		1986	< 21	15+-3	41+-4	< 44
	Susquehanna Flats	1985	< 23	< 22	5+-11	< 46
Edible Finfish Gut	Holtwood Reservoir	1985	< 20	< 20	< 24	< 30
		1986	< 576	< 518	< 544	< 1340
	Conowingo Pond	1985	< 10	< 10	< 12	242+-136
		1986	111+-19	21+-12	168+-319	110+-42
	Conowingo Dam Tailrace	1985	< 690	< 644	18+-8	74+-57
		1986	< 289	< 285	< 313	133+-108
	Susquehanna Flats	1985	< 493	< 620	< 449	< 3202
Edible Finfish (Whole)	Holtwood Reservoir	1985	< 94	< 82	< 91	< 227
		1986	< 13	< 11	1+-5	< 23
	Conowingo Pond	1985	40+-7	36+-6	64+-7	136+-25
		1986	< 17	< 17	12+-9	44+-27
	Conowingo Dam Tailrace	1985	< 6	< 6	8+-4	4+-8
		1986	< 8	< 6	9+-4	< 16

Table V-10 (continued)

Maximum Concentrations of radionuclides attributed to Peach Bottom Atomic Power Station in various aquatic biota for the period 1985-1986

Sample Type Collected	Collection Location	Year	Radionuclide Concentration (pCi/wet kg)) Cobalt-60	Cesium-134	Cesium-137[1]	Zinc-65
	Upper Bay	1985	50+-13	13+-5	570+-20	<84
		1986	45+-13	43+-7	691+-16	46+-19
	Holtwood Reservoir	1985	< 81	< 70	196+-14	< 167
		1986	< 26	< 28	183+-19	< 58
Sediment (Sand) (pCi/dry kg units)	Conowingo Pond	1985	348+-9	127+-5	631+-72	256+-13
		1986	594+-12	201+-7	644+-24	272+-13
	Susquehanna Flats	1985	12+-4	33+-10	207+-17	< 69
		1986	12+-5	28+-4	207+-17	< 69
	Upper Bay	1985	< 36	< 34	379+-27	< 86

Source: McLean and Domotor 1988b.

(a) Primary attributable to weapons testing fallout. However, when Cs-134 is also detected, some power plant-produced Cs-137 imcrement is indicated.

Table V-10 (continued)

Maximum Concentrations of radionuclides attributed to Peach Bottom Atomic Power Station in various aquatic biota for the period 1985-1986

Sample Type Collected	Collection Location	Year	Radionuclide Concentration (pCi/wet kg)) Cobalt-60	Cesium-134	Cesium-137 [a]	Zinc-65
	Susquehanna Flats	1985	< 404	< 323	1+-6	< 752
		1986	< 18	< 15	< 18	< 32
Crayfish	Holtwood Reservoir	1985	< 134	< 112	< 137	< 276
		1986	< 85	< 76	< 87	< 190
	Conowingo Pond	1985	15+-12	13+-23	34+-39	13+-31
		1986	< 39	< 40	10+-15	< 84
Mussels (*Elliptio complanata*)	Holtwood Reservoir	1985	< 32	< 28	< 33	< 61
		1986	< 29	< 31	< 34	< 64
	Conowingo Pond	1985	2+-2	4+-2	4+-7	28+-11
		1986	2+-2	< 138	< 196	19+-8
	Susquehanna Flats	1985	< 10	< 10	1+-5	< 21
		1986	< 30	< 27	< 27	< 60
Submerged Aquatic Vegetation	Conowingo Pond	1986	13+-5	10+-3	26+-5	< 16
	Susquehanna Flats	1985	< 4	0.6+-0.8	5+-3	< 8
		1986	< 20	< 16	8+-8	< 39
	Upper Bay	1985	< 88	< 78	18+-5	< 187
Sediment (Clay) (pCi/dry kg units)	Holtwood Reservoir	1985	< 55	< 51	204+-16	< 106
	Conowingo Pond	1985	226+-22	171+-14	772+-27	151+-13
		1986	394+-12	204+-15	694+-23	258+-19
	Susquehanna Flats	1985	46+-9	93+-7	429+-14	< 41
		1986	15+-11	39+-9	169+-14	< 48

Uptake of PBAPS radioactivity was evident in freshwater mussels and crayfish introduced and held in cages in the Conowingo Pond. Detected in these organisms were low levels of Co-60, Cs-134 and Cs-137 and Zn-65. Zn-65 levels were substantially lower than in prior years. Levels of Co-60 and radiocesium were similar to prior years. None of these radionuclides was detected in the Holtwood Reservoir, implying that this radioactivity in Conowingo Pond is due exclusively to PBAPS.

- Sediments

Heavy metal radionuclides (e.g., radiocobalt, radiocesium) released to the Susquehanna River by PBAPS are generally very particle-reactive -- that is, they readily become associated with particulate material suspended in the river water column. Most of this suspended, particle-bound radioactivity is ultimately deposited on the river or Bay bottom. The sediment surface may be periodically eroded, resulting in the relocation and renewed bioavailability of the radioactivity. Radiological analysis of Susquehanna River and Chesapeake Bay sediments is conducted to determine the fate and temporal and spatial distribution of PBAPS radioactivity released into Conowingo Pond.

Co-60, Zn-65 and Cs-134 and Cs-137 have been detected in Susquehanna and Upper Bay sediments in previous years, and were evident during 1985 and 1986. Concentrations of these nuclides are generally highest in the Conowingo Pond. Transport of particle-bound radioactivity to the Susquehanna Flats and Upper Chesapeake bay is apparent (Table V-10). Particle dilution, dispersion and radioactive decay during transport (or during residence in the Conowingo Pond) cause concentrations to diminish with distance down river. Mass balance estimates (the ratio of radionuclide quantity in sediments to that released) indicate that about 4-12% of the Co-60, 2-8% of the Cs-134 and about 4-21% of the Zn-65 released to the river is found in the surface sediments of the Conowingo Pond. Most of the remainder is transported downriver and down-Bay (McLean *et al.* 1988). As with biota, concentrations of these radionuclides in sediments were similar to those observed before 1983 and generally about 50% lower than observed in 1983 and 1984. As in prior years, with the exception of some weapons-test fallout Cs-137, no man-made radionuclides were detected upstream of the PBAPS influence (in Holtwood Reservoir). Cs-134, which would be attributable to the Chernobyl accident, was not detected. However, land runoff may eventually provide a Cs-134 increment in Susquehanna sediments.

Radiation Dose To Humans

Radioactivity released to the atmosphere by PBAPS was not detectable during the subject period; therefore, no radiation dose via this pathway is indicated. For the aqueous pathway, the annual total body dose associated with consumption of drinking water containing tritium, radiocesium and Zn-65 in the quantities released (Table V-8), assuming an average river flow of 36,000 cfs, is estimated to be less than 0.01 mrem. This is an overestimate, because treating the water for drinking purposes would remove almost all of the cesium and zinc.

The maximum annual hypothetical radiation dose to individuals consuming finfish caught in the Conowingo Pond or Dam tailrace utilizing the maximum recorded concentration of plant-related radionuclides as determined by PPRP monitoring would be 0.16 mrem to the total body. The highest calculated organ dose commitment would be 0.23 to a teenager's liver. Table V-11 summarizes dose commitments to a maximum exposed individual. These small plant-related doses are similar to those estimated for previous years. For comparison, the highest total body dose estimated was just over 1 mrem, for the 1978-1980 period.

The plant-attributable total body dose increment associated with the aqueous pathway is estimated to be less than 0.2 mrem per year for the period 1985-1986 -- considerably within the regulatory constraint of 6 mrem/yr. For context, the average total body radiation dose attributable to natural radioactivity (including Radon gas) is estimated to be about 300 mrem/yr (NCRPM 1988).

Summary

Releases of radioactivity to the atmosphere from the Peach Bottom Station resulted in no detectable radionuclide concentrations in the terrestrial environment or atmosphere. Releases of radioactivity to the Susquehanna River produced low

Table V-11

Maximum dose commitment(a) (in mrem) for an individual consuming finfish affected by PBAPS effluents

	ADULT		TEEN		CHILD	
	1985	1986	1985	1986	1985	1986
Total Body:						
Zn-65	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003
Cs-134	0.0480	0.0430	0.0280	0.0250	0.0110	0.0100
Cs-137	0.1065	0.0705	0.0590	0.0390	0.0226	0.0150
TOTAL	0.155	0.114	0.087	0.064	0.034	0.025
Bone:						
Zn-65	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002
Cs-134	0.0250	0.0220	0.0250	0.0230	0.0310	0.0270
Cs-137	0.1190	0.0787	0.1270	0.0840	0.1600	0.1060
TOTAL	0.144	0.101	0.152	0.107	0.191	0.133
Liver:						
Zn-65	0.0000	0.0006	0.0000	0.0006	0.0000	0.0005
Cs-134	0.0590	0.0530	0.0600	0.0540	0.0500	0.0450
Cs-137	0.1630	0.1076	0.1690	0.1120	0.1530	0.1020
TOTAL	0.222	0.161	0.229	0.167	0.203	0.148
Kidney:						
Zn-65	0.0000	0.0004	0.0000	0.0004	0.0000	0.0003
Cs-134	0.0190	0.0170	0.0190	0.0170	0.0160	0.0140
Cs-137	0.0550	0.0365	0.0576	0.0380	0.0500	0.0330
TOTAL	0.074	0.054	0.077	0.055	0.066	0.047
GI Tract:						
Zn-65	0.0000	0.0004	0.0000	0.0003	0.0000	0.0001
Cs-134	0.0010	0.0010	0.0010	0.0010	0.0003	0.0003
Cs-137	0.0030	0.0021	0.0024	0.0016	0.0009	0.0007
TOTAL	0.004	0.004	0.003	0.003	0.001	0.0011

(a) Based upon maximum radionuclide concentrations given in Table V-10. Calculations assume ingestion quantities and dose conversion factors of USNRC Reg. Guide 1.109.

levels of Co-60, Zn-65, Cs- 134 and Cs-137 in aquatic biota and sediments. Sediment inventories are highest in the Conowingo Pond, and are detectable at lower concentrations on the Susquehanna Flats and Upper Chesapeake Bay. It is estimated that annually from 5% to 14% of PBAPS radiocobalt, radiozinc and radiocesium is found in the surface sediments of Conowingo Pond. Consumption of finfish and Susquehanna River water would produce an extremely small radiation dose increment, well within regulatory limits.

C. Three Mile Island Nuclear Station

The Three Mile Island Nuclear Station (TMINS), owned jointly by Metropolitan Edison Co., Pennsylvania Electric Co. and Jersey Central Power and Light Co., is operated by the General Public Utilities Nuclear Corporation (GPUN). The plant is located on an island in the Susquehanna River approximately 8 miles southeast of Harrisburg Pennsylvania. This location is approximately 30 air miles and 42 river miles from the Maryland border. Each of the plant's two units is a pressurized water reactor with a maximum dependable capacity of 824 MWe.

Unit 1, shut down since the March 1979 accident involving Unit 2, was returned to operation on October 3, 1985, and achieved full power on January 6, 1986. Unit 2, crippled in the accident, continues to undergo decontamination and fuel removal. Accident-generated water is being reused in the clean-up, processed to remove most of the radioactivity, and stored onsite. Completion of the Unit 2 clean-up and defueling is expected sometime in 1989. The utility proposes to monitor and maintain the unit in a secure and stable condition until it can be decommissioned.

Releases to the Environment

Quantities of radionuclides discharged to the atmosphere and the Susquehanna River during 1985 and 1986 are presented in Tables V-12 and V-13. Due to the fact that Unit 1 saw limited operation during this period, and Unit 2 was not in operation, the facility released relatively small quantities of radioactivity. Atmospheric releases were comprised principally of tritium and noble gases, with Xenon-133 (Xe-133) dominant, (which is an indication of Unit 1 operation).

Table V-12

Total quantities (curies) of radionuclides released to the atmosphere by TMINS, 1985, 1986.

Radionuclide	Unit 1		Unit 2		Total	
	1985	1986	1985	1986	1985	1986
Summary						
Tritium	0.023	24.6	19.8	40.1	19.8	64.7
Noble Gases [a]	108.400	3803.5	0.1	0.3	108.5	3803.8
Iodines	0.000	0.00006	0.0	0.00001	0.0	0.0
Particulates	0.00002	0.00037	0.00005	0.00008	0.0	0.0
Total Curies	108.4	3828.1	19.9	40.4	128.3	3868.5
H-3	0.23	24.6	19.8	40.1	19.82	64.7
Ar-41	0.477	3.42	0.00	0.00	0.477	3.42
Kr-85	13.6	7.04	0.00	0.28	13.60	7.32
Kr-85m	0.486	0.633	0.00	0.00	0.49	0.63
Kr-87	2.32	0.00116	0.00	0.00	2.32	0.00116
Kr-88	0.485	0.298	0.00	0.00	0.485	0.298
Xe-131m	0.036	23.1	0.00	0.00	0.036	23.1
Xe-133	80.3	3650.0	0.133	0.0277. [b]	80.43	3650.0
Xe-133m	1.12	14.3	0.00	0.00	1.12	14.3
Xe-135	9.58	104.0	0.00	0.00	9.58	104.0
Xe-135m	0.00	0.66	0.00	0.00	0.00	0.66
I-131	0.00	0.00003	0.00	0.00001 [b]	0.00	0.00004
I-132	0.00	0.00001	0.00	0.00	0.00	0.00001
I-133	0.00	0.00001	0.00	0.00	0.00	0.00001
1-134	0.00	0.00001	0.00	0.00	0.00	0.00001
Sr-89	0.00001	0.00	0.00	0.00	0.00001	0.00
Sr-90	0.00001	0.00001	0.00002	0.00007	0.00003	0.00008
Cs-137	0.00	0.00036	0.00003	0.00001	0.00003	0.00037

Source: GPUN 1986, 1987.
(a)Argon-41 included.
(b)Of Unit 1 origin, released via Unit 2.

Table V-13

Total quantities (curies) of radionuclides released to the Susquehanna River via the aqueous pathway by the TMINS, 1985, 1986.

Radionuclide	Unit 1		Unit 2		Total	
	1985	1986	1985	1986	1985	1986
Summary						
Tritium	9.061	170.0	0.002	0.00146	9.063	170.00146
Dissolved Noble Gases	0.00036	0.02636	0.00	0.00	0.00036	0.2636
Iodines	0.00	0.0006	0.00	0.00	0.00	0.0006
Particulates	0.00667	0.01355	0.00018	0.00018	0.00685	0.01373
Total Curies	9.06803	170.04051	0.00218	0.00164	9.07021	170.04215
Kr-85m	0.00	0.00001	0.00	0.00	0.00	0.00001
Xe-133	0.00034	0.026	0.00	0.00	0.00034	0.026
Xe-135	0.00002	0.00035	0.00	0.00	0.00002	0.00035
I-131	0.00	0.00060	0.00	0.00	0.00	0.00060
Fe-55	0.00055	0.00013	0.00	0.00	0.00055	0.00013
Co-58	0.00	0.00859	0.00	0.00	0.00	0.00859
Co-60	0.00064	0.00011	0.00	0.00	0.00064	0.00011
Sr-90	0.00011	0.00001	0.00014	0.00012	0.00025	0.00013
Ag-110m	0.00	0.00014	0.00	0.00	0.00	0.00014
Sb-125	0.00012	0.00	0.00	0.00	0.00012	0.00
Cs-134	0.00025	0.00047	0.00	0.00	0.00025	0.00047
Cs-137	0.005	0.00397	0.00004	0.00006	0.00504	0.00397
Ba-140	0.00	0.00004	0.00	0.00	0.00	0.00403
La-140	0.00	0.00009	0.00	0.00	0.00	0.00009

Source: GPUN 1986, 1987.

Quantities released to the Susquehanna were likewise very small, attributable to Unit 1, and composed almost exclusively of tritium.

Atmospheric and Terrestrial Radionuclide Distributions

Monitoring in the plant vicinity by the utility, the Pennsylvania DER, and the EPA have revealed no radioactivity in the terrestrial environment or the atmosphere that is attributable to TMINS. Historic weapons-test fallout and radionuclides attributable to the Chernobyl event were in evidence (GPUN 1987).

Aquatic Radionuclide Distributions

Low-level releases to the Susquehanna River by TMINS Unit 1 produced no detectable concentrations of radioactivity in 1985. Releases during 1986 produced a low-level concentration of Co-58 in crayfish caged downstream of the discharge, and occasionally caused slightly elevated levels of tritium in river water. I-131 was also detected in river water in the TMINS vicinity. Since this nuclide was also detected at similar or greater concentrations upstream of the plant's influence (GPUN 1987; McLean and Domotor 1988a), its presence is attributed to Hershey Medical Center, which discharges to the Swatara Creek upstream of Three Mile Island.

Monitoring by PPRP of biota and sediments in the Holtwood Reservoir (an impoundment of the Susquehanna River downstream of TMINS but upstream of PBAPS) has detected only natural and weapons test radioactivity in addition to the I-131 mentioned above.

Summary

The ongoing cleanup of TMINS Unit 2 and the startup of Unit 1 resulted in releases of low levels of radioactivity to the environment during 1985 and 1986. Radioactivity released via the atmospheric pathway was not detected in the environment during either year. Releases to the Susquehanna produced, in 1986, a detectable concentration of Co-58 in crayfish on one occasion, and, on several occasions, slightly elevated levels of tritium in river water. The environmental impact of these concentrations is insignificant.

These releases and environmental radionuclide concentrations are substantially lower than those observed in the period 1970-1980. Radioactivity attributed to Three Mile Island Station has not been detected in Maryland either in this reporting period (1985-1986) or previously.

D. Radioactive Waste Disposal

The operation of a nuclear power plant produces two types of radioactive waste requiring offsite disposal: low-level waste and spent fuel. Low-level waste (LLW) is characterized by relatively low concentrations of radionuclides, and includes such items as spent decontamination resins, filter sludges, contaminated equipment and protective clothing. Spent fuel is reactor fuel that has completed its useful life.

In 1980 Congress passed the Low-Level Radioactive Waste Policy Act. This legislation granted individual states the authority to form compacts to establish regional facilities for LLW disposal. As of January 1986, any compact region may restrict the import of wastes to compact member states. This could result in the restriction or closure to Maryland and Pennsylvania power plants of the three current disposal sites in the states of Washington, Nevada and South Carolina.

In an effort to alleviate a potential disposal problem, Maryland has joined with Pennsylvania, Delaware and West Virginia in forming a regional compact, termed the Appalachian Compact. Pennsylvania has agreed to host the first disposal facility for this region.

During 1985 and 1986, all LLW generated at Calvert Cliffs, Peach Bottom, and Three Mile Island Unit 1 was shipped to either Barnwell, South Carolina or Hanford, Washington (Table V-14 presents the volumes and radioactivity levels of waste shipped). LLW generated as a result of the TMINS Unit 2 cleanup was shipped to Hanford or Richland, Washington (Table V-14). 1986 also saw five rail-car shipments of Unit 2 reactor fuel debris sent to the Idaho National Engineering Laboratory in Scoville, Idaho.

Table V-14

Low-level solid waste shipped off-site for disposal by CCNPP, PBAPS, and TMINS

1985

	CCNPP	PBAPS	TMI-1	TMI-2
Volume (Cu Ft.)	13,737	96,417	16,545	17,057
Activity (Ci)	15,085	121,306	19	6,345
No. of Shipments	34	291	41	47

1986

	CCNPP	PBAPS	TMI-1	TMI-2
Volume (Cu Ft.)	7,493	52,577	7,515	11,583
Activity (Ci)	451	18,807	8	58
No. of Shipments	19	301	26	33

Source: BG&E 1986, 1987; PECO 1986, 1987; GPUN 1986, 1987.

E. The Chernobyl Accident

On April 26, 1986, Unit 4 of the four-reactor Chernobyl complex in the Ukraine, U.S.S.R. exploded as a result of a rapid rise in fuel element criticality. Steam pressure lifted a 1000-ton cover plate and exposed the uncontrolled reactor to the environment. Large quantities of radioactivity were released over a period of about 10 days. It has been estimated that about 3% of the heavy elements of the core, about 13% of the radiocesium and about 20% of the radioiodine in the reactor were released (Wilson 1986). Most of the radioactivity was deposited in Northern Europe and Scandinavia, but gaseous and particulate radioactivity was detected within days throughout the Northern Hemisphere. A variety of fresh fission products from the event were detected in the Maryland/Pennsylvania region by the second week of May 1986 (Table V-15). Routine radiological monitoring conducted by nuclear power plant utilities and state and federal agencies detected Chernobyl-related radioactivity in the atmosphere, terrestrial vegetation, precipitation, milk, soil and aquatic biota (BG&E 1987; GPUN 1987; McLean 1986). With the exception of very low levels of radiocesium, Chernobyl radioactivity was not detectable in our region after two months.

Given the deposition presented in Table V-15, it is estimated that the Susquehanna River (from TMINS to the mouth) received about 0.4 mCi of I-131, 0.08 mCi of Cs-134 and 0.16 mCi of Cs-137 (McLean 1986). This compares with an estimated 200 mCi of I-131, 0.2 mCi of Cs-134 and 1.5 mCi of Cs-137 released during the TMINS Unit 2 accident (McLean and Magette 1979). Monitoring programs in the vicinity of Calvert Cliffs, Peach Bottom and Three Mile Island readily detected the Chernobyl radioactivity. Reasonable agreement among atmospheric concentrations of I-131 and particulate gross beta radioactivity measurements from four monitoring locations (Figure V-1) indicate that regional dispersion was relatively uniform. The event also provides an indication of the efficacy of the monitoring programs and the cross-comparability of the results.

A radiation dose of this size is many orders of magnitude lower than levels attributable to natural radiation sources. The impact of this event in the U.S. was most significant in demonstrating that the potential and actual environmental

Table V-15

Concentration of radionuclides attributed to the Chernobyl accident detected in Maryland

Radionuclide	Atmospheric[a] Concentration (pCi/L)	Deposition[b] Concentration (pCi/m²)
Zr-95	—	0.23
Ru-103	0.000022	8.00
Ru-106	—	3.00
I-131	0.00018	13.70
Te-132	0.000029	---
Cs-134	0.000038	2.50
Cs-136	0.0000071	0.20
Cs-137	0.00007	5.00
Ba-140	0.00001	0.60
La-140	0.00001	1.20
Ce-141	0.00000032	0.08

(a) Derived from DHMH data 5-11 May 1986.
(b) Derived from McLean 1986.

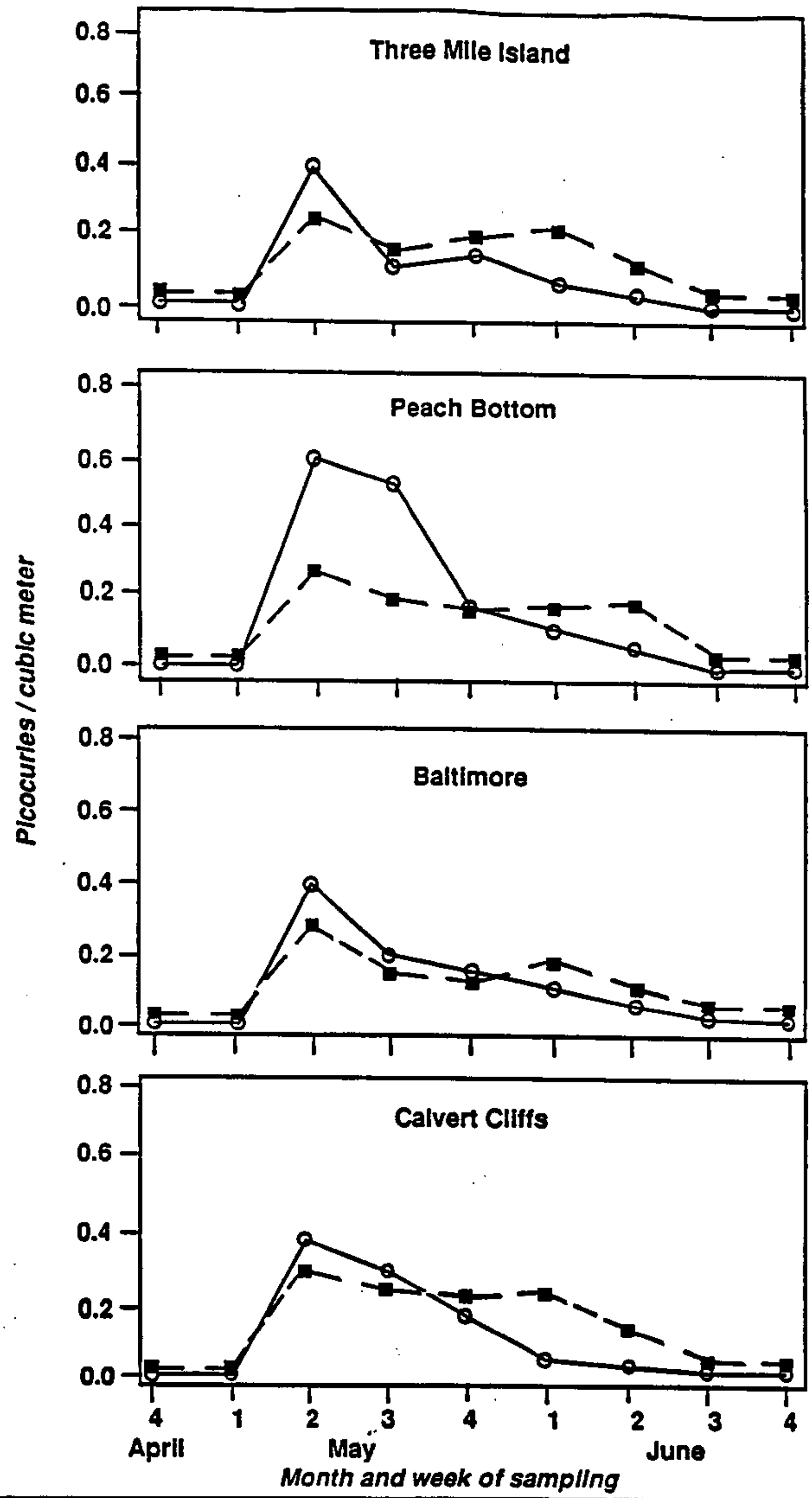

Figure V-1. Iodine-131(-o-) and particulate gross beta (-■-) radioactivity detected in air samples collected from Three Mile Island, Peach Bottom, and Calvert Cliffs monitoring stations following the Chernobyl reactor accident on April 26, 1986.

and health effects of releasing major quantities of radioactivity occur on a global scale. International recognition of this fact has given oversight agencies and major reactor operators new incentives to cooperate in the exchange of related information to more effectively enhance reactor safety.

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CHAPTER VI

GROUND WATER IMPACT

The potential for power plant operations to affect the quantity and quality of ground water resources in Maryland remains an important issue. The significant quantity of ground water utilized by some power plants has raised concerns regarding the lowering of water levels in critical regional aquifers. Concerns regarding potential impacts on ground water quality arise from the handling and storage of large quantities of fuel oil and coal, the generation and landfilling of oil and coal combustion by-products, and the generation of other low-volume wastes from routine operations and maintenance.

The potential for power plant operations to affect ground water quantity and quality in Maryland has been addressed in the two previous CEIR's (MD-PPRP 1984, 1986). The review of ground water impacts in these two reports concluded that the most significant effects on ground water resources were declining water levels in aquifers utilized by power plants, and minor ground water quality degradation at coal ash landfill sites. As background information, the 1986 CEIR also included discussions of the geology and occurrence of ground water in Maryland; the reader is referred to that report for a further understanding of ground water resources in Maryland.

The purpose of this chapter is to update information on the impacts of Maryland power plants on ground water quantity and quality in the State. This discussion provides information on ground water consumption by the power plants during 1985 and 1986, and addresses the cumulative regional impacts of power plant withdrawals on the Aquia and Magothy aquifers in Southern Maryland since the middle 1970's. It also presents a summary of potential sources of ground water contamination from power plant operations and reviews available information concerning degradation of ground water quality by Maryland power plants.

A. Ground Water Withdrawal

Potential Impacts From Ground Water Withdrawal

Routine operations of steam-generating power plants require large volumes of exceptionally high-quality water for equipment cooling, boiler makeup, potable water supply, and air pollution control equipment. These water usage requirements are satisfied by drawing upon surface or ground water sources. Four Maryland power plants (Calvert Cliffs, Chalk Point, Morgantown, and Vienna) rely on ground water to provide the quality and quantity of water required to meet their supply needs. These power plants are located in the Coastal Plain Physiographic Province, which contains several prolific aquifers capable of yielding the necessary quantities of water (see Figure VI-1).

High-volume (yield) ground water withdrawals have the potential to create two problems in areas surrounding power plants. First, long-term pumping of high-yield wells can, in some cases, lower the ground water levels in nearby wells (well interference), leaving them with little or no water available for withdrawal. When it occurs, this type of well interference is a localized problem (Figure VI-2). Second, high-yield ground water withdrawals can also affect the movement of dissolved constituents (solutes) in ground water, which are determinants of water quality. The cone of influence created by a pumping well (see Figure VI-2) alters the natural flow gradients in the ground water system. These flow gradient alterations may increase vertical and horizontal rates of solute migration or change the direction of solute movement toward the pumping well. In the Coastal Plain areas of Maryland, alterations of ground water flow gradients can cause movement of brackish and saline water into an aquifer from surface water bodies (salt water intrusion) or draw contaminants from other aquifers within the pumping influence of the well.

To date neither of these potential problems has been identified in areas surrounding Maryland power plants. Although ground water use at power plants has lowered aquifer water levels, there have been no reported cases of shallow wells going dry. Furthermore, there has been no evidence of saltwater intrusion or other ground water quality degradation problems caused by power plant withdrawals. Long-term monitoring of aquifer water levels by the

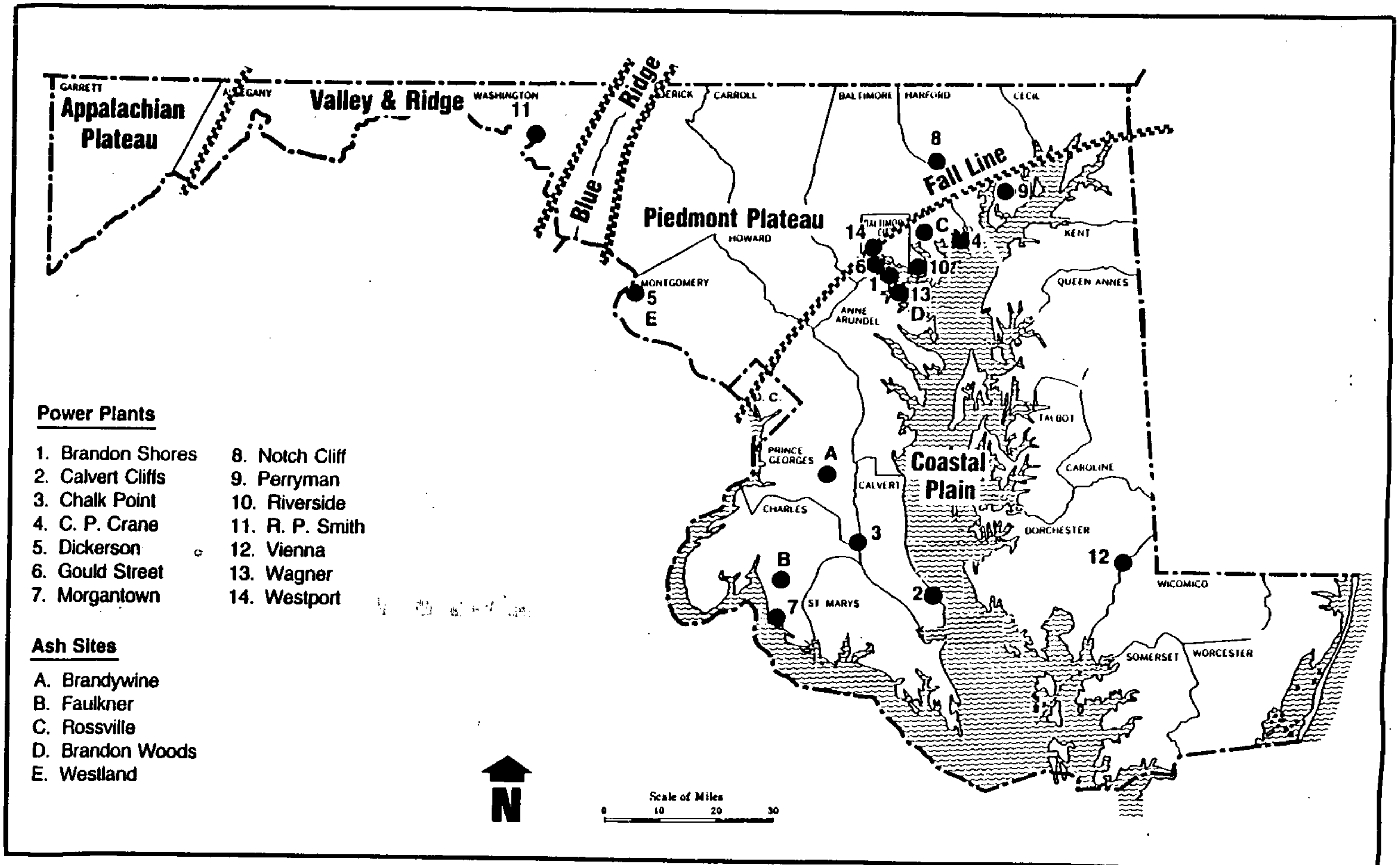

Figure VI-1. Locations of existing Maryland power plants and ash sites in relation to physiographic provinces

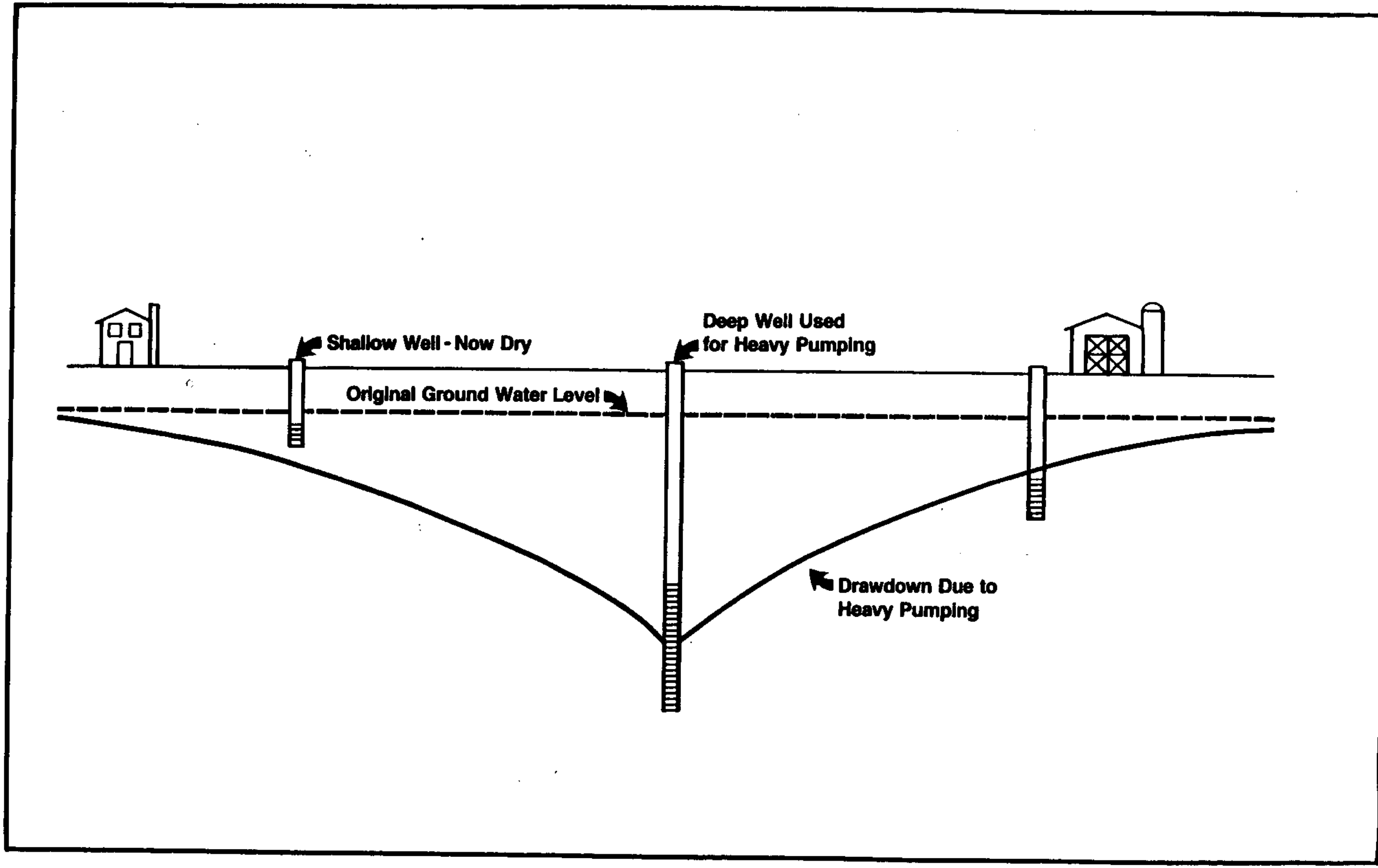

Figure VI-2. Impact of pumping on local ground water levels

Maryland Department of Natural Resources Geological Survey (MGS) and U.S. Geological Survey (USGS) has provided the necessary database to identify localized well impacts from power plant withdrawals.

The most significant issue concerning ground water withdrawal by the electric utility industry in Maryland is its cumulative impact on the Coastal Plain aquifers in southern Maryland and the Eastern Shore, where these aquifers are utilized for water supply needs. Continued growth and economic development, especially in the Waldorf area of southern Maryland, has placed increasing demands on ground water supplies. Because ground water pumpage has increased each year, the water levels in the Aquia and Magothy aquifers have gradually declined. Since 1979, regional water levels in the Aquia have declined as much as 30 feet in some areas of southern Maryland, with an average decline ranging from 10 to 20 feet throughout most of the aquifer. In the Magothy aquifer, regional water level declines range from 3 to 45 feet, with the greatest declines occurring in the Waldorf area. As discussed later in this chapter, ground water withdrawals by power plants have contributed to the overall decline of water levels in these aquifers.

In order to abate the decline of water levels in the Magothy aquifer, the Maryland Department of Natural Resources Water Resources Administration (WRA) has limited further development of this aquifer. This effort includes limiting withdrawals by existing users of the aquifer through permit allocations and encouraging further development of the deeper Patapsco aquifer by major ground water users, including power plants. As will be discussed later in more detail, the preliminary results indicate that this strategy is producing positive results.

Ground Water Withdrawal Impacts at Maryland Power Plants

In Maryland, four power plants (Calvert Cliffs, Chalk Point, Morgantown and Vienna) withdraw significant quantities of ground water for plant operations from Coastal Plain aquifers. Specifically, these aquifers include the Aquia, Magothy, Columbia, and Patapsco aquifers. In 1985 and 1986, these four power plants collectively withdrew an average total of approximately 1.8 million gallons per day (mgd) from these four aquifers. This rate is slightly less than the 2.0 mgd average total reported for 1983 and 1984.

The following sections describe the ground water withdrawals by each of the four Maryland power plants and the impact of these withdrawals on the State's ground water resources.

- Calvert Cliffs Nuclear Power Plant (BG&E)

The Calvert Cliffs Nuclear Power Plant (see Figure VI-1 for location) withdraws ground water from the Aquia aquifer via three 620-foot wells. The daily average withdrawal rate has remained fairly constant since 1983. In 1985 and 1986, the plant pumped an average of approximately 0.26 mgd, slightly less than the 0.28 mgd pumped during 1983 and 1984, and significantly less than the WRA-permitted allocation of 0.45 mgd.

Figure VI-3 provides a summary of water level measurements and monthly pumping rates for the Aquia aquifer at the Calvert Cliffs plant from 1972 through 1986. Water level data for 1972 through late 1983 were collected from well CA-Ed 27, which was an observation well used at Calvert Cliffs to provide water level data for MGS. The wide range of fluctuations between monthly high and low water levels for this period are attributed to the proximity of observation well CA-Ed 27 to the pumping wells. Well CA-Ed 27 was replaced in 1984 by well CA-Ed 47, which is located at a greater distance from the center of the well field. Fluctuations between monthly high and low water levels for well CA-Ed 47 are subsequently more subdued, since its location is less affected by fluctuations caused by on/off cycling of the pumps for the water supply wells. The average water level measurements for well CA-Ed 47 have declined approximately 10 feet since 1984, even though the withdrawal rate has remained fairly constant during that period. This water level decline appears to reflect the regional lowering of water levels throughout the Aquia aquifer as a result of the cumulative withdrawals by all of its users.

Figure VI-4 shows the potentiometric surface of the Aquia aquifer in southern Maryland for the fall of 1986. In comparison to the potentiometric surface constructed in September 1984 (MD-PPRP 1984), this map indicates that there has been a change in the potentiometric surface in the vicinity of the plant. The minus 40 foot contour (40 feet below mean sea level) has expanded to the south,

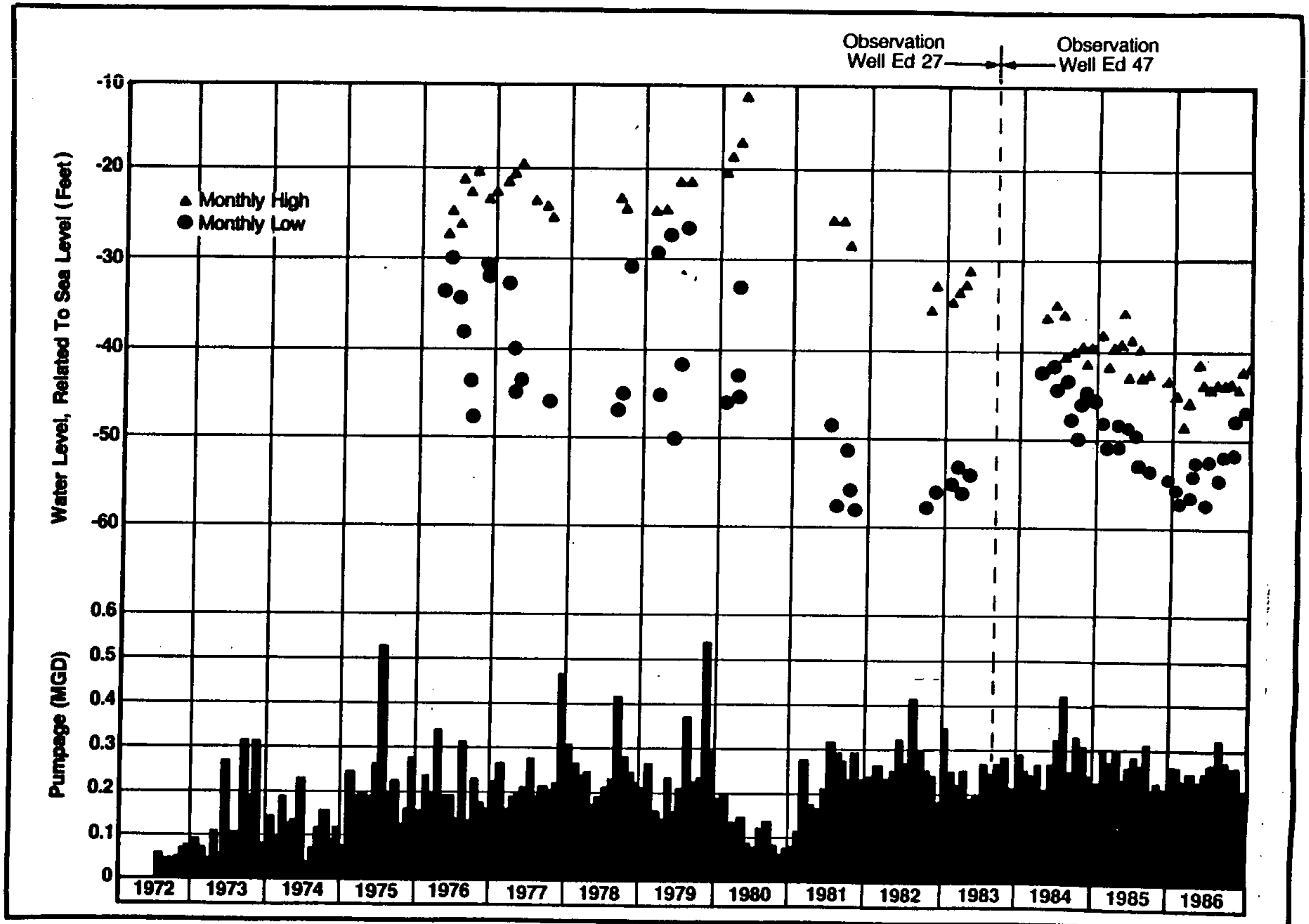

Figure VI-3. Ground water pumpage and water levels at the Calvert Cliffs Nuclear Power Plant from first operation through 1986

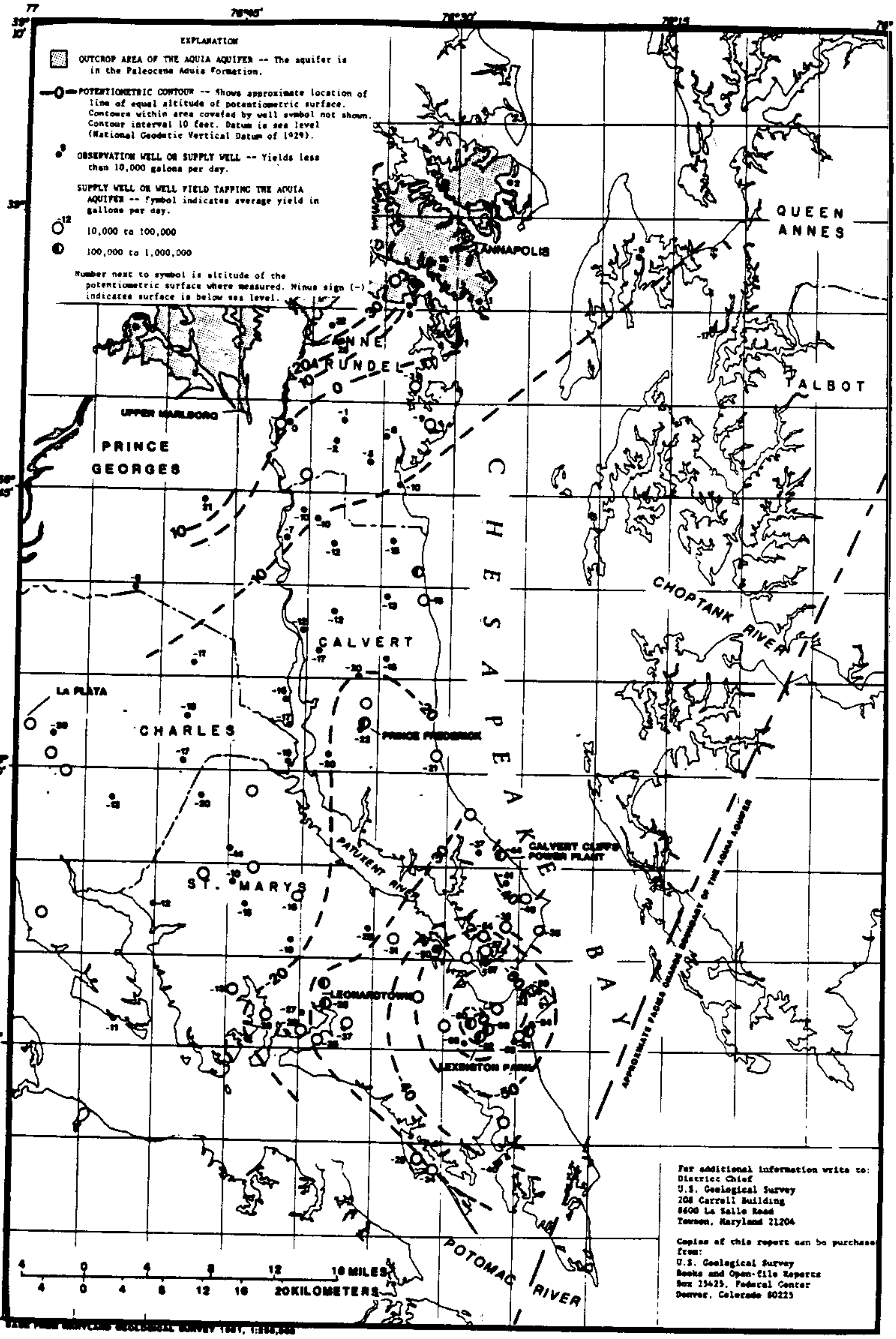

Figure VI-4. Potentiometric surface of the Aquia aquifer in southern Maryland during fall of 1986

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possibly indicating that the drawdown near the plant has not reached equilibrium. The shift in the location of the contour may be due to well interference between the Calvert Cliffs wells and other pumping wells located south of the power plant. Future water level monitoring in this area will indicate whether this condition persists or is only temporary.

The potentiometric surface for the rest of the Aquia aquifer is generally similar to the potentiometric surface of September 1984. The only major change has been a slight northwest shift of the minus 10 foot and minus 20 foot contours, indicating a continued decline in the Aquia potentiometric surface in St. Mary's, Calvert, Charles and Prince George's counties over the two year period. This decline is attributed to increased withdrawals from domestic and public supply wells in these counties (Mack 1987).

Figure VI-5 illustrates the difference between the potentiometric surfaces of the Aquia aquifer between the spring of 1979 and the fall of 1986 (the duration of the MGS/USGS/PPRP monitoring project). This map indicates that ground water withdrawal at the Calvert Cliffs power plant during this time has caused the Aquia potentiometric surface to decline locally by approximately 20 feet. This decline is attributed to an increase in ground water withdrawal from an average of 0.16 mgd (1979 to 1981) to 0.26 mgd (1981 to present). Despite the declines in the Aquia potentiometric surface, approximately 400 feet of hydraulic head remains in this aquifer. Consequently, there does not appear to be any real possibility of dewatering the aquifer in the near future.

Some recent concerns have been raised that the ground water withdrawal at the Calvert Cliffs plant is decreasing water levels in residential wells on the Eastern Shore of the Chesapeake Bay (Mack 1987). However, it is difficult to determine whether these concerns are warranted since it is not known whether these wells are screened in the Aquia, and current water level data for the Aquia aquifer are not available. Steps are now being taken to include Aquia observation wells for Dorchester County in the existing monitoring network (Mack 1988). Furthermore, long-term trends observed in the Aquia aquifer indicate that its water levels have gradually declined since the early 1950's (Chapelle and Drummond 1983). Thus, if water levels in the residential wells are truly

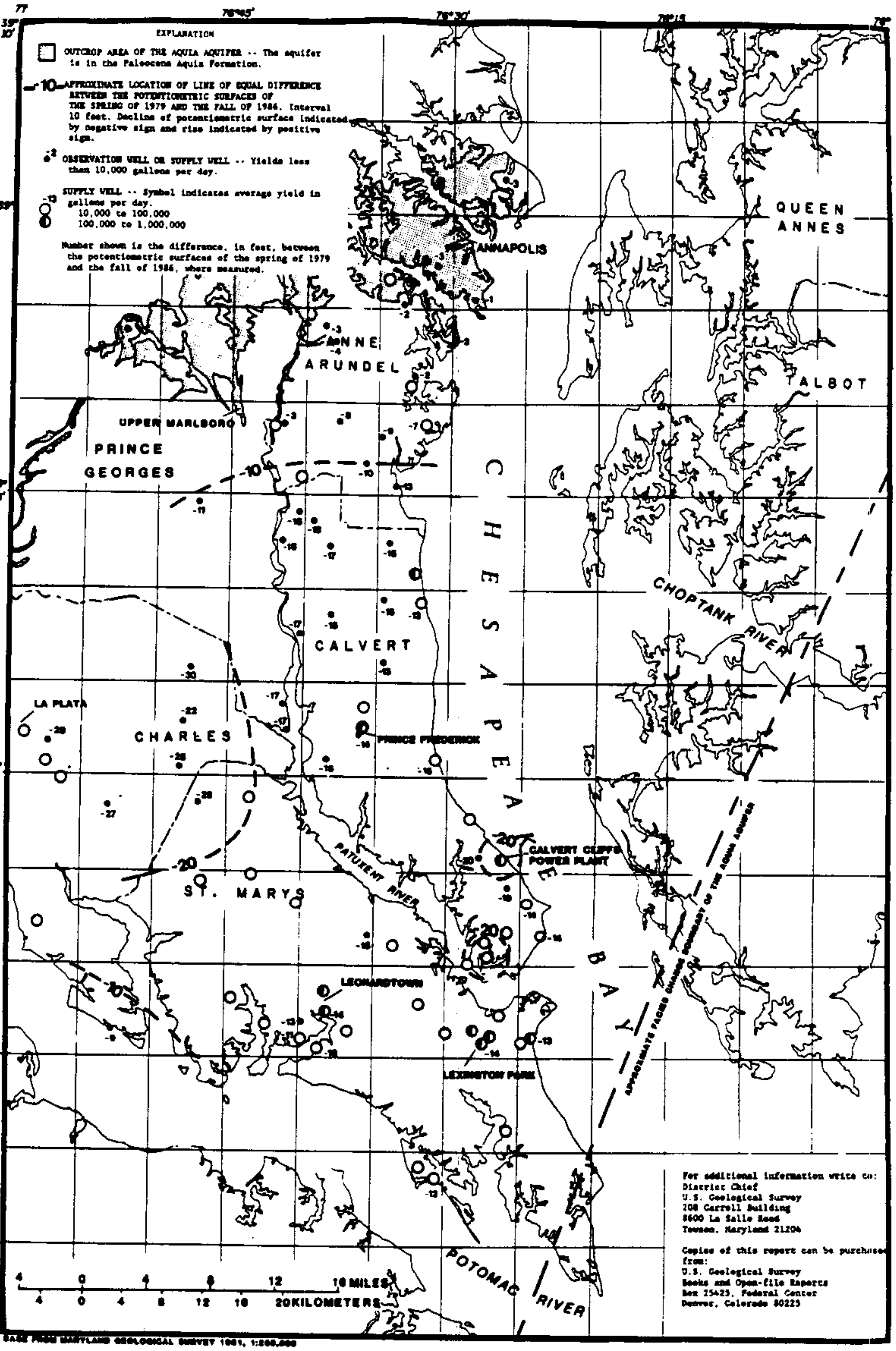

Figure VI-5. Difference between the potentiometric surfaces of the Aquia aquifer in spring of 1979 and fall of 1986 in southern Maryland

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declining, the declines do not appear to be due to Calvert Cliffs, but are the result of regionally declining water levels. This issue may be partially resolved with the collection of water level data from Dorchester County.

- Chalk Point Power Plant (PEPCO)

The Chalk Point Power Plant (Figure VI-6) obtains ground water supplies from five wells in the Magothy aquifer at an average depth of 615 feet, and a single well in the Patapsco aquifer at a total depth of 1066 feet. Data presented in Figure VI-7 show the monthly pumpage from both aquifers during 1985 and 1986. In 1985, an average of 0.64 mgd were pumped from the Magothy aquifer and 0.26 mgd were pumped from the Patapsco aquifer, for a combined total average of 0.90 mgd. In August and September 1985, however, all the withdrawal was from the Magothy aquifer due to a temporary shutdown of the Patapsco well. In 1986, withdrawal from the Magothy aquifer decreased to an average of 0.50 mgd, and pumping from the Patapsco increased to 0.41 mgd, for a combined total average of 0.91 mgd. This adjustment was made by PEPCO to keep its Magothy withdrawal rates from approaching the WRA appropriated limit of 0.83 mgd for the Chalk Point site (Keiller 1988). The total daily pumping rates in 1985 and 1986 were somewhat less than the combined withdrawal rates of 1.1 mgd in 1983 and 0.99 mgd in 1984.

Water level measurements from the observation wells screened in the Magothy, Patapsco, and Aquia aquifers at Chalk Point are shown in Figure VI-7 (see Figure VI-6 for well locations). Water levels measured in the Magothy aquifer observation well PG-Hf 41 indicate that the aquifer responds rapidly to changes in pumpage rates, and that it has the capacity to recover quickly once the pumping rates are reduced in the plant vicinity. Overall, the magnitude of water level fluctuations in the Magothy aquifer for 1985 and 1986 remained fairly constant and generally followed the same pattern as the fluctuations in the water level data for 1983 and 1984. Figure VI-8 shows that after a steady decline from an elevation of 14 feet below sea level in 1975 to 35 feet below sea level in 1982, the water levels in the Magothy aquifer at Chalk Point appear to have stabilized. If PEPCO continues to cut back on withdrawal from the Magothy aquifer, the potentiometric surface will probably recover some in that locality.

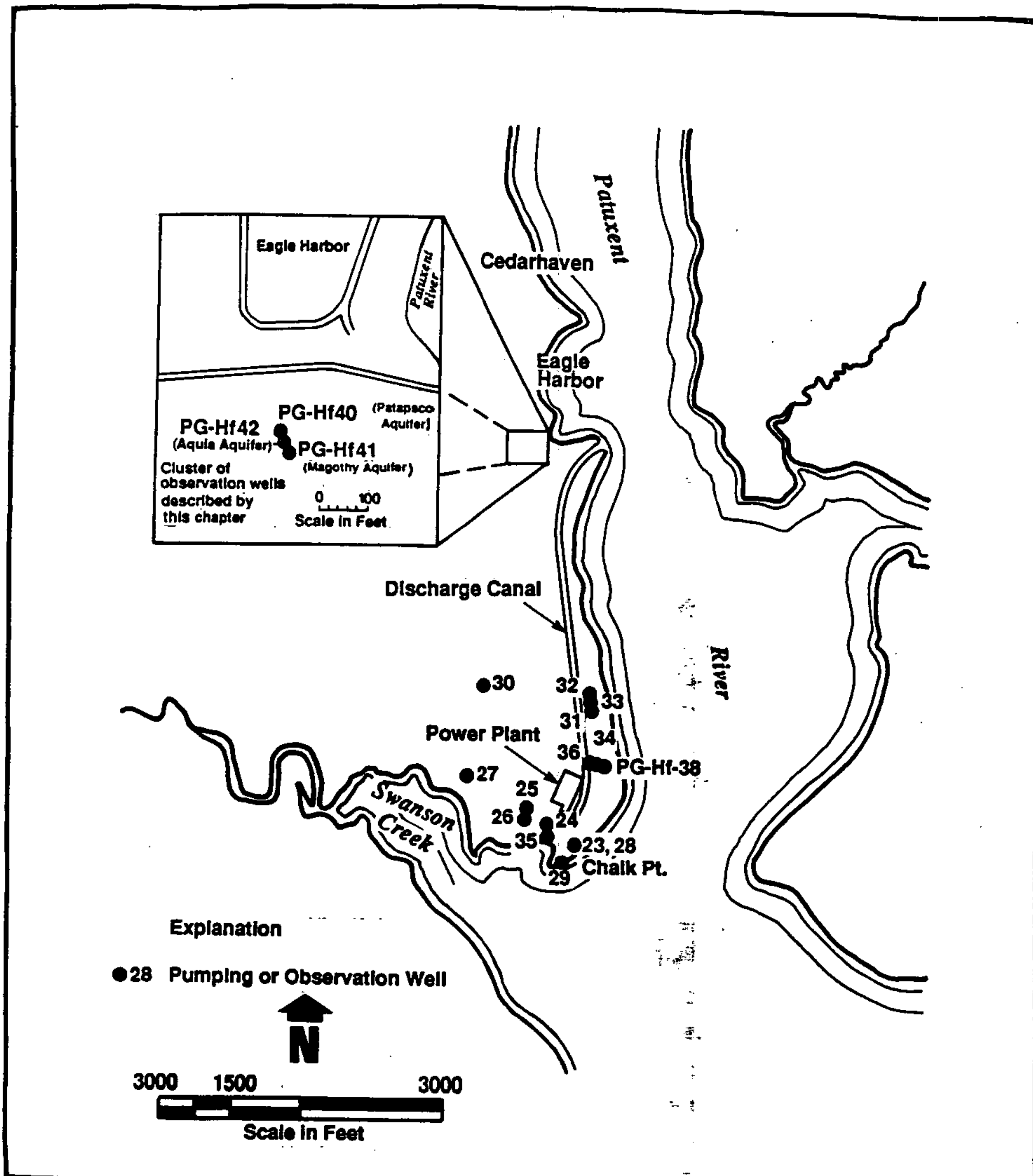

Figure VI-6. Maps showing the location of wells surrounding PEPCO's Chalk Point Power Plant

Source: Mack 1976

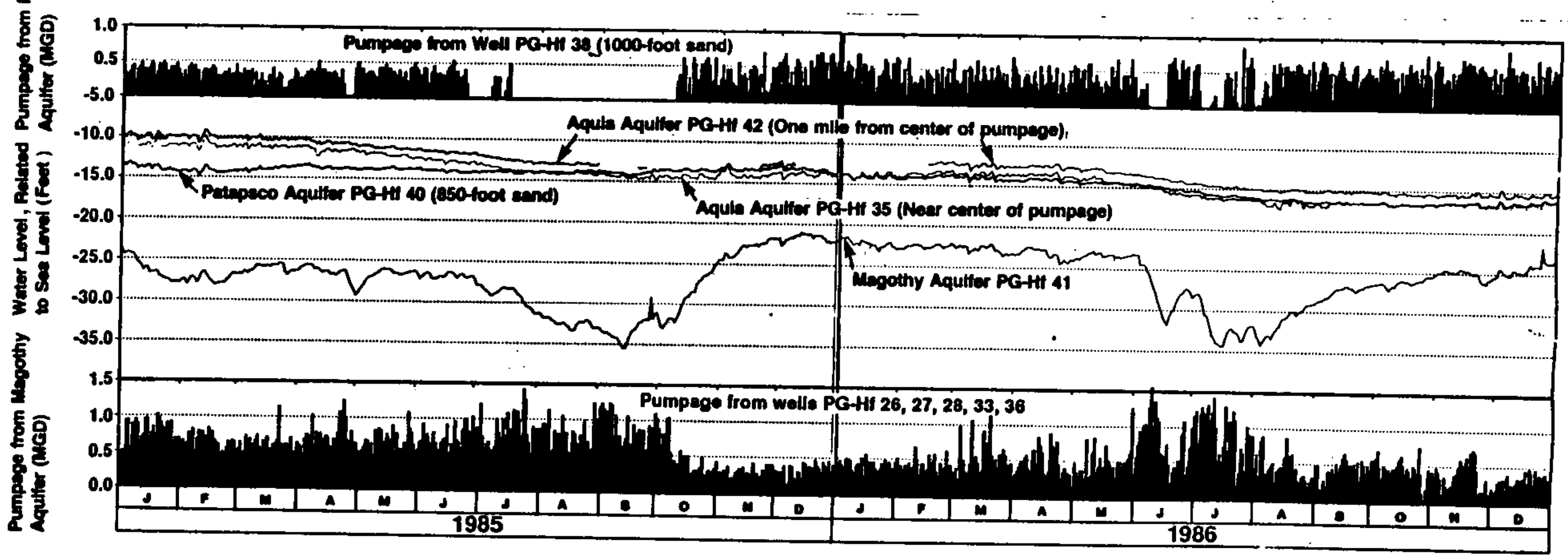

Figure VI-7. Daily water levels and pumpage record for Chalk Point (January 1985 - December 1986)

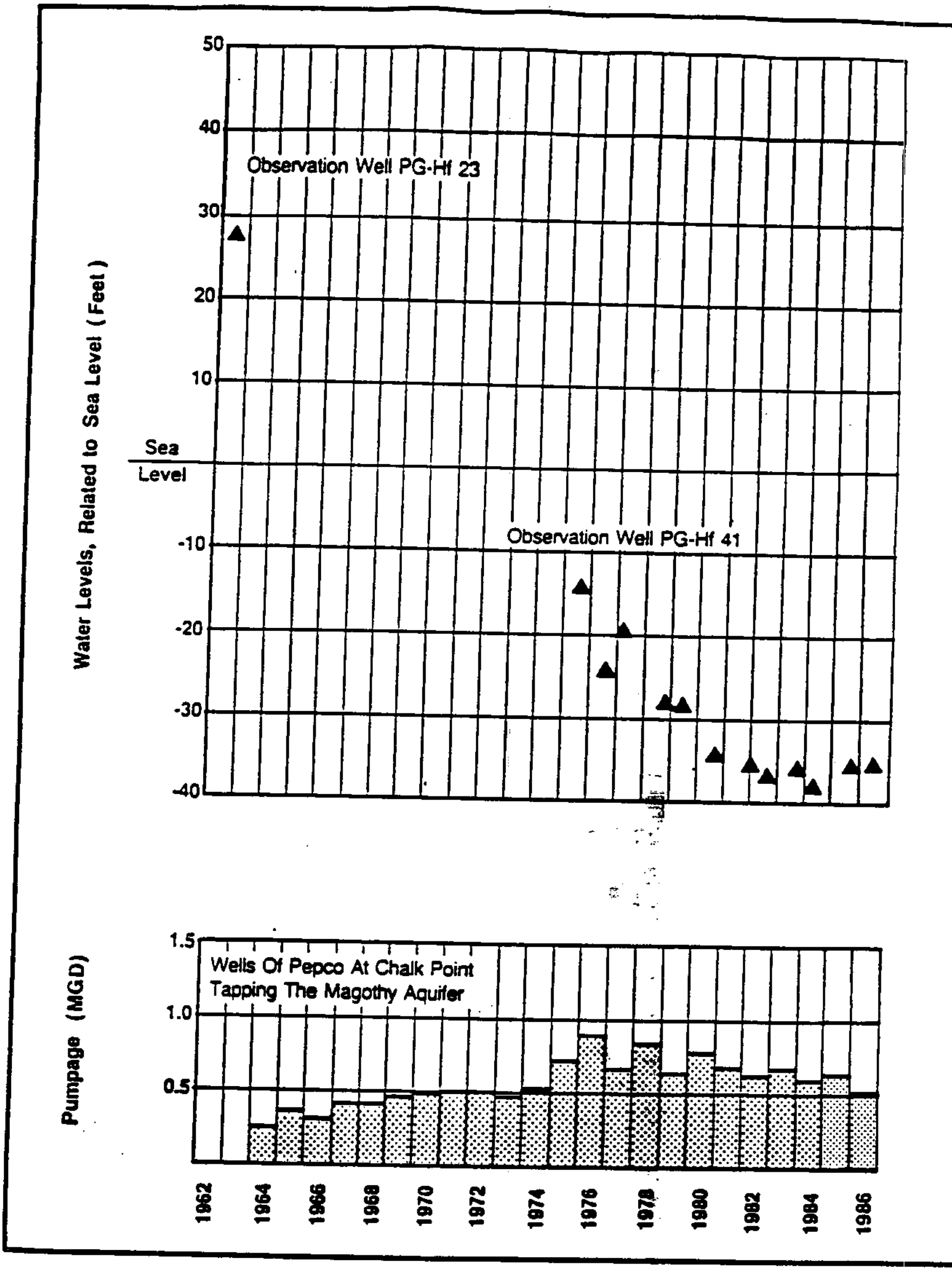

Figure VI-8. Relationship between annual low water levels and average annual water pumpage at Chalk Point (1962 - 1986)

Figure VI-9 shows the monthly pumping rates and water levels measured in the PEPCO production well tapping the Patapsco aquifer for the period 1975 through 1986. The large fluctuations in the water level measurements collected from the production well reflect the various stages of the on/off cycling of the pumps. Due to influences of well field pumping cycles, these measurements do not provide as true an indication of the overall response of the aquifer to pumping as the measurements collected from an observation well. However, even with this limitation, the "pump off" data indicate that after a period of water level decline between 1975 and 1979, there has been no significant change in the "pump off" water level in this well since 1979. Recently, there appears to be a decline in the "pump on" level attributable to the increased pumpage from the Patapsco Aquifer. Further observations will indicate whether this increased pumpage will create a decline in the "pump off" level in the well.

Figure VI-7 also shows the water level measurements from observation well PG-Hf 40, located approximately one and a half miles north of the production well and screened in a thin sand layer at a depth of 850 feet in the Patapsco aquifer. The Patapsco, unlike the thinner Magothy and Aquia aquifers, does not consist of one continuous layer of sand, but instead is comprised of several sandy units separated by low-permeability layers (aquitards). In 1985, well PG-Hf 40 showed some short-term fluctuations in the water level, but no overall declining water level trend. These conditions were also observed in 1983 and 1984 (MD-PPRP 1986). During 1986, however, this well showed a water level decline of approximately 5 feet. This decline is attributed to the increased withdrawal of water from the Patapsco aquifer at Chalk Point during 1986, and indicates:

- the presence of some interconnection between the "850 foot" sand unit and the "1000 foot" sand unit within the Patapsco aquifer; and

- a fairly large cone of influence in the Patapsco formed as a result of pumping the Chalk Point production well.

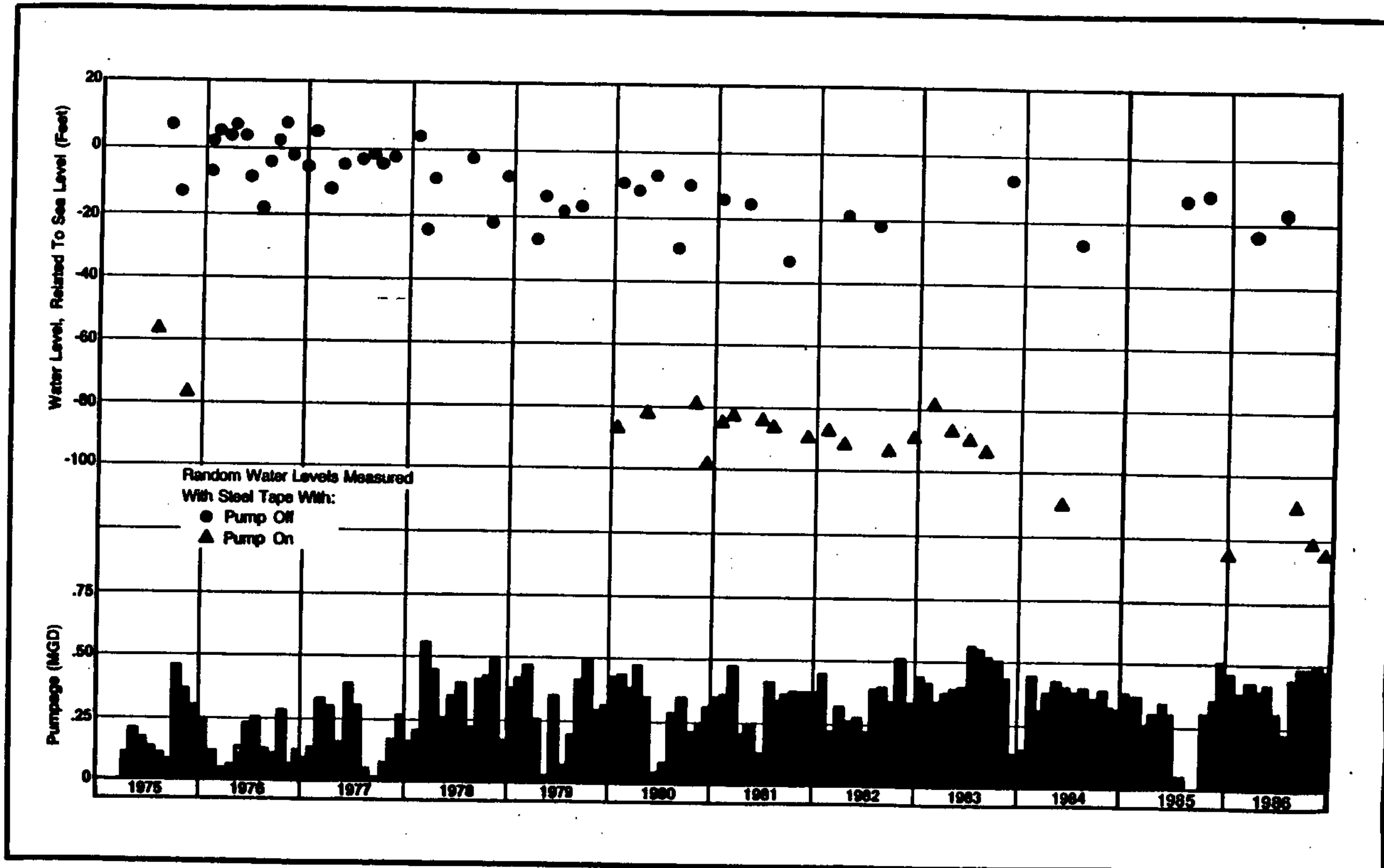

Figure VI-9. Ground water pumpage and water levels as measured in production well PG-Hf38 for the Patapsco aquifer at the Chalk Point Power Plant