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

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Cs-134	0.31288		0.14318	
Cs-136	0.00278		0.00250	
Cs-137	0.45985		0.21209	
Ba-140	0.00101		0.00001	
La-140	0.00249		0.00340	
Ce-139	0.00002		ND	
Ce-141	0.00038		0.00015	
Ce-144	0.01767		0.00011	
W-187	0.00074		ND	
P-32	ND		ND	
Fe-59	0.00071		0.01426	
Fe-55	ND		0.20039	
Te-127	0.00210		ND	
Te-129	0.00887		0.00719	
Zr-97	0.00036		0.00000	
Ba-139	0.00030		0.00000	
Y-91m	ND		ND	
Total	**1.34492**	**0.08%**	**1.73373**	**0.27%**
Total Curies	**1774.263985**		**637.86876**	

Source: BGE 1993b, 1994b
ND = No data

3.5.2.2 *Environmental Concentrations of Radionuclides*

Through the environmental monitoring programs of BGE, MDE, and PPRP, the patterns of deposition and accumulation of radioactive material released from CCNPP can be analyzed in detail. Radiological data and details of methodology used to address these issues can be found in the source material (BGE 1993a, 1994a; Fletcher and Abell 1993, 1994; Stanek *et al.* 1995a).

Atmospheric Distribution

Monitoring the atmospheric distribution of radionuclides involves sampling the air at various locations around the plant. Samples were collected weekly from the plant site and distant locations during 1992 and 1993. Gamma analysis of these samples yielded no detectable radioactivity attributable to CCNPP in air particulate, air iodine, or precipitation samples. Small concentrations of Cs-137 were detected in samples from various air monitoring stations. This radionuclide has been consistently observed in all prior monitoring periods at levels that are likely attributable to past nuclear weapons testing. Naturally occurring beryllium-7 (Be-7) was also detected commonly in air particulate and precipitation samples from all sampling locations throughout the two-year period (BGE 1993a, 1994a; Fletcher and Abell 1993, 1994).

Ambient radiation attributable to atmospheric and terrestrial sources was also monitored using **thermoluminescent dosimeters** (TLDs). TLDs were deployed at 23 locations surrounding CCNPP in 1993, and at 40 locations surrounding CCNPP and the independent spent fuel storage installation in 1994. Doses calculated using these measurements indicated that releases of radioactive material from CCNPP during 1992 and 1993 did not contribute to off-site radiation levels (BGE 1993a, 1994a).

Terrestrial Distribution

The terrestrial environment was monitored by analyzing vegetation samples collected on site and from distant farms for gamma radiation. Low concentrations of Cs-137 were detected sporadically. This radionuclide has been detected in vegetation samples during previous reporting periods and is likely attributable to residual fallout from nuclear weapons tests.

Aquatic Distribution

The aquatic environment was monitored by analyzing samples of Bay water, biota, and sediment for gamma radiation. These samples revealed detectable concentrations of plant-related Co-58, Co-60, Zn-65, and Ag-110m. Ag-110m was the plant-related nuclide detected most frequently in Bay biota collected during 1992 and 1993. Co-60 was the most frequently detected radionuclide in sediment samples; Co-58 and Ag-110m also were detected sporadically (BGE 1993a, 1994a; Stanek *et al.* 1995a). Table 3-15 presents the maximum concentrations of plant-related radionuclides detected in Chesapeake Bay and Susquehanna River media during this two-year reporting period.

Table 3-15 ***Maximum Concentrations of Radionuclides Attributed to Calvert Cliffs Nuclear Power Plant and Peach Bottom Atomic Power Station in Environmental Samples Collected from the Susquehanna and Chesapeake Bay: 1992-1993***

Sample Type	Site	Year	Silver-110m	Cesium-134	Cesium-137	Cobalt-58	Cobalt-60	Zinc-65
			Radionuclide Concentrations (pCi/wet kg)					
Oyster Flesh	Calvert Cliffs	1992	32±27	< 18	< 22	< 21	< 22	< 47
		1993	99±20	< 10	< 11	< 17	< 11	< 24
	Farfield	1992	< 15	< 19	< 20	< 25	< 20	< 42
		1993	< 17	< 7	< 9	< 12	< 17	< 35
Edible Finfish Flesh	Conowingo	1992	< 112	< 10	10±5	< 14	< 14	< 31
		1993	< 124	< 44	13±5	< 733	< 13	< 184
Edible Finfish Guts	Conowingo	1992	< 109	< 99	< 104	< 189	< 103	< 245
		1993	< 127	< 45	< 51	< 105	< 56	< 201
Forage Finfish	Conowingo	1992	< 13	< 146	14±5	< 179	9±5	< 339
		1993	< 9	< 2	< 3	< 18	< 8	< 55
Submerged Aquatic Vegetation	Susquehanna	1992	< 7	< 2	4±2	< 2	< 3	< 5
		1993	< 7	< 3	3±3	< 22	< 4	< 13
	Upper Bay	1992	< 6	< 11	8±7	< 9	< 10	< 24
		1993	< 7	< 4	8±4	< 25	< 5	< 12
			Radionuclide Concentrations (pCi/dry kg)					
Bay Sediment (Clay)		1992	< 94	< 65	576±105	47±16	47±30	< 62
		1993	< 43	< 13	724±27	8±7	212±13	< 45
Bay Sediment (Sand)		1992	< 23	< 94	76±4	33±10	20±8	< 38
		1993	< 6	< 19	41±4	< 10	4±3	< 93
Sediment (Clay)	Conowingo	1992	< 84	< 54	360±37	< 39	23±14	< 130
		1993	< 199	< 13	294±19	< 63	12±7	< 44
	Upper Bay	1992	< 32	< 20	140±18	< 28	< 24	< 54
		1993	< 13	< 7	133±8	< 27	< 9	< 25
Sediment (Sand)	Conowingo	1992	< 16	< 4	132±17	< 7	48±13	123±30
		1993	< 8	< 7	60±5	< 13	18±6	< 14
	Susquehanna	1992	< 11	< 13	106±16	< 12	< 9	< 24
		1993	< 6	< 4	42±4	< 12	< 4	< 12

Source: Stanek *et al.* 1995a, 1995b.

Several radionuclides originating from natural sources and nuclear weapons tests also were detected. Naturally occurring potassium-40 (K-40) and radionuclides from the thorium and uranium decay series were detected routinely in biota and were present in all sediment samples. Be-7 also was detected frequently in both biota and sediment. Limited concentrations of Cs-137 were detected regularly in Bay sediments. CCNPP releases small quantities of Cs-137 as a liquid effluent; however, a comparison of the concentrations detected at the plant with the concentrations at more distant locations indicates that fallout from weapons tests is the principal source (McLean *et al.* 1992).

Bay Water

Both BGE and MDE periodically analyze Bay water collected in the vicinity of Calvert Cliffs for radioactivity. The almost daily releases of tritium in Calvert Cliffs' liquid effluent may occasionally produce concentrations in Bay water that exceed levels attributable to weapons tests. Dispersion and dilution within Bay water rapidly reduces these tritium concentrations to background levels. Plant-related tritium may be discernible only if water samples are collected soon after tritium release. Because 99% of all aqueous releases are tritium, it is not surprising that BGE and MDE detected tritium occasionally at CCNPP's liquid discharge site. Although tritium concentrations in previous years have been attributable to the plant, the concentrations measured during 1992 and 1993 were consistent with levels attributable only to fallout from weapons tests (less than 500 picocuries per liter, pCi/l).

Biota

Bay oysters (*Crassostrea virginica*) are ideal indicators of environmental radionuclide concentrations because they do not move and they readily ingest and concentrate metals. Oysters are harvested commercially in the vicinity of Calvert Cliffs and have the greatest potential to provide a human radiation dose through consumption. PPRP immerses oysters in cages in the vicinity of the Calvert Cliffs liquid effluent discharge and then collects them quarterly for tissue analysis of radionuclide content. Radiosilver continues to be the principal plant-related radionuclide accumulated by oysters; it was detected consistently in oysters located on natural bars throughout 1992 and in test oysters throughout 1992 and 1993 (BGE 1993a, 1994a; Stanek *et al.* 1995a).

Bay oysters have contained Ag-110m consistently, and low concentrations of other CCNPP-related radionuclides (specifically Co-58 and Co-60) sporadically since oyster monitoring began in 1978 (McLean *et al.* 1982; Domotor and McLean 1987, 1988; PPRP 1993). Monitoring has shown no long-term accumulation of radioactivity in natural bar oysters collected from the plant site. The oyster caging study has shown that radionuclide concentrations are correlated with the quantity of effluent released and environmental conditions (e.g., water temperature) over the season of exposure. It has also shown that, although oysters can accumulate certain radionuclides, they can eliminate concentrations rapidly if the source of radionuclides is eliminated. A detailed discussion of the oyster caging study, including a statistical analysis and modeling of Ag-110m concentrations in bay oysters, can be found elsewhere (Rose *et al.* 1988, 1989).

Sediment

PPRP collects sediment samples seasonally from eight transects extending north and south of the Calvert Cliffs plant. Aquatic sediments are useful indicators of environmental radionuclide concentrations because they are natural sinks for both stable and radioactive metals. Co-60 was the most frequently detected plant-related radionuclide in Bay sediments during 1992 and 1993. Another form of radiocobalt, Co-58, declined in frequency of detection and concentration compared with previous years, largely because of decreased concentrations in liquid effluent from CCNPP. Radiosilver was not detected during 1992 and 1993 (McLean *et al.* 1992).

Analysis for radionuclides in sediments showed detectable concentrations of plant-related radiocobalt in samples from three miles south of Calvert Cliffs along the western shore of the Chesapeake Bay. This indicates that particle-bound radioactive material is transported away from the immediate plant vicinity, generally in a southward, down-bay direction. Transport of these sediments is facilitated by estuarine circulation, sediment scouring, suspension of particles, and dispersion. These hydrological and physical processes also reduce the potential for nearfield accumulation of radioactive material from CCNPP (McLean *et al.* 1992).

3.5.2.3 *Radiation Doses and Environmental Impact*

As part of the monitoring program, PPRP estimates doses of radiation to individuals who consume seafood. The **dose commitment** calculations are based on three variables. The first variable is the maximum, or worst-case, estimate of plant-related radionuclide concentrations in oysters harvested in the vicinity of CCNPP. The second variable is an estimate of the maximum quantity of seafood consumed by an individual. Table 3-16 shows usage values expressed as consumption rates. The third variable is the dose from the intake of a radionuclide (USNRC 1977).

Table 3-17 presents estimated radiation dose equivalents for adults, teenagers, and children. During 1992 and 1993, the estimated maximum dose, to an adult's gastrointestinal tract from consumption of oysters was less than 0.03 mrem/year. The estimated maximum total body dose to an adult, teen, or child was less than 0.0002 mrem/year. Figure 3-36 presents an historical illustration of maximum dose commitments to the adult gastrointestinal tract. (Figure 3-36 also illustrates similar information on Peach Bottom; see Section 3.5.3 for discussion.)

Table 3-16 Recommended Usage Values for the Maximally Exposed Individual

Pathway	Child	Teen	Adult
Fish (kg/y) (fresh or salt)	6.9	16	21
Other seafood (kg/y) (oysters)	1.7	3.8	5
Drinking water (l/yr)	510	510	730

Source: USNRC 1977

Figure 3-36
Estimated Maximum Dose Commitments to an Adult's Gastrointestinal Tract from Consuming Oysters Affected by CCNPP-Related Releases and Finfish Affected by PBAPS-Related Releases

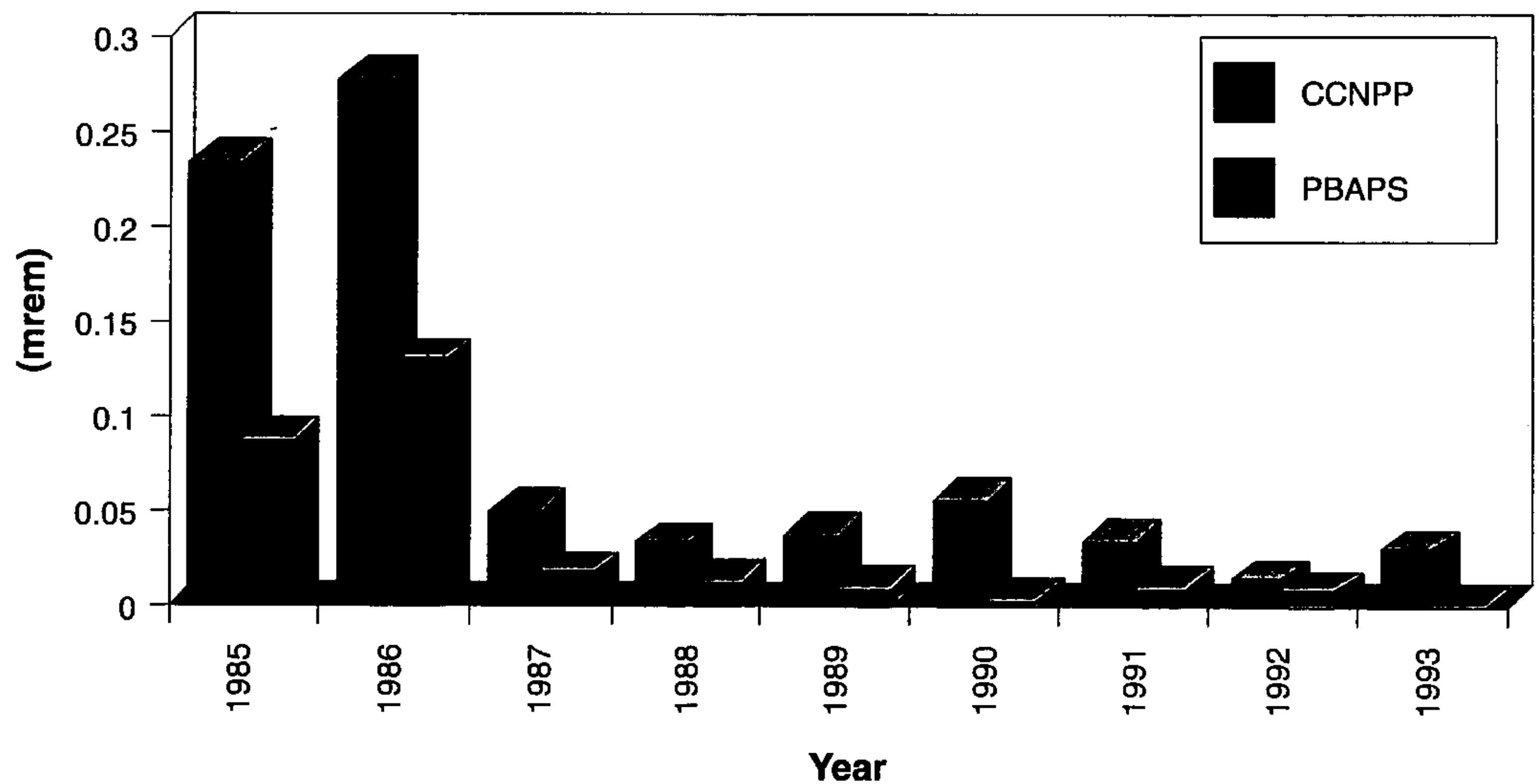


Table 3-17 ***Maximum Estimated Dose Commitments* (in mrem) for an Individual Consuming Oysters Affected by CCNPP Releases***

	ADULT		TEEN		CHILD	
	1992	1993	1992	1993	1992	1993
Total Body						
Co-58	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Co-60	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag-110m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.0002**	**0.0000**	**0.0002**	**0.0000**	**0.0002**	**0.0000**
Bone						
Co-58	-----	-----	-----	-----	-----	-----
Co-60	-----	-----	-----	-----	-----	-----
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag-110m	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001
Total	**0.0000**	**0.0001**	**0.0000**	**0.0001**	**0.0000**	**0.0001**
Liver						
Co-58	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Co-60	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag-110m	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001
Total	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Kidney						
Co-58	-----	-----	-----	-----	-----	-----
Co-60	-----	-----	-----	-----	-----	-----
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag-110m	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001
Total	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0000**	**0.0001**
GI-LLI						
Co-58	0.0009	0.0000	0.0006	0.0000	0.0002	0.0000
Co-60	0.0006	0.0000	0.0004	0.0000	0.0001	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag-110m	0.0124	0.0299	0.0085	0.0205	0.0030	0.0073
Total	**0.0139**	**0.0299**	**0.0095**	**0.0205**	**0.0034**	**0.0073**

*Based upon maximum radionuclide concentrations given in Table 3-15. Recommended consumption values and dose factors used in calculations are from USNRC 1977.

Since the start of operations at Calvert Cliffs, radiation doses to a hypothetical, maximally exposed individual have not exceeded 0.28 mrem/year to the gastrointestinal tract, and total body doses have been less than 0.01 mrem/year (PPER 1991). These estimated doses are well below regulatory limits (see Table 3-11) and license requirements.

3.5.2.4 *Radioactive Waste*

CCNPP generates two kinds of radioactive waste products that require disposal: low-level waste (LLW) and spent nuclear fuel. The LLW is characterized by relatively low concentrations of radionuclides and includes items such as spent decontamination resins, filter sludges, and contaminated equipment and protective clothing. Table 3-18 presents the total volume and activities of LLW from CCNPP during 1992 and 1993. Figure 3-37 compares the total activity of LLW during this period with activity during previous years (including data for Peach Bottom also; see Section 3.5.3). All LLW shipped from Calvert Cliffs during 1992 and 1993 was shipped to either Barnwell, South Carolina or Oak Ridge, Tennessee.

Spent nuclear fuel from CCNPP has been stored in a spent fuel pool at the plant since the late 1970s, awaiting shipment to a federal disposal site. Because Calvert Cliffs' existing pool storage is at capacity, and a Federal disposal site is not expected until after 2010, BGE applied in 1989 for an NRC license to build an independent spent fuel storage installation (ISFSI).

PPRP and the NRC extensively evaluated BGE's application, and the NRC issued a 20-year license for the ISFSI in December 1992. The $24 million facility will ultimately consist of 120 concrete modules, each housing a dry-shielded canister containing 24 fuel assemblies, for a total storage capacity of 2,880 assemblies. The ISFSI is to be constructed incrementally to match the utility's on-site storage needs. Two of the five licensed phases, a total of 48 modules, have been built; through December 1994, nine dry canisters had been loaded (216 fuel assemblies). The third phase is now under construction, which will add 24 more concrete modules. The facility design and 20-year license will accommodate all of the spent fuel generated by CCNPP under the plant's current operating license.

Table 3-18 ***Low-Level Solid Waste Shipped Off Site for Disposal by CCNPP: 1992 and 1993***

Year	Volume (m^3)	Activity (Ci)	# of Shipments
1992	679.2	167.47	17
	738.8	6,165.84	13
Total	1,418.0	6,333.31	30
1993	1,193.4	41.60	22
	195.6	4,946.71	9
Total	1,389.0	4,988.31	31

Source: BGE 1993b, 1994b

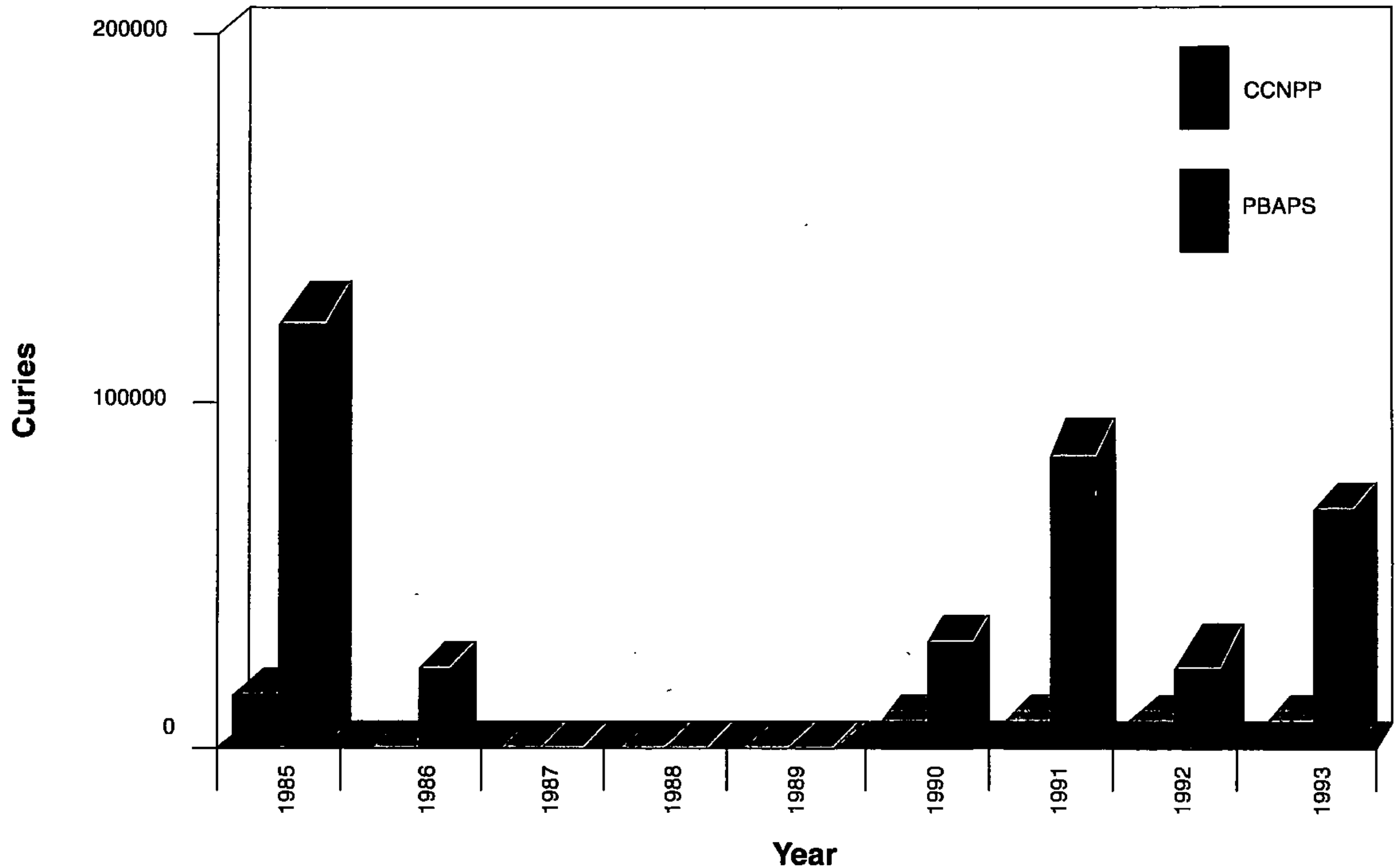
3.5.2.5 *Summary*

Atmospheric releases of radioactive material from CCNPP produced no detectable concentrations of plant-related radionuclides in air or crop samples collected from the immediate vicinity of the plant during 1992 and 1993. Plant-related radioactive material released to the Chesapeake Bay via the aqueous pathway produced low levels of Co-58 and Co-60 in sediments. As in previous years, low levels of Co-58 and Co-60 were detected in sediments as far as three miles south of the power plant, indicating that net transport of plant-related radioactivity in sediment is down-bay. Ag-110m was the principal plant-related radionuclide detected in oyster flesh.

Comparing radionuclide concentrations in environmental samples collected between 1992 and 1993 with concentrations since 1978 indicates that:

- in general, the levels of plant-related radionuclides detected during 1992 and 1993 are similar to the range of concentrations detected over the previous decade;
- although radionuclide concentrations fluctuate seasonally and annually, no long-term accumulation of plant-related radioactivity in Bay aquatic life and sediments is evident;
- the radioactivity introduced into the environment by CCNPP is small compared with background radioactivity from natural sources and the fallout from weapons tests;

Figure 3-37
Low-Level Solid Waste Shipped Off Site for Disposal



- atmospheric and aqueous releases and radiation doses to humans are well within regulatory limits; and
- environmental, biological, and human health effects of releases of radioactivity from CCNPP are insignificant.

3.5.3 *Peach Bottom Atomic Power Station*

The Peach Bottom Atomic Power Station (PBAPS) is owned jointly by PECO, Public Service Gas and Electric Company, Delmarva Power, and Atlantic Electric Company. The plant is operated by PECO. Its two operating units, Units 2 and 3, are boiling water reactors, each with a currently licensed capacity of approximately 1,065 MW. Units 2 and 3 were placed into commercial service in July and December 1974, respectively. Unit 1, a 40-MW high-temperature, gas-cooled reactor, was decommissioned in 1975. The power plant is in Pennsylvania, approximately three miles north of the Pennsylvania/Maryland border, on the western shore of the Susquehanna River (Figure 3-34).

3.5.3.1 *Radioactivity Released*

PBAPS releases 8,000 to 9,000 Curies of radioactivity annually in the form of radioactive gaseous and liquid effluents into the atmosphere and the Susquehanna River. The kinds and quantities of radioactive material contained in these effluents depend upon plant operating conditions and power levels, the condition of the nuclear fuel, and the operating efficiency of the radioactive waste processing systems. Since PBAPS has been in operation, all liquid and atmospheric releases of radioactivity have been well within regulatory limits.

Atmospheric Releases

Over 99% of the radioactive material released from the PBAPS is released to the atmosphere. Table 3-19 presents releases of radionuclides to the atmosphere by PBAPS during 1992 and 1993, as reported by PECO. Radioactive noble gases, primarily xenon (Xe-133, Xe-135, Xe-135m, Xe-138) and krypton (Kr-85m, Kr-87, Kr-88), constitute more than 99% of all radioactivity material released to the atmosphere by PBAPS. Noble gases are chemically inert, are not readily incorporated into biological tissues, and are not bioconcentrated. They are readily dispersed in the atmosphere upon release from the plant, and most have short half-lives decaying rapidly to stable forms; therefore, the noble gases do not represent a significant threat to human or ecological health.

Table 3-19 Total Quantities (Curies) of Radionuclides Released to the Atmosphere by PBAPS (Main Stack and Roof Vents): 1992 and 1993

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Tritium	39.69000	0.50%	22.80000	0.25%
Noble Gases				
Ar-41	ND		7.42	
Kr-85	ND		ND	
Kr-85m	331.70		355.40	
Kr-87	137.20		481.00	
Kr-88	220.35		335.10	
Xe-131m	24.40		ND	
Xe-133	4876.69		3403.40436	
Xe-133m	53.82		9.61	
Xe-135	1798.65		1703.40	
Xe-135m	389.52		1055.90	
Xe-138	142.10		1471.00	
Total	**7974.43**	**99.50%**	**8822.23**	**99.73%**
Iodines				
I-131	0.02806		0.04797	
I-133	0.07279		0.18071	
I-135	0.04123		0.19531	
Total	**0.14208**	**0.00%**	**0.42398**	**0.00%**
Particulates				
Co-58	< 0.00000		< 0.00000	
Co-60	< 0.00000		0.00007	
Zn-65	0.00006		< 0.00000	
Sr-89	0.00211		0.00490	
Sr-90	0.00002		0.00002	
Sr-91	0.00208		0.00376	
Cs-134	ND		0.00006	
Cs-137	0.00008		0.00030	
Cs-138	0.10927		0.21488	
Ce-144	ND		0.00005	
Ba-139	0.02283		0.04012	
Ba-140	0.00132		0.00244	
Y-91m	0.02214		0.01978	
Mo-99	0.00002		0.00004	
Te-132	< 0.00000		< 0.00000	
La-140	0.00083		0.00209	
Zr-97	0.00002		ND	
Tc-99m	0.00002		0.00007	
Cd-109	0.00022		0.00010	
Total	**0.16102**	**0.00%**	**0.28869**	**0.00%**
Total Curies	**8014.42310**		**8845.74267**	

Source: PECO 1993b, 1994b
ND = No data

Other notable radionuclides contained in the plant's atmospheric releases were tritium (H-3) and radioiodine (I-131, I-133, and I-135).

Aqueous Releases

Table 3-20 presents releases of radionuclides to the Susquehanna River (to Conowingo Pond) by PBAPS during 1992 and 1993, as reported by PECO. Radioactive tritium constitutes approximately 99% of the radionuclides released to the Susquehanna River by PBAPS.

Very small quantities of radioactive chromium, iron, cobalt, zinc, and cesium accounted for most of the remaining radioactive material released in liquid effluent. These particular radionuclides are environmentally significant because they can be accumulated by aquatic life such as finfish, mussels, and crayfish. These radionuclides may also become associated with particulate material and deposited to the sediment bed of the Susquehanna River and Chesapeake Bay (McLean *et al.* 1988; McLean and Domotor 1988; Domotor and McLean 1989).

Figure 3-35 depicts the historical trends in quantities of aqueous releases of environmentally significant radionuclides from PBAPS. Releases of Co-60, Zn-65, Cs-134, and Cs-137 significantly decreased during the period 1978 through 1988, and have remained relatively small since then.

3.5.3.2 *Environmental Concentrations of Radionuclides*

Through the environmental monitoring programs of PECO, MDE, and PPRP, the patterns of deposition and accumulation of radioactive material released from PBAPS can be analyzed in detail. Specific radiological data and details of methodology used to address these issues can be found in the source material (PECO 1993a, 1994a; Stanek *et al.* 1995b).

Table 3-20 Total Quantities (Curies) of Radionuclides Released to the Susquehanna River by PBAPS via the Aqueous Pathway: 1992 and 1993

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Tritium	17.70000	99.52%	7.20500	98.90%
Dissolved Noble Gases				
Kr-85	ND		ND	
Kr-85m	ND		ND	
Xe-131m	ND		ND	
Xe-133	0.03778		0.00781	
Xe-133m	0.00017		0.00003	
Xe-135	0.02164		0.01574	
Xe-135m	0.00008		0.00012	
Total	**0.05968**	**0.34%**	**0.02370**	**0.33%**
Iodines				
I-131	0.00002		< 0.00000	
I-132	ND		ND	
I-133	0.00001		ND	
I-135	< 0.00000		ND	
Total	**0.00003**	**0.00%**	**0.00000**	**0.00%**
Particulates				
Na-24	ND		ND	
Cr-51	0.00451		0.00136	
Mn-54	0.00023		0.00698	
Co-57	ND		ND	
Co-58	0.00005		0.00190	
Co-60	0.00254		0.02176	
Zn-65	0.00314		0.01874	
Sr-89	0.00042		0.00019	
Sr-90	0.00289		0.00006	
Sr-92	0.00005		ND	
Zr-95	ND		ND	
Nb-95	0.00005		ND	
Nb-97	ND		ND	
Mo-99	ND		ND	
Tc-99m	ND		ND	
Ru-103	ND		ND	
Ru-106	ND		ND	
Ag-110m	0.00071		0.00001	
Sn-113	ND		ND	
Sb-122	ND		ND	
Sb-124	ND		ND	
Sb-125	ND		ND	
Te-132	ND		ND	

Table 3-20 Total Quantities (Curies) of Radionuclides Released to the Susquehanna River by PBAPS via the Aqueous Pathway: 1992 and 1993 (continued)

Radionuclide	1992	% of Annual Total	1993	% of Annual Total
Cs-134	0.00004		0.00052	
Cs-136	ND		ND	
Cs-137	0.00016		0.00136	
Ba-140	ND		ND	
La-140	ND		ND	
Ce-139	ND		ND	
Ce-141	ND		ND	
Ce-144	ND		ND	
W-187	ND		ND	
P-32	0.00615		0.00104	
Fe-59	ND		ND	
Fe-55	0.00519		0.00266	
Te-127	ND		ND	
Te-129	ND		ND	
Zr-97	ND		ND	
Ba-139	ND		ND	
Y-91m	ND		0.00001	
Total	**0.02613**	**0.15%**	**0.05659**	**0.78%**
Total Curies	**17.78583**		**7.28531**	

Source: PECO 1993b, 1994b
ND = No data

Atmospheric Distribution

Monitoring the atmospheric distribution of radionuclides involves sampling the air at various locations around the plant. Samples were collected weekly from the plant site and distant locations during 1992 and 1993. Analysis of these samples yielded no detectable gamma radiation attributable to PBAPS from samples of air particulates and air iodine. Gross beta concentrations were characteristic of area background levels measured during previous years.

Ambient radiation levels were monitored by analyzing TLDs deployed at 47 locations surrounding PBAPS during 1992 and 1993. Ambient gamma radiation levels were consistently below 10 milliroentgen per month for the study period. These results were consistent with those from previous years (PECO 1993a, 1994a).

Terrestrial Distribution

The terrestrial environment was monitored by analyzing milk and vegetation samples from on-site and distant farms. These samples were analyzed for I-131 and gamma radiation. Low concentrations of Cs-137 were detected sporadically in vegetation samples collected from the plant site and distant locations during 1992 and 1993. All results, including strontium-89 (Sr-89) and Sr-90 analyses, were similar to those of previous years. There was no difference between radionuclide concentrations in samples from the plant site and control locations. All results from these analyses were consistent with those of previous years (PECO 1993a, 1994a).

Aquatic Distribution

The aquatic environment (Susquehanna River) was monitored by analyzing samples of water, biota, and sediment for gamma radiation. These samples revealed detectable concentrations of plant-related Co-60, Zn-65, Cs-134, and Cs-137. Cs-137 was detected most frequently; Co-60 was detected sporadically in sediment collected during 1992 and 1993. Plant-related radionuclides were rarely detected in biota during the study period (PECO 1993a, 1994a; Stanek *et al.* 1995b).

Concentrations and distributions of Cs-137 (attributable to both releases from PBAPS and weapons tests) in sediments and biota were similar to those reported during previous years. Naturally occurring K-40 and radionuclides of the thorium and uranium decay series were detected in most biota and all sediments. Be-7 was detected frequently in sediments, but not in biota. Table 3-15 presents maximum concentrations of CCNPP- and PBAPS-related radionuclides detected in various environmental media from the Susquehanna River-Chesapeake Bay system during 1992 and 1993.

Biota

PPRP collects finfish samples semi-annually from the Conowingo area (including Conowingo Pond and tailrace) to monitor the aquatic distribution of radionuclides. Analysis for gamma radiation in these finfish revealed detectable concentrations of both plant-related and fallout-related radionuclides. Cs-137 was detected sporadically; Co-60 was detected in less than 5% of the finfish collected during 1992 and 1993. Cs-134, however, was not detected in forage finfish collected during 1992 and 1993, as it had been during previous years.

PPRP collects submerged aquatic vegetation (SAV) semi-annually from the mouth of the Susquehanna River and the upper Chesapeake Bay to monitor the aquatic distribution of radionuclides. Cs-137 was detected sporadically at low concentrations in SAV collected during 1992 and 1993. SAV collected from these sites occasionally contained detectable levels of I-131. Medical facilities in the Harrisburg, Pennsylvania, area (which discharge wastewater containing radioiodine into the Susquehanna River) are thought to be the primary sources of I-131 detected in SAV. This theory is supported by consistent detection of I-131 in SAV collected from the Swatara Creek (located up-river of both PBAPS and Three Mile Island) and downstream locations at comparable concentrations (GPUN 1993, 1994; McLean and Domotor 1988).

Sediment

PPRP collects sediment samples semi-annually from a grid of transects in Conowingo Pond, and downstream at the Susquehanna Flats and upper Chesapeake Bay. PBAPS-related heavy metal radionuclides (e.g., radiocobalt and radiocesium) are extremely particle-reactive. They rapidly become associated with particulate material suspended in the water column and may ultimately be deposited on the river bottom or transported down-river/down-bay. Analysis of sediment samples provides an indication of the accumulation, transport, and relocation of particle-bound radioactive material in the Susquehanna River-Chesapeake Bay system.

PBAPS-related radioactive material was detected in sediments collected down-river from the plant. Co-60 and Cs-137 have been detected in Susquehanna and upper Chesapeake Bay sediments during previous years and were detected during 1992 and 1993. Concentrations of Co-60 and Cs-137 were highest in the Conowingo Pond area, as they have been during previous years. Particle dilution, dispersion, and radioactive decay during transport cause concentrations to diminish with distance down-river.

Estimates of mass balance (the ratio of radionuclide concentrations detected in sediments to the total released by the plant) indicate that less than 20% of the plant-related radiation released by PBAPS remains in the surface sediments of Conowingo Pond (McLean *et al.* 1988). Deep-core sediment samples confirm that some of this radioactive surface sediment remains within the reservoir, trapped in discrete locations by subsequent sediment accumulation. The remaining radionuclide mass appears to be transported downstream to the Chesapeake Bay in dissolved or particle-associated forms.

3.5.3.3 *Radiation Doses and Environmental Impact*

PPRP estimates doses of radiation to individuals who consume fish. Doses were calculated using the maximum plant-related radionuclide concentrations for Co-60, Zn-65, Cs-134, and Cs-137. Table 3-21 presents estimated dose commitments to adults, teenagers, and children. During 1992 and 1993, the estimated maximum dose from consumption of finfish was less than 0.04 mrem/year, to a teen's liver. The estimated maximum total body dose to an adult, teen, or child was less than 0.25 mrem/year. Figure 3-36 presents an historical illustration of maximum dose commitments to an adult's gastrointestinal tract, showing the decrease in maximum dose over time.

The Susquehanna River is a source of drinking water and may contribute to a human radiation dose. The annual total body dose associated with the consumption of drinking water containing tritium, radiocesium, Co-60, and Zn-65 in the concentrations reported released by PBAPS (PECO 1993a, 1994a) during the study period is estimated to be less than 0.021 mrem/year for the hypothetical, maximally exposed adult.

3.5.3.4 *Radioactive Waste*

As does Calvert Cliffs, PBAPS generates two kinds of radioactive waste products: LLW and spent nuclear fuel. Table 3-22 presents total volumes and activities of LLW shipped from PBAPS during 1992 and 1993. All LLW generated at PBAPS was shipped to either Barnwell, South Carolina, or Oak Ridge, Tennessee. Figure 3-37 compares the total activity of shipments in this study period with that of previous years.

Spent nuclear fuel from PBAPS is stored in spent fuel pools at the plant. Storage capacity at PBAPS is not a limiting factor in the near future.

Table 3-21 *Maximum Estimated Dose Commitments* (in mrem) for an Individual Consuming Finfish Affected by PBAPS Releases*

	ADULT		TEEN		CHILD	
	1992	1993	1992	1993	1992	1993
Total Body						
Co-60	0.0009	0.0000	0.0009	0.0000	0.0010	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-137	0.0210	0.0240	0.0116	0.0113	0.0045	0.0051
Total	**0.0219**	**0.0240**	**0.0125**	**0.0113**	**0.0055**	**0.0051**
Bone						
Co-60	-----	-----	-----	-----	-----	-----
Zn-65	-----	-----	-----	-----	-----	-----
Cs-134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-137	0.0234	0.0268	0.0251	0.0287	0.0316	0.0361
Total	**0.0234**	**0.0268**	**0.0251**	**0.0287**	**0.0316**	**0.0361**
Liver						
Co-60	0.0004	0.0000	0.0004	0.0000	0.0003	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-137	0.0320	0.0366	0.0334	0.0381	0.0302	0.0346
Total	**0.0324**	**0.0366**	**0.0338**	**0.0381**	**0.0305**	**0.0346**
Kidney						
Co-60	-----	-----	-----	-----	-----	-----
Zn-65	-----	-----	-----	-----	-----	-----
Cs-134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-137	0.0109	0.0124	0.0114	0.0130	0.0099	0.0113
Total	**0.0109**	**0.0124**	**0.0114**	**0.0130**	**0.0099**	**0.0113**
GI-LLI						
Co-60	0.0076	0.0000	0.0053	0.0000	0.0018	0.0000
Zn-65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cs-137	0.0006	0.0007	0.0005	0.0005	0.0002	0.0002
Total	**0.0082**	**0.0007**	**0.0058**	**0.0005**	**0.0020**	**0.0002**

*Based upon maximum radionuclide concentrations given in Table 3-15. Recommended consumption values and dose factors used in calculations are from USNRC 1977.

Table 3-22 Low-Level Solid Waste Shipped Off Site for Disposal by PBAPS: 1992 and 1993

Year	Volume (m^3)	Activity (Ci)	# of Shipments
1992	242.2	23,400.00	95
	257.6	1,050.00	143
Total	499.8	24,450.00	238
1993	237.2	7,440.00	98
	208.9	61,100.00	119
Total	446.1	68,540.00	217

Source: PECO 1993b, 1994b

3.5.3.5 *Summary*

No PBAPS-related radionuclides were detected in the atmosphere or terrestrial environment during 1992 and 1993. Plant-related radioactivity released via the aqueous pathway to the Susquehanna River-Chesapeake Bay system produced low levels of Cs-137 in aquatic biota (including edible finfish, forage finfish, and SAV). These radionuclides also were found in river and Bay sediments collected down-river of PBAPS.

Comparing PPRP's radiological monitoring of PBAPS-related radioactivity of aquatic life and sediments collected from 1992 to 1993 with monitoring results since 1978 indicates that:

- the low levels of plant-related radioactive material detected in aquatic life and sediments represent a small portion of the radioactive material in the Susquehanna River-Chesapeake Bay system compared with the amount of material from natural sources and fallout from weapons tests;
- no long-term accumulation of plant-related radioactive material in river biota is evident;
- long-term operation of PBAPS has not caused significant accumulation of radioactive material within the Conowingo Pond;
- atmospheric and aqueous releases and radiation doses to humans are well within regulatory limits; and
- environmental, biological, and human health effects of releases of radioactivity from PBAPS are insignificant.

3.6 SOCIOECONOMIC IMPACTS

Power plants in Maryland have influenced more than the physical environment. Power plants have integrated themselves into local economies as employers, as purchasers of goods and services, and as taxpayers. These facilities have also imposed social costs on their neighbors in the forms of increased traffic, compromised viewsheds, and various aesthetic and nuisance impacts. In recognition of this, PPRP's environmental assessments of utility power plants and transmission lines include the analysis and consideration of social impacts.

Social impacts encompass a number of concepts. In general, there are potential economic impacts, expressed in terms of employment and income; demographic impacts, such as population and housing; fiscal impacts, both in terms of revenues and expenditures; transportation and land use impacts; cultural impacts; and aesthetic impacts. This section concentrates primarily on three social impact categories that are relevant to several recent power plant siting projects: economic/fiscal impacts, property value impacts, and transportation impacts.

3.6.1 Power Plants and the Economy

Power plants affect the economy in numerous ways. During construction, they employ hundreds of construction workers and purchase millions of dollars worth of goods and services. Once operational, income from employment, operations and maintenance (O&M) expenditures, and tax payments flow into the economy from power plants.

3.6.1.1 Construction Expenditures and Employment

Construction of a power plant is a major investment that results in the concentration of workers, equipment, and materials for periods of time ranging from months to years. Although a portion of construction dollars are spent outside of Maryland, construction of a power plant usually results in a net infusion of income into host economies and the state. Recently completed environmental assessments for the Panda Energy Corporation's proposed Panda-Brandywine cogeneration facility near Brandywine, and Delmarva Power's proposed Dorchester Unit 1 near Vienna bear this out.

For example, construction of the Panda-Brandywine cogeneration facility is expected to require an average work force of 175 workers over an 18-month construction period. During the peak construction period, the construction work force will be about 300 workers. Most of the construction labor will be drawn from Prince George's and neighboring counties in Maryland. The total payroll of the construction work force is projected to be $35.6 million (1993 dollars) over the entire construction period. Purchases of goods and services by Panda are expected to add another $10 to $14 million to the Maryland economy.

Delmarva Power projects the average annual construction labor force for Dorchester Unit 1 will be approximately 466 full-time equivalent employees over a 38-month construction period, earning an estimated annual payroll of $27.7 million. Employment is expected to peak at about 700 workers about 20 months into the construction schedule. In-state purchases of goods and services by Delmarva Power over the construction period are projected to total $44 million (1993 dollars).

Power plant impacts extend beyond their direct effects upon construction employment and industry sales. Income from construction workers is spent on food, housing, and other consumption goods, which increase the sales of retail and service establishments. These establishments may subsequently add workers or extend the hours of its current employees to satisfy the added demand, which generates additional income that results in more consumption, and so on. On the industry side of the ledger, additional sales of goods and services from power plant construction contracts may induce supplying industries to increase production, adding to payrolls in the form of new employment or longer hours, and increasing purchases from industries that supply them with raw materials. In other words, power plant construction expenditures for goods and services ripple through the economy through inter-industry linkages when businesses respond to increased demand by increasing production and purchasing of inputs to their production processes.

This concept is known as the **multiplier**, which measures the total economic effect from a direct stimulus to the economy. Multipliers for construction investment in Maryland are quite significant. The Maryland Department of Economic and Employment Development (DEED) estimates the following state-wide construction industry multipliers (Ahmadi 1993):

- Income 3.01
- Output 2.02
- Employment 3.58

The income multiplier represents the total dollar change in earnings of Maryland households for each additional dollar of earnings paid to households employed in new construction. Therefore, an income multiplier of 3.01 implies that every additional dollar of earnings by construction worker households would change total Maryland household earnings by $3.01. Similarly, an output multiplier of 2.02 means that total output of Maryland industries would increase by approximately two dollars with each additional dollar of output generated by new construction. Finally, according to the employment multiplier, more than 3.5 jobs would be created in Maryland from the creation of each new construction job.

Using these multipliers, the total economic benefits from construction of the Panda and Dorchester facilities can be estimated (Table 3-23). Panda Brandywine is expected to generate almost 1,000 person-years of employment and more than $100 million in total earnings over the 18-month construction period. Maryland's industrial output is expected to increase by $21 million, as a result of direct construction expenditures and indirect effects of the Panda construction project. Dorchester's estimated impacts are even larger: more than 5,000 person-years of employment created, $264 million in earnings, and almost $90 million in output added to the economy.

Table 3-23 Estimated Multiplier Effects of Power Plant Construction on the Maryland Economy, Panda-Brandywine and Dorchester Projects

	Panda-Brandywine		Dorchester	
	Project	Annual	Project	Annual
Construction employment (1)	263	175	1476	466
Indirect employment (1)	679	453	3808	1203
Total employment (1)	942	628	5284	1669
Construction earnings (2)	$35.6	$23.7	$87.7	$27.7
Indirect earnings (2)	$71.6	$47.7	$176.3	$55.7
Total earnings (2)	$107.2	$71.5	$264.0	$83.4
Construction expenditures (2),(3)	$10.5	$7.0	$44.0	$13.9
Indirect output (2),(4)	$10.7	$7.1	$44.9	$14.2
Total output (2)	$21.2	$14.1	$88.9	$28.1

(1) Jobs times years (person-years of employment). Annual columns contain average jobs created per year.
(2) Millions of 1993 dollars.
(3) In state construction expenditures for goods and services.
(4) Total indirect output from in-state construction expenditures.

Although the economic impacts from power plant construction are generally positive, the degree to which the stimulatory effects can be internalized by a host community depends upon a number of factors. For example, the availability of a skilled construction work force within commuting distance of the site returns a higher proportion of incomes and tax revenues to the host community. Although few areas of Maryland are distant from skilled construction labor, the proximity of Delmarva Power's Dorchester site to Delaware and its location just beyond the normal commuting distances from labor pools in Annapolis and Baltimore will result in a greater leakage of Delmarva Power's construction investment than Panda's investment in southern Prince George's County.

Furthermore, although power plant construction boosts local economies with the jobs and income it generates, its temporary nature limits its impacts on host communities. All job and income creation attributable to construction effectively ends when construction ends. Panda projects that construction of its proposed cogeneration facility will take about 18 months, while Delmarva Power expects that Dorchester Unit 1 will be completed in slightly more than three years. Within these construction periods, changing needs during the various stages of construction add both dynamics and uncertainty to local economies. Relative to the economies in which they are situated, these construction projects are moderately significant but are not expected to more than marginally disrupt the business environments of the host communities.

3.6.1.2 *Ongoing Expenditures and Employment*

Although employment requirements and annual outlays for goods and services are considerably less than construction-era levels, power plants are important sources of payrolls and tax revenues for host communities. On a broader scale, power plants interact with the economy through purchases of goods and services as part of ongoing operations and maintenance.

Two types of costs are incurred by utilities in the provision of electric service: expenses associated with the annual operation and maintenance of the electric utility facilities, and capital carrying costs associated with the construction of generating facilities. In 1991, total O&M expenses accounted for 59% of electric operating revenue received by major investor-owned utilities in the United States (EIA 1993). O&M expenses comprise generation (including electric purchases), distribution, transmission, and customer service and administration expenses. In 1991, internal generation production expenses (generation expenses less electric purchases) comprised 49% of total electric operating expenses. Internal generation production expenses include costs of labor, materials, and supplies used at the plant, plus the cost of fuel for electric generation (EIA 1993).

The labor requirements of power plants vary by plant type. Employment at base load coal and nuclear facilities is invariably higher than at combustion turbine peaking facilities, for example. Panda projects O&M employment will be 30 full-time jobs at the 248-MW gas- and oil-fired Panda-Brandywine cogeneration facility, compared to Delmarva Power's estimate of 68 jobs at the 300-MW coal-fired Dorchester Unit 1.

Fuel costs as a percentage of total internal production expenses also vary by plant type. Fuel costs in 1991 averaged 77% of total production expenses for fossil-fueled steam electric plants, but only 58% of total production expenses of gas turbine and small scale electric plants. O&M costs also vary with the age of the facility (EIA 1993).
Even though fuel accounts for the majority of power plant O&M expenses, power plants also purchase materials and supplies for maintenance. Maryland utilities are estimated to have spent over $300 million on goods and services in 1993 (Table 3-24). This represents a nominal increase of more than 12% over 1992 and a nearly 40% increase since 1989. Accounting for inflation, O&M expenditures by Maryland utilities have risen by an average of 4% annually since 1989.

Table 3-24 Goods and Services Provided by Generation O&M Expenditures of Maryland Utilities, 1993 (thousands of dollars)

	PEPCO	Delmarva Power	COPCO[2]	BGE	PE	TOTAL
Generation						
O&M	$724,643	$404,221	$54,662	$831,389	$395,122	$2,018,855
less: Fuel	$339,183	$203,055	0	$349,926	$153,587	$1,035,751
less: Labor	$58,817	$26,096	0	$136,373	$16,327	$237,613
less: Other[1]	$276,582	$98,066	$54,662	$198,740	$198,425	$826,475
Goods & Services	$50,061	$77,004	0	$146,350	$36,783	$310,198

(1) Other power supply expenses, comprising purchased power plus system control and dispatching.

(2) COPCO purchased all power from PECO Energy in 1993.

Source: FERC Form No. 1

The major suppliers of goods and services to the utility industry can be identified in input-output accounts, which quantify the transactions that flow between industries that make up the economy. Input-output tables show the value of commodities used in production by an industry or purchased by final users, and the value-added generated in production (BEA 1980). Dividing the values of commodities purchased by the total output of the producing industry yields direct purchases per dollar of output. Major suppliers to U.S. utilities for 1987 are shown in Table 3-25.

Table 3-25 ***Direct Purchase Coefficients of Private Electric, Water, and Sanitary Services, 1987 (1987 dollars)***

Industry Name	**Direct Purchases ($) per Dollar of Output**
Coal mining	.0655
Crude petroleum & natural gas	.1083
Repair & maintenance construction	.0549
Chemicals & selected chemical products	.0033
Petroleum refining & related industries	.0252
Engines & turbines	.0040
Motor vehicles & equipment	.0033
Scientific & controlling instruments	.0025
Transportation & warehousing	.0178
Electric, water & sanitary services	.1054
Wholesale & retail trade	.0075
Finance & insurance	.0290
Real estate	.0033
Hotels, personal & repair services	.0027
Business services	.0139
Federal government enterprises	.0027

Source: Survey of Current Business (1992)

As expected, most major suppliers to the electric utilities industry are fuel-related (coal mining, crude petroleum and natural gas, petroleum refining and related industries, and transportation and warehousing), or are related to purchases of electricity (electric utilities and federal government enterprises). However, expenditures are also made for maintenance and repair construction, and for manufactured goods such as machinery associated with the generation of electricity, including instrumentation. Finally, power plant O&M consumes services, particularly those related to finance and insurance, and business services.

In Maryland, the situation is similar to national totals. Although industries are not directly comparable, direct purchase coefficients of Maryland's electric utilities (Table 3-26) show major Maryland-based suppliers to the industry are fuel-related (mining, gas production and distribution, railroads and related services), plus other government, finance, insurance and real estate, business services, and other construction. Expenditures for manufactured goods such as machinery associated with the generation of electricity, including instrumentation, make up a lower proportion of Maryland utility purchases than at the national level. This indicates that utility O&M expenditures leak from the Maryland economy for purchases of manufactured goods, such as engines and turbines, and other goods and services which are not produced in the state.

Table 3-26 Direct Purchase Coefficients of Maryland's Electric Utilities (1991 dollars)

Industry Name	Direct Purchases ($) per Dollar of Output
Engines & turbines	.0006
Aircraft & parts	.0016
Railroads & related services	.0116
Motor freight transport & warehousing	.0013
Water transportation	.0023
Other services	.0035
Other mining	.0050
Other construction	.0288
Communications	.0010
Gas production & distribution	.0186
Wholesale trade	.0027
Finance, insurance & real estate	.0073
Business services	.0060
Engineering & research services	.0007
Other government	.0119
U.S. Postal Service	.0015

Source: Ahmadi 1994.

What does this mean for Maryland business? Last year, Maryland utilities spent more than $300 million on goods and services. Although their distribution is unknown, the State estimates that about one-half of the expenditures were made within Maryland. (Delmarva Power estimated that 70% of O&M expenditures for Dorchester Unit 1 would be made within Maryland, including 40% spent locally.) DEED estimates the statewide output multiplier for electric services is 1.54, indicating that each dollar of output would generate a total of $1.54 of total output by Maryland industries throughout the state. Although estimates are necessarily speculative, O&M expenditures by electric utilities for goods and services probably accounted for nearly $250 million of total output throughout the Maryland economy. As more power plants, such as Perryman, Panda-Brandywine, and Dorchester Unit 1 come on line, this total can be expected to increase in future years.

3.6.2 *Electricity Generation and Property Values*

3.6.2.1 *How and Why Power Plants Affect Property Values*

Utility impacts on nearby properties have been subject to research for many years. In general, power plants and their associated facilities such as transmission lines, substations, by-product disposal areas, and fuel storage and transshipment facilities have been considered undesirable to nearby property owners because of the real or perceived **externalities** they generate. Externalities associated with these facilities include the host of factors subject to review by PPRP, such as the air, water, terrestrial, socioeconomic, aesthetic, and other impacts that are discussed in this report. Generally, utilities have attempted to control externalities by minimizing impacts or by mitigating their effects.

Most undesirable impacts from power plants decline with distance. As a result, landowners in proximity to power plants are affected more often and more severely by power plant construction and operation than those at greater distances. As the cumulative environmental impact of power plants is generally perceived to be undesirable, its effect upon nearby properties can be to reduce their value.

However, little consensus has evolved over the degree to which power plants affect property values. This is partly due to the nature of activities that typically are proximate to power plants, such as agricultural or industrial, which are not as severely affected by visual, noise, traffic, and other nuisance impacts associated with power plants. It is also attributable to the substantial land buffers that utilities often establish between power plant structures or activities and adjacent properties.

Virtually all of the literature on property value impacts from power plants has examined the effects of nuclear power plants, to which property owners associate perceptions of risk that are distinct from non-nuclear facilities. However, even with a heightened concern over the health and safety aspects of nuclear power, research has found no consistent effects.

3.6.2.2 *Electric Transmission Lines and Property Values*

Property value impacts have also been an issue with respect to the associated facilities of power plants, particularly high voltage overhead electric transmission lines. In the past, the primary effects of transmission lines were considered to be aesthetic in nature, relating in a negative sense to the visual intrusion of power lines and transmission towers, and in a positive sense to the open space afforded to adjacent property owners provided by the transmission line right-of-way. More recently, issues related to perceived health risks from **electromagnetic fields** (EMF) have been examined in the literature.

Most studies examining the aesthetic impacts from transmission lines on residential property values have suggested that transmission lines have no adverse effects on property values, although findings are far from conclusive.

The Edison Electric Institute sponsored the most recent summary and analysis of the literature on property value effects, examining studies and articles produced between 1975 and 1990 (EEI 1992a). Reviewed studies were grouped into four categories: literature reviews and summary articles; appraisal studies; attitudinal studies; and statistical analyses. It is difficult to draw many conclusions from their analysis because the results of the individual studies are so varied. For example, of the 14 appraisal studies, seven concluded that transmission lines had no impact on property values. The remaining seven studies did find some property value impact, although the impacts tended to be small. The analysis of the nine attitudinal studies showed that in eight cases, more than one-half respondents to the survey felt that transmission lines negatively impacted property values. Of the 15 statistical analyses, five found no impact on property values while the others showed an inconclusive or small negative impact on property values.

DNR's analysis of the effect of overhead transmission lines on residential property values produced similar mixed results (PPSP 1983). In a study in which the cost of lots and house structures were examined separately for two Maryland subdivisions, statistical analysis revealed that the cost of lots adjoining the transmission line right-of-way in one subdivision was lower than the cost of the remaining lots in the subdivision, but there was no detectable difference due to transmission line proximity in the other subdivision. Furthermore, the transmission line had no effect on the cost of the house structure in either subdivision.

Although evidence is largely incomplete, several findings have emerged from research into transmission line impacts on property values (EEI 1992a):

- Overhead transmission lines have the potential to reduce the sales price of residential and agricultural property.
- Price effects upon single-family homes are generally less than 10%, but could be as high as 15% in rural areas.
- Other factors such as neighborhood amenities, lot size, and accessibility have a greater influence on housing prices than overhead transmission lines.

- Most property value impacts from transmission lines are confined to adjacent properties.
- Property values of parcels adjacent to transmission lines may be positively impacted due to the open space and recreational opportunities afforded by the right-of-way.
- Transmission line impacts may be greater for smaller properties.
- Transmission line impacts on property values may diminish over time following the construction of a new line through existing neighborhoods.

However, the review also noted that despite the large number of studies conducted since 1975, many unanswered questions remain. Diverse research designs, data limitations, and disparate geographic scopes have all contributed to the inability to synthesize study findings into coherent, comparable conclusions. As a result, relationships between proximity to transmission lines and property values are suggestive, but are still uncertain. Questions that remain largely unanswered include:

- *Magnitude of impacts* - Studies that attempt to quantify property value impacts have estimated such a wide range of effects (both positive and negative) that a consensus estimate is not possible.
- *Source of impacts* - The contributory effects of individual attributes of transmission lines are not well understood. Rather than estimating relationships between amenities, such as open space, aesthetic nuisance factors, such as transmission towers and lines, or risk factors related to health and safety, most research has instead lumped all transmission line attributes into a proximity variable.
- *Effects by land use* - Most research has studied relationships between transmission lines and single-family residential property values, virtually ignoring potential effects on multi-family, commercial, open space, and other land uses.
- *General surroundings* - With most research conducted in suburban residential areas, little is known whether impacts vary with the degree to which the environment hosting the transmission corridor is urbanized or industrialized.
- *Socioeconomic characteristics* - Research has not determined whether socioeconomic status differentially affects the degree to which property values are impacted by proximity to transmission lines.
- *Health effects* - Recently raised concerns about the health risks associated with proximity to transmission lines have not been extensively analyzed in the literature dealing with property values.

Most of the analysis in this area has generally been limited to attitudinal studies.

- *Effects of time* - No studies have effectively addressed the issue of how time influences the relationship between transmission lines and property values. For example, how do maturing buffers between affected properties and transmission lines change property value impacts, and how do changing perceptions about health risks change the relationship?

3.6.2.3 *Electric Transmission and Risk*

In the past few years, a new issue has emerged with respect to electric transmission lines. This is the perceived risk associated with EMF. Few, if any, of the previous studies took EMF into account because the public was unaware of this risk.

To the extent that they have been researched, EMF issues have been studied in attitudinal surveys to determine public perceptions towards transmission lines. EEI's recent review of ten detailed studies and assessments and eight informal assessments of public perceptions (EEI 1992b) found only two studies specifically focused upon EMF issues, although the broader issue of health and safety was one of seven major issues areas examined in attitudinal surveys.

EEI's review of research on public perceptions toward electric transmission lines found public awareness of controversies over the possible relationship between electricity and health to be fairly consistent among studies, suggesting awareness among approximately 30% of the public. On the other hand, about 60% of those surveyed expressed concern about health effects from transmission lines.

EEI found the public to be relatively uninformed about EMF. There is also evidence to suggest that misperceptions about EMF, such as the rate at which EMF levels fall with distance, are widely spread. Of particular concern to EEI in its review of the literature was the absence of inquiry into the relationship between EMF and other factors. For example, are EMF concerns higher when a project is opposed for other reasons? Does knowledge about EMF increase or reduce public concerns about the health and safety of transmission lines? Do changes to voltage, right-of-way design, and tower height affect perceptions about EMF?

Although evidence is scant, in one of the studies reviewed (Priestley and Evans 1990), concerns about health and safety were found to be greater than perceptions toward aesthetics and property values. A positive attitude about the open space and recreational amenities provided by transmission line corridors tended to reduce concerns about health and safety impacts associated with transmission lines, however.

Given the absence of a consensus on the impact of transmission lines on property values, it is not surprising that EEI's review of studies of public perceptions toward transmission lines found little evidence linking EMF to property values. Though Priestley and Evans (1990) found that concerns about transmission lines clustered into three distinct dimensions relating to health and safety, aesthetics, and property values, and that some degree of relationship existed between property value concerns and aesthetics, only a weak link was found in the data between property value concerns and issues of health and safety.

Since 1990, only a small number of new studies have been published investigating the relationship between EMF from transmission lines and property values. Only two appraiser-type studies (Kansas City Power and Light 1993; Kung and Seagle 1992) attempted to relate EMF to property values. Kansas City Power and Light found that 79% of the respondents reported that transmission lines did not influence the price they paid for housing, and 48% indicated that transmission lines would not affect the sales price. Kung and Seagle found that no measurable price difference could be found between homes located adjacent to transmission lines and those located further away. In an attitudinal survey administered to master appraisers, Delaney and Timmons (1992) found that 84% indicated that the market value of residential property is negatively affected (by a mean value of 10%) when located near overhead transmission lines. When asked the reasons for the reduced assessment, almost 59% responded that health problems were the cause.

PPRP recently funded a study to determine whether there has been any measurable change in the relationship between residential property values and proximity to transmission line corridors over the past two decades. This work updates an earlier study sponsored by PPRP and prepared during the late 1970s (PPSP 1983), which failed to find any significant impact on residential property values. Since that study was conducted, public awareness of transmission lines, relating to aesthetic considerations, EMF health concerns and other factors, has increased.

The recently completed study approached the issue by conducting a repeat sales analysis upon residential properties in the two suburban Maryland middle-income subdivisions that were analyzed in the 1983 study. Repeat sale statistical models failed to support the hypothesis that increased public perceptions of transmission lines affect the extent to which proximity to such lines affect residential property values. However, this was partly attributable to a study design which attempted to test for a plausible but subtle change in public perceptions with a relatively small data set.

Although suggestive of a link between property values and perceived risk from EMF, research in this area is far from conclusive. The EEI literature review (1992a) appropriately noted that our current understanding has not yet evolved to where it can assist in project siting and design, impact prediction, or the prescription of mitigation measures. More rigorous research is clearly needed to assist decisionmakers in the formulation of appropriate policy with respect to overhead transmission lines.

3.6.3 *Transportation Issues*

3.6.3.1 *Importance of Transportation Infrastructure in Power Plant Siting*

Accessibility is an important consideration in power plant siting. Power plants require a well-developed transportation infrastructure for carrying its workers, supplies, fuel, and other inputs to the plant site, and for discharging by-products and other waste streams. To the extent that electric transmission is a form of transportation, power plants must be accessible to regional grids through electric transmission lines.

Road accessibility has traditionally been an important factor in power plant siting because roads servicing the plant must be able to support automobile traffic of construction workers and O&M employees, as well as trucks delivering goods and services to the plant site. Most automobile traffic is generated during power plant construction, when the number of construction workers commuting to a site can exceed 1,000 during the peak construction period.

As the generating facilities of electric utilities have in recent years been located in rural areas, transportation improvements to local county or state roads leading to the site have usually been required. However, regional highway access to the areas in which power plants have recently been located has been adequate to enable construction workers to commute from major labor markets in Maryland rather than relocate to nearby communities. The existence of adequate regional highways connecting power plant sites to major labor markets has therefore helped to minimize socioeconomic impacts from power plant construction.

Rail accessibility is also a consideration in power plant siting, although its importance depends primarily upon whether electricity is generated from the combustion of coal. Typically, coal is delivered to power plants in unit trains of up to 100 cars in length, each with a capacity of about 100 tons. Unit trains require track which conforms to the American Railway Engineering Association standard loading for unit coal trains. Track which does not conform to these specifications must be upgraded by replacing existing rails with heavier rails before a power plant can be considered accessible for coal delivery by rail. Railroads are also often used to transport large power plant components to the site during construction.

Although often considered a substitute for rail, accessibility to water transportation facilities can be an important consideration in power plant siting. Fuel transportation by barge using the navigable inland waterway system has both inherent advantages and disadvantages over other modes of transportation. In general, barges can transport higher tonnage than other conventional transportation modes. In addition, fuel and maintenance costs are generally lower than for rail or trucks. However, barges require waterfront development and access, both of which are limited under Maryland's Chesapeake Bay Critical Areas program. Furthermore, fuel for power plants not adjacent to unloading facilities must be transshipped via truck or rail, which increases fuel supply costs. Currently, seven of 11 power plants located in Maryland are fueled in total or in part by barges (FERC 1993).

As natural gas is invariably transported to generation facilities via pipeline, proximity to gas pipelines can be a consideration in power plant siting, depending upon the combustion technology planned for a site. Proximity to gas pipelines is less of a consideration if a branch pipeline can be routed to the facility along available rights-of-way from a main pipeline interconnect.

3.6.3.2 *Transportation and Electric Generation*

The primary role that transportation plays in electric generation is in the transport of fuel to generation sites. Transportation can also be critical for removing combustion by-products from coal-fired facilities to solid waste disposal areas.

Fuel deliveries in 1993 to Maryland power plants are shown in Table 3-27. Most notable in the table is the variety of modes used to transport fuel. Coal is shipped to Maryland utilities by rail, barge, and truck. For two of BGE's facilities, coal is shipped via rail to intermediate terminals and then barged to power plant sites. Fuel oil is transported by barge, truck, and pipeline; natural gas is transported by pipeline.

In most cases, provision of carriers for the transportation of fuel is the responsibility of fuel suppliers or is contracted to third parties. However, BGE owns and operates all barges that service its Brandon Shores, Gould Street, Wagner, Riverside, and Westport facilities. PEPCO owns 244 coal

Table 3-27 ***Fuel Deliveries to Maryland Utilities in 1993, by Transportation Mode***

Company	Plant Name	Bituminous Coal		#2 Fuel Oil		#6 Fuel Oil		Natural Gas	
		(tons x 1000)	Mode	(bbl x 1000)	Mode	(bbl x 1000)	Mode	(mcf x 1000)	Mode
BGE	Brandon Shores	2,648	Rail, Barge	40	Truck				
	C.P. Crane	732	Rail	4	Truck				
	Gould Street					270	Barge		
	H.A. Wagner	718	Rail, Barge			1,064	Barge	1,757	Pipeline
	Riverside					42	Barge	861	Pipeline
	Westport					62	Barge		
Delmarva Power	Vienna					1,009	Barge		
PE	R.P. Smith	154	Truck	4	Truck				
PEPCO	Dickerson	1,183	Rail	29	Truck				
	Chalk Point	1,148	Rail	175	Truck	3,031	Pipeline	2,183	Pipeline
	Morgantown	1,925	Rail	54	Barge	409	Pipeline, Barge		

Source: FERC 1993

cars, which service its Chalk Point and Morgantown facilities in trains operated by Conrail.

Rail delivery of coal to power plants generates significant revenues to railroads. Rail lines that service coal-fired power plants in Maryland are operated either by Conrail or CSX Corporation. In 1993, rail deliveries of coal to Maryland power plants totaled more than 8.5 million tons (FERC 1993). Transportation cost is a critical factor in the delivered cost of coal, accounting for approximately one-fourth of the delivered price of contract coal to electric utilities (EIA 1991).

Barge transportation is employed by BGE to ship coal and #6 fuel oil to several of its power plants. In addition, PEPCO transports #2 fuel oil to its Morgantown facility via barge. The Vienna power plant is supplied with #6 fuel oil by barge. BGE employs dual mode systems to transport coal and oil to several of its facilities. For Brandon Shores, coal is carried over the C&O Railroad (CSX) from mines in Eastern Kentucky and southwest West Virginia to Newport News, where it is transferred onto barge for shipment to the plant. Coal is transported to the Wagner power plant on the B&O Railroad (CSX) from mines in central West Virginia to Curtis Bay, where it is loaded onto barge. BGE dispatches #6 fuel oil onto barges for delivery to its Gould Street, Wagner, Riverside, and Westport facilities from tank farms in Baltimore Harbor.

Although often used only to supply fuel to auxiliary generators or to supply auxiliary fuels for combustion, trucks are the sole mode for carrying coal to Potomac Edison's R. Paul Smith plant in Washington County. Coal is trucked to the facility from mines in Allegany and Garrett Counties in Maryland and Somerset County in Pennsylvania. On the basis of 1993 consumption figures, coal shipments to the facility averaged between 30 and 40 round trip truck-trips on area roads each workday. Trucks are also used to transport #2 fuel oil to PEPCO facilities at Dickerson, Chalk Point, and Morgantown.

Both fuel oil and natural gas are transported via pipeline to electric utilities in Maryland. PEPCO's Chalk Point and Morgantown power plants receive #6 fuel oil via pipeline, although fuel oil can also be supplied to Morgantown by barge. All three natural gas burning facilities in Maryland — BGE's Wagner and Riverside power plants, and PEPCO's Chalk Point — are supplied natural gas via pipeline.

Trends in fuel deliveries to Maryland utilities are evident from recent historical data (Figure 3-38). Although coal deliveries have remained relatively constant, natural gas deliveries in 1993 were less than one-third of the 1989 total. Fuel oil deliveries have declined reducing the utilization of pipeline and barge transportation modes. Rail and truck traffic, on the

Figure 3-38
Fuel Deliveries to Maryland Utilities 1989-1993