Environmental Assessment
for Renewal of Source Material License No. SMB-920

Docket 40-6940

Cabot Performance Materials
Cabot Corporation
Boyertown, Pennsylvania

U.S. Nuclear Regulatory Commission
Fuel Cycle Safety and Safeguards

September 1996

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ABBREVIATIONS AND ACRONYMS

Cb	columbium
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Ci	curie
cm	centimeter
cm^2/s	square centimeter per second
CPM	Cabot Performance Materials
D&D	decontamination and decommissioning
EA	environmental assessment
EDE	effective dose equivalent
EPA	Environmental Protection Agency
ft	foot
gal	gallon
g/cm^3	gram per cubic centimeter
HF	hydrofluoric acid
H_2NbF_7	fluocolumbic acid
HNO_3	nitric acid
H_2SO_4	sulfuric acid
H_2TaF_7	fluotantalic acid
ICRP	International Commission on Radiological Protection
K	potassium
K_2TaF_7	potassium fluotantalum
m^3	cubic meter
$\mu Ci/ml$	microcurie per milliliter
$\mu g/m^3$	microgram per cubic meter
MIBK	methyl isobutyl ketone
MMI	Modified Mercalli Intensity
MMW	mausoleum monitoring well
mrem	millirem
m/s	meter per second
MW	monitoring well
Nb	niobium
NbO	niobium oxide
Nb_2O_5	diniobium pentoxide
NEPA	National Environmental Policy Act
NH_3	ammonia
NO_x	nitrous oxides
NPDES	National Pollution Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
Pb	lead
pCi/g	picocurie per gram
pCi/L	picocurie per liter
PM-10	particulate matter

ppm	parts per million
s^{-1}	per second
s/m^3	second per cubic meter
SO_2	sulfur dioxide
Ta	tantalum
TEDE	total effective dose equivalent
Th	thorium
ThF_4	thorium tetrafluoride
ThO_2	thorium dioxide
U	uranium
U_3O_8	triuranium octoxide
UF_4	uranium tetrafluoride
wt	weight
yr	year

1. PURPOSE AND NEED FOR ACTION

1.1 Introduction

On November 23, 1988, Cabot Performance Materials (CPM) requested the renewal of its Source Material License No. SMB-920 for a period of 5 years. The U.S. Nuclear Regulatory Commission (NRC) has prepared this environmental assessment (EA) pursuant to the Council on Environmental Quality (CEQ) regulations [40 CFR Parts 1500-1508 (Ref. 1)] and NRC regulations [10 CFR Part 51 (Ref. 2)], which implement the requirements of the National Environmental Policy Act (NEPA) of 1969 (Ref. 3). The purpose of this document is to assess the environmental consequences of the proposed license renewal.

1.2 Operation Mission

The CPM facility near Boyertown, Pennsylvania, is authorized under SMB-920 to possess a maximum of 360 metric tons (400 tons) of source material. The facility processes tin slags, tantalite, and columbite ores to extract tantalum (Ta) and niobium (Nb). The ores and slags contain uranium and thorium [the combination of uranium and thorium at up to 2 wt % (Ref. 4)]. The main operations at the Boyertown facility include extraction of Ta and Nb from ores, fabrication of products, treatment of industrial liquid waste prior to release to the environment, and storage of by-product sludge containing valuable rare earth components. The by-product sludges are classified as source material because they contain in excess of 0.05 percent uranium and thorium (in combination) by weight (Ref. 4). The by-product sludges also contain significant concentrations of Nb, also known as columbium, Ta, and other rare earth elements.

The applicant plans to use some of the currently stored sludge as supplemental feedstock. A sintered, pelletized material classified as source material would be the residual from the revised digestion process. The residue could either be disposed of as low-level radioactive waste or recycled if a recycling alternative [e.g., transfer to a uranium mill for uranium recovery (about 1 percent uranium content)] could be developed.

The major facilities related to source material processing and storage include buildings 073 and 074 where the ores and slags are digested and the Ta and Nb separated, slag and drum storage areas, the sludge storage area, a wastewater treatment area, and warehouses used for raw material storage. There are also six lagoons on site. Lagoons (basins) 1 and 2 are for collecting storm water, noncontact cooling water, and steam condensate prior to release to West Swamp Creek (Ref. 5). These lagoons also function as a containment system in the event of a major chemical spill. Lagoons (reservoirs) 3 and 4 contain water pumped from West Swamp Creek for process use. Lagoons 5 and 6 contain treated industrial liquid effluent before discharge to West Swamp Creek. These facilities are shown on Figure 1.1.

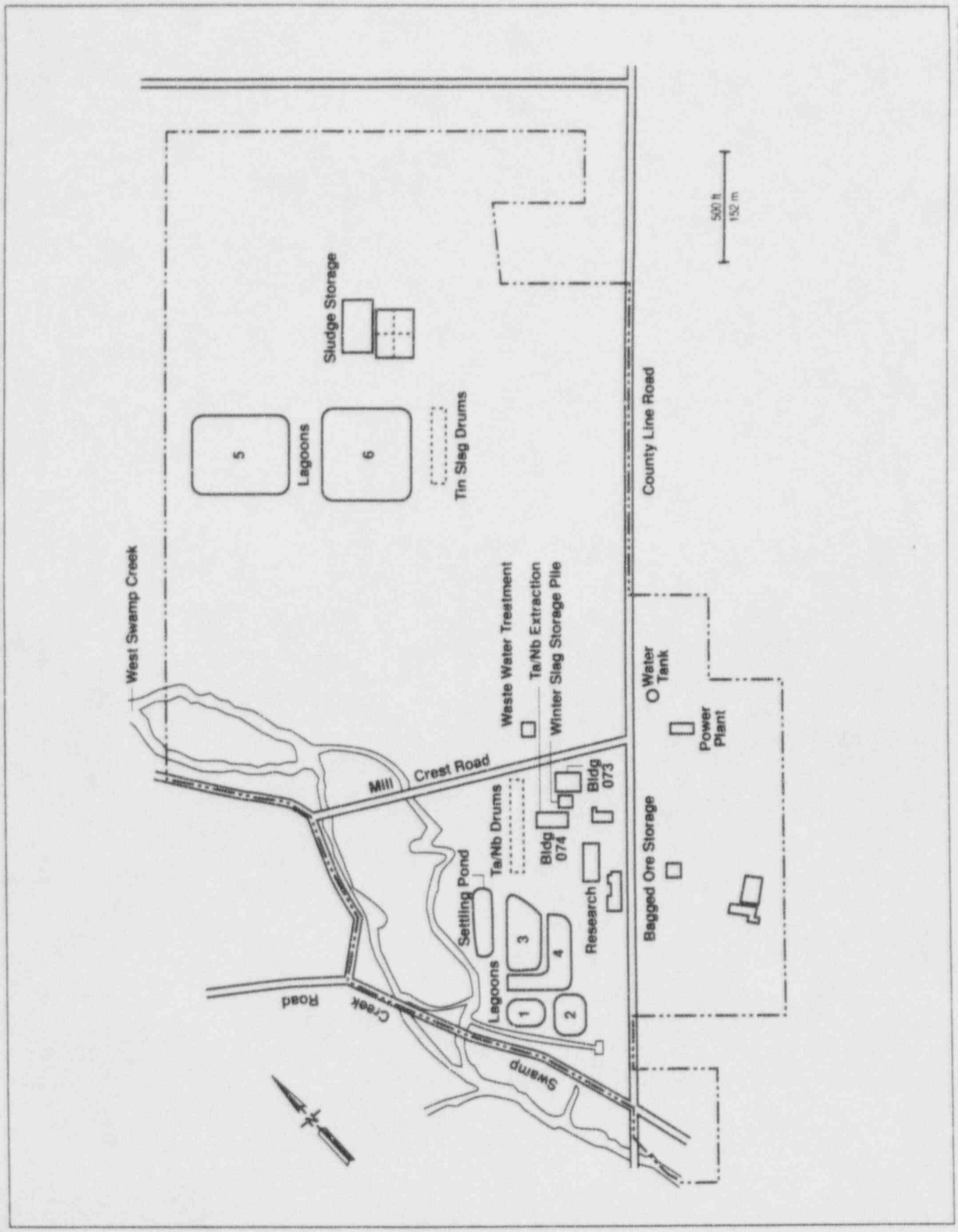


Figure 1.1 Plot plan of the Cabot Performance Materials facility

Other than the planned sludge processing expansion, there have been no major changes to the physical plant since the last license renewal and CPM expects to operate the facility in a manner similar to the recent past.

1.3 Description of the Proposed Action

The proposed action is the renewal of the CPM License No. SMB-920 for 5 years and a planned processing change that will allow currently stored by-product sludge to be used as supplemental feedstock, thus eliminating the need for on-site storage of by-product sludge.

1.4 Need for the Proposed Action

The CPM facility near Boyertown is one of many similar extraction metallurgy facilities in the United States that provide strategically valuable metal products for a broad range of industrial applications, some of which are relat national defense. This facility is not unique in having to manage small quantitie. ,f unwanted radioactive materials. Denial of license renewal for the metal-recovery operations could result in increased activity at a similar plant with consequent environmental impacts. Although denial of renewal of the SMB license is an alternative for the NRC, it would only be considered if public health and safety issues could not be resolved to the satisfaction of the regulatory authorities.

1.5 References for Section 1

1. *U.S. Code of Federal Regulations*, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," Parts 1500-1508, Chapter 5, Title 40, "Protection of Environment."

2. *U.S. Code of Federal Regulations*, "Environmental Protection Regulations for Domestic Licensing and Regulatory Functions," Part 51, Chapter 1, Title 10, "Energy."

3. National Environmental Policy Act, as amended, 42 U.S.C. §4321 et seq., 1970.

4. Cabot Performance Materials, Cabot Corporation, "Application for Renewal of Source Material License No. SMB-920 (NRC Docket No. 40-6940)," March 16, 1994.

5. Cabot Performance Materials, Cabot Corporation, "Response to Request for Additional Information Regarding License Renewal (TAC No. L10014)," August 17, 1995.

2. THE PROPOSED ACTION AND ALTERNATIVES

Alternatives under consideration for the CPM facility include the proposed alternative, renewal of the license, and a single alternative, non-renewal of the license. Selection of either alternative implies decontamination and decommissioning (D&D) of the facility at some time in the future. This section describes the production and waste management operations of the proposed alternative and introduces the no-license renewal alternative and D&D requirements.

2.1 The License Renewal Alternative

Implementation of the license renewal alternative involves continued operation of the facility at levels consistent with recent practice. A planned process modification would treat stored sludges and improve management of future sludge waste. Manufacturing and waste management practices are described in this section. Process descriptions are from the license application (Ref. 1), licensee response to NRC staff requests for additional information (Ref. 2, Ref. 3), and previous NEPA analysis (Ref. 4).

2.1.1 Description of Current and Proposed Operations

The CPM site is located in southeastern Pennsylvania approximately 2.4 kilometers (1.6 miles) northeast of the borough of Boyertown in a sparsely populated area where agriculture is the primary land use. The major facilities include administrative and chemical processing buildings, a lagoon system, and feed, chemical, and waste storage facilities as shown in Figure 1.1. Currently, source materials are handled or stored in a limited number of the site facilities, including the feed solids and sludge waste storage (i.e., the sludge storage mausoleums) areas, the main process building (building 073), and lagoons 5 and 6. In a planned process modification, source materials would also be processed in a new building located near buildings 073 and 074.

Operations at the CPM facility recover Ta and Nb metals from ores and smelter slags using digestion, extraction, crystallization, and reduction processing steps. The plant feed rate is approximately 5,000 kilograms per day (11,000 pounds per day) with ores/slags containing between 20 and 80 wt % Ta and Nb oxides (NbO). A block diagram of the current Ta/Nb recovery process is presented in Figure 2.1. The planned modification of this process would add a second digestion stage where the feed would be sludge generated from the first stage and stored sludges from previous operations. Process streams containing source materials include the feed ores/slags, intermediate process flows, and liquid and solid effluent streams. The following paragraphs discuss the equipment and operations used to process streams containing source materials.

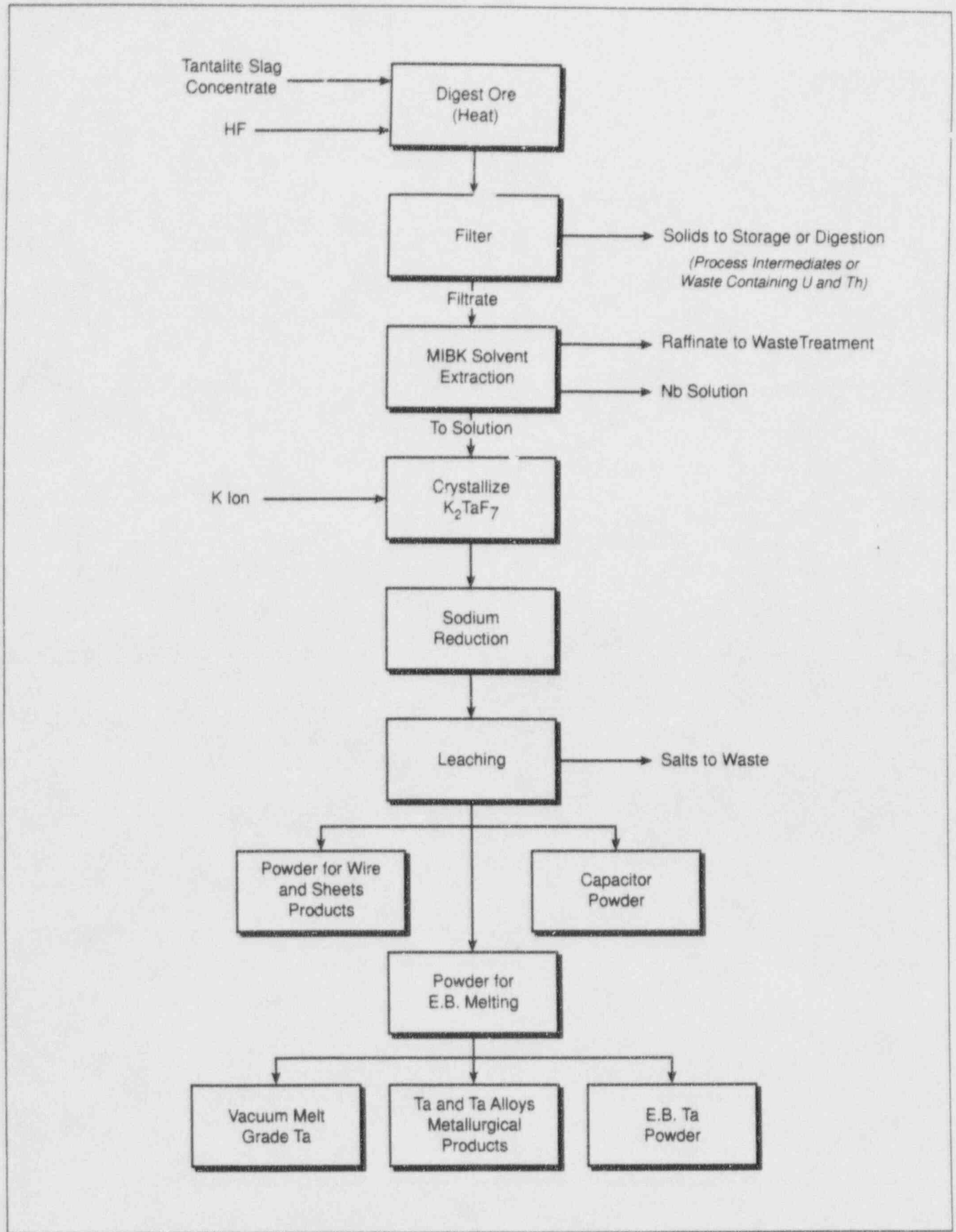


Figure 2.1 Metal recovery process diagram

2.1.1.1 Feed Material Handling

Feed materials received at the CPM facility are ores and smelting process slags containing from 0.03 to 0.40 wt % triuranium octoxide (U_3O_8) and from 0.02 to 0.15 wt % thorium dioxide (ThO_2). Approximately 400,000 kilograms (900,000 pounds) of feed materials are stored on site in buildings 010, 040, and 111; in storage trailers located near the sludge storage mausoleums; and in a covered pile located near the main process building (building 073). Feed materials, primarily in 0.21-cubic meter (55-gallon) drums, are transferred to a grinding and classifying circuit. The grinding and sizing equipment are within a closed system and effluent air is filtered before being released to the atmosphere.

2.1.1.2 Feed Material Digestion and Liquid/Solids Separation

In the current process, sized material from the grinding circuit is dissolved in hydrofluoric acid (HF) in heated digestors. Tantalum and NbO are converted to soluble fluotantalic acid (H_2TaF_7) and fluocolumbic acid (H_2NbF_7). Uranium and thorium impurities form insoluble fluoride compounds [UF_4 (uranium tetrafluoride) and ThF_4 (thorium tetrafluoride)] in this process step. Vapors escaping from the digestors are passed to a packed-bed scrubber to remove fluorides prior to release to the atmosphere. The acid slurry produced in the digestors is separated into a filtrate containing the dissolved Ta and Nb and a sludge stream containing uranium, thorium, and other insoluble feed impurities. The sludge stream is approximately 40% water by weight.

In the planned process modification, 2,310 kilograms per day (5,100 pounds per day) of sludge from the first stage digestors and 17,690 kilograms per day (39,000 pounds per day) of stored sludge generated by past operations would be fed to a second stage digestor. Hydrofluoric and sulfuric (H_2SO_4) acids would be used as the dissolution agents. Like the current process, off-gas would be scrubbed to remove fluorides; dissolved Ta and Nb would be recovered in the liquid phase; and uranium, thorium, and other impurities would form a suspended solid. Solids and liquids would be separated again in a filter press system. In the modified process, the second-stage sludge material would be re-slurried and fed to a sintering kiln heated to approximately 350 °C (660 °F). The kiln off gas would pass through a mist eliminator and packed-bed scrubber before release to the atmosphere.

2.1.1.3 Metal Product Recovery

Tantalum and Nb compounds are recovered from the acid filtrate in a two-stage extraction process. In the first stage, Ta and Nb are extracted from the aqueous phase through contact with methyl isobutyl ketone (MIBK). The aqueous raffinate stream is processed for MIBK recovery. In the second stage, the Ta and Nb compounds are extracted from the organic phase into an aqueous stream which is treated with HF and H_2SO_4 to separate the Ta from the Nb compounds.

Niobium is precipitated from the aqueous stream and ammonia (NH_3) washed to produce diniobium pentoxide (Nb_2O_5), which is calcined in a gas-fired kiln to produce NbO. Separation of Ta is primarily by a crystallization/reduction/heat treatment process. Potassium ion is used to form crystals of potassium fluotantalum (K_2TaF_7), which are reduced by contact with metallic sodium, and heated in an electric furnace to produce Ta powder. The Ta may be packaged and sold or formed into foil, wire, or sheets.

2.1.1.4 Water Supply and Use

The CPM facility uses West Swamp Creek as its primary water source and an on-site water supply well as a secondary water source. Feed water is held in lagoons 3 and 4 before use. A system schematic and approximate water balance are presented in Figure 2.2 and Table 2.1. Water is used for direct process, non-contact cooling, steam generation, and sanitary purposes. Effluent from the sanitary system is pumped to the Berks-Montgomery Municipal Authority Sewer System. There are also discharges to West Swamp Creek and evaporation losses.

Table 2.1 Summary of water usage at the CPM facility

	Consumption		Discharge/Evaporation		
Use	m^3/day	gal/day	m^3/day	gal/day	Discharge Location
Filter Backwash	190	50,000	190	50,000	West Swamp Creek (Discharge 003)
Sanitation	76	20,000	76	20,000	BMMA[a]
Boiler Feed	303	80,000	34	9,000	West Swamp Creek (Outfall 002)
			190	55,000	Evaporation
Non-contact Cooling	511	135,000	322	85,000	West Swamp Creek (Outfall 002)
			189	55,000	Evaporation
Process Use	625	165,000	378	100,000	West Swamp Creek (Outfall 001)
			208	55,000	Evaporation
			39	10,000	in sludge

a. Berks-Montgomery Municipal Authority Sewer System.

Source: Cabot Corporation, "Response to NRC Request for Additional Information," Docket No. 40-6940, August 17, 1995 (Ref. 2).

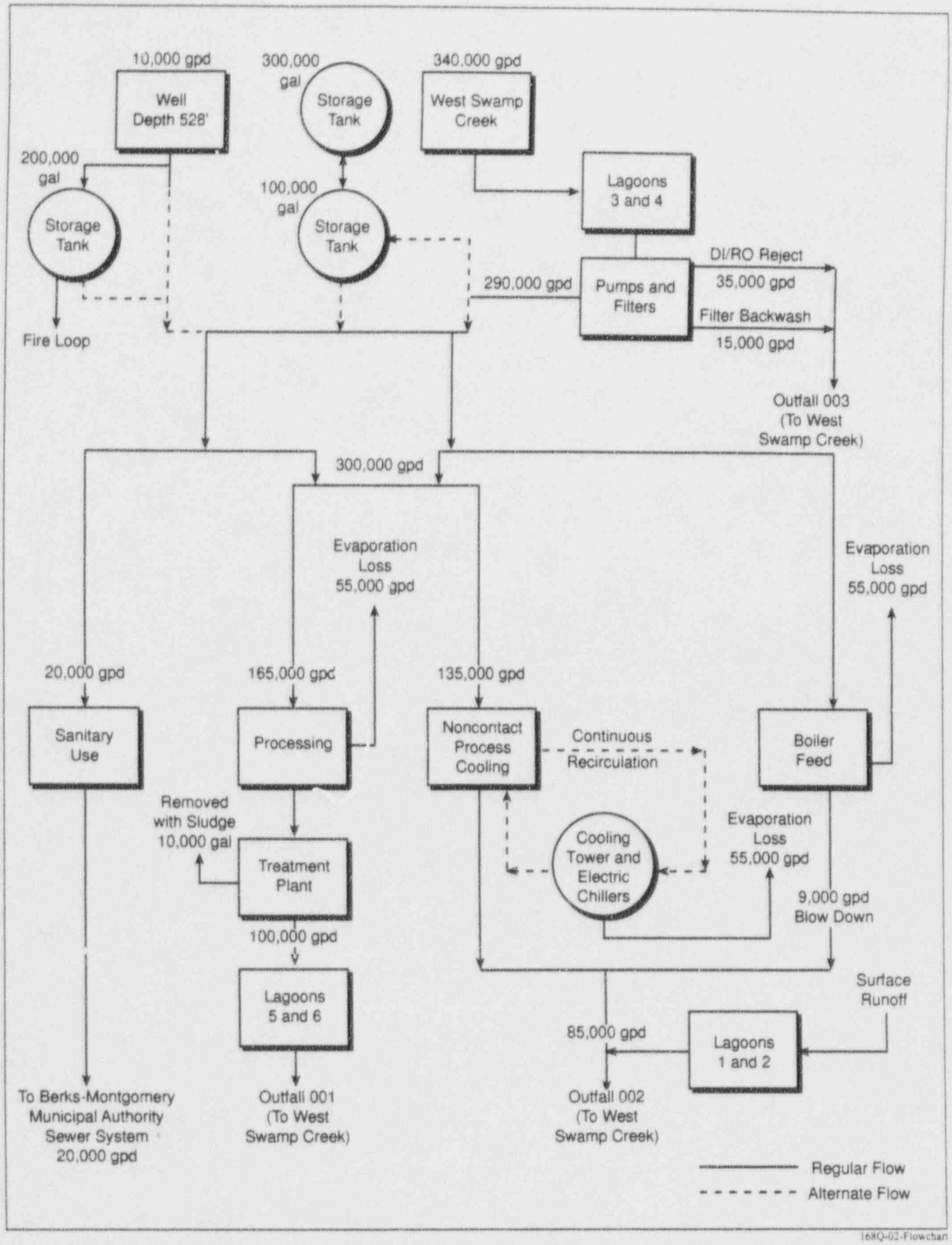


Figure 2.2 CPM facility water distribution diagram

2.1.1.5 Process Chemical Storage

Various acids, bases, and other potentially hazardous chemicals are used in industrial operations at the CPM facility. Chemicals stored in large quantities include HF, H_2SO_4, and nitric acids (HNO_3); NH_3; MIBK; chlorine; fuel oil; and propane as summarized in Table 2.2. Fuel oil, MIBK and acids are stored in tanks as liquids at ambient conditions while anhydrous ammonia, chlorine, and propane are stored as liquids under pressure at ambient temperature. Storage areas are diked, monitored, or provided with absorbent materials as appropriate. The installation Preparedness, Prevention, and Contingency Plan (Ref. 1) provides procedures to prevent spills and to respond to unplanned releases.

Table 2.2 Quantities of stored chemicals

Chemical	Quantity (gallons)[a]	Location
No. 6 Fuel Oil	20,000	Bldg 039
	72,000	Bldg 039
Propane	2,000	Bldg 022
Anhydrous Ammonia	10,000	Bldg 018
Chlorine (lb)	2,000	Bldg 055
	2,000	Bldg 055
Sulfuric Acid (93 wt %)	6,500	Bldg 035
	7,000	Bldg 074
	5,500	Bldg 083
Hydrofluoric Acid (70 wt %)	7,300	Bldg 015
	6,300	Bldg 019
	9.400	Bldg 074
	5,100	Bldg 058
	11,400	Bldg 073
	17,300	Bldg 073

a. To convert gallons to liters, divide by 0.26418.

Source: Cabot Performance Materials, Cabot Corporation, "Renewal Applications: License SMB-920 and License SMC-1562," Docket No. 6940, March 1994 (Ref. 1).

2.1.2 Waste Management Operations

Gaseous, liquid, and solid effluent streams are generated at the CPM facility. This section describes the nature of these streams, current waste management practices, and estimates release rates of source material to the environment.

2.1.2.1 Gaseous Waste Management

Gaseous effluents containing source material and other potentially hazardous chemicals are generated by feed storage and transfer feed grinding and digestion, and by sludge treatment and storage. Potentially haza:..us constituents which may be released to the atmosphere include uranium, thorium, and their decay products, and HF.

Feed Material Releases

Feed ores are stored in a temporary storage pile and in sealed drums and bags. The storage pile is covered with a tarpaulin and is approximately 12 meters long, 6 meters wide, and 1.5 meters high (39 x 20 x 5 feet). Fugitive dust may be released from the pile as ores are added to or removed from the pile. The quantity of emissions varies with the volume of ore transferred to or from the pile, with the ambient wind speed, and with the physical properties of the ore. Correlations for predicting representative emission factors for ore materials have been developed (Ref. 5) and were applied to the CPM conditions. Using a daily feed rate of 5,000 kilograms (11,000 pounds), an annual average wind speed of 2.5 meters per second (8 feet per second), and parameters for taconite ore; an emission factor of 0.0067 grams per kilogram and a total particulate release rate of 10.7 kilograms per year (23.6 pounds per year) were estimated for the temporary storage pile. With an average U_3O_8 and ThO_2 weight content of 0.4 and 0.15 % (Ref. 2), annual average release rates of 1.2×10^{-5} and 1.7×10^{-6} Ci per year were estimated for uranium-238 (U-238) and thorium-232 (Th-232), respectively. Similar quantities of decay products could be released with the parent uranium and thorium. These estimates agree with previous NRC estimates based on different estimation methods (Ref. 4). NRC staff also considered the release of radon gas from sealed drums and bags. Radon would continuously be generated in storage containers and would decay in proportion to the quantity in the container. The radon over-pressure required to balance in-growth with decay is a small fraction of atmospheric pressure (3.5×10^{-7} pascals [3.5×10^{-12} atmospheres]) and therefore is unlikely to cause container leakage. Thus, fugitive emissions from the temporary storage pile are the only significant identified source for release of feed material to the atmosphere.

Grinding Process Particulate Releases

Size reduction in grinding circuits is the initial step in ore processing. The two building 073 grinding circuits are enclosed and equipped with effluent particulate filtration systems. The combined air flow rate through the systems is 5.7 cubic meters per second (12,000 cubic feet per minute) and minimum collection system pressure drops are maintained to ensure efficient removal. The total particulate stack release rate was reported as 4.74 grams per hour (0.0105 pounds per hour) (Ref. 2). Given an average U_3O_8 and ThO_2 weight content of 0.4 and 0.15 % (Ref. 2), annual average release rates of 4.7×10^{-5} and 6.4×10^{-6} Ci per year were estimated for U-238 and Th-232, respectively. Equivalent quantities of each decay product could be released

with the parent uranium and thorium. Hydrogen fluoride in ore-digestor off gas is absorbed in a scrubber system prior to release to the atmosphere. Residual HF released to the atmosphere was reported as 816 grams per hour (1.4 pounds per hour) (Ref. 2).

Stored Sludge Radon Releases

Residual solids from the feed ore digestion process contain most of the uranium and thorium in the feed material. These residual solids are separated from the digestion liquor, producing a sludge by-product. Currently, about 1.6×10^7 kilograms (3.6×10^7 pounds) of sludge with a volume of approximately 1.1×10^4 cubic meters (4.0×10^5 cubic feet) is stored in eight concrete mausoleums located near lagoons 5 and 6. The mausoleums are 3.7 meters (12 feet) tall with 0.2-meter (8-inch) walls covering a total floor area of 5,570 square meters (59,900 square feet) (Ref. 2). Based on feed material and process characteristics, the sludge could contain as much as 1% uranium by weight. Uranium-bearing solids decay, producing gaseous radon which may diffuse through the solid matrix and be released to the atmosphere. The relatively slow diffusion rate and short half-life of radon (3.8 days for Rn-222) reduces the release rate of the gas to the atmosphere. Radon production and release rates can be estimated using activity balances that consider diffusion, decay, and transient accumulation. NRC has recommended using the following relation to predict radon fluxes through earthen materials (Ref. 6):

$$J_t = 1.0 \times 10^4 \times R_t \times \rho_t \times E_t \times \sqrt{(\lambda \times D_t)} \times \tanh[x_t \times \sqrt{(\lambda / D_t)}]$$

where:

J_t = radon flux from tailings pile, $pCi/m^2/s$

R_t = specific activity of Ra-226 in tailings, pCi/g

ρ_t = dry bulk density of tailings, g/cm^3

E_t = radon emanation coefficient for tailings, dim

λ = Rn-222 decay constant, s^{-1}

D_t = diffusion coefficient for radon in tailings pore space, cm^2/s

x_t = thickness of tailings layer, cm

Applying this relation to the sludge volumes and mausoleum dimensions using NRC recommended parameter values (Ref. 6) yields an estimate of 617 Ci per year of radon-222 released to the atmosphere. In the planned process modification, stored and newly generated sludge would be processed into a form suitable for recycling or

off-site disposal. Thus, presently stored sludge inventories provide a reasonable basis for estimating maximum environmental impacts.

2.1.2.2 Liquid Waste Management

Filtrates produced in the feed/sludge digestion and filtration process steps contain low levels of uranium and thorium. These aqueous filtrates are processed through the MIBK extraction and recovery systems and ultimately transferred to the waste treatment system along with non-radioactive effluent streams. The flow rate of the potentially radioactively contaminated stream is approximately 30.3 cubic meters per day (8,000 gallons per day) with a uranium concentration of 8.0×10^{-10} μCi/ml. In addition to radionuclides derived from uranium and thorium, the use of large quantities of potassium (K) salts to precipitate Ta and Nb introduces the naturally occurring beta-emitter, K-40, into the liquid effluent. The total liquid effluent flow rate is approximately 385 cubic meters per day (100,000 gallons per day). Liquid waste treatment consists of precipitating fluoride compounds with lime, transferring the liquid to lagoons 5 and 6, and ultimately discharging to West Swamp Creek through the National Pollution Discharge Elimination System (NPDES) outfall 001. Lagoons 5 and 6 are hypalon-lined with an individual capacity of 4.5×10^4 cubic meters (1.2×10^7 gallons), each underlain by a perforated-pipe leachate collection system. Gross alpha and gross beta concentrations in lagoons 5 and 6, as measured in the underdrains and at outfall 001, are summarized in Table 2.3. On the basis of the above data, annual liquid effluent release rates of U-238, Th-232, U-235, and K-40 are estimated as 1,428; 200; 64; and 660,000 μCi/yr, respectively. Decay daughters are assumed to be released at the same rates as parent radionuclides. Non-radiological characteristics of the outfall effluent are summarized in Table 2.4.

Table 2.3 Summary of liquid effluent radiological characteristics

	Gross Alpha (pCi/L)			Gross Beta (pCi/L)		
Year	Lagoon 5[a]	Lagoon 6[a]	Outfall 001	Lagoon 5[b]	Lagoon 6[b]	Outfall 001
1990	50	43	48	6,250	4,850	5,650
1991	115	100	128	3,850	4,625	4,175
1992	110	170	52	4,975	6,425	5,003
1993	95	52	55	31	18	4,108
1994	215	61	58	58	28	5,025

a. Refer to Figure 4.1 for location of the sampling points.

b. Gross beta concentrations reported for lagoons 5 and 6 for the years 1993 and 1994 do not include the contribution of K-40.

Source: Cabot Performance Materials, Cabot Corporation, "Response to NRC Request for Additional Information," Docket No. 40-6940, August 17, 1995 (Ref. 2).

Table 2.4 Non-radiological characteristics of outfall 001 effluent

Parameter	Value[a, b]		
	Average	Minimum	Maximum
pH	6.95	6.00	8.80
Chloride	4,259.22	1,120.00	7,760.00
Fluoride	16.59	3.00	84.00
Ammonium	34.83	5.46	168.90
Ammonium as Nitrogen	27.05	4.24	131.15
Total Dissolved Solids	13,842.22	1,180.00	18,800.00
Total Suspended Solids	4.45	2.10	12.40
Sulfate	4,222.27	3,260.00	5,130.00
Phosphate[c]	<0.16	<0.15	1.45
Aluminum[d]	<0.27	<0.10	1.23
Magnesium[d]	<0.34	<0.10	1.18
Manganese[d]	<0.13	<0.10	0.28
Zinc[d]	<0.10	<0.10	0.31

a. Data for the period January 7, 1988, through June 27, 1995, unless otherwise noted.
b. All data are concentrations in parts per million by weight except pH.
c. Data are for the period January 6, 1989, through June 27, 1995.
d. Data are for the period January 31, 1992, through June 27, 1995.

Source: Cabot Corporation, "Response to NRC Request for Additional Information," Docket No. 40-6940, August 17, 1995 (Ref. 2).

In addition to aqueous effluents, hazardous waste streams containing ethanol and methyl alcohol are generated at the CPM facility. These wastes are stored in drums and shipped to Ecoflo Corporation in North Carolina for incineration. The average annual production rate for these wastes is approximately 37.9 cubic meters (10,000 gallons).

2.1.2.3 Solid Waste Management

Solid wastes generated at the CPM facility include low-level radioactive waste, filtrate sludge, and miscellaneous non-radioactive trash. A combination of reprocessing, off-site disposal, and recycling are used to manage these wastes.

Low-level radioactive waste is generated at about a rate of 2,310 kilograms per day (5,100 pounds per day), and consists of digestor solids with approximately 1 wt % uranium and thorium. This material is stored on site in the sludge storage mausoleums. Under the planned process modification, newly generated and stored

waste would be processed and dried to a form suitable for off-site disposal as low-level radioactive waste. The projected generation rates for the reprocessed material would be 13,600 kilograms per day (30,000 pounds per day).

Filtrate sludge containing near-background levels of uranium and thorium is generated in the liquid waste treatment system at a rate of 56,700 kilograms per day (125,000 pounds per day). From 1988 through 1992, the uranium and thorium content averaged 5.8 and 3.0 parts per million, respectively. The material was disposed of at the Pottstown landfill.

Non-radioactive waste including disposable and recyclable materials are generated at a combined rate of 6,610 kilograms per day (14,600 pounds per day). Approximately 5,670 kilograms per day (12,500 pounds per day) of wood, fiberglass, packaging, and equipment are disposed of at the Pottstown landfill.

Approximately 940 kilograms per day (2,100 pounds per day) of paper, glass, and scrap metal are recycled through local contractors.

2.2 The No License Renewal Alternative

The alternative of denying the license renewal at the CPM facility implies cessation of ore processing and finished metal manufacturing and commencing D&D. Activities related to D&D are discussed in the following section. Because commercial demand for CPM facility products is likely to remain strong, cessation of production at the CPM facility would imply an increase in production of the same products at another facility with environmental impacts similar to those currently projected at the CPM facility.

2.3 Decontamination and Decommissioning

Before termination of License SMB-920, CPM will decontaminate the facilities to provide for protection of the environment and public health and safety. The objective of decontamination activities is to remediate the site to criteria specified by the NRC so that the site is suitable for unrestricted release and the license can be terminated.

2.4 References for Section 2

1. Cabot Performance Materials, Cabot Corporation, "Renewal Applications: License SMB-920 and License SMC-1562," Docket No. 40-6940, March 16, 1994.

2. Cabot Corporation, "Response to NRC Request for Additional Information," Docket No. 40-6940, August 17, 1995.

3. Cabot Corporation, "Response to NRC Request for Additional Information, Renewal Application dated March 16, 1994," Docket No. 40-6940, February, 1996.

4. U.S. Nuclear Regulatory Commission, "Environmental Impact Appraisal for Renewal of Source Material License No. SMB-920," NUREG-1027, November 1983.

5. U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," Third Edition, Supplement No. 14 PB83-250720, U.S. EPA, Research Triangle Park, North Carolina, May 1983.

6. U.S. Nuclear Regulatory Commission, "Regulatory Guide 3.64: Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," June 1989.

3. AFFECTED ENVIRONMENT

3.1 Site Description

The CPM facility is located on a 78-hectare (193-acre) site on the border of Berks and Montgomery Counties, about 2.4 kilometers (1.6 miles) northeast of the Borough of Boyertown, Pennsylvania (Figure 3.1). The site, on County Line Road about 0.8 kilometers (0.5 miles) from State Route 100, is located in a generally rural area with rolling hills and farmlands. The plant is located in a valley between two ridges. Residences border the plant on the northeast, southwest, and southeast side of the site. The on-site facilities associated with source materials are shown on Figure 1.1. Most of the operations occur on about 18 hectares (44 acres).

The northwestern and southwestern portions of the site are bordered by West Swamp Creek. The nominal river elevation near lagoon 1 and lagoon 2, located immediately adjacent to West Swamp Creek, is about 94 meters (310 feet) above mean sea level. A hill due north of the site rises to an elevation of about 210 meters (700 feet) above mean sea level. Forested areas are located north of the operating areas and along West Swamp Creek on the southwest part of the site.

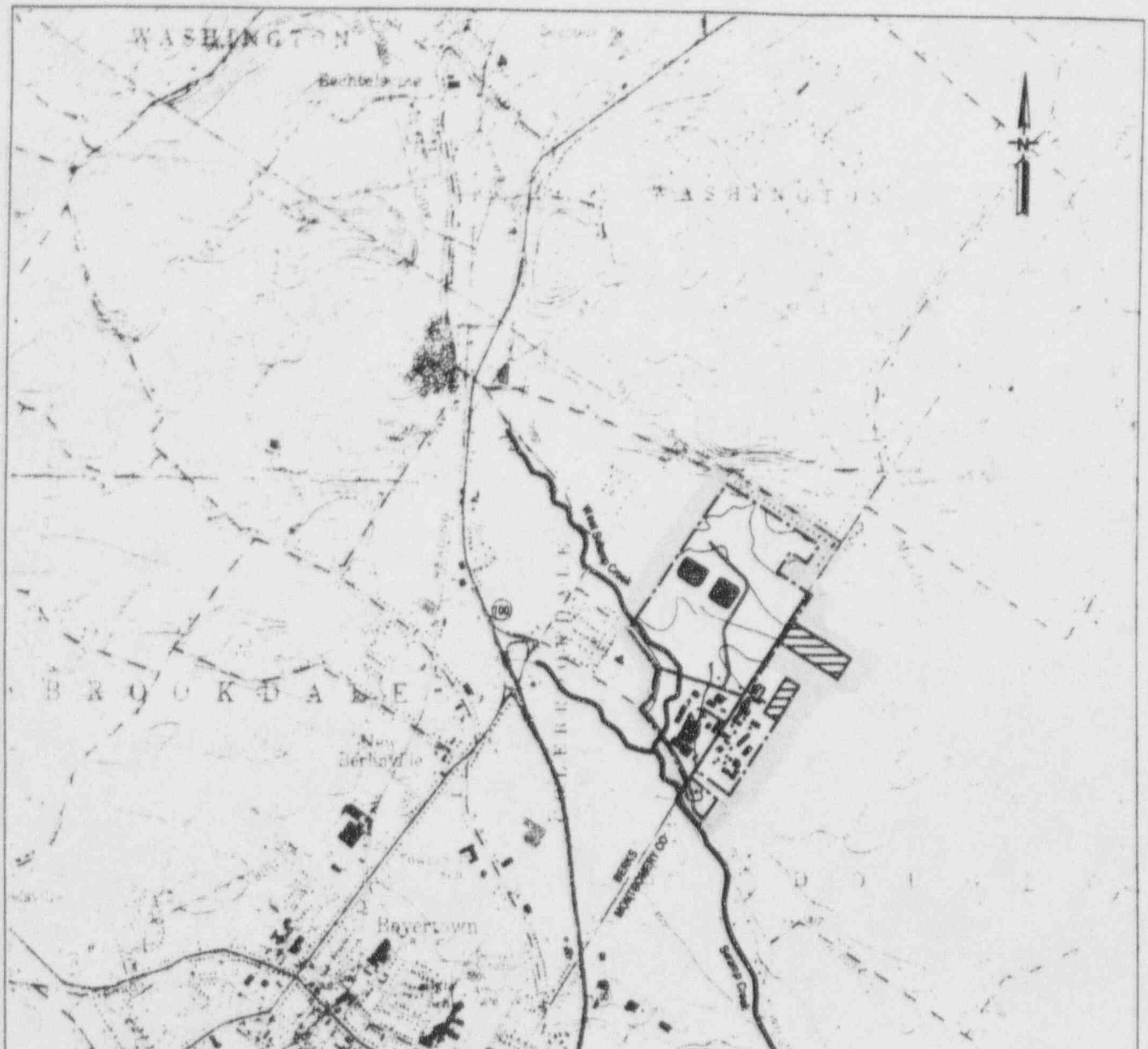
3.2 Climatology and Meteorology

On-site meteorological data are not collected; therefore, data collected at the Limerick Generating Station, about 13 kilometers (8 miles) southeast of the CPM facility, were used to describe the meteorological conditions.

3.2.1 Climatology

The climate of the area is characterized as humid continental with humid summers and moderately cold winters dominated by continental air masses. Temperatures in the area rarely exceed 38°C (100°F) or drop below -17°C (0°F). The mean monthly temperatures from 1972 to 1976 for the Limerick Generating Station are shown on Table 3.1. The maximum temperature recorded during the period of record was 35.7°C (96.2°F) and the minimum was -17.4°C (0.7°F). The annual mean temperature is about 11°C (52°F) based on five years of data collected at the Limerick Generating Station (Ref. 1).

Precipitation at the site is fairly uniform throughout the year as shown in Table 3.2. The annual mean precipitation measured from 1972 through 1976 was 151.3 centimeters (59.57 inches). The maximum hourly precipitation [5.72 centimeters (2.25 inches)] was recorded during hurricane Agnes in June, 1972 (Ref. 1). The maximum monthly total [36.14 centimeters (14.23 inches)] was in November, 1972. The majority of the precipitation at the site has an intensity of less than 0.13 centimeters/hour (0.05 inches/hour), but from 1972 through 1976, hourly totals exceeding 2.54 centimeters (1 inch) were recorded nine times (Ref. 1). The



Explanation:

— · · — Property Boundary

▤ Approximate Area for Forage Sampling

Figure 3.1 CPM facility near Boyertown, Pennsylvania (modified from U.S. Geological Survey, Boyertown quadrangle, 1980, and Sassamanville quadrangle, 1990)

Table 3.1 Means and extremes of monthly average temperature (°F)[a,b]

Month	Monthly Mean	Monthly Maximum	Monthly Minimum
January	31.6	67.9	0.7
February	30.2	67.2	3.4
March	40.8	75.5	11.6
April	51.2	91.5	21.4
May	60.3	88.0	31.1
June	69.0	91.1	40.1
July	73.2	90.9	51.0
August	72.2	96.2	45.1
September	64.5	91.6	36.0
October	53.4	85.2	25.0
November	44.5	80.3	11.8
December	34.5	65.9	5.9
Annual	52	96	0.7

a. To convert from °F to °C, subtract 32 and divide the difference by 1.8.
b. The period of record is 1972-1976.

Source: Philadelphia Electric Company, "Limerick Generating Station Units 1 and 2, Updated Final Safety Analysis Report," Rev. 3, November 1, 1993 (Ref. 2).

mean relative humidity at 7:00 a.m. and 1:00 p.m. are 81 and 57 percent, respectively. The number of heavy fog days [i.e., visibility less than 0.4 kilometer (0.25 mile)] ranges from 25 to 29 days based on data from the Philadelphia and Allentown Airports.

3.2.2 Winds, Tornadoes, and Storms

Winds near the CPM facility are predominantly from the west northwest with an average annual speed of 2.7 meters per second (6 miles per hour) as measured at the Limerick Generating Station. High winds are principally the result of thunderstorms. Hurricanes are rare at an inland site such as the CPM facility. The primary effect from hurricanes passing parallel to the shoreline is increased precipitation from the storms moving inland and dissipating. The fastest mile wind recorded at the regional National Weather Service station in Philadelphia was 25 meters per second (57 miles per hour) in June 1969.

Table 3.2 Climatological data for the Boyertown area, 1972-1976

	Precipitation (inches)[a]				Relative Humidity (%)	
	5-Year Total	Mean	Month	Maximum Hour	Morning (7 a.m.)	Afternoon (1 p.m.)
January	18.09	4.19	6.11	1.22	79	63
February	15.34	3.07	4.39	0.45	76	56
March	23.45	4.89	6.39	0.86	74	54
April	25.75	5.54	8.74	0.55	74	51
May	28.35	5.74	7.63	1.19	80	56
June	38.13	7.78	12.40	2.25	85	60
July	16.16	4.01	7.66	1.90	82	55
August	16.94	3.69	6.29	1.50	84	54
September	25.09	5.39	6.91	1.17	89	59
October	18.91	4.26	6.53	0.55	88	56
November	18.93	4.13	14.23	0.50	82	56
December	28.72	6.64	10.10	0.65	78	61
Annual	273.86	59.57	—	—	81	57

a. To convert inches to centimeters, multiply by 2.54.

Source: Philadelphia Electric Company, "Limerick Generating Station Units 1 and 2, Updated Final Safety Analysis Report," Rev. 3, November 1, 1993 (Ref. 1).

Eighty-five tornadoes landing within an 80-kilometer (50-mile) radius of the Limerick Generating Station were reported for the period from 1950 through 1981 (Ref. 1). An annual frequency of 1.16 tornadoes per year was calculated for a 1 degree square surrounding the Limerick Generating Station, using the statistical methods of Thom. A strike probability of once every 9,179 years for any point within the 1 degree square was calculated using Thom's formula (Ref. 1).

Thunderstorms occur seasonally with 27 and 32 thunderstorm days reported yearly at the Philadelphia and Allentown National Weather Service stations, respectively. Ninety percent of these storms occur between April and September.

3.2.3 Meteorology

Because meteorological conditions are not measured at the CPM facility, data from the Limerick Generating Station were used in the assessment (Ref. 1). The data indicates that winds are from the west through northwest directions approximately 30 percent of the time and relatively evenly distributed over the remaining directions for the balance of the time. Seasonal variations in wind direction are reported to be small.

Wind speeds are less than 3 meters per second (22 miles per hour) approximately 70 percent of the time. Neutral (Class D) and slightly stable (Class E) conditions occur approximately 70 percent of the time with stable (Class F) conditions observed approximately 20 percent of the time. Frequencies of occurrence of wind speed and stability class are summarized in Table 3.3. Annualized morning and afternoon mixing heights are 650 meters (2,132 feet) and 1,500 meters (4,921 feet), respectively (Ref. 3). Annual average concentrations per unit source (χ/Q) based on the joint frequency of meteorological data are presented in Appendix A.

Table 3.3 Frequency of occurrence of wind speed and stability class (percent)

	Average Wind Speed (m/s)[a]					
Stability Class	0.67	2.2	4.2	6.7	9.2	11.9
A	0.2	0.4	0.6	0.3	0.0	0.0
B	0.3	0.9	1.0	0.5	0.1	0.0
C	0.8	1.9	2.2	1.2	0.2	0.0
D	6.8	14.9	11.0	5.3	1.2	0.3
E	12.0	12.1	3.9	1.0	0.3	0.0
F	16.5	1.9	0.1	0.0	0.0	0.0
G	1.8	0.2	0.0	0.0	0.0	0.0

a. To convert meters per second to miles per hour, divide by 0.447.

Source: Philadelphia Electric Company, "Limerick Generating Station Units 1 and 2, Updated Final Safety Analysis Report," Rev. 3, November 1, 1993 (Ref. 1).

3.2.4 Air Quality

The Commonwealth of Pennsylvania has adopted the National Ambient Air Quality Standards and several standards of its own including fluorides and sulfates (see Table 3.4). The standard of concern for the CPM facility in particular is the maximum 24-hour ambient fluoride concentration (as HF) of 5 $\mu g/m^3$. Results of the fluoride sampling are discussed in Section 4.2.1.

The site is located near the boundary of three air basins monitored by the state for the pollutants identified in Table 3.4 and it also lies between Philadelphia and Reading, two industrial areas. Review of the ambient monitoring data for the period from 1985 to 1994 indicates this area has been in attainment for all of the pollutants monitored in the region except ozone (Ref. 2).

Table 3.4 Pennsylvania ambient air quality standards[a]

	Averaging Times						
Pollutants (Units)	1-Hour	3-Hour	8-Hour	24-Hour	30-Days	1-Quarter	1-Year
Carbon Monoxide (ppm)	35		9				
Nitrogen Dioxide (ppm)							0.05
Ozone (ppm)	0.12						
PM-10 Suspended				150			50
Particulates ($\mu g/m^3$)				(150)[b]			(50)[b]
Sulfur Dioxide (ppm)		(0.5)[b]		0.14			0.03
Lead ($\mu g/m^3$)						1.5	
Settleable Particulate (tons/mile^2/month)					43		23
Beryllium ($\mu g/m^3$)					0.01		
Sulfates ($\mu g/m^3$)				30	10		
Fluorides ($\mu g/m^3$) (Total soluble as HF)				5			
Hydrogen Sulfide (ppm)	0.1			0.005			

a. The Commonwealth of Pennsylvania has adopted all of the National Ambient Air Quality Standards.

b. Values represent secondary standards.

Source: Commonwealth of Pennsylvania, "Pennsylvania 1994 Air Quality Report," Department of Environmental Resources, Bureau of Air Quality Control, 2700-BK-DER0407 (Ref. 2).

3.3 Demography and Socioeconomics

The CPM facility is located in a generally rural area of Berks and Montgomery Counties. The incremental and cumulative populations within 80 kilometers (50 miles) of the site are given in Tables 3.5 and 3.6, respectively. The data are provided as a function of direction and distance for a combination of 16 directional sectors and 10 radial distances. The 1990 population within an 80-kilometer (50-mile) radius of the facility is approximately 6,942,333 people, an overall increase of 2.6 percent since the 1980 census. Although the population within a 1.6-kilometer (1-mile) radius of the CPM facility has decreased by 18 percent since 1980, the population within 3.2 to 8 kilometers (2 to 5 miles) radius of the CPM facility has increased the most (about 22 percent), reflecting the growth of nearby towns including Boyertown and Pottstown. CPM-Boyertown employs 362 full-time workers. Although the CPM facility is one of the top 25 major employers in the tri-county area of Berks, Montgomery, and Chester Counties, less than 1 percent of the working population within a 16-kilometer (10-mile) radius is employed at the site. The labor force within a 16-kilometer (10-mile) radius of the site comprises about 69 percent of the total population (Ref. 4). The other major employers in the Borough of Boyertown include the school district, banking, and light industry (Ref. 5).

3.4 Land Use

As noted in Section 3.1, the CPM facility covers about 78 hectares (193 acres) on both sides of County Line road, which separates Berks and Montgomery Counties (Figure 3.1). Of this, 18 hectares (44 acres) are used for operations. A few additional acres are used for ore storage and vehicle parking. The developed portions of the site are generally flat and are bounded on the west by the West Swamp Creek and on the east and south by poorly drained areas (Figure 3.1). The northern-most portion of the site is relatively undeveloped farmland and woods.

3.4.1 Adjacent Area

The CPM facility is located about 11 kilometers (7 miles) north of Pottstown, and about 45 kilometers (28 miles) northwest of Philadelphia. The site is surrounded by agricultural and wooded lands and a few residences. Farming is the dominant land use in the area. Most crops in the immediate area are those used to support dairy herds (i.e., corn, alfalfa, and clover). No state or federal protected areas (e.g., game management areas, refuges, or parks) are located within 8 kilometers (5 miles) of the site, although several residential and business districts are within this area. The business districts contain small manufacturing facilities, shopping centers, schools and churches.

Table 3.5 1990 incremental population data within 80 kilometers (50 miles) of the CPM facility

Direction	Distance in miles[a]									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	136	164	483	334	269	2,298	24,962	33,111	35,464	8,654
NNE	112	156	261	384	1,001	3,272	125,955	147,777	35,990	45,873
NE	35	101	167	234	312	6,037	18,496	79,996	89,816	38,754
ENE	33	101	168	220	292	6,917	28,193	13,399	20,289	62,537
E	34	100	211	316	431	3,884	43,683	51,044	36,837	182,390
ESE	34	100	238	341	438	4,520	70,607	169,068	394,035	340,927
SE	48	308	279	340	436	5,023	55,859	251,832	1,535,614	480,357
SSE	113	562	466	491	689	6,343	53,266	128,645	438,597	75,725
S	140	736	756	1,026	1,439	19,547	17,676	106,920	105,553	330,879
SSW	259	905	715	799	883	20,722	11,282	65,106	27,592	42,957
SW	158	1,906	592	408	521	5,818	7,904	21,426	31,250	34,117
WSW	171	2,035	784	304	385	2,906	22,807	30,292	82,807	174,199
W	153	482	766	402	399	2,280	140,531	41,233	28,136	73,946
WNW	152	383	356	325	376	2,335	22,246	15,010	13,832	17,116
NW	152	240	328	154	169	1,769	17,071	11,486	44,320	51,377
NNW	153	379	533	203	191	2,384	11,347	6,995	30,885	58,040
1990 Total	1,883	8,658	7,103	6,283	8,231	96,055	671,885	1,173,340	2,951,047	2,017,848
1980 Total	2,320	4,834	6,243	7,049	5,987	86,305	630,403	1,089,822	2,971,314	1,961,846
Percent Change	(18)	79	13.7	(10.8)	37.4	11.3	6.5	7.6	(0.6)	2.8

a. To convert from miles to kilometers, multiply by 1.609.

Source: U.S. Department of Commerce, Bureau of the Census, Economic and Statistics Administration, "Summary Tape File 3 on CDROM," 1990 Census of Population and Housing, May 1992 (Ref. 4).

Table 3.6 Cumulative 1990 population data within 80 kilometers (50 miles) of the CPM facility

Direction	Distance in miles[a]									
	0-1	0-2	0-3	0-4	0-5	0-10	0-20	0-30	0-40	0-50
N	136	300	783	1,117	1,386	3,684	28,646	61,757	97,251	105,905
NNE	112	268	529	913	1,914	5,186	131,141	278,918	314,908	360,781
NE	35	136	303	537	849	6,886	25,382	105,378	195,194	233,948
ENE	33	134	302	522	814	7,731	35,924	49,323	69,612	132,149
E	34	134	345	661	1,092	4,976	48,659	99,703	136,540	318,930
ESE	34	134	372	713	1,151	5,671	76,278	245,346	639,381	980,308
SE	48	356	635	975	1,411	6,434	62,293	314,125	1,849,739	2,330,096
SSE	113	675	1,141	1,632	2,321	8,664	61,930	190,575	629,172	704,897
S	140	876	1,632	2,660	4,099	23,646	41,322	148,242	253,795	584,674
SSW	259	1,164	1,879	2,678	3,561	24,283	35,565	100,671	128,263	171,220
SW	158	2,064	2,656	3,064	3,585	9,403	17,307	38,733	69,383	104,100
WSW	171	2,206	2,990	3,294	3,679	6,585	29,392	59,684	142,491	316,690
W	153	635	1,401	1,803	2,202	4,482	145,013	186,246	214,382	288,328
WNW	152	535	891	1,216	1,592	3,927	26,173	41,183	55,015	72,131
NW	152	392	720	874	1,043	2,812	19,883	31,369	75,689	127,066
NNW	153	532	1,065	1,268	1,459	3,843	15,190	22,185	53,070	111,110
1990 Total	1,883	10,541	17,644	23,927	32,158	128,213	800,098	1,973,438	4,924,485	6,942,333
1980 Total	2,320	7,154	13,397	20,446	26,433	112,738	743,141	1,832,963	4,804,277	6,766,123
Percent Change	(18)	47.3	31.7	17	21.7	13.7	7.7	7.7	2.5	2.6

a. To convert from miles to kilometers, multiply by 1.609.

Source: U.S. Department of Commerce, Bureau of the Census, Economic and Statistics Administration, "Summary Tape File 3 on CDROM," 1990 Census of Population and Housing, May 1992 (Ref. 4).

3.4.2 Historic Significance

There are four sites within an 8-kilometer (5-mile) radius of the CPM facility that are listed on the National Register of Historic Places. These facilities are listed in Table 3.7 together with the date of listing. The closest site is about 1.2 kilometers (0.75 mile) west of the CPM facility in New B⁻⁻linville.

Table 3.7 Places listed on the National Register of Historic Places within an 8-kilometer (5-mile) radius of the CPM facility

Site Name	Location	Date Listed
Bahr Mill Complex	Gabelsville, Pennsylvania	11/08/90
Borneman Mill	Bally, Pennsylvania	11/08/90
Dale Furnace and Forge Historic District	Bally, Pennsylvania	9/06/91
Nicholas Johnson Mill	New Berlinville, Pennsylvania	11/08/90

Source: National Register of Historic Places 1966 to 1994 (Ref. 6).

3.4.3 Floodplains and Wetlands

Several wetland areas are located on the site based on review of the National Wetlands Inventory (Ref. 7), although a site-specific wetlands assessment has not been conducted. The wetlands are primarily forested areas of broad-leaved deciduous trees in the West Swamp Creek floodplain. There are two poorly drained open areas on the southeast part of the site that have been mapped as wetlands (Ref. 7).

Portions of the site are located in the 100-year floodplain including lagoons 1, 2, 3, and 4; the settling pond; and building 055. The base flood level next to these facilities ranges from 95 to 96 meters (313 to 315 feet) above sea level (Ref. 8). The ponds are diked to an elevation of about 1.8 meters (6 feet) above the ground surface.

3.5 Hydrology

3.5.1 Surface Water

West Swamp Creek is a relatively small creek which flows along the southern portion of the Cabot site. West Swamp Creek discharges into the Schuylkill River, near Pottstown, which in turn empties into the Delaware River near Philadelphia. The estimated maximum, minimum, and average flow rates of the West Swamp Creek are 48.6 cubic meters per second (1,716 cubic feet per second), 0.0057 cubic meters per second (0.2 cubic feet per second), and 0.48 cubic meters per second (17 cubic feet per second), respectively. The Schuylkill River is an important source of drinking

water to Pottstown and other downstream communities. The average daily flow rate on the Schuylkill River from 1926 to 1969 is estimated as 50.8 cubic meters per second (1,793 cubic feet per second) (Ref. 1). Discharges from the plant's lagoon treatment system to the Creek are regulated under NPDES permit No. 0011266.

3.5.2 Groundwater

The CPM facility has 23 wells: 22 monitoring wells and 1 water supply well. The monitoring wells monitor groundwater quality in three areas on the plant. Five wells are used to monitor groundwater quality in the vicinity of the storage mausoleums; four wells monitor lagoons 5 and 6; and the remaining wells monitor groundwater quality on the downgradient portion of the site near the southern and southwestern boundaries of the facility. The completion depth, depth to water, and screened interval are summarized in Table 3.8.

The five mausoleum monitoring wells (MMWs) installed in 1995 and monitored under the NRC license are completed to an approximate depth of 22 meters (71 feet) in the Brunswick Formation (Ref. 9). The depth to water averages 1 meter (3.5 feet) in the vicinity of the mausoleum monitoring wells. The direction of groundwater flow under the storage mausoleums as well as under the site is generally southwest and mimics the topographic surface (compare Figures 3-2 and 4-2). The transmissivity of the aquifer at about 30 meters (100 feet) was calculated as 767 liters/minute/day (220 gallons/minute/day) based on pump test data collected from the 1985 mausoleum monitoring wells, and the permeability was calculated as 0.09 meter per day (0.3 foot per day) (Ref. 10). The transmissivity is from fractures in the bedrock as indicated by the wells' response to the pump tests. The aquifer has been interpreted as consisting of a semi-confined fractured bedrock system overlain by a water table (Ref. 10).

The four wells that monitor water quality in the vicinity of lagoons 5 and 6 have an average completion depth of 16 meters (53 feet) and the depth to water is about 3.3 meters (11 feet), reflecting the different water-bearing zones being monitored at the storage mausoleums and the lagoons. The monitoring wells on the southwest part of the site (located west of Mill Crest Road) monitor a shallow and deep zone (Table 3.8). The shallow monitored zone extends from about 3 to 15 meters (10 to 50 feet) below the ground surface and the deep monitored zone ranges in depth from about 17 to 27 meters (55 to 90 feet) below the ground surface. However, the average depth to water in both the shallow and deep wells is about 1.6 and 0.9 meters (3.8 and 3 feet), respectively, indicating that these two water-bearing zones may be hydraulically connected.

The water table is in a shallow weathered zone [less than 6 meters (20 feet)] which has significantly lower permeability than the underlying fractured bedrock; therefore,horizontal groundwater flow in the weathered zone is not considered an important pathway (Ref. 10). However, the water table provides recharge to the underlying fractured rock system.

Table 3.8 Summary of groundwater wells at the CPM facility

Well Number	Total Depth (ft)[a]	Depth to Water (ft)[a]	Date Measured	Screened Interval (ft)[a]	Purpose
1A[b]	360	140	unknown	N/A[c]	Monitor sources
2[b]	528	110	unknown	N/A	Monitor sources
3[b]	-10	unknown	-----	N/A	Upgradient well
4[b]	-10	unknown	-----	N/A	Downgradient of lagoons 1,2,3, and 4
MMW-1[b]	73	3.3	12/18/95	43-73	Storage mausoleum monitoring well
MMW-2[b]	75	5.2	12/18/95	44-74	Storage mausoleum monitoring well
MMW-3[b]	74	4.3	12/18/95	45-75	Storage mausoleum monitoring well
MMW-4[b]	75	2.5	12/18/95	45-75	Storage mausoleum monitoring well
MMW-5[b]	70	2.5	12/18/95	40-70	Storage mausoleum monitoring well
90-1S[d]	30.0	3.0	01/29/91	10-30	Evaluate groundwater quality
90-1D[d]	89.5	1.4	01/29/91	69-81	Evaluate groundwater quality
90-2S[d]	34	2.6	01/29/91	21-31	Evaluate groundwater quality
90-2D[d]	86	2.8	01/29/91	56-86	Evaluate groundwater quality
90-3S[d]	37.0	5.6	09/05/95	16-36	Evaluate groundwater quality
90-3D[d]	89.2	6.4	01/29/91	69-89	Evaluate groundwater quality
90-4S[d]	31.6	1.8	01/29/91	12-32	Evaluate groundwater quality
90-5S[d]	30.8	3.5	01/29/91	21-31	Evaluate groundwater quality
90-6S[d]	47	6.7	09/05/95	17-47	Evaluate groundwater quality
90-7S[d]	54	3.5	09/05/95	N/A	Evaluate groundwater quality
95-01[d]	60	14.6	09/05/95	30-60	Upgradient of lagoons 5 and 6
95-02[d]	57	10.3	09/05/95	37-57	Monitor lagoons 5 and 6
95-03[d]	38	10.8	09/05/95	28-38	Monitor lagoons 5 and 6
95-04[d]	60	8.0	09/05/95	40-60	Monitor lagoons 5 and 6

a. To convert feet to meters divide by 3.2808.
b. Well monitored under the NRC license. Refer to Figure 4.1 for monitoring well locations.
c. N/A = not available.
d. Refer to Figure 4.2 for groundwater well locations.

The water supply well (well no. 2) is completed to a depth of 161 meters (528 feet) and the average production rate is 38 kiloliters (10,000 gallons) per day (Ref. 11).

3.6 Geology

The CPM facility is located in the Triassic Lowland section of the Piedmont physiographic province (Figure 3.2). This region is bounded to the southeast by the coastal plain and to the northwest by the valley and ridge province. Each of these provinces are characterized by a unique association of geologic formations. The Piedmont province is an eroded plateau of low relief and rolling topography that is underlain by shales and sandstones at the CPM facility.

3.6.1 Geology and Soils

The site is located in the Newark Basin, part of a series of basins that extend from north-central New Jersey to Maryland and that parallel the northeast-southwest structural trend of the area. The basin is filled with the red shales and sandstones of the Brunswick Formation. In general, the rocks tilt to the north and northwest between 5 and 20 degrees (Ref. 1). These sedimentary rocks have been intruded by igneous dikes and sills.

The major structural features in this region are shown on Figure 3.3. The dominant structure is the Appalachian mountains. Major faults and structures are associated with the development of the mountains. The entire stratigraphic section is faulted although the type of faulting varies depending on the period of time during which it occurred. The most recent faulting occurred 140 - 200 million years ago (Ref. 1). The locus of seismic activity parallels the trend of the geologic structure in the Appalachian mountains.

The monitoring wells installed in the vicinity of the storage mausoleums penetrated about 0.9 meter (3 feet) of soil before encountering red or gray shale of the Brunswick Formation. The soil varied from fine to coarse sand, silt, and gravel to silty clay. The soil associations in this area formed from the weathering of the underlying siltstone and shale in the Brunswick Formation, and the soil can contain coarse fragments. Surface runoff is slow to medium depending on the soil type, and the soils have moderate permeability and moisture capacity (Ref. 12).

3.6.2 Seismicity

The CPM facility is located in a region that has experienced a moderate amount of earthquake activity. The Unified Building Code (1988) has classified the area as seismic hazard zone 2A, which means moderate damage is expected. Almost 60 earthquakes of Modified Mercalli Intensity (MMI) IV-V (i.e., felt by nearly everyone) or greater have been located within 160 kilometers (100 miles) of the site since the

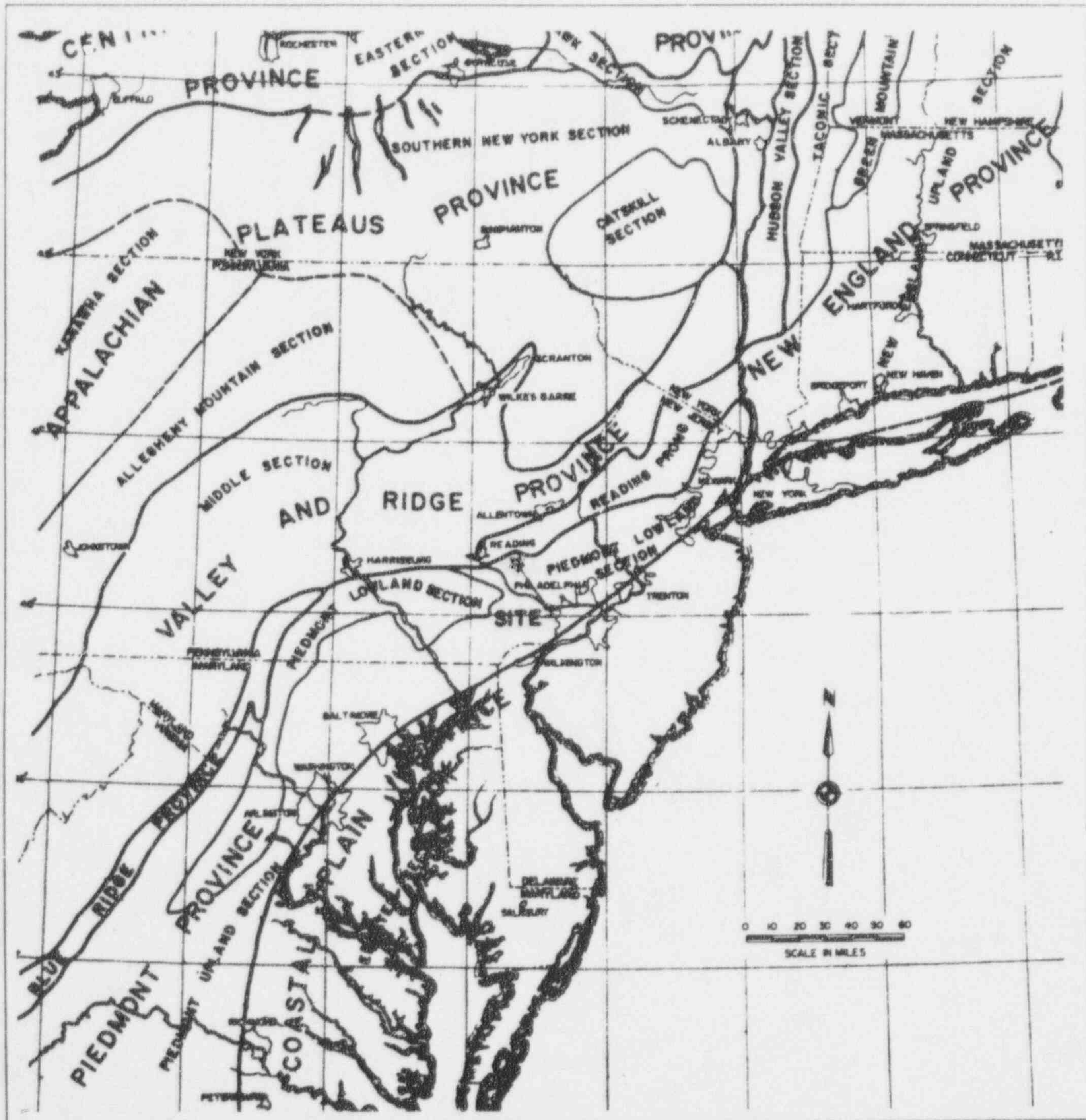
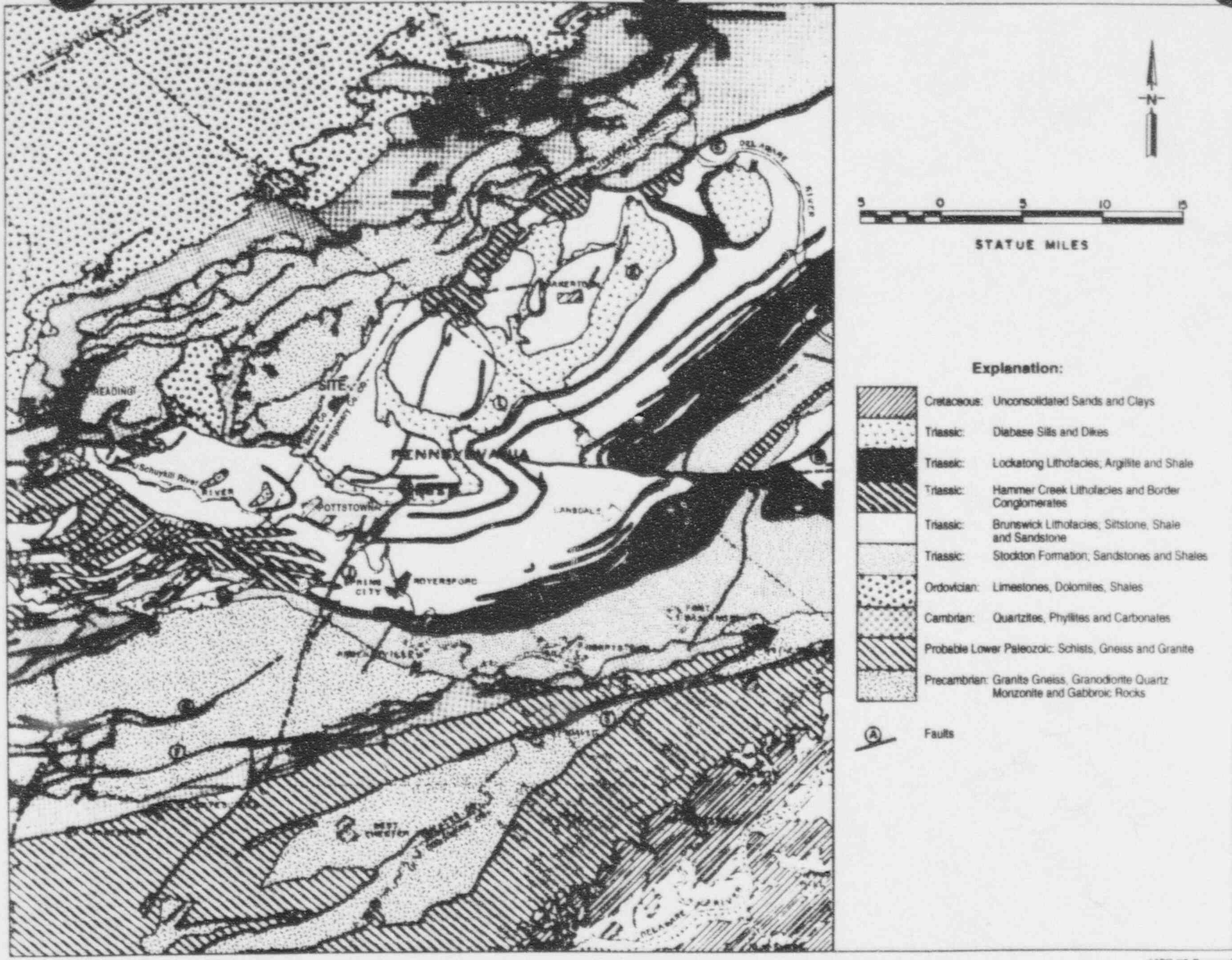


Figure 3.2 Physiographic provinces in the vicinity of the CPM facility (modified from PEC 1993)



168Q-05-Regional

Figure 3.3 Regional geology in the vicinity of the CPM facility (modified from PEC 1993)

early 1700s. The Wilmington, Delaware earthquake of October 9, 1871, was the largest and the only MMI VII-earthquake (i.e., damage to chimneys) to have been recorded in an 80-kilometer (50-mile) radius of the site.

3.6.3 Mineral Resources

No surface or underground mining occurs near the site. A gravel pit is located about 1.9 kilometers (1.2 miles) northwest of the CPM facility (see Figure 3.1). The anthracite coal region is more than 48 kilometers (30 miles) to the north and northwest (Ref. 13).

3.7 Biota

The natural climax vegetation in the region is classified as Appalachian oak forest (Ref. 13). Dominant species include white oak *(Quercus alba)* and red oak *(Q. rubra)*. Other common species include red maple *(Acer rubrum)*, sugar maple *(A. saccharum)*, swamp hickory *(Carya cordiformis)*, and several other species of oak and hickory. The native vegetation of the region has been modified by farming and urban use over the past 200 years. Woodlands in Montgomery County consist mainly of second- and third-growth stands of red oak (60% of the county), ash-maple-elm (19%), eastern red cedar (18%), and sugar maple-beech-yellow birch (3%) (Ref. 13).

No surveys of the vegetation on the site have been conducted. About 30% of the site is covered by plant facilities and the remainder of the site consists of about equal areas of woodlands and open fields. Common trees on and in the vicinity of the site include several species of oak, hickory, maple, elm (*Ulmus* spp.), and ash (*Fraxinus* spp.). The open fields consist of grasslands and crops (primarily corn). Approximately 55 species of reptiles and amphibians, 42 species of mammals, and 176 species of birds range throughout the area, based on literature about the area.

The most common field animals are the eastern cottontail rabbit (*Sulvilagus floridanus*) and ring-necked pheasant (*Phasianus colchicus*). Bobwhite quail (Colinus virginianus), mourning dove (*Zenaidura macroura*), and red fox (*Vulpes*) are also found in this habitat. In the woodland habitats, the gray squirrel (*Sciurus carolinensis*) and red squirrel (*Tamiasciurus hudsonicus*) are common. Raccoons (*Procyon lotor*), opossums (*Didelphis marsupialis*), and striped skunks (*Mephitis*) are also found throughout the woodland habitats. The on-site lagoons are often used by Canada geese (*Branta canadenis*) during migration. Other waterfowl commonly found in the area include mallards (*Anas platyrhynchos*), green-winged teal (*A. carolinensis*), and black ducks (*A. rubripes*).

West Swamp Creek has a fauna and flora characteristic of small warm-water streams. During a May 1967 biological survey of the creek, 12 species of fish were found, including shiners, dace, suckers, chubsuckers, killifish, and sunfish. The major plant species in West Swamp Creek include duckweed, waterweed, mud plantain, arrowhead, and pondweed.

Threatened and Endangered Species

The Commonwealth of Pennsylvania "Natural Diversity Inventory" was reviewed to determine if there are either Federal or State protected species in the area (Ref. 14). Listings from Berks and Montgomery Counties indicated there are three Pennsylvania protected species in the vicinity of the site as summarized in Table 3.9. There are no threatened or endangered plants or animals known to occur on the CPM site.

Table 3.9 Pennsylvania threatened and endangered species in the vicinity of the CPM facility

	Common Name	Scientific Name	Status	Area (Quadrangle)
Animals	Upland Sandpiper	Bartramia longicauda	Threatened	Sassamansville
Plants	Slender Cotton-grass	Eriophorum gracile	Endangered	Sassamansville
	Atlantic Sedge	Carex sterilis	Threatened	East Greenville

Source: Pennsylvania Department of Environmental Resources, "Pennsylvania Natural Diversity Inventory," November 1, 1995 (Ref. 14).

3.8 Radiological Characteristics (Background)

Naturally occurring background radiation in the Boyertown area is from cosmic and terrestrial sources. These sources produce both external and internal doses as described below. The data are derived from National Council on Radiation Protection and Measurement reports (Ref. 15) for the U.S. and Canada.

3.8.1 External Background Radiation

Particles entering the atmosphere from space interact with the atmospheric gases producing gamma- and X-radiation. Radionuclides in the earth also decay producing gamma- and X-radiation (terrestrial sources). The total body doses from cosmic and terrestrial sources are approximately 2.6×10^{-4} and 2.8×10^{-4} Sv/yr (26 and 28 mrem/yr), respectively.

3.8.2 Internal Radiation

Cosmic radiation interacts with gases in the upper atmosphere to produce radionuclides, primarily carbon-14 (C-14), which contribute to internal doses. Radionuclides in soil are also incorporated into the body, introducing a second source of internal radiation. The total body dose from cosmic and terrestrial sources are 1.0×10^{-5} and 4.0×10^{-4} Sv/yr (1.0 and 40.0 mrem/yr), respectively. Radon is an additional highly variable terrestrial source. Average dose rates of 2.4×10^{-2} Sv/yr (2.4 rem/yr) to the bronchial epithelium, or about 3.0×10^{-3} Sv/yr (300 mrem/yr) effective may occur (Ref. 15).

3.9 References for Section 3

1. Philadelphia Electric Company, "Limerick Generating Station Units 1 and 2, Updated Final Safety Analysis Report," Rev. 3, November 1, 1993.

2. Commonwealth of Pennsylvania, "Pennsylvania 1994 Air Quality Report," Department of Environmental Resources, Bureau of Air Quality Control, 2700-BK-DER 0407.

3. Holzworth, G.C., "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," PB-207-203, U.S. EPA Office of Air Programs, January 1972.

4. U.S. Department of Commerce, Bureau of the Census, Economic and Statistics Administration, "Summary Tape File 3 on CDROM," 1990 Census of Population and Housing, May 1992.

5. Tri-County Chamber of Commerce, "Tri-County Area's Top 25 Major Employers," Pottstown, Pennsylvania, August 1995.

6. National Register of Historic Places 1966 to 1994.

7. U.S. Department of Interior, "National Wetlands Inventory," Boyertown Quadrangle, April 1982.

8. Federal Emergency Management Agency, Flood Insurance Rate Map, "Township of Colebrookdale, PA, Berks County," May 1, 1984.

9. Cabot Corporation, "Response to NRC Request for Additional Information, Renewal Application dated March 14, 1994," Docket No. 40-6940, February 1996.

10. Rogers, Golden & Halpern, "Installation of a Dedicated Ground Water Monitoring System," Philadelphia, Pennsylvania, December 1985.

11. Cabot Performance Materials, Cabot Corporation, "Response to Request for Additional Information Regarding License Renewal (TAC No. L10014)," August 17, 1995.

12. U. S. Department of Agriculture, Soil Conservation Service, "Soil Survey Berks County, Pennsylvania," September 1970.

13. U.S. Nuclear Regulatory Commission, "Environmental Impact Appraisal for Renewal of Source Material License No. SMB-920," NUREG-1027, U.S. NRC, Washington, DC, November 1983.

14. Pennsylvania Department of Environmental Resources, "Pennsylvania Natural Diversity Inventory," November 1, 1995.

15. National Council on Radiation Protection and Measurement, "Exposure of the Population in the United States and Canada from Natural Background Radiation," NCRP Report No. 94, Bethesda, Maryland, December 30, 1987.

4. EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM

The CPM facility conducts effluent and environmental monitoring programs to provide a basis for evaluation of public health and safety impacts, for compliance with the NRC license and environmental regulations, and for development of mitigation measures as appropriate. Liquid and solid waste streams are monitored as part of the effluent monitoring program and air, surface water, sediment, and groundwater are monitored as part of the environmental monitoring program as described in the subsections that follow. Forage sampling, performed under the previous license, will not be performed under the renewed license for the reason discussed in Section 5.1.1.

4.1 Effluent Monitoring

The CPM facility generates gaseous, liquid, and solid effluent streams potentially containing radioactive material. Gaseous effluent streams are not monitored for flow rate or radioactive material content.

The liquid waste treatment system generates liquid and solid streams containing radioactive material. The liquid stream is routed to lagoons 5 and 6 for final treatment and released from lagoon 6 through outfall 001 to West Swamp Creek. The water flow rate through the outfall is monitored continuously under the NPDES program. Lagoons 5 and 6 and outfall 1 are sampled quarterly and analyzed for gross alpha and gross beta levels. Action levels for uranium and thorium are 1.1 and 0.11 Bq/L (3.0×10^{-8} and 3.0×10^{-9} μCi/ml), respectively. Actions include re-analysis, investigation and correction of cause, and verification of correction. Minimum detection levels are reported as 0.085 and 0.059 Bq/L (2.3 and 1.6 pCi/L) for gross alpha and gross beta analysis, respectively.

The solid material generated in the liquid waste treatment system is sampled each week for 3 consecutive weeks at the beginning of each quarter. If the analysis indicates a combined uranium and thorium content less than 0.37 Bq/g (10 pCi/g), the material is cleared for release to a landfill. The minimum detection level is reported as 0.037 Bq/g (1.0 pCi/g) for sediment samples.

4.2 Environmental Monitoring Program

CPM conducts an environmental monitoring program that samples sediment and surface water in West Swamp Creek and air and groundwater at locations on or near the facility as summarized in Table 4.1. The frequency of sampling and the constituents sampled as part of this program are also summarized in Table 4.1. The location of sampling points for soil and air are shown on Figure 4.1. The location of the groundwater sampling points are shown on Figure 4.2.

Table 4.1 Summary of environmental monitoring program[a]

Sample Medium	Number of Stations	Analytical Frequency	Sample Type	Type of Analysis
Air	7	Quarterly	Continuous	fluoride
— On Site	6	Quarterly	Continuous	fluoride, gross alpha
— Off Site	1	Semi-Monthly	Continuous	gross alpha
Sediment	3	Quarterly	Composite	gross alpha, gross beta
Groundwater[b]	9	Quarterly	Grab	gross alpha, gross beta, fluoride, chloride, ammonia, pH, total dissolved solids
Surface Water	2	Quarterly	Grab	fluoride

a. Refer to Figures 3.1 and 4.1 for sampling locations.
b. Wells monitored as part of the NRC license.

4.2.1 Air Monitoring

Ambient air is sampled continuously at five locations either located downwind of plant operations or at or near the site boundary. Four of these locations shown on Figure 4.1 are monitored for fluoride and location C (Walker's sampler) on Figure 4.1 is monitored for gross alpha. Composite samples are collected semi-monthly and analyzed for fluoride at locations PT, SW, BH, and EN as shown on Figure 4.1. Composite samples are collected quarterly at location C (Walker's sampler) and analyzed for gross alpha. Two more radiological air samplers were added to the air sampling network as of August 1995 as shown by the solid black circles near County Line Road on Figure 4.1.

The results of the environmental monitoring for fluoride for the period from 1989 through 1994 are shown on Table 4.2. Results of the biweekly sampling for fluoride concentrations from 1989 to 1994 indicate there were 47 excursions above the Commonwealth of Pennsylvania fluoride standard of a maximum 24-hour concentration of 5 $\mu g/m^3$ for fluorides (as HF), indicating fluoride emissions from the plant are contributing to some fluoride contamination of the surrounding environment.

The results from radiological air sampling at location C (Walker's sampler) are summarized in Table 4.2. The highest concentration measured at location C (Walker's sampler) was 0.00515 pCi/m^3 or 0.05 percent of the action level (0.1 pCi/m^3).

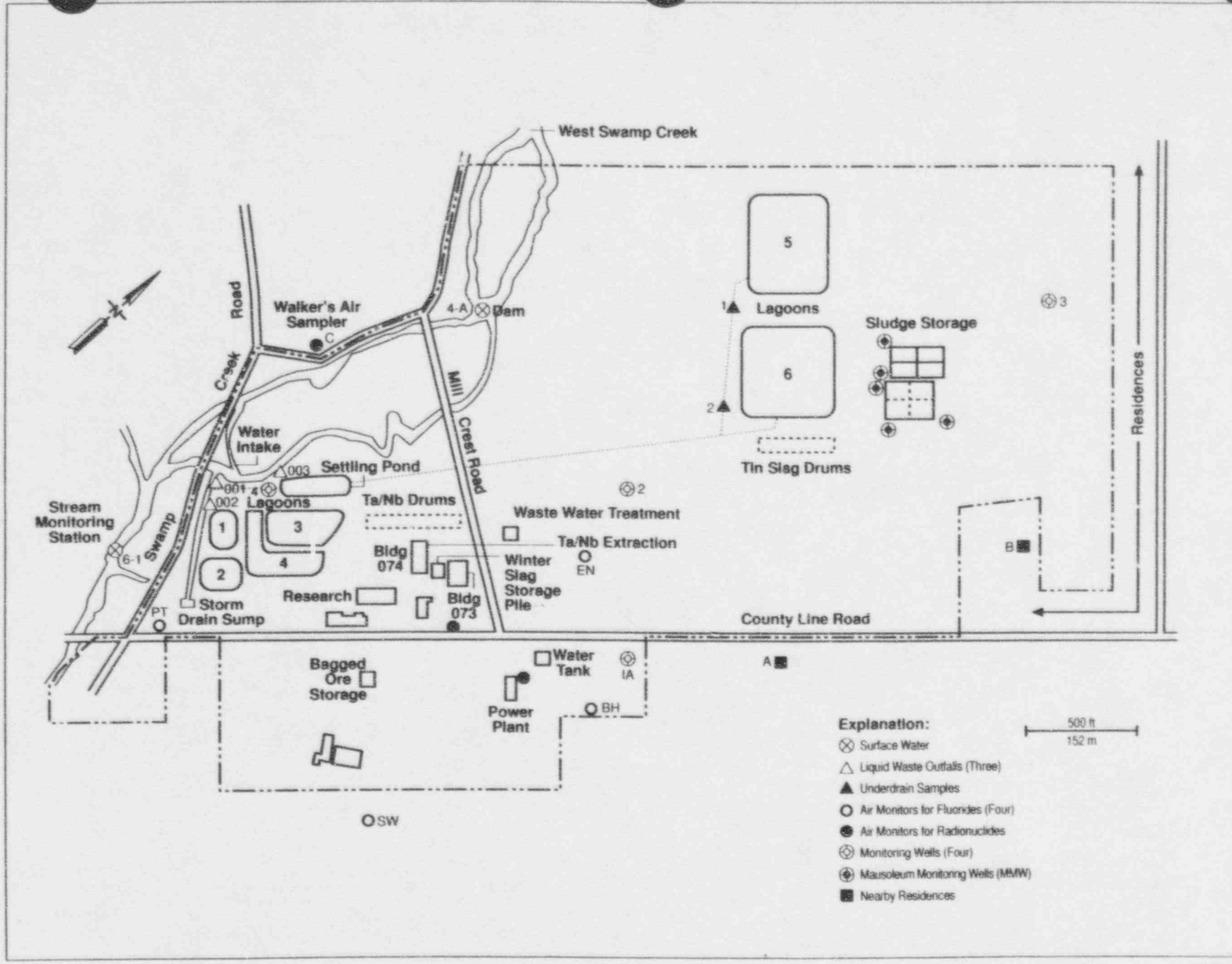


Figure 4.1 Environmental monitoring sample locations for air, surface water, sediment, and forage

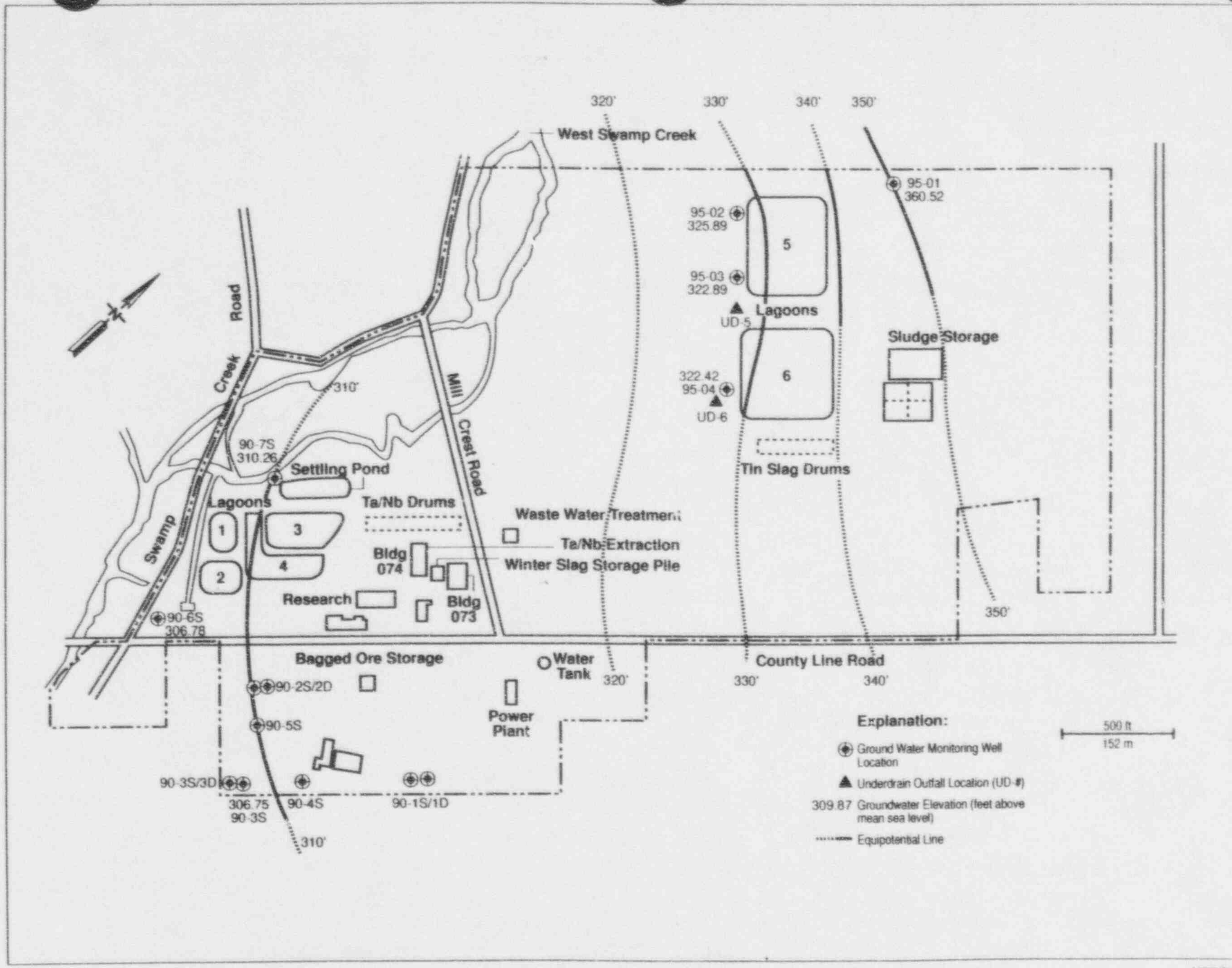


Figure 4.2 Groundwater monitoring locations

Table 4.2 Environmental monitoring for fluoride concentrations ($\mu g/m^3$) in air on or near the CPM facility

	Location			
Year-Quarter	SW	SH	EN	PT
1989-1	4.51	3.06	3.72	2.31
1989-2	1.97	2.68	2.62	1.99
1989-3	2.35	3.76	4.13	1.70
1989-4	3.30	2.63	2.99	2.60
Average	3.03	3.03	3.37	2.15
1990-1	3.14	4.11	6.84	1.95
1990-2	1.31	2.96	3.72	1.30
1990-3	1.03	2.09	2.82	1.20
1990-4	2.56	1.42	1.46	1.31
Average	2.16	2.64	3.71	1.44
1991-1	1.36	1.38	1.16	1.29
1991-2	1.83	3.08	2.51	1.51
1991-3	1.26	2.26	3.04	1.41
1991-4	1.19	1.14	1.43	1.23
Average	1.41	1.96	2.04	1.36
1992-1	1.95	1.88	1.98	2.03
1992-2	2.03	3.14	4.74	1.79
1992-3	2.05	2.85	4.22	2.13
1992-4	1.84	2.20	3.34	2.87
Average	1.97	2.52	3.57	2.20
1993-1	4.02	3.30	6.12	1.80
1993-2	1.76	2.14	3.18	1.67
1993-3	2.30	3.67	2.68	1.85
1993-4	1.62	2.64	2.61	1.60
Average	2.42	2.94	3.65	1.73
1994-1	2.54	3.06	3.27	2.00
1994-2	2.89	3.14	2.94	2.99
1994-3	2.92	3.36	3.70	2.65
1994-4	2.76	2.76	3.56	4.29
Average	2.78	3.08	3.36	2.98

Source: Cabot Performance Materials, Cabot Corporation, "Response to Request for Additional Information Regarding License Renewal (TAC No. L10014)," August 17, 1995 (Ref. 1).

4.2.2 Forage Sampling

Under the previous license, ten samples of forage crops consisting of 6 corn samples and 4 grass samples were collected twice during the harvest season at locations on the east side of County Line Road in the approximate lined area shown on Figure 3.1.

The results of the forage sampling for the period from 1988 to 1993 are presented in Table 4.3 for corn and grass. The results of these analyses indicate that the annual average fluoride concentrations in the forage crops have exceeded the 40 parts per million reporting action level, which has been determined by research to be a level of fluoride in the total ration fed to dairy cows measured seasonally at which dental and bone effects have been observed (Ref. 2). Average background concentrations in the area are about 25 to 30 parts per million (Ref. 2). The values are higher in corn compared to the grasses, because fluoride accumulates in the corn foliage continuously until the end of the growing season; whereas grasses are harvested several times during the growing season (Ref. 2).

4.2.3 Surface Water and Sediment Sampling

Two locations in West Swamp Creek are sampled for surface water and sediment. One location is located 3.6 meters (12 feet) downstream from outfall 001 and the other location is located about 79 meters (260 feet) upstream of outfall 001. The samples are analyzed quarterly for gross alpha and gross beta emitters. The sample results for the period from 1988 through 1993 are shown in Table 4.4.

Review of the surface water data indicates that the gross alpha emitter concentrations remain relatively constant at both sampling locations, upstream and downstream of the 001 outfall, although they are somewhat higher downstream of the 001 outfall. There have been no reported excursions above the 15 pCi/L action level for gross alpha emitters either upstream or downstream of outfall 001. The gross beta emitter concentrations in surface water vary considerably by quarter particularly at the downstream sampling location. The concentration would be expected to vary with the concentration discharged from the 001 outfall and with the flow rate in West Swamp Creek. There has been one excursion above the 50 pCi/L action level for gross beta emitters at the upstream sampling location and 12 excursions above the action level at the downstream sampling location, reflecting the influence of discharges from the plant.

Table 4.4 also shows the results of the sediment sampling for the period from 1988 through 1993. These data show that there is not much variability in the gross alpha emitter concentrations between upstream and downstream sampling locations, and the concentration of gross alpha emitters in sediment is higher at the upstream sampling location in nearly half (10) of the reported results compared to the downstream sampling location. The profile of gross beta emitter concentrations was similar to that reported for gross alpha in that there is no significant distinction between the concentration at upstream and downstream sampling locations. None

Table 4.3 Environmental monitoring results for forage crop sampling (fluoride, ppm)

		Location[a]							Location[a]						
	Date	1	2	3	4	Average		Date	1	2	3	4	5	6	Average
Grass	1988	59.1	69.3	ND[b]	ND	64.2	Corn	1988	92.5	94.6	195.3	175.5	142.4	66.9	127.9
	1989	10.2	37.9	21.5	22.9	23.1		1989	169.0	257.0	242.0	174.0	ND	ND	210.5
	1990	22.7	28.4	28.9	ND	26.7		1990	96.6	92.0	58.3	73.8	8.4	ND	65.8
	1991	34.5	41.5	55.2	62.1	48.3		1991	227.0	146.0	161.0	157.0	100.0	164.0	159.2
	1992	50.0	40.0	56.0	54.0	50.0		1992	177.0	166.0	222.0	174.0	218.0	128.0	180.8
	1993	29.0	40.0	51.0	65.0	46.2		1993	205.0	135.0	147.0	144.0	91.0	150.0	145.3

a. Refer to Figure 3.1 for approximate locations of forage crop samples.
b. ND = No data available for this period.

Source: Cabot Performance Materials, Cabot Corporation, "Renewal Applications License SMB-920 and License SMC-1562," Boyertown, Pennsylvania, March 1994 (Ref. 3).

Table 4.4 Environmental monitoring for gross alpha and gross beta emitters in surface water samples and stream sediment

	Location							
	Upstream				Downstream			
	Alpha		Beta		Alpha		Beta	
Year-Quarter	Water (pCi/L)	Sediment (pCi/g)	Water (pCi/L)	Sediment (pCi/g)	Water (pCi/L)	Sediment (pCi/g)	Water (pCi/L)	Sediment (pCi/g)
1988-1	3.0	10.0	2.0	42.0	5.0	10.0	49.0	54.0
1988-2	1.0	6.7	2.2	45.0	2.0	5.3	2.8	45.0
1988-3	2.0	6.0	7.2	39.0	2.0	7.2	4.9	50.0
1988-4	2.0	11.0	4.8	52.0	3.0	11.0	18.0	51.0
Average	2.0	8.4	4.0	44.5	3.0	8.4	18.7	50.0
1989-1	2.0	5.5	32.0	44.0	2.0	8.7	170.0	53.0
1989-2	2.0	9.1	3.6	47.0	3.0	12.0	68.0	49.0
1989-3	2.0	6.0	2.2	56.0	2.0	6.5	2.0	55.0
1989-4	1.0	5.9	2.8	47.0	1.0	9.3	6.4	49.0
Average	1.8	6.6	10.1	48.5	2.0	9.1	61.6	51.5
1990-1	2.0	6.1	2.0	43.0	3.0	4.0	45.0	40.0
1990-2	1.0	4.7	2.0	39.0	2.0	10.0	80.0	39.0
1990-3	2.0	8.4	4.5	39.0	3.0	6.0	11.0	41.0
1990-4	1.0	6.0	4.3	40.0	2.0	6.0	190.0	42.0
Average	1.5	6.3	3.2	40.2	2.5	6.5	81.5	40.5
1991-1	1.0	12.0	3.2	19.0	3.0	7.5	41.0	41.0
1991-2	2.0	12.9	62.0	45.0	3.0	15.0	160.0	39.0
1991-3	2.0	9.2	5.2	56.0	4.1	4.1	8.9	44.0
1931-4	3.0	21.0	5.0	52.0	4.0	18.0	88.0	55.0
Average	2.0	13.8	18.9	43.0	3.5	11.1	74.5	44.8
1992-1	2.0	20.0	2.0	54.0	3.0	26.0	58.0	59.0
1992-2	2.0	7.1	29.0	57.0	11.0	3.0	150.0	47.0
1992-3	2.0	18.0	6.0	46.0	3.0	12.4	60.0	50.0
1992-4	2.0	18.0	8.0	53.0	3.0	12.4	105.0	56.0
Average	2.0	15.8	11.2	52.5	5.0	13.5	93.3	53.0
1993-1	2.0	10.5	4.5	53.0	3.0	23.0	39.0	53.0
1993-2	4.0	15.0	4.0	45.0	10.0	25.0	480.0	51.0
1993-3	2.0	12.8	11.9	47.0	3.0	5.0	64.0	53.0
1993-4	2.0	9.0	5.0	41.0	4.0	4.0	90.0	41.0
Average	2.5	11.8	6.4	46.5	5.0	14.3	168.3	49.5

Source: Cabot Performance Materials, Cabot Corporation, "Renewal Applications License SMB-920 and License SMC-1562," Boyertown, Pennsylvania, March 1994 (Ref. 3).

of the reported concentrations have exceeded 100 pCi/g, the action level for sediment samples.

4.2.4 Groundwater Monitoring

The groundwater quality is monitored for radionuclides at several areas on the site as shown on Figure 4.2. A series of five wells are used to monitor the groundwater quality in the vicinity of the storage mausoleums as described in Section 3.5.2. The monitoring results for the period from 1988 to 1993 are presented in Table 4.5. The results of this sampling show that the concentration of gross alpha and gross beta emitters has not increased above that measured when the wells were completed in 1985 (Ref. 4). Review of the analytical results for the mausoleum monitoring wells indicates there have been a few excursions above the 15 pCi/L action level for gross alpha (MMW-1 and MMW-3) and one excursion above the 50 pCi/L action level for gross beta emitters (MMW-3) from 1988 to 1993 (see Table 4.6). These excursions are considered to be analytical outliers since there is no consistent pattern of exceedances.

Table 4.6 shows the monitoring results for the remaining four wells monitored by the NRC staff (refer to Table 3.8 for wells monitored under the NRC license). The analytical results collected from monitoring wells 1 through 4 indicate gross beta and fluoride contamination in MW-4. Monitoring well no. 4, completed to a depth of 3.6 meters (12 feet) is located between lagoons 3 and 4 and was contaminated by leakage from the lagoons before they were lined in 1978 (Ref. 5). The fluoride concentrations in MW-1A, MW-2, and MW-3 have been below the 2 ppm action level based on the quarterly monitoring conducted from 1988 to 1993 (Table 4.6). The annual gross beta emitter concentration in MW-4 has ranged from about 24 to 62 pCi/L over the five-year period of record, with 15 excursions above the 50 pCi/L action level. The annual fluoride concentration in MW-4 has ranged from about 3 to 11.5 ppm over the five-year period of record (see Table 4.6).

Table 4.5 Environmental monitoring for gross alpha emitters, gross beta emitters, and fluoride in the mausoleum groundwater monitoring wells

Year-Quarter	Alpha (pCi/L)					Beta (pCi/L)					Fluoride (ppm)				
	MMW-1	MMW-2	MMW-3	MMW-4	MMW-5	MMW-1	MMW-2	MMW-3	MMW-4	MMW-5	MMW-1	MMW-2	MMW-3	MMW-4	MMW-5
1988-1	5.0	5.0	5.0	6.7	5.0	4.1	3.8	6.2	4.9	3.1	0.210	0.290	0.240	0.550	0.270
1988-2	2.0	3.0	5.0	[illegible]	3.0	4.3	6.4	6.1	6.6	5.2	0.200	0.260	0.220	0.440	0.250
1988-3	2.0	4.0	4.0	3.0	3.0	2.2	3.5	3.0	4.2	2.6	0.210	0.290	0.230	0.520	0.230
1988-4	2.0	3.0	3.0	2.0	2.0	4.0	6.2	9.3	5.5	2.0	0.200	0.280	0.270	0.330	0.280
Average	2.8	3.8	4.3	3.4	3.3	3.7	5.0	6.2	5.3	3.2	0.205	0.280	0.240	0.460	0.258
1989-1	3.0	3.0	5.5	3.5	3.0	3.3	5.2	6.3	2.5	2.9	0.150	0.250	0.240	0.330	0.250
1989-2	2.0	2.0	4.0	4.0	3.0	6.2	4.7	6.1	10.0	4.7	0.230	0.280	0.360	0.560	0.320
1989-3	2.0	3.0	5.0	3.0	4.0	4.5	7.0	7.8	12.0	4.4	0.200	0.280	0.370	0.610	0.390
1989-4	3.0	3.0	14.6	8.9	3.0	5.8	6.8	7.3	5.3	2.0	0.300	0.260	0.410	0.490	0.350
Average	2.5	2.8	7.3	4.9	3.3	5.0	5.9	6.9	7.5	3.5	0.220	0.268	0.345	0.498	0.328
1990-1	2.0	2.0	4.0	3.0	3.0	8.5	2.5	6.3	4.7	3.5	0.150	0.250	0.280	0.520	0.270
1990-2	3.0	3.0	5.0	3.0	3.0	4.5	6.3	7.2	7.6	3.8	0.130	0.240	0.370	0.390	0.420
1990-3	3.0	4.0	5.0	3.0	3.0	3.8	4.4	6.2	4.2	2.0	0.140	0.260	0.340	0.430	0.400
1990-4	2.0	2.0	5.0	3.0	1.0	5.7	9.0	9.6	6.7	5.6	0.180	0.310	0.300	0.320	0.400
Average	2.5	2.8	4.8	3.0	2.5	5.6	5.6	7.3	5.8	3.7	0.150	0.265	0.323	0.415	0.373
1991-1	2.0	2.0	3.0	2.0	3.0	2.0	2.3	3.7	2.0	2.0	0.140	0.250	0.330	0.440	0.400
1991-2	3.0	4.0	5.0	3.0	3.0	6.7	6.9	9.1	6.5	4.6	0.130	0.250	0.360	0.420	0.450
1991-3	3.0	3.0	14.5	4.0	4.0	2.0	5.8	8.6	8.1	3.0	0.150	0.260	0.780	0.540	0.460
1991-4	2.0	5.8	9.7	2.0	2.0	5.0	4.6	8.0	2.0	4.6					
Average	2.5	3.7	8.1	2.8	3.0	3.9	4.9	7.4	4.7	3.6	0.140	0.253	0.490	0.467	0.437
1992-1	22.0	4.0	17.0	4.0	8.6	19.0	3.0	52.0	3.0	3.0	0.130	0.350	0.270	0.270	0.650
1992-2	4.0	4.0	26.0	4.0	5.0	11.5	3.0	6.9	3.0	3.0	0.150	0.360	0.360	0.290	0.710
1992-3	2.0	2.0	3.0	2.0	2.0	7.9	3.0	6.1	3.0	5.1					
1992-4	5.4	2.0	4.0	5.7	6.3	7.8	3.0	7.9	3.0	5.5	0.170	0.420	0.410	0.330	0.780
Average	8.4	3.0	12.5	3.9	5.5	11.6	3.0	18.2	3.0	4.2	0.150	0.377	0.347	0.297	0.713
1993-1	3.0	4.0	11.6	4.0	5.0	10.2	5.9	10.3	3.0	7.4	[illegible]	0.406	0.412	0.282	0.997
1993-2	4.0	5.0	5.0	5.0	5.0	11.0	15.0	6.0	5.0	5.0	0.142	0.366	0.448	0.280	1.020
1993-3	4.0	4.0	6.0	4.0	4.0	15.0	3.0	8.4	3.0	3.0	0.156	0.383	0.409	0.238	0.871
1993-4	3.0	3.0	11.7	11.6	4.0	7.4	8.9	8.3	16.0	17.0	0.160	0.390	0.390	0.260	1.000
Average	3.5	4.0	8.6	6.2	4.5	10.9	8.2	8.3	6.8	8.1	0.148	0.386	0.415	0.265	0.972

Source: Cabot Performance Materials, Cabot Corporation, "Renewal Applications License SMB-920 and License SMC-1562," Boyertown, Pennsylvania, March 1994 (Ref. 3).

Table 4.6 Environmental monitoring for gross alpha emitters, gross beta emitters, and fluoride in groundwater monitoring wells

Year-Quarter	Alpha (pCi/L)				Beta (pCi/L)				Fluoride (ppm)			
	MW-1A	MW-2	MW-3	MW-4	MW-1A	MW-2	MW-3	MW-4	MW-1A	MW-2	MW-3	MW-4
1988-1	6.3	10.0	3.0	4.0	3.0	5.0	2.0	57.0	0.30	0.42	0.46	11.0
1988-2	ND[a]	4.0	1.0	3.0	ND	3.0	2.0	63.0	ND	0.34	0.36	5.0
1988-3	ND	7.3	1.0	3.7	ND	7.9	4.0	58.0	ND	0.34	0.16	8.0
1988-4	ND	4.0	1.0	2.0	ND	2.7	2.5	41.0	ND	0.38	0.15	10.0
Average	1.6	6.3	1.5	3.2	0.8	4.7	2.6	54.8	0.08	0.37	0.28	8.5
1989-1	3.0	5.0	1.0	2.0	3.0	52.0	3.4	49.0	0.20	0.26	0.10	12.0
1989-2	4.0	4.0	2.0	3.0	8.2	3.0	1.8	66.0	0.38	0.14	0.18	5.0
1989-3	4.0	4.0	2.0	2.0	2.0	3.0	2.5	25.0	0.10	0.10	0.10	4.0
1989-4	4.8	3.0	1.0	2.0	7.8	5.1	3.7	62.0	0.22	0.38	0.34	13.0
Average	4.0	4.0	1.5	2.3	5.3	15.8	2.9	50.5	0.23	0.22	0.18	8.5
1990-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1990-2	2.0	5.0	2.0	3.0	2.0	2.0	2.0	4.5	ND	ND	ND	ND
1990-3	2.0	5.0	2.0	2.0	2.0	3.0	2.0	44.0	ND	ND	ND	ND
1990-4	2.0	4.0	2.0	2.0	2.3	4.5	3.6	47.0	ND	ND	ND	ND
Average	1.5	3.5	1.5	1.8	1.6	2.4	1.9	23.9	ND	ND	ND	ND
1991-1	2.0	3.0	1.0	1.0	2.0	5.0	3.5	50.0	0.30	0.54	0.92	20.0
1991-2	3.0	5.0	2.0	14.0	3.7	5.4	3.5	66.0	0.24	0.40	0.18	8.0
1991-3	6.6	4.0	2.0	2.0	5.9	4.0	6.8	65.0	0.18	0.36	0.60	10.00
1991-4	3.0	6.0	2.0	3.0	4.5	3.0	2.0	68.0	0.40	0.40	0.28	8.00
Average	3.7	4.5	1.8	5.0	4.0	4.4	4.0	62.3	0.28	0.43	50	11.5
1992-1	2.0	6.0	1.0	1.0	3.0	3.6	2.0	54.0	0.10	0.24	0.10	4.0
1992-2	4.0	8.0	2.0	9.8	10.4	8.2	10.8	89.0	0.10	0.26	0.10	3.0
1992-3	3.0	7.0	2.0	2.0	6.6	3.0	4.5	45.0	0.10	0.18	0.10	2.0
1992-4	8.0	6.0	2.0	2.0	32.0	41.0	6.4	47.0	0.98	0.22	0.10	2.0
Average	4.3	6.8	1.8	3.7	13.0	14.0	5.9	58.8	0.32	0.23	0.10	2.8
1993-1	3.0	3.0	2.0	2.0	3.0	3.0	3.0	53.0	0.12	0.18	0.20	3.0
1993-2	6.0	10.0	9.4	4.0	9.8	56.0	20.0	49.0	0.18	0.32	0.14	2.0
1993-3	3.0	4.0	2.0	2.0	10.9	5.0	4.0	53.0	0.20	0.32	0.28	6.0
1993-4	6.7	6.0	2.0	3.0	5.9	4.8	3.0	6.4	0.42	0.32	0.26	6.0
Average	4.7	5.8	3.9	2.8	7.4	17.2	7.5	40.4	0.23	0.29	0.22	4.3

a. ND = No data available for this period.

Source: Cabot Performance Materials, Cabot Corporation, "Renewal Applications License SMB-920 and License SMC-1562," Boyertown, Pennsylvania, March 1994 (Ref. 3).

4.3 References for Section 4

1. Cabot Performance Materials, Cabot Corporation, "Response to Request for Additional Information Regarding License Renewal (TAC No. L10014)" August 17, 1995 (Ref. 1).

2. Davis, Donald D., "Influence of Fluoride Pollution to Vegetation Growing Near Kawecki - Berylco Industries Boyertown, Pennsylvania," 4th Annual Report, June 1, 1982.

3. Cabot Performance Materials, Cabot Corporation, "Renewal Applications License SMB-920 and License SMC-1562," Boyertown, Pennsylvania, March 1994.

4. Rogers, Golden & Halpern, "Installation of a Dedicated Ground Water Monitoring System," Philadephia, Pennsylvania, December 1985.

5. S.D. Wyngarden, U.S. Nuclear Regulatory Commission, Submittals from Kawecki Berylco, February 27, 1984.

5. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED LICENSE RENEWAL AND ALTERNATIVE ACTIONS

Implementation of the proposed action, renewal of the Cabot license, involves both beneficial and negative impacts. The beneficial impacts include support for production of economically valuable electrical components and the associated negative impact from continued plant operations include releases to air and surface water from plant operation. Implementing either the proposed action or the alternative action, nonrenewal of the license, involves decontamination and decommissioning (D&D) of the facility. Section 5.1 provides an evaluation of the environmental impacts of the proposed action. Section 5.2 presents a discussion of the impacts of the no action alternative.

5.1 Environmental Consequences of Proposed License Renewal

For the proposed action, renewal of the Cabot license, the continued handling of materials and normal operations of the facility will result in the continued release of low levels of hazardous or radioactive constituents. Under accident conditions, the facility could release higher concentrations of materials over a short period of time. This section evaluates the impacts of normal operations and postulated accidents at the CPM facility. The facility will eventually be decontaminated and decommissioned at the end of its useful life, but the impacts of such decontamination and decommissioning are beyond the scope of this environmental assessment. The environmental impacts from normal operations are described in Section 5.1.1 and the impacts from postulated accidents are described in Section 5.1.2.

5.1.1 Normal Operations

Normal operations at the CPM facility will involve groundwater withdrawals, discharges to surface waters, discharges to the atmosphere, and generation of various solid and liquid waste streams. In addition, continued operation of the CPM facility involves employment of personnel at the plant. The impacts of normal operations are discussed below. Nonradiological impacts are discussed in subsection 5.1.1.1 and radiological impacts are discussed in subsection 5.1.1.2.

5.1.1.1 Nonradiological

Air Quality

Normal operation of the CPM facility is not expected to have a significant effect on off-site nonradiological air quality, although fluoride concentrations measured in air have exceeded the State of Pennsylvania 24-hour maximum of 5 $\mu g/m^3$ on occasion (see Table 4.2). State-issued operating permits for processing activities include release limits for compounds of fluorides. CPM is required to monitor and

report fluoride emissions and ambient air fluoride concentrations under its state-issued air quality control operating permit. The State enforces this ambient air concentration at the CPM facility and has taken enforcement action in cases where the limit has been exceeded.

A maximum annual average air fluoride concentration of 0.67 $\mu g/m^3$ was estimated using the licensee fluoride emission estimate of 0.23 grams per second (1.8 pounds per hour) (Ref. 13) and atmospheric dispersion analysis. The dispersion analysis used the XOQDOQ code (Ref. 2) to predict the concentration per unit source (χ/Q) for the maximally exposed individual for elevated building 073 releases as 3.1×10^{-6} s/m^3 in the southeast direction. Continued operation of the plant will contribute to fluoride levels in the air, plants, and soils near the site. The potential impact on Biotic Resources is discussed below.

Water Quality

Surface water quality is protected by enforcement of release limits and monitoring programs as required under the NPDES permit. Annual average concentrations of parameters regulated by the NPDES permit have been below discharge limits established for outfall 001. Discharges are not expected to have significant impact on the surface water quality in West Swamp Creek because of the dilution volume in the creek.

Previous operation of the plant has resulted in localized groundwater contamination from seepage from lagoons 3 and 4 as described in Section 4.2.4. Lagoon liners were installed to mitigate this impact. Groundwater monitoring data of radiological constituents collected since 1988 has not indicated groundwater contamination on other parts of the plant. Therefore, no impact on groundwater is expected from continued operation of the plant.

Land Use

Although the proposed expansion will disturb some land, the construction would occur adjacent to an existing facility in an area previously disturbed. Therefore, continued operation of the plant would be consistent with its current land use.

Biotic Resources

There would be no terrestrial impacts from continued plant operation because no major expansion of existing facilities has been proposed. Therefore, no construction-related impacts that would disturb existing habitat, increase noise, or result in additional traffic are expected.

The primary potential impact on the terrestrial resources is from the nonradiological constituents released to the environment. The effects of these releases were examined in 1982 (Ref. 1), and it was concluded that operation of the facility had resulted in elevated fluoride concentrations in forage crops growing adjacent to the plant. Biannual monitoring of both corn and grasses since 1988 indicates that the annual average fluoride concentration has exceeded the 40 parts per million reporting level required by the previous license for reporting results to the Pennsylvania Department of Environmental Resources and the NRC.

There are no State or federal standards for fluoride concentration in forage. While there has been research in this area, as reported in Section 4.2.2 of this EA, no specific regulatory limits are currently applied to this aspect of the environment. Additionally, there are no federal ambient air quality standards for fluoride. Because the action level for reporting fluoride in forage to the NRC has not been promulgated into a requirement by any federal agency or by the Commonwealth of Pennsylvania, CPM will no longer monitor forage crops for fluoride; however, CPM will continue to monitor fluoride concentrations in ambient air in accordance with Commonwealth of Pennsylvania regulations.

Surface water, sediment, and groundwater monitoring indicate no significant impact from fluoride via these pathways. There has been no increased degradation in off-site vegetation from fluoride since the previous assessment, and the expected releases will be the same as or less than those from previous operations. Therefore, no adverse impacts to the off-site environment are expected from the continued operation of the facility.

Cultural Resources and Socioeconomics

Operation of the CPM facility has not affected regional historic and cultural resources. Continued normal operation of the facility is not expected to have any impact on these resources.

The primary socioeconomic impact of continued operation of the CPM facility is from local employment. Less than 0.5 percent of the employment sector within a 16-kilometer (10-mile) radius of the CPM facility is employed at the site. Continued operation of the plant will have a positive economic impact for those employed there.

5.1.1.2 Radiological Impacts

The radiological impacts of the continued operation of the CPM facility were assessed by calculating the radiation dose to the maximally exposed individual located at the nearest residence and the collective radiation dose to the local population living within 80 kilometers (50 miles) of the plant site. The results and methodology of the dose assessments are summarized in this section, and a detailed description of the methodology is provided in Appendix A.

Throughout this section, the generic term "radiation dose" is used. This term means the total effective dose equivalent (TEDE), which is the sum of (1) the effective dose equivalent (EDE) from exposure to external radiation for a period of one year, and (2) the 50-year committed effective dose equivalent (CEDE) from internal exposure from the intake of radionuclides for a period of one year. The generic term radiation dose may be applied to an individual, in which case it has units of Sv per year (mrem per year), or to populations, in which case it is the collective radiation dose with units of per-Sv per year (person-rem per year).

Potential radiological impacts from the proposed license renewal include release of small quantities of radioactive material to the atmosphere and surface water. Radionuclides which may be released include K-40, U-238, uranium-235 (U-235), Th-232, and their decay daughters, including radon-222. The sources of the releases are the main process building (building 073) stack, the ore storage pile, the sludge storage mausoleums, and the liquid waste system lagoons. Releases to the atmosphere from the building 073 stack and the storage pile are solid particulates; the releases from the storage mausoleums are gaseous radon. Releases to surface water from the lagoons are suspended and dissolved solids. Most of the releases are expected to be in the insoluble oxide and tetrafluoride chemical forms. A description of the nature of these releases and the release rates is presented in Section 2.

Potentially exposed individuals for the atmospheric releases are primarily residents along the northeast and north boundaries of the site. Atmospheric dispersion analysis performed with the XOQDOQ computer code (Ref. 2) established that the maximally exposed individual would be located on the northeast boundary of the site, 915 meters (3,002 feet) from the building 073 stack and 205 meters (673 feet) from the sludge storage mausoleums. Liquid effluents are released into West Swamp Creek, a tributary of the Schuylkill River. Because of its low and irregular flow, West Swamp Creek is not a drinking water supply for area residents. Therefore, the analysis assumed that an individual along the Schuylkill River, and the surrounding population out to a distance of 80 kilometers (50 miles), used this potentially contaminated water.

The radionuclide doses were estimated using the GENII computer code (Ref. 3) except for radon. Atmospheric release exposure pathways included inhalation, ingestion of contaminated crops and resuspended dirt, and external exposure to the airborne plume and contaminated ground. Liquid release exposure pathways included ingestion of contaminated drinking water, fish, and irrigated crops; and external exposure during recreational activities. Because GENII does not simulate radon inhalation impacts, the NRC staff developed independent dose estimates using dose factors specific to radon-222 (Ref. 4). Details on the method of radiological impact analysis are presented in Appendix A.

Atmospheric Pathway Impacts

Potential impacts from releases to the atmosphere from the CPM facility are summarized in Tables 5.1 and 5.2 for the maximally exposed individual and the population, respectively. For particulate releases from building 073 and the ore storage pile, the largest tissue dose is to the bone surface from inhalation of Th-230. For gaseous radon releases from the storage mausoleums, the largest tissue dose is to the lung. For the maximally exposed individual, the CEDEs for combined releases from building 073 and the ore storage pile were estimated as 6.5×10^{-7} Sv/yr (0.065 mrem/yr) while the CEDE for release from the storage mausoleums was estimated as 2.5×10^{-5} Sv/yr (2.5 mrem/yr). External doses are a factor of 10,000 less than internal doses. The doses are a small fraction of background doses for both the maximally exposed individual and other members of the population.

Liquid Pathway Impacts

Potential impacts for the maximally exposed individual and the population from releases to surface water are presented in Table 5.3. The largest tissue doses are to the bone surface from ingestion of lead-210 (Pb-210), and external doses are a factor of 10,000 smaller than internal doses. The CEDE for the maximally exposed individual was estimated as 2.8×10^{-6} Sv/yr (0.28 mrem/yr). For both the maximally exposed individual and other members of the population, doses are a small fraction of background sources.

Cumulative Radiological Impacts

NRC regulations (10 CFR 20.1301) require that the TEDE for members of the public not exceed 1.0×10^{-3} Sv (100 mrem) per year (Ref. 5). For atmospheric releases of radionuclides other than radon, Environmental Protection Agency (EPA) regulations (40 CFR Part 61, Subpart I) require that the annual effective dose equivalent not exceed 1.0×10^{-4} Sv (10 mrem) (Ref. 6). Although not applicable to the CPM facility because it does not process uranium for the production of electric power, EPA regulations (40 CFR Part 190) require that for routine releases, the annual dose equivalent for all pathways not exceed 2.5×10^{-4} Sv (25 mrem) to the whole body, 7.5×10^{-4} Sv (75

Table 5.1 Radiological impacts to the maximally exposed individual from releases to the atmosphere, Sv/yr[a]

	Building 073 Stack	Ore Storage Pile	Mausoleums	Total
Gonads	8.5×10^{-9}	2.2×10^{-9}	2.5×10^{-8}	3.6×10^{-8}
Breast	4.7×10^{-9}	1.2×10^{-9}	3.6×10^{-13}	5.9×10^{-9}
Red bone marrow	3.9×10^{-7}	1.0×10^{-7}	1.5×10^{-7}	6.4×10^{-7}
Lungs	2.6×10^{-6}	6.8×10^{-7}	2.1×10^{-4}	2.1×10^{-4}
Thyroid	4.7×10^{-9}	1.2×10^{-9}	2.7×10^{-8}	3.3×10^{-8}
Bone surface	4.7×10^{-6}	1.2×10^{-6}	9.3×10^{-7}	6.7×10^{-6}
Liver	2.3×10^{-7}	6.0×10^{-8}	-	2.9×10^{-7}
Kidneys	1.3×10^{-7}	3.3×10^{-8}	1.2×10^{-6}	1.4×10^{-6}
Spleen	1.1×10^{-7}	2.8×10^{-8}	-	1.4×10^{-7}
Lower large intestine	1.2×10^{-8}	3.2×10^{-9}	6.2×10^{-10}	1.6×10^{-8}
Upper large intestine	7.1×10^{-9}	1.8×10^{-9}	2.8×10^{-9}	1.2×10^{-8}
Small intestine	-	-	4.7×10^{-9}	4.7×10^{-9}
Stomach	-	-	1.4×10^{-8}	1.4×10^{-8}
CEDE[b]	5.2×10^{-7}	1.3×10^{-7}	2.6×10^{-6}	2.7×10^{-6}
External	6.1×10^{-11}	1.6×10^{-11}	-	7.7×10^{-11}
TEDE[c]	5.2×10^{-7}	1.3×10^{-7}	2.6×10^{-6}	2.7×10^{-6}

a. To convert Sv/yr to rem/yr multiply by 100,000.
b. CEDE = Committed effective dose equivalent.
c. TEDE = Total effective dose equivalent.

Table 5.2 Radiological impacts to the population from releases to the atmosphere, per-Sv/yr[a]

	Building 073 Stack	Ore Storage Pile	Mausoleums	Total
Gonads	2.1×10^{-4}	5.5×10^{-5}	6.7×10^{-5}	3.3×10^{-4}
Breast	8.9×10^{-5}	2.3×10^{-5}	9.8×10^{-10}	1.1×10^{-4}
Red bone marrow	1.3×10^{-2}	3.3×10^{-3}	4.1×10^{-4}	1.7×10^{-2}
Lungs	9.4×10^{-2}	2.4×10^{-2}	5.8×10^{-1}	7.0×10^{-1}
Thyroid	8.9×10^{-5}	2.3×10^{-5}	7.4×10^{-5}	1.9×10^{-4}
Bone surface	1.6×10^{-1}	4.0×10^{-2}	2.5×10^{-3}	2.0×10^{-1}
Liver	5.2×10^{-3}	1.3×10^{-3}	-	6.5×10^{-3}
Kidneys	2.4×10^{-3}	6.1×10^{-4}	3.4×10^{-3}	6.4×10^{-3}
Spleen	2.0×10^{-3}	5.1×10^{-4}	-	2.5×10^{-3}
Lower large intestine	2.1×10^{-4}	5.4×10^{-5}	1.7×10^{-6}	2.7×10^{-4}
Upper large intestine	1.2×10^{-4}	3.2×10^{-5}	7.6×10^{-6}	1.6×10^{-4}
Small intestine	-	-	1.3×10^{-5}	1.3×10^{-5}
Stomach	-	-	3.8×10^{-5}	3.8×10^{-5}
CEDE[b]	1.8×10^{-2}	4.6×10^{-3}	7.0×10^{-2}	9.3×10^{-2}
External	1.4×10^{-6}	1.4×10^{-7}	-	1.8×10^{-6}
TEDE[c]	1.8×10^{-2}	4.6×10^{-3}	7.0×10^{-2}	9.3×10^{-2}

a. To convert Sv/yr to mrem/yr multiply by 100,000.
b. CEDE = Committed effective dose equivalent.
c. TEDE = Total effective dose equivalent.

Table 5.3 Radiological impacts from releases to surface water

	Maximally Exposed Individual (Sv/yr)[a]	Population (per-Sv/yr)
Gonads	7.5×10^{-7}	2.6×10^{0}
Breast	7.1×10^{-7}	2.5×10^{0}
Red bone marrow	3.0×10^{-6}	8.1×10^{0}
Lungs	7.3×10^{-7}	2.5×10^{0}
Thyroid	7.1×10^{-7}	2.5×10^{0}
Bone surface	3.5×10^{-6}	8.4×10^{1}
Liver	9.6×10^{-6}	2.4×10^{1}
Kidneys	4.4×10^{-6}	1.1×10^{1}
Spleen	1.1×10^{-6}	3.9×10^{0}
Lower large intestine	7.7×10^{-7}	2.8×10^{0}
Upper large intestine	7.4×10^{-7}	2.7×10^{0}
CEDE[a]	2.8×10^{-6}	7.5×10^{0}
External	1.2×10^{-8}	8.0×10^{-4}
TEDE[b]	2.8×10^{-6}	7.5×10^{0}

a. To convert Sv/yr to mrem/yr multiply by 100,000.
b. CEDE = Committed effective dose equivalent.
c. TEDE = Total effective dose equivalent.

mrem) to the thyroid, and 2.5×10^{-4} Sv (25 mrem) to any other organ (Ref. 7). Doses from CPM facility operations are dominated by releases to the atmosphere. For the maximally exposed individual, the annual TEDE including dose from radon was estimated as 2.6×10^{-5} Sv (2.6 mrem), well within the limits established by the NRC and EPA. The largest annual tissue dose was estimated as 2.1×10^{-4} Sv (21 mrem) to the lung. While this tissue dose approaches the 40 CFR 190 limit, it is entirely because of releases from the storage mausoleums, which would be eliminated by implementing the planned process modifications. Estimated doses for all other releases are small fractions of applicable limits.

5.1.2 Evaluation of Potential Accidents

The handling, processing, and storage of material containing radioactive constituents at the CPM facility could result in uncontrolled release of radioactive material to the environment in the event of an accident. Use of hazardous chemicals in operations at the facility could also result in uncontrolled releases, posing a potential risk to worker and public health and safety. The relatively small quantities and low concentrations of the radioactive constituents constrain the impacts of potential accidents. The balance of this section describes accident analysis methods and summarizes the results for a representative set of potential accidents.

5.1.2.1 Accident Analysis Methods

The accident analysis identified potential hazards, reviewed potential accident initiators and release mechanisms, developed accident scenarios, and estimated consequences for a set of potential accident scenarios. The analysis is based upon the inventory, equipment, and process descriptions presented in the license application (Ref. 8) and in previous NRC analysis (Ref. 9). The hazard review identified the primary hazards as radionuclides in the feed material, process equipment, and sludge storage mausoleums, and the hazardous chemicals stored on site as shown in Table 2.2. For radioactive material in solid form, the primary release mechanisms would be drop and resuspension during transfer, and failure of the filtration systems during processing. For radioactive material in liquid solution, the primary release mechanism would be equipment failure during processing and transfer. Because all buildings and process areas have floor drains connected to process or storage tanks, small-scale spills would likely be completely contained. The failure of storage equipment is the scenario with the largest potential impact for hazardous chemicals.

The NRC has provided guidance in Regulatory Guide 1.145 (Ref. 10) for estimating concentrations of materials released to the atmosphere per unit source (χ/Q) for accident conditions. Airborne contaminant concentrations were estimated consistent with procedures in this guidance. The predicted concentrations were those expected to occur less than 5 percent of the time. Dose factors for both air and water

pathways were estimated using the GENII computer code (Ref. 3) described in Appendix A.

5.1.2.2 Accident Evaluations

Based on the above considerations, a feed ore spill during transfer, a large-scale leak of treated liquid radioactive waste, and release of anhydrous ammonia from tank storage were selected as representative accidents. Consequences for these events are summarized in the following paragraphs.

Feed Ore Spill

Feed ore is transferred to process equipment from a storage pile located near building 073. Equipment failure or improper operation could lead to inadvertent dumping of the load. The typical capacity of a front-end loader was estimated as 0.5 cubic meters (17.7 cubic feet) or 850 kilograms (1,870 pounds). Previous NRC analysis established that the fraction of spilled material that becomes airborne after a drop event correlates with gravitational energy (Ref. 11). For a drop of 1 meter (3.3 feet), the amount of airborne material was estimated to be 58.6 grams (0.13 pounds). For the maximum estimated ore uranium and thorium content, this corresponds to a release of 0.066 and 0.009 μCi of U-238 and Th-232, respectively. Based on dispersion analysis, the maximally exposed individual would be 205 meters (673 feet) northeast of building 073 and the χ/Q value occurring lers than 5 percent of the time would be 0.003 s/m^3. The CEDE for this release was estimated as 4.0 x 10^{-7} Sv (0.04 mrem), indicating insignificant risk to public health and safety.

Treated Liquid Waste Spill

Approximately 30,280 liters (8,000 gallons) of liquid radioactive waste are processed daily at the CPM facility. Radionuclides are removed as filtered solids during processing, and the resulting liquid is mixed with other liquid streams to generate an overall average daily flow of approximately 378,500 liters (100,000 gallons). The largest capacity tank in the system is a 378,500-liter (100,000 gallon) tank for storing treated liquid. Failure of this tank with release to surface water bounds potential accidents associated with the waste treatment system. The released liquid would be diluted in West Swamp Creek and the Schuylkill River, and the maximally exposed individual could receive a CEDE of 5.8 x 10^{-9} Sv (5.8 x 10^{-4} mrem). This dose is a very small fraction of normal background radiation, indicating insignificant risk to public health and safety.

Release of Anhydrous Ammonia

Ammonia is stored under pressure as a liquified gas in a 37,850-liter (10,000 gallon) tank located on the southeast side of County Line Road. Failure of a transfer or relief

line could cause an uncontrolled release with potential health and safety impacts. This event was represented as development of a 2.5-centimeter (1 inch) diameter hole in the tank vapor space, with isentropic escape through the hole. At a storage temperature of 27 °C (80 °F) and a pressure of 1.05 megapascals (153 pounds per square inch), liquid density would be 0.6 grams per milliliter (37.5 pounds per cubic feet) (Ref. 12) and the tank could contain as much as 22,700 kilograms (50,000 pounds) of ammonia. Under these conditions, the release rate was estimated, based on mass and momentum balance principles (Ref. 13), as 930.0 grams per second (2.05 pounds per second). The release time with no operator response could be as long as 6 hours. Dispersion analysis established that the maximally exposed individual would be located 330 meters (1,083 feet) north-northeast of the release point and that the χ/Q occurring less than 5 percent of the time would be 0.0012 seconds per cubic meter. Ambient ammonia concentrations were estimated as 1.3 grams per cubic meter (930 parts per million) at the location of the maximally exposed individual. This is less than the potential lethal concentration of 1000 parts per million for long-term exposures. The potential for ammonia release to occur for an extended period of time is unlikely, because CPM would take response actions in accordance with their Preparedness, Prevention, and Contingency Plan. In addition, since individuals could reduce their exposure by leaving the plume area, the expected dose to an individual should be less than 200 parts per million, which has only a transient irritation effect (Ref.14).

5.2 Impacts of the No License Renewal Alternative

If the license to continue plant operations were not renewed, the facility would move into the D&D phase. Cabot would do a thorough survey of the site grounds and buildings and prepare a detailed D&D plan. This plan would include areas where source material was either handled or managed including building 073, the ore storage piles, the sludge storage mausoleums, and the lagoons. The plan would also identify the potential off-site shipment of low-level waste and disturbance of potentially contaminated soils.

It is expected that the D&D activities would result in the release of small amounts of activity to the atmosphere and to West Swamp Creek. Specific estimates of the quantities and doses associated with these activities are not available, but it is expected that the impacts would be similar to those associated with current operation.

After the site was decontaminated, decommissioned, and released for unrestricted use, there could be a negative socioeconomic impact from termination of the manufacturing operations.

5.3 References for Section 5

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6. *U.S. Code of Federal Regulations,* "Emission Standards for NRC Licensed Facilities," Part 61; Title 40, "Environmental Protection."

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6. REGULATORY CONSULTATION

During the preparation of the EA, various state agencies were contacted for gathering information. The nature of these contacts is summarized in Table 6.1.

Table 6.1 Information consultations

Agency	Point of Contact	Date of Consultation	Purpose for Consultation
Commonwealth of Pennsylvania, Tri-County Area Chamber of Commerce		September 29, 1995	Obtain employment data for the Boyertown area
Commonwealth of Pennsylvania, Department of Conservation and Natural Resources	Ed Dix	October 6, 1995	Obtain records of occurrence for threatened and endangered species reported to the Pennsylvania Natural Diversity Inventory
Commonwealth of Pennsylvania, Department of Environmental Protection	Jim Rebarchak	July 30, 1996	Obtain information on state regulation of fluoride emissions
Commonwealth of Pennsylvania, Registry of Historic Places	Patrick Andrus	October 2, 1995	Obtain updated information on cultural resources

APPENDIX A
METHODS FOR ASSESSMENT OF RADIOLOGICAL IMPACTS

This appendix describes the radiological impact and environmental pathway models used in this environmental assessment. Radionuclides released from the CPM facility could travel through the environment and potentially cause adverse impacts to members of the population around the plant. These impacts were assessed by estimating of the amount of material leaving the facility, the rate of travel and change in concentration as the material moved through the environment, and by developing an estimate of the potential harm given contact with individuals. The estimate of material released from the facility was described in Section 2 and is presented on a radionuclide-specific basis in Table A.1. The rate and dispersion of material moving through the environment was estimated using mass balance models similar to those recommended by the NRC in Regulatory Guide 1.109 (Ref. 1). The potential for harm was assessed using methods developed by the International Commission on Radiological Protection (ICRP) (Ref. 2 and Ref. 3).

A.1 Radiological Impact Models

Radionuclides can cause harm by depositing energy generated during decay in the various body tissues. External radiation is energy deposited in the body by radionuclides outside the body, while energy deposited in the body by radionuclides within the body is referred to as internal radiation. External radiation only causes harm during the period of immediate exposure, while inhaled or ingested radionuclides continue to deposit energy over later periods of time. The ICRP models used for this assessment (Ref. 2 and Ref. 3) represent bodily tissues as compartments capable of retaining and exchanging material. The time dependent rate of energy deposition in tissues was estimated by simultaneous solution of a set of differential mass and energy balances formulated for each body tissue and each radionuclide. The amount of energy deposited in a unit mass of tissue, corrected for effectiveness of the energy, is termed equivalent dose. The risk-weighted sum of tissue equivalent doses is termed effective dose equivalent (EDE) and the summation of EDE over time is referred to as committed effective dose equivalent (CEDE). The sum of internal CEDE and external dose is termed total effective dose equivalent (TEDE). Dose factors for external and internal doses for all radionuclides except radon were calculated using the GENII computer code (Ref. 4). Because GENII does not estimate radon dose factors, models specifically developed for the NRC (Ref. 5) were used to estimate impacts for this radionuclide. Radionuclides considered in the analysis included K-40, U-238, U-235, Th-232, and their decay daughters. The factors used to estimate internal and external doses are summarized in Table A.2.

Table A.1 Radionuclide release rates for atmospheric and liquid effluents

	Release Rates (μCi/yr)			
	Atmospheric Sources			
Radionuclide	Building 073	Storage Pile	Storage Mausoleums	Liquid Source
K-40	-	-	-	660,000
U-238	47.1	12.2	-	1428
Th-234	47.1	12.2	-	1428
U-234	47.1	12.2	-	1428
Th-230	47.1	12.2	-	1428
Ra-226	47.1	12.2	-	1428
Rn-222	47.1	12.2	617	1428
Pb-210	47.1	12.2	-	1428
Bi-210	47.1	12.2	-	1428
Po-210	47.1	12.2	-	1428
Th-232	6.4	1.7	-	200
Ra-228	6.4	1.7	-	200
Ac-228	6.4	1.7	-	200
Th-228	6.4	1.7	-	200
Ra-224	6.4	1.7	-	200
Pb-214	6.4	1.7	-	200
Bi-212	6.4	1.7	-	200
U-235	2.2	0.6	-	64
Th-231	2.2	0.6	-	64
Pa-231	2.2	0.6	-	64
Ac-227	2.2	0.6	-	64
Th-227	2.2	0.6	-	64
Ra-223	2.2	0.6	-	64

Table A.2 Committed effective dose equivalents over 50 years per unit intake of activity

Radionuclide	Dose Conversion Factor (Sv/Bq) Inhalation	Ingestion
K-40	3.2×10^{-9}	4.8×10^{-9}
U-238	3.2×10^{-5}	6.5×10^{-9}
Th-234	9.5×10^{-9}	3.6×10^{-9}
U-234	3.6×10^{-5}	7.2×10^{-9}
Th-230	7.0×10^{-5}	1.4×10^{-7}
Ra-226	2.2×10^{-6}	2.6×10^{-7}
Rn-222	7.6×10^{-11}	-
Pb-210	3.2×10^{-6}	1.3×10^{-6}
Bi-210	5.3×10^{-8}	1.6×10^{-9}
Po-210	2.1×10^{-6}	3.5×10^{-7}
Th-232	3.1×10^{-4}	7.6×10^{-7}
Ra-228	1.1×10^{-6}	2.3×10^{-7}
Ac-228	3.5×10^{-8}	5.8×10^{-10}
Th-228	9.3×10^{-5}	1.1×10^{-7}
Ra-224	8.1×10^{-7}	3.5×10^{-8}
Pb-212	4.7×10^{-8}	1.3×10^{-8}
Bi-212	5.4×10^{-9}	3.0×10^{-10}
U-235	3.4×10^{-5}	7.3×10^{-9}
Th-231	2.3×10^{-10}	3.6×10^{-10}
Pa-231	2.3×10^{-4}	2.9×10^{-6}
Ac-227	3.4×10^{-4}	3.8×10^{-6}
Th-227	4.4×10^{-6}	1.0×10^{-8}
Ra-223	2.3×10^{-6}	7.2×10^{-8}

A.2 Environmental Pathway Models

A schematic representation of the potential paths radionuclides may follow through the environment is shown in Figure A.1. As indicated in Figure A.1, transport through the atmosphere and through surface water occur by different mechanisms; therefore, different exposure modes may be involved. The models used to estimate impacts for each release mode are described below.

A.2.1 Atmospheric Pathways

Radionuclides released to the atmosphere are dispersed by wind and transported to potential receptors. Radionuclide concentrations are reduced during transport by mixing and decay, and deposited on plant and ground surfaces. The atmospheric dispersion model in the XOQDOQ computer code (Ref. 6) was used to estimate radionuclide concentrations in the atmosphere. The XOQDOQ model implements NRC guidance (Ref. 7) by using a Gaussian plume dispersion model and the joint frequency of occurrence of wind velocity, stability class, and direction to estimate annual average concentrations per unit quantity of material released (χ/Q). Because site specific data are not available for the CPM facility, meteorological data from the Limerick Generating Station, located 13 kilometers (8 miles) southeast of the CPM facility, were used in the analysis (Ref. 8). The estimated annual average χ/Qs are presented in Table A.3 for 10 radial distances and 16 compass directions centered on the sludge storage mausoleums at the CPM facility. The estimated release rates for the facility combined with the atmospheric dispersion modeling, established that the maximally exposed off-site individual for atmospheric pathways would be located 915 meters (3,003 feet) north-northeast of building 073 and 205 meters (672 feet) east of the sludge storage mausoleums.

The exposure pathways analyzed included inhalation of potentially contaminated air, ingestion of crops potentially contaminated by deposition from air, ingestion of animal products fed with potentially contaminated crops, ingestion of resuspended soil contaminated by deposition, and direct exposure from the airborne plume and from ground potentially contaminated by deposition from the air. The exposure rates for these pathways were estimated using the GENII computer code (Ref. 4), which implements pathway distribution models similar to those recommended by the NRC (Ref. 1). The major parameters analyzed were derived from NRC guidance and are summarized in Table A.4. In addition to the maximally exposed individual, impacts were estimated for the population surrounding the CPM facility out to a distance of 80 kilometers (50 miles).

Greater than 90 percent of the estimated dose from the atmospheric pathway for each individual occurred through inhalation of potentially contaminated air. For this exposure mode, air radionuclide concentrations were estimated as the product of χ/Q and the radionuclide release rate. The inhaled amount was estimated as the product of radionuclide concentration and breathing rate, while the dose was estimated as the

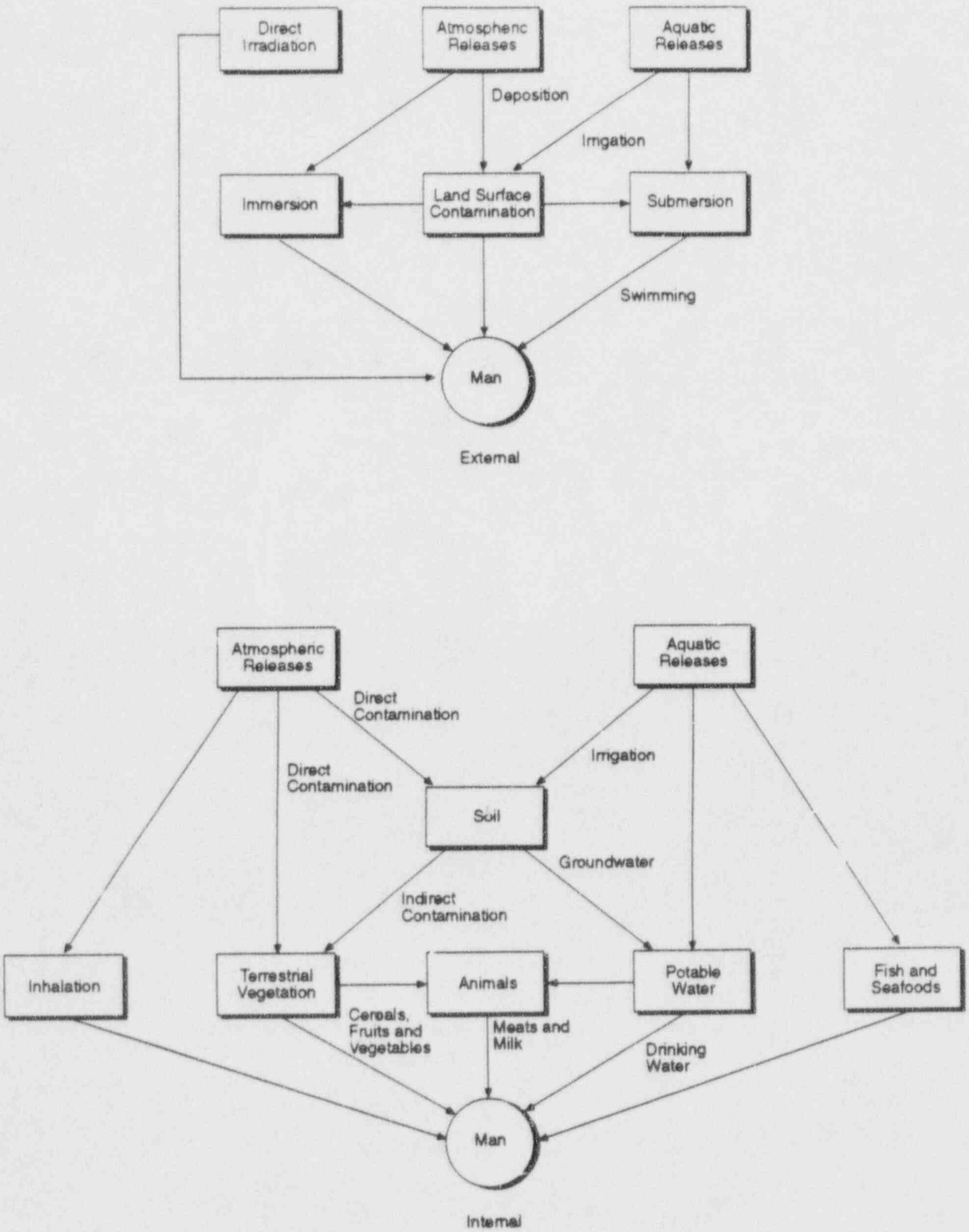

Figure A.1 Pathways for exposure to man from external sources (upper diagram and from intake of radionuclides released to the environment (lower diagram)

Table A.3 Annual average concentrations per unit source term (X/Q) for releases from the sludge storage mausoleums (s/m^3)[a]

	Distance (km)[b]									
Direction	0 - 1.6	1.6 - 3.2	3.2 - 4.8	4.8 - 6.4	6.4 - 8.0	8.0 - 16.0	16.0 - 32.0	32.0 - 48.0	48.0 - 64.0	64.0 - 80.0
N	8.2×10^{-6}	1.3×10^{-6}	5.9×10^{-7}	3.6×10^{-7}	2.5×10^{-7}	1.2×10^{-7}	4.5×10^{-8}	2.3×10^{-8}	1.4×10^{-8}	1.0×10^{-8}
NNE	6.4×10^{-6}	1.0×10^{-6}	4.6×10^{-7}	2.8×10^{-7}	1.9×10^{-7}	9.3×10^{-8}	3.6×10^{-8}	1.8×10^{-8}	1.1×10^{-8}	8.1×10^{-9}
NE	6.2×10^{-6}	9.8×10^{-7}	4.5×10^{-7}	2.8×10^{-7}	1.9×10^{-7}	9.3×10^{-8}	3.6×10^{-8}	1.8×10^{-8}	1.2×10^{-8}	8.3×10^{-9}
ENE	6.3×10^{-6}	9.9×10^{-7}	4.6×10^{-7}	2.8×10^{-7}	1.9×10^{-7}	9.3×10^{-8}	3.6×10^{-8}	1.8×10^{-8}	1.2×10^{-8}	8.3×10^{-9}
E	8.7×10^{-6}	1.4×10^{-6}	6.3×10^{-7}	3.8×10^{-7}	2.7×10^{-7}	1.3×10^{-7}	5.0×10^{-8}	2.5×10^{-8}	1.6×10^{-8}	1.2×10^{-8}
ESE	1.3×10^{-5}	2.0×10^{-6}	9.2×10^{-7}	5.6×10^{-7}	3.9×10^{-7}	1.9×10^{-7}	7.3×10^{-8}	3.7×10^{-8}	2.3×10^{-8}	1.7×10^{-8}
SE	1.0×10^{-5}	1.6×10^{-6}	7.4×10^{-7}	4.5×10^{-7}	3.2×10^{-7}	1.5×10^{-7}	6.0×10^{-8}	3.0×10^{-8}	1.9×10^{-8}	1.4×10^{-8}
SSE	6.0×10^{-6}	9.5×10^{-7}	4.4×10^{-7}	2.7×10^{-7}	1.8×10^{-7}	9.0×10^{-8}	3.5×10^{-8}	1.7×10^{-8}	1.1×10^{-8}	8.0×10^{-9}
S	5.6×10^{-6}	9.0×10^{-7}	4.1×10^{-7}	2.5×10^{-7}	1.7×10^{-7}	8.5×10^{-8}	3.3×10^{-8}	1.6×10^{-8}	1.0×10^{-8}	7.5×10^{-9}
SSW	5.0×10^{-6}	7.9×10^{-7}	3.7×10^{-7}	2.2×10^{-7}	1.6×10^{-7}	7.5×10^{-8}	2.9×10^{-8}	1.5×10^{-8}	9.4×10^{-9}	6.7×10^{-9}
SW	5.7×10^{-6}	9.0×10^{-7}	4.1×10^{-7}	2.5×10^{-7}	1.8×10^{-7}	8.6×10^{-8}	3.3×10^{-8}	1.7×10^{-8}	1.1×10^{-8}	7.7×10^{-9}
WSW	7.3×10^{-6}	1.2×10^{-6}	5.3×10^{-7}	3.2×10^{-7}	2.2×10^{-7}	1.1×10^{-7}	4.2×10^{-8}	2.1×10^{-8}	1.3×10^{-8}	9.6×10^{-9}
W	9.8×10^{-6}	1.6×10^{-6}	7.2×10^{-7}	4.4×10^{-7}	3.0×10^{-7}	1.5×10^{-7}	5.6×10^{-8}	2.8×10^{-8}	1.8×10^{-8}	1.3×10^{-8}
WNW	6.6×10^{-6}	1.1×10^{-6}	4.9×10^{-7}	3.0×10^{-7}	2.1×10^{-7}	1.0×10^{-7}	3.9×10^{-8}	2.0×10^{-8}	1.3×10^{-8}	9.0×10^{-9}
NW	6.8×10^{-6}	1.1×10^{-6}	5.0×10^{-7}	3.0×10^{-7}	2.1×10^{-7}	1.0×10^{-7}	4.0×10^{-8}	2.0×10^{-8}	1.3×10^{-8}	9.2×10^{-9}
NNW	6.7×10^{-6}	1.1×10^{-6}	4.8×10^{-7}	2.9×10^{-7}	2.0×10^{-7}	9.9×10^{-8}	3.8×10^{-8}	1.9×10^{-8}	1.2×10^{-8}	8.7×10^{-9}

a. To convert second per cubic meter to second per cubic foot, multiply by 0.02832.

b. To convert kilometers to miles, multiply by 0.6214.

Table A.4 Exposure pathway intake parameters

Parameter	Maximally Exposed Individual	Average Member of Population
Fruits, vegetables, & grain (kg/yr)[a]	520	190
Leafy vegetables (kg/yr)[a]	64	24
Milk (L/yr)[b]	310	110
Meat & poultry (kg/yr)[a]	110	95
Fish (kg/yr)[a]	21	6.9
Drinking water (L/yr)[b]	730	370
Inhalation (m^3/yr)[c]	8,000	8,000

a. To convert kilograms to pounds, multiply by 2.205.
b. To convert liters to gallons, multiply by 0.2642.
c. To convert cubic meters per year to cubic feet per year, multiply by 35.315.

product of dose conversion factor and amount inhaled. This radionuclide dose estimate was expressed as:

$$D_{i,i} = (\chi/Q) \times Q_{i,a} \times BR \times DCF_i$$

where:

$D_{i,i}$ = inhalation dose from radionuclide i, Sv/yr

χ/Q = atmospheric concentration per unit source term, s/m^3

$Q_{i,a}$ = annual release rate of radionuclide i to the atmosphere (Table A.1), Bq/yr

BR = breathing rate (Table A.4), m^3/s

DCF_i = inhalation dose conversion factor for radionuclide i (Table A.2), Sv/Bq

Total individual dose was estimated as the sum of the doses of all radionuclides. The values of χ/Q for the maximally exposed individual for releases from building 073, the storage pile, and the sludge storage mausoleums were 5.0×10^{-6}, 5.0×10^{-6}, and 6.7×10^{-5} s/m^3 (1.4×10^{-7}, 1.4×10^{-7}, and 1.9×10^{-6} s/ft^3), respectively. Population dose was estimated as the sum of the doses for individuals located in 160 sectors surrounding the facility. The number of individuals in each sector was presented in Table 3.3, while the χ/Q values for each sector were presented in Table A.3. Dose estimation methods for the food ingestion and external exposure modes are more complex, but since these pathways contribute a small portion of the total dose, the methods are not presented here.

The results for the maximally exposed individual and the population are summarized in Tables A.5 and A.6, respectively. As shown in the tables, external doses are small fractions of internal doses, and the TEDEs are numerically equal to the CEDEs.

Table A.5 Radiological impacts to the maximally exposed individual from releases to the atmosphere (Sv/yr)

	Building 073 Stack	Ore Storage Pile	Storage Mausoleums	Total
Gonads	8.5×10^{-9}	2.2×10^{-9}	2.5×10^{-8}	3.6×10^{-8}
Breast	4.7×10^{-9}	1.2×10^{-9}	3.6×10^{-13}	5.9×10^{-9}
Red bone marrow	3.9×10^{-7}	1.0×10^{-7}	1.5×10^{-7}	6.4×10^{-7}
Lungs	2.6×10^{-6}	6.8×10^{-7}	2.1×10^{-4}	2.1×10^{-4}
Thyroid	4.7×10^{-9}	1.2×10^{-9}	2.7×10^{-8}	3.3×10^{-8}
Bone surface	4.7×10^{-6}	1.2×10^{-6}	9.3×10^{-7}	6.7×10^{-6}
Liver	2.3×10^{-7}	6.0×10^{-8}	-	2.9×10^{-7}
Kidneys	1.3×10^{-7}	3.3×10^{-8}	1.2×10^{-6}	1.4×10^{-6}
Spleen	1.1×10^{-7}	2.8×10^{-8}	-	1.4×10^{-7}
Lower large intestine	1.2×10^{-8}	3.2×10^{-9}	6.2×10^{-10}	1.6×10^{-8}
Upper large intestine	7.1×10^{-9}	1.8×10^{-9}	2.8×10^{-9}	1.2×10^{-8}
Small intestine	-	-	4.7×10^{-9}	4.7×10^{-9}
Stomach	-	-	1.4×10^{-8}	1.4×10^{-8}
CEDE	5.2×10^{-7}	1.3×10^{-7}	2.6×10^{-5}	2.7×10^{-5}
External	6.1×10^{-11}	1.6×10^{-11}	-	7.7×10^{-11}
TEDE	5.2×10^{-7}	1.3×10^{-7}	2.6×10^{-5}	2.7×10^{-5}

A.2.2 Surface Water Pathways

Radionuclides released to surface water are diluted by stream flow and may impact individuals through various pathways. Liquid release pathways analyzed included ingestion of potentially contaminated drinking water, ingestion of crops irrigated with potentially contaminated water, ingestion of animal products grown with potentially contaminated crops, ingestion of fish harvested from the potentially contaminated stream, and direct exposure during recreational activity in or near the potentially contaminated stream. The exposure rates for these pathways were estimated using the GENII computer code (Ref. 4). The major parameters used for analysis of the surface water pathways are summarized in Table A.3. The stream dilution model used for the analysis is the same as that recommended in NRC guidance (Ref. 9). Because flow in West Swamp Creek is low and irregular, it is not a drinking water source. Therefore, the maximally exposed individual was located along the Schuylkill River downstream of the confluence with West Swamp Creek. The population out to a distance of 80 kilometers (50 miles) was also assumed to use this potentially contaminated water.

Table A.6 Radiological impacts to the population from releases to the atmosphere (per-Sv/yr)

	Building 073 Stack	Ore Storage Pile	Storage Mausoleums	Total
Gonads	2.1×10^{-4}	5.5×10^{-5}	6.7×10^{-5}	3.3×10^{-4}
Breast	8.9×10^{-5}	2.3×10^{-5}	9.8×10^{-10}	1.1×10^{-4}
Red bone marrow	1.3×10^{-2}	3.3×10^{-3}	4.1×10^{-4}	1.7×10^{-2}
Lungs	9.4×10^{-2}	2.4×10^{-2}	5.8×10^{-1}	7.0×10^{-1}
Thyroid	8.9×10^{-5}	2.3×10^{-5}	7.4×10^{-5}	1.9×10^{-4}
Bone surface	1.6×10^{-1}	4.0×10^{-2}	2.5×10^{-3}	2.0×10^{-1}
Liver	5.2×10^{-3}	1.3×10^{-3}	-	6.5×10^{-3}
Kidneys	2.4×10^{-3}	6.1×10^{-4}	3.4×10^{-3}	6.4×10^{-3}
Spleen	2.0×10^{-3}	5.1 x 1[illegible]	-	2.5×10^{-3}
Lower large intestine	2.1×10^{-4}	5.4×10^{-5}	1.7×10^{-6}	2.7×10^{-4}
Upper large intestine	1.2×10^{-4}	3.2×10^{-5}	7.6×10^{-6}	1.6×10^{-4}
Small intestine	-	-	1.3×10^{-5}	1.3×10^{-5}
Stomach	-	-	3.8×10^{-5}	3.8×10^{-5}
CEDE	1.8×10^{-2}	4.6×10^{-3}	7.0×10^{-2}	9.3×10^{-2}
External	1.4×10^{-6}	3.7×10^{-7}	-	1.8×10^{-6}
TEDE	1.8×10^{-2}	4.6×10^{-3}	7.0×10^{-2}	9.3×10^{-2}

For surface water pathways, fish ingestion doses dominated the drinking water, irrigated food ingestion, and direct exposure doses. Concentrations of each radionuclide in the water were estimated as the quotient of release rate and river flow rate. Radionuclide intake in drinking water was estimated as the product of radionuclide concentration and water usage rate, and dose was estimated as the product of intake rate and dose conversion factor. For each exposed individual and each radionuclide, dose was expressed as:

$$D_{dw,i} = (Q_{i,l}/Q_r) \times IR_{dw} \times DCF_i$$

where:

$D_{dw,i}$ = drinking water dose for radionuclide i, Sv/yr

$Q_{i,l}$ = liquid effluent release rate of radionuclide i (Table A.1), Bq/s

Q_r = river flow rate, m^3/s

IR_{dw} = drinking water ingestion rate (Table A.4), m^3/yr

DCF_i = ingestion dose conversion factor (Table A.2), Sv/Bq

Total dose was estimated as the sum of the doses for all radionuclides and the river flow rate was 50.8 m^3/s (1,794 ft^3/s). The concentration of each radionuclide in fish was determined using the estimated river water concentration and the bioaccumulation factors presented in Table A.7. The dose from ingestion of fish was estimated as:

$$D_{f,i} = (Q_{i,l}/Q_r) \times B_{i,f} \times IR_f \times DCF_i$$

where:

$D_{f,i}$ = fish ingestion dose for radionuclide i, Sv/yr

$B_{i,f}$ = bioaccumulation factor for radionuclide i in fish (Table A.7), (Bq/kg)/(Bq/m^3)

IR_f = fish ingestion rate (Table A.4), kg/yr

and all other variables are defined as above. Total dose was estimated as the sum of the dose of all radionuclides. For the liquid pathway, all individuals were equally exposed, and the collective dose was estimated as the product of the number of people and the average individual dose estimated as described above. Dose estimation methods for food ingestion and external exposure were more complex but account for a small portion of the total dose. Therefore, the methods are not presented here.

Table A.8 summarizes the analysis for the maximally exposed individual and the population. As with atmospheric releases, external doses are small fractions of the internal doses.

Table A.7 Fresh water fish bioaccumulation factors

Element	Bioaccumulation Factor (Bq/kg per Bq/L)
K	0
U	50
Th	100
Pa	30
Ac	330
Ra	50
Rn	0
Pb	2,000
Bi	15
Po	50

Source: Napier, B.S., R.A. Peloquin, D.L. Strenge, and J.V. Ramsdell, "GENII - The Hanford Environmental Radiation Dosimetry Software System," PNL-6584, Pacific Northwest Laboratory, Richland, Washington, December 1988 (Ref. 4).

Table A.8 Radiological impacts from releases to surface water

	Maximally Exposed Individual (Sv/yr)	Population (per-Sv/yr)
Gonads	7.5×10^{-7}	2.6×10^{0}
Breast	7.1×10^{-7}	2.5×10^{0}
Red bone marrow	3.0×10^{-6}	8.1×10^{0}
Lungs	7.3×10^{-7}	2.5×10^{0}
Thyroid	7.1×10^{-7}	2.5×10^{0}
Bone surface	3.5×10^{-5}	8.4×10^{1}
Liver	9.6×10^{-6}	2.4×10^{1}
Kidneys	4.4×10^{-6}	1.1×10^{1}
Spleen	1.1×10^{-6}	3.9×10^{0}
Lower large intestine	7.7×10^{-7}	2.8×10^{0}
Upper large intestine	7.4×10^{-7}	2.7×10^{0}
CEDE	2.8×10^{-6}	7.5×10^{0}
External	1.2×10^{-8}	8.0×10^{-4}
TEDE	2.8×10^{-6}	7.5×10^{0}

A.3 References

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