CHAPTER IX

SOLID WASTE MANAGEMENT

Burning of coal produces combustion gases that contain solid flyash and gaseous sulfur oxides. When these products are cleaned from the stack gas by the use of precipitators and scrubbers, large volumes of flyash and sludge are generated. Lesser quantities of bottom ash and boiler slag are also produced. Broadly speaking, such wastes must either be used, stored temporarily, or permanently disposed of. Engineering costs and environmental hazards may be associated with any of these approaches.

Where possible, waste product utilization is desirable. Bottom ash is frequently used as a road base, as a drainage blanket, and as an aggregate in concrete. Federal law requires the use of flyash in cement in federal projects, where feasible, and Maryland law requires that flyash be stored in a manner permitting its subsequent recovery and use (1). The principal potential uses of flyash take advantage of its hardening properties in the mixing of concrete; in structural fill; and in admixture with other wastes to simplify their disposal and minimize leachate generation. Calcium sulfate scrubber sludge, or "abatement gypsum", from non-recoverable processes can sometimes be used as a soil conditioner, in wallboard manufacture, or as a set-retarding agent in concrete. Elemental sulfur or sulfuric acid is obtained from recoverable sulfur removal processes.

At present some flyash is being sold for re-use and the remainder is being placed in managed landfills. Previously, ash was placed wet in unlined disposal ponds or deposited on marshland. Such disposal is no longer likely to meet land use and environmental regulations in most areas of Maryland. No scrubber sludge will be generated in Maryland until a scrubber begins operation in 1988 at the Vienna plant of Delmarva Power and Light (DPL).

Quantities of waste requiring disposal will probably increase in response to increased coal use and more stringent air and water pollution controls motivated by environmental and health concerns.

Potential adverse impacts associated with landfill disposal include withdrawal of land from productive use, destruction of visual attractiveness, and particulate emission during handling and placement. These effects are not discussed further in this chapter because they are relatively obvious or reasonably amenable to control. The most important problem is potential surface and groundwater contamination by runnoff and leachate, with a consequent degradation of drinking water aquifers and impacts on aquatic and terrestrial organisms.

Problems associated with waste disposal are site-specific because waste properties, dispersal mechanisms, and resources at risk can vary substantially. Variation in waste properties can occur because of differences in mineral content of the coal, options in process design and control, and in waste disposal practices and facility design. Dispersal of the waste is governed by topography, climate and geology. The geologic strata underlying the relatively flat terrain of the Coastal Plan generally constitute a water table aquifer and one or more underlying artesian aquifers, which are often of lesser quality. Waste leachate could enter and contaminate one or more of these aquifers and possibly enter surface streams. On hilly terrain, leachate will tend to seek and follow the underlying natural drainage channel to emerge and enter a nearby stream or pass into the fracture system in the underlying rock. The impact of such waste dispersal would depend on the extent to which the affected aquifers and streams are important for drinking water and ecological purposes.

Waste disposal is governed by both State and Federal regulation. Regulations in each case are complex, inter-related, and in flux; they are enforced through a state permitting process based on the Environmental Protection Agency (EPA) criteria. Utility waste from coal combustion is regarded as a high volume, low hazard waste and is specifically excluded at the state and federal level from designation as a hazardous waste. In most instances such waste can be contained to whatever extent is necessary through engineering measures discussed in Section B. The tradeoffs between reuse, facility siting, and containment of wastes are complicated by rapidly changing regulations, disposal technology and reuse economics.

A. Chemical and Engineering Properties of Flyash and Scrubber Sludge

The need to provide environmentally sound disposal for the principal wastes, flyash and scrubber sludge, is governed by their chemical properties. The manner of providing safe disposal is governed by their engineering properties.

As a hydrocarbon, coal consists principally of hydrogen, carbon, oxygen, nitrogen and sulfur, which will air form gaseous compounds during combustion. The sulfur content of coal commonly used by utilities ranges up to 6 percent. An additional 3 to 30 percent of the coal consists of compounds that fuse and form ash. These are mostly complex aluminosilicates, iron, calcium, sodium and a large number of trace elements.

The liquid resulting from the contact of water with waste is called a leachate. Table IX-1 lists the concentrations of trace elements in ash leachate and compares them with several standards which are likely to be applicable in the vicinity of a disposal site. It is not usually possible to predict the quality of leachate from any particular ash without testing. Laboratory extraction procedures have been developed by EPA (2) and the American Society for Testing Materials (ASTM), and the ability of these tests to predict leachate quality is currently under scrutiny (3).

The principal non-recoverable scrubber sludge component is a mixture of calcium sulfite hemihydrate and calcium sulfate dihydrate ("abatement gypsum"). The calcium sulfite hemihydrate can be converted to the gypsum form by an excess of oxygen in the scrubber or through forced oxidation after it leaves the scrubber. Calcium sulfite is thixotropic (water holding) in nature. If it is left in the unoxidized form, a common option for its disposal is ponding, with an attendant threat to ground water from leachate discharge. It can also be disposed of by blending with flyash alone or by stabilization in a chemical fixation process with flyash and lime. Stabilization is facilitated by oxidizing the sludge to calcium sulfate. Table IX-2

Table IX-1
Representative Trace Elements Concentrations in Coal Ash Leachate[a]

Species	Range mg/l	Mean mg/l	EPA Primary Standard[b] mg/l	EPA Secondary Standard[c] mg/l
Antimony	.002 to .04	.02	---	---
Arsenic	.0001 to .42	.03	.05	---
Barium	.1 to .5	.31	1.0	---
Beryllium	.0004 to .01	.002	---	---
Boron	.17 to 3.2	1.2	---	---
Cadmium	.0001 to .005	.002	.01	---
Chromium	.0006 to .07	.035	.05	---
Cobalt	.0003 to .01	.005	---	---
Copper	.004 to .08	.03	---	1
Fluorine	.2 to 20	5	1.4 to 2.4	---
Iron	.01 to 4.6	.59	---	.3
Lead	.006 to .25	.02	.05	---
Manganese	.001 to .90	.27	---	.05
Mercury	.0004 to .08	.007	.002	---
Molybdenum	.002 to .056	.02	---	---
Nickel	.001 to .12	.04	---	---
Selenium	.001 to .12	.02	.01	---
Silver	.0003 to .01	.004	.05	---
Uranium	.002 to .1	.006	---	---
Vandium	.005 to .23	.14	---	---
Zinc	.01 to .4	.07	---	---

(a) Thirty different coal ash leachates and pond liquors were reviewed.
(b) EPA's National Interim Primary Drinking Water Standards (NIPDWS).
(c) EPA's National Secondary Drinking Water Regulations (NSDWR).

Data from Reference (4).

Table IX-2
Representative Trace Elements Concentrations in Scrubber Sludge Liquor[a]

Species	Range mg/l	Mean[d] mg/l	EPA Primary Standard[b] mg/l	EPA Secondary Standard[c] mg/l
Antimony	.09 to 2.9	.2	---	---
Arsenic	.004 to .3	.009	.05	---
Barium	(e)	(e)	1	---
Beryllium	.0006 to .14	.013	---	---
Boron	.9 to 46	(e)	---	---
Cadmium	.002 to .044	.032	.01	---
Chromium	.005 to .4	.08	.05	---
Cobalt	.1 to .7	(e)	---	---
Copper	.002 to .6	.20	---	1
Fluorine	.7 to 3.0	1.5	1.4 to 2.4	---
Iron	.02 to 8.1	(e)	---	.3
Lead	.001 to .4	.016	.05	---
Manganese	.007 to 2.5	.74	---	.05
Mercury	.0004 to .07	.01	.002	---
Molybdenum	.07 to 6.3	(e)	---	---
Nickel	.005 to 1.5	.09	---	---
Selenium	.001 to 2.2	.14	.01	---
Silver	.005 to .6	(e)	.05	---
Uranium	---	(e)	---	---
Vandium	.001 to .67	(e)	---	---
Zinc	.03 to 2.0	0.18	---	5

(a) Thirteen different sludge liquors were reviewed.
(b) EPA's National Interim Primary Drinking Water Standard (NIPDWS).
(c) EPA's National Secondary Drinking Water Regulations (NDWR).
(d) Underscored values are equal to or greater than most stringent reference standard.
(e) Sufficient data were not available for the meaningful calculation of a significant mean.

Data from Reference (4).

identifies the range of concentrations of trace elements in scrubber sludge liquors (slurry water) from one set of tests and compares these concentrations to EPA drinking water standards.

A common disposal technique for plants that produce both flyash and scrubber sludge is to mix or blend the wastes together and (usually) to "fix" the mix by the addition of lime (5). After a brief setting period the mixture is put at the disposal site and compacted. The fixation reaction is a pozzolonic reaction consisting of the formation of calcium silicate links between the flyash and lime particles. This is the same type of process responsible for the setting of portland cement. The formation of this mixture takes up some of the remaining water in the sludge. In addition, some gypsum may react with the lime and flyash to form a mineral called etrringite. The rate at which leachate can be generated depends on whether the materials are blended or fixed, but leachate concentrations, as illustrated in Table IX-3, are estimated to be the same for either process. It should be noted that for any scrubber waste the use of saline water as make-up to the scrubber could significantly increase the chlorides and total dissolved solids concentrations.

When wastes are to be stored in a landfill, the physical properties of concern include compactibility, shear strength, and permeability. Obviously the greater the compactibility, the more waste can be placed on a single piece of land; the same is true for shear strength, which governs the permissible steepness of the sideslopes of the waste pile. In general all of the wastes discussed here, except untreated unoxidized sludge, can be placed in unconfined piles.

Permeability determines the rate at which leachate may be generated by infiltrating water. Table IX-4 gives illustrative permeabilities for various wastes. Fixed scrubber sludge is generally less permeable than other wastes, but the rigidity of the material is such that differential settlement may eventually cause cracks which would increase the bulk permeability.

A topic of current interest is the extent of trace amounts of radioactivity in coal wastes. Table IX-5 provides an indication of radioactivity present in coal, flyash, bottom ash, and scrubber ash from two power plants. There are indications that radio-nuclides become enriched in the ash (relative to the coal) and tend to concentrate on the finer particles. Draft criteria would label a waste as radioactive should the radium-226 concentration exceed 5 picocuries per gram,or the total single source emission exceed 10 microcuries (6).

B. Disposal Techniques

Power plants produce large volumes of solid waste. The specific quantities depend on many factors, such as the type of furnace, composition of the coal, and type of flyash precipitator. Scrubber sludge may not be produced at all if a utility has the option to burn low sulfur coal; the decision depends upon a number of regulatory and economic considerations. If a scrubber is used, the quantities of scrubber sludge will usually be greater than the quantity of flyash.

Table IX-3

Representative Permeate Concentrations for Blended or Fixed Scrubber Sludge (All concentrations mg/l)

Total Dissolved Solids	8800
Sulfate	1350
Chlorinde	2970
Arsenic	0.094
Cadmium	0.21
Selenium	0.12
Barium	1.0
Chromium	0.001
Lead	0.005
Mercury	0.0005
Silver	<0.001
Iron	0.86
Manganese	2.39
Zinc	5.4
pH	7.5

Data from Reference (7).

Table IX-4

Representative Permeabilities of Utility Solid Wastes

Material	Permeability - cm/sec
Flyash	10^{-4} to 10^{-5}
Fixed scrubber sludge	10^{-5} to 10^{-7}
Blended flyash and scrubber sludge	10^{-4} to 10^{-5}

Table IX-5

Contents of the Various Radionuclides in Coal, Bottom Ash and Fly Ash[a]

	ppm			pCi/g						
	U	Th	K	^{40}K	^{228}Th	^{228}Pa	^{210}Pb	^{226}Ra	^{238}U	^{235}U
Plant A[b]										
Coal	0.71	1.6	806	0.73	0.17	0.17	0.26	0.21	0.24	0.012
ESP fly ash	5.6	15	9400	8.1	1.7	1.7	1.4	2.3	1.9	0.093
Bottom ash	4.6	14	7900	6.8	1.5	1.5	0.58	1.9	1.5	0.072
Plant B[c]										
Coal	2.6	5.0	1660	1.4	0.56	0.55	0.68	0.64	0.85	0.037
ESP fly ash	11	22	7400	6.3	2.4	2.4	2.2	2.9	3.5	0.14
Bottom ash	8.4	19	7200	6.2	2.2	2.1	0.84	2.5	2.8	0.11
Scrubber ash	11	22	7200	6.2	2.5	2.5	2.8	3.0	3.6	0.14
Plant B[c]										
Post-ESP (stack)										
Fly ash (mmd)[d]										
17 µm	16	25	8200	7.0	2.8	2.7	4.3	3.3	5.4	0.17
6 µm	20	31	8600	7.3	3.3	3.5	10	4.6	6.8	0.28
3.8 µm	30	36	8600	7.4	3.3	4.0	14	5.3	10	0.39
2.5 µm	36	38	8100	7.0	3.3	4.2	17	5.9	12	0.50

(a) 10-20% propagated 1 σ error from the mean.
(b) Samples from Plant A; input coal contains 11.3% H_2O, 9.2% ash, and 0.52% sulfur.
(c) Samples from Plant B; input coal contains 6.8% H_2O, 23.2% ash, and 0.46%
(d) mmd = mass median diameter determined by centrifugal sedimentation.

Data from Reference 6.

Table IX-6 shows typical waste quantities for a 500 MWe plant. An acre-foot is a volume one foot high over one acre. As an illustration, thirty years of waste would cover a 150 acre disposal area to a height of almost 50 feet.

Table IX-6
Typical Waste Quantities for a 500 MWe Plant Using 2.5% Sulfur Coal
(Volume in Acre-Feet)

Waste	Annual Volume per MWe	Annual Total Volume	30-Year Volume
Flyash	0.14	72	
Bottom Ash	0.03	14	
Oxidized Scrubber Sluge	0.35	174	
Total: Flyash and Sludge[a]	0.49	246	7380

(a) Since bottom ash is often sold for commercial use it is not included in total waste requiring land-fill disposal.

Where wastes are not to be re-used, disposal or long-term storage is necessary at either the plant or an off-site location. Land-filling is the most widely available option for disposal. (The past use of unlined disposal ponds was only a specialized form of landfilling; such ponds in contact with ground water or subject to leaching are no longer likely to meet environmental regulations.) Blending of ash and sludge allows the pozzolanic properties of ash to improve the engineering properies of scrubber sludge and adding lime or "fixing" tends to further harden the resulting product. The special technique of employing fixed scrubber sludge in the construction of artificial reefs is an option still under study and even if viable would only be available to power plants in suitable locations. Ocean disposal is possible, but regulatory attitudes, the cost of transportation, and the permanent loss of a potential resource suggest that off-shore disposal is unlikely to become commonplace. Thus, for Maryland, landfilling will probably be the principal method of utility waste disposal in the immediate future.

Transportation is an important consideration in disposal planning. Scrubber sludge in the form of calcium sulfite is a semi-liquid and can only be transported by slurry pipeline or an especially suited vehicle unless it is first dewatered or stabilized. Sludge in the form of calcium sulfate can be transported as a solid, and ash may be transported either as a solid or a slurry. Solids can be moved by truck or railcar. Slurry transport implies either ponding at the disposal site or that dewatering facilities must be provided. The decanted supernatant can be re-used or must meet discharge standards. Dewatered slurried wastes will still be high in moisture content unless dried, leading to excessive land requirements, unstable waste piles, and leachate release as the pile settles. On the other hand, dry waste disposal may produce fugitive emissions. Increased truck traffic and random spillage are possible added concerns whenever vehicle transport is used. In general there is a trend away from wet disposal systems because of difficulties in meeting environmental regulations.

Rarely is the installation of a properly designed and operated landfill seen as an improvement over existing land uses. Beyond concern for the loss of the site from productive use during active disposal, responsibility for long term use and maintenance also concerns communities in the site vicinity. Future use and maintenance of the site must be part of preliminary planning since suitability for future use can only be guaranteed through proper initial design followed by adequate quality control throughout the operating period.

Structural stability of the waste depends on both the properties of the material and on proper site design and operating procedures. Calcium sulfite remains thixotropic and must be retained in a pond or behind dikes unless dewatered or stabilized. Calcium sulfate is a solid and will stand in a pile, but is subject to erosion and leaching. Flyash is relatively stable and can be piled alone. Additional stability is achieved when flyash is blended with scrubber sludge or fixed with scrubber sludge and lime. In any case proper drainage and dike design must be provided, and allowances made for ground settlement beneath the weight of the pile.

Several options exist for the prevention or reduction of leachate entry into ground water. The formation of leachate may be prevented by capping the landfill with a waterproof material such as compacted clay or synthetic rubber covered by vegetated soil. Sufficient experience is not available on cover durability, but inspection and repair of a cover is feasible since it is accessible. Entry of rain during construction may also require control, but under some circumstances, such as rapid construction with relatively dry waste, the amount of rain water may be small enough to preclude significant leachate generation. If a cap is not used and leachate must be collected, a barrier made of the capping materials mentioned above can be placed between the waste and the ground water with a collection system located in the layer between the two. This system may consist of granular material alone or with a pipe grid collection system added. Both the barrier and the collection systems are susceptible to damage due to settlement, and inspection and repair are nearly impossible. Under some circumstances, fixation of the waste may provide adequate control of leachate generation. Such measures may be unnecessary where leachates will be dispersed.

Where surface water will traverse the open face of the landfill (for example in rainstorms), collection and treatment of contaminated runoff should be carefully considered. Grading to prevent water running onto the waste is good engineering practice.

Just as potential environmental impacts of utility waste disposal vary from site to site, disposal costs also vary, and for many of the same reasons -variability of source coal, variability of plant processes, and variability of the engineering effort needed to protect the resources at risk. The total cost of a waste disposal facility includes the sum of the initial capital costs (purchase of land and equipment, design and licensing, construction),and the total of all operating and maintenance costs throughout the lifetime of the facility. Costs of closure and perpetual maintenance, such as leachate collection and treatment, must also be included. Since disposal facilities have varying lifetimes, total costs among facilities are best compared on a present value basis or on a present value basis or on a cost per unit quantity of waste per unit of electricity generated.

Although it is desirable to present some indication of waste disposal costs, the many factors to be considered in any single situation make a general approach impractical. An illustration is provided here and the reader is referred to estimating techniques published by the Electric Power Research Institute in 1979 for further information (7).

For a 500 MWe plant operating at a 70 percent capacity factor, trucking 299 tons per day of dry ash over one mile of public roads to a landfill without special containment features, the annual cost for flyash disposal is estimated to be, in 1979 dollars, 0.78 million dollars. This is equivalent to $7.15 per dry ton, or 0.255 mills per kilowatt-hour, or $1562 per year per installed megawatt. Wide variability in actual situations may be expected.

For the same plant, burning coal with 12 percent ash and 2.5 percent sulfur, and disposing jointly of 299 tons of ash blended with 399 tons of oxidized scrubber sludge daily in a landfill without special containment features, the total annual cost for disposal of both wastes is 5.15 million dollars, equivalent to $20.22 per dry ton of combined ash and scrubber sludge, or 1.68 mills per kilowatt-hour, or $10,308 per year per installed megawatt. The incremental cost of scrubber sludge disposal is thus $8746 per year per installed megawatt. As noted above wide variability around this estimate may be expected.

C. Environmental Impacts

The most important potential environmental impacts of discharges from utility waste disposal areas are due to elevated concentrations of total dissolved solids, salts and trace elements. Uncontrolled discharges could cause ground water in the vicinity of the site to exceed some of the primary and secondary standards given in Section A. This situation would usually be monitored by wells adjacent to the site. The extent to which discharges are a problem will depend on current and planned future uses of the affected aquifer. In some circumstances such discharges may be unimportant because the aquifer is unsuitable for drinking water purposes in its natural state.

The biological impacts of discharges to surface water are currently under study. A detailed discussion is contained in Chapter 7 of Reference (8). In general there are no indications that even low concentrations of trace elements such as arsenic, selenium and cadmium can cause developmental deformities in fish larvae. Potential releases from disposal areas need to be evaluated on a case-by-case basis to determine the likely extent of impact.

D. Regulatory Status

The regulatory situation regarding the disposal of utility wastes is complex because both the federal and state governments are in the process of implementing broad regulations covering the disposal of many types of waste.

There are still many uncertainties regarding both the philosophy and the technical details of the proposed regulations. At present utility wastes are specifically excluded from classification as "hazardous" and are therefore "solid wastes". The federal requirements for disposal as proposed by the Environmental Protection Agency are less severe for solid waste than for hazardous waste, but are still stringent. A disposal facility must not cause primary and secondary drinking standards shown in Table IX-7 to be exceeded in the ground water beyond the edge of the waste pile or at an alternative boundary set by the State.

Table IX-7
Drinking Water Standards

Primary Standards

Contaminant	Level (mg/l)
Arsenic	.05
Barium	1.
Cadmium	.01
Chromium	.05
Fluoride	1.4 - 2.4
Lead	.05
Mercury	.002
Nitrate (as N)	10.
Selenium	.01
Silver	.05

Secondary Standards

Contaminant	Level
Chloride	250. mg/l
Color	15. color units
Copper	1. mg/l
Foaming Agents	.5 mg/l
Iron	.3 mg/l
Manganese	.05 mg/l
Odor	3 threshold odor No.
pH	6.5 - 8.5
Sulfate	250. mg/l
TDS	500. mg/l
Zinc	5. mg/l

Code of Maryland Regulations require a permit from the Department of Health and Mental Hygiene (DHMH) for discharges to the ground water regardless of the material, but the constraints vary depending on the nature of the material. In general the State can regulate facility design, discharge concentrations and receiving water quality. For the disposal area recently proposed at Vienna, Maryland (see next Section) the preliminary state regulatory criteria include meeting primary and secondary drinking water standards at all depths at the edge of the waste pile and preventing direct contact of the waste with the water table. Discharges to surface waters from a waste disposal facility are also regulated by the State through the NPDES permitting process. The general criterion is that waters must be free from substances in concentrations which are harmful to human, animal, plant or aquatic life. The only applicable specific criterion is pH outside of a designated mixing zone, but other criteria are likely to be proposed on a case-by-case basis.

In addition to the regulation of discharges from utility waste disposal facilities by DHMH and EPA, it is possible that the Maryland Public Service Commission could impose conditions on the siting and operation of such facilities to insure that waste disposal is handled safely and economically.

Compliance with regulations would usually be determined by monitoring the quality of discharge and receiving waters. For ground water such monitoring is complicated because discharges are not readily observable and the concentrations of some constituents in the ground water may exceed standards due to natural conditions or agricultural practices. Baseline monitoring is usually necessary to determine such conditions. A more detailed discussion of the regulatory situation is contained in Chapter 2 of Reference 8.

E. Vienna Example

A study by the Power Plant Siting Program has recently been completed of Delmarva Power's plans for disposal of solid waste for the proposed 500 MWe Unit 9 at Vienna (8). Flyash and scrubber sludge would be blended together to form a damp, soil-like material and disposed of in a landfill at the rate of approximately two-thirds acre-foot per day. After 30 years the waste pile would cover 165 acres to a maximum height of approximately 50 feet. The waste would be placed over a layer of fill to maintain a five foot separation of the waste from the ground water. An impermeable cover would be installed over the waste after emplacement to eliminate contact with rain water. A layer of soil would be placed over the cover and planted with Kentucky 31 fescue.

An artist's sketch of the general features of the waste pile after 30 years of operation is shown in Figure IX-1. The grading would route rainfall runoff from completed area of the landfill to natural drainage. The emplacement procedure for the waste would be to work in ten successive 16.5 acre tracts. Runoff from the active area would be collected in a lined sedimentation basin and recycled into the scrubber system. Analysis indicates that infiltration of rain water during emplacement of the waste would be insufficient to cause the pile to saturate, so no leachate would result. The proposed design is predicted to result in a negligible amount of leachate reaching the ground water or surface waters.

The above design was developed after laboratory and field studies and discussions between the Power Plant Siting Program and the utility. Because of site features such as a high watertable, localized soft foundation soil

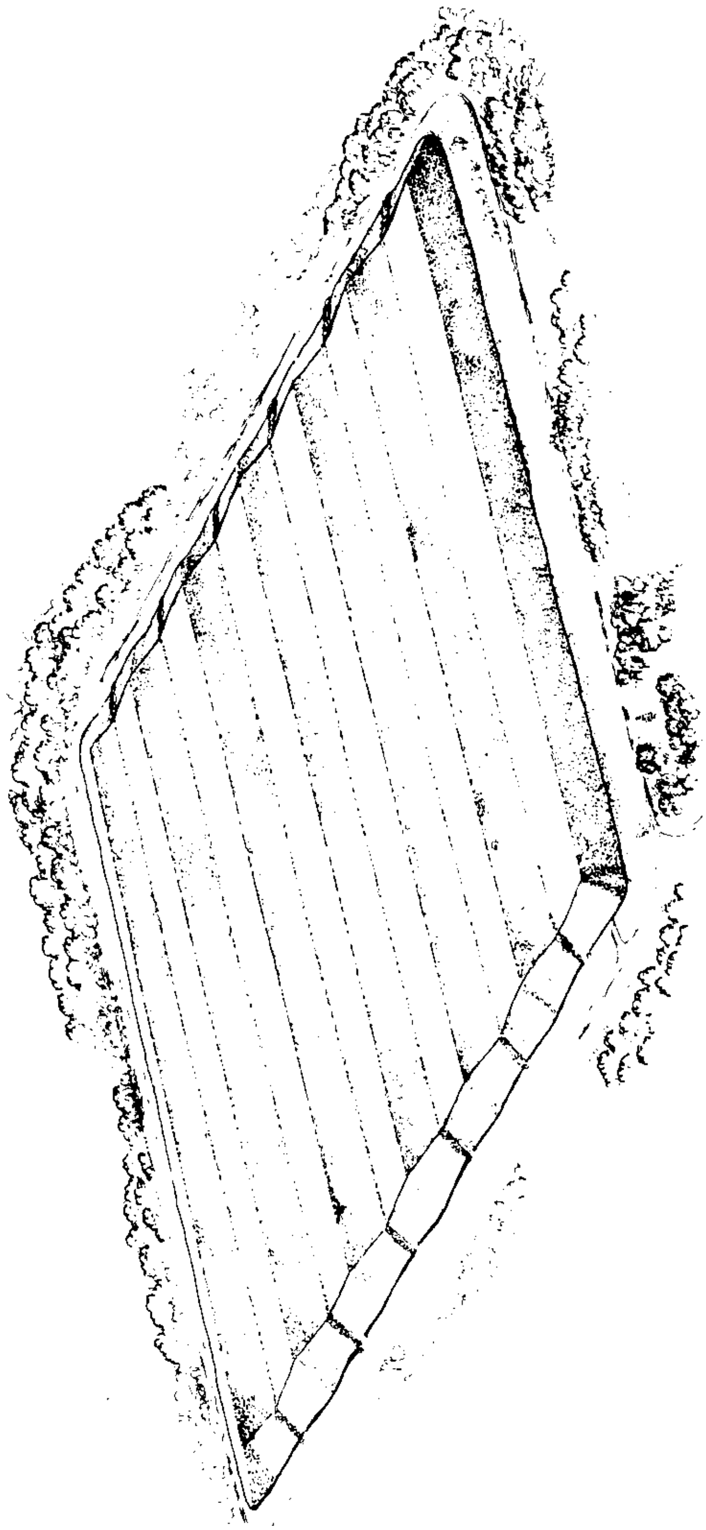

Fig. IX-1 Artist's concept of solid waste disposal area.

and the proximity of important natural resources, usual disposal approaches such as waste fixation or use of an underdrain could not be employed. The facility design was therefore tailored to the characteristics of the waste and the site. The most important aspect of facility design was the study of factors affecting the ability of the cover to prevent infiltration by rain water, such as liner performance, sideslope stability, settlement, and water budget. Another important facet of the evaluation was analyses of dispersion and attentuation of discharges in the ground water and surface water and the resulting biological consequences.

The results of the design study are contained in references 8, 9, and 10. The design concept was found adequate to meet regulations and to prevent contamination of the drinking water aquifer or damage to natural resources in the adjacent surface water bodies.

F. Waste Disposal in Maryland

At present, there are no utility flue gas desulfurization systems operating in Maryland; all of the utility waste being generated is flyash and bottom ash. Currently there are five coal burning plants: Baltimore Gas and Electric Company (BG&E) and Potomac Edison Company (PECO) each has one, and Potomac Electric Power Company (PEPCO) has three. Delmarva Power (DPL) is planning a major new coal-burning facility at Vienna which will include a scrubber. Also, BG&E is planning to burn coal at its new Brandon Shores plant and eventually to convert most of its oil burning plants to coal. Scrubbers will not be used at the Brandon Shores plant because it is exempted from the most recent New Source Performance Standards. The need for scrubbers at the converted BG&E plants and at the future plants of PEPCO and PECO is presently unknown.

Information currently available about the present ash disposal situation is presented below.

- Baltimore Gas and Electric Company

  The Wagner 3 station presently generates 61 acre-ft of flyash and 15 acre-ft of bottom ash annually. When the conversion of the Charles P. Crane station is completed in 1983, 46 acre-ft/yr of flyash and 46 acre-ft/yr of bottom ash will be produced, and in 1988, when Brandon Shores Unit No. 2 becomes operational an additional 191 acre-ft (in the same proportion of flyash to bottom ash) will be generated annually. BG&E reports a continuing effort to market its flyash. In 1979, 10 percent of the Wagner ash was sold, and this amount was doubled in 1980. In 1981, ash from Wagner will be used in the parking lot and road system at the Calvert Cliffs nuclear plant. Earlier, flyash from the Riverside plant was used in the construction of Liberty Dam for the Baltimore City water supply system. It is further anticipated that from 25% to 50% of the ash from Brandon Shores will be marketed.

  Material not marketed in the past was sent to the Boehm-Joy landfill near Crownsville in Anne Arundel County. Since that landfill was closed in November 1980, ash has been sent to a landfill in a sand and gravel quarry near Joppa in Harford County. Unsold material from Brandon Shores is planned to be used as structural fill material near the plant assuming all necessary permits can be obtained.

- Delmarva Power and Light Company

  The Vienna plant on the Nanticoke River where it is crossed by U.S. 50 operated coal-fired units from 1928 until 1972. Coal refuse was deposited in a diked marshland of approximately 90 acres across the Nanticoke River. For the planned addition to the Vienna plant, blended coal ash and scrubber sludge will be placed in an engineered landfill on-site. The landfill design, worked out through negotiations with the Power Plant Siting Program, will keep the waste isolated from groundwater and ambient precipitation and is expected to create no environmental hazard. Environmental review by the Public Service Commission and the Office of Environmental Programs is still required, however.

- Potomac Edison Company

  (Subsidiary of the Allegheny Power System). The R. Paul Smith Plant at Williamsport on the Potomac River in Washington County generates 40 acre-ft per year of flyash and 10 acre-ft per year of bottom ash. These wastes are slurried across the Potomac River to settling ponds, now filled, on the plant site in Maryland.

- Potomac Electric Power Company

  This company operates coal-fired plants at Chalk Point on the Patuxent River in Prince George's County, at Dickerson on the Potomac River in Montgomery County and at Morgantown, also on the Potomac River in Charles County.

The Chalk Point plant has disposal sites both at the plant and at an engineered site nearby in Brandywine. Annual ash production includes 11 acre-ft of bottom ash and 138 acre-ft of flyash. When new precipitators become operational in 1980, these amounts will be increased by 10 percent. Between 1964 and 1971, the ash was disposed of on-site. Since 1971 it has been landfilled at Brandywine.

At Dickerson, annual ash production is 48 acre-ft of bottom ash and 119 acre-ft of flyash. From 1960 to 1967, this material was disposed of in on-site ponds. From 1967 to 1979 the ash was shipped to Pennsylvania, and since 1979 it has again been disposed of on-site.

At Morgantown, annual ash production is 130 acre-ft of bottom ash and 191 acre-ft of flyash. This material has been stored at the Faulkner site on a managed basis since 1974, with unmanaged use of the site extending back to 1971. Earlier disposl sites are unknown but assumed to be on-site.

For the existing disposal sites of each utility it is not possible without further study to determine whether any contaminants exist that are producing leachate in harmful concentrations and whether remedial measures will be necessary. Existing sites are currently under study by the Power Plant Siting Program.

G. Long Term Considerations

Waste disposal areas will require perpetual care. Although the wastes are not legally hazardous, they can cause contamination of drinking water and environmental impacts unless properly controlled. In contrast to some other types of waste, the contaminant level of utility waste in ground water will not decrease to zero over time unless there is a substantial depletion of dissolved materials by release to the environment. It is therefore important to have disposal approaches that minimize routine maintenance and are relatively immune to extremes in natural conditions such as storms. From this point of view facilities that require the collection and treatment of leachate or the active maintenance of drainage systems are undesirable. But even facilities which require no direct routine care are subject to eventual failures from causes such as erosion and deterioration of materials. Therefore institutional arrangements to insure maintenance, prevent disturbance of the facility, monitor for releases and provide for possible reuse of stored materials are important.

Institutional arrangements include such topics as the mechanism of ownership, management responsibility, liability, regulatory responsibility, insurance, and the posting of bonds. The State of Maryland is currently in the process of drafting a comprehensive solid waste management plan which should address these considerations.

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CHAPTER X

TRANSMISSION LINES

Environmental impacts of a transmission line may arise from the construction or presence of the line, from the maintenance of the right-of-way, or from electromagnetic effects associated with the operation of the line. Construction and maintenance may lead to effects on vegetation, wildlife, and fish populations. The presence of a transmission line can potentially impact land uses and values, and also be a visual intrusion. Electromagnetic fields generated in the vicinity of high voltage transmission lines can cause:

- Audible noise
- Radio and television interference
- Ozone production
- Spark discharges to persons touching large, ungrounded metallic objects located in or near the transmission line right-of-way

Electrical fields under transmission lines may create health effects although the existence of such effects have not been confirmed.

Transmission lines are necessary to transmit electrical power from generating stations to the electrical distribution grid, and compose that part of the distribution system operating at 69 kilovolts (kV) and higher. Lines energized at less than 69kV are distribution lines, and form the network that actually brings electricity to the customer.[1] Prior to constructing a transmission line of voltage greater than 69kV, a utility must obtain a Certificate of Public Convenience and Necessity from the Maryland Public Service Commission. The utility must demonstrate, in a public hearing, the need for the transmission line, and the acceptability of the route being proposed. These issues, especially that of route acceptability, are independently evaluated by various State agencies, including the Power Plant Siting Program. A map of transmission lines of 230 kV and higher in Maryland is shown in Figure X-1.

A. Environmental Impacts

The construction of a transmission line will inevitably cause some environmental impact, but there are several ways by which such impact can be minimized. The first and most obvious way is judicious routing. Identifying a transmission corridor which avoids those areas considered to be unique or environmentally very sensitive obviates the need for special mitigating actions. Performing route selection studies, such as that done in conjunction with the Potomac Edison Company's application to construct the Montgomery - Damascus - Mt. Airy transmission line (1) is useful for identifying

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[1]While 69KV is a transmission voltage by definition, it can be utilized for either transmission or distribution.

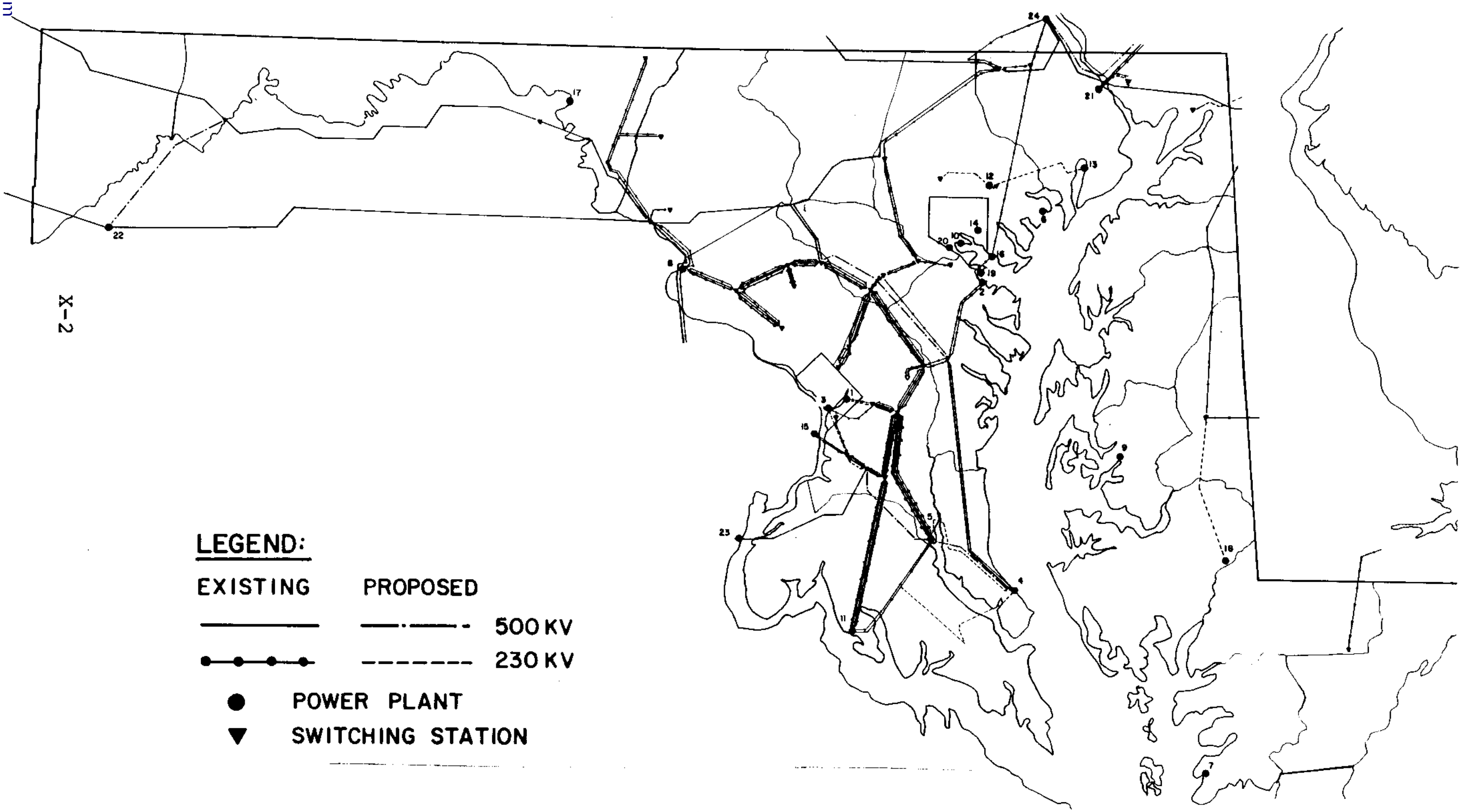

Fig. X-1. Transmission Lines in Maryland available options and tradeoffs necessary for choosing the most acceptable route. Several techniques are available for performing such studies, and the most appropriate is best selected on a site specific basis (2).

One of the most obvious environmental impacts associated with construction of a transmission line is the deforestation which occurs when a right-of-way (ROW) is being cleared. While the location of the ROW will dictate the extent to which land must be cleared, it is difficult to conceive of a route not requiring the removal of some trees. Since deforestation is a problem of increasing magnitude in eastern states such as Maryland, the area of woodlands to be removed becomes a crucial factor in comparing right-of-way alternatives.

Reducing forested areas, while an adverse impact in itself, can lead to secondary effects such as alteration and/or elimination of wildlife habitat, and increased erosion. Wildlife habitat may be altered by ROW clearing, but a habitat is rarely totally eliminated. Species diversity can actually increase when forested areas are interrupted by a corridor populated by shrub and bush species. Exactly how such a habitat change will affect local populations depends upon many factors.

Clearing of a ROW may also affect fish populations. Such effects are of two types: introduction of excess sediments to waterways because of soil erosion, and warming of waters as a result of the elimination of shade trees. Increasing the temperature of a stream can render it unsuitable for existing fish populations. This is most important in the case of natural trout streams. Introducing sediments to waterways can have an adverse impact on the spawning of resident and migratory fish. Sediment blanketing of eggs has been documented as a cause of increased mortality during spawning (3). This is a severe problem in areas composed of highly erodible soils. Mitigative measures, however, are both simple and effective. Seeding and mulching immediately following soil exposure, and restricting construction to the summer growing season should limit sediment damage (4).

Once a transmission line is in place, wildlife can be impacted by the presence of the line and ROW maintenance. A transmission line can, for example, effect birds in flight. Collision related deaths are known to occur, and may be significant on species with dangerously low populations, where any added source of mortality is nontrivial (5). Several site specific factors influencing the frequency of waterfowl collisions have been identified: number of birds present, visibility, species composition, behavior, disturbance, and familiarity with the area (6). There are many uncertainties associated with this problem, but one should weigh the desirability of avoiding those environmentally sensitive areas which can be identified.

Some impact to wildlife will occur as a result of ROW maintenance, which is necessary to prevent vegetation from either compromising transmission line safety, or restricting ROW access. Several techniques, including winter burning, mowing, hand clearing, and selective basal or aerial spraying of chemical herbicides, are commonly used for maintenance. Use of chemical herbicides holds the potential for environmental problems, but recent development of fairly innocuous herbicides, and care in using them can eliminate any undesireable impact. The use of selective basal spraying is generally preferred to broadcast spraying. The Power Plant Siting Program recommends that certificates granted for the construction of transmission lines restrict the use of chemical herbicides to selective basal application.

The aesthetic impact associated with the presence of a transmission line has become a very contentious point in several Public Service Commission hearings. Such impacts are inherently subjective and vary greatly, but invariably invoke very emotional responses from some of the affected individuals. While it has been shown that some people do not wish to see transmission lines, the assumption that transmission lines are intrusive and that no-one wants to see them is unproven (7). Unfortunately, regardless of the route selected, there is usually some aesthetic impact.

Although this impact is very subjective in nature, many technical factors affect its severity. The appearance of a transmission line is a function of such engineering factors as voltage, line configuration, number of circuits, and number of conductors per phase, and such external factors as the vegetation and topography which characterize the ROW. In addition, the structures used for transmission lines range from a single wooden pole to latice steel towers of heights exceeding 150 feet. All of these factors also result in great variation in the width of the ROW. Because of this, the extent to which a transmission line visually impacts an area varies greatly.

Because of the potential for aesthetic impact, and the expense of obtaining rights-of-way, transmission lines are generally located away from urban centers. This generally results in a reduction in the number of people whose surroundings are negatively affected. Unfortunately such routes can result in a more significant deterioration of what was formerly a very scenic area. Areas where viewers would be especially sensitive to the presence of a transmission line, e.g., National or State forests and parks, scenic rivers, and sites of historic or cultural significance, can generally be avoided during the route selection process.

Attempting to avoid creating a visual impact can itself actually result in environmental impact. For example, scenic impacts are often reduced by locating transmission lines in low lying areas. Unfortunately streams also tend to be located in low lying areas. Routing around such areas can result in placing a transmission line on land considered to be highly desireable for various human activities, such as agriculture and development. This causes an inevitable conflict over land use.

Whenever a transmission line passes through or in close proximity to residential areas or land proposed for residential development, it is typically claimed that a transmission line adjacent to a lot will drastically reduce the value of the property, possibly even rendering it unsellable. Several studies have been undertaken to determine if there actually is a direct relationship between proximity to transmission line and property value. There are numerous studies supporting both the contention that the presence of a transmission line adjacent to a residential lot will cause a reduction in property value (8), and that no such reduction will result (9). A study done in Maryland for PPSP found a slight reduction in one community and no effect in another (10). While these effects can occur, although they are usually small, there is great variance from case to case.

Another consideration is the effect on agricultural operations. Although the impact is generally minimal, a transmission line spanning agricultural lands can result in a loss of productivity. Such losses result from land lost around structures and guy wires, adverse effects on soil profile and drainage from construction, structure interference with harvesting patterns, and weed propagation around structures (11). In addition, aerial operations for crop control in the vicinity of a transmission line will be restricted.

Obviously, there are some unavoidable impacts associated with the routing of any transmission line, and not all can be mitigated by judicious routing. Selecting a route requires tradeoffs between the various potential impacts. Any areas where the impact would be unacceptably severe can generally be avoided in the route selection process.

B. Electrical Effects

The operation of a transmission line has certain electrical effects on its surroundings. These effects usually are negligible at voltages below 230 kV, and can be divided into two categories: corona effects and field effects.

Corona discharge occurs at the conductor surface because local field strengths at some points on the conductor become great enough to ionize air. Such concentrations of field strength are enhanced by surface irregularities, e.g., dirt, scratches and water droplets. Corona discharges result in such electrical effects as audible noise, radio and television interference, and ozone production (12). Each of these effects becomes more severe in wet weather, a result of the increase in water droplets on conductors.

Audible noise occurs as a buzzing sound under very high voltage lines, such as those 500 kV and greater. Noise levels will tend to reach a maximum during periods of fog or mist, and are lower during dry weather. During heavy rain the loudness of the rain itself exceeds noise generated by the transmission line. While the posibility of annoyance to nearby residents cannot be discounted, it is nonetheless highly unlikely to occur.

The electromagnetic energy in corona discharges can cause interference with radio or television reception. This effect is generally significant only during wet weather, and is principally associated with voltages of 500 kV and greater (although it can occur on lower voltage lines, especially if they are older). Radio interference can be experienced by residents located near a transmission line as a reduction in quality of AM reception, but rarely during fair weather. Television interference near 500 kV lines has been shown to be a problem only when the following conditions exist: 1) television set located less than 300 feet from ROW; 2) indoor antenna only; 3) tuned to low frequency stations (channels 2 through 6); and 4) in use during rain (13).

The other result of corona discharge is the production of ozone from normal oxygen. The production efficiency varies greatly, and is dependent upon line voltage, electric field strength, conductor geometry, conductor surface condition, and meteorological conditions. Attempts to detect ozone, a highly reactive gas, produced by corona discharge have generally failed. Under worst case conditions, concentrations averaging less than 1 ppb above peak background fluctuations have been found (14). Ozone produced by transmission lines is not expected to have any significant effect on ambient air quality.

Field effects can result from either electric fields or magnetic fields which are created around the conductors. Electric fields are basically a function of line voltage, while magnetic fields are basically a function of conductor current. These fields can cause transfer of electrical energy through induction to conducting objects within the fields.

Both electric and magnetic fields contribute to induction on conducting objects, although the mechanisms vary. Induction from magnetic fields is important on long conductors with a connection to ground (such as fences), while electric fields tend to effect conducting objects which are well insulated from the ground (such as motor vehicles).

People touching objects on which voltages have been induced may experience noticeable effects as a result of induced currents or spark discharges. The magnitude of these effects ranges from the threshold of perception, to actual discomfort or startle reaction. Under worst case conditions, induced currents can theoretically reach levels (the "let-go" threshold) at which hand and arm muscles involuntarily contract, preventing one from releasing one's grip. These levels are, however, usually far higher than those induced by transmission lines on objects such as long fences.

More likely to be a problem, but still typically one of discomfort or annoyance rather than an actual safety hazard, is the spark discharge experienced from touching a conducting object on which a voltage has been induced. The associated sensation is not unlike that experienced when touching a metallic object after walking across a carpeted room in winter. A hazardous situation might arise if someone climbing a ladder on a house near a transmission line touches a gutter on which voltage has been induced, the individual may be startled and fall down. Several conditions must be met before this accident could be expected to occur; one example meeting the proper conditions would be a house 40 feet long with a raingutter 15 feet high, and located 120 feet from the center of a 500 kV ROW. While only preliminary work has been completed, a detailed study is now being undertaken to define exactly how people react to short duration, high voltage shocks (15).

A spark discharge could possibly ignite gasoline vapors given the proper conditions. This highly unlikely event requires conditions such as refueling of a large gasoline powered vehicle under a transmission line where the electric field strength is 5 kV/m or greater. The vehicle would have to be well insulated; e.g., standing on asphalt or crushed stone, the individual refueling the vehicle would have to be well grounded, e.g., standing on damp earth, the gasoline vapors and air would have to be mixed in proportions necessary for combustion, and the neck of a metal gas can would have to come close enough to the vehicle to cause a spark discharge. The Public Service Commission did consider a recommendation that conductor heights above surfaced roadways be raised to a minimum of 50 feet because of the possibility of fuel ignition, but ruled that the likelihood of such an event did not merit altering the existing 42 foot minimum height standard.

C. HEALTH EFFECTS

Transmission lines rated at 345 kV and above have been in existence for about 30 years. No health hazards to the general public exposed to the electric and magnetic fields produced by these transmission lines have been documented. Effects from long-term exposure to these fields could nonetheless exist.

Concern about this intensified in the early 1970s when reports of adverse health effects on workers in 500 kV and 700 kV switchyards were received from the Soviet Union. Various individuals have suggested that these studies prove that field strengths associated with transmission lines pose a health hazard. However, similar studies with workers in the United States, Canada and other countries have failed to reproduce the Soviet results, and more recently, some Soviet experts have expressed doubts about the earlier work from their country.

Of the many projects to look for effects of power frequency fields on laboratory animals, some found associated health effects and others did not. It is important to resolve questions as to whether the fields from high-voltage transmission lines can have long-term effects on humans or animals. To this end the utility industry, various governmental bodies, and others have initiated broad and extensive research programs. It is hoped that these programs will resolve most of the existing issues, and in the near future permit an improved assessment of any risks resulting from long-term exposure to transmission line fields.

Although no direct health effects associated with electric and magnetic fields have been identified, some states have chosen to set limits on the strength of fields permitted under transmission lines based upon consideration of shock effects. Both Oregon and Minnesota have maximum permissible field strengths with a right-of-way, 9 kV/m and 8 kV/m, respectively, while New York has effectively limited field strengths to 1.6 kV/m at the right-of-way edge (16). Oregon has actually limited field strengths by law; the other restrictions have come in required construction permits. Current acceptable National Electrical Safety Code clearances would probably keep the maximum induced field to less than 10 kV/m. Typical values for maximum field strengths under powerlines in Maryland are 7 to 7.5 kV/m. No limits have been imposed in Maryland.

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CHAPTER XI

COOLING TOWERS

Two general types of condenser cooling systems are currently in use at Maryland power plants. Open or once-through systems predominate. Cooling towers are alternatives which may be required by Maryland law. Cooling towers require less water to operate (as much as a 50 fold reduction), so their aquatic impacts are considerably reduced as discussed in Chapter IV. They could, however, have adverse terrestrial impacts that require site specific evaluations.

Cooling towers can use natural draft or fan-induced, "mechanical" draft. Both types remove heat by evaporation. In the process an aerosol is created which may drift beyond the exit point of the tower. This drift may contain concentrated dissolved solids as well as the chemicals used in biofouling control. Concentrated saline aerosols resulting from cooling tower operation in brackish water regions of the Bay could have an adverse impact on native vegetation, crops, and soils. Fogging and icing may occur under certain meteorlogical conditions and must be considered when highways or buildings are within the plume impact region. Noise impact, created by cascading water (natural and mechanical types) and fans (mechanical type) on neighboring communities, must be evaluated. Visual impacts of cooling towers and plumes must be considered within the context of existing visual elements at the site.

Chalk Point plant has two natural draft towers. The proposed expansion of Vienna will also use a natural draft tower. Present and predicted impacts at each site are discussed below.

A. Chalk Point

Chalk Point Unit 3 is equipped with a natural draft cooling tower. It has operated in a brackish water region of the Patuxent since 1975. This unit also emits brackish water steam from a stack scrubber. Drift emissions from the stack is approximately equal to the emission from the tower. Detailed studies have been made of the extent of this salt drift and its effect on crops, soils and native vegetation in the vicinity of the plant. These studies show that maximum deposition occur within 1 km of the source. This distance is within the plant boundary and the measured deposition rate of 8 kg/ha-month is below the rate at which commercial crops (soybeans, corn and tobacco) exhibit foliar damage (20 kg/ha-month). There appears to be no buildup of Na^+ or increases in electrical conductivity of the soil due to dustfall accumulation (1). Experimental studies using five species of native woody trees showed an increase of Na^+ and Cl^- with increased exposure to saline aerosol. In all species, except dogwood, the accumulation levels of Cl^- at the end of a growing season were less than the levels causing foliar damage (0.4-1.8% on a dry weight basis). Normal autumn color in dogwood, however, obscured observations (2) of any foliar damage due to Cl^-.

Unit 4 at Chalk Point is also equipped to operate with a similar cooling tower, but it has not operated to date. The predicted off-site deposition from cooling towers and stack drift from both units is estimated (3) to be less than 5 kg/ha-month.

B. Vienna

A natural draft cooling tower has been proposed for DP&L's 500 megawatt coal fired expansion at Vienna. The issues of salt deposition, plume visibility, fogging/icing, and visual intrusion were considered by PPSP for natural and mechanical draft cooling towers.

The Chalk Point Cooling Tower Drift Simulation Model was used to predict salt drift both on and off site at Vienna for the optimal type of cooling tower (natual draft). Maximum off-site deposition rate occurred in the autumn and was less than 25 kg/ha-month. No significant accumulation is predicted to result from this amount. Reduction in crop yield of corn and soybeans is estimated to be on the order of a few percent. Weathering and corrosion of materials at the boundary will be similar to that found at sites 1 km inland from the ocean coast (4).

The impact of visual intrusion of the cooling tower and related plume is difficult in quantify. The tower itself will be 122 meters high, and on most days the plume will exceed 100 meters in length. The visual impact of the tower and plume, however, must be considered as an incremental visual impact in addition to the 171 m stack, turbine (30.5 m) and boiler buildings (76.2 m) of the proposed facility. Because of vacation traffic along Route 50, the number of people exposed to the view could be as high as 14,000 per year. Fogging and icing on the Route 50 bridge is expected to be minimal because of the plume elevation.

On the basis of these studies, the PPSP has recommended to the Maryland Public Service Commission that a natural draft cooling tower be used at the proposed Vienna expansion (5).

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