CHAPTER VI

OTHER IMPACTS

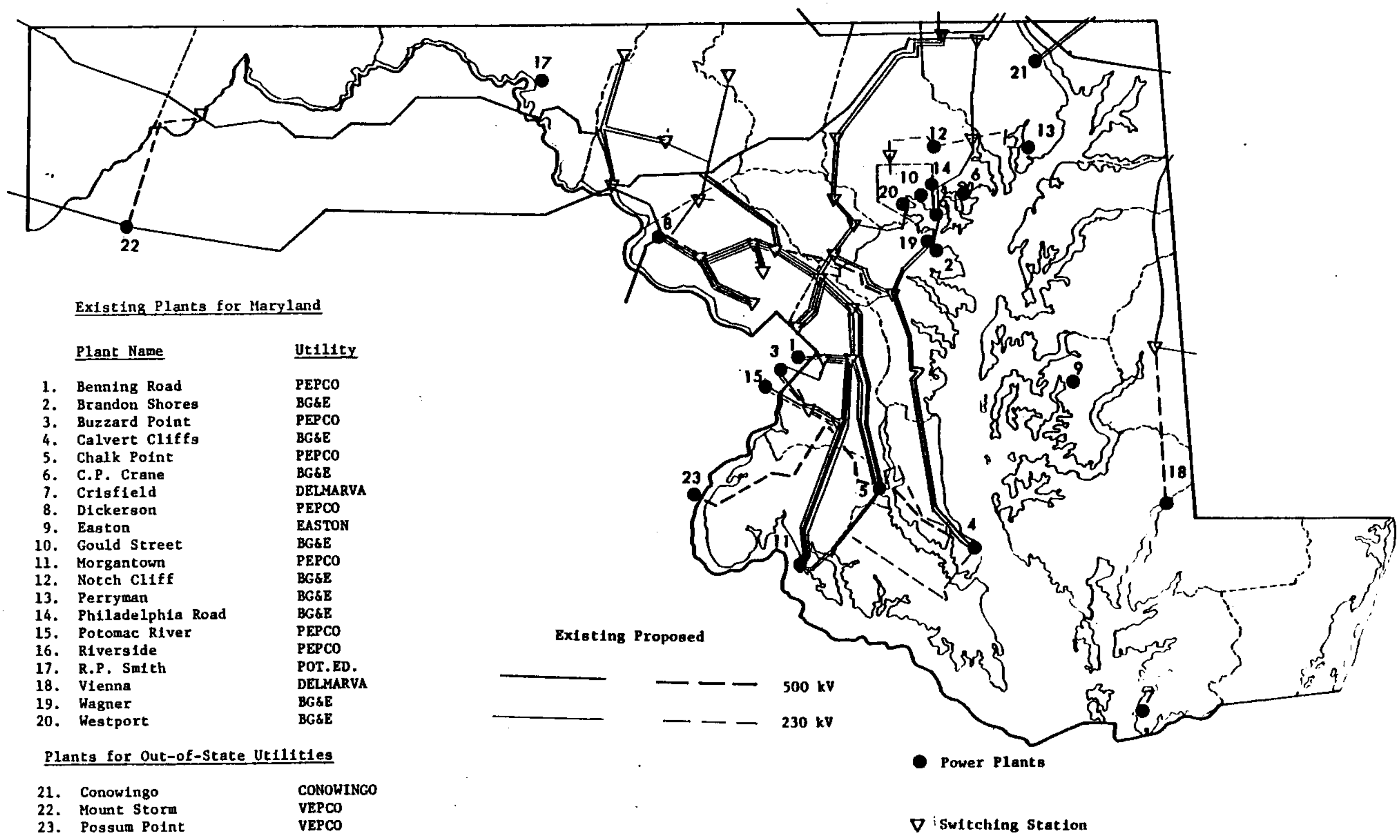
A. Transmission Lines

Electrical power is carried from generating stations to the users of electricity by a system of power lines, transformers and switching stations. The higher voltage lines, called "transmission lines," connect generating stations to each other and to major transformer substations located near load centers. Figure VI-1 depicts the transmission system in Maryland. All power lines above 69,000 volts in the State are designated as transmission lines, and the highest voltage currently used or planned for use in the State is 500,000 volts (Table VI-1). Power lines carrying 69,000 volts or less are designated as "distribution lines." They form a grid system throughout each service area, connecting each consumer of electricity to the transmission lines and hence to the generators.

Several types of impacts may be associated with power lines. Ecological impacts, both positive and negative, may result from the clearing created to permit the passage of power lines through natural areas. Aesthetic impacts may occur when direct view of the lines or their clearings interfere with the other elements of the natural visual scene. Physical effects caused by the electrical fields near higher voltage transmission lines include spark discharges and currents to which a person may be subjected if he touches an ungrounded metallic object. Audible noises are also generated by these electrical fields, such as "sizzling" sounds produced by 500,000 and some 230,000 volt lines, and discrete tones ("60 cycle hum") produced by transformers and some higher voltage lines. Radio and television interference may be caused by the corona discharges on high voltage lines and by loose connections which cause sparking in lower voltage equipment. Health effects from the oscillating electrical field under high voltage lines have recently been alleged, and are presently the subject of much national debate and study.

The magnitude of each of these effects depends upon the voltage carried by the power line, the design of the line's conductors and towers, and the location and situation of the line. The visual surroundings, the extent, type and proximity of nearby human activities, the strength of commercial radio and television signals in the area, and the nature of the local ecosystem are all factors which will determine the extent and severity of adverse effects. In general, the potential for adverse effects increases as the voltage of the power line is increased. Higher voltage lines create greater electric fields, stronger radio frequency emissions, and require larger, more visible towers and wider clearings for rights-of-way. Balanced against these effects is a reduction in the number of transmission lines needed to carry the given amount of power.

Ecological impacts of power lines can largely be mitigated by proper routing to avoid unusually sensitive or unique areas, by careful sedimentation



Existing Plants for Maryland

	Plant Name	Utility
1.	Benning Road	PEPCO
2.	Brandon Shores	BG&E
3.	Buzzard Point	PEPCO
4.	Calvert Cliffs	BG&E
5.	Chalk Point	PEPCO
6.	C.P. Crane	BG&E
7.	Crisfield	DELMARVA
8.	Dickerson	PEPCO
9.	Easton	EASTON
10.	Gould Street	BG&E
11.	Morgantown	PEPCO
12.	Notch Cliff	BG&E
13.	Perryman	BG&E
14.	Philadelphia Road	BG&E
15.	Potomac River	PEPCO
16.	Riverside	PEPCO
17.	R.P. Smith	POT.ED.
18.	Vienna	DELMARVA
19.	Wagner	BG&E
20.	Westport	BG&E

Plants for Out-of-State Utilities

21.	Conowingo	CONOWINGO
22.	Mount Storm	VEPCO
23.	Possum Point	VEPCO

Figure VI-1. Power plants and transmission lines in the Maryland region

Table VI-1. Pole miles of transmission lines and circuit miles of underground cables in Maryland

Existing or under construction as of December 31, 1977, per annual reports to the Maryland Public Service Commission

Utility	Line Voltages					Existing Corridors (Acres)
	500 kV	230 kV	138 kV	115 kV	69 kV	
BG&E						9,698
Pole Miles	195.7	214.6 (a)	15.3	333.4	-	
Und. Cable	-	-	-	58.9	-	
PEPCO						5,997
Pole Miles	52.4	341.5	-	- (c)	-	
Und. Cable	-	16.3	48.2	11.7	-	
Conowingo						925
Pole Miles	24.1	1.7 (c)	2.4 (d)	-	-	
Und. Cable	-	-	-	-	-	
Susquehanna						930
Pole Miles	-	13.9 (c)	-	-	-	
Und. Cable	-	-	-	-	-	
Delmarva						7,209
Pole Miles	-	61.0	125.7	-	311.6 (e)	
Und. Cable	-	-	-	-	-	
Pot. Edison						6,760
Pole Miles	90.4	72.8	260.5	-	17.7	
Und. Cable	-	-	-	-	-	
Southern Md.						3,379
Pole Miles	-	-	-	-	264.6	
Und. Cable	-	-	-	-	0.3	
TOTALS						34,898
Pole Miles	362.6	705.5	403.9	333.4	593.9	
Und. Cable	-	16.3	48.2	70.6	0.3	

(a) Plus 6.4 circuit miles of sub marine cable.

(b) Plus 26.4 miles on structures of another line.

(c) 200 kV

(d) Plus 2.1 miles on structures of another line, all voltage 132 kV

(e) Plus 0.6 miles of submarine cable

and erosion control practices during construction, and by selective clearing and maintenance. Right-of-way maintenance for enhanced wildlife productivity is possible for some species which require grasses, dense brush or edge habitats. Where power lines traverse areas that are otherwise solidly forested, power line corridors may actually increase the diversity of species. Other species, however, particularly those requiring mature trees or forests, can only have their available habitat decreased by power line rights-of-way. Where power line corridors open otherwise secluded areas to human traffic, particularly noisy traffic such as motor bikes, all-terrain vehicles and snowmobiles, habitat may become unacceptable to timid species and erosion may be caused by vehicular traffic. These impacts must be evaluated on a case-by-case basis.

Aesthetic impacts are subjective but no less significant. Selective clearing and vegetative screening can mitigate visual intrusion in natural areas, but it is usually not possible to hide power lines completely from human view. A trade-off arises between routing a line through a more secluded area, where less people see it but the aesthetic impact per person is high, and routing it along a more populated urbanized corridor which is already visually impacted but where more people will see it. The effects such views create on property values have not yet been quantified for the various types of residential settings and power line configurations in Maryland. Residential situations vary from low cost row housing to estates situated near focal points of natural scenic beauty. Transmission lines range from single wooden poles carrying three wires, to bridgework tower structures over 150 feet tall, carrying bundles of wires. Again, impacts must be considered case by case.

Radio interference, audible noise, and ozone production are all caused by corona discharges which occur when the local electric field strength at the surface of the transmission line wires exceeds the breakdown potential of the air. These effects are particularly noticeable in wet weather when water droplets on the conductors increase corona discharge.

Audible noise consists of a "sizzling" sound in wet weather and a barely audible crackling noise in dry weather. For example, during wet weather, one 500 kV double circuit line reached a level of 43 dbA* near the transmission line ROW, and 30 dbA (corresponding to the background noise in a very quiet rural area at night) at a distance of 200 ft from the ROW (1). The 43 dbA level is considerably below the Maryland State Limit of 50 dbA (night), although the possibility of annoyance cannot be absolutely ruled out. Under wet weather conditions, ambient noise levels are exceeded at high frequencies (above 500 Hz) at locations close to the line. Fortunately, the higher frequencies characteristic of transmission line noise are more rapidly attenuated with distance (1).

Radio interference (RI) is a collective term for the various types of electromagnetic interference. RI from power lines is caused by corona discharge, an effect that is particularly important in wet weather. In such

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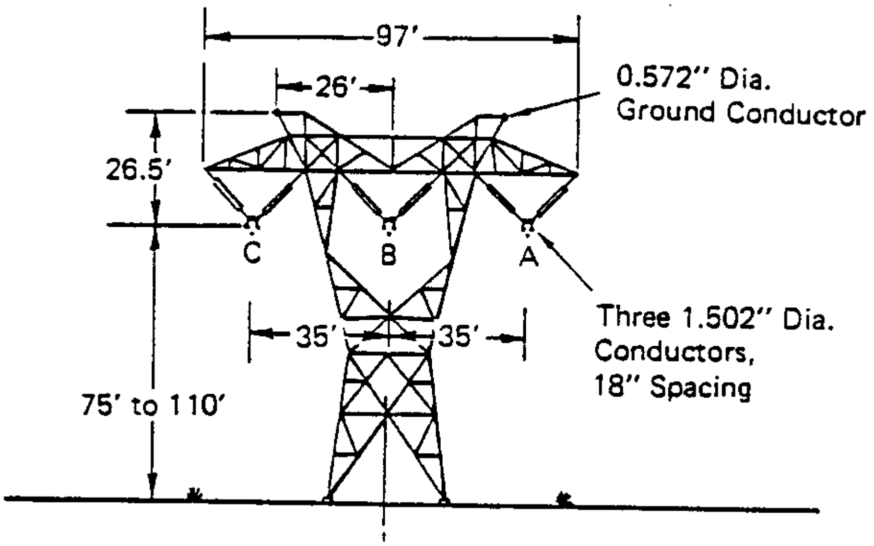
* dB or decibel is a relative measure, here equal to the logarithm of the ratio of a measured energy to some reference energy. dBA is the total energy over a frequency band similar to that perceived by the human ear, referenced to a pressure of 2×10^{-4} μ bars = 20 μNm^{2}.

conditions, it may be bothersome for AM reception for residents located close to the line (1). During fair weather, residents nearby the ROW experience minimal interference. For example, investigations (2) involving the proposed Brighton-High Ridge 500-kV line indicate that at least 18 AM radio stations would maintain an acceptable signal-to-noise ratio (21 dB). During light rain and heavy fog, residents extremely close to the ROW (less than 100 ft) for this line may notice a degradation in signal quality, but between 5 and 10 radio stations would still be available at an acceptable quality level. During heavy rain (a condition which often brings electrical interference of its own), interference effects extend to greater distances, but between 2 and 7 radio stations would still be available at distances of 100 feet from the ROW (2).

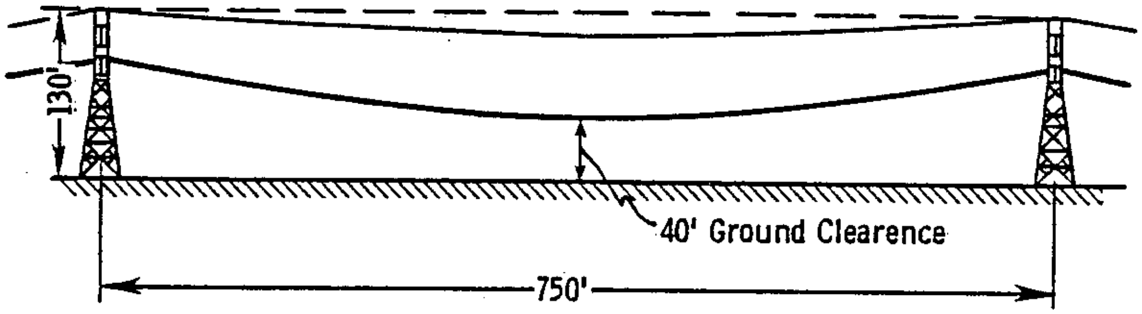
Studies indicate that TV interference would not be bothersome, except possibly for sets located close to the ROW (< 300 feet) using indoor antennas (rabbitears) tuned to a weak, low wavelength station (channels 2-6) during a heavy rainstorm. In most cases, installation of a directional, outdoor antenna would eliminate this problem (1,2). For FM broadcasts and higher wavelength TV reception (channels 7-13 and UHF), no significant interference is expected outside the ROW.

Corona processes from EHV power transmission lines also produce ozone by a method analogous to that occurring during lightning discharges. Several laboratory programs and modelling efforts have investigated the corona production and dispersion processes (1). The efficiency of the production rate varies widely with line voltage, electric field strength, conductor geometry and condition, and meteorological conditions around the transmission lines. On very humid days (but without precipitation), with clean conductors, and with conductor configurations designed to minimize the electric field strength, corona loss and ozone production will be reduced. During heavy rain, with nicked or contaminated conductor surfaces, corona loss and ozone production will be increased. Laboratory measurements have determined that ozone is generally produced at a rate of 0.5 to 5 grams per kW-hr of corona energy loss, depending on conditions (1). Field studies (as reviewed in Ref. 1) have either failed to detect ozone contributions due to transmission lines or have, under worst case conditions, averaged less than 1 ppb above peak background fluctuations. Based upon these results, it is reasonable to conclude that ozone production from transmission lines is not expected to have any significant effect on the local or regional environment.

Electric and magnetic fields are generated around an operating power line. Magnetic fields are present any time current flows in the line, but the magnitude of these fields is small and their effects negligible when compared to the effects of electric fields, which can induce charges on metallic surfaces such as vehicles, gutters on adjacent structures, fences, and masts of sailboats. People touching these objects may draw a steady current through their body or may be subjected to spark discharges upon approaching these objects. The magnitude of the electric field varies with location, conductor height, and the configuration of the line. For example, for the line configuration shown in Figure VI-2, the maximum field intensity varies from about 7.0 kV/m at the minimum clearance point to below 3 kV/m at conductor heights above 65 feet (Figure VI-3). For all heights, the field at the edge of the ROW would be below 2.5 kV/m.



a) Lattice Structure



b) Example Span Profile

Figure VI-2. Typical 500 kV transmission line

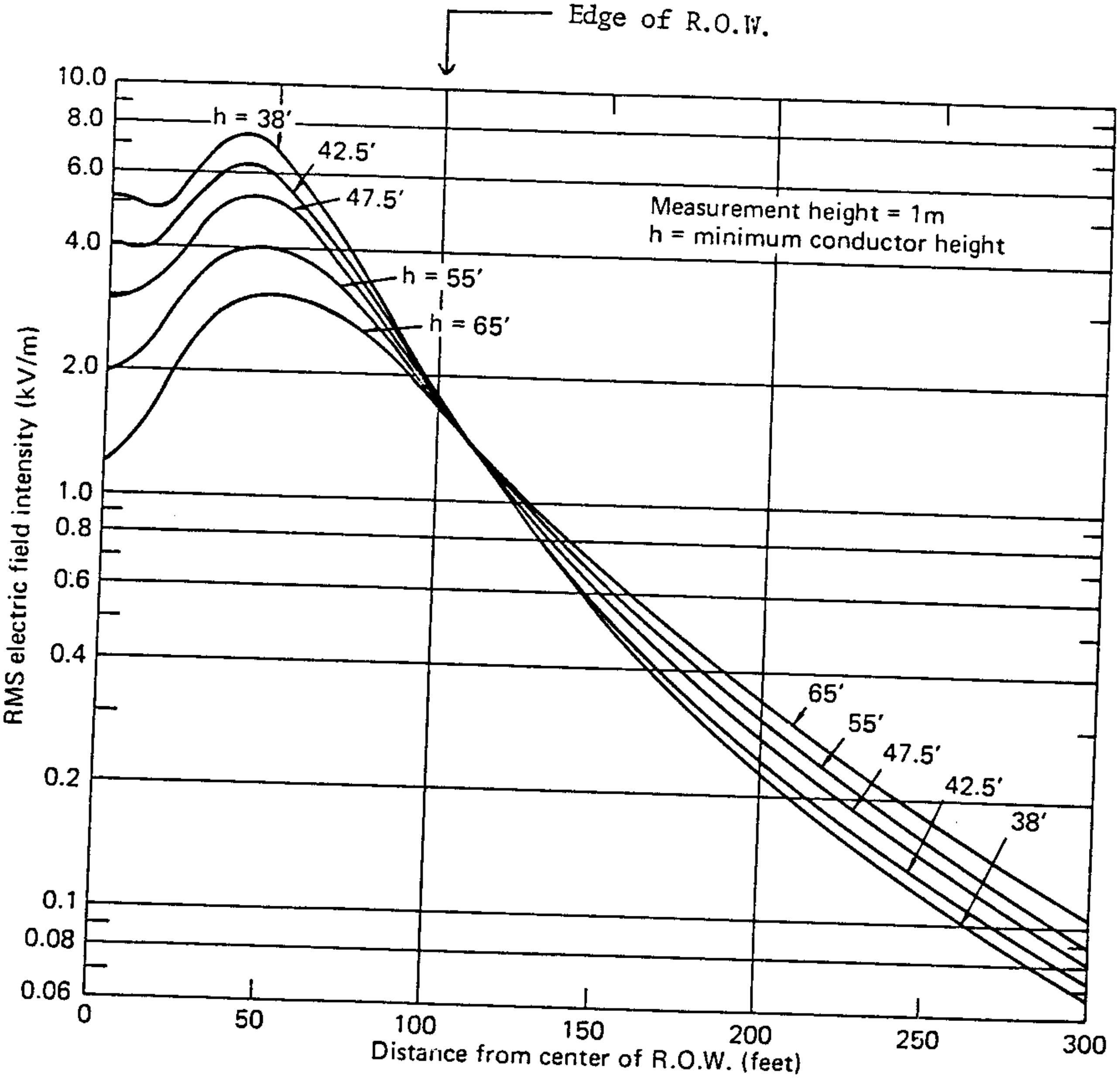


Figure VI-3. Electric field profile for 500 kV horizontal configuration with three sub-conductors

The magnitude of these effects has been calculated for several representative "worst case" situations assuming a typical 500 kV power line configuration (1). Effects depend on the distance to the transmission line and the size and orientation of the object causing the effect on the human. In field tests, actual observed effects have varied from 10 to 100 percent of the calculated "worst case" results, reflecting the fact that many unknown and uncontrollable factors (such as insulation or leakage resistance under different conditions of soil, vegetation, and moisture content, and capacitance of irregular objects) are of central significance. Effects to quantify these factors (allowing a more realistic risk assessment) are now in progress (3). Figures VI-4 and VI-5 give the maximum "worst case" induced currents and spark discharge currents for various objects exposed to the fields surrounding the line depicted in Figure VI-2. Also shown in the figures are the range of human responses. The "let-go" current is the level at which a person is unable to release his grip on a conductor. This level, obviously, is considered to be potentially dangerous. Another possible hazard is that a spark discharge may cause ignition during fueling of a vehicle under a transmission line near midspan. Figure VI-6 shows ignition potential for some typical vehicles when located in the maximum "worst case" electric field at the point of minimum height (40 ft) for the line shown in Figure VI-2 (note that a tractor-trailer normally will use diesel fuel not subject to ignition under these conditions). Actual tests have shown that the chances of such ignition are extremely remote, but it is nevertheless good practice not to refuel under a transmission line. The Power Plant Siting Program has recommended, as a result of these calculations, that the minimum height of new 500 kV lines over roads be raised to about 50 feet (depending upon configuration) so that refueling a vehicle the size of a school bus will not entail any risk of fuel ignition.

Questions have been raised concerning the health effects of chronic exposure to oscillating electric fields at magnitudes found within (or possibly adjacent to) transmission line rights-of-way. Soviet literature contains reports of medical evaluations of personnel working in 400 kV to 765 kV switchyards. A majority of those studied developed pathological reactions attributed to their exposure to the electric fields. As a result, Soviet work regulations limit the time a worker may be exposed to fields equal to or in excess of 5 kV/m. Maximum field intensities from some 500 kV lines currently in use in Maryland may reach peak intensities within the right-of-way of 6.7 kV/m at a height of 1 meter above the ground, and 7.5 kV/m at a height of 3 meters above the ground. These peak intensities occur at the lowest point of conductor sag. The Soviet work rules would limit a person's exposure to such fields to 3 hours per day. In contrast to the Russian reports, a major U.S. study of the medical effects of 10 linemen (4), working with 138 kV and 345 kV equipment over a 9-year period, concluded that the health of these men had not been affected by their exposure to the high-voltage lines.

The question of the health effects of exposure to 60 Hz electric fields is under study by many researchers (5). Both the Energy Research and Development Administration and Electric Power Research Institute are sponsoring major research programs to determine the long-term chronic health effects of exposure to electric fields. At the present time, safe limits for exposure to electric fields from transmission lines have not been established in the

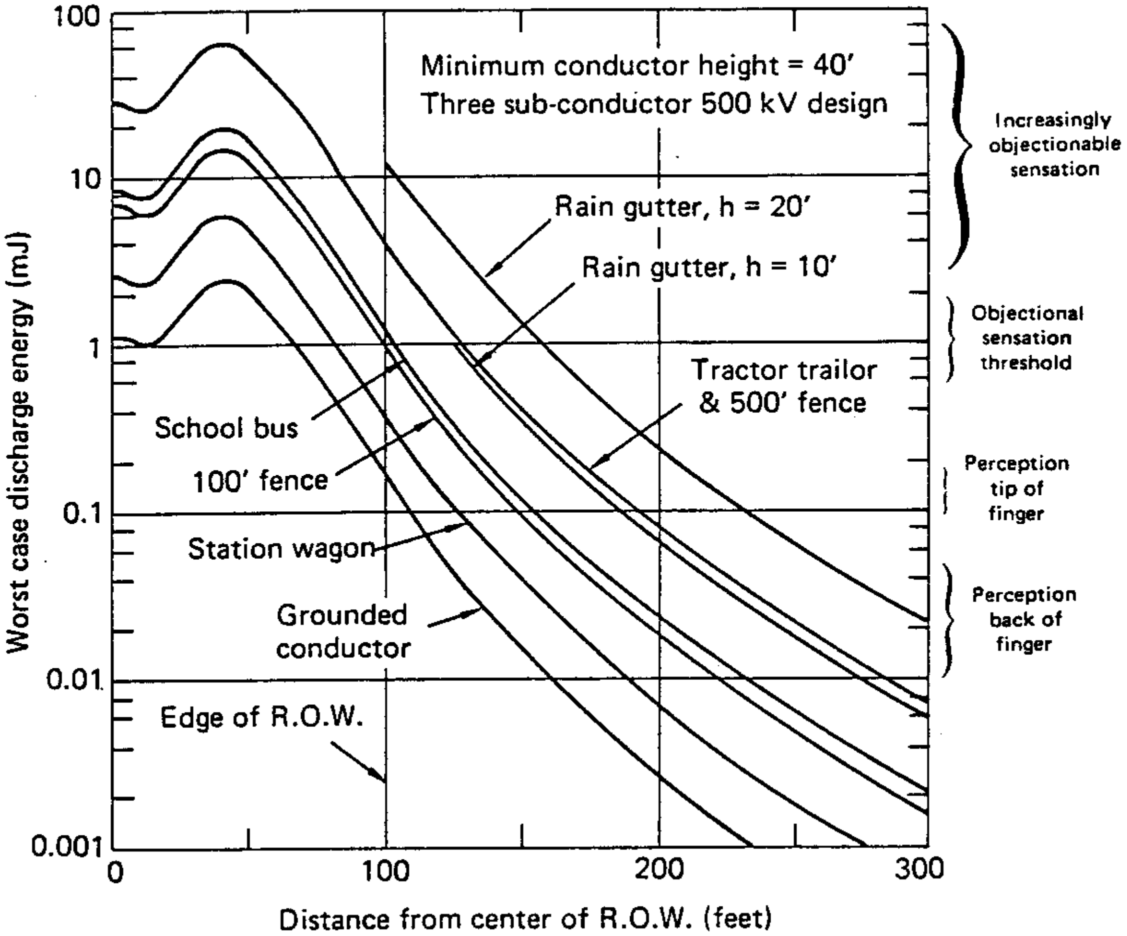


Figure VI-4. Worst case electrostatically induced spark discharge for people touching various objects

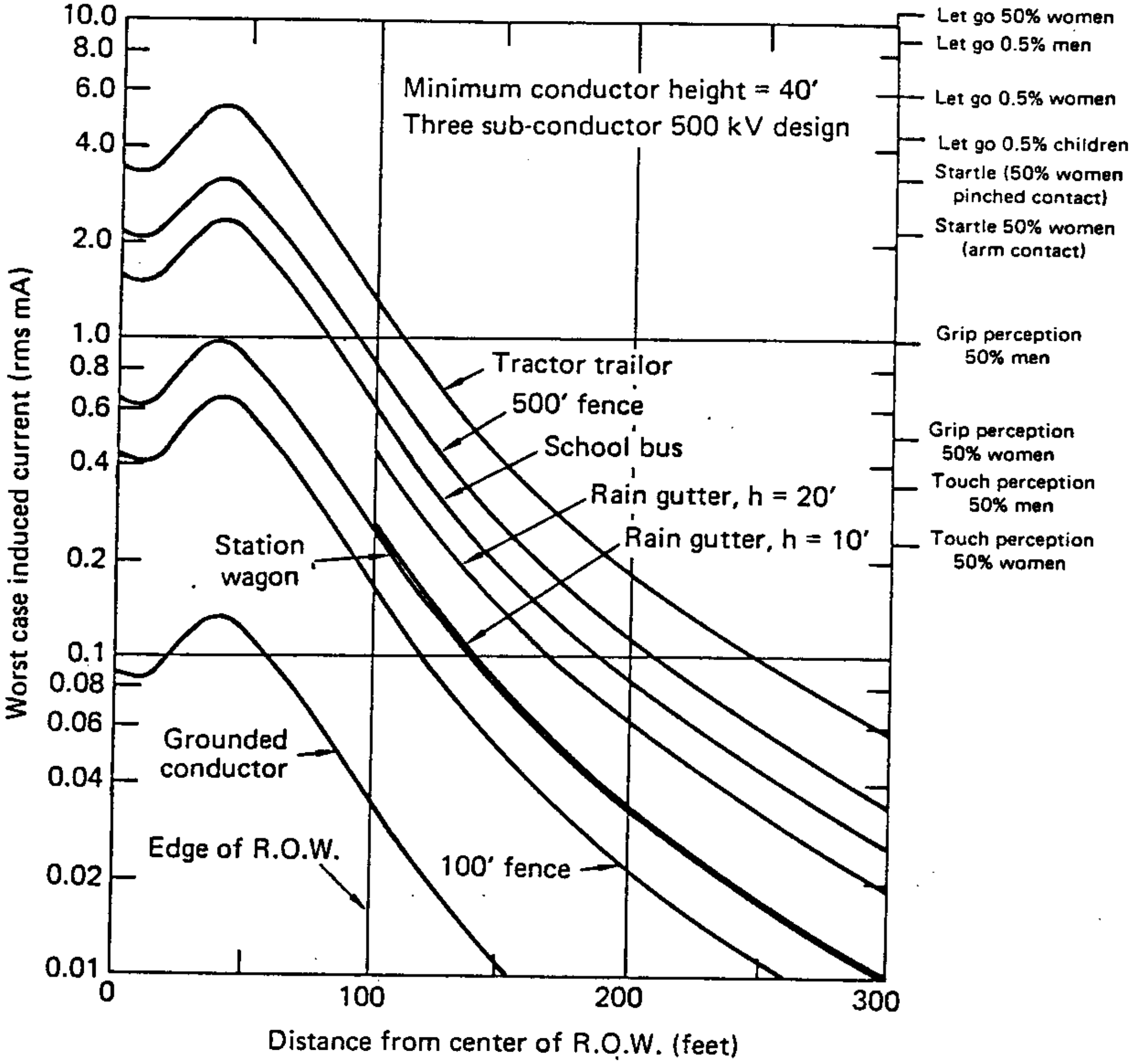


Figure VI-5. Worst case electrostatically induced currents for people touching various objects

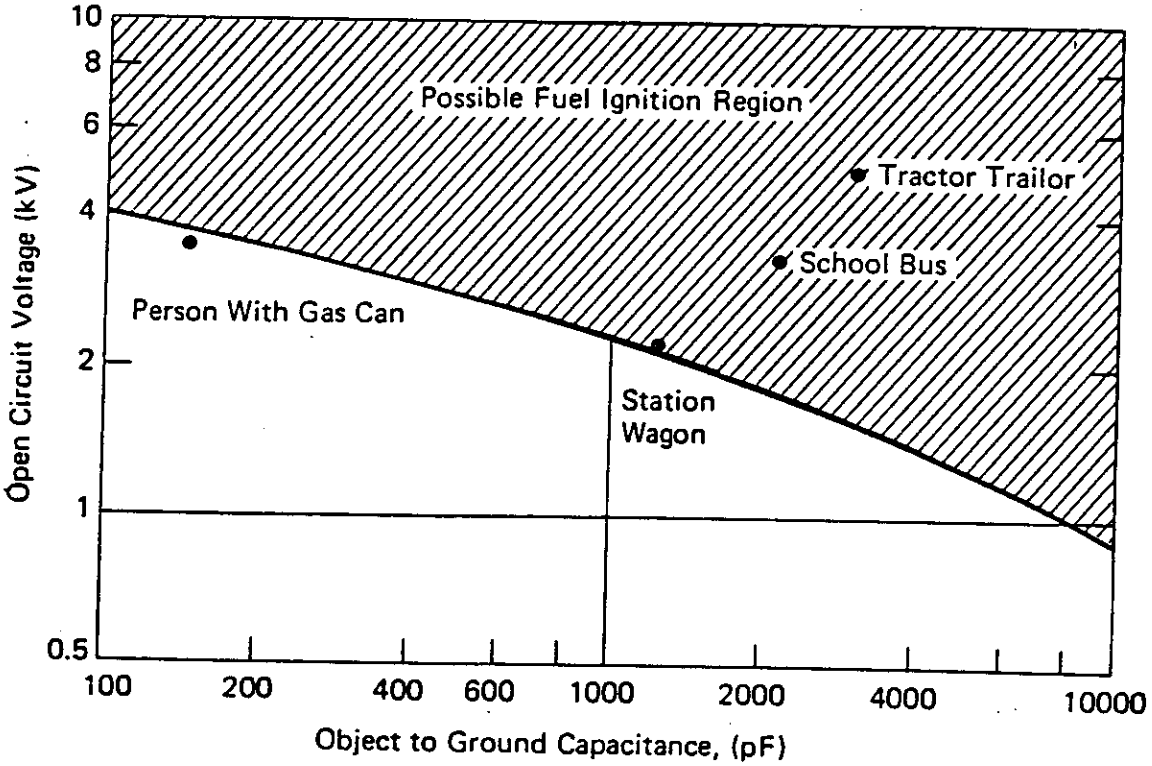


Figure VI-6. Gasoline ignition potential from AC spark discharges. (Test results obtained on a warm, dry day.) Points apply to worst case open circuit voltage under proposed 500 kV line. Minimum conductor height = 40 feet

U.S. Several factors should be appreciated in evaluations of available literature on transmission line health effects:

- Neither Soviet nor U.S. reports on health of linemen and switchyard workers present adequate test data or discuss control procedures.
- Linemen and switchyard workers may be exposed to higher fields (up to 25 kV/m) then would be experienced by other people under the transmission lines.
- Generally, levels of the electric field from transmission lines along the ROW are below levels at the lowest point of conductor sag.
- Exposure to the highest field intensity occurs only when a person is almost directly under one of the conductors. Within the ROW, the average intensity is lower.
- Beyond the edge of the ROW, intensities drop rapidly below peak levels. It is in this reduced intensity region that residents would be likely to receive extended exposure.

Table VI-1 summarizes the status of transmission lines in Maryland. Since the last CEIR, several changes have occurred. First, BG&E has upgraded their low-level (115-138 kV) transmission system substantially. PEPCO has started work on a 500 kV distribution loop around Washington, D.C. Finally, Delmarva has completed 61 miles of their 230 kV distribution loop for power distribution on the Delmarva peninsula. These trends in upgrading voltage and distribution nets are expected to continue.

Conclusions

The routing of transmission lines deals with effects that may have aesthetic, ecological, health, and physical implications. The aesthetic effects generally involve trade-offs between rural and urban routes. Ecological effects can be both positive and negative and must be evaluated on a case-by-case basis. The electrical effects are now well understood and are potentially significant only for locations within or extremely close to the ROW. The health effects remain an area of controversy, mainly due to differing medical results from U.S. and Soviet studies in this field.

While the dangers to personal safety are relatively remote for anyone who is only occasionally in the proximity of transmission lines, the Maryland Power Plant Siting Program has taken steps to reduce that risk even further, so that the possible hazards from transmission lines, except under highly unusual conditions, are virtually negligible.

B. Groundwater

In addition to the need for cooling described in the aquatic chapter, power plants also require freshwater for boiler make-up, pump cooling, sanitary water supply, and pollution control equipment. These uses can be considerable - up to 1.6 million gallons daily for 2000 MW of fossil-fueled capacity and 500,000 gallons daily for a 2000 MW nuclear plant. This water can be drawn from four sources, depending upon the plant location.

- Non-tidal river - Usually, the water is withdrawn from the river and purified for use. Examples of plants using this type of withdrawal are Dickerson and R.P. Smith.
- Industrial water supply - Large cities like Baltimore and Washington provide water of industrial quality to power plants and other large users.
- Groundwater/Desalination - For plants located near brackish surface water, but remote from municipal supplies, there are two alternatives: to desalinate the surface water or to use groundwater. For four of the Maryland plants (Morgantown, Chalk Point, Calvert Cliffs, and Vienna), the choice has been to use groundwater. The potential impact of these wells on adjacent users is discussed below.

A generalized cross section of the coastal plain sediments, shown in Figure VI-7, indicates the water-yielding formations ("aquifers") available for groundwater withdrawals in Southeastern Maryland. The potential impact of the use of groundwater lies not so much in a reduction of the quantity of water available, but in a decrease in the hydraulic head or "potentiometric surface" in the area surrounding the point of withdrawal. This surface represents the level to which the water would rise if a well were drilled into the aquifer in question. As the well is pumped, a "cone of depression" centered around the well is created in this surface. If pumpage lowers the surface below the intake level of the pump of a neighboring well in the same aquifer, then that well becomes "dry". In such a case, the pump would have to be lowered to a depth that would remain below future lowerings of the potentiometric surface.

The Calvert Cliffs plant has 3 wells averaging 620 feet in depth that withdraw water from the Aquia aquifer (6). The average monthly usage (Figure VI-8) is far below the allowed average and maximum appropriations of 600,000 gpd and 865,000 gpd, respectively (6). Water levels in an observation well located about a quarter mile from the plant have declined approximately 10 feet due to pumpage (Figure VI-8) (7). No significant lowering would be expected outside the plant property due to this pumping (8). Several other users in the area (e.g., U.S. Naval Research Laboratory, Patuxent Naval Air Center, Randle Cliffs) use similar or larger amounts of groundwater from the aquifer (6).

The Vienna plant draws from 5 wells, four of which are screened in an unconfined aquifer (Quaternary) (35-54 feet) and the other of which draws

Figure VI-7. General cross-section through unconsolidated coastal plain sediments in Southeastern Maryland

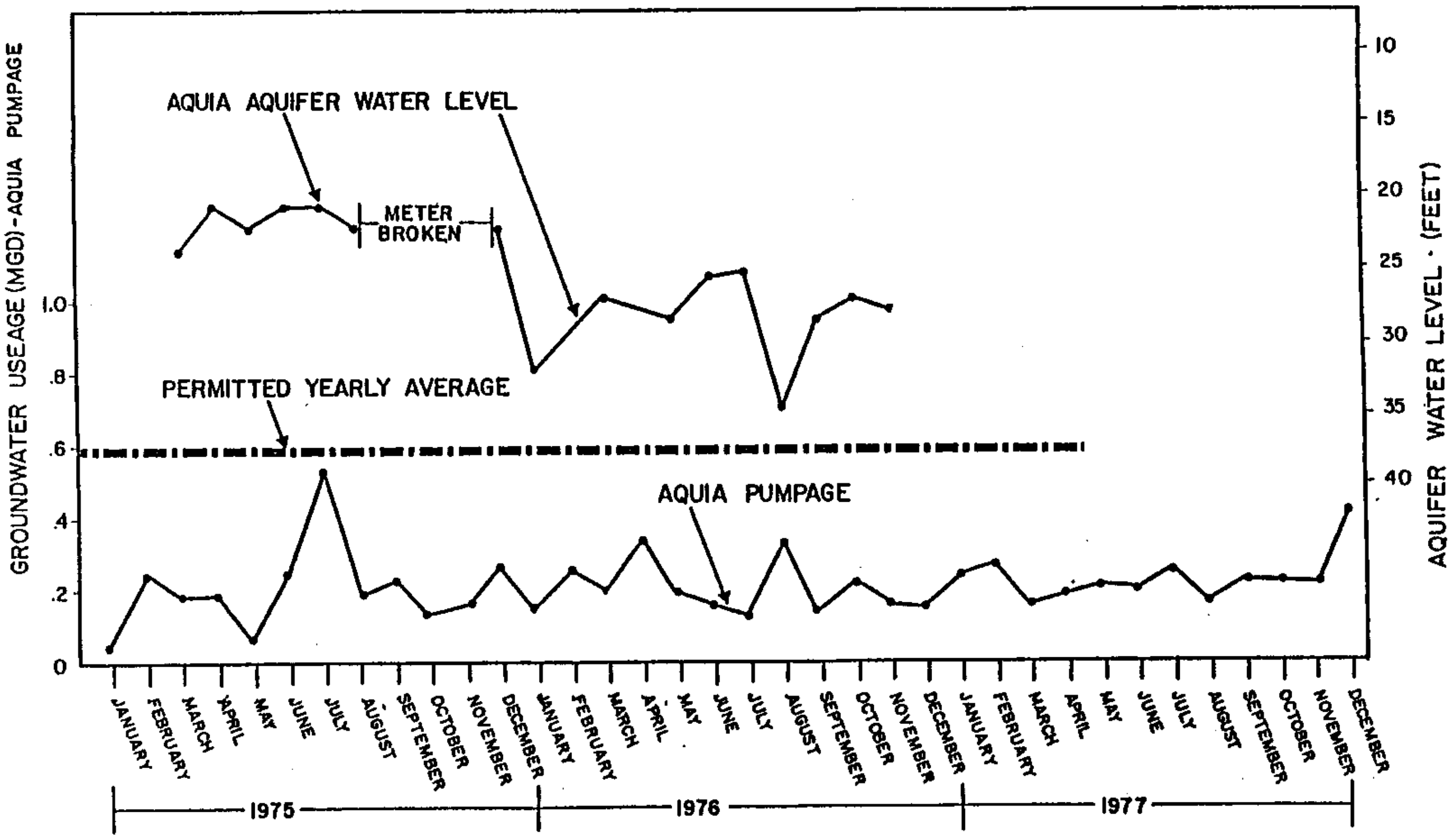


Figure VI-8. Pumpage and water levels of the Aquia aquifer at the Calvert Cliffs Nuclear Plant from the Cheswold aquifer (310 feet) (6,9). The average withdrawal rate for both aquifers is shown in Figure VI-9. Average withdrawal decreases during winter periods because the Nanticoke River is used as a supplemental fresh water supply (9). Because the Quaternary aquifer is likely recharged on an annual basis directly from precipitation and possibly seasonally from the Nanticoke River (5), the pumpage is expected to have no long-term effect. However, nearby domestic wells could be impacted on a seasonal basis (i.e. during periods of little recharge and heavy pumpage) (10). The town of Vienna supplies most of the local domestic water from the Cheswold aquifer (45,000 gpd). Overall groundwater usage at this plant will increase by about 220,000 gpd in the 1980's if a proposed 400 MW expansion is constructed (11). This increase will be partially offset by retirement of the existing once-through units. The detailed investigations needed to characterize the groundwater resources in this area are now in progress (12).

The Morgantown plant has 5 wells, averaging 1100 feet in depth, that withdraw water from the Patuxent aquifer (6). The average withdrawal (Figure VI-10) is eight hundred thousand gallons daily (6). Water levels of the Patuxent aquifer have declined 80-90 feet (13), as measured by an observation well near the plant. Water levels of the upper aquifers have declined at rates basically unchanged since before PEPCO began pumping, indicating that the plant is not directly linked to the decline (13). At the request of the Power Plant Siting Program, the U.S. Geological Survey is installing a continuous water-level recorder on an observation well screened in the Patuxent aquifer at this site.

The Chalk Point plant draws from two aquifers, the Patapsco (1066 feet) and the Magothy (630 feet). The average withdrawals, shown in Figure VI-11, indicate that the plant exceeded the permitted yearly average withdrawal for the Magothy aquifer in 1976* (14). Drawdown in the Magothy aquifer due to pumping from the plant (also shown in Figure VI-11) has been consistent since operations began in 1963, reaching a maximum of 55 feet in August/September 1976 (15). The plant does not pump from the upper aquifer (Aquia) used for domestic wells in the area. There are no other users of the Magothy in the immediate vicinity of the plant (< 8 miles). Plant influence can be put in perspective by looking at the effect of these withdrawals on the potentiometric surface in the area. Figure VI-12, a survey (USGS) of the Magothy surface taken during early September, 1977 shows a "cone of depression" near the plant. Similar cones exist near Waldorf (as shown on map), Annapolis, and Severna Park. At present, the impact of these cones upon nearby users appears to be minimal. However, should Waldorf expand its withdrawal rate significantly or another major user locate in the general area, the combined cones may affect users who cannot adjust their well pumps with water level (so-called "telescopic wells") (16). Detailed studies (as required under Title 8 of the Natural Resources Articles and proposed revisions to Water Resources Regulation .08.05.02) would have to be carried out before such expansion would be allowed. The USGS (17) has prepared a model of the Magothy aquifer that can be used to clarify the possible interactive effects of increased usage near the Waldorf-Chalk Point area.

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* There is an unresolved question, whether the maximum monthly average pumpage permit limitation of 2 mgd must be divided between the two aquifers (18,19).

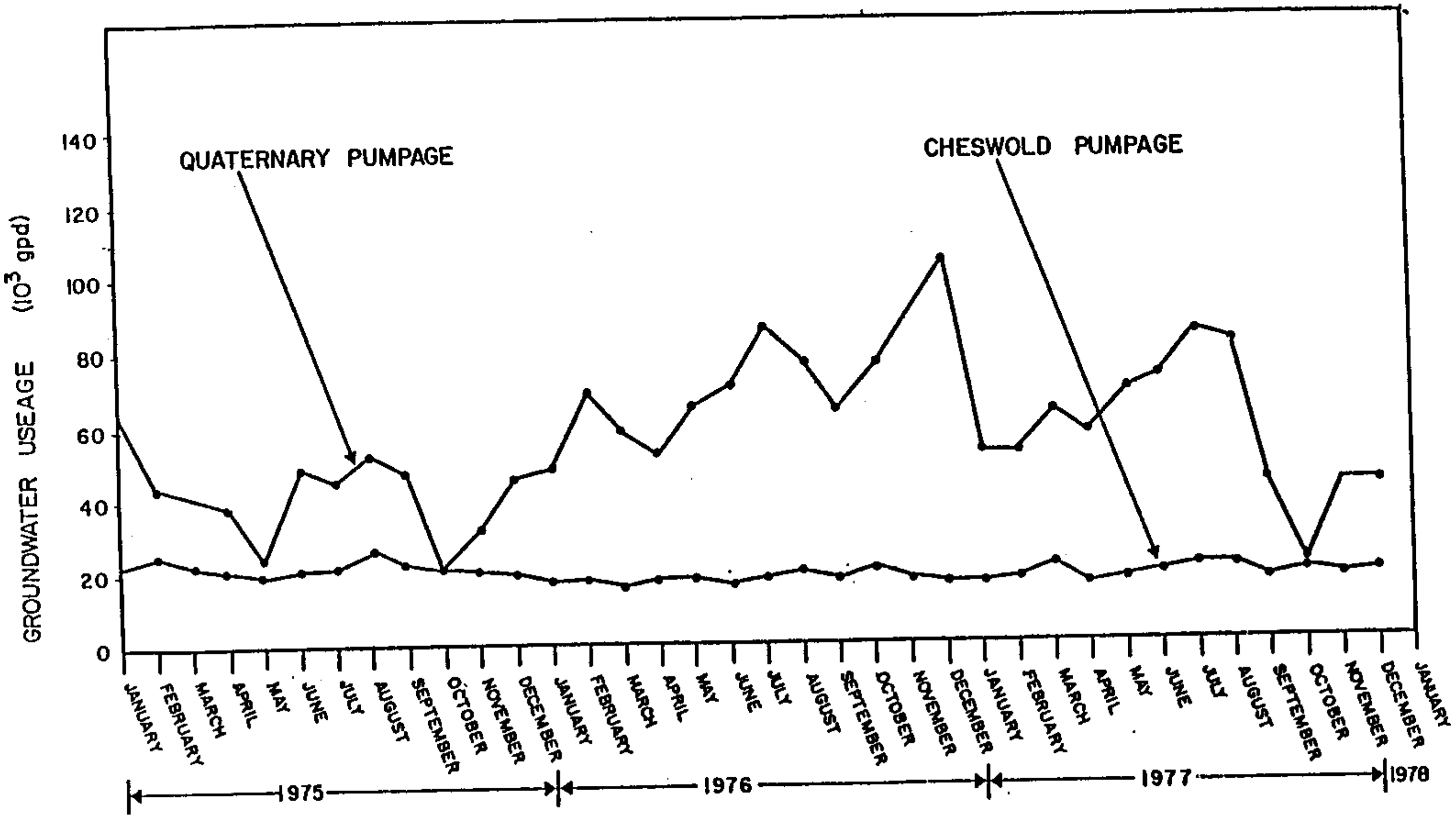


Figure VI-9. Pumpage from the Quaternary and Cheswold aquifers at Vienna Power Plant

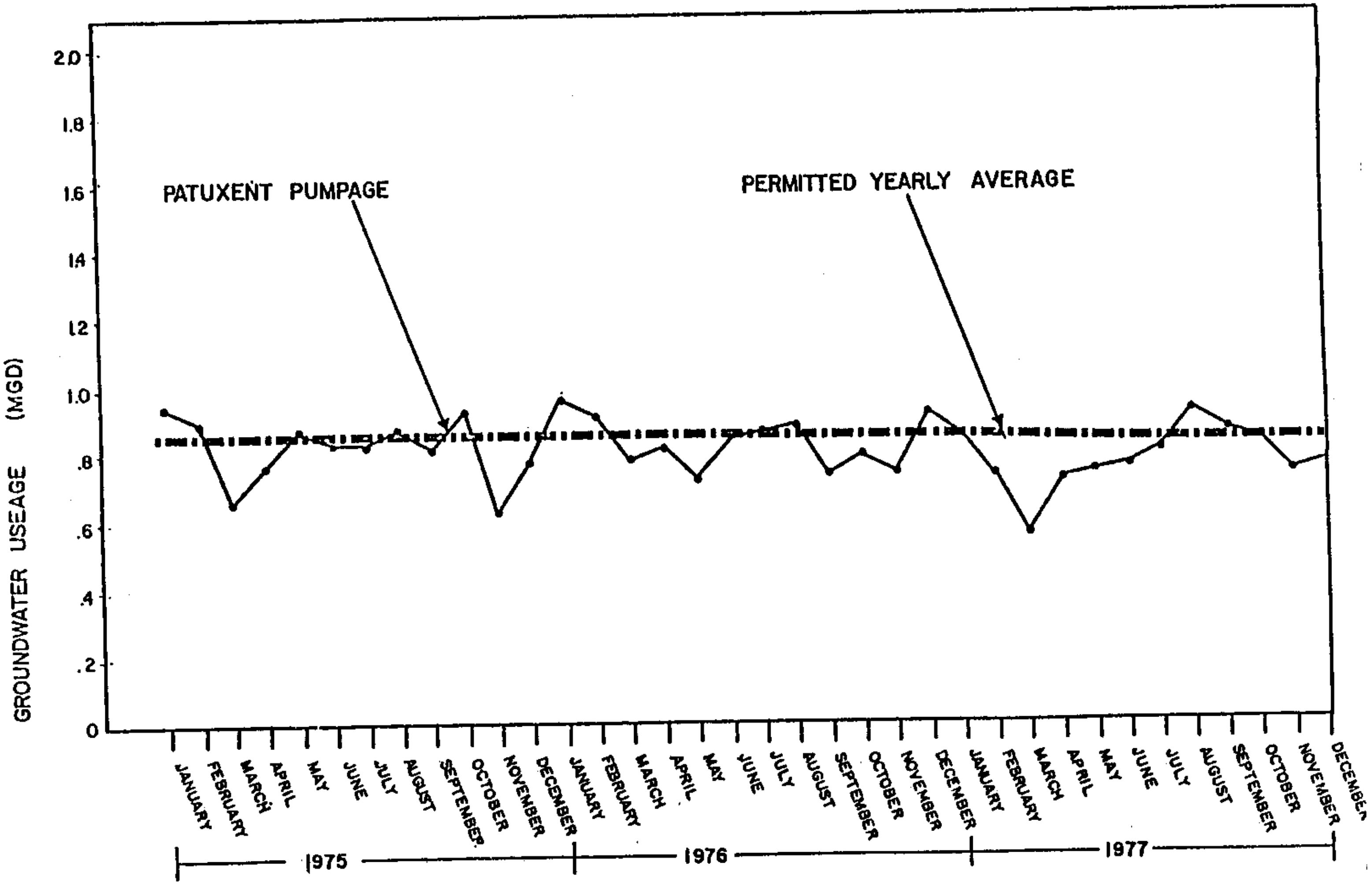


Figure VI-10. Pumpage from the Patuxent aquifer at the Morgantown Power Plant

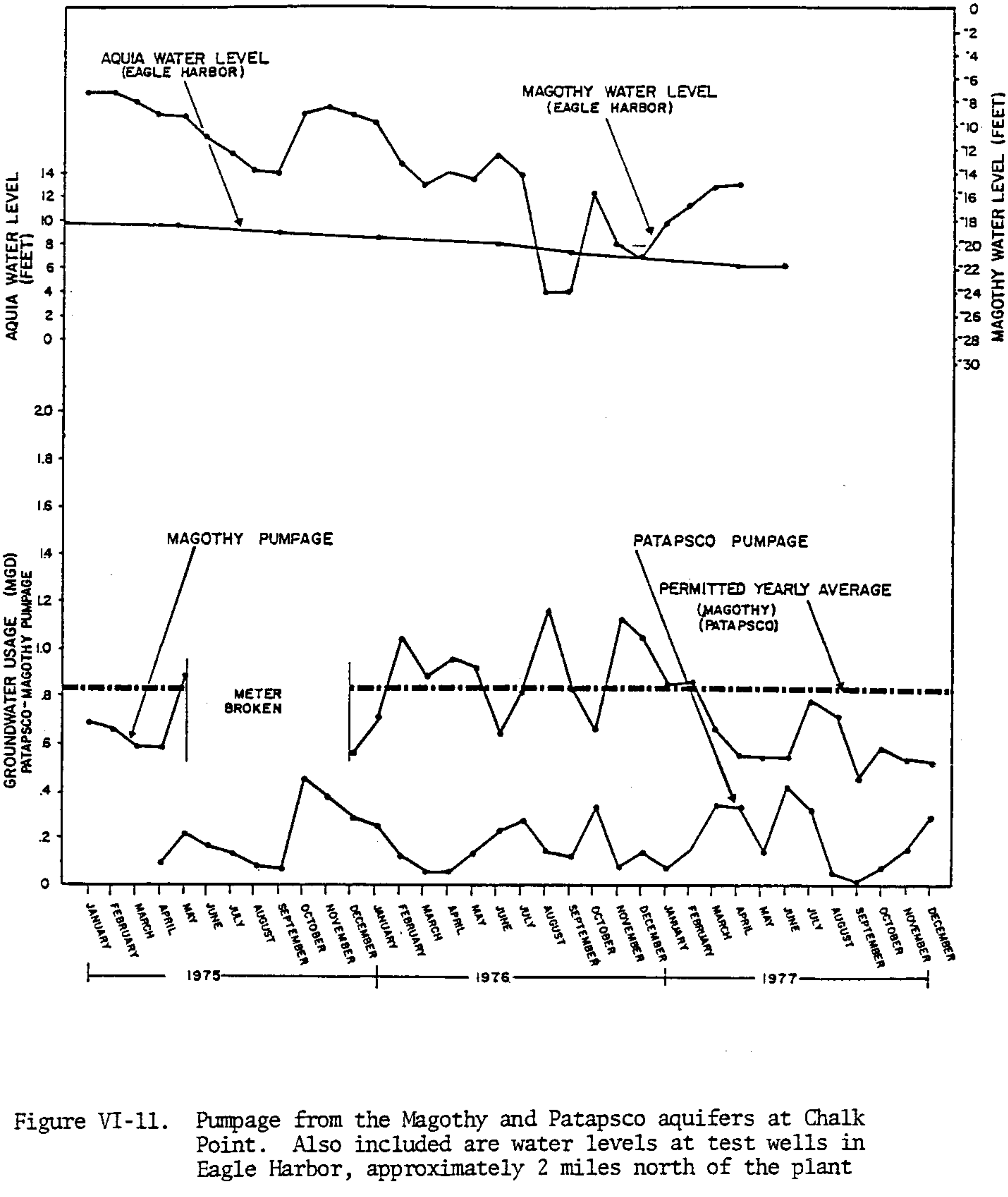
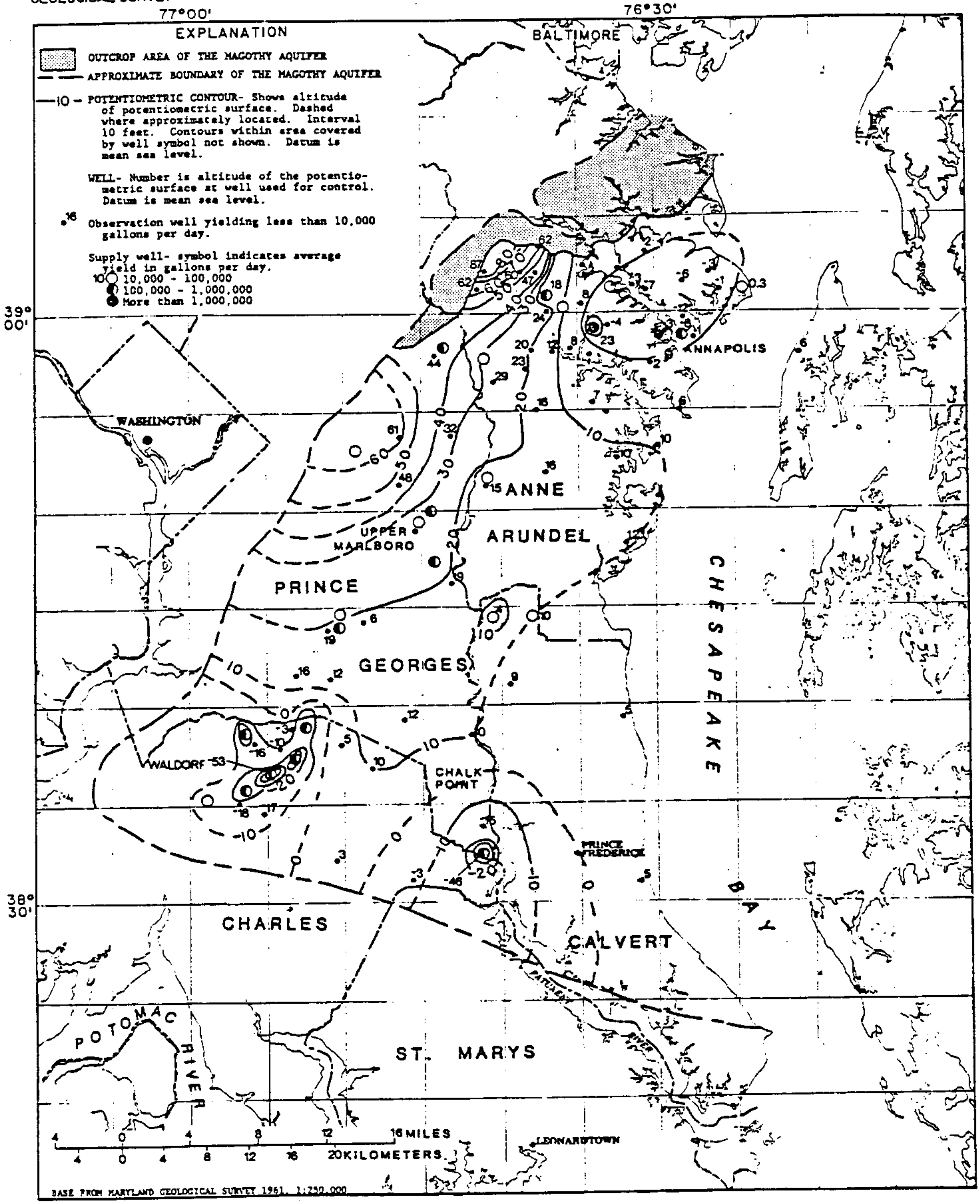


Figure VI-11. Pumpage from the Magothy and Patapsco aquifers at Chalk Point. Also included are water levels at test wells in Eagle Harbor, approximately 2 miles north of the plant

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
MARYLAND GEOLOGICAL SURVEY
AND
MARYLAND ENERGY AND COASTAL ZONE ADMINISTRATION

OPEN FILE MAP 78-999



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

Figure VI-12. Map showing the potentiometric surface of the Magothy aquifer in Southern Maryland, September 1977, by Frederick K. Mack, Judith C. Wheeler, and Stephen E. Curtin, 1978

VI-20

Conclusions

Although the use of groundwater is relatively large at power plants compared to most other industrial sources, due to the relatively sparse usage of the deep aquifers they have tapped, there has been no significant impact upon present wells near these plants. However, if a major increase in withdrawals from the Magothy aquifer were to occur in the neighborhood of Chalk Point, there could be significant impact upon users of the Magothy aquifer in that area.

C. Cooling Towers

Once-through cooling systems use large amounts of water, typically about 2 cfs per MW for a fossil fuel plant, and almost 3 cfs per MW for a nuclear plant, in both cases for a 10° F temperature rise across the condenser. Although this water does not immediately disappear from the natural water system (eventual consumptive loss for a once-through system is about 10-70% of that for a cooling tower), it may never-the-less be necessary to reduce the intake flow under three conditions:

- If a large water intake causes potentially excessive entrainment losses, (e.g., Douglas Point site on the Potomac);
- If the natural river flow is not sufficient to guarantee adequate cooling flow at all times, (e.g., Dickerson units 4 & 5 on the Potomac River);
- If the cooling water volume is such a large portion of the available natural flow that the heating of the river may be unacceptable, (e.g., as might be the case of a large plant on a small body of water).

The alternative to once-through cooling is a closed loop cooling system, such as cooling towers, spray ponds, and cooling ponds. In Maryland, due to factors such as amount and cost of available land, the preferred alternative is the cooling tower. There are many design options which tailor performance to site-specific needs. Towers can be of two basic types: dry or wet. In a dry tower, the condenser cooling water rejects its heat to the air in a totally enclosed system similar to the cooling system in an automobile. A dry cooling tower requires very large heat exchange surfaces, and is typically not economically feasible for large power plants. A dry system does, however, have the advantage of being the only system where there is no evaporative loss of water. In a wet cooling tower the hot water is brought into contact with the air, and a large proportion of the cooling is accomplished by evaporation, a potentially troublesome situation where consumptive water use is a major consideration (as on the fresh water portion of the Potomac River). The water can be sprayed into the passing air, or more commonly, the air is passed through porous surfaces around or through the area where the water also passes. The air can be moved either by fans (mechanical draft towers) or by natural circulation (natural draft towers). While the use of cooling towers may be beneficial as far as aquatic impacts are concerned, it can introduce adverse impact in the terrestrial environment. Possible impacts may result from:

- formation of ground-level fog
- ground-level icing
- salt deposition (if the cooling water is saline)
- noise
- visual effects of the plume and the cooling tower, aesthetically offensive to some people.

For the above effects that are caused by the condensation of the saturated air in a wet cooling tower exhaust, these impacts can be alleviated (if they are found to be significant) by use of a wet/dry combination tower where the exiting air is kept below saturation.

Various cooling towers have been investigated in detail by the Power Plant Siting Program, particularly in connection with the proposed Dickerson and Douglas Point Plants, to see what tradeoffs can be made with respect to the more important of the impacts listed above (20,21). An extensive measurement program has been carried out at the Chalk Point plant to study the effect on vegetation of salt drift from a brackish water cooling tower, as will be discussed subsequently.

Six different cooling tower designs were considered in the Douglas Point study. They were: (a) a natural draft tower; (b) a fan-assisted natural draft tower; (c) a full wet mechanical draft tower; (d) two wet/dry mechanical draft designs with varying degrees of wet-to-dry cooling ratios; and finally, (e) a round mechanical draft tower. The characteristics of each type of tower can be briefly described as follows:

- The natural draft tower is a big chimney, usually a hyperboloid (for mechanical reasons) where an updraft is created by the air being heated The air flow through the tower is entirely determined by ambient air temperature, relative humidity, and by the temperature of the cooling water. The air flow is highest at low ambient temperature, and decreases by almost 50 percent as the ambient temperature rises from the freezing point to the 90's.

- The fan-assisted natural draft tower uses fans around the base of the tower to stabilize the air flow through the tower so that it becomes almost independent of external conditions. Such a tower also has a slightly higher rate of evaporation at low temperatures, but approaches that of the natural draft tower at high temperatures. Its main advantage is its smaller size.

- The mechanical draft tower has its air flow completely controlled by fans and can be much smaller than natural draft towers, at the expense of additional power consumption.

- The wet/dry towers reduce evaporation, particularly in the winter (when the river flow may be low, and the decrease in water uptake may be important).

- The round mechanical draft tower is a special design where the fans are arranged in a centered configuration giving rise to enhanced updraft, thereby alleviating some of the environmental impacts of the low mechanical draft towers by dispersing the moist airborne plume more effectively.

Common to all evaporative cooling systems is the fact that the evaporated pure water leaves behind increasingly saline water. This concentrated water must be diluted or discharged (blow-down) from time to time (or continuously). This concentrated discharge may also carry residual biocides (such as chlorine) if not treated to neutralize them.

In addition, all cooling towers extract an energy penalty of 0.5 - 5.0% during temperature extremes due to increased condenser back-pressure. New types of turbines allow the maximum penalty to be shifted to either cold or warm weather, depending on the peak electrical demand of the utility and the inlet temperature of the cooling water.

The results of the Douglas Point study (20) are summarized in Table VI-2. The conclusions are that there is little ground fog induced for any of the tower designs considered; and that the natural draft tower is, as expected, the least susceptible to this effect. The wet/dry design offers little advantage over the all wet mechanical tower. The persistence of visible elevated plumes is highest for the natural draft tower, but long plumes (> 2 km) are not common. The salt drift deposition is appreciably smaller for the natural draft tower than for any other design, about a factor of 5 less than for the mechanical draft tower. Icing is not a significant factor for any of the configurations. Noise is the least from the natural draft tower, which also requires the least power for its operation. Natural draft towers may be aesthetically objectionable because of their great height. On balance, the natural draft tower appears to have the least impact on the physical and biological environment.

Chalk Point Cooling Tower Project

The cooling tower at the Chalk Point power plant (PEPCO) is the world's first large natural draft hyperbolic cooling tower to use brackish water. It began operation in 1975. Because the water in the cooling tower is brackish with the salinity ranging from 4 to 15 parts per thousand, the potential for damage to the terrestrial biota, accelerated corrosion, and the contamination of water bodies has been investigated. The Chalk Point Cooling Tower Project (CPCTP) of the State of Maryland Power Plant Siting Program has received the full cooperation of PEPCO and has been jointly supported by the U.S. Environmental Protection Agency, the U.S. Energy Research and Development Administration, the Electric Power Research Institute and the State of Maryland. This program, the first long-term, full-scale endeavor of its kind, has received world-wide attention.

CPCTP analyses and field programs (22) are being conducted to determine the extent of visible plumes, and the mechanisms of drift emissions and transport, as well as the impact of salt deposition on local vegetation and crops. Of particular interest is the effect on tobacco grown in the field surrounding Chalk Point, since it is known that chlorides can significantly effect burning qualities. A preliminary analysis of this data has been made, indicating that the cooling tower is not likely to produce off-site crop

Table VI-2. Comparison of cooling tower alternatives for the proposed Douglas Point power plant. The power plant consists of 2 generating units, each unit generating 1,100 MW with a condenser heat load of 16×10^9 BTU/hr (20).

Environmental Factors	Natural-Draft Tower	Fan-Assisted Natural-Draft Tower	Mechanical-Draft Tower			Round Tower
			Full-Wet	Wet-Dry Design 1	Wet-Dry Design 2	
Size	Height: 120-150 m Top Diameter: 55 m Bottom Diameter: 115 m	Height: 61 m Top Diameter: 49 m Bottom Diameter: 76 m	Each cell: height, 21 m length, 12 m width, 20 m	Each cell: height, 21 m length, 12 m width, 20 m	Each cell: height, 21 m length, 12 m width, 20 m	Height: 21 m Diameter: 75 m
Number of towers	One per generating unit	Two per generating unit [(a)]	~35 cells per generating unit [(a)]	~43 cells per generating unit [(a)]	~53 cells per generating unit	Two per generating unit
Ground-level fog induced off-site, hours per year	<4 at any particular off-site location	<10 at any particular off-site location	<25 at any particular off-site location	<22 at any particular off-site location	<21 at any particular off-site location	<5 at any particular off-site location
Elevated visible plume lengths: (annual average, percent of time exceeding indicated distance)	500 m (30%) 1,500 m (25%)	500 m (25%) 1,500 m (20%)	500 m (60%) 1,500 m (10%)	500 m (25%) 1,500 m (0%)	500 m (8%) 1,500 m (0%)	500 m (40%) 1,500 m (20%)
Salt drift deposition, pounds per acre per year	<42 at any particular off-site location, extreme conditions; <16 typical conditions	<91 at any particular off-site location, extreme conditions; <35 typical conditions	<226 at any particular off-site location, extreme conditions; <88 typical conditions, very high on-site	< Full-wet	<Design 1	<201 at any particular off-site location, extreme conditions; <78 typical conditions

Table VI-2. Comparison of cooling tower alternatives (Continued)

Environmental Factors	Natural-Draft Tower	Fan-Assisted Natural-Draft Tower	Mechanical-Draft Tower			Round Tower
			Full-Wet	Wet-Dry Design 1	Wet-Dry Design 2	
Near-term salt drift effects (b)	Off-site: none On-site: some corrosion and vegetation damage during periods of extreme river salinity	Off-site: limited effect on crops On-site: modest corrosion and damage to vegetation	Off-site: reduced crop yields On-Site: severe corrosion and damage to vegetation	Off-site: reduced crop yields On-site: severe corrosion and damage to vegetation	Off-site: reduced crop yields On-site: severe corrosion and damage to vegetation	Similar to fan-assisted natural-draft towers
Icing	None expected	None expected	Occasionally near tower	Less than full-wet	Less than Design 1	None expected
Noise from total plant complex	32.2 dB(A) at 5000 ft; this is 1.9 dB(A) increase over ambient noise level	Less than round mechanical-draft	36.3 dB(A) at 5000 ft; this is 5.9 dB (A) increase over ambient noise level	Slightly more than with full-wet tower	Slightly more than with Design 1 tower	Less than full-wet
Auxiliary power required for fans, MW per generating unit	None	≈8.2	≈5.3	≈6.5	≈8.0	≈8.2
Visual, aesthetic impact; ranking, 1 = most impact 6 = least impact	1	2	4	5	6	3

(a) Depends upon tower manufacturer and particular design.

(b) Long-term effects cannot be predicted.

damage. Peak depositions from the cooling tower fall within 1 km of the plant and effects beyond 1 mile will be small. At the point of maximum ground deposition, approximately 0.5 km (0.3 mi) from the cooling tower, the maximum monthly deposition is approximately 8 kg/ha (7 lb/acre). To date no evidence of salt damage has been observed to corn, soybeans, or tobacco grown on experimental field plots surrounding the site. In addition, experiments to determine the sensitivity of corn, soybeans, or tobacco to aerosol salt deposition indicate that no significant effects occur in the growing season at drift deposition rates up to 20 kg/ha/mo (18 lb/acre/mo). This far exceeds the drift deposition rates from the cooling tower at all off-site locations.

During the experimental program, it was discovered that the "wet" particulate scrubber associated with one of the generating units was also a major source of drift, which suggests that in all future siting on brackish water, it is important to consider the salt emissions from scrubbers when evaluating the environmental impact.

Future work in the program is directed towards improving the confidence in the predicted values of salt drift and evaluating the long-term effects of salt deposition.

Conclusions

The use of cooling towers is an environmentally acceptable alternative to "once-through" cooling systems. Basically, a cooling tower exchanges consumptive water use and possible terrestrial effects for effects in the aquatic environment. Because the balance of these effects is site-specific, each plant location should be examined to determine the appropriate cooling system.

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