demand using population estimates and water demand estimates published by the Washington Area Interstate Water Resources Program. Through the graphical solution of supply and demand functions it was possible to determine the length of time for which demand would exceed supply assuming various upstream flow augmentation schemes under consideration. The results of the study are concisely presented in Table 8, which shows the number of consecutive days during which withdrawal of Potomac water would aggravate an inadequate supply as a function of recurrence interval and year. It was suggested that PEPCO could handle this problem by storage of water in an on-site reservoir; the needed capacity of the reservoir could be calculated using the Table for any recurrence interval. PEPCO has been required by the Public Service Commission to have the capability of eliminating their dependence on the river for the equivalent of 16 consecutive days through a combination of modified operating procedures and the construction of an on-site reservoir with nine days make-up capacity.

IV. OTHER POWER GENERATION IMPACTS

In addition to the major issues of air and water pollution, the power plant has potential for many other impacts. Among the more important of these are: community noise, groundwater availability, sediment and erosion control, dredging and dredge spoil disposal, visual impact, oil spill potential, and coal pile dust. These are included in our studies as required, and some are treated in this section.

Potential Noise Impact

All environments, no matter how remote from the activities of man, will have sound energy present. Such "ambient noise" often cannot be traced to any specific source. An assessment of the noise impact of a proposed power plant must start with a determination of the ambient conditions to provide a base against which potential intruding plant noise can be compared.

The magnitude of sound is generally described in terms of decibel units (dB)*, with zero dB being approximately the quietest sound a normal person can hear. To describe noise from the point of view of human perception and annoyance, it is generally necessary to describe its decibel level in individual portions of the frequency spectrum. This is important because the way people perceive sound and the manner in which they might be annoyed will depend on the frequency distribution of the noise.

Therefore, it is customary to describe sound levels in individual portions of the frequency spectrum; typically nine separate bands are used which are centered at 31, 62, 125, 250, . . . 800 Hz, each band being one octave wide. Many times a simpler description of noise is used by assigning an equivalent "dBA" rating. The term dBA indicates that the total sound energy is modified by a frequency characteristic similar to that of the human ear.

The introduction of a power plant will add noise originating from generating units, cooling towers, fuel handling facilities, and vehicular traffic. Each of these noise sources must be described in separate octave bands in order to adequately assess the noise that will be propagated off-site and its annoyance potential. In the APL/JHU noise assessment program, these source level models are determined through a combination of APL/JHU measurements, manufacturer's data, published information, and theoretical principles.

Sound levels propagated to residents surround-

* The basic unit of reference is 0.0002 dynes/cm^2

ing the plant are determined from source levels by considering geometry, atmospheric sound absorption, and terrain diffraction and shielding properties. These propagated levels must then be compared with the ambient conditions prior to the existence of the plant in order to assess the potential for annoyance.

An Example Study—The results of the Dickerson, Maryland, site study illustrate the methodology used in the noise assessment program. If the total generating capacity at Dickerson (2250 MWe, including an existing 550 MWe unit) were reduced to the unit 1000 MWe capacity, calculated sound levels would be reduced by approximately 3 dB.

Ambient noise measurements surrounding the proposed Dickerson facility were made in the spring and summer of 1973. For low winds (which occur more than 50 percent of the time), typical ambient levels are 35 dBA during the spring and 37 dBA during the summer. Figure 11 shows typical summer spectra. Major exceptions to these levels are at locations influenced by the present plant, near major roads, and at the Monocacy Aqueduct during the summer. Aircraft produced peak levels typically reaching 55 to 60 dBA.

Table 9 summarizes the source level models used in the Dickerson study. These levels are what one would expect without careful application of noise abatement technology.

In addition to octave-band levels, the possibility of discrete tones (narrow-band energy) must be addressed separately since people are annoyed differently by tones than by broad frequency sources. Based on APL/JHU measurements on the existing plant at Dickerson, it was determined that a modest reduction in tone levels (7 to 8 dB) could remove them as a significant feature of the plant noise.

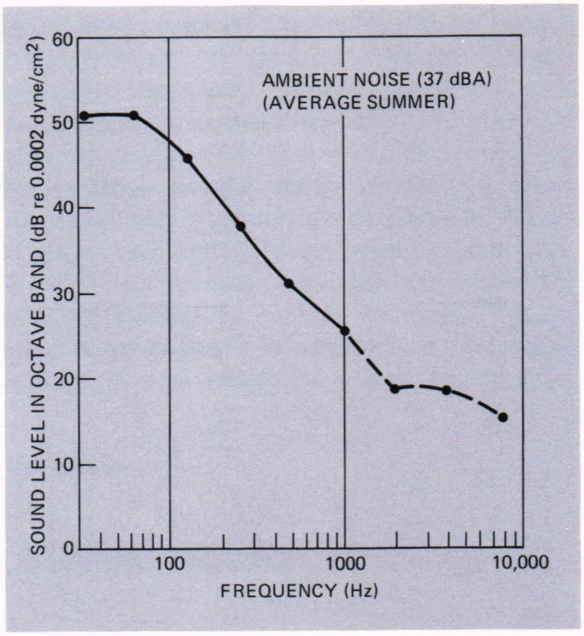

Fig. 11—Typical summer ambient spectra measured around Dickerson site.

Propagated sound levels for the Dickerson site are summarized by the dBA contours of Fig. 12. Terrain shielding reduces the levels at the Chesapeake & Ohio towpath levels by 18 dBA as determined by application of diffraction principles. Most other off-site locations are nearly within line-of-sight of the expanded plant center. For these areas, terrain will not be of significance in reducing noise.

Annoyance Potential—The calculations of off-site noise in the form of octave-band values, are used to assign equivalent annoyance ranks giving a measure of community response to noise environment.[11] The expected community response for

[11] K. N. Stevens, *et. al.*, "Community Reaction to Noise: Can It Be Forecast?" *Noise Control*, p. 63–71, Jan. 1955.

TABLE 9

OCTAVE BAND LEVELS FOR MAJOR SOURCES AT 2000 FEET REFERENCE DISTANCE

	Sound Level in Indicated Octave Band (dB)									*dBA*
	31	*62*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
Existing Facility	55	53	52	44	43	37	28	16	−2	43
New Facility	66	65	63	54	51	48	45	42	20	54
Mechanical Draft* Cooling Tower (2 req'd)	62	58	55	51	47	43	35	23	7	49
Natural Draft* Cooling Tower (2 req'd)	46	47	48	42	40	42	40	33	15	46
Coal Handling (2 req'd)	57	53	51	44	47	44	36	28	4	48
Large Truck	33	49	50	46	40	40	34	17	−10	44

* Data are given for both tower types considered.

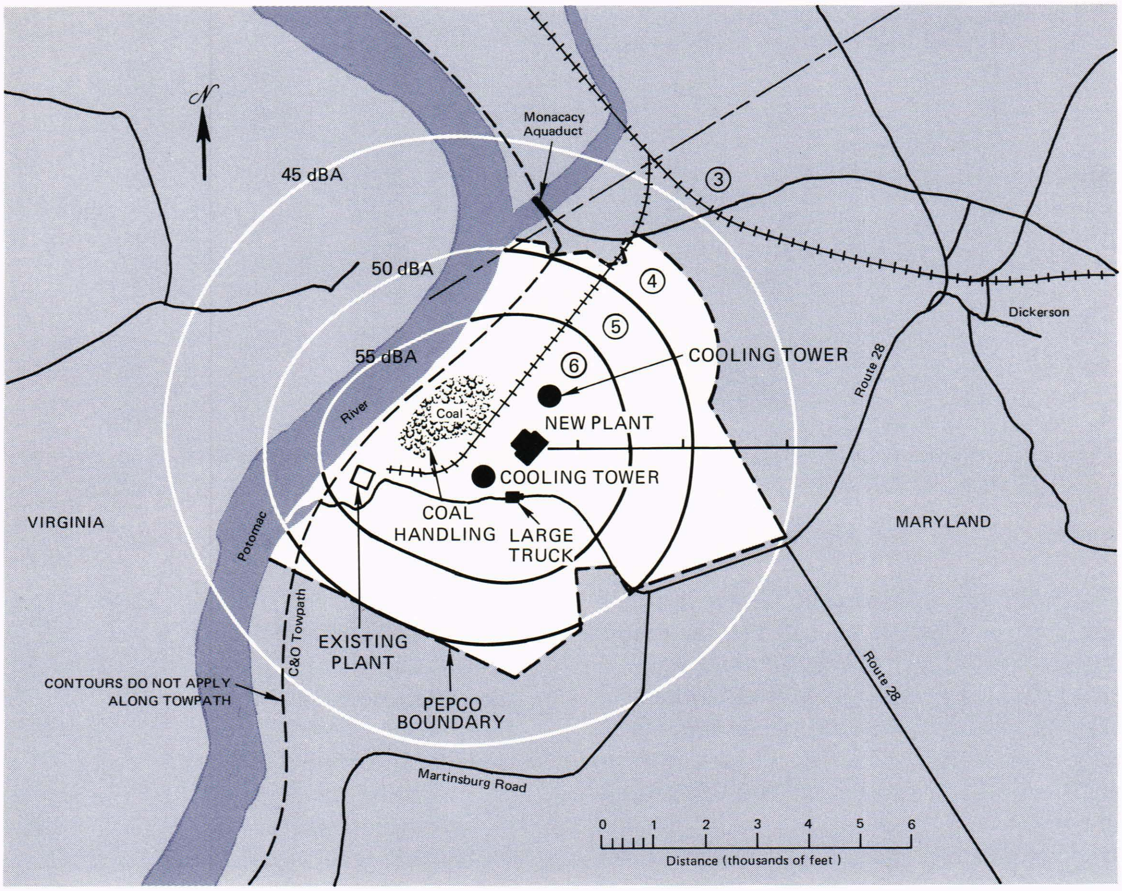

Fig. 12—Contours of equal noise levels (in dBA) for entire present Dickerson plant complex. Circled numbers approximately represent regions of equal annoyance rank.

various noise ranks is shown in Fig. 13. The method relates annoyance potential to intruding noise level, ambient background, time of day, presence or absence of dominant tones and other factors. For the Dickerson study, the regions of equal annoyance rank were approximately separated by the dBA contours as seen in Fig. 12. Based on anticipated community response to these calculated levels, it was determined that constraints on plant noise emissions were desirable.

Table 10 lists constraints that were developed for the Dickerson facility, based on an off-site noise rank limited to 3 or less. These constraints were subsequently recommended by the Department of Natural Resources as a condition of license.

Groundwater

When surface water, which is sufficiently free of dissolved and suspended constituents to permit its use for steam cycle makeup and sanitary needs is not available in the quantities required, groundwater is most often sought as the most economical alternate source. Failing groundwater, currently extraordinary sources such as recycling or desalination would be required.

Depending somewhat on the nature of the steam cycle, other plant processes, and the size of the plant operating staff, freshwater requirements ranging from one to four million gallons per day (700 to 2800 gallons per minute) may be needed. Water in such quantities is not everywhere easily obtainable from the ground. Its availability depends on local geology and climate, and often cannot be taken without interfering with other present or prospective groundwater users. For this reason, the State of Maryland strictly controls use of groundwater, requiring permits both to drill wells

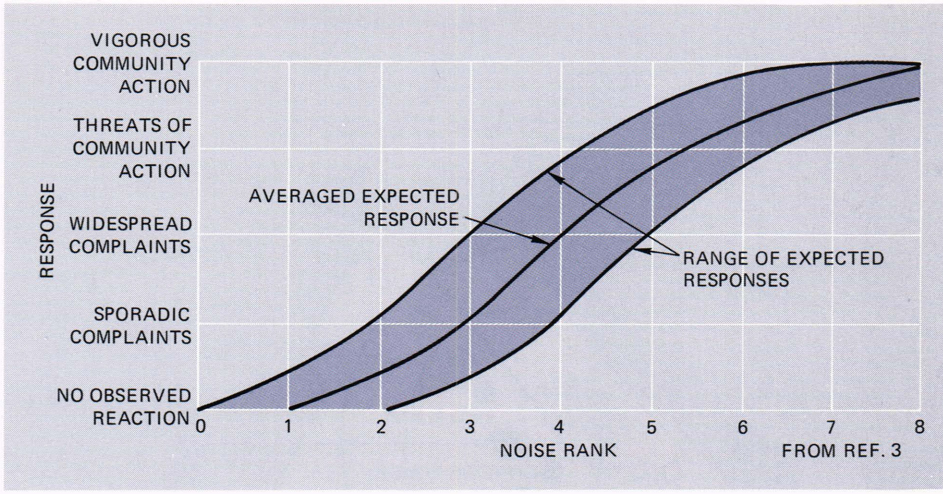

Fig. 13—Relation between noise rank and anticipated response.

and to appropriate groundwater. Water is found both in the pore spaces of soil and in cracks within rock formations. Normally, more water is available where proportionally greater amounts of soil (and included pore spaces) occur than where the subsurface consists primarily of rock with its proportionally much smaller volume for storage within cracks.

Groundwater is an integral part of the hydrologic cycle. During wet seasons, rainfall percolates into groundwater storage; during dry seasons it is withdrawn by the joint processes of evaporation and transpiration by growing plants (evapotranspiration). When water is withdrawn from the ground by pumping, the operation of the hydrologic cycle tends to replenish, within physical limits, the amounts withdrawn.

TABLE 10
CONTINUOUS NOISE CONSTRAINTS ALONG DICKERSON PLANT BOUNDARIES FOR A NOISE RANK EQUAL TO 3

Octave Band (Hz)	*Octave-Band Median Level (dB)*
31	69
62	65
125	58
250	50
500	45
1000	38
2000	31
4000	29
8000	27

Notes: Octave band constraints are in addition to an overall constraint of 45 dBA.
Median levels are measured over any given three-minute time interval.
No dominant tones present.

In Maryland, the climate is generally adequate for annual recharge of water to the groundwater system. Maryland has two significantly different geological domains, however. East of the Fall Line, which crosses the State on a line from the District of Columbia through Baltimore to eastern Cecil County, the State is in the Atlantic Coastal Plain Province, where the sediments which overlie the basement rock are relatively thick and groundwater is consequently relatively plentiful. West of the Fall Line, basement rock is close to ground surface, occurring under overburden which is seldom more than 100 feet thick and often much less than that. There, groundwater is obtainable only from the overburden or from fissures in the rock and quantities are consequently usually not sufficient for power plants. It should be noted, though, that above the Fall Line the same geologic properties that retard the percolation and accumulation of groundwater and thus limit its availability will also usually contribute to surface water availability and, hence, tend to make recourse to groundwater unnecessary.

In the Coastal Plain, where groundwater is most often sought by large users, the water occurs in the pores of various sediment layers put down during successive epochs of geologic time. Some of these layers yield water readily and are called aquifers, and some yield water less readily and are called aquitards. Within aquifers the water is usually under pressure; and when the aquifer is penetrated by a well, the water will usually rise initially to within a few feet of ground surface. As the well is pumped, the water level declines with time. The amount of decline increases with increasing amounts of withdrawals but decreases logarithmically with distance from the well, forming a cone of depression around the well and theoretically extending all the way to the boundaries of the aquifer.

When more than one well is pumped from an aquifer, the cones of depression overlap and are additive. Many wells pumping at the same time can noticeably affect local or regional water levels, and a single dominant well can literally drop the regional water level below the reach of wells that had formerly been sufficiently deep and had had adequate pumping capacity. Fortunately, each separate water-yielding layer can, within recognized limits, be considered a separate groundwater reservoir; and in many cases, even major withdrawals from one layer will have little noticeable effect on the yield of wells constructed into other layers.

The purpose of environmental studies of power plant use of well water is to assure that water is taken from formations where it is available without interference with the other users, especially domestic users.

Dredging and Spoil Disposal

When river bottoms must be deepened to create water intake and outfalls and the opportunity for handling marine traffic, special attention must be given to potential stream pollution during removal of the bottom and during and after placement of the material removed (spoil).

Bottom modifications are frequently carried out by hydraulic dredging, an operation best described as the operation of a wet vacuum cleaner which continuously discharges a mixture of one part mud to four or five parts of water. During dredging, the surrounding waters are potentially subject to pollution from the solution or suspension of toxic material or organic sludge present in the bottom sediments. Turbidity is usually enhanced; dredging must sometimes be scheduled so as not to interfere with sensitive aquatic life. Disposal of the dredged material, whether elsewhere on the river bottom or on fastland, presents further problems related to keeping the spoil in place and to preventing water pollution due to the leaching of toxic materials.

Dredging is subject to numerous controls: the Maryland Wetlands Board must give a license and the U. S. Army Corps of Engineers must give a permit. Both are subject to certification for meeting EPA and State water quality standards. Because licenses/permits for in-stream disposal are becoming increasingly rare, fastland disposal is necessarily becoming more common.

Disposal of dredge spoil usually takes place behind a dike that affords the solids an opportunity to settle out while the entrained water is allowed to flow over a spillway and return to the river. The dike and sedimentation area must be sized to receive the spill and allow for sedimentation. During dredging the spoil "bulks up," and the Corps of Engineers usually follows a rule of thumb that the volume available in the disposal area should be twice the volume of material removed.

Sediment and Erosion Control

When vegetation is removed and earth is disturbed for construction, the land surface exposed to weathering becomes relatively smoother than before, while the soil-binding capacity of the vegetative root structure is simultaneously lost. When rainfall strikes the exposed surface, the speed with which water runs across the ground is enhanced so that it accumulates faster and can easily suspend and remove the unprotected ground soil. Thus, each rainstorm produces a greater rate of runoff than had existed previously and which creates a stream of muddy water which flows downhill. The greater runoff rate poses a real flood threat, and when flow rates finally recede, the load of suspended earth settles in depressions and in stream beds. Each rainstorm further aggravates the situation.

These difficulties are best prevented by minimizing both the area and time of exposure, and by installing storm drainage and sediment retention works which retard and channelize the stormwater runoff and which permit the collection of the suspended sediment in selected locations.

Visual Intrusion

Modern power generating plants are large. A typical fossil fuel plant may have a generator building of 150-foot height, cooling towers of 300- to 400-foot height and a stack of 800 feet to 1000 feet in height. Good design can enhance the appearance of such structures, but they cannot be camouflaged or screened. Further, the fact that these large plants are preferentially being placed in rural areas creates considerable opposition to such visual intrusion.

It is an emotional issue, not well suited to analytical treatment, and one on which reasonable people often reach strongly opposing views. With respect to this issue, the Public Service Commission must depend on its knowledge of power needs, acceptable alternatives, and the general policies of the government concerning this type of development with concurrent regard for aesthetic interests as expressed by the public.

V. PROGRAM EFFECTIVENESS

The program has been effective in exercising environmental controls through constraints imposed in the regulatory permit process. The studies place the environmental basis for such constraints in a form suitable for consideration by all concerned parties.

Power plant siting is, indeed, a multidisciplined effort, intended to support the state in its quest for expanded power generation, while assuring that environmental factors are properly considered and that unavoidable impacts are evaluated in advance of the decision to commit the resources in question. The evaluation studies are site specific giving emphasis to the major problems of the site while striving for an acceptable degree of completeness relative to all environmental problems that might arise.

APL's role, and also that of the other Johns Hopkins University participants, is scientific, experimental, and analytic. The product is a series of technical reports that are delivered to the Maryland Power Plant Siting Program. These reports form the scientific basis for technical recommendations to the Public Service Commission. They are submitted in evidence at the Public Service Commission hearings as a State exhibit, and are made available to the general public. Sections of the report have, in turn, been used by intervenors to support their case against approval of construction.

University staff members have appeared as witnesses in Public Service Commission and Zoning Board hearings to explain and clarify the contents of the technical reports. Thus far, testimony has been given in Brandon Shores and Dickerson hearings. In addition, staff members have appeared in public information presentations in Charles County to describe technical studies under way at Douglas Point (nuclear). Neither in report, hearing, or information meeting does the University recommend concerning the basic question of approval or denial of the application.

The reports issued and the testimony given relative to environmental matters have been treated by the hearing boards as a significant and competent effort on the part of the State government and the University to provide answers to these important questions. Environmental data and analysis are being made available to a depth never before experienced in these hearings.

As a result, the hearings have moved relatively smoothly in these areas. There are, of course, deep probing questions, and a search to be sure that significant problems have not been overlooked. Nor does the availability of the material necessarily alter personal positions which are often based on a complex of both technical and nontechnical considerations. The work does serve to place the technical conditions which must be imposed on the utility and the environmental reasons for those restrictions in a position to be understood by all parties.