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MASTER

LAND USE SUITABILITY SCREENING FOR POWER PLANT SITES IN MARYLAND*

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Since 1974 Oak Ridge National Laboratory (ORNL) has been engaged in developing an automated procedure for land use suitability screening. The Nuclear Regulatory Commission has funded the project to aid in the selection of power plant sites in Maryland. Its purpose is to identify candidate areas from which specific candidate sites can be chosen for detailed analyses. The ORNL approach assures that certain key variables are examined empirically for every cell in the study region before candidate sites are selected. Each variable is assigned an importance weight and compatibility score based upon its effect on the economic, social, or ecologic costs associated with construction in a given cell. The weighted scores for each variable are aggregated and output as a suitability score for each cell.

The program is designed as a user-oriented computer package in which all major parameters — cell size, number of variables, importance weights, compatibility scores, and coordinates of the study area — are set by the user. The Maryland Power Plant Siting Project employs a 90-acre cell grid with 21 variables for each cell in the northern eight counties of the state. For demonstration purposes each variable has been assigned an importance weight from 1 to 5 and a compatibility score from -3 to +2. Already, it is apparent that the range of importance weights must be increased if they are to reflect accurately the overwhelming influence of certain key variables such as proximity to water.

The advantage of this automated procedure is that all criteria can be stated objectively and applied to every 90-acre cell in the state. By changing the criteria one can identify the trade-offs between various technological options of power production and cooling or predict the likely alternative land uses competing for a site. Moreover, these options can be examined from any particular viewpoint. For example, one set of criteria could be designed to measure ecologic impact and another construction costs.

The goal of research during fiscal year 1976 is to refine the siting criteria for Maryland and to make the procedure transportable to other regions and applicable at various scales. Specific recommendations regarding the parameters listed above will be required and these will be based on rigorous analyses. When this phase of the research is completed, the land use screening procedure will be used in a practical siting exercise in Western Maryland.

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LAND USE SUITABILITY SCREENING FOR POWER PLANT SITES IN MARYLAND

Recent environmental legislation and heightened awareness of detrimental impacts have given impetus to the quest for a comprehensive procedure to be used in regional screening for land use suitability. Many land use planners, corporate decision makers, and regulatory agency officials would welcome an automated procedure capable of scoring the suitability of every cell in a region, identifying the trade-offs between all possible alternatives, and considering all viewpoints on any siting issue. The ideal is unlikely to be achieved, but significant gains have been made in the past five years.

The National Environmental Protection Act of 1969 (NEPA) required impact statements containing an assessment of alternatives to each proposed federally funded or regulated project (Sec. 102(2)Ciii). This was never interpreted to mean that every possible site should be examined in detail, and the courts quickly ruled that it applied only to alternatives under the jurisdiction of the specific agency responsible for the impact statement.[1] Nevertheless, NEPA encouraged planners and decision-makers to broaden their focus from specific site analysis to regional site selection. Simultaneously long-standing geographic techniques of regional analysis were popularized with the publication of McHarg's *Design with Nature*.[2] The fervor with which many planners seized upon such a simple concept as the overlay map is evidence of their eagerness for small-scale screening tools at that time.

By 1971 other planners were using computers to store cellular data and print composite maps.[3] That same year Argonne National Laboratory

began to examine the feasibility of such a procedure in the siting of energy related facilities.[4] A similar project began at Oak Ridge National Laboratory (ORNL) in 1974.[5] Today both laboratories have computer programs for regional screening of cellular data, and both are engaged in refining their suitability criteria and data bases. This paper reports on the Maryland Power Plant Siting Project as an application of the land use screening procedure developed at ORNL.

Purpose

The purpose of the ORNL land use screening procedure is to aid in the identification of candidate areas from which specific sites can be chosen for detailed analysis. Heretofore, power plant siting has relied upon an almost intuitive selection at this stage followed by empirical comparisons of a few candidate sites. The ORNL approach assures that certain key variables are examined empirically for every cell in the study region before the selection of candidate sites. This is viewed as an improvement because the least suitable sites are eliminated and potential problems are identified much earlier in the siting process.

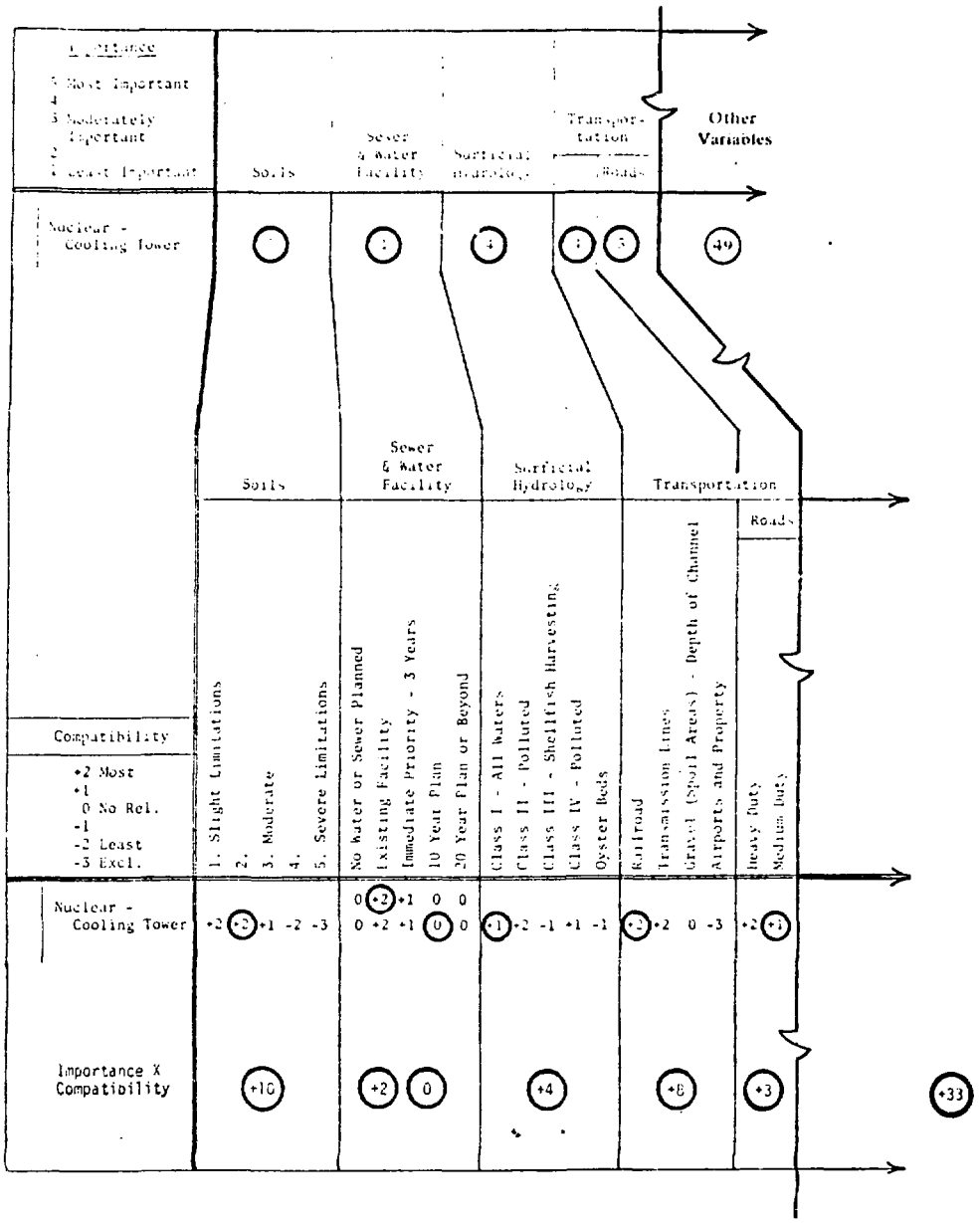
The ORNL Land Use Screening Procedure

A major advantage of automated screening techniques is that they offer the option of assigning compatibility scores and importance weights to each variable. In the ORNL land use screening procedure the compatibility scores for each variable in a cell are weighted by the importance of that variable in determining the economic, social, or ecologic costs associated with construction there. The weighted scores for each variable are aggregated and output as a suitability score for each

cell. The program is designed as a user-oriented computer package in which all major parameters — cell size, number of variables, importance weights, compatibility scores, and coordinates of the study area — are set by the user. Most users, however, prefer some persuasive guidance in determining these values, and research during this fiscal year will focus on refining them through rigorous analyses.

The Maryland Power Plant Siting Project employs a 90-acre cell grid with 21 variables digitized for each cell in the northern eight counties of the state. For demonstration purposes each variable has been assigned an importance weight from 1 to 5 and a compatibility score from -3 to +2. Table 1 shows how these are calculated as an aggregate suitability score. This example emphasizes construction costs. Hence proximity to water is given the largest importance weight, 5, and cells near water receive the highest compatibility score, +2. These are multiplied and their product, +10, is the compatibility score for the proximity to water variable in that cell. All of the scores for that cell are added and normalized to produce an aggregate suitability score. The scores of all cells are then mapped as in Figure 1.

A comprehensive screening procedure of this type obviously requires a substantial data base which could occupy more research time than the development of the procedure itself. Numerous variables already were digitized for Maryland by the Office of State Planning. The Maryland Automated Geographical Information System (MAGI) consisted of 24 variables (Table 2) for each 90-acre cell in the state. Of these 11 were considered relevant to the siting criteria. Four additional variables were digitized at ORNL, and six proximity variables were calculated.



. Example calculation of a suitability score. Summed score per technology per cell = Σ (importance × compatibility)/2 Σ (importance) = 60/132 = .45.

Table 1.

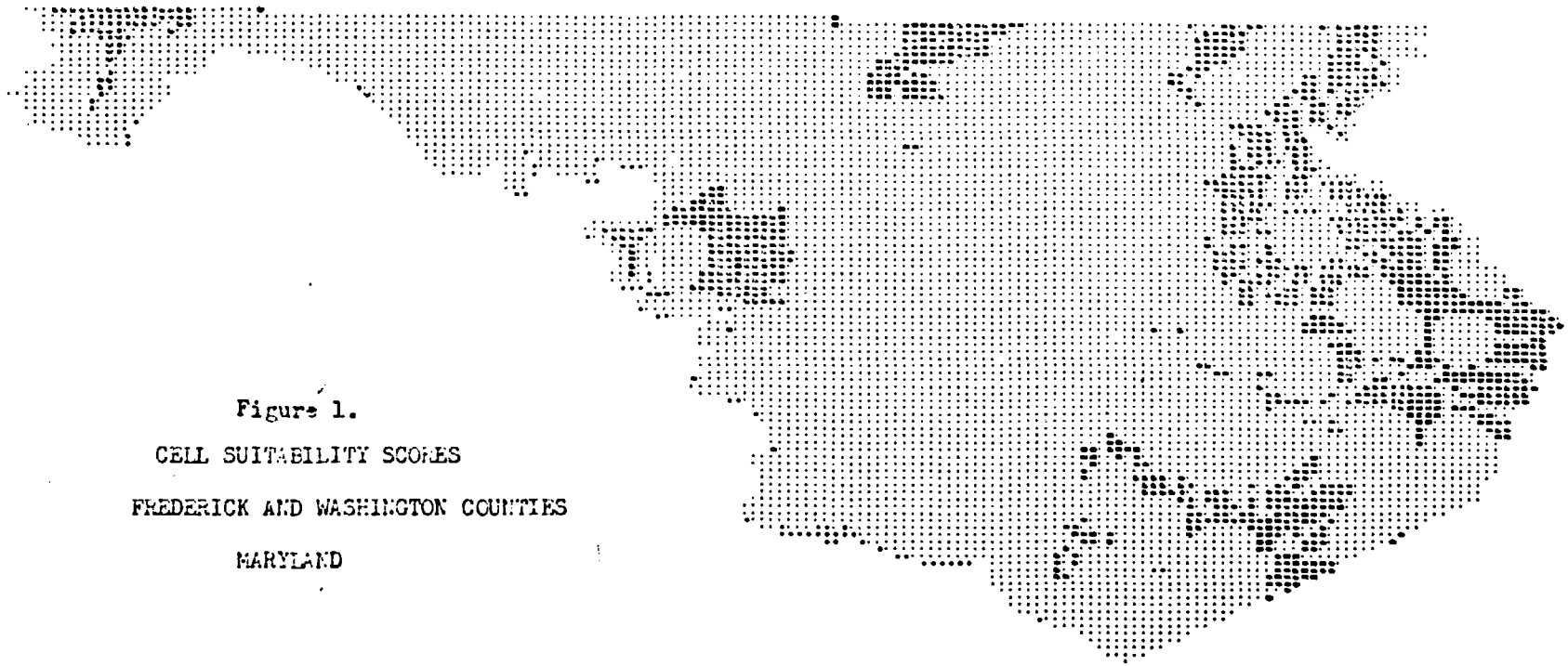
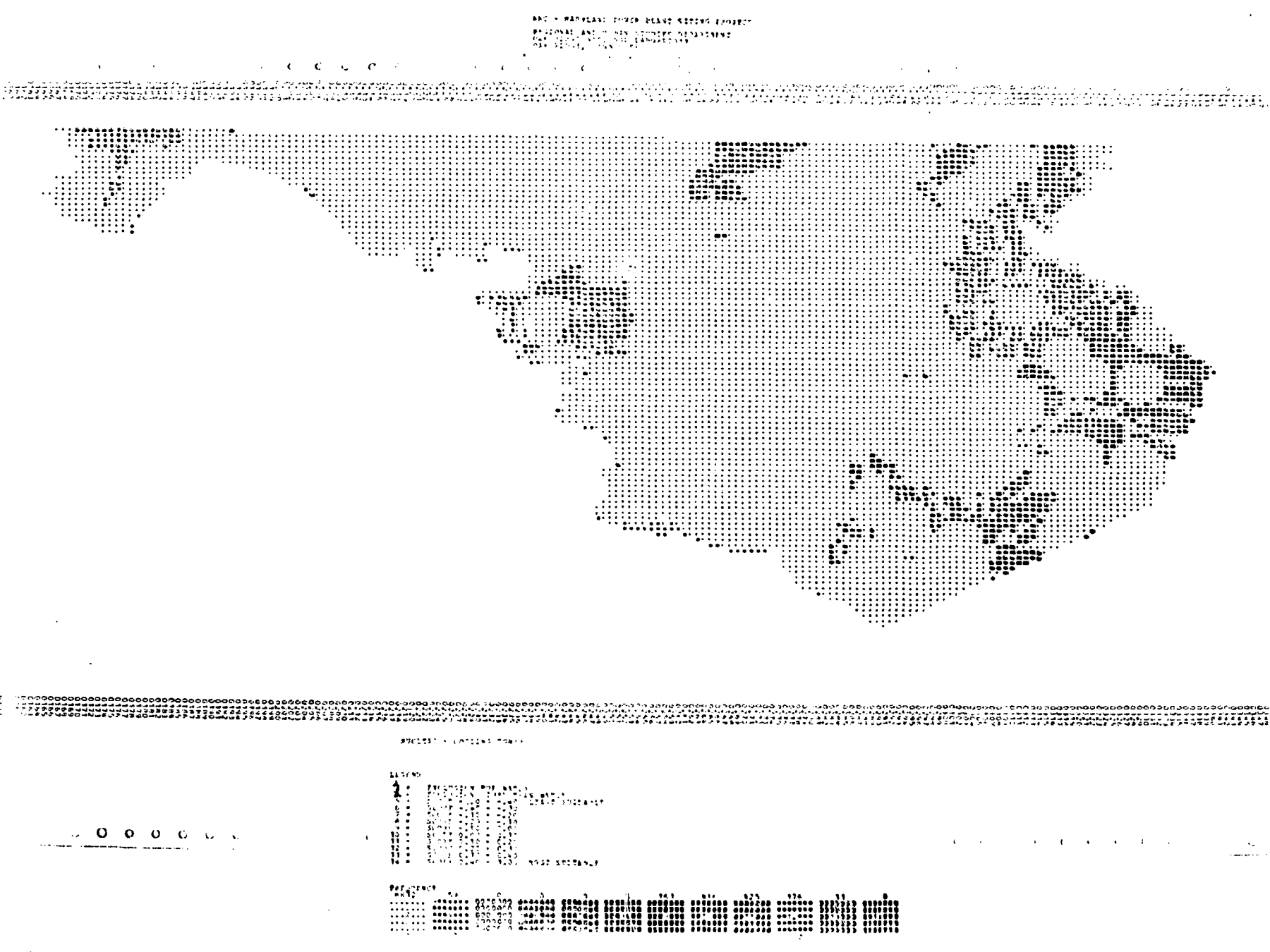


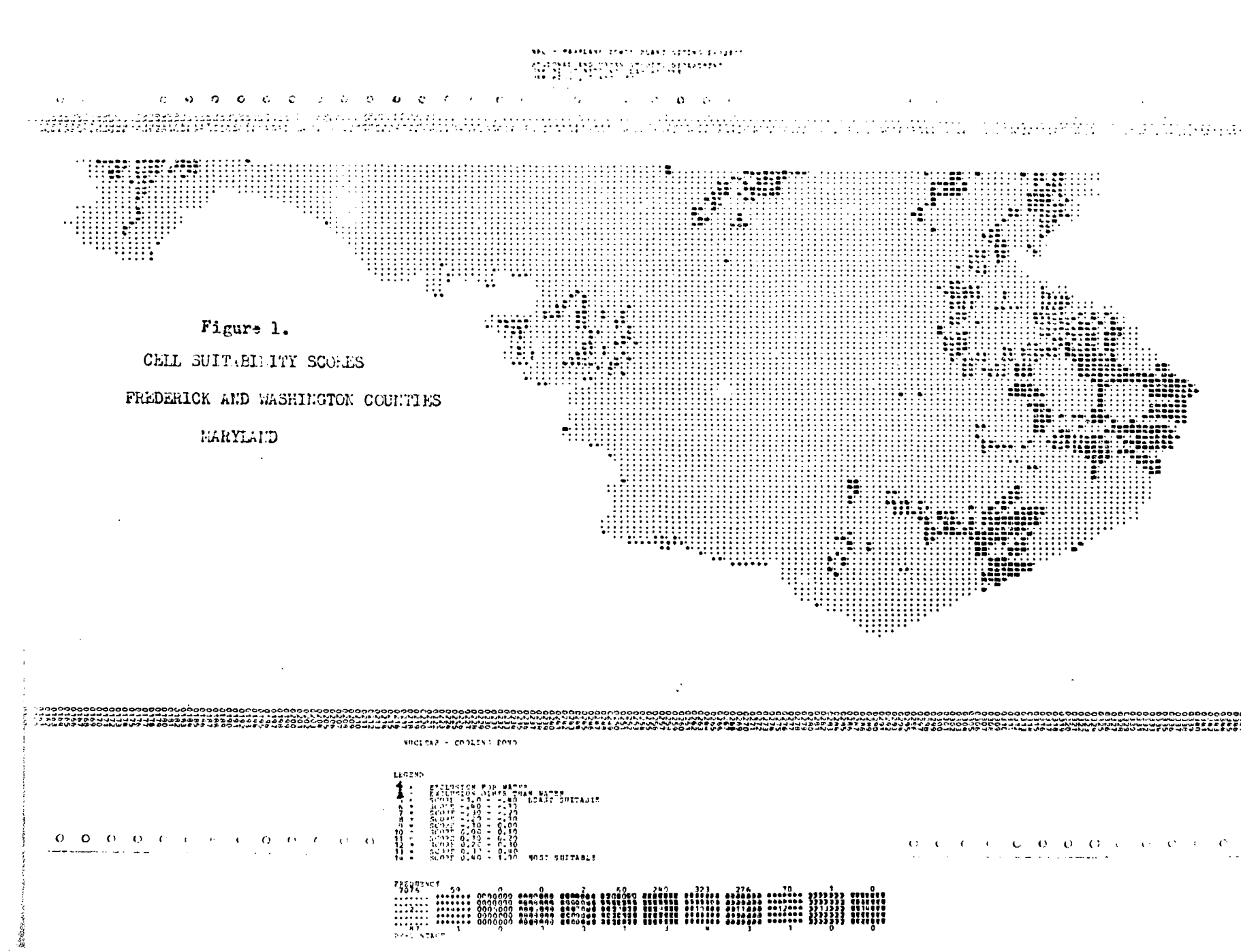
Figure 1.

CELL SUITABILITY SCORES

FREDERICK AND WASHINGTON COUNTIES

MARYLAND





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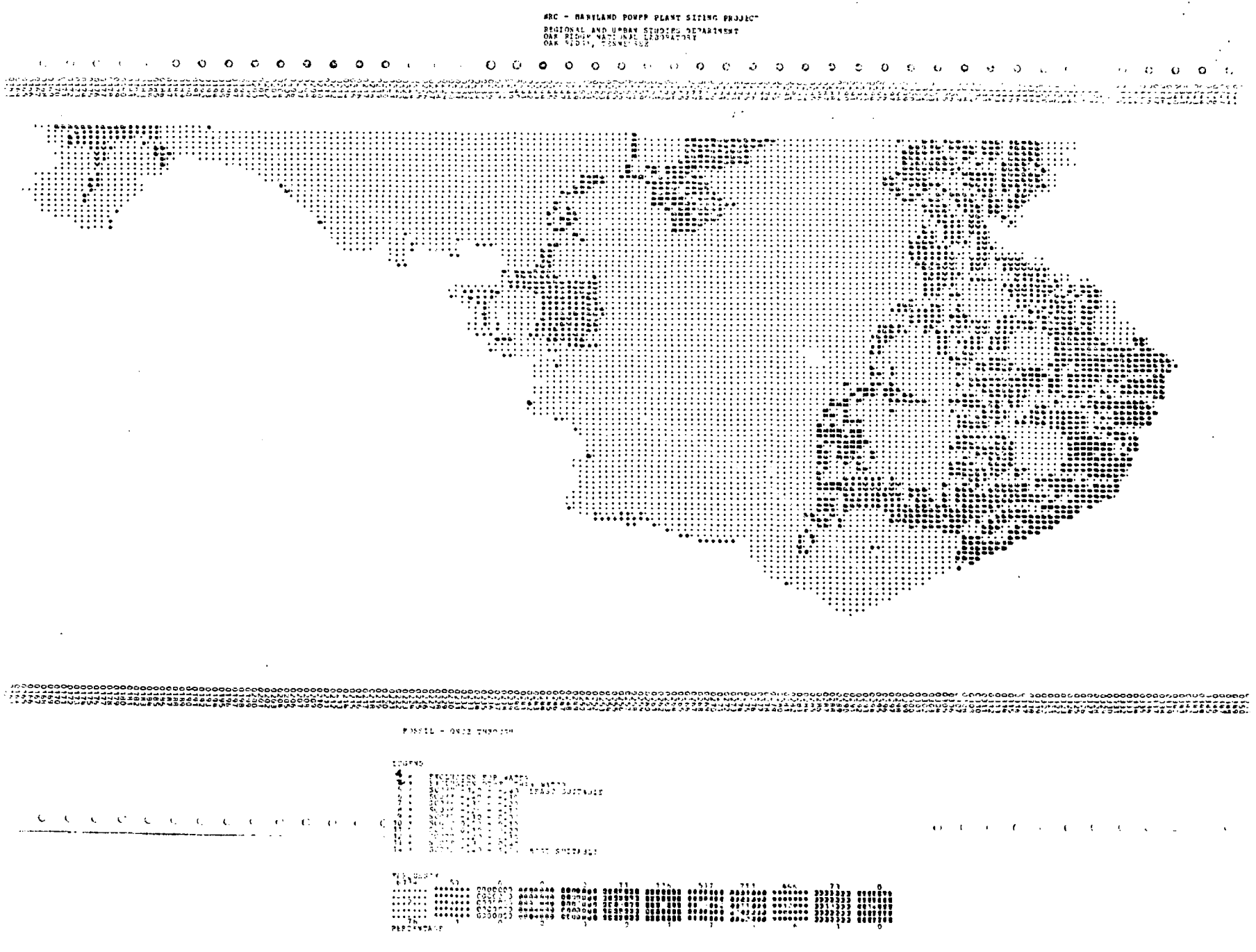
CELL SUITABILITY SCORES

FREDERICK AND WASHINGTON COUNTIES

MARYLAND


ARC - MARYLAND POWER PLANT SITING PROJECT
REGIONAL AND URBAN STUDIES DEPARTMENT
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE
FOSSIL - GAS ENDPOINT
LEGEND
PERCENTAGE

FOSSIL - COOLING TOWER

LEGEND

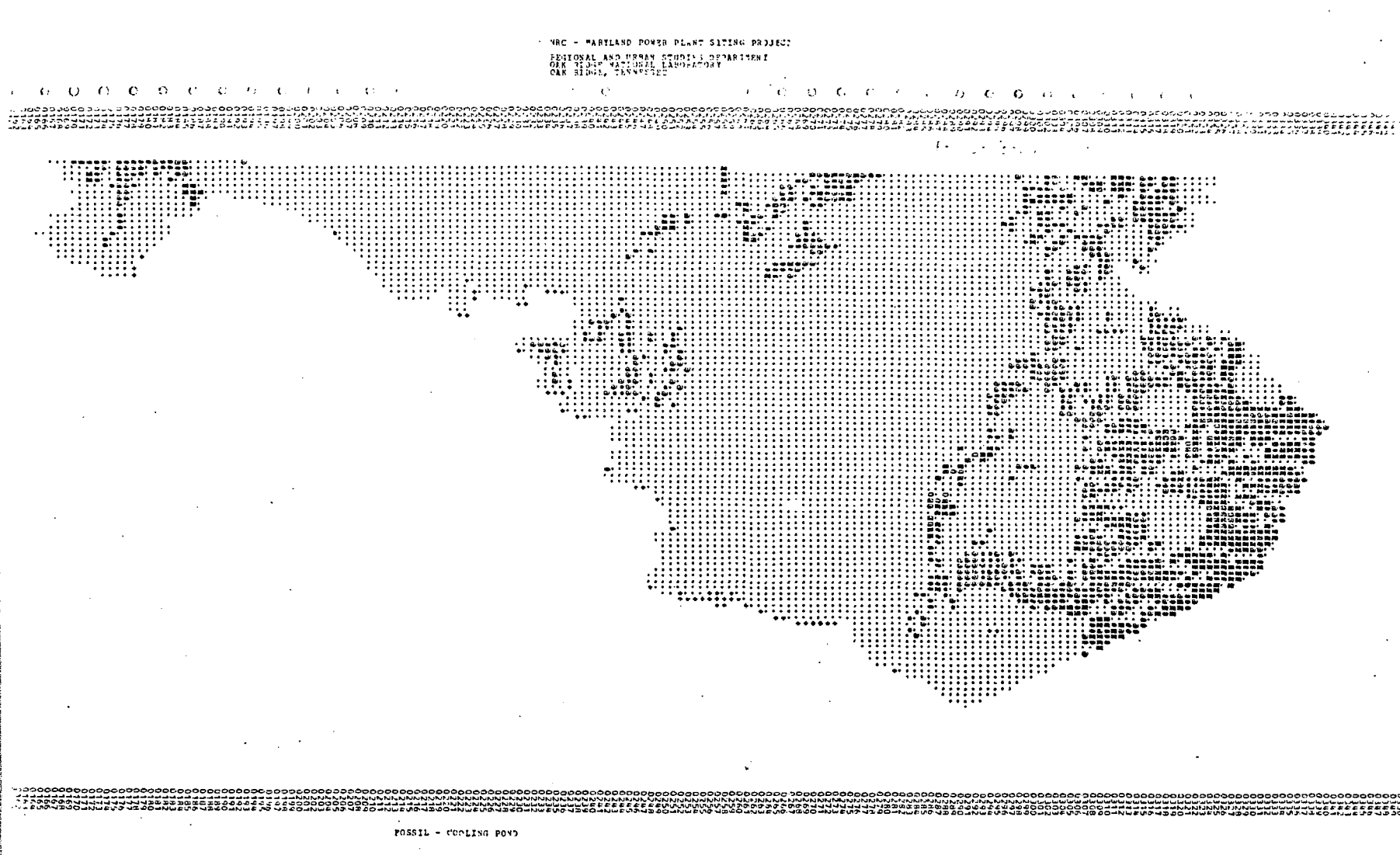
- 1 = EXCLUSION FOR WATER
- 2 = EXCLUSION OTHER THAN WATER
- 5 = SCORE -1.0 - -.40 LEAST SUITABLE
- 6 = SCORE -.40 - -.30
- 7 = SCORE -.30 - -.20
- 8 = SCORE -.20 - -.10
- 9 = SCORE -.10 - 0.00
- 10 = SCORE 0.00 - 0.10
- 11 = SCORE 0.10 - 0.20
- 12 = SCORE 0.20 - 0.30
- 13 = SCORE 0.30 - 0.40
- 14 = SCORE 0.40 - 1.00 MOST SUITABLE

FREQUENCY

6211	59	0	0	0	9	86	452	631	521	77	0

NRC - MARYLAND POWER PLANT SITING PROJECT

REGIONAL AND URBAN STUDIES DEPARTMENT
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE



FOSSIL - COOLING POND

LEGEND

1	*	EXCLUSION FOR WATER	
2	*	EXCLUSION OTHER THAN WATER	
3	*	SCORE -1.0 - -.90	LEAST SUITABLE
4	*	SCORE -.90 - -.80	
5	*	SCORE -.80 - -.70	
6	*	SCORE -.70 - -.60	
7	*	SCORE -.60 - -.50	
8	*	SCORE -.50 - -.40	
9	*	SCORE -.40 - -.30	
10	*	SCORE -.30 - -.20	
11	*	SCORE -.20 - -.10	
12	*	SCORE -.10 - 0.00	
13	*	SCORE 0.00 - 0.10	
14	*	SCORE 0.10 - 0.20	
15	*	SCORE 0.20 - 0.30	
16	*	SCORE 0.30 - 0.40	
17	*	SCORE 0.40 - 1.00	MOST SUITABLE

FREQUENCY

Maryland Power Plant Siting Project Data Base

Maryland Automated Geographical Information System Variables (MAGI Variables)	MAGI Variables Included in Screening Procedure	Additional Variables Used in Screening Procedure	
		Digitized	Calculated
Electoral Districts	Historic Sites (first in cell)	Fish Resources	Proximity to Bays/Estuaries
Engineering Geology (primary)	Land Surface Slope (primary)	Public Facilities	Proximity to Fish Resources
Engineering Geology (secondary)	Land Use (primary)	Railways	Proximity to Railroads
Historic Sites (first in cell)	Mineral Resources	Roadways	Proximity to Roadways
Historic Sites (second in cell)	Natural Features (primary)		Proximity to Streams/Waterways
Historic Sites (third in cell)	Ownership (primary)		
Land Surface Slope (primary)	Sewer and Water Districts		
Land Surface Slope (secondary)	Soils (primary)		
Land Use (primary)	Surficial Hydrology (water quality)		
Land Use (secondary)	Transportation (primary)		
Mineral Resources	Vegetation		
Natural Features (primary)			
Natural Features (secondary)			
Ownership (primary)			
Ownership (secondary)			
Sewer and Water Districts			
Soils (primary)			
Soils (secondary)			
Soils (tertiary)			
Surficial Hydrology (water quality)			
Transportation (primary)			
Transportation (secondary)			
Vegetation			
Watershed and Subwatershed			

Table 2.

The suitability map in Figure 1 was prepared using probative criteria to screen the MAGI data. It illustrates that the computer program is operational and suggests the need for rigorous analyses of the siting criteria. For example, the frequency distribution of cell suitability scores is suspiciously normal as one would expect from a random selection (Figure 2). A cursory examination reveals that this probably results from the small range of importance weights which do not allow realistic appraisals of certain overwhelmingly influencial variables like proximity to water. If each variable is weighted approximately the same, factors affecting the aggregate scores approach entropy as the number of variables increases. This can be corrected by increasing the range of importance weights or by treating them as ordinal numbers.

The proximity variables create a second problem which affects cells near the periphery. Because the data base does not include information for extraneous cells, proximity measurements are inaccurate to a distance of 6.1 kilometers (3.8 miles) — the maximum proximity registered — from each edge. The problem can be overcome by digitizing the pertinent variables to a similar distance beyond the edges, but this entails considerable effort and is even more difficult when jurisdictional boundaries are crossed.

The two problems discussed above illustrate some of the recommendations that will have to be made to the user. When this phase of the research is complete in the summer of 1976, the land use screening procedure will be tested in a practical siting exercise.

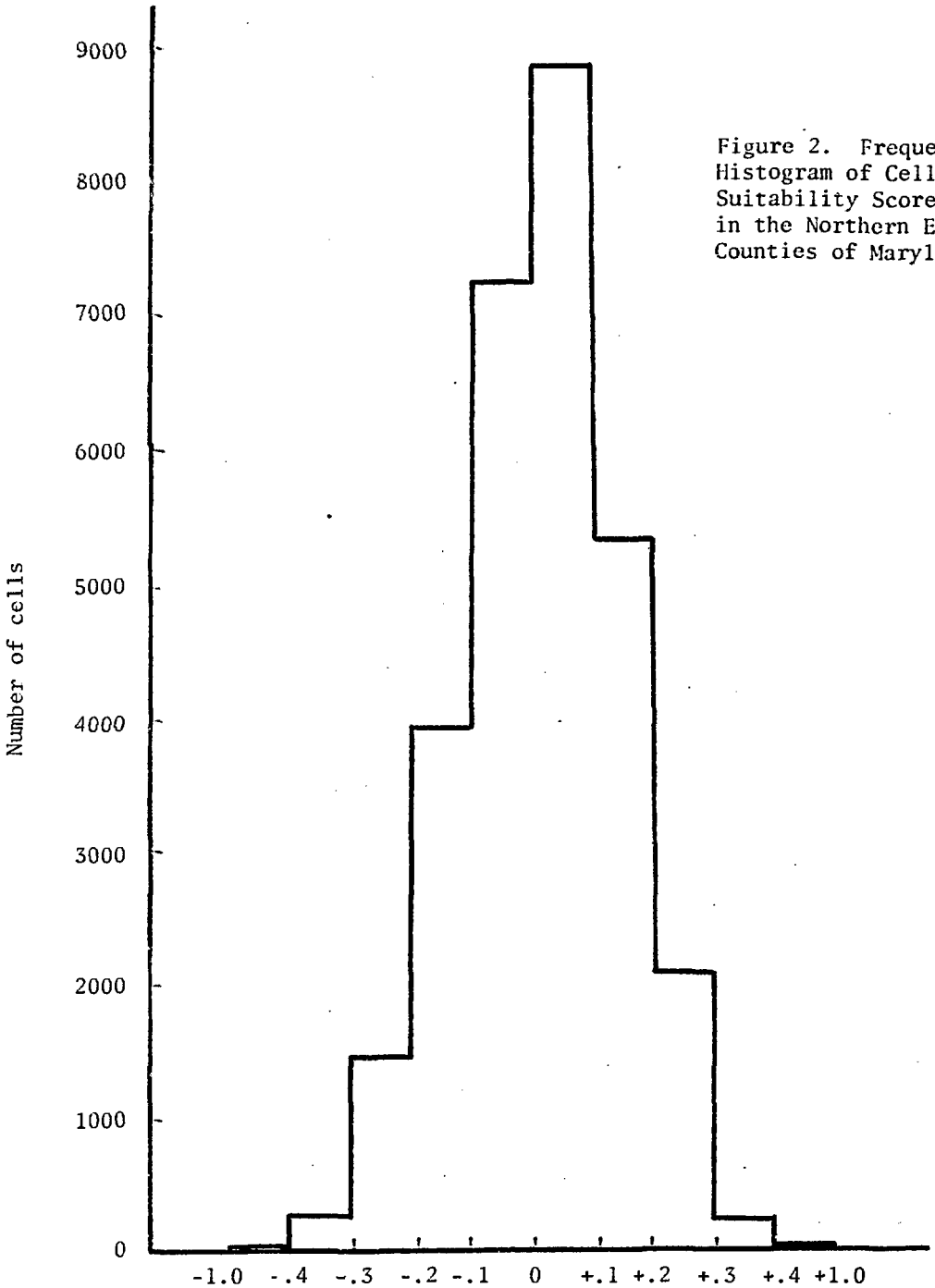


Figure 2. Frequency Histogram of Cell Suitability Scores in the Northern Eight Counties of Maryland.

Application of the Land Use Screening Procedure

The Maryland Power Plant Siting Project is funded by the Nuclear Regulatory Commission for the State of Maryland. Upon completion the procedure will be used by the Department of Natural Resources, Power Plant Siting Program to predesignate sites for actual use. The state has enacted legislation empowering that office under the direction of Kenneth E. Perkins to purchase such sites for future use. The power companies can recommend new sites to the state, but they can only develop those which have been approved by Perkins' office. The siting research at ORNL is coordinated continually with the federal and state regulatory agencies and frequently with the power companies themselves.

It should be noted that the purpose at ORNL is to develop tools for siting rather than to choose sites. The latter function is the responsibility of Perkins' office. Hence, he will make the final decision as to what criteria are employed in the user-oriented siting procedure developed by ORNL. The advantage of using the automated procedure is that all criteria can be stated objectively and applied to every 90-acre cell in the state. Even if the sites chosen by this procedure were to be no better than those chosen intuitively, they at least could be discussed more objectively in public hearings and court proceedings. Moreover, there would be greater assurance that every alternative site was considered.

By providing siting criteria for the specific requirements of each technological option, one can identify the trade-offs between various alternatives of power production and cooling systems. For example, the cell scores could indicate that one site was more suitable

for a nuclear plant with cooling tower and another for a fossil plant with cooling pond. Furthermore, the criteria can be chosen with any particular viewpoint in mind. For example, one set could be used to score cells according to the likelihood of ecological damage and another could be based on construction costs. Cells with the best scores on both sets of criteria could be identified as likely candidate sites.

The computer program is flexible enough to be used with any set of criteria. Thus, suitability for any other land use can be measured like that of power plants. This capability allows one to examine the likely alternative land uses competing for a site. For instance, one could identify sites with high power plant suitability scores and low recreational scores as candidate sites with a low probability of opposition by recreationists. If there is opposition from recreationists, the reason for the decision can be demonstrated. In fact, representative opposition groups could be asked to submit their own criteria to be considered in the initial siting decision.

Research during fiscal year 1976 will examine the possibilities discussed above. The goal is to refine the siting criteria for Maryland and to make the procedure transportable to other regions and applicable at various scales. This will require specific recommendations as to which variables should be included in the data base and the optional cell size at each scale. This phase of the research is scheduled for completion in June 1976.

REFERENCES

1. H. Floyd Sherrod, Jr., ed., *Environmental Law Review* (New York: Clark Boardman Company, Ltd., 1975), p. 184.

2. Ian L. McHarg, *Design With Nature* (New York: Natural History Press, 1969).

3. G. Tyler Miller, Jr., *Living in the Environment, Concepts, Problems, and Alternatives* (Belmont, California: Wadsworth Publishing Company, Inc., 1975), pp. 196-197.

4. N. A. Frigerio, L. J. Habeggar, R. F. King, L. J. Hoover, N. A. Clark, and J. M. Cobian, *Site: A Methodology for Energy Facility Site Screening and Regional Environmental Impact Assessment* (Argonne, Illinois: Energy and Environmental Systems Division, Argonne National Laboratory, 1975).

5. Steven L. Yaffee and Curtis A. Miller, *Toward a Regional Power Plant Siting Method: AEC-Maryland Regional Siting Factors Study, FY 1974 Progress Report* (Oak Ridge, Tennessee: Regional and Urban Studies Department, Energy Division, Oak Ridge National Laboratory, 1974).