ORNL/NUREG/TM-80

# A Cell-Based Land Use Screening Procedure for Regional Siting Analysis


J. S. Jalbert
J. E. Dobson



Prepared for the U.S. Nuclear Regulatory Commission
Office of Standards Development
Under Interagency Agreement 40-543-75



OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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ENERGY DIVISION

# A CELL-BASED LAND USE SCREENING PROCEDURE FOR REGIONAL SITING ANALYSIS

Jeffrey S. Jalbert
Jerome E. Dobson

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OAK RIDGE NATIONAL LABORATORY
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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

**MARYLAND POWER PLANT SITING PROJECT REPORTS**

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|---|---|---|---|
| *The Maryland Power Plant Siting Project: An Application of the ORNL Land Use Screening Procedure* | J. E. Dobson | 79 | 1977 |
| *A Cell-Based Land Use Screening Procedure for Regional Siting Analysis* | J. S. Jalbert<br>J. E. Dobson | 80 | 1977 |
| *Power Plant Siting: An Application of the Nominal Group Process Technique* | A. H. Voelker | 81 | 1977 |
| *A System for Regional Analysis of Water Availability* | J. S. Jalbert<br>A. D. Shepherd | 82 | 1977 |

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A CELL-BASED LAND USE SCREENING PROCEDURE
FOR REGIONAL SITING ANALYSIS

J. S. Jalbert*
J. E. Dobson

ABSTRACT

An energy facility site-screening methodology which permits the land resource planner to identify candidate siting areas has been developed by personnel in the Regional and Urban Studies Section of Oak Ridge National Laboratory. Through the use of spatial analysis procedures and computer graphics, a selection of candidate areas is obtained. Specific sites then may be selected from among candidate areas for environmental impact analysis.

The computerized methodology utilizes a cell-based geographic information system for specifying the suitability of candidate areas for an energy facility. The criteria to be considered may be specified by the user and weighted in terms of importance. Three primary computer programs have been developed. These programs produce (1) thematic maps, (2) proximity calculations, and (3) suitability calculations. Programs are written so as to be transferrable to regional planning or regulatory agencies to assist in rational and comprehensive power plant site identification and analysis.

*On leave from Denison University.

## ACKNOWLEDGMENTS

The authors wish to thank Peter A. Lesslie of the Computer Sciences Division for his extended efforts and his management of the Data Systems during the initial stages of the project, and especially for the Proximity Program. Richard G. Mashburn also contributed to the early development of these programs.

We wish to thank our colleagues of the Energy Division for their help in the development and presentation of this research. Alfred H. Voelker participated in many discussions throughout the development of our ideas and the interpretation of results. Robert B. Honea has continued to provide stimulation and leadership of the siting effort as a whole. Dale Honeycutt provided assistance in compiling the MAGI data description. Steven L. Yaffee, Curtis A. Miller, and Carey S. Rosemarin conducted the research early in the project. Garvin J. Morris and Mary C. Ogle digitized many of the data variables. Gary V. Downer assisted in many of the computer runs and helped prepare this document.

The Maryland Department of State Planning provided access to the Maryland Automated Geographic Information System (MAGI), from which 27 of the 42 raw data variables were obtained.

Darrell C. West of the Environmental Sciences Division identified and mapped the habitats of rare and endangered species in Maryland.

We appreciate the effort and patience that went into the typing and assembling of this report. For this we thank Bonnie W. Brummitt of the Energy Division and members of the Technical Publications Department in the Information Division.

We wish to thank the members of the Maryland Power Plant Siting Program for their help in understanding the siting process and for their comments and criticisms of previous reports and presentations.

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# 1. INTRODUCTION

This report describes an automated power plant site-screening procedure designed to assist the land resource planner or regulatory official in identifying and specifying the suitability of land parcels within a potential siting region for various types of land uses. The Maryland Power Plant Siting Project (MPPSP),[1] for which these computer programs were developed, focuses upon assisting the state in identifying possible sites for power plants. It is intended that the procedures also should provide valuable assistance in other types of land use or facility location decisions.

The concensus of our research findings at Oak Ridge National Laboratory (ORNL) is that energy-facility siting must be viewed in the context of a spatial hierarchy of physical, social, and economic systems. Site selection should proceed from the regional to the local scale, with emphasis placed on different criteria at each level. In this manner only a minimum of information needs to be considered at each scale. The amount and type of data considered are determined by the areal units of observation. The suitability of a particular area is determined through iterative screenings starting from small-scale (large area) analysis and stepping down to large-scale (small area) analysis. The Maryland study represents a large-scale analysis.

Large-scale analyses focus on siting considerations which may vary considerably over small areas. Appropriate variables are land-surface slope, land use, vegetation, soils, water, and geologic structure, among others. Such geographic characteristics form highly discontinuous surfaces. The ultimate goal is to identify candidate areas considerably larger than a single site from which specific potential sites can be selected for further analysis by utilities or resource planners. An extensive geocoded data base is required because of the need to characterize

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numerous areal units (cells)* equal to or smaller than the size of an average power plant site.

It was a purpose of the Maryland Power Plant Siting Project (MPPSP) to explore cell-based analysis procedures and to develop appropriate tools to implement this methodology. A complete description of the research is presented in *The Maryland Power Plant Siting Project: An Application of the ORNL Land Use Screening Procedure*.[2] It is the purpose of this document to (1) present a detailed description of the cell-based methodology, (2) provide a user's guide to the ORNL cell-based programs, (3) provide program documentation for the ORNL cell-based programs, and (4) outline the data base used in the MPPSP as an example of the type of data that can be manipulated in such a method.

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*A cell is an artificially defined area on the surface of the earth and is assumed to be regular in shape and uniform in its characteristics. Varying sizes are possible, and the appropriate size ultimately must be based upon the scale of the siting effort.

# 2. METHODOLOGY

## 2.1 Geocoding System

As previously noted, the fundamental areal unit in this analysis is the cell on which all data are defined. Its characteristics and position with reference to other cells represent the geography of a region. The size of a cell determines the spatial resolution of the analysis and the amount of effort needed to process information for a study region. A cell should be of sufficient size to provide the required resolution for a given problem. A 100-acre cell is too large for siting a 10-acre activity; it provides too little resolution. In contrast, a 1-acre cell used for siting a 1000-acre power plant provides more resolution than necessary and generates a volume of data that may be unmanageable even with computer assistance.

The cell size used in the Maryland study is 91.8 acres, or 2000 ft on a side.* This provides sufficient resolution for siting a 1000-acre power plant and yet retains a manageable number of cells. Approximately 31,000 cells were used for the northern tier of eight counties examined in this study.

Each cell is referenced graphically according to the Maryland State Plane Coordinate System. The state plane coordinates, however, must be converted to a system which is easily handled by the computer. If we let column number and row number be the horizontal and vertical position of the centroid of any given cell, then in state plane coordinates, easting positions (in feet) are equal to [2000 × (column number - 1)] + 90,000, and northing positions (in feet) are equal to 700,000 - [2000 × (row number - 1)]. With this notation, the northern tier of counties in Maryland is represented by cells with column numbers from 1 to 530 and row numbers from 1 to 110.

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*The cell size was previously determined for planning purposes by the Maryland Department of State Planning.

## 2.2 The Maryland Data Base

The Maryland Data Base consists of data and information obtained from the Maryland Automated Geographic Information System (MAGI) and additional variables digitized by ORNL staff (Table 2.1). The MPPSP was fortunate to have available an extensive geographic base file provided by the Maryland Department of State Planning. The final data set contains information covering a broad range of social, economic, and physical phenomena. Physical characteristics, transportation facilities, population densities, and land use are particularly well represented.

Most of the variables are simply measured or "raw" variables (e.g., land surface slope) available in MAGI, but a few, such as the site population factor, were obtained from modeling of multiple parameters. These variables, not subject to direct measurement, are called factors to distinguish them from measured variables.

Certain raw variables are presumed to influence siting decisions in surrounding cells. Hence, it is often necessary to calculate proximity measurements indicating centroid-to-centroid distances between a given cell and the nearest cells containing a specific feature (e.g., railroads or habitats of endangered species). Proximity variables near the border are inaccurate because of a lack of information regarding cells outside the study area. The obvious solution is that all raw variables which affect site selection in adjacent cells should be collected for an extended band outside the study area. Unfortunately, neither MAGI nor the Maryland Data Base includes data for bordering states; therefore, the site screening procedure is adversely affected near the state borders.

Clearly, various types of factors and variables must be handled in different ways. Their fundamentally different natures, ranging from continuous ordered measurements to mere classification or a "yes/no" indicating the presence or absence of a particular feature, must be recognized in the interpretation of quantified data. Each variable is expressed either as a range of values forming an ordered continuum or

Table 2.1. The Maryland Data Base

| Variable No. (Columns 1–2) | Variable name (Columns 3–22) | Source |
|---|---|---|
| 1 | Grid cell row number | |
| 2 | Grid cell column number | |
| 3 | County or city number | MAGI |
| 4 | Surface water quality/fish and shellfish | MAGI |
| 5 | Geologic formation (primary) | MAGI |
| 6 | Geologic formation (secondary) | MAGI |
| 7 | Transportation and transmission (primary) | MAGI |
| 8 | Transportation and transmission (secondary) | MAGI |
| 9 | State and Federal lands (primary) | MAGI |
| 10 | State and Federal lands (secondary) | MAGI |
| 11 | Mineral resources | MAGI |
| 12 | Sewer facilities; water facilities | MAGI |
| 13 | Forest type | MAGI |
| 14 | Soil group (primary) | MAGI |
| 15 | Soil group (secondary) | MAGI |
| 16 | Soil group (tertiary) | MAGI |
| 17 | Natural features (primary) | MAGI |
| 18 | Natural features (secondary) | MAGI |
| 19 | Land surface slope (primary) | MAGI |
| 20 | Land surface slope (secondary) | MAGI |
| 21 | Watersheds | MAGI |
| 22 | Electoral district | MAGI |
| 23 | Historic sites (first) | MAGI |
| 24 | Historic sites (second) | MAGI |
| 25 | Historic sites (third) | MAGI |
| 26 | Land use and land cover (primary) | MAGI |
| 27 | Land use and land cover (secondary) | MAGI |
| 28 | Land use and land cover (tertiary) | MAGI |
| 29 | Planned land use and land cover (primary) | MAGI |
| 30 | Planned land use and land cover (secondary) | MAGI |
| 31 | Planned land use and land cover (tertiary) | MAGI |
| 32 | Highways and proposed highways | ORNL |
| 33 | Seismicity | ORNL |
| 34 | Fish spawning and nursing areas in the Chesapeake Bay | ORNL |
| 35 | 30-Mile site population factor (SPF) | ORNL |
| 36 | Endangered species | ORNL |
| 37 | Excavation requirements | ORNL |
| 38 | Overburden thickness | ORNL |
| 39 | Aquifer recharge zones | ORNL |
| 40 | 5-mile site population factor (SPF) | ORNL |
| 41 | Stream flow | ORNL |
| 42 | Population density | ORNL |
| 43 | Proximity to highways | ORNL |
| 44 | Proximity to railroads | ORNL |
| 45 | Proximity to stream flow | ORNL |
| 46 | Proximity to residential land use | ORNL |
| 47 | Proximity to agricultural land use | ORNL |
| 48 | Proximity to transmission lines | ORNL |
| 49 | Proximity to fish spawning and nursing areas | ORNL |
| 50 | Proximity to airports and airport property | ORNL |
| 51 | Proximity to endangered species | ORNL |
| 52 | Proximity to natural features | ORNL |

as a set of discrete categories with numerical codes. For example, "30 to 40 people per square mile" is a range of values of the continuous variable "population density," and "scrub oak" is a discrete category of the variable "forest type."

The record for each cell contains finite values for each variable as well as geocoordinates identifying the spatial location of the cell and distinguishing it from all other cells.

## 2.3 The Screening Algorithm

The screening procedure used in this analysis has been designed to specify a "suitability score" for each cell as a host for differing types of power plant facilities. The suitability is determined through the use of siting criteria* applied to the Maryland Data Base. Each set of criteria is a quantitative expression of considerations which might be evaluated by a resource planning group or individual in siting a power plant. Each variable in the data base is assigned an importance weight of 0 through 10 indicating the relative influence it is considered to have on siting decisions. The most important variables are given a weight of 10; unimportant variables are indicated by a zero (0) and do not enter into the calculation of cell suitability scores.

In addition to importance weights, each value or category of each variable is assigned an index from 0 through 10 indicating the influence it might have on the ability of a cell to support the proposed facility. Highly compatible characteristics are given a value of 10, and highly incompatible ones are assigned a zero (0). Neutral characteristics are given an index of 5, and all others are graduated between these three reference indices. In cases where the variable is of great importance and

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*Siting criteria are expressed as plant requirements in terms of the available data. For example, it may be required that the site is within 6 miles of a stream with a specified flow and that cells close to the stream are scored higher than those farther away. Criteria may be defined by assessing expert opinion or consulting interest groups.

the value or category is highly repulsive, a negative index (-1) may be assigned to indicate that cells possessing this trait are excluded from the final selection regardless of how positive their other characteristics may be. Such cells are rejected on this basis, and the cell suitability score is not calculated. In order to arrive at a final "suitability score" for each nonexcluded cell, compatibility indices and importance weights are combined in a linear fashion as follows:

$$S_i = \sum_{V=1}^{N} C_{Vi} I_V \Big/ \sum_{V=1}^{N} I_V \quad ,$$

where

$S_i$ = suitability score for cell i,

V = variable (e.g., land use, proximity to stream flow),

N = total number of variables,

$C_{Vi}$ = compatibility index for value of variable V occurring in cell i,

$I_V$ = importance weight of variable V.

A basic issue with regard to screening algorithms of this type is whether the importance weights and compatibility indices assigned to the variables are ordinal or interval numbers. For a complete discussion of this and other methodological issues see *Analytical Power Plant Siting Methodologies: A Theoretical Discussion and Survey of Current Practice.*[3]

## 2.4 Application of the Screening Procedure

Factors calculated from models must be assembled into a data base along with the raw variables before analysis can progress. Usually extensive mapping of raw data is required at this stage to serve as a tool in understanding the information and as a means of checking for errors. After raw variables are added to the data base, proximity variables are calculated. Proximity variables also should be mapped for error checking and better understanding of the geographic situation.

Once all necessary raw variables, factors, and proximity variables have been obtained, suitability calculations are performed, and the scores are mapped. Usually several calculations are performed using various sets of criteria to determine the effects of different siting objectives.

The following section describes the three programs used at ORNL to implement this process. It also contains illustrative examples and presentations of the output to be expected with the use of these programs.

# 3. SYSTEM LOGIC

This section describes the logic used in the organization of the system of data and programs in the ORNL Land Use Screening Procedure (ORNL LUSP). Its purpose is to allow those with moderate programming skills to install and maintain the system at their installations.

## 3.1 Organization of Data Base

The data base is accessed as a sequential file and therefore may reside on any sequentially accessible medium such as magnetic tape or disk. For most applications, the data base will be so large as to require use of magnetic tape.

Each cell in the data base is assigned a single record, and each record contains 99 variables. All of these variables may be used freely, except variables 1 and 2. Variable 1 is reserved for the row coordinate of the cell, and variable 2 is reserved for the column coordinate. All data are read from and written to the data base in unformatted mode. Thus, the data undergo no conversion when being read or written.

The cells in the data base are ordered first by column number and then by row number within each column. The study area is indicated by those cells which are present. Cells outside the study area need not appear in the data base.

All variables are maintained in floating-point format. Thus, all data are treated in exactly the same way. No difficulty is experienced in maintaining integer values as long as they are kept under 7 significant digits (on a system with 32 bit floating-point format).

Any variable slot (except 1 or 2) is capable of holding any type of data item. In practice, the first slots hold the actual raw (measured) data, the next slots hold the proximity variables plus any modeled or computed factors, and the last slots are used for the suitability scores.

The programs that change data items rewrite the entire file with only that data item changed. In this way, it is possible to construct a sequence of calculations on a single file, maintaining early versions of the file while creating new ones. Enough space is provided to accommodate numerous calculated variables.

### 3.2 The Proximity Program

The proximity program is the simplest of the three programs. It is a two-pass program. On the first pass, the data base is read and the appropriate variable examined. If the variable possesses the desired characteristics, the program enters that cell into an internal table. Simultaneously the proximity to that cell is entered for all cells within the specified range of neighboring cells, unless a smaller proximity already exists in the table. Since the table is initialized to 99 before the start of the calculation, it contains all of the necessary proximity data as soon as the entire data base has been read. This internal table is large enough to hold a region of 530 cells by 110 cells.

When the table has been completed, the program again reads through the data base. As each cell is read, the appropriate variable position in its record is modified using row and column coordinates to locate the position in the internal table. The program reports its completion and then terminates.

### 3.3 Thematic Mapping

The thematic mapping program consists of a main-line routine and six subroutines. All specific functions of the program have been isolated into subroutines to allow for easy maintenance and efficient coding.

The input section is in the subroutine DATAIN. This subroutine has the complete responsibility for reading, checking, and echoing all input data. It accesses two files. The map description file is on FORTRAN Logical Unit 50. After its data are read completely, the shade cards are read from Logical Unit 5. If two separate card input files are not allowed, the shade cards can be placed after the map description cards in the same deck and the single line reading the shade cards modified to reflect the changed file.

The program reads the data base a single time and builds up to ten output maps in parallel. With spooling, all of these maps can be assigned to the system print device. If no spooling is available, these maps can be built sequentially by modifying the main-line program so that it reads the input file once for each map. The input file is located on FORTRAN Logical Unit 25. A single change to statement 10 of the main program would enable the user to reassign this unit. The output files for the maps are allocated to FORTRAN Logical Units 11 through 20 and can be modified by changing the first line of the subroutines COLUMN, LEGEND, and LINES. The log file echoing the input data is assigned to FORTRAN Logical Unit 6 and can be changed by modifying the appropriate lines of the subroutine DATAIN.

The entire mapping program is set up to handle an input matrix of up to 530 columns and 110 rows. The columns are printed one at a time as they are found on the input file. It was this consideration that dictated the organization of the input file. With this program there really is no inherent limitation to the actual number of columns in the data base.

The program expects the row numbers to be in the range 1 to 110. Again, this can be modified simply by a change to the mapping subroutine LINESH. The change would be to print the first 110 positions on one map file and the next 110 on a second file and so forth. These files can be assembled together after they are printed.

The program allows for many symbols to be created by overstriking up to four printing characters. Frequently, fewer than four strikes will be needed for a line. The program checks ahead and does not overprint totally blank lines. The use of symbols with few overstrikes is to be encouraged if printing costs are of concern. High density can be obtained with as few as three characters.

Several variable classes can be assigned to the same shade symbol, but the program allows only a single legend per symbol. The last legend read is the one printed. If the same printing symbol is desired for several variable classes, but distinct legend entries are also necessary, the shade deck can be altered to produce several shade numbers with the same printing pattern. These then can be assigned to different variable classes.

### 3.4 Suitability Program

The suitability program consists of a main-line program, function subprogram, and two subroutines. All data input functions are isolated in the subroutine INDATA. The function subroutine FIND classifies variables into appropriate categories and finds the compatibility score for that variable class in the compatibility table. The subroutine ANALYS produces the histogram and statistics.

As data cards are read and analyzed, a complete table of these is echoed in a formatted fashion on FORTRAN Unit 6. Any errors detected are also printed on this unit. Two warnings may be given. One indicates that a variable specification has been changed by the program; the other indicates that all importance weights are zero.

It is possible that a variable may not be specified completely by the input classes. If this is found during calculation, the program attempts to provide a "neutral" compatibility score for that variable in the cell. The value assigned is 5.0. The user should be warned that no indication of this fact is ever given; it occurs automatically.

After all data cards have been read, the data file is read one record at a time from FORTRAN Unit 24. The suitability calculations are performed for the cell, and the updated records are written on FORTRAN Unit 25. As each calculation is made, the resultant suitability scores are analyzed, and a table is built showing how many cells are in each score interval of 0.1 in the range 0 through 10. The number of exclusion cells in each calculation also is maintained. When all of the data have been read from the input file, the histograms are prepared and written. Each histogram is titled and contains 100 lines for the actual graph. The histograms are written on FORTRAN Unit 6.

# 4. USER'S GUIDE

Three distinct programs are presented with this package. These are thematic (single variable) mapping, proximity calculation, and suitability calculation. These programs are written in FORTRAN IV for the IBM system 360, and they require less than 270 K bytes of memory. Flow diagrams of the program logic are presented in Appendix C.

## 4.1 Thematic Mapping

The mapping of data and results is central to the siting problem. Numerous maps are required to detect details hidden in the data. Repeated runs with different data groupings are useful.

The mapping routines provided with this package allow up to ten maps to be produced in a single run. Only one variable can be shown on a single map, but the run can include maps of up to ten different variables. The cost per map decreases as the number of maps in the run increases.

Variables are plotted on the map in different shades for each value or range of values for which a shade or symbol number (from 1 to 30) has been assigned. The shade numbers determine the patterns to be printed and are input data to the program. More than one class of values of a variable may be assigned the same shade. The shading scheme specified by the user is printed in the legend for the map, and any given shade pattern may be assigned more than one of the shade numbers if the user desires. In this case, the legends and frequencies for all categories will be printed separately, but they will have the same representation on the map.

Each map is printed with a border indicating the row and column coordinates of all cells. Map titles, institutional identifications, and legends also are printed. Simple frequencies and percentages of cells in each class accompany the legend.

The program is driven by several sets of control cards:

• The first group of control cards for the program contains the institutional identification. The first card indicates in columns 1 and 2 the number of institution cards that are to follow. The cards (up to ten) may have any identifying information the user wishes. All information between columns 1 and 40, inclusive, will be printed under each map.

• Following the institution cards is a single card specifying the number of maps to be produced in this run. The number is punched in columns 1 and 2.

• The next group of cards describes the various maps requested. It consists of *N* sets of map specification cards, one for each map to be produced (*N* may not be more than 10). These map specification cards completely determine each map to be produced. Each set consists of the following:

Identification card

| | |
|---|---|
| Columns 1-4 | The variable number of the variable to be shown on this map |
| Columns 5-8 | Number of shade cards that are used to describe this map |
| Columns 9-80 | The map title |

Shade cards

| | |
|---|---|
| Columns 1-4 | The shade number assigned to this class |
| Columns 5-9 | The lower bound that the value of the variable may assume for this class |
| Columns 10-14 | The upper bound that the value of the variable may assume for this class |
| Columns 15-80 | Legend for this shade class |

• For the program to operate properly the number of shade cards must equal the number specified on the identification card.

• A shade card must be provided for each category or range of values which the variable may have. Each category or class thus appears as a distinguishable spatial pattern on the resultant map. The shade cards may be arranged in any order. If two classes of the variable are assigned to a single shade, the legend on the last card only is printed. The legends are printed in order by ascending shade number.

• All numeric data items must be right-justified in their respective fields. All numbers except lower and upper bounds should be keypunched without decimal points. The bounds should have decimal points punched.

• A value is determined to fall into a particular class if it is greater than or equal to the lower bound and less than the upper bound. The upper bound itself is not included in the range. In order to include the maximum of a value, the upper bound must be set higher than the actual maximum value. If a class has only a single value, each bound is set equal to that value.

• Following the institution cards is a single card which specifies the number of maps to be produced in this run. The number is punched in columns 1 and 2.

An illustration of the input data for a two-map run is shown in Fig. 4.1 (exclusive of the institutional identification).

The program will produce an audit listing of the input data as indicated in Fig. 4.2. This is intended to allow a check on the validity of the input data used by the program.

A deck of shade description cards also is used by this program. The different shades are produced by overprinting up to four characters on a single cell position. These characters must be supplied by the user. Up to 30 different shade values are allowed. These may be different print densities or different patterns that allow the eye to distinguish between different symbols of equal density. A sample shade deck is shown in Fig. 4.3. Because it is seldom changed, the shade deck is not incorporated into the map description deck. The map description

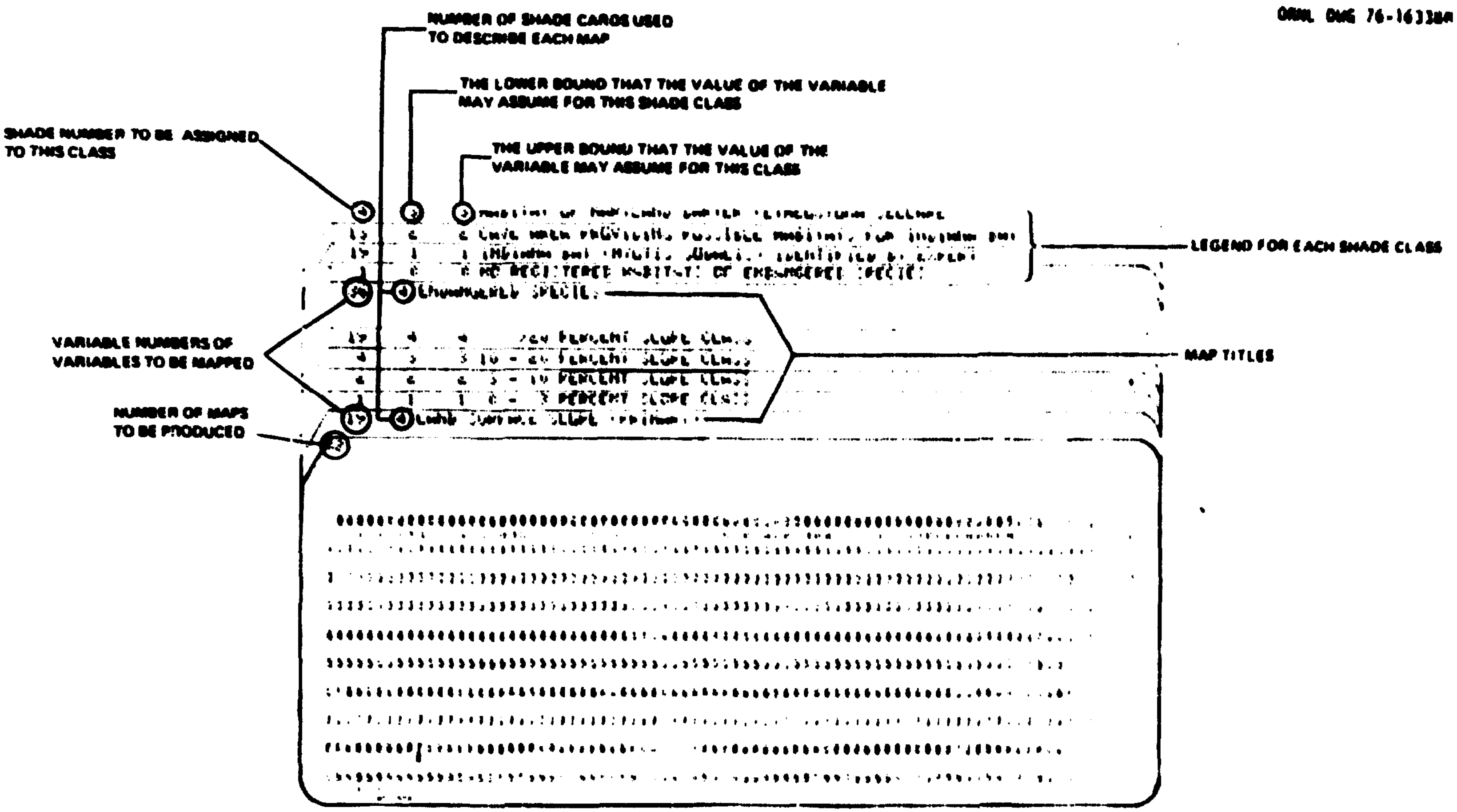


**Fig. 4.1. A control deck for a two-map run.**

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```
                              LISTINGS OF INPUT DATA

INSTITUTIONAL INPUT DECK
  NO OF INSTITUTION CARDS =    6

  MARYLAND POWER PLANT SITING PROJECT
  REGIONAL AND URBAN STUDIES SECTION
  ENERGY DIVISION
  OAK RIDGE NATIONAL LABORATORY
  OAK RIDGE, TENNESSEE 37830
  AUGUST 10, 1976

MAP INPUT DECK
  THERE ARE    2 MAP(S) REQUESTED

                            MAP # =  1
   19     4  LAND SURFACE SLOPE (PRIMARY)

    1       1.000       1.000    0 -  3 PERCENT SLOPE CLASS
    2       2.000       2.000    3 - 10 PERCENT SLOPE CLASS
    4       3.000       3.000   10 - 20 PERCENT SLOPE CLASS
   10       4.000       4.000      >20 PERCENT SLOPE CLASS

                            MAP # =  2
   36     4  ENDANGERED SPECIES

    1       0.0         0.0     NO REGISTERED HABITATS OF ENDANGERED SPECIES
   19       1.000       1.000   INDIANA BAT (MYOTIS SODALIS) IDENTIFIED BY EXPERT
   13       2.000       2.000   CAVE AREA PROVIDING POSSIBLE HABITATS FOR INDIANA BAT
    4       3.000       3.000   HABITAT OF MARYLAND DARTER (ETHEOSTOMA SELLARE)
```

Fig. 4.2. Sample documentation of input data by thematic mapping program.

ORNL DWG 76-16340

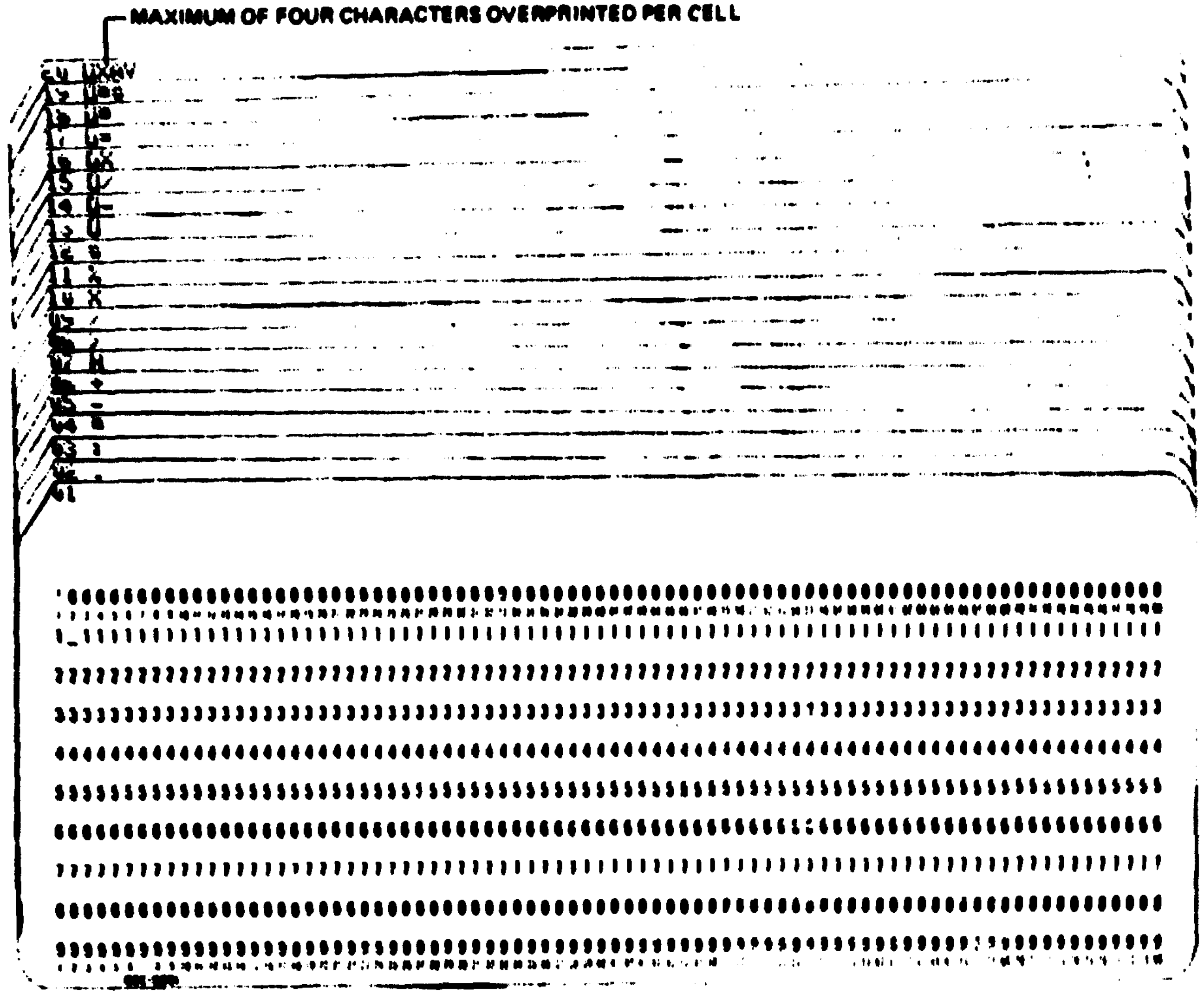



Fig. 4.3. Sample shade deck listing.

deck is read from FORTRAN Logical Unit 50, and the shade description deck from Logical Unit 5. The program user must be sure that these units are available on his system.

The shade description card layout is:

| | |
|---|---|
| Columns 1-2 | Shade number (1 to 30) |
| Column 3 | First character of shade |
| Column 4 | Second character of shade |
| Column 5 | Third character of shade |
| Column 6 | Fourth character of shade |

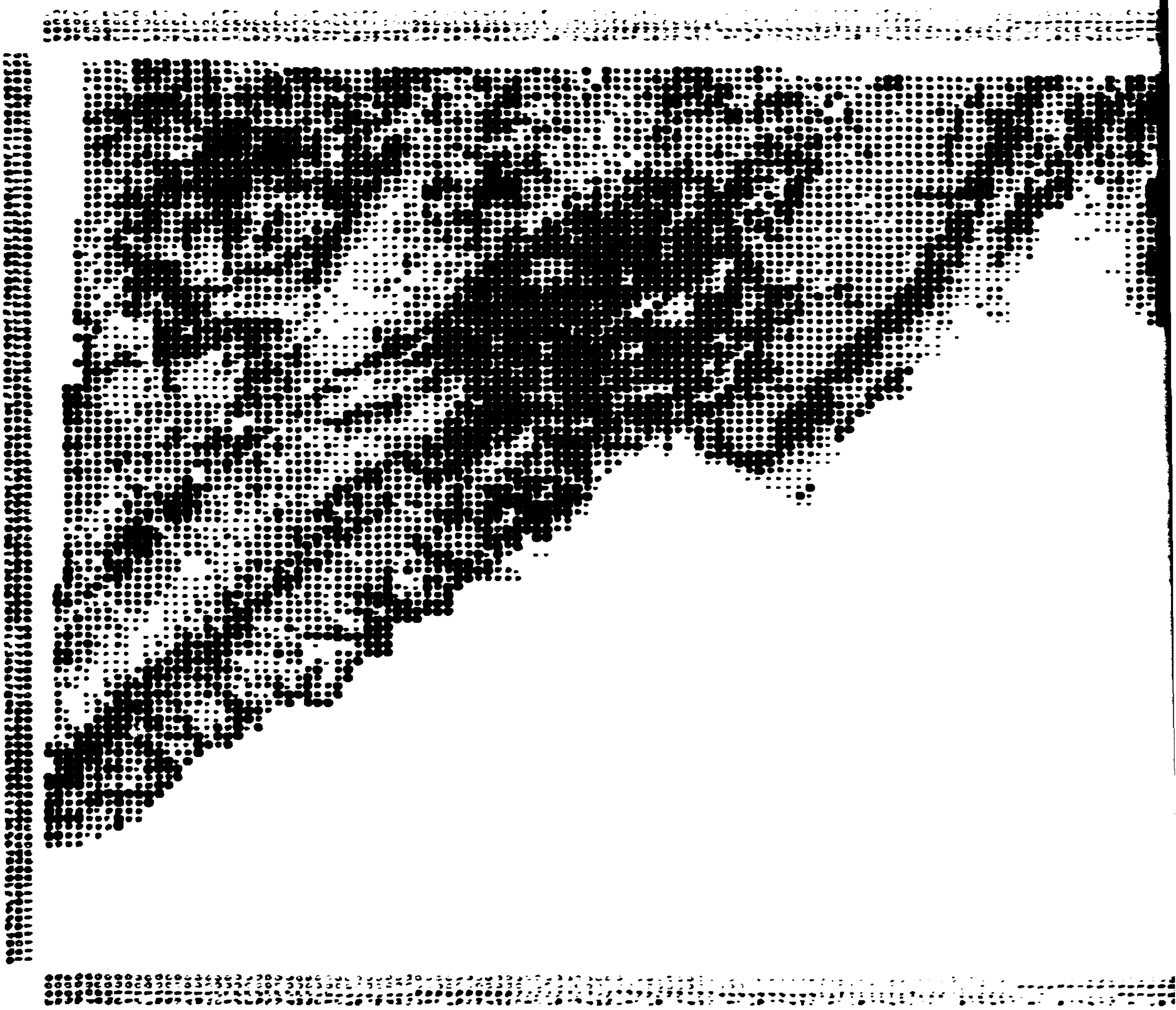
• The actual printing characters in columns 3 through 6 comprise the shade pattern. Any or all of these may be blank. However, if a character is blank, those to its right also should be blank. Erratic results for shading can occur if this rule is not followed.

• The first of the two maps requested by the input deck in Fig. 4.1 is shown in Fig. 4.4. The institutional identification and shade description input decks need to be added to the deck shown in Fig. 4.1 to produce this map. The legend and other explanatory information in this figure have been reproduced at a larger scale so they can be read more easily.

### 4.2 Proximity Program

The proximity program allows the system user to compute the distance from a given cell to another cell that possesses a specified category or value of a raw variable. The distances computed are the centroid-to-centroid distances between the two cells expressed in units equal to the width of one cell. If more than one cell possesses the specified characteristic, the program selects the nearest cell for the proximity calculation.

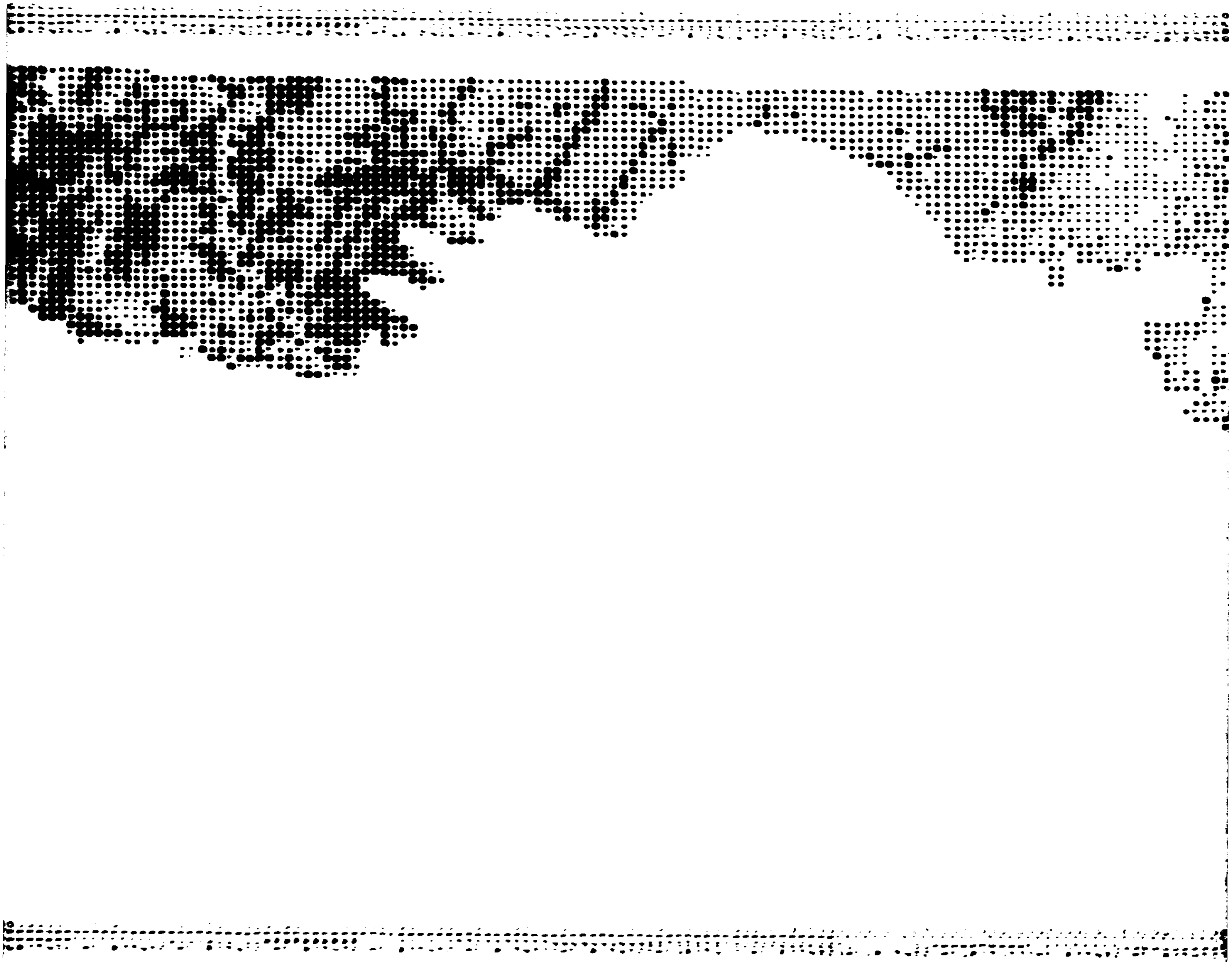
Since each pair of cells theoretically could be compared, the program allows a limit to be placed on the distance searched for the desired property. If no cell is found within this ring, then a proximity value



LAND SURFACE SLOPE (PRIMARY)

LEGEND

| Shade | Frequency | Percent | Definition |
|---|---|---|---|
| ☐ | 3046 | 10.4 | 0 - 3 Percent Slope Class |
| | 8786 | 30.1 | 3 - 10 Percent Slope Class |
| ▤ | 13578 | 46.5 | 10 - 20 Percent Slope Class |
| ■ | 3799 | 13.0 | > 20 Percent Slope Class |



2

Fig. 4.4. Sa

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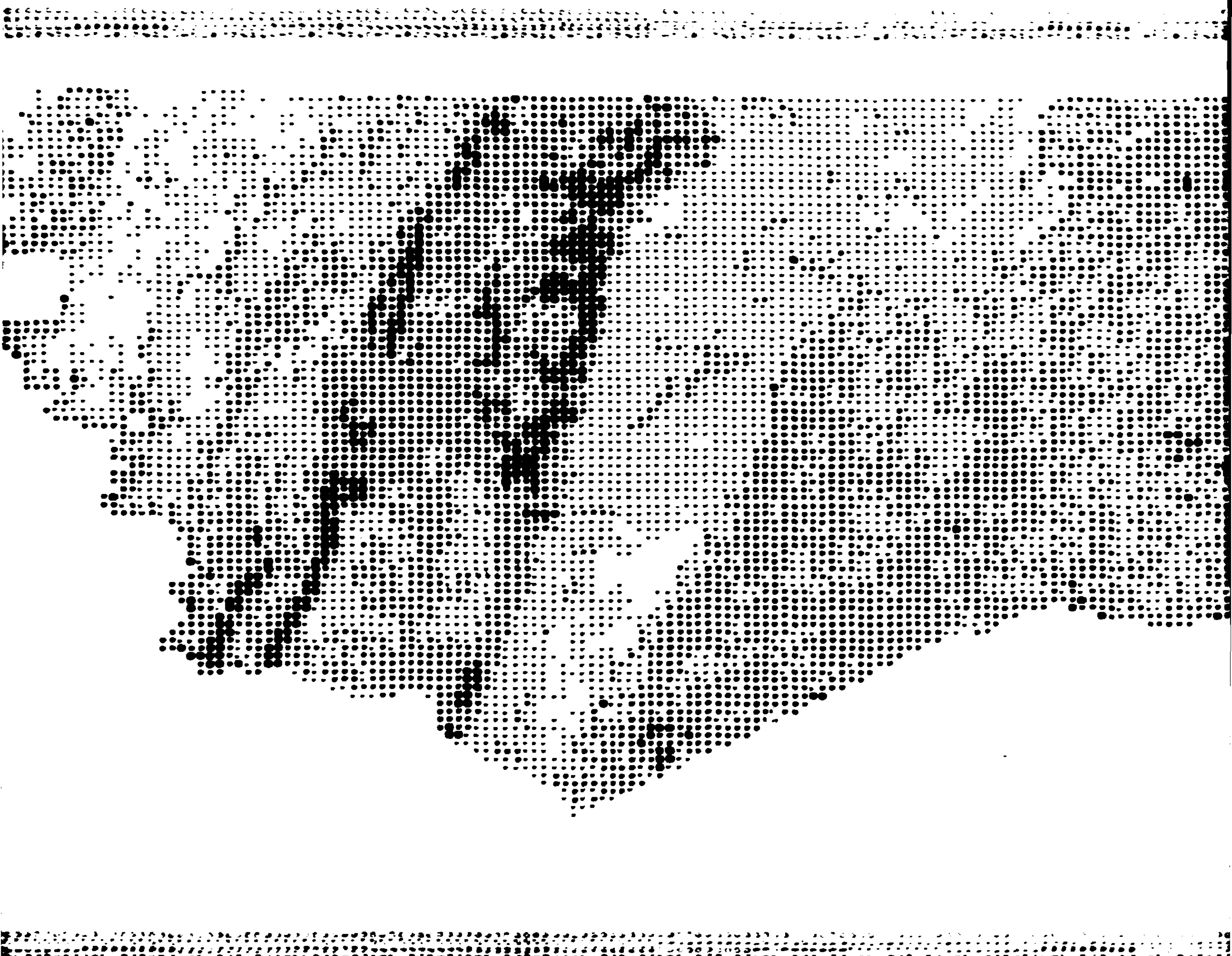

3

4. Sample line printer map produced by thematic mapping program.

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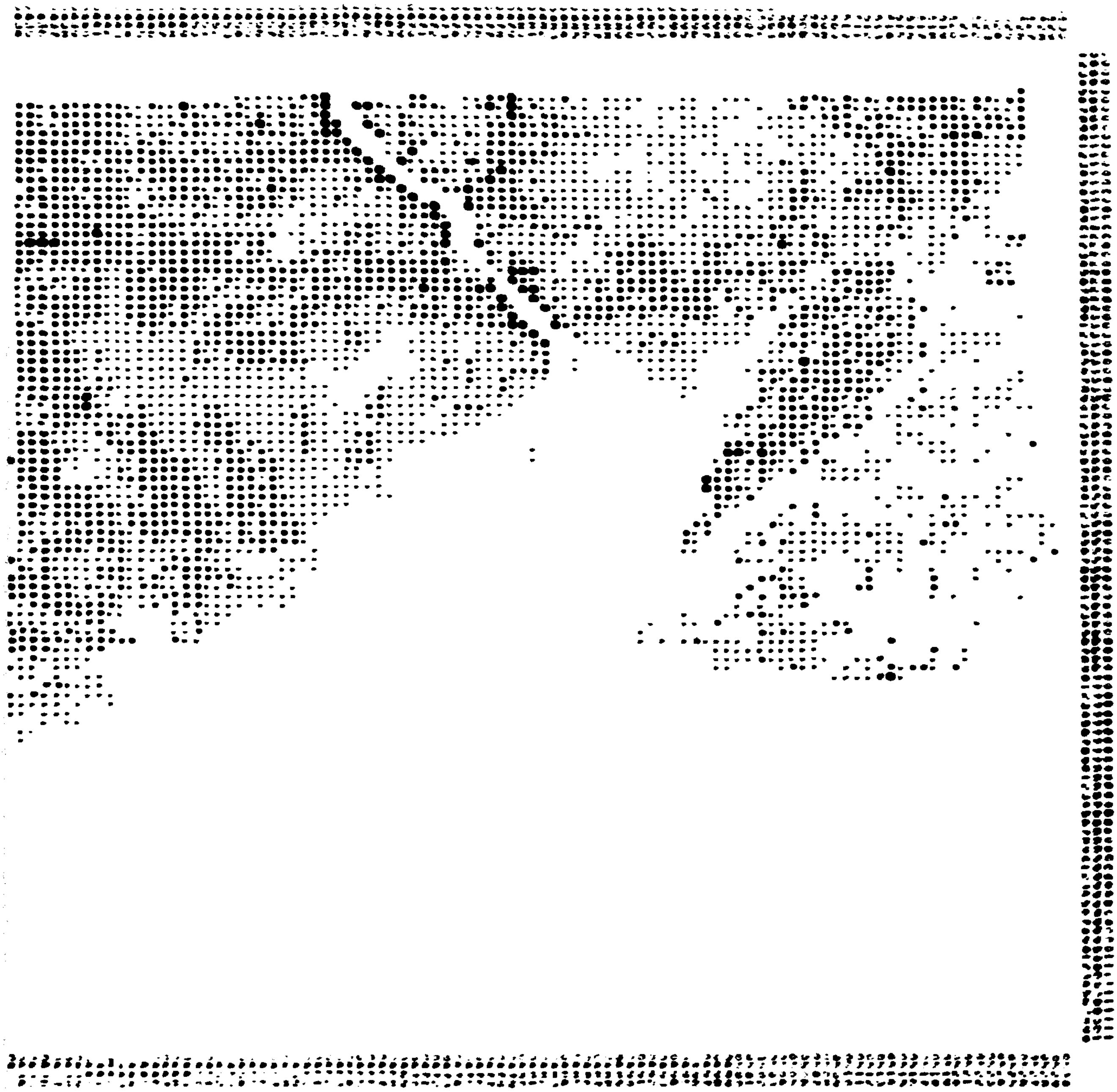

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of 99 is associated with that cell. The program allows up to six values of variables to be specified for a single proximity calculation. In this case any one of the six can initiate the scanning mechanism.

Control of this program proceeds through a single data card. Its format is:

| | |
|---|---|
| Columns 1-2 | Variable for which proximity is being calculated |
| Columns 3-4 | Maximum number of rings to scan around cell |
| Columns 5-8<br>Columns 9-12<br>Columns 13-16<br>Columns 17-20<br>Columns 21-24<br>Columns 24-28 | Values of the variable that will trigger the proximity scanning mechanism. A blank or zero value terminates the list if there are less than six values |
| Columns 29-30 | The variable number assigned for the output of this calculation |

• All values must be right-justified in their fields.

### 4.3 Suitability Program

The suitability program computes the suitability score for a cell by the algorithm described in Section 2.3. This program allows up to six such calculations to proceed simultaneously. The suitability indices so calculated become a part of the data base on the output tape.

The program produces two reports: The first is an orderly presentation of the input data as read by the program. This report is intended to provide an error-checking capability for the input data. The second is a statistical analysis of each suitability index calculated in a given run. The statistics are calculated according to Chou.[4] Each of these analyses consists of a list of statistical moments and summary data describing the distribution of cell scores as well as a histogram illustrating the frequency with which the calculated suitability scores fall into intervals of 0.1 on a range of 0 through 10. The user should be warned that these intervals are arbitrary and that, if there are too few variables in the calculation, the quality of the histogram may be poor.

The card deck for the suitability program is arranged as follows. The first card contains general parameters of the run as follows:

| | |
|---|---|
| Columns 1-2 | The number of suitability calculations to be performed in this run |
| Columns 3-4 | The number of variables to be included in this calculation |
| Columns 5-6 | Th value to be used by the program to indicate exclusion (usually -1) |
| Columns 7-8 | The number of cards following this one which contain general information to identify this run |
| Columns 9-10<br>Columns 11-12<br>Columns 13-14<br>Columns 15-16<br>Columns 17-18<br>Columns 19-20 | Up to six consecutive positions used to indicate the variable number into which the suitability scores should be stored |

• As before, all numbers are right-justified in their fields.

• All of the designated variables are used by the program in each calculation, but a variable can be dropped from a particular calculation by setting the appropriate importance weight equal to zero.

Following the general description card should come the indicated number of identification cards.

• These may be keypunched in free format, anywhere on the card.

• The information punched on them is printed on the hard-copy output for identification purposes.

The next set of cards describes which variables are to be used and how each variable is to be broken down into classes.

• The same variables and classes are used for all calculations in a run.

• A class may be defined as a discrete category of a variable or as a single value or continuous range of values of a variable. Because of the number of such classes into which a variable may be partitioned, up to three cards may be used to describe each variable.

• The format of the variable description card is:

| | |
|---|---|
| Columns 1-2 | The variable identification number to be used |
| Columns 3-4 | The number of classes described by a single value of the variable |
| Columns 5-6 | The number of classes described by a range of values of the variable |
| Columns 7-10<br>Columns 11-14<br>etc.<br>Columns 77-80 | These columns are used to prescribe the values of the variable for each class |

• The values of the categories may be continued onto a second and third card (starting in column 7 on each) as necessary.

• The first three fields may not contain decimal points, but the specification fields may.

• All entries should be right-justified in their respective fields.

• The single-value classes are described first, with each category entry specifying a class.

• The range classes are described, with the lower bound of the range specified first and then the upper bound. A variable will fall into a range class if its value is greater than or equal to the lower bound and less than the upper bound.

• No empty fields should be left between the single and range entries.

• In total there may be 54 entries.

• Because of the limited number of columns allowed by this format, a value of 9999 entered for any class will be modified by the program to the resulting value of 9999999. A warning message is printed to alert the user to this change.

• The order of the variable classes is assigned implicitly by the position of the class definition in the list above. This ordering of classes must be maintained when assigning compatibility weights.

• One variable card or set of cards must be included for each variable in the calculation. No extra cards are allowed. If a user attempts to use more than three cards for a variable, an error message is printed and all processing is terminated.

After the variable description cards are read, the importance weights and compatibility indices are read for each calculation. All cards for a given calculation are kept together, and a complete set consists of the following cards:

• First is the identification card associated with the calculation. This is a single card with all 80 columns used in free format style. The information on this card is used to title the histogram for this calculation.

• Next is a set of cards, one per variable, each of which specifies the variable being described, the importance weight that the variable has in this calculation, and the compatibility indices that the classes of the variable are to receive. (These compatibilities are specified in the same order in which the classes were defined earlier.) Up to three cards may be used as necessary to give these values. The format is as follows:

| | |
|---|---|
| Columns 1-2 | The variable number described by this card(s) |
| Columns 3-4 | The importance weight to be assigned to this variable for this calculation |
| Columns 5-6 | Blank |
| Columns 7-10<br>Columns 11-14<br>Columns 15-19<br>etc.<br>Columns 77-80 | These columns are used to specify the compatibility indices for the classes defined earlier. Up to two additional cards starting in column 7 may be used to complete the list |

• All data items should be right-justified in their respective fields. The single-value compatibility scores are specified first, and each uses one of the compatibility fields.

• The range compatibilities are then specified with two fields each. The leftmost field is ignored. The actual compatibility used is that in the rightmost field. This is done to allow easy visual comparison between the variable-specification and the compatibility-specification cards.

• One card or set of cards should appear for each of the variables used in the calculations.

• Each set of cards for each calculation has the same format. If a variable is defined but is not to be used in a calculation, then its importance may be set to zero. The compatibilities, however, still must be specified. This may be done by leaving the appropriate columns blank, but the extra cards, if required, must also be included.

• Another set of data cards must provide the program with the names of the variables in the data base. Since the content of these cards will not change for a given study, they are isolated to a separate card file on FORTRAN Logical Unit 1. The format is:

| | |
|---|---|
| Columns 1-2 | Variable identification number |
| Columns 3-22 | Name of variable |

• An example of the input data to the suitability program is given in Fig. 4.5, and the auxiliary card file is presented in Table 2.1. A sample output of the suitability program reflecting the input data of Fig. 4.5 is given in Fig. 4.6.

The histograms in Figs. 4.7 and 4.8 were produced from criteria matrices generated by two separate panels of siting specialists.

• The first column of the histogram calibrates the vertical axis of cell scores, and the second column lists the number of cells achieving each score at intervals of 0.1. The length of each bar on the histogram is scaled so that the longest will reach across a complete printed page.

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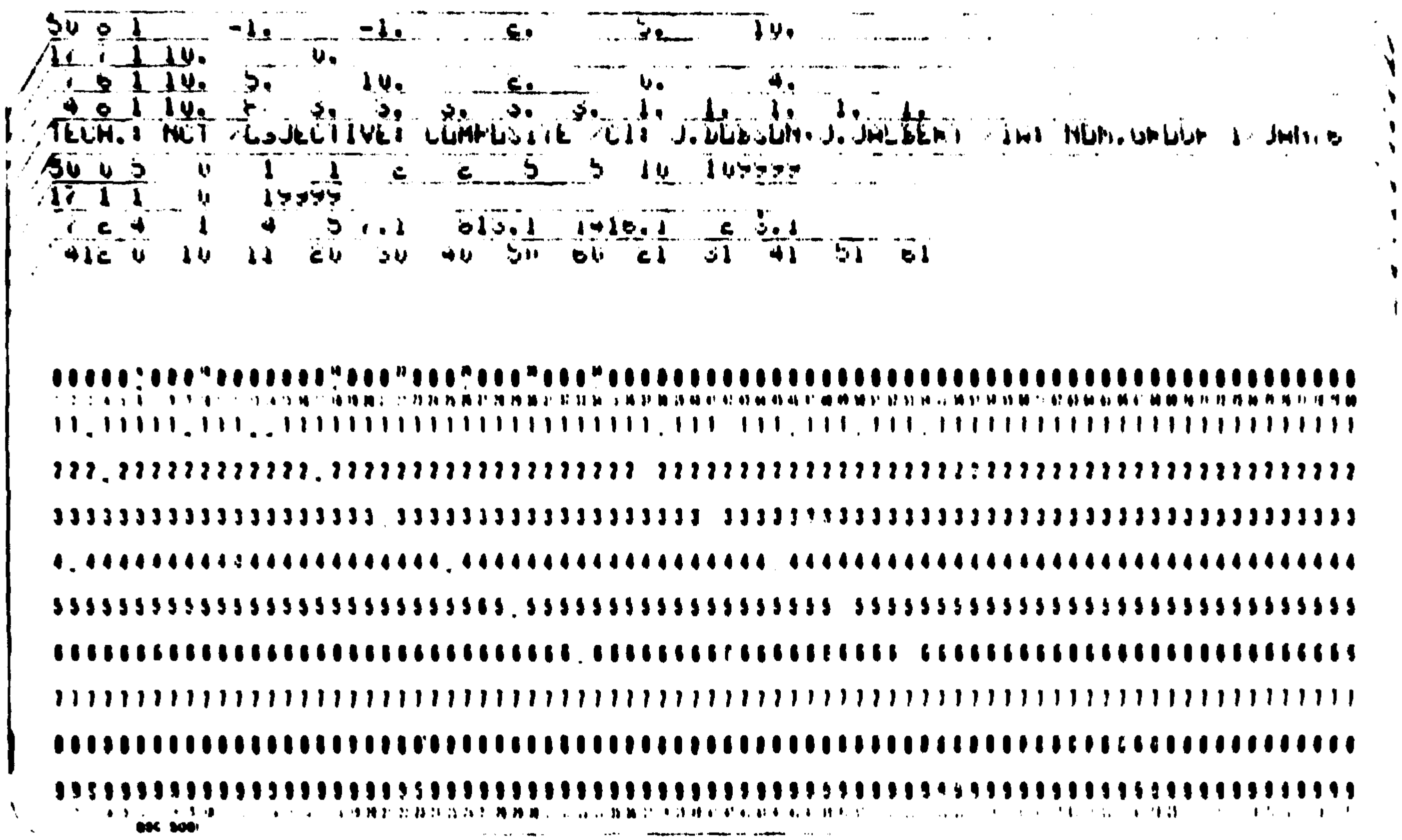

Fig. 4.5. Sample listing of the input data to the suitability program.

Source: The importance weights and compatibility weights are those obtained from the nominal group process discussed by A. H. Voelker in *Power Plant Siting: An Application of the Nominal Group Process Technique*, ORNL/NUREG/TM-81, Oak Ridge National Laboratory, Energy Division, Resource Analysis Group.

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```
                                         COMPATABILITY/IMPORTANCE MATRIX
                                         CALC1   CALC2   CALC3   CALC4   CALC5   CALC6
VAR # 4----SURFACE WATER QUALIT
IMPORTANCE =                               8.0     9.0
COMPATABILITIES FOR VALUES
        10.00                             10.0    10.0
        11.00                              8.0     8.0
        20.00                              3.0     3.0
        30.00                              3.0     3.0
        40.00                              3.0     3.0
        50.00                              3.0     3.0
        60.00                              3.0     3.0
        21.00                              1.0     1.0
        31.00                              1.0     1.0
        41.00                              1.0     1.0
        51.00                              1.0     1.0
        61.00                              1.0     1.0

VAR # 7----TRANSPORTATION AND T
IMPORTANCE =                               8.0     3.0
COMPATABILITIES FOR VALUES
        1.00                              10.0    10.0
        4.00                               5.0     5.0
        5.00  TO        7.10              10.0    10.0
        8.00  TO       13.10               2.0     2.0
       14.00  TO       16.10               0.0     0.0
        2.00  TO        3.10               4.0     4.0

VAR #17----NATURAL FEATURES(PHI
IMPORTANCE =                               7.0     5.0
COMPATABILITIES FOR VALUES
        0.0                               10.0    10.0
        1.00  TO 9999999.00                0.0     0.0

VAR #50----PROXIMITY TO AIRPORT
IMPORTANCE =                               8.0     4.0
COMPATABILITIES FOR VALUES
        0.0   TO        1.00              -1.0    -1.0
        1.00  TO        2.00              -1.0    -1.0
        2.00  TO        5.00               2.0     2.0
        5.00  TO       10.00               5.0     5.0
       10.00  TO 9999999.00               10.0    10.0
```

Fig. 4.6. Verification output of the suitability program. This listing is used to verify program interpretation of the input data.

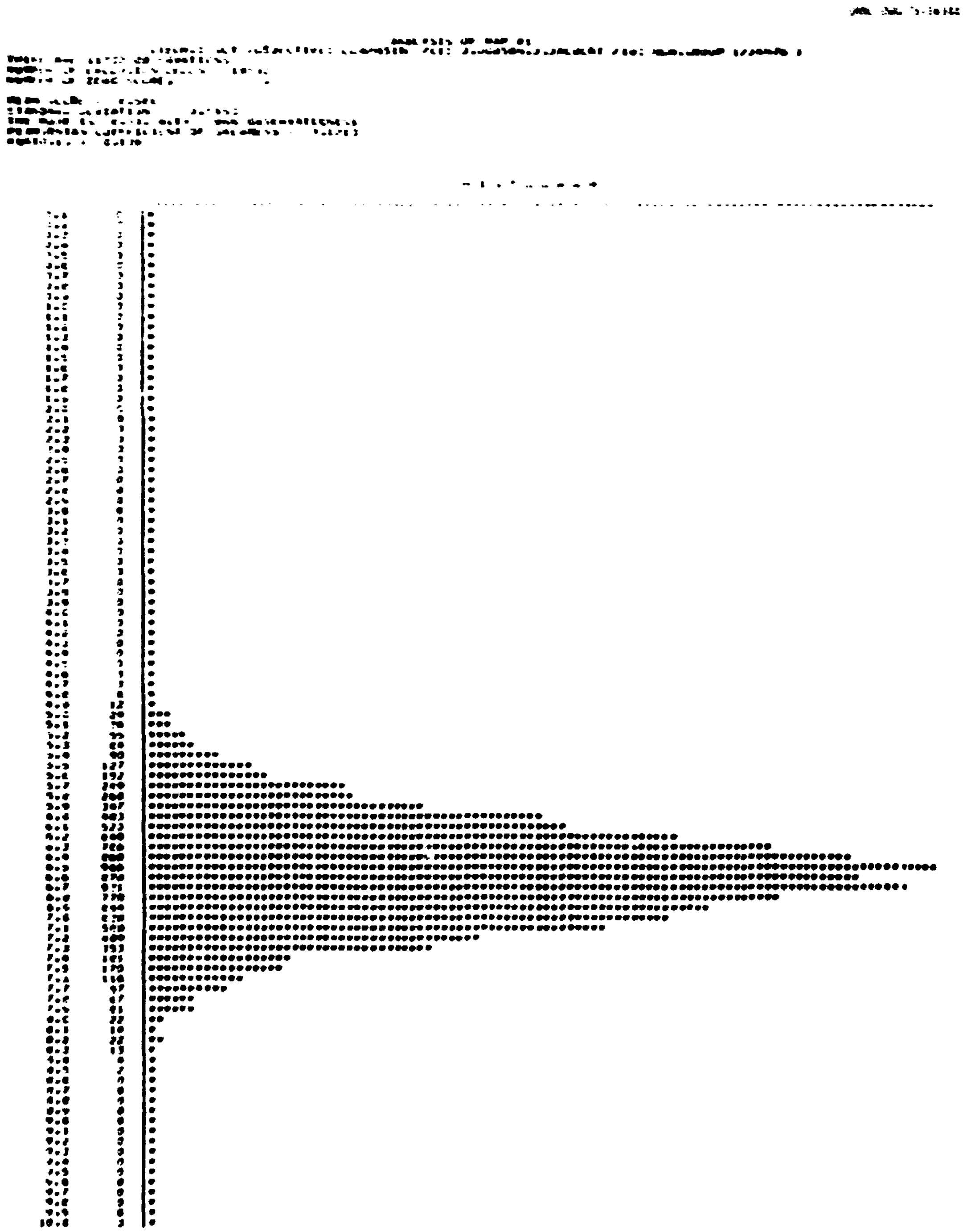

**Fig. 4.7. Histogram for first nominal group.**

Fig. 4.8. Histogram for second nominal group.

• It is possible to compare the forms of distribution between histograms, but absolute frequencies cannot be compared visually. Analysis and interpretation of results should follow a detailed inspection of a map of the resultant suitability scores.

## 5. CONCLUSIONS AND RECOMMENDED APPLICATIONS

These programs have been designed to aid in identifying candidate areas for power plant sites. Operation of these programs within the ORNL Land Use Screening Procedure (LUSP) indicates that they are useful tools for regional and local analyses through cell-based geographic information systems.[2] In the Maryland Power Plant Siting Project the LUSP was used successfully to simulate various siting alternatives expressed in criteria matrices designed by the Maryland Power Plant Siting Program, by ORNL personnel, and by two groups of power plant siting specialists assembled from other organizations.

The LUSP proved to be sensitive to variations in siting priorities and understandings of the data base and screening procedure among the four groups. Hence, it is recommended that, for best results, the procedure should be run with multiple sets of criteria obtained from numerous source groups (respondents). It was further concluded that the spatial distribution of candidate areas can be made to reflect differences in siting objectives. By employing criteria for specific objectives, such as minimization of adverse ecologic or socioeconomic impact, and for a composite of all siting objectives the user can identify potential conflicts even within candidate areas which score highly on the composite matrix. Resource planners, utility siting specialists, and regulatory officials can utilize this capability to anticipate adverse impacts before large sums of money have been invested in analyses of specific sites. The early application of the screening procedure can help incorporate the views of diverse groups while it is still possible to accommodate their views.

The LUSP also could aid in modeling future scenarios of energy supply by serving as a means to determine the availability of sufficient sites. It may be possible, for example, to project approximately how much additional electrical generating capacity can be sited before it is necessary to resort to locations unacceptable in regard to ecologic impact or economic feasibility.

# REFERENCES

1. Oak Ridge National Laboratory, *Energy Div. Annu. Prog. Rep. Dec. 31, 1975*, p. 116, ORNL-5124, Oak Ridge, Tennessee, 1975.

2. J. E. Dobson, *The Maryland Power Plant Siting Project: An Application of the ORNL Land Use Screening Procedure*, ORNL/NUREG/TM-79, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1977.

3. B. F. Hobbs and A. H. Voelker, *Analytical Power Plant Siting Methodologies: A Theoretical Discussion and Survey of Current Practices*, ORNL/TM-5749, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1977.

4. Y. L. Chou, *Statistical Analysis*, pp. 46–74, Holt, Rinehart, and Winston, Inc., 1975.

# Appendix A

# PROGRAM LISTINGS

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# THEMATIC MAPPING PROGRAM

```
C
C     MAIN, THE PROGRAM TO PRODUCE MAPS
C
      DIMENSION [illegible]
      REAL [illegible]
      INTEGER [illegible]
      INTEGER [illegible]
      COMMON [illegible]
      DATA [illegible]
C
C     READ IN THE INPUT DATA
C
      CALL DATA[illegible]
     *     [illegible]
      L[illegible]
C
C     SET UP COLUMN HEADS ON THE OUTPUT MAPS
C
      DO 5 I=1,NMAPS
    5 CALL COLUMN(I)
C
C     ZERO LINES ARRAY BEFORE FIRST TIME
C
      DO 7 I=1,NMAPS
      DO 7 J=1,113
    7 LINES(I,J)=0
C
C     THIS IS THE MAJOR LOOP TO READ IN THE INPUT DATA
C
   10 READ(25,[illegible])VARS
      IF(VARS(2).[illegible]) GO TO [illegible]
C
C     THIS AREA IS REACHED TO PRINT THE CURRENTLY GENERATED MAP.
C     FIRST CONVERT THE LINE NO TO A STRING.
C
   30 CALL CONVERT(LINENO,STRING)
      LINENO=LINENO+1
C
C     PROTECT AGAINST LINE LOOP
C
      IF(LINENO.[illegible]) GO TO 34
      WRITE(6,35)VARS(2)
   35 FORMAT(1X,'INVALID COLUMN NUMBER',[illegible]))
      GO TO [illegible]
   34 CONTINUE
      DO 50 I=1,NMAPS
      CALL LINESHE(LINES,STRING,I)
C
C     ZAP THE LINE JUST PRINTED
C
      DO 40 J=1,113
   40 LINES(I,J)=0
   50 CONTINUE
C
C     NOW GO CHECK AGAIN TO MAKE SURE THERE ARE NO LINES MISSED
C
      IF(VARS(2).NE.LINENO) GO TO 30
C
C     RESUME HERE TO ADD THIS CELL'S DATA TO THE LINES
C
   60 INDEX=VARS(1)
      DO 70 I=1,NMAPS
      J=NUMVAR(I)
      N=LSHADE(VARS(J),I)
      LINES(I,INDEX)=N
      IF(N.EQ.0)N=11
      NAM(I,N)=NAM(I,N)+1
   70 CONTINUE
C
C     RETURN AND GET ANOTHER CELL
C
      GO TO 10
C
C     GET HERE AT THE END OF THE DATA ON THE INPUT FILE
C     PUT OUT THE LAST LINE,HEADINGS AND LEGENDS
C
  100 CALL CONVERT(LINENO,STRING)
      DO 110 I=1,NMAPS
      CALL LINESHE(LINES,STRING,I)
```

```
  110 CALL COLUMN(I)
C     NOW COMPUTE THE FREQUENCIES
      DO 140 I=1,NUMAPS
      SUM=0.0
      DO 120 J=1,30
  120 SUM=SUM+RAW(I,J)
      IF(SUM.EQ.0.0)SUM=1.0
      DO 130 J=1,30
  130 FREQ(J)=(FLOAT(RAW(I,J))/SUM)*100.
  140 CALL LEGND(I,RESERC,TITLE,LEGEND,FREQ,RAW)
      STOP
      END


C
C
C     THIS ROUTINE BUILDS A STRING VARIABLE TO REPRESENT AN INTEGER
C
      SUBROUTINE CONVER(I,ISTRIN)
      DIMENSION ISTRIN(4)
      INTEGER DIGIT(10)
      DATA DIGIT/'0','1','2','3','4','5','6','7','8','9'/
      J=1000
      K=I
      DO 100 L=1,4
      M=K/J+1
C
C     THIS SELECTS THE DIGIT REQUIRED
C
      ISTRIN(L)=DIGIT(M)
C
C     NOW PEEL OFF THE LEADING DIGIT
C
      K=K-(M-1)*J
C
C     AND LOWER THE DIVISOR BY AN ORDER OF MAGNITUDE
C
      J=J/10
  100 CONTINUE
      RETURN
      END


C
C     THIS ROUTINE WILL PRINT THREE ROWS OF NUMBERS TO INDICATE
C    COLUMN HEADINGS (REALLY ROWS ON THE SF MAPS)
C
      SUBROUTINE COLUMN(IOUT)
      DIMENSION LINE1(110),LINE2(110),LINE3(10)
      DATA LINE1/100*' ',10*'1'/
      DATA LINE2/ 9*' ',10*'1',10*'2',10*'3',10*'4',10*'5',10*'6',
     * 10*'7',10*'8',10*'9',10*'0','1'/
      DATA LINE3/'1','2','3','4','5','6','7','8','9','0'/
      IOU= IOUT+10
      WRITE(IOU ,20)
      WRITE(IOU ,10)LINE1
      WRITE(IOU ,10)LINE2
      WRITE(IOU ,10)(LINE3,I=1,11)
   10 FORMAT(6X,110A1)
      WRITE(IOU ,20)
   20 FORMAT(' ')
      RETURN
      END


C
C     THIS ROUTINE COMPUTES THE SHADE VALUE TO BE USED FOR MAPPING
C     IT LOOKS AT THE VARIABLE AND COMPARES FOR SELECTED RANGES
C
      FUNCTION LSHADE(INPUT,MAPNO)
      DIMENSION NSHADE(10)
      INTEGER SHADES(10,50)
      REAL LOWER(10,50),UPPER(10,50),INPUT
```

```
      COMMON LOWER,UPPER,SHADES,NSHADE
C
C     GET MAXNO OF SHADES FOR THIS MAP
C
      MAXSHA=NSHADE(MAPNO)
C
C     NOW SEARCH THE LIST
C
      DO 40 I=1,MAXSHA
      IF(LOWER(MAPNO,I)-INPUT)10,20,40
   10 IF(UPPER(MAPNO,I).LE.INPUT)GO TO 40
   20 LSHADE=SHADES(MAPNO,I)
      RETURN
   40 CONTINUE
C
C     FALL THRU MEANS THAT THE RESULT IS UNDEFINED AND WE RETURN A ZERO
C
      LSHADE=0
      RETURN
      END


C
C     ROUTINE TO READ IN THE DATA CARDS
C
      SUBROUTINE DATAIN(NOMAPS,RESERC,TITLE,LEGEND,NOFVAR,LOWER,UPPER,
     *                  SHADES,NSHADE)
      DIMENSION RESERC(10,10),TITLE(10,18),LEGEND(10,30,14),NOFVAR(10)
      REAL LOWER(10,50),UPPER(10,50)
      INTEGER SHADES(10,50),NSHADE(10)
      INTEGER SHADE(4,30),BLANK
      DATA BLANK/' '/
      COMMON /SHADEX/SHADE
C
C     READ THE INSTITUTIONAL TITLE
C
      READ(50,10)NLINES
   10 FORMAT(I2)
      WRITE(6,15)NLINES
   15 FORMAT(T30,' LISTINGS OF INPUT DATA',////,' NO OF INSTITUTION CARDS
     * = ',I3,/)
      DO 20 I=1,NLINES
      READ(50,30)(RESERC(I,J),J=1,10)
   20 WRITE(6,35)(RESERC(I,J),J=1,10)
   30 FORMAT(10A4)
   35 FORMAT(1X,10A4)
C
C     INPUT THE MAP DESCRIPTIONS
C
      READ(50,10)NOMAPS
      WRITE(6,37)NOMAPS
   37 FORMAT(//' THERE ARE ',I2,' MAP(S) REQUESTED',/////)
      DO 70 I=1,NOMAPS
      READ(50,40)NOFVAR(I),NSHADE(I),(TITLE(I,J),J=1,18)
      WRITE(6,45)I,NOFVAR(I),NSHADE(I),(TITLE(I,J),J=1,18)
   40 FORMAT(2I4,18A4)
   45 FORMAT(////,T30,' MAP # = ',I2,/,1X,2(I4,1X),18A4,///)
      J=NSHADE(I)
      DO 60 K=1,J
      READ(50,50)L,LOWER(I,K),UPPER(I,K),(LEGEND(I,L,M),M=1,14)
C     IF USER TRYING TO GO HIGH THEN GO ALL THE WAY
      IF(UPPER(I,K).EQ.99999.)UPPER(I,K)=9999999.
      WRITE(6,55)L,LOWER(I,K),UPPER(I,K),(LEGEND(I,L,M),M=1,14)
C
C     NOTE THAT L=SHADE-NO HERE AND IT MUST BE USED AS AN INDEX TOO
C
   50 FORMAT(I4,2F5.0,14A4)
   55 FORMAT(1X,I4,2(F11.3,1X),14A4)
   60 SHADES(I,K)=L
   70 CONTINUE
C
C     READ IN THE SHADE MATRIX
C
      DO 80 I=1,4
      DO 80 J=1,30
   80 SHADE(I,J)=BLANK
   90 READ(5,100,END=110)I,(SHADE(J,I),J=1,4)
  100 FORMAT(I2,1X,4A1)
      GO TO 90
  110 RETURN
      END
```

```
C
C
C     THIS ROUTINE PRINTS THE LEGENDS ON THE MAPS  MAPNO=OUTPUT UNIT
C     NOTE  ALL LITERAL DATA FOR THIS ROUTINE IS STORED A4
C
      SUBROUTINE LEGND(MAPNO,RESERC,TITLE,LEGEND,FREQ,RAW)
      DIMENSION RESERC(19,10),TITLE(10,18),LEGEND(10,30,14)
      DIMENSION FREQ(30)
      INTEGER RAW(10,31),SHADE(4,30),STRING(4,5)
      COMMON /SHADEX/SHADE
      MAPN=MAPNO+10
C
C     SPACE A LINE
C
      WRITE(MAPN,5)
    5 FORMAT(' ')
C
C     PRINT THE TITLE OF THIS MAP AND THE INSTALLATION ID
C
      WRITE(MAPN,10)(TITLE(MAPNO,I),I=1,18),(RESERC(1,I),I=1,10)
   10 FORMAT(/,1X,18A4,5X,10A4)
      DO 50 I=2,10
C
C     COMPARE FOR UNINITIATED DATA = BLANK LINE
C
      DO 20 J=1,10
      IF(RESERC(I,J).NE.BLANK)GO TO 30
   20 CONTINUE
C
C     LAST LINE WAS BLANK SO DON'T PRINT IT
C
      GO TO 50
   30 WRITE(MAPN,40)(RESERC(I,J),J=1,10)
   40 FORMAT(78X,10A4)
   50 CONTINUE
C
C     NOW PRINT THE LEGEND
C
      WRITE(MAPN,5)
      WRITE(MAPN,53)
   53 FORMAT(20X,'L E G E N D',//)
      WRITE(MAPN,5)
      WRITE(MAPN,55)
   55 FORMAT(' SHADE',4X,'FREQUENCY',5X,'PERCENT',10X,'DEFINITION')
      WRITE(MAPN,5)
      DO 120 I=1,30
C
C     CHECK FOR ALL BLANK LEGEND
C
      DO 60 J=1,14
      IF(LEGEND(MAPNO,I,J).NE.IBLANK)GO TO 70
   60 CONTINUE
C
C     FALL THRU MEANS LEGEND BLANK AND WE IGNORE IT
C
      GO TO 120
C
C     BUILD 5 CHARACTER STRINGS FOR PRINTING THE SHADE BLOCK
C
   70 DO 75 K=1,4
      DO 75 L=1,5
   75 STRING(K,L)=SHADE(K,I)
C
C     WRITE 3 LINES OF SHADE
C
      DO 79 K=1,3
      WRITE(MAPN,76)(STRING(1,L),L=1,5)
   76 FORMAT(1X,5A1)
      DO 79 M=2,4
   79 WRITE(MAPN,110)(STRING(M,L),L=1,5)
      WRITE(MAPN,80)RAW(MAPNO,I),FREQ(I),(LEGEND(MAPNO,I,J),J=1,14)
   80 FORMAT('+',10X,I8,2X,F10.1,3X,14A4)
C
C     PUT OUT 2 LINES OF SHADE
C
      DO 100 K=1,2
      WRITE(MAPN,76)(STRING(1,L),L=1,5)
      DO 100 M=2,4
  100 WRITE(MAPN,110)(STRING(M,L),L=1,5)
```

```
  110 FORMAT(' +',5A1)
      WRITE(MAPN,5)
  120 CONTINUE
      WRITE(MAPN,130)RAW(MAPN),3I)
  130 FORMAT(5(/),1X,I5,' CELL(S) UNDEFINED BY INPUT DATA')
      RETURN
      END


C
C     THIS ROUTINE PRINTS A LINE OF MAP DATA ON UNIT IOUT
C     UP TO 4 PASSES ARE MADE ON A SINGLE LINE.  THE FIRST
C     PASS PRINTS THE LINE ID NO AS WELL AS THE FIRST CHARACTER.
C     THE OTHER 3 PASSES PRINT ANY OVERSTRIKES NECESSARY.   A
C     CHECK IS MADE TO SEE IF A LINE REALLY NEED BE PRINTED
C
      SUBROUTINE LINES(LINE,ISTRIN,IOUT)
      DIMENSION LINE(10,110),ISTRIN(4),LINEO(110)
      INTEGER SHADE(4,30),BLANK
      COMMON /SHADEX/SHADE
      IOU= IOUT+10
C
C     PREPROCESS THE INPUT LINE TO MAKE SURE IT IS IN THE RANGE
C
      DO 5 I=1,110
      IF(LINE(IOUT,I).LE.0.OR.LINE(IOUT,I).GT.30)LINE(IOUT,I)=1
    5 CONTINUE
      DO 10 I=1,110
      J=LINE(IOUT,I)
      LINEO(I)=SHADE(1,J)
   10 CONTINUE
C
C     PRINT THE FIRST LINE INCLUDING THE LINE NUMBER HEADER
C
      WRITE(IOU,20)ISTRIN,LINEO,ISTRIN
   20 FORMAT(1X,4A1,1X,110A1,1X,4A1)
C
C     NOW BUILD AND PRINT SUCCESSIVE PARTS TO THE LINE FOR OVERSTRIKES
C
      DO 70 K=2,4
      DO 30 I=1,110
      J=LINE(IOUT,I)
   30 LINEO(I)=SHADE(K,J)
C
C     NOW CHECK FOR BLANKS
C
      DO 40 I=1,110
      IF(LINEO(I).NE.BLANK)GO TO 50
   40 CONTINUE
C     FALL THROUGH MEANS THAT THIS LINE IS COMPLETELY BLANK AND
C     THE JOB IS DONE
      RETURN
   50 WRITE(IOU,60)LINEO
   60 FORMAT(' +',5X,110A1)
   70 CONTINUE
C
C     NOW ALL 4 LINES HAVE BEEN PRINTED
C
      RETURN
      END
```

## PROXIMITY PROGRAM

```
      REAL ITEM(42),ICAT(6),VARS(96)
      DIMENSION TITLE(10),
     * PROXM(15), SUITBL(12)
      INTEGER*2 PROXIM(110,537)
      EQUIVALENCE (VARS(1),ITEM(1)),
     *            (VARS(43),PROXM(1)),
     *            (VARS(58),SUITBL(1))
      DATA PROXIM/58300*9900/
      DATA LROW,MROW,LCOL,MCOL,NITMS,NPROX,NSCRS/1,110,1,530,42,15,6/
      ICONT=0
      READ(5,100) IVAR,NRGS,(ICAT(I),I=1,6),IPROX
  100 FORMAT(2I2,6F4.0,I2,4I3,3I2)
      IF(NRGS.LT.200 )GO TO 4
      WRITE(6,1)NRGS
    1 FORMAT(' REQUESTED PROXIMITY TOO LARGE ',I8)
      STOP
    4 ICONT=ICONT+1
    3 READ(24,END=30)VARS
  105 FORMAT(2I3,6I2,2I5,3I2,5I3,2I1,I4,I2,3I6,3I4,3I6,10I3,
     * I6,21F5.2)
      IR = ITEM(1)
      IC = ITEM(2)
      IF (((IR.LT.LROW.OR.IR.GT.MROW).OR.(IC.LT.LCOL.OR.IC.GT.MCOL))
     * GO TO 3
      IF (IR.EQ.0.OR.IC.EQ.0) GO TO 3
      K=IVAR
      IF (ICAT(1).EQ.9999.) GO TO 61
      DO 60 IK=1,6
      IF (ICAT(IK).EQ.0.) GO TO 3
      IF (ICAT(IK).EQ.ITEM(K)) GO TO 70
   60 CONTINUE
      GO TO 3
   61 IF(ITEM(K).EQ.0)GO TO 3
C
C     A CELL WITH DESIRED CHARACTERISTICS HAS BEEN FOUND
C     NOW CALCULATE AROUND IT THE DESIRED CIRCULAR RANGE
C
   70 IBGRW=IR-NRGS
      IBGCL=IC-NRGS
      IENRW=IBGRW+(NRGS*2)
      IENCL=IBGCL+(NRGS*2)
C
C     MAKE SURE REGION SCANNED IS WITHIN SPECIFIED BOUNDARY
C
      IF(IBGRW.LT.LROW)IBGRW=LROW
      IF(IBGCL.LT.LCOL)IBGCL=LCOL
      IF(IENRW.GT.MROW)IENRW=MROW
      IF(IENCL.GT.MCOL)IENCL=MCOL
      DO 8 IRW=IBGRW,IENRW
      DO 8 ICL=IBGCL,IENCL
      DIST=SQRT(FLOAT((IR-IRW)**2+(IC-ICL)**2))*100.
      IF (DIST.LT.PROXIM(IRW,ICL)) PROXIM(IRW,ICL)=DIST
    8 CONTINUE
C
C     THE REGION HAS NOW BEEN SCANNED GO GET THE NEXT CELL
C
      GO TO 3
   30 REWIND 24
   50 READ(24,END=25)VARS
      IR = ITEM(1)
      IC = ITEM(2)
      IF (IR.EQ.0.OR.IC.EQ.0) GO TO 50
      IF (((IR.LT.LROW.OR.IR.GT.MROW).OR.(IC.LT.LCOL.OR.IC.GT.MCOL))
     * GO TO 40
C
C     GET 4 BYTE INTEGER AND THEN RESCALE AND PUT INTO RECORD
C
      IXXX=PROXIM(IR,IC)
      PROXM(IPROX)=FLOAT(IXXX)*0.01
   40 WRITE(25)VARS
      GO TO 50
   25 CONTINUE
      WRITE(6,20) IVAR,LROW,MROW,LCOL,MCOL
   20 FORMAT('HAVE CALCULATED THE PROXIMITY OF EACH CELL TO VARIABLE',/
     * I4,' FOR THE REGION INCLUDING ROWS',I4,' THRU',I4,/
     * ' AND COLUMNS',I4,' THRU',I4)
      STOP
      END
```

# SUITABILITY PROGRAM

```
C
C     PROGRAM TO PERFORM THE SUITABILITY CALCULATIONS
C     FOR THE TIES AND SITING ALGORITHM
C
      DIMENSION VARS(99),CATGRY(99,54),COMPAT(99,54,6)
      INTEGER OUTVAR(6),RANGE(99),SINGLE(99),CLCVAR(99)
      INTEGER TABLE(6,102)
      REAL IMPORT(6,99),TOTSUT(6)
      LOGICAL*1 NAME(6,80)
      DATA TABLE/612*0/
      COMMON VARS,CATGRY,RANGE,SINGLE,COMPAT
C
C     READ THE INPUT DATA AND ECHO IT TO THE LINE PRINTER
C
      CALL INDATA(CATGRY,COMPAT,OUTVAR,RANGE,SINGLE,IMPORT,6,99,54,
     1NOSUIT,NOVARS,TOTSUT,EXCLUD,CLCVAR,NAME)
C
C     NOW READ INPUT TAPE. FOR EACH RECORD COMPUTE THE REQUISITE NUMBER
C     OF SUITABILITIES
C
   10 READ(24,END=70 )VARS
C     LOOP ON NO OF SUITS
      DO  60 I=1,NOSUIT
C     FOR EACH SUIT LOOP ON VARS IN CALCULATION
        SUITBL=0.0
        DO  20 J=1,NOVARS
         K=CLCVAR(J)
      COMPAB=FIND(K,I)*IMPORT(I,K)
          IF(COMPAB.LE.EXCLUD)GO TO 40
         SUITBL=SUITBL+COMPAB
   20   CONTINUE
        SUITBL=SUITBL/TOTSUT(I)
        GO TO 50
C     GET HERE IF THIS CELL IS EXCLUDED
   40   SUITBL=EXCLUD
   50   K=OUTVAR(I)
        VARS(K)=SUITBL
C
C       NOW COMPUTE TABLE ENTRIES FOR HISTOGRAM
C
        L=SUITBL*10.+2.
        IF(L.LE.0)L=1
        IF(L.GT.102)L=102
   60 TABLE(I,L)=TABLE(I,L)+1
      WRITE(25)VARS
      GO TO 10
C
C     GET HERE AT END OF INPUT DATA
C
   70 CALL ANALYS(TABLE,NOSUIT,NAME)
      STOP
      END
```

```
C
C     THIS ROUTINE SEARCHES THE INPUT TABLES TO FIND THE SUITABILITY
C     VALUE FOR A GIVEN VARIABLE VALUE
C
      FUNCTION FIND(IVAR,I)
      REAL VARS(99),CATGRY(99,54),COMPAT(99,54,6)
      INTEGER RANGE(99),SINGLE(99),SINGLS,RANGS
      COMMON VARS,CATGRY,RANGE,SINGLE,COMPAT
C
C     EXTRACT THE VARIABLE VALUE
C
      VARSB=VARS(IVAR)
C
C     GET NO OF SINGLE AND RANGES FOR THIS ONE
C
      SINGLS=SINGLE(IVAR)
      RANGS=RANGE(IVAR)
C
C     SEARCH SPECIFIED RANGES FOR A MATCH. IF FOUND THEN PICK
C     OUT THE COMPATABILITY FROM THE TABLE
C
       IF(SINGLS.EQ.0)GO TO 30
      DO 10 M=1,SINGLS
```

```
      IF(VARSSB.NE.CATGRY(IVAR,M))GO TO 10
C     GET HERE IF WE MADE A MATCH ON A SINGLE
      FIND=COMPAT(IVAR,M,I)
      RETURN
   10 CONTINUE
C     FALL THROUGH MEANS IS NOT FOUND GO TO RANGE CHECK
   30 IF(RANGE.EQ.0)GO TO 60
      LOW=SINGLE+2
      IHI=LOW+2*RANGE-2
      DO 40 M=LOW,IHI,2
      IF(VARSSB.LT.CATGRY(IVAR,M-1))GO TO 40
      IF(VARSSB.GE.CATGRY(IVAR,M))GO TO 40
      FIND=COMPAT(IVAR,M,I)
      RETURN
   40 CONTINUE
C
C     FALL THROUGH MEANS THAT THE VALUE OF THIS VARIABLE WAS NOT FOUND
C     IN THE INPUT LIST.  THE COMPATABILITY IS SET TO 5.0, AN UNBIASED
C     VALUE ON THE SCALE 0 TO 10
C
   60 FIND=5.
      RETURN
      END
```

```
C
C
C     ROUTINE TO READ IN THE DATA CARDS
C
      SUBROUTINE INDATA(CATGRY,COMPAT,OUTVAR,RANGE,SINGLE,IMPORT,I6,I53,
     1I54,NOSUIT,NOVARS,TOTSUT,EXCLUD,CLCVAR,NAME)
      DIMENSION CATGRY(163,154),COMPAT(163,154,16)
      INTEGER OUTVAR(16),RANGE(163),SINGLE(163),CLCVAR(153),CARD(20)
      REAL IMPORT(16,163),TOTSUT(16)
      LOGICAL*1 NAMES(99,20),USED(99),NAME(6,80)
      LOGICAL*1 CHANGE
      DATA USED/99*.FALSE./
C
C     READ IN GENERAL SPECS
C
      READ(5,10)NOSUIT,NOVARS,EXCLUD,IN,OUTVAR
   10 FORMAT(I2,I2,F2.0,I2,6I2)
      WRITE(6,20)
   20 FORMAT(T40,'S U I T A B I L I T Y   C A L C U L A T I O N S',///)
      DO 50 I=1,IN
      READ(5,30)CARD
   30 FORMAT(20A4)
      WRITE(6,40)CARD
   40 FORMAT(T40,20A4)
   50 CONTINUE
      WRITE(6,60)NOSUIT,NOVARS,EXCLUD
   60 FORMAT(' NUMBER OF CALCULATIONS = ',I2,/,
     1       ' NUMBER OF VARIABLES    = ',I2,/,
     2       ' VALUE FOR EXCLUSION    = ',F3.0)
      WRITE(6,70)(OUTVAR(I),I=1,NOSUIT)
   70 FORMAT(' OUTPUT VARIABLES ARE   = ',6(I2,1X))
C
C     NOW READ THE INPUT VARIABLES,THEIR RANGES AND THEIR CATEGORYS
C
      DO 100 I=1,NOVARS
      READ(5,80)IVAR,SINGLE(IVAR),RANGE(IVAR),(CATGRY(IVAR,J),J=1,18)
   80 FORMAT(3I2,18F4.0)
      NUMBR=SINGLE(IVAR)+2*RANGE(IVAR)
      IF(NUMBR.GT.18)READ(5,90)(CATGRY(IVAR,J),J=19,36)
      IF(NUMBR.GT.36)READ(5,90)(CATGRY(IVAR,J),J=37,54)
      IF(NUMBR.GT.54)GO TO 1000
   90 FORMAT(6X,18F4.0)
      ILCVAR(I)=IVAR
      USED(IVAR)=.TRUE.
  100 CONTINUE
C
C     READ IN VARIABLE NAMES FOR USE ON OUTPUT
C
      DO 120 I=1,63
      READ(1,110,END=130)J,(NAMES(J,L),L=1,20)
  110 FORMAT(I2,20A1)
  120 CONTINUE
```

```
  130 WRITE(6,140)
  140 FORMAT(5(/))
C
C     CHANGE THE CATEGORY SPECIFICATIONS IF THE INPUT CATEGORY =9999
C     WHICH INDICATES THAT THE HIGHEST POSSIBLE VALUES ARE TO BE USED
C
      CHANGE=.FALSE.
      DO 160 I=1,154
      DO 160 J=1,163
      IF(CATGRY(J,I).NE.9999.)GO TO 160
      CATGRY(J,I)=9999999.
      CHANGE=.TRUE.
  160 CONTINUE
      IF(CHANGE)WRITE(6,170)
  170 FORMAT(//' *********WARNING*********',/,' CATEGORY LIMITS RAISED ON
     * AT LEAST ONE VARIABLE',////)
C
C     NOW READ IN AND THE DATA FOR EACH COMPATABILITY AND IMPORTANCE
C     FOR THE REQUISITE NUMBER OF CALCULATIONS
C
      DO 290 I=1,NOSUIT
      READ(5,240)(NAME(I,J),J=1,80)
  240 FORMAT(80A1)
      WRITE(6,250) I,(NAME(I,J),J=1,80)
  250 FORMAT(' SUITABILITY # ',I2,' IS ',80A1)
      DO 280 J=1,NOVARS
      READ(5,260)INVAR,IMPORT(I,INVAR),(COMPAT(INVAR,L,I),L=1,18)
  260 FORMAT(I2,F2.0,2X,18F4.0)
      NUMBR=SINGLE(INVAR)+2*RANGE(INVAR)
      IF(NUMBR.GT.18)READ(5,270)(COMPAT(INVAR,L,I),L=19,36)
  270 FORMAT(6X,18F4.0)
      IF(NUMBR.GT.36)READ(5,270)(COMPAT(INVAR,L,I),L=37,54)
  280 CONTINUE
  290 CONTINUE
      WRITE(6,140)
C
C     WRITE OUT THE ENTIRE COMPATABILITY/IMPORTANCE MATRIX
C
      WRITE(6,300)
  300 FORMAT(T40,'COMPATABILITY/IMPORTANCE MATRIX',/,
     *       T40,'CALC1  CALC2  CALC3  CALC4  CALC5  CALC6')
      DO 350 I=1,163
      IF(.NOT.USED(I))GO TO 350
      WRITE(6,310)I,(NAMES(I,L),L=1,20),(IMPORT(L,I),L=1,NOSUIT)
  310 FORMAT(' VAR #',I2,'----',20A1,/,
     *       ' IMPORTANCE = ',T40,6(F4.1,3X))
C
C     NOW SPIT OUT THE RANGES AND ASSOCIATED COMPATABILITIES
C
      WRITE(6,315)
  315 FORMAT(' COMPATABILITIES FOR VALUES')
      ISINGS=SINGLE(I)
      IRANGS=RANGE(I)
      IF(ISINGS.EQ.0)GO TO 330
      DO 325 J=1,ISINGS
      WRITE(6,320)CATGRY(I,J),(COMPAT(I,J,M),M=1,NOSUIT)
  320 FORMAT(5X,F8.2,T40,6(F4.1,3X))
  325 CONTINUE
  330 IF(IRANGS.EQ.0)GO TO 345
      DO 340 J=1,IRANGS
      K=ISINGS+2*J
      WRITE(6,335)CATGRY(I,K-1),CATGRY(I,K),(COMPAT(I,K,M),M=1,NOSUIT)
  335 FORMAT(5X,F8.2,' TO ',F10.2,T40,6(F4.1,3X))
  340 CONTINUE
  345 WRITE(6,355)
  350 CONTINUE
  355 FORMAT(//,100('-'),//)
C
C     FIND THE TOTAL SCORES FOR NORMALIZING THE RESULTS
C
      DO 370 I=1,NOSUIT
      SUM=0.0
      DO 360 J=1,NOVARS
  360 SUM=SUM+IMPORT(I,CLCVAR(J))
  370 TOTSUT(I)=SUM
      WRITE(6,380)(TOTSUT(I),I=1,NOSUIT)
  380 FORMAT(' TOTAL OF ALL IMPORTANCES :',T40,6(F5.0,1X))
      DO 400 I=1,NOSUIT
      IF(TOTSUT(I).GT.0.0)GO TO 400
```

```
      TOTSUT(I)=1.0
      WRITE(6,390)I
  390 FORMAT(/,' *****WARNING ***** SUITABILITY',I2,' IS ZERO ')
  400 CONTINUE
      RETURN
 1030 WRITE(6,1010)IVAR
 1010 FORMAT(' TOO MANY CATEGORIES REQUESTED FOR VARIABLE # ',I2)
      WRITE(6,1020)NUMBR
 1020 FORMAT(' MAXIMUM REQUESTED MAY HE 54 ',I4,'WERE SPECIFIED')
      STOP
      END



C
C     ROUTINE TO GENERATE STATISTICS ON SUITABILITY SCORES.  THEY ARE
C     ALREADY CLASSIFIED IN UNITS OF .01 FROM 0 TO 10.
C
      SUBROUTINE ANALYS(TABLE,NCATG,NAME)
      INTEGER TABLE(6,102),LINE(100),STAR
      LOGICAL*1 NAME(6,80)
      DATA LINE/100*' '/
      DO 190 I= 1,NCATG
      WRITE(6,10)I
      WRITE(6,15)(NAME(I,J),J=1,80)
   10 FORMAT('1',T50,'ANALYSIS OF MAP #',I1)
   15 FORMAT(T20,'(',80A1,')')
      SUM=0.
      NUMBR=0
      SUMSQ=0.
      IMAX=3
      NMAX=0
C
C     NOW SCAN THE DATA AND GET SUMS,SUMS OF SQUARES AND NUMBER OF CASES
C     ALSO FIND MODAL POINT
C
      DO 30 J=3,102
      IF(TABLE(I,J).LE.NMAX)GO TO 20
      NMAX=TABLE(I,J)
      IMAX=J
   20 SUM= SUM + FLOAT(TABLE(I,J))*FLOAT(J-2)/10.
      SUMSQ=SUMSQ+FLOAT(TABLE(I,J))*(FLOAT(J-2)/10.)**2
      NUMBR=NUMBR+TABLE(I,J)
   30 CONTINUE
      WRITE(6,40)NUMBR
      WRITE(6,170)TABLE(I,1)
      WRITE(6,180)TABLE(I,2)
      IF(NMAX.EQ.0)GO TO 200
   40 FORMAT(' THERE ARE ',I5,' OBSERVATIONS')
      STDDEV=(SUMSQ-SUM*SUM/FLOAT(NUMBR))/FLOAT(NUMBR-1)
      STDDEV=SQRT(STDDEV)
      AMEAN= SUM/FLOAT(NUMBR)
      WRITE(6,50)AMEAN,STDDEV
   50 FORMAT(/,' MEAN SCORE = ',F8.3,/,' STANDARD DEVIATION = ',F9.4)
      AMODE=FLOAT(IMAX-2)/10.
      WRITE(6,60)AMODE,NMAX
   60 FORMAT(' THE MODE IS ',F6.3,' WITH ',I5,' OBSERVATION(S)')
      SKEWPR=(AMEAN-AMODE)/STDDEV
      WRITE(6,70)SKEWPR
   70 FORMAT(' PEARSONIAN COEFFICIENT OF SKEWNESS = ',F7.4)
C
C     NOW FIND ELEMENTS FOR KURTOSIS
C
      N=0
      DO 110 J=3,102
      N=N+TABLE(I,J)
      IF(N.LT.0.9*NUMBR)GO TO 80
      GO TO 120
   80 IF(N.LT.0.75*NUMBR)GO TO 90
      X75= FLOAT(J-2)/10.
      GO TO 110
   90 IF(N.LT.0.25*NUMBR)GO TO 100
      X25= FLOAT(J-2)/10.
      GO TO 110
  100 IF(N.LT.0.1*NUMBR)GO TO 110
      X10=FLOAT(J-2)/10.
  110 CONTINUE
```

```
  120 X90=FLOAT(J-2)/10.
      AKURTO = 0.5*(X75-X25)/(X90-X10)
      WRITE(6,130)AKURTO
  130 FORMAT(' KURTOSIS = ',F6.3)
C
C     NOW  CREATE THE HISTOGRAM
C
      WRITE(6,140)
  140 FORMAT(///,T60,'H I S T O G R A M ',//,19X,103('-'))
      DO 160 J=3,102
      X=FLOAT(J-2)/10.
      NG= IFIX(100.*(FLOAT(TABLE(I,J))+0.5)/FLOAT(NMAX))
      WRITE(6,150)X,TABLE(I,J),(LINE(K),K=1,NG)
  150 FORMAT(1X,F8.1,2X,I5,2X,'|',100A1)
  160 CONTINUE
  170 FORMAT(' NUMBER OF EXCLUSION CELLS = ',I5)
  180 FORMAT(' NUMBER OF ZERO SCORES      = ',I5)
  190 CONTINUE
      RETURN
  200 WRITE(6,210)
  210 FORMAT(5(/),'CANNOT PRESENT HISTOGRAM---TABLE EMPTY')
      RETURN
      END
```

# Appendix B

## DESCRIPTION OF THE MARYLAND DATA BASE

The data base used with the ORNL-LUSP has 99 variables, of which 52 contain data. The other variable positions can be used to contain suitability scores calculated for differing siting objectives. This procedure allows 47 different suitability scores to be maintained in the file at any one time. Statistical analyses then become feasible in analyzing a diversity of importance and compatibility matrices.

Table 2.1 gives a list of the variables by name and indicates the source of the variable. The following is a brief description of each variable. More complete descriptions of the sources and methods of coding of the MAGI variables may be found in *Maryland Automated Geographic Information System*, Publication No. 207 (Baltimore, March 1974) and other documentation by the Maryland Department of State Planning.

## B.1 List of Variables

### B.1.1 Raw data variables

| | Variable name |
|---|---|
| Variable No. 1 | Grid cell row number |
| Variable No. 2 | Grid cell column number |
| Variable No. 3 | County or city number |

Code:

| | |
|---|---|
| Allegany | 01 |
| Anne Arundel | 02 |
| Baltimore County | 03 |
| Baltimore City | 04 |
| Calvert | 05 |
| Caroline | 06 |
| Carroll | 07 |
| Cecil | 08 |
| Charles | 09 |
| Dorchester | 10 |
| Frederick | 11 |
| Garrett | 12 |
| Harford | 13 |
| Howard | 14 |
| Kent | 15 |
| Montgomery | 16 |
| Prince Georges | 17 |
| Queen Annes | 18 |
| St. Marys | 19 |
| Somerset | 20 |
| Talbot | 21 |
| Washington | 22 |
| Wicomico | 23 |
| Worcester | 24 |

| | | Variable name |
|---|---|---|
| Variable No. 4 | | Surface water quality/fish and shellfish |

Code:

| | |
|---|---|
| Class I waters (general use and recreation) | 10 |
| Class I waters not meeting standards | 11 |
| Class II waters (shellfish harvesting streams) | 20 |
| Class II waters not meeting standards | 21 |
| Class III waters (natural trout streams) | 30 |
| Class III waters not meeting standards | 31 |
| Class IV waters (recreational trout streams) | 40 |
| Class IV waters not meeting standards | 41 |
| Oyster beds open to fishing | 50 |
| Oyster beds closed to fishing because of pollution | 51 |
| Clam beds open to fishing | 60 |
| Clam beds closed to fishing because of pollution | 61 |

Source: MAGI — surface water quality variable

Water quality characteristics were compiled for all second- and third-order stream systems within the state. This variable serves two functions. One is to identify different classes of surface waters in terms of meeting water quality guidelines, and the other is to locate surface waters classified as trout streams, shellfish harvesting areas, oyster beds, and clam beds. The majority of data was obtained from *The Continuing Planning Process for Water Quality Management*, issued by the Water Resources Administration, Maryland Department of Natural Resources, in February 1973.

Additional information on shellfish harvesting areas, indicating the location of designated oyster and clam beds, was combined with the water quality data. This information had been compiled by the Coast and

Geodetic Survey for the Maryland Department of Natural Resources, Tidewater and Fisheries Administration. Location and extent of oyster and clam beds were identified by field surveys, and the beds were located photogrammetrically by the Coast and Geodetic Survey. These data were mapped initially at a scale of 1:20,000 and subsequently transferred to the 1:62,500 series for digital encoding.

| Variable No. 5 | Variable name<br>Geologic formation (primary) |
|---|---|

Code:

The codes for geologic formations are listed in Maryland Department of State Planning, *Geology, Aquifers, Minerals*, Publication No. 205, Baltimore, December 1973, pp. 12-118. This is a four-digit code, with the first two digits being the county code number of Variable 3. The last two digits refer to individual formations and are county-specific. For general usage these will have to be reformatted in classes of homogeneous engineering characteristics.

Source: MAGI.

The engineering geology data were adopted primarily from the *Engineering Geology Tables of the Maryland Engineering Soil Study* (June 1965). Basic geologic data for the state were classified for engineering applications by the Civil Engineering Department of the University of Maryland, using Maryland highway maps (1:63,360 scale). These data include hardness, excavation requirements, extent of rock weathering, durability of fresh rock, and overburden thickness. Additional maps and reports from the U.S. Geological Survey were used, and the Maryland Geological Survey was consulted concerning the usefulness of these data as input to the Maryland Generalized Land Use Plan.

| Variable No. 6 | Variable name<br>Geologic formation (secondary) |
|---|---|

Code: Same as for Variable 5

Source: Same as for Variable 5.

| Variable No. 7 | Variable name<br>Transportation and transmission (primary)* |
|---|---|
| **Code:** | |
| Railroad | 01 |
| Gas or other petroleum pipeline | 02 |
| Transmission line | 03 |
| Channel spoils disposal site | 04 |
| Channel 27 ft or greater | 05 |
| Channel 35 ft or greater | 06 |
| Channel 42 ft or greater | 07 |
| Existing intersection of controlled access highway and controlled access highway | 08 |
| Proposed intersection of controlled access highway and controlled access highway | 09 |
| Existing intersection of controlled access highway and noncontrolled access highway | 10 |
| Proposed intersection of controlled access highway and noncontrolled access highway | 11 |
| Combination of two rights-of-way | 12 |
| Combination of three rights-of-way | 13 |
| Airports and airport property | 14 |
| Rapid rail | 15 |
| Commuter rail | 16 |

Source: MAGI — transportation facilities variable.

Maps from Maryland state agencies and other organizations were used as source materials. Among these were charts and maps produced by the Federal Power Commission and the U.S. Geological Survey. Proposed highways were obtained from the State Highway Administration "Twenty Year Needs Study."

---

*If multiple facilities exist in a cell, the one occupying the greatest area is listed as primary.

| | Variable name |
|---|---|
| Variable No. 8 | Transportation and transmission (secondary)* |

Code: Same as for Variable 7 except the following undocumented codes are found in the secondary classification:

17 (three cells)
19 (one cell)
20 (three cells)
21 (one cell)
22 (two cells)
23 (one cell)
24 (one cell)
25 (one cell)

Source: Same as for Variable 7.

| | Variable name |
|---|---|
| Variable No. 9 | State and federal lands (primary)† |

Code:

State:

| | |
|---|---|
| State of Maryland (general) | 10 |
| Department of Health and Mental Hygiene | 11 |
| Department of Natural Resources | 12 |
| Fish and Wildlife Administration | 13 |
| Department of Forests and Parks | 14 |
| Maryland State Police | 15 |
| Department of Corrections | 16 |
| General Services | 17 |
| State Aviation Administration | 18 |
| Mass Transit Administration | 19 |
| Maryland Port Authority | 20 |
| Motor Vehicles Administration | 21 |

---

*If multiple facilities exist in a cell, the one occupying the second greatest area is listed as secondary.

†If a cell contains land owned by more than one state or federal agency, the agency owning the largest area is listed as primary.

Code:

| | |
|---|---|
| State Highways Administration | 22 |
| Military Department | 23 |
| State Department of Education | 24 |
| Agriculture and Industry Agency | 25 |
| Board of Public Works | 26 |
| Undocumented code (one cell) | 40 |

Federal

| | |
|---|---|
| Federal Government (general) | 50 |
| Department of Agriculture | 51 |
| Department of the Air Force | 52 |
| Department of the Army | 53 |
| Corps of Engineers | 54 |
| Department of the Navy | 55 |
| Department of Commerce | 56 |
| Department of Health, Education, and Welfare | 57 |
| National Institutes of Health | 58 |
| Social Security Administration | 59 |
| Department of Transportation | 60 |
| Coast Guard | 61 |
| Atomic Energy Commission | 62 |
| Federal Communications Commission | 63 |
| General Services Administration | 64 |
| National Aeronautics and Space Administration | 65 |
| Department of the Interior | 66 |
| Fish and Wildlife Bureau | 67 |
| Postal Service | 68 |
| Veterans' Administration | 69 |
| Department of Justice | 70 |
| Treasury Department | 71 |

Municipal

| | |
|---|---|
| Municipal parks | 80 |
| Municipal ownership | 82 |
| Municipal ownership | 83 |

Source: MAGI

Tax maps, computerized listings of federal lands, and inventories of State Highway Administration lands were used by the Department of State Planning to locate all state- or federally-owned properties of 10 acres or larger. A complete description of the data collection and ownership can be found in Maryland Department of State Planning Technical Series Document, *State and Federal Land Inventory* (Pub. No. 211, 1974).

| | Variable name |
|---|---|
| Variable No. 10 | State and Federal lands (secondary)* |

Code: Same as for Variable 9

Source: Same as for Variable 9.

| | Variable name |
|---|---|
| Variable No. 11 | Mineral resources |

Code:

| Mineral resource | Status | |
|---|---|---|
| Deep coal mine | Inactive | 01 |
| Deep coal mine | Active | 02 |
| Strip coal mine | Inactive | 03 |
| Strip coal mine | Active | 04 |
| Sand and/or gravel pit | Active | 05 |
| Stone quarry | Active | 06 |
| Clay and shale pit | Active | 07 |
| Greensand area | Contingent upon conditions | 08 |
| Diatomite area | Active pit | 09 |
| Gas field | In operation | 10 |
| Gas field | Under development | 11 |
| Gas field | Used for storage | 12 |
| Peat pit | Contingent upon conditions | 13 |
| Copper deposits† | Contingent upon conditions | 14 |
| Gold deposits | Contingent upon conditions | 15 |
| Undocumented | (12 cells) | 16 |
| Undocumented | (44 cells) | 17 |

*If a cell contains land owned by more than one state or federal agency, the agency owning the second largest area is listed as secondary.

†Includes lead, zinc, chrome, iron and silver as accessory minerals.

Source: MAGI

The Maryland Geological Survey and U.S. Geological Survey were consulted for data on mineral resources. The geologic formation boundaries were used to help locate productive mineral commodities or deposits with development potential. Due to their high degree of credibility, little additional investigation was necessary.

| | Variable name |
|---|---|
| Variable No. 12 | Sewer facilities<br>Water facilities |

Code:

0. No facilities or plans for facilities within 20 years
1. Existing or under construction

   "Existing Service Area" means the area currently served. "Under Construction" means a work or works of community water supply or sewerage where actual work is progressing or where a notice to proceed with a contract for such work has been issued as of the effective date of the plan, its amendment or revision.

2. Future development, 1 to 6 years

   "Immediate Priority" means a work or works of community water supply or sewerage for which the beginning of construction is scheduled to start within two years following the date of adoption of the plan, its amendment or revision by the county. "Five or Six-Year Period" means that period, depending upon the county's Capital Improvement Program, five or six years following the date of adoption of the plan, its amendment or revision by the county.

3. Future development, 7 to 10 years

   "Ten-Year Period" shall mean that period of seven through ten years following the date of adoption of the plan, its amendment or revision by the county.

4. Future development, 11 to 20 years

   "Twenty-Year Period" shall mean that period of eleven through twenty years following the adoption date of the plan, its amendment or revision by the county.

Source: MAGI — Sewer and water service areas variable.

County Water and Sewer Plans, which are updated annually, were examined. A two-digit code was developed for this variable with the first digit being sewer facilities and the second being water facilities.

| Variable No. 13 | Variable name<br>Forest type |
|---|---|

Code:

Forest type (Modified from Society of American Foresters classification)

| | |
|---|---|
| Aspen, pin cherry | 5 |
| Northern hardwoods, white pine | 7 |
| White pine, hardwoods | 8 |
| Oak, white pine | 9 |
| White pine | 10 |
| Hemlock | 11 |
| Northern hardwoods | 12 |
| Undocumented code (two cells) | 21 |
| Undocumented code (fifty cells) | 22 |
| Undocumented code (two cells) | 23 |
| Scrub oak | 35 |
| Chesnut oak | 36 |
| Hard pine — pitch, short-leaf, and Virginia pine | 38 |
| Undocumented code (two cells) | 39 |
| Undocumented code (one cell) | 40 |
| Hard pine — oak | 41 |
| Oak — hard pine | 42 |
| White oak | 50 |
| Red oak | 52 |
| Undocumented code (four cells) | 54 |
| Cove hardwoods | 55 |
| River birch, sycamore | 59 |
| Bottomland hardwoods | 60 |
| Loblolly pine | 69 |
| Loblolly pine, hardwoods | 70 |
| Hardwoods, loblolly pine | 71 |
| Red gum, yellow poplar | 77 |
| Southern white cedar | 90 |
| Southern cypress | 94 |

Source: MAGI — forest vegetation variable.

At the time this variable was compiled by Maryland, there were no recent vegetation surveys in existence. One significant series of topographic maps outlining forest types was found and used as the basis for a new map updating effort. These maps were produced between 1949 and 1959 by what is now known as the State Department of Natural Resources. This source was combined with the 1970 Land Use Inventory and 1972 high altitude aircraft photography to compile a new series of maps at a scale of 1:63,360. A further description of sources and types can be found in MDSP Technical Series entitled *Forest Vegetation in Maryland* (October 1974).

| | Variable name |
|---|---|
| Variable No. 14 | Soil group (primary)* |

Code:

A thorough description of each soil group and interpretation of its engineering limitations are provided in Maryland Department of State Planning, *Natural Soil Groups of Maryland*, Publication No. 199, Baltimore, December 1973, pp. 21-54. A brief description is given below:

| Code number | Group | Slope class† | Description |
|---|---|---|---|
| 110 | A1 | | Deep, sandy, excessively drained, very rapidly permeable, highly acidic |
| 111 | | a | |
| 112 | | b | |
| 113 | | c | |
| 120 | A2 | | Loose sands, depth of 1 to 10 ft or more, very rapidly permeable, pH is highly variable |
| 210 | B1 | | Deep, permeable, silt or loam at surface, clay in subsoil, pH highly variable |
| 211 | | a | |
| 212 | | b | |
| 213 | | c | |
| 220 | B2 | | Well drained, strongly acidic, slowly permeable layers of gravel and clay below 2 to 3 ft |
| 221 | | a | |
| 222 | | b | |
| 223 | | c | |

*If multiple soil groups occur within a cell, the one occupying the largest area is listed as primary.

†a — 0 to 8%; b — 8 to 15%; c — 7 to 15%.

| Code number | Group | Slope class[†] | Description |
|---|---|---|---|
| 230 | B3 | | Deep, well drained, unstable structure, subsurface clays, gently sloping to rolling surface, plastic, sticky, slowly permeable, strongly acidic |
| 310 | C1 | | 20 to 40 in. in depth, shaly surface with localized stony spots, strongly acidic |
| 311 | | a | |
| 312 | | b | |
| 313 | | c | |
| 320 | C2 | | Well drained, nonacidic, clayey, tough, intractable, usually surface slope is >15%, plastic, dense, very slowly permeable, contains natural lime |
| 410 | D1 | | <20 in. in depth, high content of rocky fragments, well to excessively drained, pH is variable, low natural fertility |
| 411 | | a | |
| 412 | | b | |
| 413 | | c | |
| 510 | E1 | | Moderately well drained, substrata of loose sand, strongly acidic, rapidly permeable |
| 520 | E2 | | Perched water table to a depth of approximately 2 ft over fragipan ("hardpan") or clayey subsoil, moderately well drained, saturated and mushy in late winter and early spring, surface is silt or loam, strongly acidic, slow permeability |
| 521 | | a | |
| 522 | | b | |
| 530 | E3 | | Deep, moderately well drained, silty, moderately slow permeability, water table to within 1.5 to 2.5 ft of the surface in late winter and early spring, strongly acidic |

| Code number | Group | Slope class | Description |
| --- | --- | --- | --- |
| 610 | F1 | | Wet, sandy, poorly drained, strongly acidic, rapidly permeable when water table is low |
| 620 | F2 | | Wet, sandy, poorly drained, strongly acidic, rapidly permeable when water table is low, generally unstable structure, fluctuating water table from surface in winter to depth of 4 to 6 ft in summer, loamy sand or sand substrata |
| 630 | F3 | | Poorly drained, dense subsoils of silt, clay, or fragipan, surface is clayey, sticky, plastic when dry, slowly permeable, strongly acidic |
| 710 | G1 | | Deep, well drained floodplains, loamy alluvium, strongly acidic to neutral, moderately permeable |
| 720 | G2 | | Deep, poorly drained floodplains, silty sediments, pH highly variable, slowly permeable |
| 730 | G3 | | Tidal marshes and swamps, saturated sand, clay, peat, or muck at surface |
| 810 | H1 | | Very stony to extremely stony soils which otherwise would be in groups B1, B2, C1, C2, D1, E2, or F3; large, loose stones |
| 811 | | a | |
| 812 | | b | |
| 813 | | c | |
| 820 | H2 | | Very rocky to extremely rocky soils which otherwise would be in groups B1, C2, or D1, hard bedrock exposed |
| 910 | ? | | These soils are termed "Made Land"; soils that are covered by urban development |
| 920 | ? | | These soils have been altered by mining or cut-and-fill |

Source: MAGI — natural soil groups variable

A soil survey of the entire state was done by the U.S. Department of Agriculture — Soil Conservation Service, but some maps had not been published at the time of the MAGI data collection. The Department of State Planning utilized published survey maps, unpublished data, and supplemental information to classify soils into groups with generally homogeneous characteristics for planning purposes.

The following codes also exist in this variable and variables 15 and 16. They are undocumented.

Cell frequency

| Code number | Primary | Secondary | Tertiary | Total |
|---|---|---|---|---|
| 511 | 6 | 5 | 1 | 12 |
| 531 | 208 | 134 | 43 | 385 |
| 612 | 4 | 12 | 5 | 21 |
| 711 | 1 | 1 | 4 | 6 |
| Total | 219 | 152 | 53 | 424 |

Variable No. 15 — Variable name: Soil group (secondary)*

Code: Same as for Variable 14

Source: Same as for Variable 14.

Variable No. 16 — Variable name: Soil group (tertiary)†

Code: Same as for Variable 14

Source: Same as for Variable 14.

Variable No. 17 — Variable name: Natural features (primary)**

---

*If multiple soil groups occur within a cell, the one occupying the second largest area is listed as secondary.

†If multiple soil groups occur within a cell, the one occupying the third largest area is listed as tertiary.

**If multiple features occur in a cell, the one occupying the largest area is listed as primary.

<u>Code</u>:

The code for this variable is presented in Maryland Department of State Planning-Smithsonian Institution, Center for Natural Areas, *Compendium of Natural Features Information,* Publication No. 231, 2 volumes, Baltimore, March 1975. This is a 7-digit code with the first two digits being the county code number of Variable 3. The third and fourth digits refer to the electoral district within the county (Variable 22). The fifth digit refers to the source of the data. The sixth and seventh digits indicate the individual feature and are county- and electoral district-specific. The presence or absence of a natural feature is indicated by a zero/nonzero interpretation of the code.

0 — No natural features occur in the cell.

≥1 — A natural feature is present in the cell.

<u>Source</u>: MAGI

Data on unique or endangered natural features and scenic areas were compiled by the Department of State Planning in an effort to update and expand the 1968 *Catalog of Natural Areas in Maryland.* Data were obtained by an exhaustive search of literature on natural areas in Maryland, personal contact with Maryland experts in the natural sciences, and public survey questionnaires.

Natural features include natural areas, landmarks, fragile ecologic systems, wild lands, and habitats of rare or endangered species. A state-sponsored inventory of "big trees" provided additional information.

For a more detailed interpretation, one should consult the *Compendium of Natural Features Information.*

| | <u>Variable name</u> |
|---|---|
| Variable No. 18 | Natural features (secondary)* |

<u>Code</u>: See Code for Variable 17.

0 — Cell does not contain multiple natural features.

≥1 — Cell contains two or more natural features.

<u>Source</u>: Same as for Variable 17.

---

*If multiple features occur in a cell, the one occupying the second largest area is listed as secondary.

Variable No. 19 — Variable name: Land surface slope (primary)*

Code+:

1. 0-3% slope class.
2. 3-10% slope class.
3. 10-20% slope class.
4. >20% slope class.

Source: MAGI — topographic slope variable.

The slope maps utilized by the Department of State Planning were originally produced as a part of the Maryland Engineering Soil Study. Later these were improved by State Planning staff and by consultants under contract to the Department.

Variable No. 20 — Variable name: Land surface slope (secondary)**

Code: Same as for Variable 19

Source: Same as for Variable 19.

Variable No. 21 — Variable name: Watersheds

Watershed name

XX is used to indicate variable digits which denominate the specific sub-portion of the watershed concerned.

---

*If multiple slope classes occur in a cell, the one occupying the largest total area is listed as primary.

+There are 2025 cells in primary Land Surface Slope that have a code of 0. For the most part, these cells are located in Chesapeake Bay and the Potomac River.

**If multiple slope classes occur in a cell, the one occupying the second largest total area is listed as secondary.

| Code | Watershed name |
| --- | --- |
| 01XX | Youghiogheny |
| 02XX | North Branch Potomac |
| 03XX | Upper Potomac |
| 04XX | Middle Potomac |
| 05XX | Metro Washington |
| 06XX | Lower Potomac |
| 07XX | Patuxent |
| 08XX | Patapsco |
| 09XX | Gunpowder |
| 10XX | Bush |
| 11XX | Susquehanna |
| 12XX | West Chesapeake |
| 13XX | Elk |
| 14XX | Chester |
| 15XX | Choptank |
| 16XX | Nanticoke |
| 17XX | Pocomoke |
| 18XX | Ocean drainage |
| 19XX | Contains all of Chesapeake Bay |

Source: MAGI.

Variable No. 22 — Variable name: Electoral district

Code:

Each district was assigned a two-digit code which must be cross-tabulated with the county number for complete identification.

Source: MAGI.

Electoral districts were digitized from U.S. Census county maps. Electoral districts are zones used to summarize voting data. There were two basic reasons for digitizing these. The first is that census tracts and statistical area boundaries are nested within electoral districts. Data from the 1960 and 1970 Census can be aggregated and used for computer mapping, various forms of analysis, and interfacing with other data bank variables. In addition, tax and land use records are maintained at the electoral district level.

| | Variable name |
|---|---|
| Variable No. 23 | Historic sites (first in cell) |

Code:

0 — No registered historic site in cell.

≥1 — At least one registered historic site in cell.

Source: MAGI.

An inventory of historic sites was provided by the Maryland Historic Trust.

| | Variable name |
|---|---|
| Variable No. 24 | Historic sites (second in cell) |

Code:

0 — Less than two registered historic sites in cell.

≥1 — At least two registered historic sites in cell.

Source: Same as for Variable 23.

| | Variable name |
|---|---|
| Variable No. 25 | Historic sites (third in cell) |

Code:

0 — Less than three registered historic sites in cell.

≥1 — At least three registered historic sites in cell.

Source: Same as for Variable 23.

| | Variable name |
|---|---|
| Variable No. 26 | Land use and land cover (primary)* |

Code (1970 version):

| | |
|---|---|
| Residential | 11 |
| Commercial and services | 12 |
| Industrial | 13 |
| Extractive | 14 |
| Transportation, communications, and utilities | 15 |
| Institutional | 16 |
| Strip and clustered settlement | 17 |
| Mixed | 18 |
| Open and other | 19 |

*If multiple categories occur in a cell, the one occupying the largest total area is listed as primary.

| | |
|---|---|
| Cropland and pasture | 21 |
| Orchards, groves, bush fruits, vineyards, and horticultural areas | 22 |
| Feeding operations | 23 |
| Other agriculture | 24 |
| Grass | 31 |
| Savannas (palmetto prairies) | 32 |
| Chaparral | 33 |
| Desert shrub | 34 |
| Heavy crown cover (40% and over) forest | 41 |
| Light crown cover (10 to 40%) forest | 42 |
| Shrub growth | 43 |
| Streams and waterways | 51 |
| Lakes | 52 |
| Reservoirs | 53 |
| Bays and estuaries | 54 |
| Other water bodies | 55 |
| Vegetated wetlands | 61 |
| Nonvegetated wetlands | 62 |
| Salt flats | 71 |
| Beaches | 72 |
| Sand other than beaches | 73 |
| Bare exposed rock | 74 |
| Other barren land | 75 |

This code was revised to a three-digit classification in 1973. The first two digits are essentially the same as those of the 1970 version on the ORNL data tape.

Source: MAGI.

The Department of State Planning in conjunction with the U.S. Geological Survey, Geographical Application Program prepared a land use inventory primarily based on high altitude (60,000 ft) color infrared photography taken by the National Aeronautics and Space Administration (Mission 144, 1970). This mission covered all of the state, except the westernmost counties. Additional materials were obtained for western Maryland to complete the state-wide inventory.

Variable No. 27 — Variable name: Land use and land cover (secondary)*

Code: Same as for Variable 26

Source: Same as for Variable 26.

Variable No. 28 — Variable name: Land use and land cover (tertiary)+

Code: Same as for Variable 26

Source: Same as for Variable 26.

Variable No. 29 — Variable name: Planned land use and land cover (primary)**

Code:

0 — No plans exist or county land use plan map is incomplete.

10. Urban and built-up land
    11. Residential
    12. Commercial and services
    13. Industrial
    15. Transportation, communications, and utilities
    16. Institutional
    17. Strip and clustered settlement
    19. Open and other
20. Agricultural land
21. Cropland and pasture
40. Forest land
50. Water

Source: MAGI — future land use variable

The Department of State Planning obtained this information from county land use plan maps.

---

*If multiple categories occur in a cell, the one occupying the second largest total area is listed as secondary.

+If multiple categories occur in a cell, the one occupying the third largest total area is listed as tertiary.

**If multiple categories are planned for a cell, the one projected to occupy the largest total area is listed as primary.

Variable No. 30 — Variable name: Planned land use and land cover (secondary)*

Code: Same as for Variable 29

Source: Same as for Variable 29.

Variable No. 31 — Variable name: Planned land use and land cover (tertiary)†

Code: Same as for Variable 29

Source: Same as for Variable 29.

Variable No. 32 — Variable name: Highways and proposed highways

Code:

0 No major highway in cell
1 Four-lane highway or interstate
2 Major two-lane highway
3 Proposed four-lane highway
4 Intersection of interstate and major two-lane highway
5 Intersection of interstate and proposed four-lane highway
6 Intersection of major two-lane highway and proposed four-lane highway

Source: Digitized at ORNL from Maryland County Highway Maps.

Variable No. 33 — Variable name: Seismicity

Code:

1. Activity level I — Seismically suitable sites can be found with little difficulty.

2. Activity level II — Detailed site-specific studies would be required to determine seismic suitability.

3. Activity level III — Considerable costs of time and money would be required to determine the seismic suitability of a specific site.

---

*If multiple categories are planned for a cell, the one projected to occupy the second largest total area is listed as secondary.

†If multiple categories are planned for a cell, the one projected to occupy the third largest total area is listed as tertiary.

Source:

Digitized at ORNL from "Areas of Relative Seismic Suitability for Nuclear Energy Centers," Nuclear Regulatory Commission Working Paper *Coarse Screening to Classify Areas Relative to Potential for Containing Sites for Nuclear Energy Centers, Attachment 1*, p. 9 (April 4, 1975).

Variable No. 34 — Variable name: Fish spawning and nursing areas in the Chesapeake Bay

Code:

0. Cell does not contain a significant population of juvenile yellow perch, white perch, striped bass, or bluefish.
1. Yellow perch spawning area.
2. White perch spawning area.
3. White perch nursing area.
4. White perch and bluefish spawning area.
5. White perch, bluefish, and striped bass spawning and/or nursing area.
6. White perch and bluefish nursing area.
7. White perch and striped bass spawning and/or nursing area.
8. Area of juvenile bluefish (<6 in. in length) concentration.

Source: Digitized at ORNL from *The Chesapeake Bay in Maryland, An Atlas of Natural Resources*, Alice J. Lippson, ed. (Baltimore: Johns Hopkins University Press, 1973).

Variable No. 35 — Variable name: 30-mile SPF

Code:

SPF stands for Site Population Factor and is a measure of the relative population density and distribution at and around a site. The region surrounding a site is divided into concentric rings. The population in each ring is weighted in inverse proportion to its distance from the center of the ring. The 5-mile SPF has an outermost ring of 5 miles, and the 30-mile SPF has an outermost ring of 30 miles radius. These variables were obtained for each cell by an interpolation process from a grid of explicitly calculated values. The grid interval for the 30-mile SPF was 0.25° in both latitude and longitude. The grid interval for the 5-mile SPF was 0.05° in both latitude and longitude. In both of these cases the SPF grid points were close enough together to cause overlap of the outermost rings. Thus, the interpolation procedure introduces little error. The interpolation proceeded by finding the four closest known grid values and weighting them in inverse proportion to the distance to find the interpolated value at the desired grid cell. The SPF values for the area surrounding the study region were included in this analysis to eliminate edge effects.

Source: Calculated at ORNL from Census Enumeration District population totals obtained from 1970 U.S. Census.

Variable name

Variable No. 36 Endangered species

Code:
0. No endangered species registered.
1. Generalized cave region of Indiana bat.
2. Estimated possible range of Indiana bat.
3. Observed location of Indiana bat.
4. Habitat of the Maryland darter.

Source: Encoded at ORNL from *A User-Accessed Computer Information System for Environmentally Sensitive Wildlife*, Technical Report No. M-74-6, U.S. Army, Engineer Waterways Experiment Station, Vicksburg, Mississippi, June 1974.

Variable name

Variable No. 37 Excavation requirements

Code:
0. No data available
1. Blasting required
2. Power grading and some blasting required
3. Power grading required
4. Dredging required

Source: Derived from the MAGI Engineering Geology and County variables. By using these two variables in conjunction, excavation requirements were determined. The determination then was spot-checked manually against the appropriate maps in order to verify its accuracy.

Variable name

Variable No. 38 Overburden thickness

Code:
0. No data available
1. Thin overburden
2. Medium overburden
3. Thick overburden
4. Variable overburden thickness

Source: Same as Variable 37.

| | Variable name |
|---|---|
| Variable No. 39 | Aquifer recharge zones |

Code:

0. Not an aquifer recharge zone
1. Hydrologic unit I of Piedmont and Appalachian Provinces (high productivity)
2. Hydrologic unit II of Piedmont and Appalachian Provinces (moderate productivity)
3. Hydrologic unit III of Piedmont and Appalachian Provinces (low productivity)
4. Sandy aquifers of the Coastal Plain province

Source: Same as Variable 37.

| | Variable name |
|---|---|
| Variable No. 40 | 5-mile SPF |

Code: Refer to Variable 35.

Source: Refer to Variable 35.

| | Variable name |
|---|---|
| Variable No. 41 | Stream flow |

Code:

0. Recorded stream flow will not support a 1000-MWe power plant.
1. Recorded stream flow will support a 1000-MWe power plant if a reservoir is constructed.
2. Recorded stream flow will support a 1000-MWe power plant with or without a reservoir.

Source: Modeled and encoded at ORNL.

Data on stream flow were obtained from Surface Water Records of the United States Geological Survey. These were entered into a reservoir model which computes the storage capacity needed to maintain a reservoir at varying levels of consumptive use. For each station an estimation was made regarding the ability of current stream flow to accommodate the cooling requirements of a 1000-MWe power generating plant. At the regional scale of analysis, it was impractical to investigate the legal and institutional availability of flowing water. Attention has been given to maintaining a minimum flow of 0.15 cfs per square mile of drainage area to avoid adverse environmental impacts on stream biota.

| | Variable name |
|---|---|
| Variable No. 42 | Population density |

Code: Population density is expressed as discrete values of persons per square mile.

Source: Interpolated at ORNL from the United States Census, First Count tapes. The average population density for each enumeration district was assigned to a cell at the center of the enumeration district. Values for all other cells were estimated by interpolation between the assigned centroid values.

## B.1.2 Proximity variables

| Variable number | Variable name | Variable number of raw data variable to which proximity is calculated |
|---|---|---|
| 43 | Proximity to highways | 32 |
| 44 | Proximity to railroads | 7, 8 |
| 45 | Proximity to stream flow | 41 |
| 46 | Proximity to residential land use | 26, 27 |
| 47 | Proximity to agricultural land use | 26, 27 |
| 48 | Proximity to transmission lines | 7, 8 |
| 49 | Proximity to fish spawning and nursing areas in the Chesapeake Bay | 34 |
| 50 | Proximity to airports and airport property | 7, 8 |
| 51 | Proximity to endangered species | 36 |
| 52 | Proximity to natural features | 17, 18 |

Code: The proximities are discrete values. To convert to feet, multiply the data entry by 2000. Currently 99.0 indicates any proximity value greater than 20 units.

Source: These are calculated directly from the 42 raw data variables. Proximities are linear distances expressed in units of 2000 ft (the length or width of one cell). Each character position can accommodate calculations up to 99.99 units, but the cost of calculation increases exponentially as the maximum distance increases. The current proximities are calculated to a maximum of 20 units (7.6 miles).

# Appendix C

## FLOW DIAGRAMS OF THE PROGRAM LOGIC

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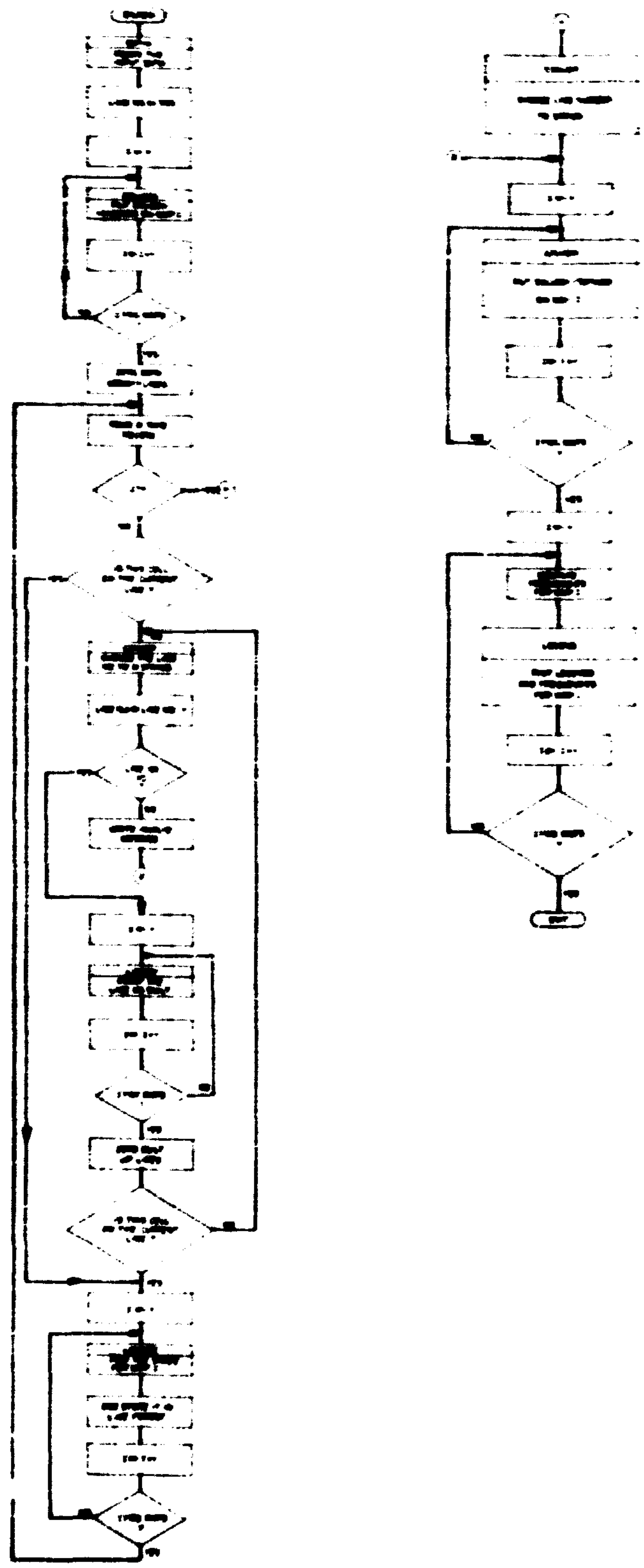

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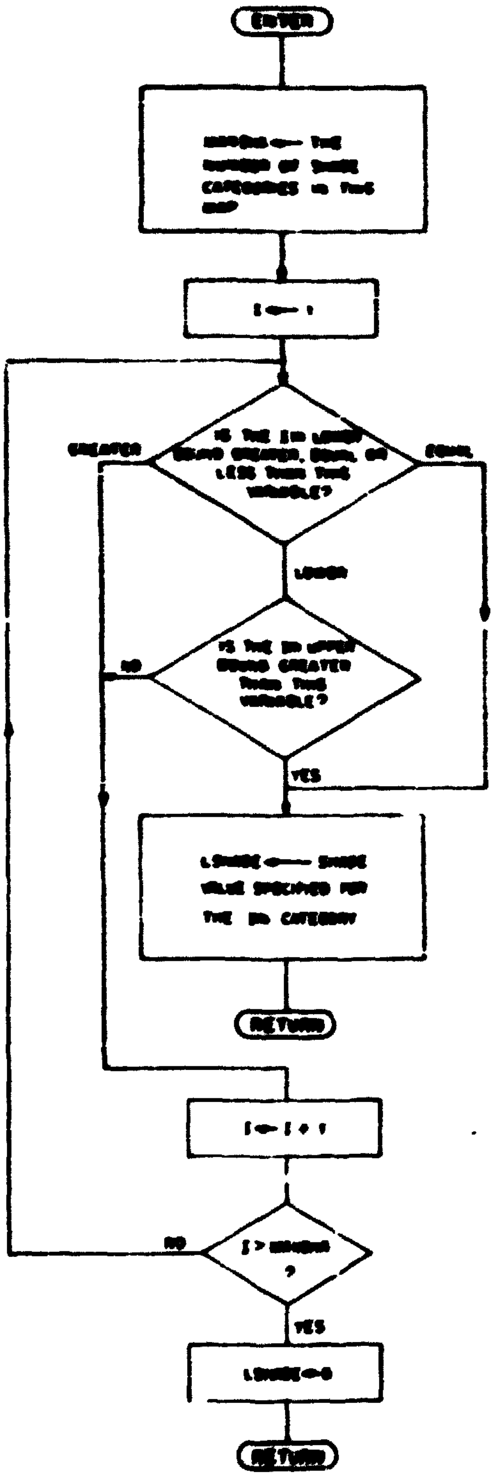
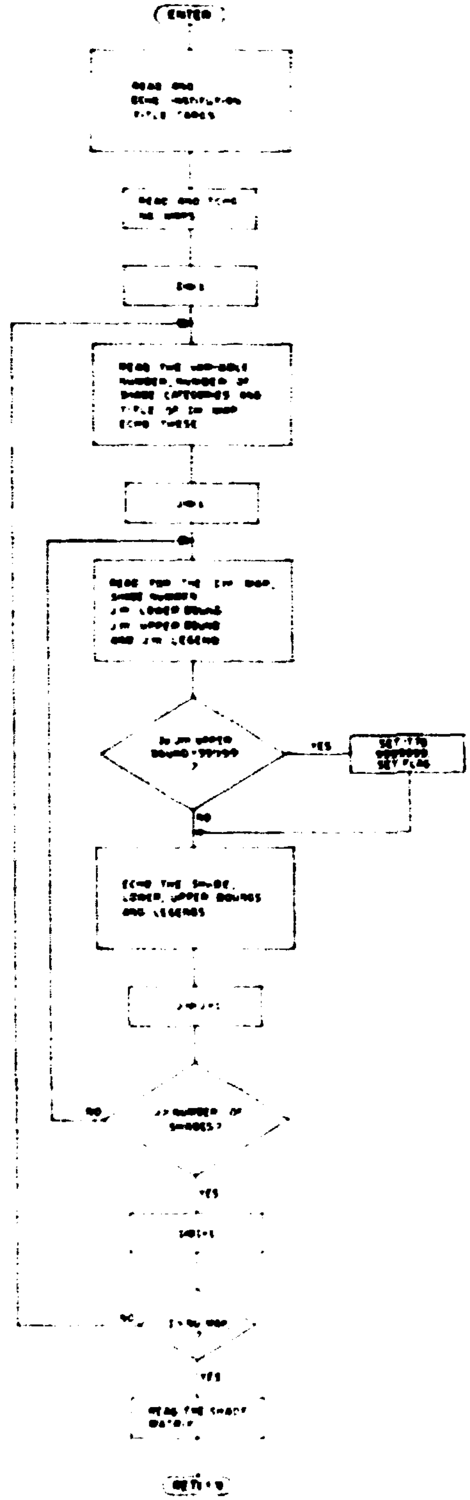


SUBROUTINE DATAIN



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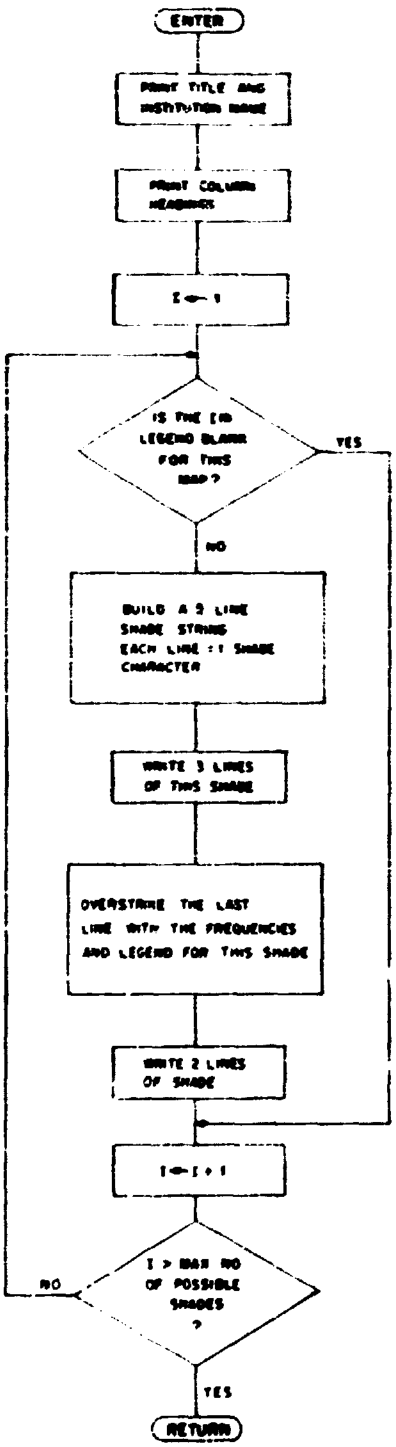

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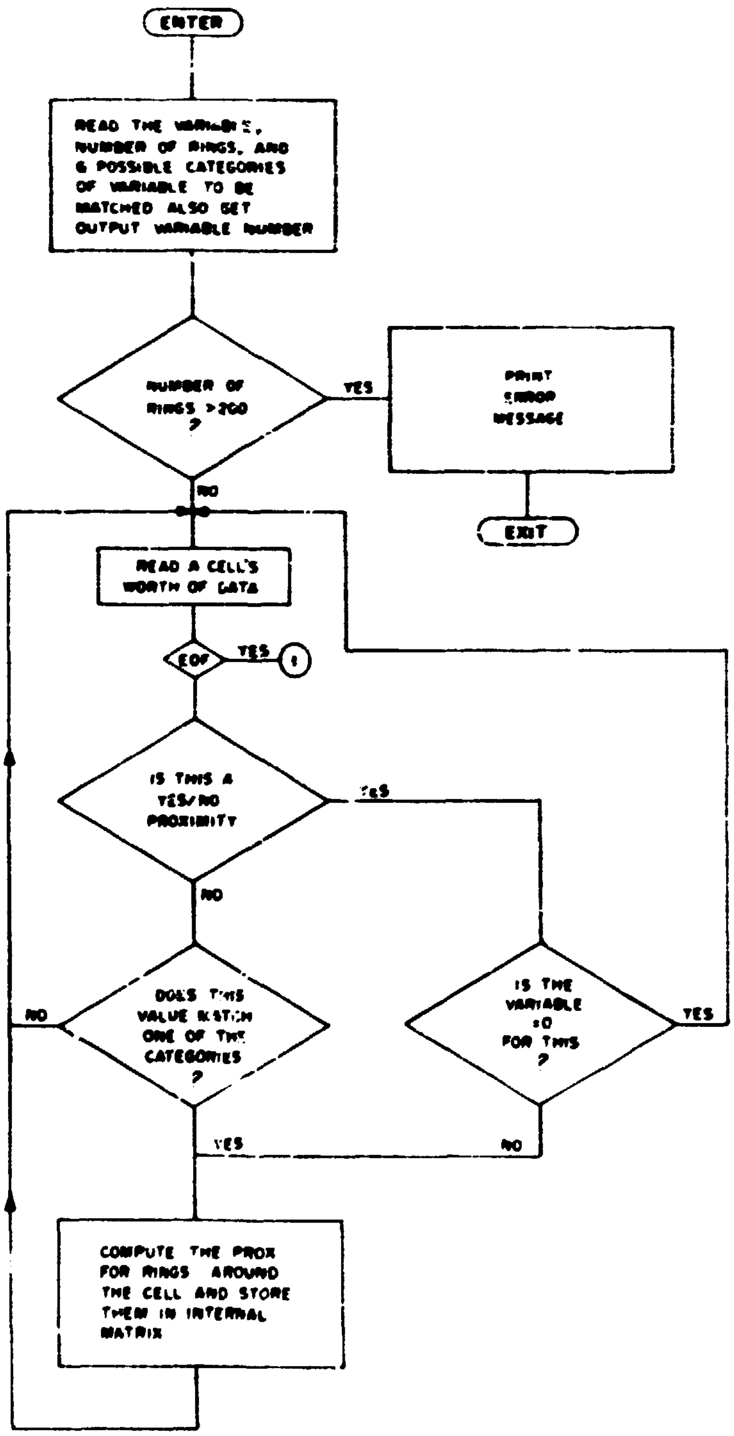
**PROXIMITY PROGRAM**



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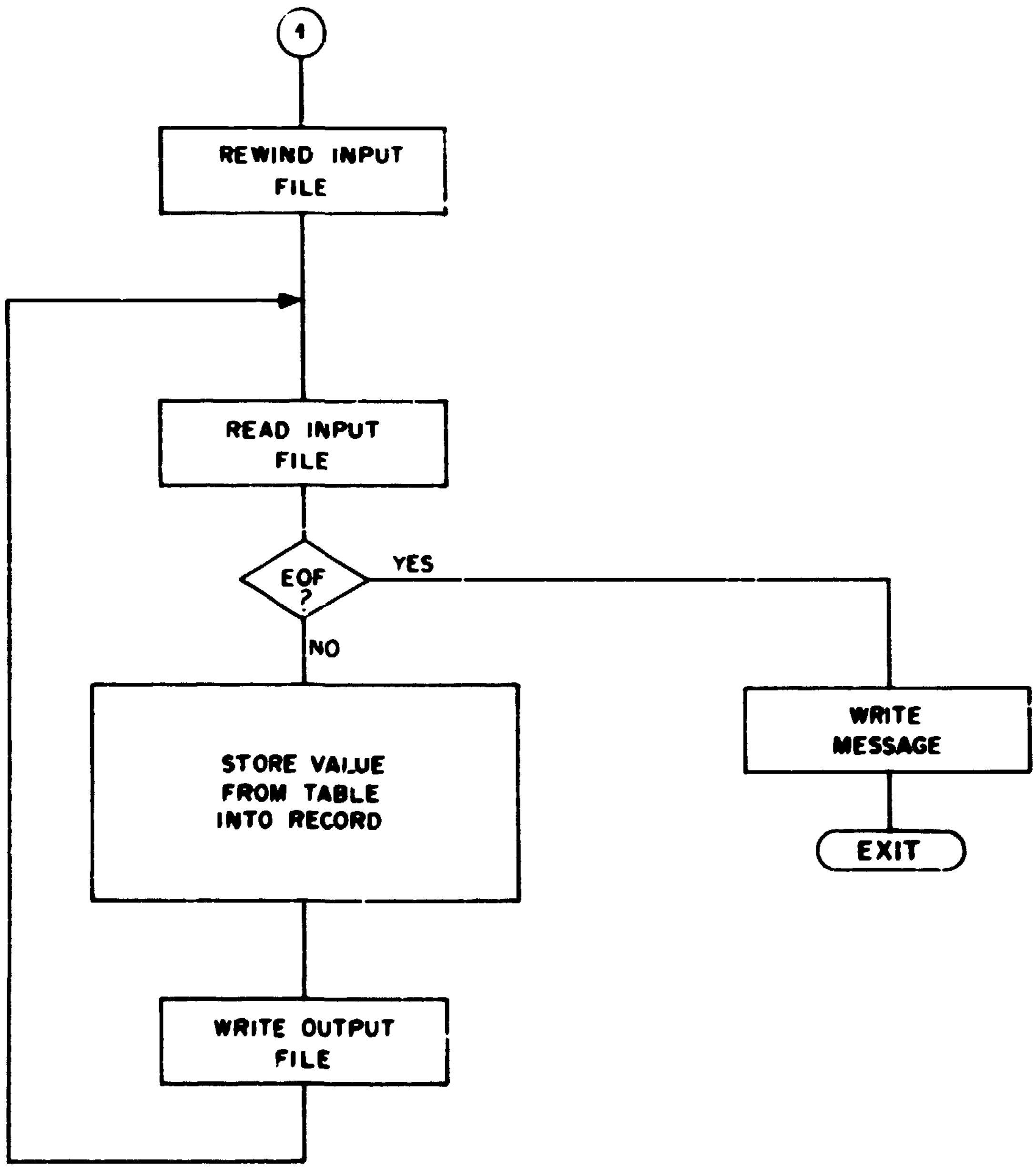
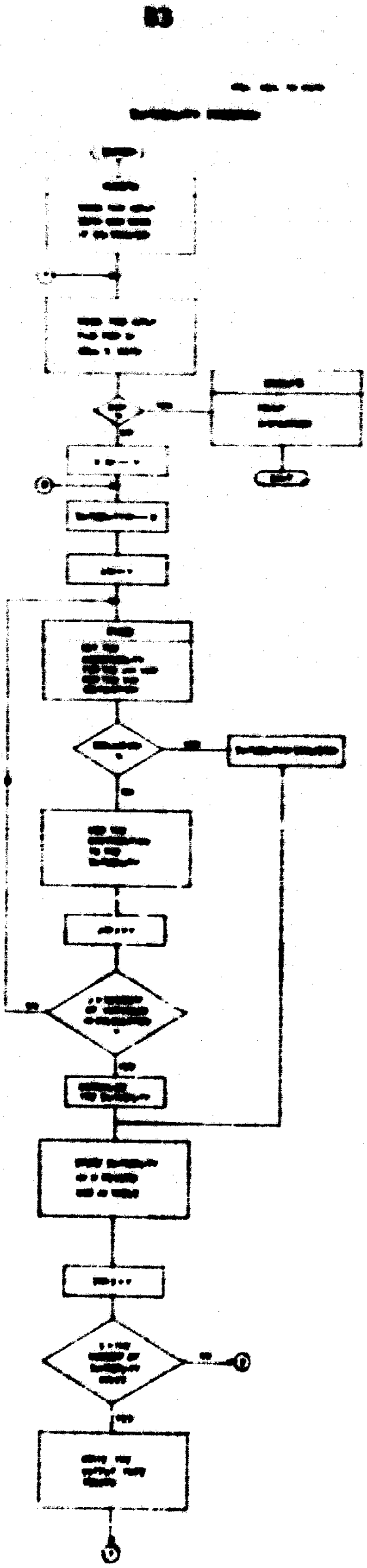
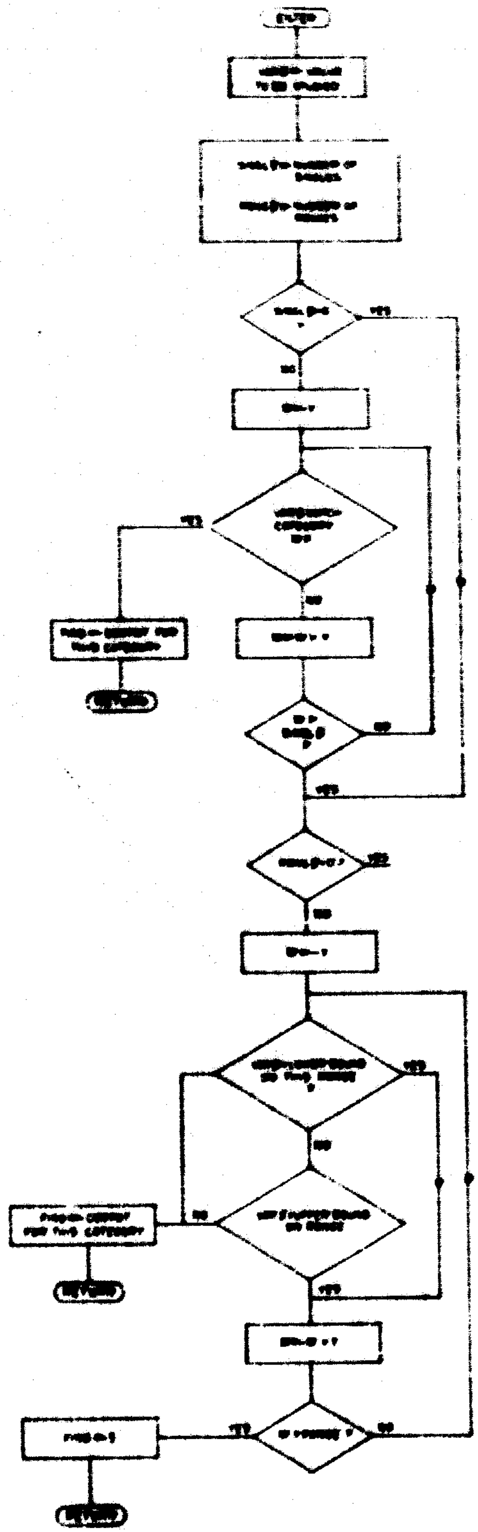
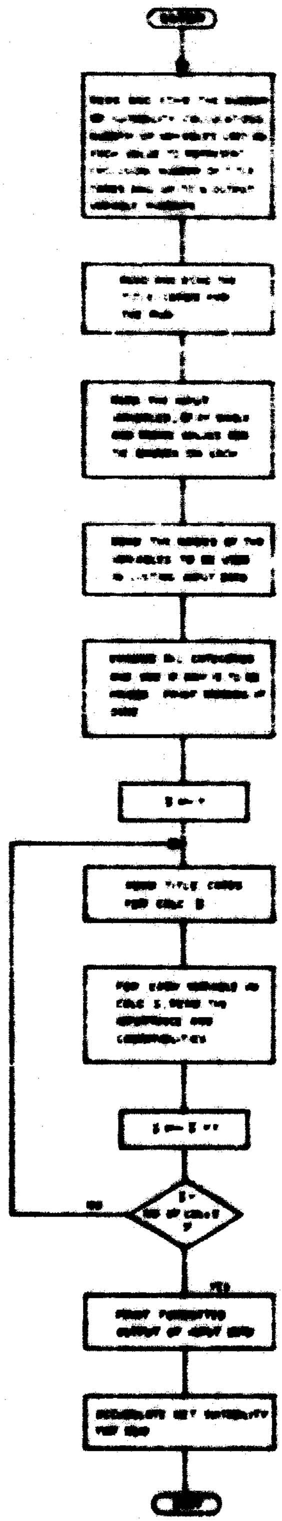
# PROXIMITY PROGRAM









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SUBROUTINE ANALYS