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KENNETH ALLEN WENNER

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This is to certify that the

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A Computer Method
for Interpretation of Natural Resource Data
for Four Types of Land Uses

presented by

Kenneth Allen Wenner

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of the requirements for

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ABSTRACT

A COMPUTER METHOD FOR INTERPRETATION OF
NATURAL RESOURCE DATA FOR FOUR TYPES OF LAND USES

By

Kenneth Allen Wenner

To help establish a public policy and a decision making framework for land use changes there is a need for broad kinds of land resource inventories and a method of analyzing the data to determine the relative suitability of different land areas for various types of land uses. Inventories and analyses of this magnitude and scope require the collection, storage, and retrieval of vast amounts of data. Using current methods of interpreting data from tables and map overlays to determine the physical suitability of an area for different land uses are very difficult and time consuming. For these reasons there is a need for an automatic data processing system that will facilitate analysis of our land resources that is expedient, efficient, and spatially oriented.

The major objectives of this study were to develop a rapid, efficient method of analyzing large volumes of natural resource data relating to site suitability for four different land uses and to develop an index rating system capable of comparing a given site for several alternative land uses.

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The major objectives of this study were to develop a rapid, efficient method of analyzing large volumes of natural resource data relating to site suitability for four different land uses and to develop an index rating system capable of comparing a given site for several alternative land uses.

In the formulation of the implicit model, the basic assumption was that the physical site suitability for a specified land use is a function of the natural resource features relating to or possessed by the site or geographic location under consideration. The land uses considered in this study were: 1) sanitary landfills-trench type; 2) residential homes on sanitary sewers-no basements; 3) residential homes on septic filter fields-no basements; and 4) continuous corn. The range of values for each of the natural resource features considered in this study was divided into classes and each class was assigned a class number. A point system of 0 through 9 was then used to measure the degree of influence each of these classes had on a particular land use. The feature class well suited to the particular land use was rated as 0 points and the feature class presenting very serious problems to the use was rated as 9 points. Points 1 through 8 were used to designate the varying degrees of suitability. The numerical class designators were transformed into indicator or dummy variables of the -1, 0, +1 type. Natural features relevant to the land use being evaluated were designated as independent variables and the total points represented by the various classes were designated as the dependent variables. A regression coefficient for each independent variable for each land use and a constant were then obtained by regression analysis using a set of theoretical observations as sample data. The test data for the study consisted of 2 sections of land in Grand Traverse

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County, Michigan. Each section was divided by a row - column grid system into 2½ acre parcels. The selected natural resource data for each parcel was entered onto a punch card. The computer program LANDUSE was written and utilized to read the data cards for each parcel, transform the data into respective indicator variables, calculate a physical site suitability index for each land use, and print these index values in table form using the row - column locations. These values can be utilized to compare the relative suitability of a site for the four land uses or they can be used to compare several sites for a given land use. An index value of 100% would be the most desirable site from a physical feasibility standpoint.

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A THESIS

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PROBLEM STATEMENT

The desire for an automatic data processing system for analyzing information relating to the location, availability, development, and management of natural resources increases as the demand for these resources becomes greater. This demand is related to the population, and the consumption needs and habits of the various cultures of the world.

In 1970 the world population was estimated at 3632 million people with a projected increase to 4933 million people by the year 1985. The Northern America (United States and Canada) population is projected to increase from 225 million people in 1970 (Golenpaul 1972) to 280 million people in 1985. (Murdoch 1971)

With population increases of this magnitude the great question facing the world and every nation concerns the "adequacy of natural resources to provide the kind of living its people want, or in some countries merely to keep the population alive." (Landsberg et al. 1963) Most countries of the world rely on the land resource as the basic unit for providing the food, fiber and space needs of its people. In the United States "we have used this land resource rather lavishly and there is not an overall land scarcity now, nor

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With population increases of this magnitude the great question facing the world and every nation concerns the "adequacy of natural resources to provide the kind of living its people want, or in some countries merely to keep the population alive." (Landsberg et al. 1963) Many countries of the world rely on the land resource as the basic unit for providing the food, fiber and space needs of its people. In the United States "we have used this land resource rather lavishly and there is not an overall land scarcity now, nor is there likely to be one for some generation, although some adjustments in land uses will be needed." (Murdoch 1971) These adjustments will require varying degrees of public control over private lands that are fair to the individual. To help establish a public policy and a land use decision-making framework there is a need for broad kinds of natural resource inventories. (Callison 1967) There is also a need for a careful examination of the natural physical characteristics of a land unit and a need to determine the relative importance of each characteristic for different land uses. (Clawson et al. 1960)

Natural resource inventories and analysis of this magnitude and scope require the collection, storage, retrieval, and interpretation of vast amounts of data. Therefore there is a great need to devise an automatic data processing system for analyzing our land resources that is expedient, efficient, and useful.

The land resource planner or user could utilize such a data system as an aid in benefit-cost analysis and in preparation of environmental impact statements. This could be accomplished by comparing the most desired set of natural physical characteristics of a specified area. The most desired set of natural characteristics for a given land use would be that set requiring the least cost of site preparation to accomplish the desired objective without generating harmful side effects within the natural environment. For example, the desired objective may be to locate areas is there likely to be one for some generation, although some adjustments in land uses will be needed." (Landsberg 1971) These adjustments will require varying degrees of public control over private lands that are fair to the individual. To help establish a public policy and a land use decision-making framework there is a need for broad kinds of natural resource inventories. (Callison 1967) There is also a need for a careful examination of the natural physical characteristics of a land unit and a need to determine the relative importance of each characteristic for different land uses. (Clawson et al. 1960)

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The examples cited in the previous paragraph represent a few of the types of objectives or land uses that could be considered in an automatic data processing system. All of these same objectives can be accomplished without the aid of a computer system, but the large amounts of data and the great number of alternative land uses create very tedious and time consuming tasks.

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PROBLEM ANALYSIS

Evaluation of the land resource generally includes use of topographic maps prepared by the Geological Survey, U.S. Department of Interior, geological maps published by the Division of State Geological Survey, Soil Surveys published by the Soil Conservation Service, U.S. Department of Agriculture, and information from other state and federal agencies such as the Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of Interior.

Soil surveys consist of maps showing the location of the various kinds of soil and a report describing each soil and its properties. This type of survey is useful in land use planning and management for both agricultural and non-agricultural uses and for this reason they are currently in great demand. But the large quantity and complexity of the data in survey reports make them relatively difficult and time consuming to use. The soil survey is made by a soil scientist walking over the land examining the soil to at least a five foot depth with the aid of a spade or soil auger. He records selected soil data (Soil Survey Manual 1951) on an aerial photograph base and after examining several acres he delineates areas of soils that have similar

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characteristics from other areas by drawing lines on the photograph separating one area from another. The soil information is recorded on the aerial photograph by use of numeric or alphabetic codes to denote the soil type, slope and erosion. A code of this type is called a mapping unit by soil scientists. Each mapping unit represents a set of natural physical characteristics and is listed in a table with interpretations for different land uses. These interpretations may be in the form of short narratives or they may be in the form of "suitability ratings." Wenner _et al_. 1968). The suitability ratings relate the degree of hazard a particular soil character or slope presents to a given land use and is generally expressed as slight, moderate, or severe. The degree of hazard may be related to: the cost of physically preparing the site for the desired use such as land grading; the need of expensive internal soil drainage; the inability of the soil to support a specified load; the potential of a given use to cause pollution through surface sedimentation or contamination; or the ability of the soil to perform a desired function such as serving as an effluent discharge area where the effluent is to be filtered through the soil. Another method of expressing the suitability rating is to examine several soil characteristics and give a general rating for the mapping unit. This general rating may be expressed as A, B, C, D, E (Wenner _et al_. 1964) or they may be expressed as good, fair, poor, or very poor. The A or good rating would indicate the soil characteristics from other areas by drawing lines on the photograph separating one area from another. The soil information is recorded on the aerial photograph by use of numeric or alphabetic codes to denote the soil type, slope and erosion. A code of this type is called a mapping unit by soil scientists. Each mapping unit represents a set of natural physical characteristics and is listed in a table with interpretations for different land uses. These interpretations may be in the form of short narratives or they may be in the form of "suitability ratings." ([illegible]emmer et al. 1968) The suitability ratings relate the degree of hazard a particular soil character or slope presents to a given land use and is generally expressed as slight, moderate, or severe. The degree of hazard may be related to: the cost of physically preparing the site for the desired use such as land grading; the need of expensive internal soil drainage; the inability of the soil to support a specified load; the potential of a given use to cause pollution through surface sedimentation or contamination; or the ability of the soil to perform a desired function such as serving as an effluent discharge area where the effluent is to be filtered through the soil. Another method of expressing the suitability rating is to examine several soil characteristics and give a general rating for the mapping unit. This general rating may be expressed as A, B, C, D, E ([illegible]emmer et al. 1964) or they may be expressed as good, fair, poor, or very poor. The A or good rating would indicate the soil is well suited to that particular land use whereas the E or very poor rating would indicate the soil is not suited to a particular land use.

The user of soil survey information must determine from the aerial photographs the mapping unit or units covering his area of interest, then refer to the interpretation tables for a suitability rating for the specified land use. He must then associate the suitability ratings or different soil characteristics for a given land use with the location of the mapping unit. If the user wishes to make comparisons of the general suitability of a given site or area for alternative land uses he must make separate interpretations for each use. Very often the user constructs a table of his own wherein he lists the mapping unit for the area of interest and the respective suitability ratings for the different uses he wishes to consider. But the user must still attempt to visually associate these ratings with their respective locations. If the area is very large, then the user has difficulty and generally resorts to making land use suitability maps by preparing several copies of the map covering his area of interest and properly locating the appropriate mapping unit delineations. He then constructs a suitability table for the different land uses he wishes to consider, prepares a color code for his suitability ratings, and prepares a color map for each land use. He then examines each map by looking at the colors. From his color code he identifies areas that are suitable for a particular land use is well suited to that particular land use whereas a D or very poor rating would indicate the soil is not suited to a particular land use.

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Another method commonly employed in preparing land use suitability maps is the preparation of soil characteristic "overlays". This consists of using the soil maps and preparing a transparent overlay for several of the different physical characteristics and rating them as to their suitability for a given land use. These overlays are generally color coded with green representing the most suitable condition, red representing the unsuitable condition, and yellow representing the intermediate situation. (Quay 1966)

Two of the difficulties in using the table method are the problems of location and the inability to make a quantitative evaluation between several alternative land uses. The degree and extent to which a site is listed as moderately suitable or not suitable depends upon the number of factors considered. As an example: if a site were evaluated on the basis of four or five physical properties and any one of these properties presented a severe limitation to the specified use then the site is listed as having a "severe limitation" or "not suited." But if another site was evaluated for the same land use using the same type of and moves this on a master land use suitability map. Certain areas of the map may be well suited for several types of land uses while other areas may be very restricted. (Montgomery and Edminster, 1966) The land use suitability map is then used in conjunction with other planning factors, such as social, economic or political, to develop a comprehensive plan for the area.

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Knowing the exact areal location of the various soils is beneficial to the user in planning the use of an area. Very often one mapping unit present within an area may be more expensive to develop for a given use than another mapping unit. The development or management costs can often be lowered if the user can select the type of use or locate different uses within the area to more nearly coincide with the suitability ratings. The final decision on land use generally must be based on natural features, and on social, political, and economic considerations.

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More sophisticated methods of combining the table method and the overlay method have been proposed for land use planning. Belknap and Furtado (1968) compared the Lewis, McHarg, and Hills approaches to utilizing the natural land unit as a planning base. They concluded from these comparisons that there are ways to identify, evaluate and incorporate ecological values into the normal planning and design process. The mechanical difficulty and complexity of utilizing natural resource information in the basic planning has prompted the use of automatic data processing.

The University of Illinois and The Northeast Illinois Natural Resource Service Center proposed a Natural Resource Information System (NARIS 1970) to provide a wide range of natural resource data for an eight county area in northeast Illinois. The system would contain information on soils, geology, hydrology, forestry, climatology, water impoundment, topography and land use. The data would be recorded for areas of forty acres in size. A library file would store information on each resource concerning various interpretations for a wide range of purposes.

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The State Planning Agency of Minnesota is developing a Minnesota Land Information System. (MLIS 1970) Data for this system are collected for 40 acre parcels and contain basic parcel location, ownership, dominant soil type and current land use for the entire state, plus various land acquisition methods, status, and management recommendation for certain state and county owned lands. The first large-scale use of this system will be to produce land-use maps for each of Minnesota's eleven planning regions. In the future maps will be produced which will permit the evaluation of each parcel for best land use and form the basis for recommendations regarding disposition of state and tax-forfeit land in the cooperating counties.

Natural resource features form an integral part of both NARIS and the MLIS systems but no stress is given to the integration of several natural resource features or factors into a composite land use suitability rating system. The NARIS system utilizes a library data file for storing soils information and the output from this file is in the form of slight, moderate or severe ratings denoting the degree of physical hazards for a given land use. The user is unable

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The State Planning Agency of Minnesota is developing a Minnesota Land Information System. (MLIS 1970) Data for this system are collected for 40 acre parcels and contain basic parcel location, ownership, dominant soil type and current land use for the entire state, plus various land acquisition methods, status, and management recommendation for certain state and county owned lands. The first large-scale use of this system will be to produce land-use maps for each of Minnesota's eleven planning regions. In the future maps will be produced which will permit the evaluation of each parcel for best land use and form the basis for recommendations regarding disposition of state and tax-forfeit land in the cooperating counties.

Natural resource features form an integral part of both NARIS and the MLIS systems but no stress is given to the integration of several natural resource features or factors into a composite land use suitability rating system. The NARIS system utilizes a library data file for storing soils information and the output from this file is in the form of slight, moderate or severe ratings denoting the degree of physical hazards for a given land use. The user is unable to retrieve the basic soil property data if he wishes to make further study of a site. Another difficulty with both of the systems is the size of the basic parcel. By limiting the data collection to a 40 acre parcel there is the assumption that the entire parcel is uniform in character and this may represent a large spatial aggregation error.

The Iowa Land Use Analysis Laboratory (Sinatra et al. 1972) is currently participating in a natural resources study of the state of Iowa. The state has been divided into 10 resource regions and data on topography, superficial water, roads, degree of urbanization, forest cover, primary soils, secondary soils, tertiary soils, buried valleys, bedrock topography, shallow bedrock aquifer, pizeometric surface and special land use are entered on a grid coordinate location matrix. To map these features the laboratory has purchased the GRID III computer program from the Computer Graphics Laboratory of Harvard University. Three mapping scales are being examined--640 acres, 169 acres and 40 acres, with supplementary projects investigating grids of 2.5 acres and squares of 100 feet. The researchers on this project indicate that it may be possible to assign weights to each of the data variables and their separate characteristics in order to select cells with optimal physical conditions for certain land uses. One of the major difficulties with the data system arises from the type of soils data input. The soils listed as occurring to retrieve the basic soil property data if he wishes to make further study of a site. Another difficulty with both of the systems is the size of the basic parcel. By limiting the data collection to a 40 acre parcel there is the assumption that the entire parcel is uniform in character and this may represent a large spatial aggregation error.

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CHAPTER 3

STUDY OBJECTIVES

The major objectives of this study were to: 1) develop a rapid, efficient method of analyzing large volumes of natural resource data relating to site suitability for different land uses; 2) spatially orient large volumes of natural resource data for automatic processing; 3) develop a site suitability index rating system capable of integrating different types of natural resource data into one index value for a specified land use; and 4) develop an index rating system capable of rapidly comparing a given site for several alternative land uses.

In selecting a method of analyzing large volumes of data the objective was not merely to synthesize the data into information for the sole purpose of demonstrating storage and retrieval methods, but rather to analyze relevant data and produce useful and meaningful interpretations. Therefore serious consideration was first given to the types of interpretations that were to be considered or that could be considered. Then several methods of analysis were considered that might possibly meet the requirements of the system. Another consideration was the selection of a method that would be flexible enough to identify sets of properties with one identifier label. This permits the identifier to

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In attempting to spatially orient data, careful consideration was given to the size or areal extent of the unit to be identified. The type of use to be made of the output determines to a great extent the size of the unit to be considered. In the case of general or broad land use suitability ratings, the units can be larger than those that are to be utilized for more detailed investigation. Therefore, the decision was made to utilize a small basic unit with the capability of aggregating the smaller units into whatever larger size was desired. It would be impossible to attempt to split a large input unit for more detailed analysis.

While developing the index rating system consideration was given to the fact that information on soils, geology, topography, and climatology were to be integrated into a composite value for a specified land use. This necessitated determining the use to be made of the rating and identifying the type of person that might utilize this rating. If the users represented a professional homogeneous group then a complex system could be developed along with an intensive training program explaining the derivation and use of the rating system. However, the potential users may represent be in primary storage and the set of corresponding iden-tifier properties to be located in a supplementary storage system. This requires the introduction of a detailed set of properties only once but the identifier may be present in the primary system numerous times. This concept reduces the size of primary storage needed.

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The framework for deriving the index rating system had to be broad enough to permit different types of information to be considered but specific enough to allow consistency and quantification.

Attempting to compare a given site for several alternative land uses utilizing an overlay or colored map procedure requires a considerable amount of time and effort. Therefore, some type of rating system was desired that could permit the analysis of a large group of natural physical properties for several alternative land uses. Again the type of audience or potential user of the index rating had to be considered in its formulation. The rating system not only had to be usful, but also simple, relatively understandable and easily computed.

CHAPTER 4

METHODS AND PROCEDURES

General Introduction

The procedures to accomplish the objectives of this study consisted of seven basic phases. In each phase there were generally several alternative methods that could be employed to meet the objective and in some phases several alternative methods were employed before a satisfactory method was obtained. There is no intent in this report to analyze all of the possible alternatives, but merely to relate the work that was performed and the results obtained. There were several assumptions made during the course of the study and these will be indicated where appropriate.

Formulation of the Implicit Model

In the formulation of the implicit model the basic assumption was made that the physical site suitability (PSS) for a specified land use is a function of the natural resource features relating to or possessed by the site or geographic location under consideration. Also, it was assumed that each land use has a unique set of desired natural physical characteristics and one element or feature within a set may be more important than other elements. Therefore, each element or feature must be evaluated

General Introduction

The procedures to [illegible]

study consist of [illegible]

were [illegible]

employed [illegible]

alternative [illegible]

method [illegible]

analyze all [illegible]

relate the [illegible]

There were several [illegible]

[illegible]

separately for each land use. This assumption was further expanded to infer that the variables within the function are additive.

The implication here is that an initial cost would be associated with overcoming or correcting a single natural feature presenting a problem for a given land use and the cost of correcting another feature of equal hazard on the same site would be relatively equal to the initial cost. But this may not always be the true situation. For example, if a site being evaluated for sanitary landfill was a very permeable sand with a flooding potential, the cost of protecting the ground water from possible contamination may or may not be equal to the cost of protecting the area from flooding. Both situations would be considered as presenting severe limitations to the use in question and would be considered as equal in the physical site suitability rating. Also, in the additive index rating system the relative cost of overcoming one hazard is considered as completely independent of overcoming another hazard. This may not always be true. However, the cost of overcoming two severe hazards is greater than the cost of overcoming just one severe hazard. Therefore, there is a need for some type of additive model. To determine the exact cost of overcoming each hazard under actual field conditions would require extensive investigations of each site. This would be very expensive.

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The alternative then is to devise a point system based on judgment and field experience to evaluate the relative difficulty of overcoming each feature that may present a problem for a given land use and add these points to get an overall quantative rating for a site.

Land Uses and Natural Features

Utilizing the above assumption the first task was to define the land uses to be considered in the study. They are: 1) sanitary landfill sites, trench type; 2) residential home sites with sanitary sewers and no basements; 3) residential home sites requiring septic filter fields and no basements; and 4) continuous corn sites.[1] In selecting these land uses the intention was to illustrate two urban classifications with slightly different physical properties being considered, one agricultural classification, and one special land classification.

The next step in the formulation of the implicit model was to determine the natural resource features that were to be considered. There were two alternative methods to consider at this point. One method considered was to devise a list of all natural resource features and catalog as much data as possible. The other approach was to carefully analyze the land uses to be considered and select natural resource features considered to be the most

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relevant, thereby limiting data collection to these features. The latter procedure was selected, while fully realizing that there are additional features to be considered. Of course, the researcher must weigh the cost of collecting extra data against the information to be gained and the objectives of the study.

In attempting to determine the resource features to consider for each land use, investigations were made as to what features the different land use planning agencies were currently utilizing and what types of interpretations were currently available from natural resource agencies. It was found that most land use planning agencies utilize information relating to natural resources that state and federal agencies are capable of supplying. The agencies supplying the bulk of this information in the mid-western states are: Soil Conservation Service (SCS), U.S. Department of Agriculture; Geological Survey, U.S. Department of Interior; State Agricultural Colleges; State Agricultural Experiment Stations; and State Natural Resource Departments. These agencies generally work very closely on the land use suitability interpretations and often publish jointly sponsored tables for different uses. Therefore, most of the interpretations relating the natural resource data to the specific land uses included in this study were obtained from these sources and are documented as to the resource person, publication, or memorandum.

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Sanitary Landfills - Trench Type

The overall purposes of a trench type sanitary land fill are to bury solid wastes in the soil without pollution to the ground water, with a minimum of odor, with a minimum of unsightliness, and at minimal cost of burying, digging, and hauling. To meet these objectives the site should have a total soil (topsoil, subsoil and underlying material) depth to allow for the excavation of a trench of at least 7 to 10 feet deep with an additional 10 to 30 feet of soil material under the trench. The slope of the land surface should not be over 25 per cent to allow the safe operation of large mechanical equipment. The permeability rate of the subsoil and underlying material should not be greater than two minutes per inch. This creates an underlying seal preventing leacheate from entering the ground water. Sufficient soil material should be readily available to permit covering of the wastes with six inches of soil on a daily basis to prevent the blowing of paper and to help control odors and with 2 feet of material when the fill is completed. The seasonal ground water table should be low enough that water never enters the trench and the area should not be subject to flooding. The relative number and size of stones is also a factor considered to be important to the ease of digging and movement of material.

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The natural resource factors considered to be most important to the achievement of the objectives for trench type sanitary land fills are; slope, texture of the underlying material, natural soil drainage, permeability of underlying material, flooding potential, and depth to bedrock. (Kellogg, 1971, page 30)

Information on these variables is readily available from soil survey maps produced by the SCS. However, soils maps are limited to interpretations of the upper five feet of material. Therefore, the value obtained from such information is somewhat limited but has the advantage of readily permitting the disqualification of potentially "unsuited" sites from further consideration. For this reason the soil survey map is considered a vital informational tool in the initial selection of land fill sites and a special interpretation table has been set up for this purpose.

Residential Homes With Sanitary Sewers

Residential home site evaluations in this study are defined as being appropriate to single family dwellings of not more than three stories high, located on ¼ to ½ acre lot sizes and without basements. The emphasis for rating soils is on stability or ability of the soil to support a foundation, and wetness potential. Other natural features influencing the cost of development are slope, depth to bedrock and stoniness. Soil permeability is an additional natural feature considered very important if the home site requires a septic tank effluent filter field. In order to type sanitary land fills are; slope, texture of the under-lying material, natural soil drainage, permeability of under-lying material, flooding potential, and depth to bedrock. (Kellogg, 1971, page 30)

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In considering the natural features for homes having access to sanitary sewers, slope classes 1 and 2 were not considered as causing a problem to development. Slopes in class 3 would require a certain amount of cutting and filling and were therefore rated as having a moderate limitation. Slope class 4 may require considerable cutting and filling operation but the aesthetics of the rolling topography would somewhat off set this additional cost. Therefore, these slopes were rated as having moderate to severe limitation. On slope classes 5 and 6 the cost of cutting and filling would be considerable and were rated as presenting severe limitations.

Surface soil texture was not considered as a dominating force in the evaluations. However, if the site consisted of texture classes 1 or 2 (clayey) or texture class 5 (sandy) for surface soil then there would be an additional difficulty in establishing a lawn or shrubs. Sites having these surface soil textures were rated as presenting moderate limitation. Soils with a subsoil texture class 1 were rated as moderate because there would be an additional hazard to foundation development due to the greater shrink-swell potential of the clay, but the hazard would not be severe.

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Natural drainage class 1, or those soils having a water table 0 to 1 foot from the surface at least part of the year, were considered as presenting a severe limitation to use. Soils in natural drainage class 2 would require special water management and were considered as presenting a moderate limitation. Moderately well drained and well drained soils (natural drainage classes 3 and 4) do not present any major problems for residential development.

Soils high in organic matter are very unstable when wet and provide a serious problem for foundations. When these same soils are dried the organic matter will oxidize and cause subsidence of the soil mass which presents an additional problem to foundation or road construction. Utilization of soil areas classified as muck or peat for roads or permanent buildings present special problems. The entire depth of organic material must be either removed, bridged, or special floating foundations must be constructed. These corrective measures are very expensive, thus the degree of hazard is considered very severe and an index value was not calculated for soils classified as muck or peat. Soils having no organic matter (class 4) would be considered as presenting a problem to landscaping and were considered as presenting a moderate limitation. Soils having 5 to 8 per cent (class 2) organic matter would require that the surface soil be removed under driveways, sidewalks and roads and were therefore rated as presenting a moderate

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The number and size of stones are directly related to the ease of excavating and grading. Stoniness classes 1 and 2 were not considered to be a problem for small excavating equipment and were rated as presenting a slight limitation. Stoniness class 3 would require larger equipment to remove the stones but their frequency would not present an impossible situation and was rated as presenting a moderate limitation. Stoniness class 4 would require constant removal with large equipment during excavation and their frequency would make avoiding them nearly impossible. Soils with this problem were rated as presenting a severe limitation.

Potential flooding is a severe situation for residential development. If an area was considered to be subject to flooding once in 25 years (class 3) this was considered to be a severe limitation. For certain types of land uses there is reason to include an intermediate class 2 but these were not included in this study. If the area did not flood then it was considered as class 1 and rated as not presenting a limitation.

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The depth to bedrock is directly related to the ease of excavating for utility lines to maintain a desired depth, and to the ease of constructing foundations for homes. If the bedrock was listed as being deeper than 60 inches (class 1) then the soil was rated as having a slight limitation. If the bedrock was at a depth of 40 to 60 inches (class 2) then there probably would be areas where minor blasting or drilling would be required and the soil was rated as presenting a moderate limitation. But if the area had bedrock within 40 inches (classes 3,4 and 5) of the surface then the amount of drilling and blasting required would be increased and the soil was rated as presenting a severe limitation.

Residential Homes With Septic Filter Fields

The natural features and their limitations that were discussed for residential homes having access to sanitary sewers are similar to the natural features influencing the ratings for residential homes requiring septic tank effluent filter fields. The exceptions are (1) the addition of subsoil permeability, and (2) changing the limitation rating of natural drainage class 2. In the development of a filter field the objective is to filter the effluent from the septic tank into the soil. For the septic tank to function properly the soils in the immediate area must be permeable enough to transmit the volume of water used in the household through the soil. Soils in permeability class 3 are generally considered too impervious for septic filter fields but with installation of extra large fields and to the cost of constructing foundations for homes. If the bedrock was listed as being deeper than 60 inches (class 1) then the soil was rated as having a slight limitation. If the bedrock was at a depth of 40 to 60 inches (class 2) then there probably would be areas where minor blasting or drilling would be required and the soil was rated as presenting a moderate limitation. But if the area had bedrock within 40 inches (classes 3,4 and 5) of the surface then the amount of drilling and blasting required would be increased and the soil was rated as presenting a severe limitation.

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The SCS in cooperation with other state and federal agencies has developed an interpretation table whereby the factors discussed for residential development are the basic units considered in this study. (Kellogg, 1971, page 28)

The interpretation table as prepared by the SCS for each of the above three land use classifications are based on individual natural feature values and each feature is rated as having slight, moderate or severe hazard for the land use in question.[1] In these tables if any one of these variables is rated as presenting a severe hazard to development for the specified land use, then the site is listed as having a severe rating. But if all the properties have

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a severe rating the site is still rated as being severe. There is no allowance for degrees of severity and all the variables are essentially rated as having equal weight in the final rating.

Continuous Corn

Ideally the best sites for continuous corn are those capable of producing the highest yields with the least production cost and without detrimental effects to the soil.

The natural resource features considered for continuous corn were not as clearly delineated in published tables. However, a composite yield rating has been developed for each soil. These composite ratings are based on experimental data and field experience on representative soils and interpolation of this information for other soils. The list of natural features and the point system actually considered in these composite ratings were obtained through a personal interview with Harry Galloway.[1] They are: slope, surface soil texture, subsoil texture, topsoil depth, organic matter, soil depth favorable to root development, available water, flooding, topographic position, and freeze free period. Currently Ray Dideriksen[2] is preparing a yield productivity table for the major agricultural

[1]Professor in the Department of Agronomy, Purdue University, West Lafayette, Indiana.

[2]State Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture, Indianapolis, Indiana.

crops of Indiana. This table evaluates the potential contribution of different soil properties to yield for certain bench mark soils. Using criteria developed in this study and as well as criteria utilized by Dideriksen, the importance of natural soil drainage was a difficult issue to evaluate. Therefore, the basic assumption for this study was that all soils were adequately drained so that timeliness of operation would not be deterred due to poor drainage. Dideriksen projected his tables to include both improved natural soil drainage and unimproved drainage.

Natural Features

All of the natural resource features considered in this study are: surface soil texture, subsoil texture, texture of the underlying material, natural soil drainage, topsoil depth, organic matter, stoniness, soil depth generally favorable to root growth, relative permeability of the subsoil, available water, slope, flooding, topographic position, and length of freeze-free period. Soil erosion was also included in the list of variables but was not considered in the suitability calculations.

The next step was to determine the units of measurements of each of these natural features and the range of these measurement values. Eight of the variables were measured in interval and ratio scale, 5 in the nominal scale, and the remainder of the variables were measured in ordinal scale. Existing tables (Kellogg 1968), (IN-SOILS-1-1970),

(Soil Survey Manual) and personal consultations with Guy Earle[1] and Harry Galloway were utilized in dividing each natural feature into classes or categories and all the measurements were converted to the nominal scale.[2] In this conversion process there is a loss of data which indicated that variables previously measured in ordinal and interval scales (actual values) now merely are within a specified range and this range is designated by a number. Also, Blalock (1960 - page 13) points out that using numbers arbitrarily associated with each category does not justify the use of the usual arithmetic operations on these numbers. This negates the validity of including standard errors in this study.

Table 1 lists the natural features, the measurement unit, the class separations, the respective numerical class designations, and a reference for the definition of each class.

Formulation of Explicit Model

In the formulation of the explicit model a method had to be devised to quantitatively evaluate each variable that was considered relevant to each land use. The first attempt in the quantification process consisted of using the class designators for the variables measured in ordinal and nominal scale and actual values for variables measured in ratio scale.

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[1]Assistant State Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture, East Lansing, Michigan.

[2]The reasons for this conversion are explained on page 33.

(Soil Survey Manual) and personal consultations with Ivan Earle[1] and Harry Galloway were utilized in dividing each natural feature into classes or categories and all the measurements were converted to the nominal scale.[2] In this conversion process there is a loss of data which indicated that variables previously measured in ordinal and interval scales (actual values) now merely are within a specified range and this range is designated by a number. Also, Blalock (1960 - page 12) points out that using numbers arbitrarily associated with each category does not justify the use of the usual arithmetic operations on those numbers. This negates the validity of including standard errors in this study.

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[2]The reasons for this conversion are explained on page 32.

TABLE 1

Natural Resource Features, Measurement Units, Their Respective Class Separation, and Numerical Designation.

Natural Features	Measurement Unit	Class Separation	Class Designation
Soil Erosion[1]		slight	1
		moderate	2
		severe	3
Surface Soil[2] Texture		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Subsoil Texture[2]		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Underlying Material[2] Texture		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Natural Soil[1] Drainage		poorly	1
		somewhat poorly	2
		moderately well	3
		well	4
		somewhat well to excessively well	5
Topsoil Depth[2]	inches	greater than 16	1
		11-16	2
		7-10	3
		3-6	4
		0-2	5
Organic Matter[2]	per cent	greater than 9	1
		5-8	2
		3-4	3
		0-2	4
Stoniness[1]		class 0	1
		class 1	2
		class 2	3
		classes 3,4,5	4

TABLE I

Natural Features, Their Measurement Units, Their Respective Class Subdivision, and Individual Ratings.

Natural Features	Measurement Unit	Class Designation	Class Rating
Soil Erosion[1]		slight	1
		moderate	2
		severe	3
Surface Soil[2] Texture		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Subsoil Texture[2]		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Underlying Material[2] Texture		fine	1
		moderately fine	2
		medium	3
		moderately coarse	4
		coarse	5
Natural Soil[1] Drainage		poorly	1
		somewhat poorly	2
		moderately well	3
		well	4
		somewhat well to excessively well	5
Topsoil Depth[2]	inches	greater than 16	1
		11-16	2
		7-10	3
		3-6	4
		0-2	5
Organic Matter[2]	per cent	greater than 9	1
		7-9	2
		3-4	3
		0-2	4
Stoniness[1]		class 0	1
		class 1	2
		class 2	3
		classes 3,4,5	4

TABLE 1 (Cont'd)

Natural Features	Measurement Unit	Class Separation	Class Designation
Soil Depth[2]	inches	greater than 60	1
		40-60	2
		20-39	3
		10-19	4
		less than 10	5
Permeability[2]	inches per hour	less than .2	1
		.2-.6	2
		.7-2.0	3
		2.1-6.0	4
		greater than 6.0	5
Available Water[2]	total inches of effective soil depth	more than 12	1
		9-12	2
		6-8	3
		3-5	4
Slope[2]	per cent	0-2	1
		3-6	2
		7-12	3
		13-18	4
		19-25	5
		greater than 25	6
Flooding	1 year in 25 years	no	1
		yes	3
Topography[3]	position	upland high ground	1
		depressional high ground	2
		terrace high ground	3
		terrace depressional	4
		bottomland or alluvial	5
Depth to Bedrock[2]	inches	more than 60	1
		40-60	2
		20-39	3
		10-19	4
		0-9	5
Freeze free period[4]	days	less than 90	1
		91-120	2
		121-150	3
		more than 150	4

TABLE 1 (Cont'd)

Natural Features	Unit	Class Description	[illegible]
Soil Depth[2]	inches	greater than 60	1
		40-60	2
		20-39	3
		10-19	4
		less than 10	5
Permeability[2]	inches per hour	less than .2	1
		.2-.6	2
		.7-2.0	3
		2.1-6.0	4
		greater than 6.0	5
Available Water[2]	total inches of effective soil depth	more than 12	1
		9-12	2
		6-8	3
		3-5	4
Slope[2]	per cent	0-2	1
		3-6	2
		7-12	3
		13-18	4
		19-25	5
		greater than 25	6
Flooding	1 year in 25 years	no	1
		yes	3
Topography[3]	position	broad level high ground	1
		[illegible] ground	2
		terrace high ground	3
		terrace or [illegible]	4
		bottomland or alluvial	5
Depth to bedrock[2]	inches	more than 60	1
		40-60	2
		20-39	3
		10-19	4
		0-9	5
Freeze free period[4]	days	less than 90	1
		90-120	2
		121-150	3
		more than 150	4

TABLE 1 (Cont'd)

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[1]Class measurement units and class qualitative terms are as described in SOIL SURVEY MANUAL (1951).

[2]Class measurement units and class qualitative terms are described in IN-SOILS-1-1970.

[3]Class measurement units and class qualitative terms are described by Galloway _et al._ (1968).

[4]Class measurements and class qualitative terms are described by Van Den Brink, _et al._ (1971).

TABLE I (Cont'd)

[1] Class measurement units and class qualitative terms are as described in Soil Survey Staff (1951).

[2] Class measurement units and class qualitative terms are described in IX-SCIII-1-1970.

[3] Class measurement units and class qualitative terms are described by Halliday et al. (1970).

[4] Class measurements and class qualitative terms are described by Van den [illegible], et al. (1970).

The predictive quality of this attempt was very poor. The second attempt was to utilize the numerical class designator for each variable in some type of additive point system. However, a class designator of 1 may be ideal for one feature whereas a designator of 3 may be ideal for another feature. An attempt was then made to arrange the classes for a given feature into an order of desirability. But the order was not consistent for different land uses which would then require a rearrangement of the classes for every land use. The concept of utilizing the actual numerical class designators or actual measurement values in further computation was discontinued in favor of using indicator variables of the -1, 0, +1 type. (Ruble 1967) The number of variables needed for each feature is N-1 where N = the number of classes or class groups to be evaluated. The following example illustrates the structure of these variables in evaluating slope for sanitary landfills.

If Slope Class = 1,2,3
X5 = 1
X6 = 0

If Slope Class = 4,5
X5 = 0
X6 = 1

If Slope Class = 6
X5 = -1
X6 = -1

Note that in the above example slope classes 1,2, and 3 present slight limitations for development of sanitary landfills and have been considered as 1 group. Slope classes 4 and 5 present moderate limitations and have been grouped together. Slope class 6 presents a severe limitation and is considered by itself, thus making a total of 3 slope class

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Note that in the above example slope classes 1,2, and 3 present slight limitations for development of sanitary landfills and have been considered as 1 group. Slope classes 4 and 5 present moderate limitations and have been grouped together. Slope class 6 presents a severe limitation and is considered by itself, thus making a total of 3 slope class groups to be considered for sanitary landfills. Applying the N-1 formula there is a need for 2 variables.

The first step to determine the relative weight or value of each variable was to devise a point system to quantify each class or class group according to its degree of suitability for the land use under consideration. A point spread of 0-9 (inclusive) was utilized, 0 points designates the most suitable class and 1-9 points represents the degree of suitability, with 9 points representing a very restrictive situation.

The second step consisted of setting up a series of observations as sample data (page 44). In these samples the dependent variable consisted of the summation of points for the occurring classes of natural features influencing a given land use (page 44). Once the total points for each observation was determined, the classes or class group were then transformed into the indicator variables as explained on page 33. The sample data were then submitted for regression analysis to determine the regression coefficient of each variable and the constant for each land use. In the final analysis of the test data (page 50) the natural feature classes were transformed into the indicator variables, and the constant and regression coefficients for the independent variables were utilized to calculate the dependent variable.

Tables 2, 3, 4, and 5 list the natural features, the class or classes, the variable identification, and the class points for sanitary landfills, residential homes with groups to be considered for sanitary landfills. Applying the N-1 formula there is a need for 2 variables.

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Tables 2, 3, 4, and 5 list the natural features, the class or classes, the variable identification, and the rating points for sanitary landfills, residential homes with

TABLE 2

The Natural Feature, the Class, Variable Designation, and the Respective Class Points for Trench Type Sanitary Landfills.[1]

Natural Feature	Class	Variable	Points[2]
Slope	1,2,3	X5	0
	4,5	X6	3
	6		9
Subsoil Texture	3	X7	0
	1,2,4	X8	3
	5		9
Natural Drainage	3,4,5	X2	0
	1,2		9
Stoniness	1,2	X10	0
	3	X11	3
	4		9
Permeability	1,2,3	X4	0
	4,5		9
Flooding	1	X3	0
	3		9
Depth to Bedrock	1	X9	0
	2,3,4,5		9

[1]The basic information for this table was taken from Kellogg (1971, Table 7, page 30). The major change being the use of points in lieu of the slight, moderate or severe limitations as defined by Kellogg.

[2]0 points denote the feature class or classes that present a slight limitation, 3 points denote the feature class or classes that present a moderate limitation, and 9 points denote the feature class or classes that present a severe limitation.

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Natural Feature	Class	Variable	Points[2]
Slope	1,2,3	X5	0
	4,5	X6	3
	6		9
Subsoil Texture	3	X7	0
	1,2,4	X8	3
	5		9
Natural Drainage	3,4,5	X2	0
	1,2		9
Stoniness	1,2	X10	0
	3	X11	3
	4		9
Permeability	1,2,3	X4	0
	4,5		9
Flooding	1	X3	0
	3		9
Depth to Bedrock	1	X9	0
	2,3,4,5		9

[1] The basic information for this table was taken from Kellogg (1971, Table 7, page 30). The major change being the use of points in lieu of the slight, moderate or severe limitations as defined by Kellogg.

[2] 0 points denote the feature class or classes that present a slight limitation, 3 points denote the feature class or classes that present a moderate limitation, and 9 points denote the feature class or classes that present a severe limitation.

TABLE 3

The Natural Features, the Class, Variable Designation and the Class Points for Residential Homes with Sanitary Sewers - No Basements.[1]

Natural Features	Class	Variable	Points[2]
Slope	1,2	X2	0
	3	X3	3
	4	X4	6
	5,6		9
Surface Texture	3,4	X5	0
	1,2,5		3
Subsoil Texture	2,3,4,5	X6	0
	1		3
Natural Drainage	3,4,5	X7	0
	2	X8	3
	1		9
Organic Matter[3]	3	X9	0
	2,4	X10	3
	1		9
Stoniness	1,2	X11	0
	3	X12	3
	4		9
Flooding[3]	1	X13	0
	3		9
Depth to Bedrock	1	X14	0
	2	X15	3
	3,4,5		9

[1]Basic information taken from Kellogg (1971, table 6, page 28) and unpublished SCORECARD FOR HOMESITE EVALUATIONS prepared by the Department of Agronomy, Purdue University, West Lafayette, Indiana. The major difference being the use of points in lieu of the slight, moderate, moderate to severe, and severe rating.

[2]0 points denote the feature class or classes that present slight limitations, 3 points denote the feature class or classes that present moderate limitations, 6 points denote the feature class or classes that present moderate to severe limitation, and 9 points denote the feature class or classes that present severe limitations.

TABLE 2

The Natural Features, the Class, [illegible] Information and the Class Points for [illegible] Residential [illegible] with [illegible] 5 years - [illegible].[1]

Natural Features	Class	Variable	Points[2]
Slope	1,2	X1	0
	3	X3	3
	4	X4	6
	5,6		9
Surface Texture	3,4	X5	0
	1,2,5		3
Subsoil Texture	2,3,4,5	X6	0
	1		3
Natural Drainage	3,4,5	X7	0
	2	X8	3
	1		9
Organic Matter[3]	3	X9	0
	2,4	X10	3
	1		9
Stoniness	1,2	X11	0
	3	X12	3
	4		9
Flooding[5]	1	X13	0
	3		9
Depth to Bedrock	1	X14	0
	2	X15	3
	3,4,5		[illegible]

[1]Basic information taken from [illegible] (1971, table 6, page 28) and unpublished land capability ratings prepared by the Department of Agronomy, Purdue University, West Lafayette, Indiana. The major difference being the use of points in lieu of the slight, moderate, moderate to severe, and severe rating.

[2]0 points denote the feature class or classes that present slight limitations, 3 points denote the feature class or classes that present moderate limitations, 6 points denote the feature class or classes that present moderate to severe limitation, and 9 points denote the feature class or classes that present severe limitations.

TABLE 3 (Cont'd)

---

[3]Organic matter class 1 and flooding class 3 were considered as very severe limitations and too difficult to overcome for residential use and no index values were calculated for sites having these values.

TABLE 4

The Natural Features, Their Class, Variable Designation, and the Class Points for Residential Homes Requiring Septic Filter Fields - No Basements.[1]

Natural Features	Class	Variables	Points[2]
Slope	1,2	X2	0
	3	X3	3
	4	X4	6
	5,6		9
Surface Texture	3,4	X5	0
	1,2,5		3
Subsoil Texture	2,3,4,5	X6	0
	1		3
Natural Drainage	3,4,5	X7	0
	2	X8	6
	1		9
Organic Matter[3]	3	X9	0
	2.4	X10	3
	1		9
Stoniness	1,2	X11	0
	3	X12	3
	4		9
Flooding[3]	1	X13	0
	3		9
Depth to Bedrock	1	X14	0
	2	X15	3
	3,4,5		9
Subsoil Permeability	4,5	X16	0
	3	X17	3
	2	X18	6
	1		9

[1]Basic information taken from Kellogg (1971, Table 6, page 28) and unpublished SCORECARD FOR HOMESITE EVALUATION prepared by the Department of Agronomy, Purdue University, West Lafayette, Indiana. The major difference is the use of the point system in this study in lieu of the slight, moderate, moderate to severe and severe ratings.

TABLE 4

The Natural Features, Their Class, Variable Designation, and the Class Points for [illegible] Filter Fields - No Restraints.[1]

Natural Features	Class	Variables	Points
Slope	1,2	X2	0
	3	X3	3
	4	X4	6
	5,6		9
Surface Texture	3,4	X5	0
	1,2,5		3
Subsoil Texture	2,3,4,5	X6	0
	1		3
Natural Drainage	3,4,5	X7	0
	2	X8	6
	1		9
Organic Matter[3]	3	X9	0
	2.4	X10	3
	1		9
Stoniness	1,2	X11	0
	3	X12	3
	4		9
Flooding[3]	1	X13	0
	3		9
Depth to Bedrock	1	X14	0
	2	X15	3
	3,4,5		9
Subsoil Permeability	4,5	X16	0
	3	X17	3
	2	X18	6
	1		9

[1]Basic information taken from Kellogg (1971, Table 6, page 28) and unpublished SOIL AND [illegible] EVALUATION prepared by the Department of Agronomy, Purdue University, West Lafayette, Indiana. The major difference is the use of the point system in this study in lieu of the slight, moderate, moderate to severe and severe ratings.

TABLE 4 (Cont'd)

---

[2]0 points denote the feature classes that present slight limitations, 3 points denote the feature classes that present moderate limitations, 6 points denote the feature classes that present moderate to severe limitations, and 9 points denote the classes that present severe limitations.

[3]Organic matter class 1 and flooding class 3 were considered to be severe limitations and too difficult to overcome for residential use and no index values were calculated for sites having these values.

TABLE 4 (Cont'd.)

---

[2] 0 points denote the feature classes that present slight limitations, 3 points denote the feature classes that present moderate limitations, 6 points denote the feature classes that present moderate to severe limitations, and 9 points denote the classes that present severe limitations.

[3] Organic matter class 1 and flooding class 3 were considered to be severe limitations and too difficult to overcome for residential use and no index values were calculated for sites having these values.

TABLE 5

The Natural Features, Their Class, Variable Designation, and the Class Points for Continuous Corn.[1]

Natural Features	Class	Variable	Points[3]
Slope[2]	1	X2	0
	2	X3	2
	3	X4	6
	4,5		9
Surface Texture	3	X5	0
	2,4	X6	3
	1,5		6
Subsoil Texture	3	X7	0
	2,4	X8	2
	1,5		4
Topsoil Depth	1,2	X9	0
	3	X10	2
	4	X11	4
	5		6
Organic Matter	1,2,3	X12	0
	4	X13	2
	5		6
Stoniness	1,2	X14	0
	3	X15	3
	4		6
Soil Depth Favorable to Root Development	1,2	X16	0
	3	X17	3
	4	X18	6
	5		9
Available Water	1,2	X19	0
	3	X20	2
	4	X21	6
	5		9
Flooding	1	X22	0
	3		6
Topographic Position	2,4,5	X23	0
	1,3		3
Freeze Free Days	3,4	X24	0
	2	X25	3
	1		9

TABLE 5

The Natural Features, [illegible]
the Class [illegible] Cont.]

Natural Features	Class	Symbol	[illegible]
Slope[2]	1	X2	0
	2	X3	2
	3	X4	[illegible]
	4,5		[illegible]
Surface Texture	3	X5	0
	2,4	X6	3
	1,5		6
Subsoil Texture	3	X7	0
	2,4	X8	2
	1,5		4
Topsoil Depth	1,2	X9	0
	3	X10	2
	4	X11	4
	5		6
Organic Matter	1,2,3	X12	0
	4	X13	2
	5		3
Stoniness	1,2	X14	0
	3	X15	3
	4		6
Soil Depth Favorable to Root Development	1,2	X16	0
	3	X17	3
	4	X18	6
	5		9
Available Water	1,2	X19	0
	3	X20	2
	4	X21	6
	5		9
Flooding	1	X22	0
	3		6
Topographic Position	2,4,5	X23	[illegible]
	1,3		[illegible]
Freeze Free Days	3,4	X24	0
	2	X25	3
	1		9

TABLE 5 (Cont'd)

---

[1]Basic information derived through consultation with Harry Galloway, professor, Department of Agronomy, Purdue University, West Lafayette, Indiana.

[2]Slope groups 4,5, or 6 were considered as a very severe limitation and too difficult to overcome and no suitability index was calculated for sites having slopes in these classes.

[3]0 points denote the most suitable classes, 1 to 8 points indicate the degree of suitability and 9 points represent the most restrictive situations.

TABLE 7 (Cont'd)

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[1]Data furnished [illegible] Harry Galloway, [illegible] Department of Agronomy, Purdue University, West Lafayette, Indiana.

[2]Slope groups 4, 5, or 6 were considered [illegible] a very severe limitation and too difficult to [illegible] suitability index was calculated for cities having [illegible] in these classes.

[3]0 points denote the most [illegible] 1 to [illegible] points indicate the [illegible] suitability [illegible] points represent the most restrictive limitations.

sanitary sewers, residential homes requiring septic filter fields, and continuous corn respectively.

The dependent variable was then considered to be the summation of the points that a particular site would have for a given land use.

A summation value for the dependent variable from this type of calculation was merely a total of the points represented by the variable classes for a given land use. This was satisfactory for comparison of a single type of land use for several sites, but the value was not adequate to compare a given site for alternative uses. The point value could be a reflection of the number of variables considered and not entirely due to the land use suitability. To illustrate the above situation assume two sites, site A and site B, are being evaluated for residential homes with sanitary sewers. A total of 8 natural physical features are considered relevant for this land use. Assume all of the natural features of site A have a moderate rating (3 points each), and site B has one feature having a severe rating (9 points) and the remaining features have a moderate rating. The total number of points for site A is 24 and for site B is 30 points. Therefore, site A is considered more physically suited for residential homes with sewers than site B. As indicated earlier in the text, this method of analysis is satisfactory for comparing several sites for a given land use. But assume the planner wishes to determine if site A is more physically suitable for continuous sanitary sewers, residential homes requiring septic filter fields, and continuous corn respectively.

The dependent variable was then considered to be the summation of the points that a particular site would have for a given land use.

A summation value for the dependent variable from this type of calculation was merely a total of the points represented by the variable classes for a given land use. This was satisfactory for comparison of a single type of land use for several sites, but the value was not adequate to compare a given site for alternative uses. The point value could be a reflection of the number of variables considered and not entirely due to the land use suitability. To illustrate the above situation assume two sites, site A and site B, are being evaluated for residential homes with sanitary sewers. A total of 8 natural physical features are considered relevant for this land use. Assume all of the natural features of site A have a moderate rating (3 points each), and site B has one feature having a severe rating (9 points) and the remaining features have a moderate rating. The total number of points for site A is 24 and for site B is 30 points. Therefore, site A is considered more physically suited for residential homes with sewers than site B. As indicated earlier in the text, this method of analysis is satisfactory for comparing several sites for a given land use. But assume the planner wishes to determine if site A is more physically suitable for continuous corn or residential homes on sewers. The number of natural physical features considered relevant for continuous corn is 11 and assume all of these features have a moderate rating (3 points each). This would make a total of 33 points for continuous corn versus a total of 24 for residential homes. But, this comparison is not really valid because the sites are about equally well adapted for both uses according to the slight, moderate, and severe rating system. The difference in the number of points is due more to the number of natural features considered than to the suitability of each feature. This makes the concept of developing an index value more justified when one wants to compare a single site for several alternative uses. The index in this study consists of dividing the number of actual points for a site for a given land use by the total number of points possible for the same land use. (assuming the worst possible natural condition) This value is then converted to a percentage which is a measure of the per cent of "goodness" of a site for a given land use and is referred to as the Physical Site Suitability Index (PSSI) in this study. The PSSI of a site for one land use can be compared to the PSSI for other land uses, or the PSSI of a site for a given land use can be compared to the PSSI of another site for the same land use. This procedure permits the type of flexibility needed in evaluating the physical features of a site.

corn or residential homes on slopes. The number of natural physical features considered relevant for continuous corn is 11 and assume all of these 11 features have a moderate rating (2 points each). This would make a total of 22 points for continuous corn versus a total of 24 for residential homes. But, this comparison is not really valid because the sites are about equally well suited for both uses according to the slight, moderate, and severe rating system. The difference in the number of points is due more to the number of natural features considered than to the suitability of each feature. This makes the concept of developing an index value more justified when one wants to compare a single site for several alternative uses. The index in this study consists of dividing the number of actual points for a site for a given land use by the total number of points possible for the same land use. (assuming the worst possible natural condition) This value is then converted to a percentage which is a measure of the per cent of "goodness" of a site for a given land use and is referred to as the Physical Site Suitability Index (PSSI) in this study. The PSSI of a site for one land use can be compared to the PSSI for other land uses, or the PSSI of a site for a given land use can be compared to the PSSI of another site for the same land use. This procedure permits the type of flexibility needed in evaluating the physical features of a site.

Sample Data

One hundred and forty four observations depicting different types of natural conditions were utilized for a multiple regression model for sanitary landfills. The observations did not represent actual field observations, but rather theoretical combinations of different natural conditions that could occur in the real world. All classes within each natural feature were represented but not all of the possible naturally occurring combinations were included.

One hundred and ninety six observations were utilized in the multiple regression model for residential homes with sanitary sewers, residential homes requiring septic filter fields, and continuous corn. The method of formulating these observations was very similar to the method utilized for sanitary landfills. The additional number of observations was necessary to include more possible combinations caused by evaluating a greater number of natural features for the latter three land uses than for sanitary landfills.

Determination of Parameters for Each Land Use

The dependent variable for each theoretical observation was calculated by converting the observation data into their appropriate classes and determining the respective points of each occurring class. The points were then summed and the summation entered as the dependent variable for that observation. Each of the class designations were then transformed into indicator variables of the -1,0,+1 type. This

Sample Data

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Data were then submitted for computer analysis using the least squares technique. (Stepwise Regression 1969)

The general form of the equation submitted for each land use was as follows:

$$Y_k = f(X_{ik} + \,..\, X_{nk})$$

Y = total point summation for land use k

k = specified land use

X = variable for land use k

i = variable identification

n = last variable

Explicit Equation

The regression coefficients obtained from the computer analysis for each land use represent the approximate weighted values of each designated independent variable for the different land uses.

Tables 6, 7, 8, and 9 list the natural features, variables, the regression coefficients and the constants for sanitary landfills, residential homes with sanitary sewers, residential homes requiring septic filter fields, and continuous corn respectively.

procedure was adhered to for each observation and for each land use. These data were then transferred onto computer cards with a card for each observation which resulted in a deck of 144 data cards representing 144 observations to be evaluated for sanitary landfills and 3 decks of 196 data cards representing 196 observations to be evaluated for each of the other land uses considered in this study.

Data were then submitted for computer analysis using the least squares technique. (Stepwise Regression 1969)

The general form of the equation submitted for each land use was as follows:

$$Y_K = f(X_{iK} + .. X_{nK})$$

Y = total point summation for land use K

K = specified land use

X = variable for land use K

i = variable identification

n = last variable

Explicit Equation

The regression coefficients obtained from the computer analysis for each land use represent the respective weighted values of each designated independent variable for the different land uses.

Tables 6, 7, 8, and 9 list the natural features, materials, the regression coefficients and the constants for sanitary landfills, residential homes with sanitary sewers, residential homes requiring septic filter fields, and continuous corn respectively.

TABLE 6

The Natural Features, Variables, Regression Coefficients, and Constant for Sanitary Landfills.

Natural Features	Variable	Regression Coefficient
Constant		26.64
Natural Soil Drainage	X2	-4.47
Flooding	X3	-4.47
Permeability	X4	-3.21
Slope	X5	-4.03
	X6	-0.96
Texture of Subsoil	X7	-1.90
	X8	+1.09
Depth to Bedrock	X9	-4.54
Stoniness	X10	-4.01
	X11	-0.93

TABLE 6

The Natural Factors, Variables, Regression Coefficients, and Constant for Sanitary Landfills.

Natural Factors	Variable	Regression Coefficient
Constant		2[illegible].64
Natural Soil Drainage	X2	-4.47
Flooding	X3	-4.47
Permeability	X4	-3.21
Slope	X5	-4.03
	X6	-0.96
Texture of Subsoil	X7	-1.90
	X8	+1.09
Depth to Bedrock	X9	-4.51
Stoniness	X10	-4.01
	X11	-0.93

TABLE 7

The Natural Features, Variables, Regression Coefficients, and Constant for Residential Homes with Sanitary Sewer - No Basements.

Natural Features	Variable	Regression Coefficients
Constant		28.07
Slope	X2	-4.40
	X3	-1.51
	X4	+1.48
Surface Soil Texture	X5	-1.44
Subsoil Texture	X6	-1.57
Natural Soil Drainage	X7	-3.97
	X8	-0.98
Organic Matter	X9	-4.03
	X10	-0.93
Stoniness	X11	-4.02
	X12	-1.04
Flooding	X13	-4.46
Depth to Bedrock	X14	-4.10
	X15	-0.81

TABLE 7

The Natural Features, Variables, Regression Coefficients, and Constant for Residential Homes with Sanitary Sewer - No Basements.

Natural Features	Variable	Regression Coefficient
Constant		22.07
Slope	X2	-4.40
	X3	-1.51
	X4	+1.48
Surface Soil Texture	X5	-1.44
Subsoil Texture	X6	-1.57
Natural Soil Drainage	X7	-3.97
	X8	-0.96
Organic Matter	X9	-4.00
	X10	-0.93
Stoniness	X11	-4.02
	X12	-1.04
Flooding	X13	-4.46
Depth to Bedrock	X14	-4.10
	X15	-0.81

TABLE 8

The Natural Features, Variables, Regression Coefficients, and Constant for Residential Homes Requiring Septic Filter Fields - No Basements.

Natural Features	Variable	Regression Coefficients
Constant		33.83
Slope	X2	-4.39
	X3	-1.51
	X4	+1.48
Surface Soil Texture	X5	-1.42
Subsoil Texture	X6	-2.10
Natural Soil Drainage	X7	-4.93
	X8	+0.96
Organic Matter	X9	-4.04
	X10	-0.90
Stoniness	X11	-4.02
	X12	-1.04
Flooding	X13	-4.46
Depth to Bedrock	X14	-4.10
	X15	-0.81
Subsoil Permeability	X16	-4.27
	X17	-1.33
	X18	+1.89

TABLE 8

The Natural Factors, Variables, Regression Coefficients, and Constant for [illegible] Requiring [illegible] Fields - [illegible].

Natural Factors	Variables	Regression Coefficients
Constant		[illegible]
Slope	X2	-4.[illegible]
	X3	-1.[illegible]
	X4	+1.4[illegible]
Surface Soil Texture	X5	-1.42
Subsoil Texture	X6	-2.10
Natural Soil Drainage	X7	-4.03
	X8	+0.96
Organic Matter	X9	-4.04
	X10	-0.[illegible]0
Stoniness	X11	-4.02
	X12	-1.04
Flooding	X13	-4.46
Depth to Bedrock	X14	-4.10
	X15	-0.51
Subsoil Permeability	X16	-4.27
	X17	-1.33
	X18	+1.99

TABLE 9

The Natural Features, Variables, Regression Coefficients, and Constant for Continuous Corn.

Natural Features	Variable	Regression Coefficients
Constant		35.00
Slope	X2	-4.12
	X3	-2.14
	X4	+1.77
Surface Soil Texture	X5	-3.08
	X6	-0.03
Subsoil Texture	X7	-1.92
	X8	+0.07
Topsoil Depth	X9	-3.14
	X10	-1.04
	X11	+1.09
Organic Matter	X12	-2.52
	X13	-0.57
Stoniness	X14	-3.15
	X15	-0.19
Soil Depth	X16	-4.39
	X17	-1.39
	X18	+1.50
Available Water	X19	-4.22
	X20	-2.16
	X21	+1.84
Flooding	X22	-2.98
Topographic Position	X23	-1.45
Freeze Free Days	X24	-3.94
	X25	-1.01

TABLE 9

The Natural Features, Variables, Regression Coefficients, and Constant for Y = Changes in Corn.

Natural Features	Variables	Regression Coefficients
Constant		[illegible]7.00
Slope	X2	-4.12
	X3	-2.1[illegible]
	X4	+1.77
Surface Soil Texture	X5	-3.03
	X6	-[illegible].03
Subsoil Texture	X7	-1.92
	X8	+0.[illegible]7
Topsoil Depth	X9	-0.1[illegible]
	X10	-1.04
	X11	+1.0[illegible]
Organic Matter	X12	-2.7[illegible]
	X13	-0.37
Stoniness	X14	-3.15
	X15	-0.1[illegible]
Soil Depth	X16	-4.39
	X17	-1.[illegible]
	X18	+1.66
Available Water	X19	-4.22
	X20	-2.1[illegible]
	X21	+1.34
Flooding	X22	-2.98
Topographic Position	X23	-1.45
Freeze Free Days	X24	-3.94
	X25	-1.91

These tables can be related to equation form simply by summing the constant and the product of each variable and its respective regression coefficient. This summation value is then converted into an index value as explained on page 43. For example, the equation for determining the PSSI for sanitary landfills is:

$$PSSI = 100-((26.64- 4.47X2-4.47X3-3.21X4-4.03X5-0.96X6-1.90X7+1.09X8-4.54X9-4.01X10-0.93X11)/45)100$$

Test Data

Test data were collected in Grand Traverse County, Michigan. Criteria for selecting the county consisted merely of choosing a county in Michigan where information on soils and topography was readily available and where contrasting differences in soils and topography existed within relatively short distances. The size of the test area consisted of two sections of land (1280 acres). Several of the soil survey maps in the Grand Traverse Soil Survey Report (Weber *et al*. 1960) were visually examined and a section of land was selected that contained differend types of land uses and contained contrasting soil conditions in terms of soil texture and natural soil drainage. A second section of land was selected from the same county but in an area where part of the section was inundated by the East Arm of Grand Traverse Bay. The purpose of selecting the second section was to permit the entering of special land use characteristics into the system and later testing the

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Data were then collected and recorded on a data sheet (appendix A) for each 2½ acre unit. Collection was restricted to the type of natural resource data listed in Table 1 and certain broad classifications of current land use as determined from the aerial photographs in the Grand Traverse County Soil Survey Report. (Weber et al. 1966) The current land use classification used included urban, recreation, transportation, agriculture, timber, and water. An estimate was made of the approximate percentage that each land use constitutes of each designated 2½ acre unit. These percentage values were then grouped into the following five classes for numerical identification: class 1 = 100 (91-100%), class 2 = 75 (65-90%), class 3 = 50 (35-64%), class 4 = 25 (10-34%), and class 5 = 0 (0-9%). The primary purpose for including current land uses was to recognize dominant landscape characteristics such as bodies of water and to recognize the importance of current land uses. For example a site index value would be meaningless for a sanitary landfill if 75% of the 2½ acre unit was currently system for possible existence of these special characteristics. A grid coordinate system was then superimposed over the soil survey map for each of the sections of land selected. The grid system divided each section of land (640 acres) into 2½ acre units or 256 parcels per section for a total of 512 parcels. Each grid unit was then identified by row - column designations as indicated in Figure 1.

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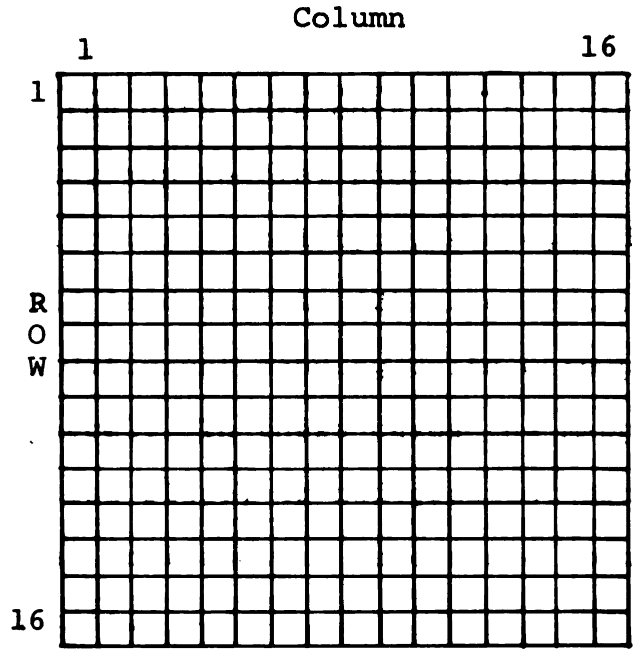
Township 29 North, Range 10 West, Section 34,
Grand Traverse County, Michigan



Township 27 North, Range 11 West, Section 36,
Grand Traverse County, Michigan

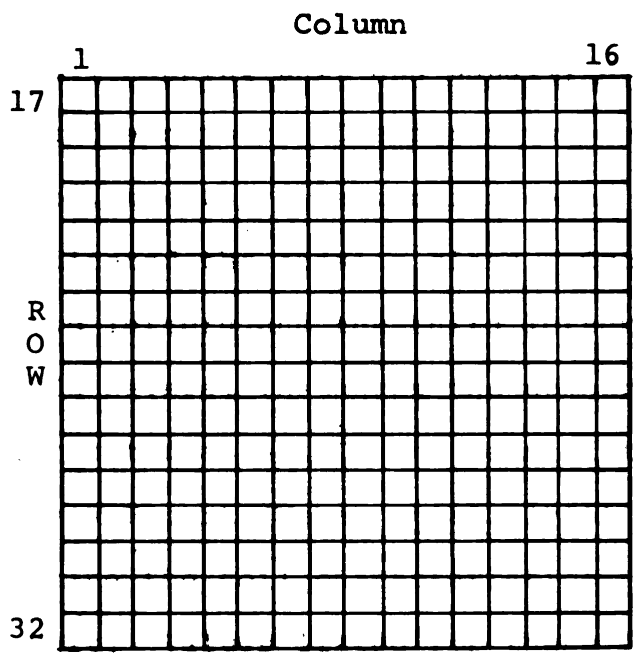
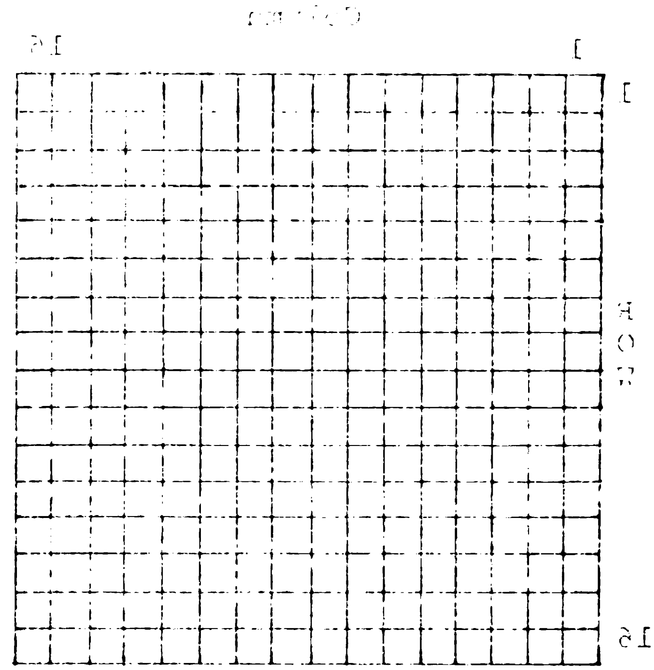


FIGURE 1. The Grid Coordinate System of Each Section of Land Showing the Row - Column Locations of Each 2½ Acre Parcel of Land.

Township 28 North, Range 10 West, Section 24,
Grand Traverse County, Michigan



Township 27 North, Range 11 West, Section 36,
Grand Traverse County, Michigan

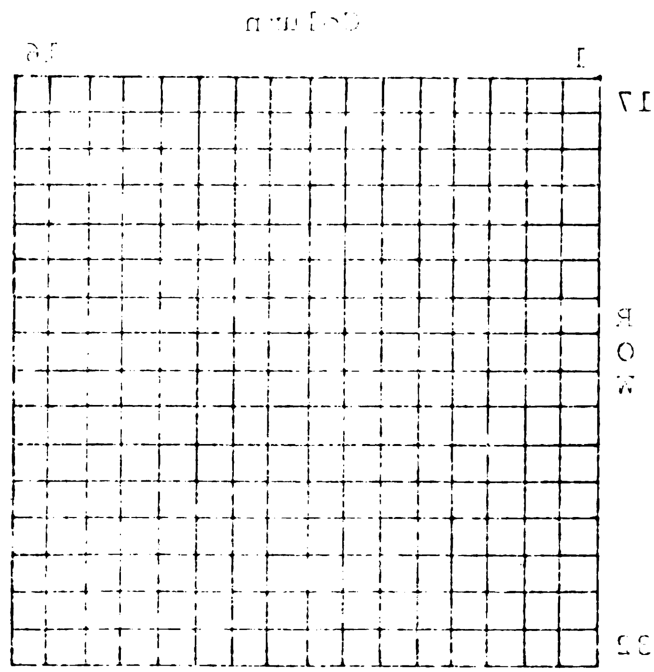


FIGURE 1. The Grid Coordinate System of Land Sections of Land Showing the Row - Column Locations of Each 2½ Acre Parcel of Land.

in an urban classification. Likewise an agricultural rating would be meaningless if 100% of the 2½ acre unit was classified as water or urban.

Natural resource data were obtained by determining from the soil survey map (aerial photograph background) the dominant mapping unit (soil type, slope, and erosion) for each of the 512 land parcels (2½ acres each). In some instances several different mapping units were present within a single parcel. In these cases the mapping unit that had the steepest slope, or had greatest erosion, or had poorest natural drainage was determined to be the critical mapping unit.

A composite list of all existing soil types, slopes and erosion combinations was made from the data sheets. Each of thse existing combinations is referenced by soil scientists as a soil mapping unit and usually designated by three letters and a number. The first two letters indicated the soil type, the third letter indicated the slope, and the number indicated the erosion class. Occasionally there were only two letters and the third letter was interpreted as an A. In several instances the number was missing and this was interpreted as a 1.[1] The text of the Grand Traverse Soil Survey Report (Weber _et al_. 1966) was then utilized to determine the soil characteristics represented by each mapping unit. Values listed for these features were

[1]The letter and number are occasionally omitted for soils that occur only in flat areas or where the erosion is always class 1.

in an urban classification. Ratings on residential rating would be meaningless if 1/3 of the 25 acre unit was classified as water or urban.

Natural resource data were obtained by determining from the soil survey map (aerial photograph background) the dominant mapping unit (soil type, slope, and erosion) for each of the 512 data cells (25 acre cells). In some instances several different mapping units were present within a single parcel. In these cases the mapping unit that had the steepest slope, or had greatest erosion, or had poorest natural drainage was determined to be the critical mapping unit.

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[1] The letter and number are occasionally omitted for soils that occur only in flat areas on which the erosion is always class 1.

then coded with the aid of a soil worksheet (appendix B) into the various classes as listed earlier in this chapter. The data for each soil was then entered onto an individual computer card using the soil type and slope letters, and the erosion class as the mapping unit identifiers and the numerical class designators to identify the class value represented for each feature.

Information on each data sheet was then entered on an individual computer card using grid coordinates to identify each 2½ acre unit along with numerical class indicators representing the percentages of the different current land uses, and the freeze free period. The soil mapping unit was identified with three letters and a number.

Data Input

The soil card data was entered into a single dimension array identified as SC(M). The SC indicated the data was from the soil card and the M denoted the 13 elements in the array. The first element of the SC array consisted of 3 alpha characters identifying the soil mapping unit. The remainder of the elements were numerical and are identified on the soil work sheets. (appendix B)

The basic data on each parcel were entered into a three dimensional array which was designated DS1(I,J,N). The first two dimensions were utilized to denote the row and column locations. The third dimension denoted the basic site data and consisted of 27 elements. The first 11 elements consisted of the numerical information entered from then coded with the aid of a soil worksheet (Appendix E) into the various classes as listed earlier in this chapter. The data for each cell were then entered onto an individual computer card using the soil type and slope letters, and the erosion class as the number with identifiers and the numerical class designators to identify the class value represented for each feature.

Information on each data sheet was then entered on an individual computer card using grid coordinates to identify each 2½ acre unit along with numerical class indicators representing the percentages of the different current land uses, and the freeze free period. The soil mapping unit was identified with three letters and a number.

<u>Data Input</u>

The soil card data was entered into a single dimension array identified as SC(N). The SC indicated the data was from the soil card and the N denoted the 12 elements in the array. The first element of the SC array consisted of 3 alpha characters identifying the soil mapping unit. The remainder of the elements were numerical and are identified on the soil work sheets. (Appendix D)

The basic data on each parcel were entered into a three dimensional array which was designated DAT(I,J,K). The first two dimensions were utilized to denote the row and column locations. The third dimension denoted the basic site data and consisted of 27 elements. The first 11 elements consisted of the numerical information entered from the data card while element number 12 was entered as three alpha characters identifying the soil type and slope with element number 13 designating the numerical erosion class. Elements 7, 8, 9, and 10 are blank in this study. These spaces were reserved for possible additional features but were not utilized. Elements 14 through 27 were reserved for the soil features that were entered into the system from the soils array SC(M).

All 512 of the site data cards were read into central storage of the computing system at the beginning of a run. Then a soils card was read and each site was checked to determine if the mapping unit identified on the soil card matched the mapping unit on the data card. If there was not a match on any of the 512 parcels between the soil type, slope and erosion then the information contained on that particular soil card was not retained and another soil card was read. However, if the soil card mapping unit matched the data card mapping unit then the data contained in elements 3 through 16 of the SC array was entered into elements 14 through 27 of the DS1 array and another soil card was read. The procedure of reading one soil card at a time and checking each site for the matching mapping unit was continued until soils information was entered for all 512 sites. An error message was incorporated into the computer program to indicate the occurrence of a missing soil card. Figure 2 is a schematic flow chart showing the basic steps of the data input system.

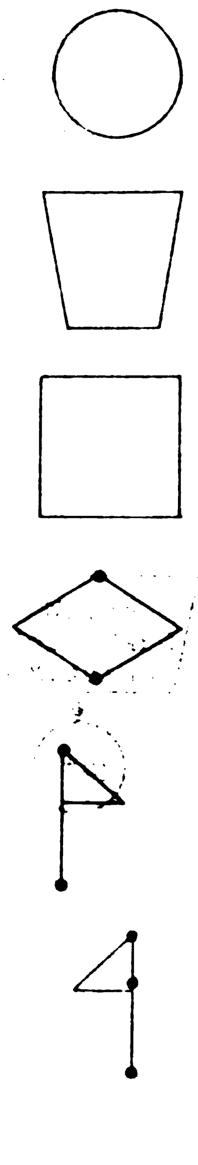
the data card while element number 12 was entered as three alpha characters identifying the soil type and slope with element number 13 designating the numerical erosion class. Elements 7, 8, 9, and 10 are blank in this entry. These spaces were reserved for possible additional features but were not utilized. Elements 14 through 27 were reserved for the soil features that were entered into the system from the soils array S(J).

All 512 of the site data cards were read into central storage of the computing system at the beginning of a run. Then a soils card was read and each site was checked to determine if the mapping unit identified on the soil card matched the mapping unit on the data card. If there was not a match on any of the 512 parcels between the soil type, slope and erosion then the information contained on that particular soil card was not retained and another soil card was read. However, if the soil card mapping unit matched the data card mapping unit then the data contained in elements 3 through 16 of the S2 array was entered into elements 14 through 27 of the PSI array and another soil card was read. The procedure of reading one soil card at a time and checking each site for the matching mapping unit was continued until soils information was entered for all 512 sites. An error message was incorporated into the computer program to indicate the occurrence of a missing soil card. Figure 2 is a schematic flow chart showing the basic steps of the data input system.

FIGURE 2

Schematic Flow Chart of Data Input and Processing

Legend



Entrance or Exit

Data Input or Output

Computations

Decision

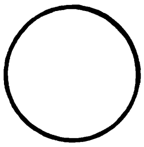
Begin Loop

End Loop

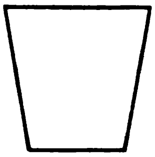
FIGURE 2

Schematic Flow Chart of Data Input and Processing

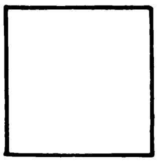
<u>Legend</u>



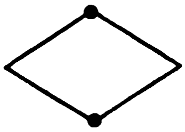
Entrance or Exit



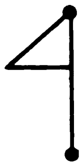
Data Input or Output



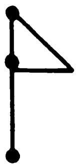
Computations



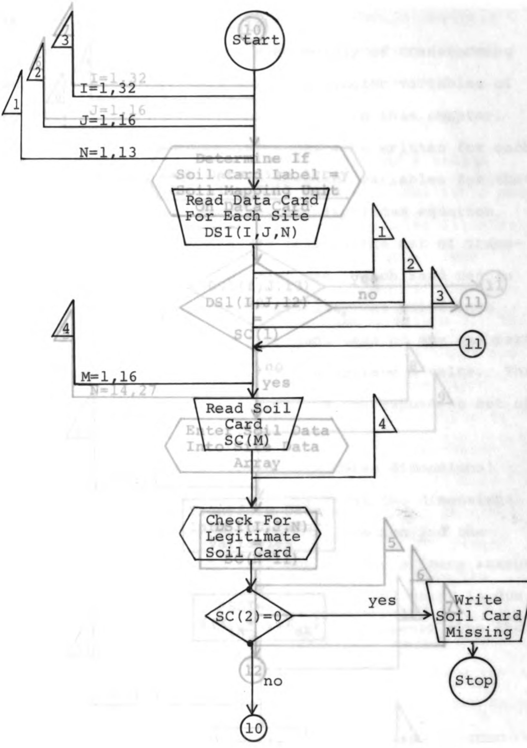
Decision



Begin Loop



End Loop



Start
10
I=1,32
J=1,16
N=1,13
1
2
3
Read Data Card
For Each Site
DSI(I,J,N)
11
M=1,16
4
Read Soil
Card
SC(M)
Check For
Legitimate
Soil Card
SC(2)=0
yes
Write
Soil Card
Missing
Stop
no

Figure 2

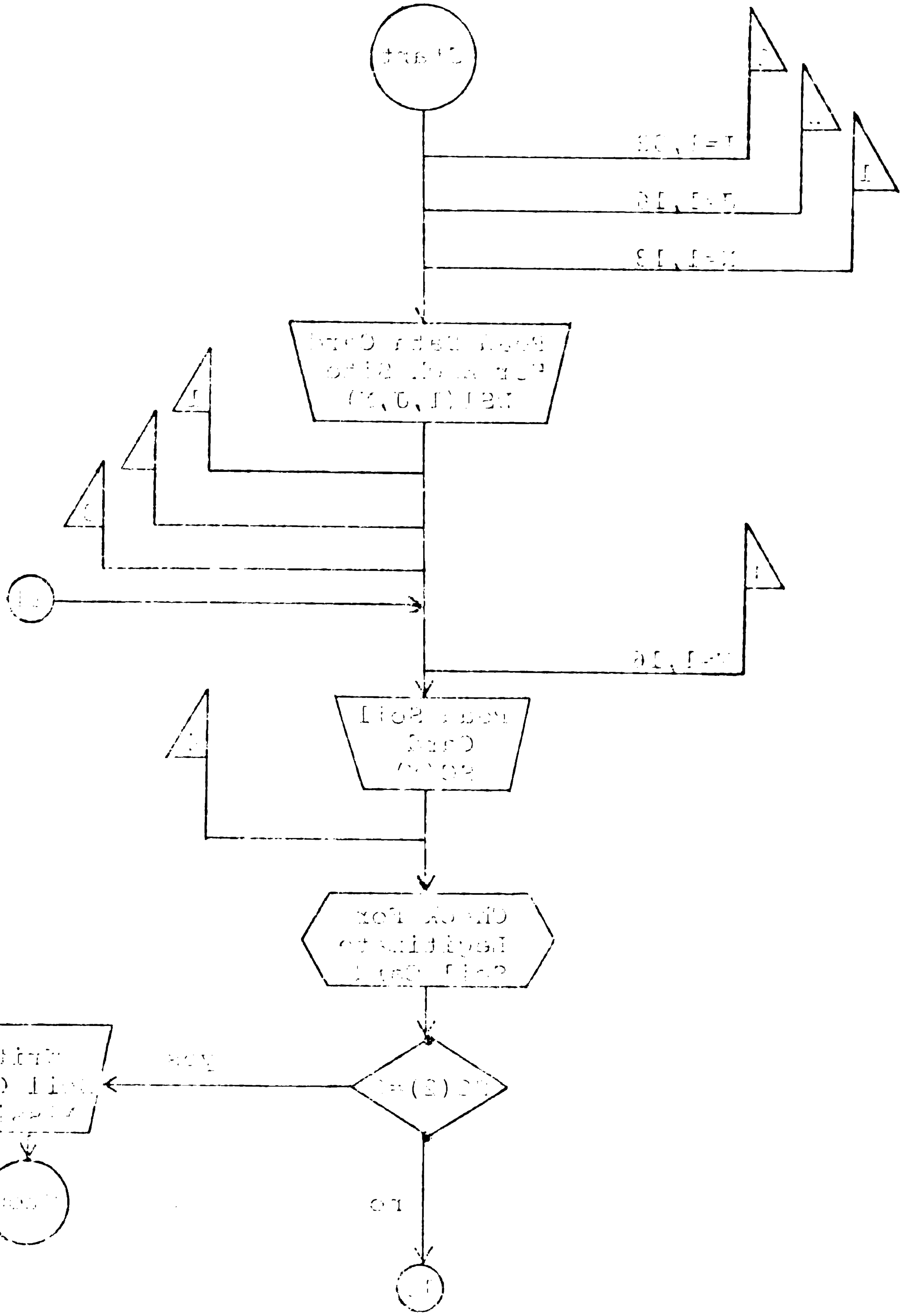

Start
I=1,20
J=1,16
K=1,12
Read Data Card for each Site
Check for Legitimate Soil Card
yes
no
Write

Figure 2

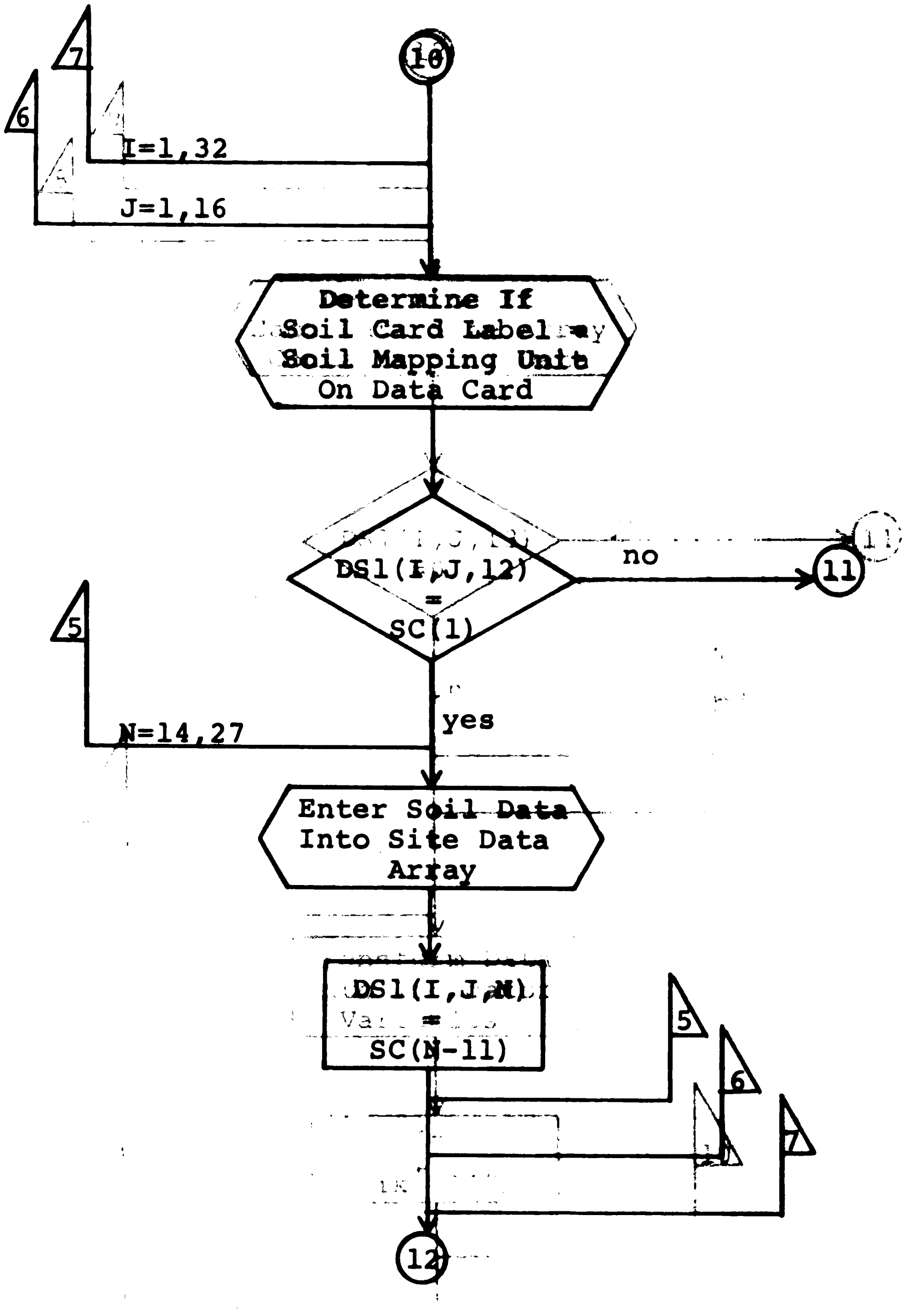


Figure 2 (Cont'd)

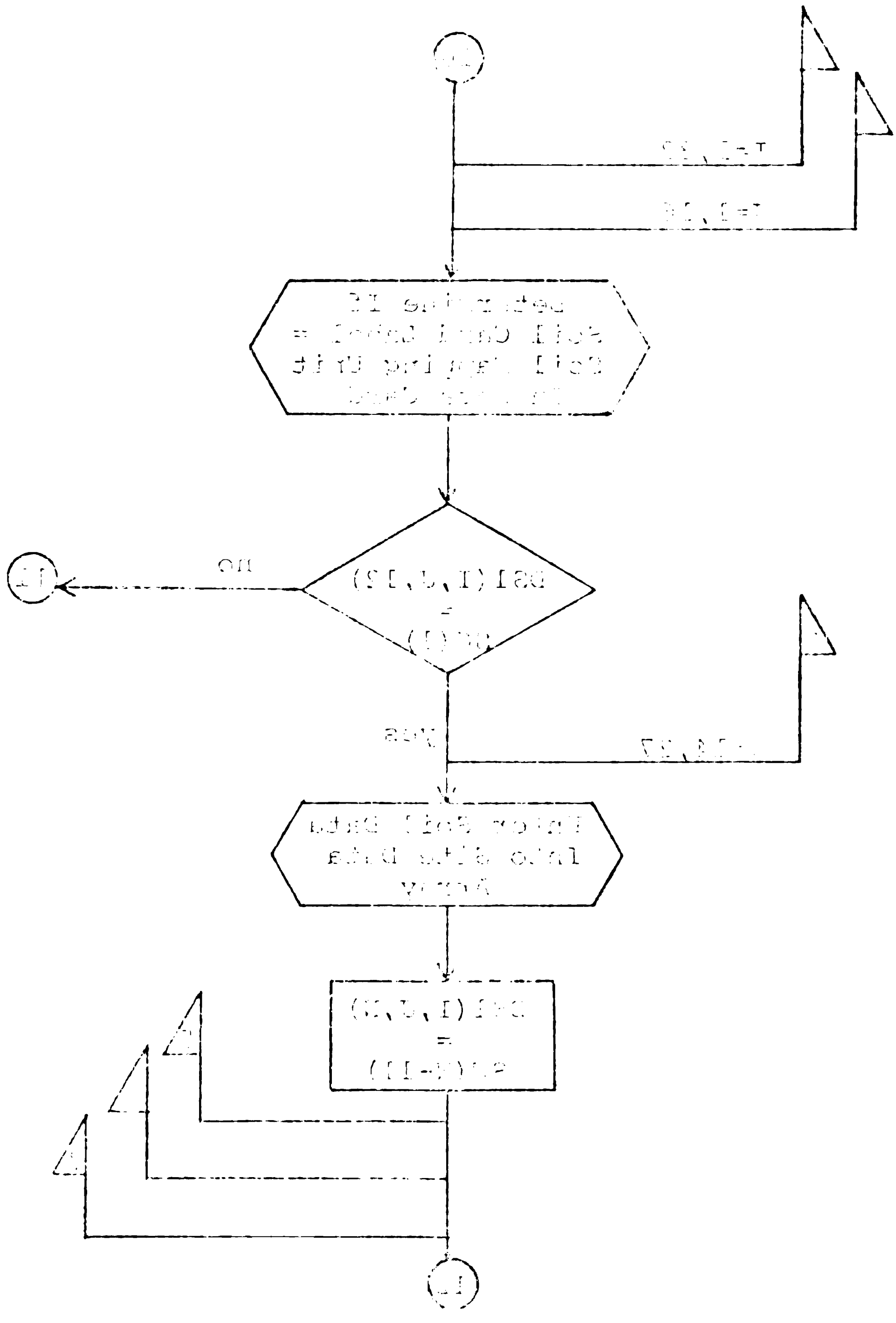


Figure 2 (Cont'd)

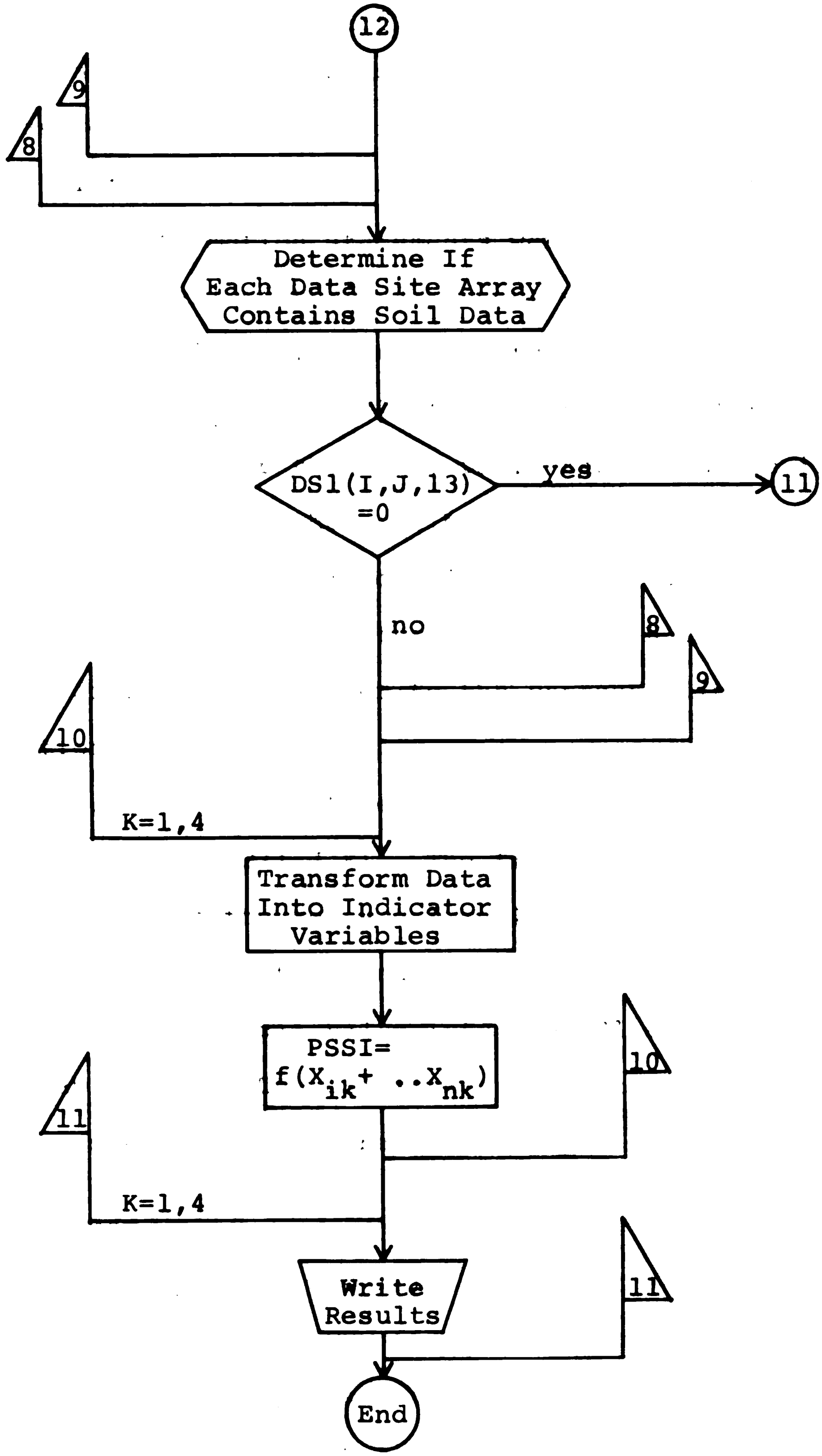


Figure 2 (Cont'd)

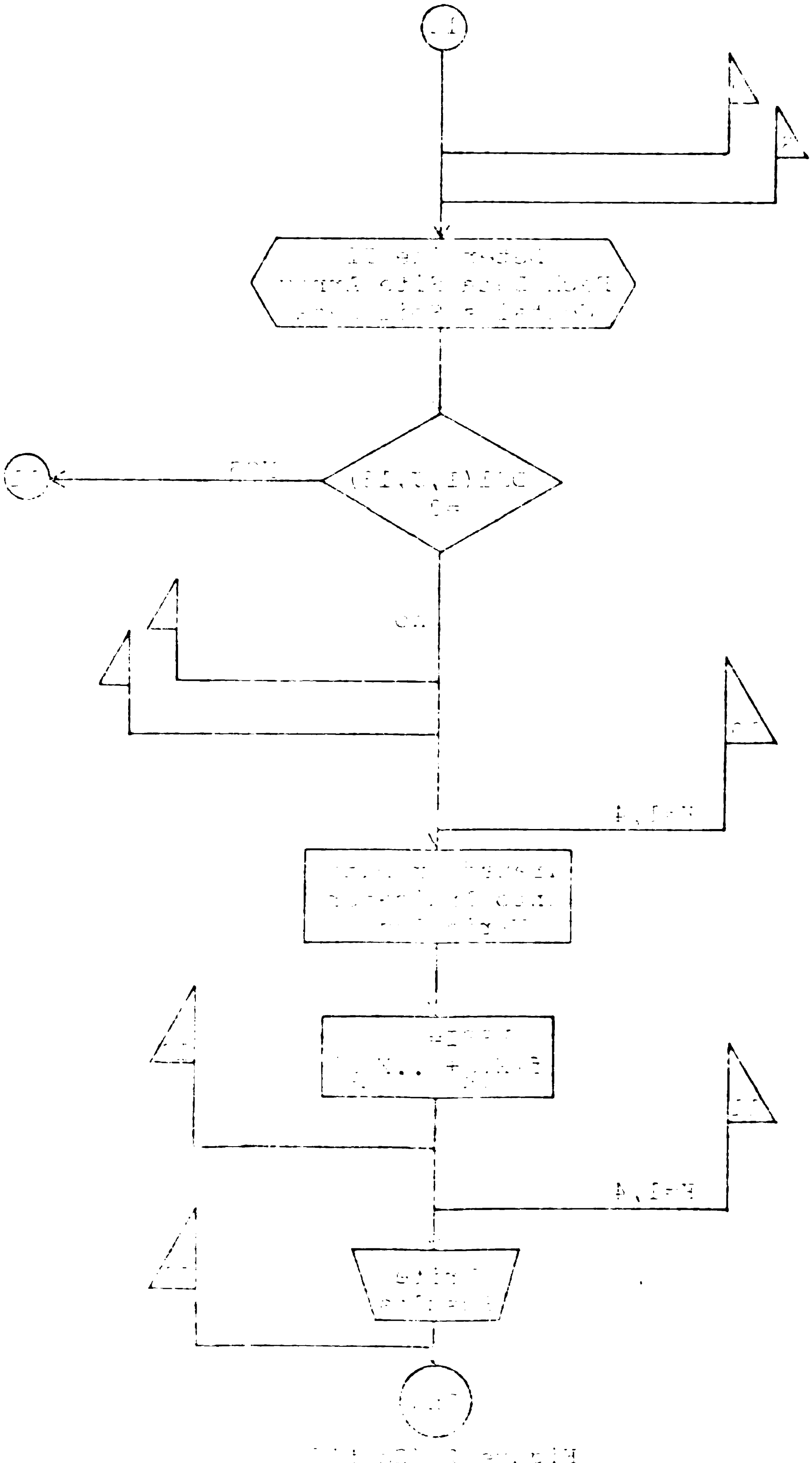


Figure 2 (Cont'd)

Data Processing and Computation

The data processing consisted mainly of transforming number class data designators into indicator variables of the -1, 0, +1 type as explained earlier in this chapter. A series of transformation statements were written for each land use covering all of the independent variables for that land use. The Physical Site Suitability Index equation for a given land use immediately follows the set of transformation statements for that land use. Each land use is denoted by a K value and the possibility was built into the system of evaluating all four land uses or any one particular land use by designating the appropriate K value. This value would direct the computer to the corresponding set of transformation statements.

The computed PSSI is stored in a three dimensional array designated as DS2(I,J,K). The first two dimensions of this array denote the row - column location and the third dimension denotes the land use K. The primary reason for not incorporating this value into the DS1 array is due to the variable type. The DS1 arrays are integer type and the DS2 arrays are stored as real type.

Computer Program

The computer program was written in Fortran IV (CDC 1969) and processed on the CDC 6500 computing system at Michigan State University, East Lansing, Michigan, and on the CDC 6500 computing system at Purdue University, West Lafayette, Indiana.

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The computed PSSI is stored in a three dimensional array designated as ISS(I,J,K). The first two dimensions of this array denote the row - column location and the third dimension denotes the land use K. The primary reason for not incorporating this value into the ISS array is due to the variable type. The ISS arrays are integer type and the DSS arrays are stored as real type.

Computer Program

The computer program was written in Fortran IV (MSU 1969) and processed on the CDC 3600 computing system at Michigan State University, East Lansing, Michigan, and on the CDC 6500 computing system at Purdue University, West Lafayette, Indiana.

The entire computer program is included in Appendix C and appropriate comment cards have been inserted for aid and assistance in following the logic and procedure.

Data Output

Output from the program is in the form of 9 tables (Appendices D and E). Appendix D consists of one table and is a partial listing of the data entered and also illustrates the ability to recall information on a particular land parcel. The first line of output is a listing of the data to be entered for location coordinate row 3, column 3. This unit was selected to illustrate the type of data input and also as a check to make sure that data were propertly entered into the program. The remainder of the output in Appendix D represents the 43 soil cards that were represented in the two sections of land. The last "soil" card represents a water area. The program was written to check for a value of zero in the 14th element of the 3rd dimension of the DS1 array. If this value was zero then the computer looked for another soil card and if none could be found the program would abort. Therefore, a method had to be divised to read a "soil" card for every coordinate regardless of whether the area was water or land and the only way of entering a positive number greater than zero into this element was through the soil array. Therefore, the three letters "000" represent a water area and the value of one can be entered into the 14th element and values for elements 15 thru 27 are listed as zero.

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Output in Appendix E is in the form of eight tables denoting the Physical Site Suitability Index for each land use and for each section. Each value in the tables represents a 2½ acre unit and is geographically located according to its row - column designation. The size of each table has been spaced into an eight inch square which is a fairly common scale for aerial photography (eight inches on the map equaling one mile). The value of 666 in Appendix E, pages 93, 97, 101, and 105 illustrate the value of the special land use character. This is the East Arm of Grand Traverse Bay and a calculated index for any type of land use would be meaningless. The special character 555 in appendix E, pages 105 and 107 illustrates the value of allowing for "overriding" features. These are topographically steep areas and to consider using them for continuous corn would be a hazardous and diffkult undertaking. Footnotes on the output pages denote potential existence of "overriding" features for different land uses that were built into the system.

[illegible] E, [illegible] is in the form of [illegible] Landing the [illegible] Suitability Table for each land use and for each section. Each value in the tables represents a 25 acre unit and is geographically located according to its row - column designation. The size of each table has been scaled into an eight inch square which is a fairly common scale for aerial photography (eight inches on the map equaling one mile). The value of [illegible] in Appendix E, pages 93, 97, 101, and 105 illustrates the value of the special land use character. This is the East Arm of Grand Traverse Bay and a calculated index for any type of land use would be meaningless. The special character 555 in appendix E, pages 105 and 107 illustrates the value of allowing for "overriding" features. These are topographically steep areas and to consider using them for continuous corn would be a hazardous and difficult undertaking. [illegible] on the output pages denote potential existence of "overriding" features for different land uses that were built into the system.

CHAPTER 5

RESULTS AND DISCUSSION

Interpretation of the Physical Site Suitability Index

The Index is a degree of suitability represented by a set of physical features for a given land use. These features represent real world situations and the size of the area evaluated is 2½ acres. This measurement of suitability is derived by comparing the set of physical features of a given area to be evaluated to a suitable set of physical features used as a standard for a given land use.[1] The index may be interpreted as representing the per cent of "goodness" of a site or area for a given land use in physical terms.

Advantages of the Index

The index and the method of calculating the index establishes a framework for integrating and analyzing various types of natural resource data into a single rating. This framework permits addition of variables to include many types of land uses. It also allows for a change in the weighted value of each variable as its relative importance to a given land use may change.

[1]The standards used in the study are referenced for the respective land uses as explained in chapter 4.

CHAPTER 5

FINDINGS AND DISCUSSION

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[1]The standards used in this study are referenced for the respective land uses as detailed in Chapter 4.

Several alternative land uses may be compared for a given site utilizing the index as a criterion.[1] Current methods of comparison relate the set of properties for a given land use as presenting slight, moderate or severe hazards (as defined on page 5) to the use in question but there is no quantitative method of evaluating degrees of suitability within a given class. The index provides a numeric rating ranging from a possible high of 100% to a possible low of 0%. To compare several alternative land uses for a site the user asks for the calculated value for a given land use covering the area in which he is interested. The land use having the highest index value is the use most physically adaptable to the site. If the index value is less than near perfect (100%) or if the user wishes he may want to examine the cause of the lower values for the other uses. To accomplish this the user asks for a listing of the natural feature values that were considered for each land use. (Illustrated in Appendix D) This provides the flexibility of being able to know the physical features of the site and knew which land use is the more adaptable.

For example the parcel of land located in row 6, column 1, section 34 has an index rating of 67 for sanitary landfills, a rating of 85 for homes on sanitary sewers, a rating

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[1]Only the four land uses specified in this study can be compared unless the program is expanded.

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of 76 for homes requiring septic filter fields, and a rating of 78 for continuous corn. This would indicate to the planner that of the 4 land uses considered, the site is most physically suitable for homes on sanitary sewers, and least suitable for a sanitary landfill. The planner also knows that the parcel is nearly equal in its rating for continueus corn and residential homes requiring septic filter fields. Since the parcel did not have a 100% rating for any of the land uses tested the planner will probably want to examine the natural features to determine why the ratings were low. He can then analyze the site in conjunction with additional data to recommend a land use or management practice.

Comparing several sites for a single land use is relatively simple utilizing the index. The user compares the calculated index value for each site in which he is interested. The site having the highest rating is the site most adaptable to the use in question.

For example the parcels of land located in row 3 column 3, and row 3 column 5 have ratings for residential homes on sanitary sewers of 92 and 79 respectively. The planner or developer would immediately know that the natural physical characteristics of the land parcel located in row 3 column 3 is better suited for this land use than the other parcel. He would then evaluate other factors such as location, accessibility, availability and other planning factors before of 76 for homes requiring septic filter fields, and a rating of 78 for continuous corn. This would indicate to the planner that of the 4 land uses considered, the site is most physically suitable for homes on sanitary sewers, and least suitable for a sanitary landfill. The planner also knows that the parcel is nearly equal in its rating for continuous corn and residential homes requiring septic filter fields. Since the parcel did not have a 100 rating for any of the land uses tested the planner will probably want to examine the natural features to determine why the ratings were low. He can then analyze the site in conjunction with additional data to recommend a land use or management practice.

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In comparing several sites for a single land use or several land uses for a single site the user not only has the flexibility of knowing the relative rating of each site for the land use considered, but he also has the option of determining the physical characteristic of each site. This flexibility can be utilized to great advantage in conjunction with other planning and decision-making factors. For example, if a user is looking for a homesite requiring septic filter fields the best alternative site based on the natural physical features may be less accessible than another site with a slightly lower rating. By examining site features having the lower rating the user may decide that he can economically overcome the less desirable features and be in a much better location. The user must make this decision.

In making land use decisions the land planner may be confronted with the situation of having a limited land area reading a final decision regarding the development or purchase of the site. Very often in these types of comparisons the user may wish to look at the suitability of the surrounding area as well as the immediate location. This would enable the user to know whether he has an isolated area or if the entire region around the site is nearly similar. After examining the index values for each site the user may wish to know why the variation existed between the values. This can be accomplished by asking for a listing of the natural feature values listed for each site. (Appendix D)

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In making land use decisions the land planner may be confronted with the situation of having a limited land area for several projected land uses. The planner needs to know critical limitations that may exist in each land parcel. He may also want to know the degree of land use adaptability of each parcel. Very often one parcel of land is well adapted to many different types of uses while other parcels are very limited as to their suitability for different uses. For example, a well drained upland soil may be rated high for several types of uses but a soil high in organic matter may have a high rating only for agriculture. Therefore, if the planner had to make a decision between zoning units, the more logical agricultural zone would be the higher organic soils. To aid in this decision process the planner may desire a location map of areas having natural features presenting a critical situation to specific land uses such as flood plain areas or organic soil areas.

To obtain this type of information the planner or a computer programmer would have to write a few statements requesting the computer to scan each parcel of land for a specified natural feature. Once a given value were found the parcel location would be noted and a value or symbol would be printed on a row - column location to denote the special condition. For example if the planner wished to obtain a print of all bottom land soils (areas subject to stream overflow) he would write program statements to look at each parcel of land for a value of 5 in the 26^{th} entry of the data array. (DS1 (I,J,26) I= row number and J= column number). If this value was found then a number 5 could be for several projected land uses. The planner needs to know critical limitations that may exist in each land parcel. He may also want to know the degree of land use suitability of each parcel. Very often one parcel of land is well adapted to many different types of uses while other parcels are very limited as to their suitability for different uses. For example, a well drained upland soil may be rated high for several types of uses but a soil high in organic matter may have a high rating only for agriculture. Therefore, if the planner had to make a decision between zoning units, the more logical agricultural zone would be the higher organic soils. To aid in this decision process the planner may desire a location map of areas having natural features presenting a critical situation to specific land uses such as flood plain areas or organic soil areas.

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The greatest single advantage of the index is the capability of analyzing a set of physical features for a number of sites very easily and efficiently through an automatic data processing procedure. The cost and time of coding and in putting the initial data for the automatic system is nearly equal to the cost of analyzing the same set of data for one land use by conventional overlays and tables. Once data are initially entered into the computing system they can be recalled for multiple uses, which reduces the cost per use. But if data are to be used only once, then there does not appear to be a great cost advantage in using the computer program.

Potential Uses of the Index

The site index represents the relative suitability of each site for given types of land use, and can be combined with location, economic, and transportation data to serve as an additional tool in local, area, state, and regional planning.

State agencies can utilize this type of information system and analysis in promoting state-wide recreation or land use planning or in preparing state wide greenbelt areas or highway corridor maps. Agencies such as the Soil and printed for that location. This would be a single objective map and all lands having a value of 5 would be potential and the planner could then utilize this type of information in his planning process.

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Water Conservation Districts and the Cooperative Extension Service can utilize the information in encouraging and promoting more local land use planning and conservation. Federal agencies such as the U.S. Forest Service and U.S. Soil Conservation Service can utilize the available information to quickly analyze data that would be of value in assisting local communities in formulating community goals and action plans. All agencies can utilize and expand the physical information system to help in evaluating their own goals and assistance plans for serving the general public.

Natural resource planners and managers can utilize the site index to help locate areas where certain types of development may be injurious to the environment without certain precautionary measures. The site index can also be of assistance in managing land resources to obtain maximum benefit or return from an individual site.

This can be accomplished by the resource planner comparing the index ratings of a site for the desired potential uses. If the index ratings are near 100 per cent for each of the uses then the manager would know that he would not have to invest in expensive site preparation costs, but if the index ratings are less than perfect he can determine from a listing of the physical properties the cause of low rating. He can then consult a land contractor to determine the cost of overcoming the problem or problems. The costs of site preparation can then be added to the cost of purchase and management and compared

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Agricultural planners can utilize the site index in making yield predictions and in evaluating areas for future agricultural production. This information can then be correlated to local zoning to help preserve certain soil areas for production of food and fiber.

Realtors and land developers can benefit from the site index by selecting areas that have a favorable rating for their needs or interests.

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The uses suggested above represent but a few of the applications that can be made of the site index. The index can also be used in teaching natural resource planning through the use of game-simulation models as well as in research and extension work.

A primary potential use of the data handling method is in the field of watershed planning and management. The current method of estimating runoff from a watershed area or reach is to determine the predominate soil areas, type of vegetative cover and general slope of the land for a broad area or entire reach. A watershed characteristic value is then determined by approximating the various categories of each unit. This value is then utilized in projecting runoff and calculating the hydrological characteristics of the watershed. With the use of automatic data processing and the coordinate location of small segments covering the entire watershed, the planner or engineer can determine the percentage of each area that is in different types of vegetative cover and determine the portion that is urban. This current land use information can then be combined with data on slope, surface soil texture, depth of topsoil, and texture of the subsoil to estimate the infiltration rate. The potential runoff can then be calculated for a specified rainfall intensity. Using smaller segments and locational orientation of resources will give a more accurate estimate of potential runoff than does the current method of using a value for a large area. The planner could

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New Technology and Techniques

The SCS (Swanson 1970) is currently engaged in the task of coding soils information for automatic processing to be used primarily for soil classification. They (SCS) are in the discussion stage of setting up a system of utilizing coded information for land use interpretations[1] and are experimenting with the use and formulation of a method to publish a digitized soil survey map. If this procedure can be accomplished, then soils information could be read directly from the map and the task of coding and reading soil maps would be greatly simplified. The SCS projection

[1]National Cooperative Soil Survey Technical Work-Planning Conference, Charleston, South Carolina, January 25-28, 1971.

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is to have the digitized mapping procedure operational by 1974.[1]

Johannsen (1968) emphasized the need for establishing an economical information processing system that has the capability of making resource information available to the user within a week and that remote sensing with automatic data processing capability may possibly meet these requirements.

The National Aeronautics and Space Administration will soon orbit an Earth Resources Technology Satellite to transmit imagery back to earth on urban and rural land uses, geologic features, and other natural features of the earth's surface. (Sattinger 1971) Other natural resource information and hopefully the information from the satellite can be utilized as input for computing the index. Philip Le Blanc,[2] at the Laboratory for Application of Remote Sensing in West Lafayette, Indiana, is currently investigating the capability of remote sensing techniques to consistently identify different types of ground cover and land use patterns. This information can become a direct input in calculating the Physical Site Suitability Index.

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[1]Personal conversation with Ray Dideriksen, State Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture, Indianapolis, Indiana.

[2]Philip N. LeBlanc, Remote Multispectral Sensing of Land Use Features, (unpublished) M.S. Thesis, Department of Agronomy, Purdue University, West Lafayette, Indiana. June 1972.

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APPENDICES

APPENDIX A

DATA WORK SHEET

APPENDIX A

DATA WORK SHEET

Location ____ ____
Row Column

Current Land Use

1. Urban

__ 100% __ 25%
__ 75% __ 0%
__ 50%

2. Transportation

__ 100% __ 25%
__ 75% __ 0%
__ 50%

3. Recreation

__ 100% __ 25%
__ 75% __ 0%
__ 50%

4. Agriculture

__ 100% __ 25%
__ 75% __ 0%
__ 50%

5. Timber

__ 100% __ 25%
__ 75% __ 0%
__ 50%

6. Water

__ 100% __ 25%
__ 75% __ 0%
__ 50%

Climatology

11. Freeze Free Period

1. __ 60-90 days
2. __ 91-120 days
3. __ 121-150 days
4. __ More than 150 days

Soils

12. Mapping Unit

____ ____
soil type slope

13. Soil Erosion

____
class

APPENDIX A

DATA WORK SHEET

Location ___ ___
Twp. Section

Climatology

11. Freeze Free Period
    1. __ 60-90 days
    2. __ 91-120 days
    3. __ 121-150 days
    4. __ More than 150 days

Soils

12. Mapping Unit

    ___ Soil Unit ___ Slope

13. Soil Erosion

    ___ tons

Current Land Use

1. Urban
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%
2. Transportation
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%
3. Recreation
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%
4. Agriculture
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%
5. Timber
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%
6. Water
   - __ 100% __ 25%
   - __ 75% __ 0%
   - __ 50%

APPENDIX B

SOIL CODING SHEET

APPENDIX B

SOIL CODING SHEET

1. Soil Label ________ ______ 2. ____________
soil type slope soil erosion

3. Slope

1 ___	0-2%	A	4 ___	13-18%	D
2 ___	3-6%	B	5 ___	19-25%	E
3 ___	7-12%	C	6 ___	More than 25%	F or G

4, 5, 6 Texture

	4. Surface	5. Subsoil	6. Underlying Material
clay silty clay sandy clay	1 ___	1 ___	1 ___
silty clay loam clay loam sandy clay loam	2 ___	2 ___	2 ___
silt silt loam loam	3 ___	3 ___	3 ___
sandy loam	4 ___	4 ___	4 ___
loamy sand sand	5 ___	5 ___	5 ___

7. Drainage

1 ___ Poorly and very poorly
2 ___ Somewhat poorly
3 ___ Moderately well
4 ___ Well
5 ___ Somewhat to excessively well

8. Topsoil Depth

1 ___ More than 16 inches
2 ___ 11-16 inches
3 ___ 7-10 inches
4 ___ 3-6 inches
5 ___ 0-2 inches

APPENDIX B

SOIL RATING SHEET

1. Soil Label ______ 2. ______
   soil type slope soil erosion

3. Slope

1	___	0-2%	A	4	___	13-15%	D
2	___	3-6%	B	5	___	19-25%	E
3	___	7-12%	C	6	___	More than 25%	F or G

4, 5, 6 Texture

	4. Surface	5. Subsoil	6. Underlying Material
clay silty clay sandy clay	1 ___	1 ___	1 ___
silty clay loam clay loam sandy clay loam	2 ___	2 ___	2 ___
silt silt loam loam	3 ___	3 ___	3 ___
sandy loam	4 ___	4 ___	4 ___
loamy sand sand	5 ___	5 ___	5 ___

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1 ___ Poorly and very poorly
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4 ___ Well
5 ___ Somewhat to excessively well

8. Topsoil Depth

1 ___ More than 16 inches
2 ___ 11-16 inches
3 ___ 7-10 inches
4 ___ 3-6 inches
5 ___ 0-2 inches

9. Organic Matter

1 ___ More than 9%
2 ___ 5-9%
3 ___ 3-4%
4 ___ 0-2%

10. Stoniness (classes)

1 ___ 0
2 ___ 1
3 ___ 2
4 ___ 3, 4, or 5

11. Soil Depth

1 ___ More than 60 inches
2 ___ 40-60 inches
3 ___ 20-39 inches
4 ___ 10-19 inches
5 ___ Less than 10 inches

12. Permeability

1 ___ Less than .2 inches/hr.
2 ___ .2-.6 inches/hr.
3 ___ .7-2.0 inches/hr.
4 ___ 2.1-6.0 inches/hr.
5 ___ More than 6.0 inches/hr.

13. Available Water

1 ___ More than 12 inches
2 ___ 9-12 inches
3 ___ 6-8 inches
4 ___ 3-5 inches
5 ___ 0-2 inches

14. Flooding (1 year in 25)

1 ___ no
3 ___ yes

15. Topographic Position

1 ___ Upland high ground
2 ___ Upland depressional
3 ___ Terrace high ground
4 ___ Terrace depressional
5 ___ Bottomland or alluvial

16. Depth to Bedrock

1 ___ More than 60 inches
2 ___ 40-60 inches
3 ___ 20-39 inches
4 ___ 10-19 inches
5 ___ Less than 10 inches

9. Organic Matter

1 ___ More than 9%
2 ___ 5-9%
3 ___ 3-4%
4 ___ 0-2%

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1 ___ 0
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16. Depth to Bedrock

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APPENDIX C

COMPUTER PROGRAM "LAND USE"

APPENDIX C

COMPUTER PROGRAM "LAND USE"

```
PROGRAM     LANDUSE

            PROGRAM LANDUSE  (INPUT, OUTPUT)
      C       PROGRAM WRITTEN BY  KENNETH A WENNER JAN 12,1972
      C            IDENTIFIER VARIABLES
      C               DS1= DATA SHEET ARRAY- 3 DIMENSIONAL
      C                  I= FIRST DIMENSION - THE ROW LOCATION
      C                  J= SECOND DIMENSION- THE COLUMN LOCATION
      C                  N= THIRD DIMENSION- 27 ELEMENTS OF THE INFORMATION
      C                  FOR IDENTIFICATION OF ELEMENTS SEE APPENDIX A
      C               DS2= 3 DIMENSION ARRAY FOR OUTPUT
      C                  I= FIRST DIMENSION- THE ROW LOCATION
      C                  J= SECOND DIMENSION- THE COLUMN LOCATION
      C                  K= INDEX VALUE FOR SPECIFIC LAND USE
      C               SC= SOIL ARRAY- 16 ELEMENTS
      C                  M= ELEMENTS OR FEATURES IN SOIL ARRAY
      C                    FOR IDENTIFICATION OF ELEMENTS SEE APPENDIX B
      C               K= SPECIFIC LAND USE
      C                  K= 1 DENOTES SANITARY LANDFILLS
      C                  K= 2 DENOTES RESIDENTIAL HOMES WITH SANITARY SEWER
      C                  K= 3 - RESIDENTIAL HOMES WITH SEPTIC FILTER FIELDS
      C                  K= 4 - CONTINUOUS CORN
      C               KK= NUMBER OF LAND USES TO BE CONSIDERED
      C               X= INDICATOR VARIABLES- SEE INDIVIDUAL LAND USE
      C                  TRANSFORMATION SECTION FOR IDENTIFICATION.
          5 INTEGER DS1(32,16,27)
          6 REAL DS2(32,16,5)
         10 INTEGER SC(16)
          7 DATA (((DS1(I,J,N),N=1,27), J=1,16),I=1,32)/13824*0/
      C      READ DATA INPUT SHEETS
         15 READ 1, (((DS1(I,J,N), N=1,13),J=1,16),I=1,32)
      C        FORMAT FOR READING THE DATA SHEET
          1 FORMAT (10X,6I3, 5I1, A3, I1)
            PRINT 8, (DS1(3,3,N),N=1,13)
          8 FORMAT (1H1,/,/,/,/,/,/, 11I4,2X,A3,I4)
      C      READ A SOILS CARD
         20 READ 2, (SC(M),M=1,16)
      C        FORMAT FOR READING SOIL SHEET
          2 FORMAT (6X, A3, 15I1)
            PRINT 9,  (SC(M),M=1,16)
          9 FORMAT ( 2X,A3,15I4)
      C      CHECK TO SEE IF SOIL CARD IS LEGITIMATE
         25 IF(SC(2).EQ. 0) GO TO 999
      C        CHECK TO SEE IF SOIL CARD LABEL=SOIL LABEL ON DATA SHEET
         30 DO 41  I=1,32
         31 DO 40  J=1,16
         32 IF(DS1(I,J,12).EQ.SC(1).AND.DS1(I,J,13).EQ.SC(2))  GO TO 33
            GO TO 40
         33 DO 39 N =14,27
         34 DS1(I,J,N)=SC(N-11)
         39 CONTINUE
         40 CONTINUE
         41 CONTINUE
      C        CHECK TO SEE IF DS1 ARRAY IS FILLED
         45 DO 60  I=1,32
         50 DO  60  J=1,16
         55 IF(DS1(I,J,14).EQ.0) GO TO 20
```

APPENDIX C

COMPUTER PROGRAM "LAND USE"

```
PROGRAM      LANDUSE

      PROGRAM LANDUSE  (INPUT,OUTPUT)
C     PROGRAM WRITTEN BY KENNETH A WEBER JAN 12,1972
      INTEGER [illegible]
C     DATA = DATA SHEET ARRAY - 3 DIMENSIONAL
C     I = FIRST DIMENSION - THE ROW LOCATION
C     J = SECOND DIMENSION - THE COLUMN LOCATION
C     K = THIRD DIMENSION - 27 ELEMENTS OF THE INFORMATION
C     FOR IDENTIFICATION OF ELEMENTS SEE APPENDIX A
C     LUSE = [illegible] ARRAY FOR OUTPUT
C     I = FIRST DIMENSION - THE ROW LOCATION
C     J = SECOND DIMENSION - THE COLUMN LOCATION
C     K = [illegible] VALUE FOR SPECIFIC LAND USE
C     [illegible] ARRAY - [illegible] ELEMENTS
C     [illegible] ELEMENTS IN SOIL ARRAY
C     [illegible] IDENTIFICATION OF ELEMENTS SEE APPENDIX B
C     [illegible]
C     K = 1 - [illegible] SANITARY LANDFILLS
C     K = 2 - [illegible] RESIDENTIAL HOMES WITH SANITARY SEWERS
C     K = 3 - [illegible] HOMES WITH SEPTIC FILTER FIELDS
C     K = 4 - [illegible]
C     [illegible] TO BE CONSIDERED
C     [illegible] SEE INDIVIDUAL LAND USE
C     [illegible] FOR IDENTIFICATION.
      [illegible]
      [illegible]
      [illegible]
    7 DATA [illegible]
C     [illegible]
   15 [illegible]
C     [illegible] DATA SHEET
    1 FORMAT [illegible]
      [illegible]
    8 FORMAT [illegible]
C     [illegible]
   20 [illegible]
C     [illegible] SHEET
    2 FORMAT [illegible]
      [illegible]
    9 FORMAT [illegible]
C     [illegible]
   26 IF [illegible]
C     [illegible] LABEL ON DATA SHEET
   30 [illegible]
   31 [illegible]
   32 IF [illegible] GO TO 33
      [illegible] GO TO 40
   33 [illegible]
   34 [illegible]
   35 [illegible]
   40 [illegible]
   41 [illegible]
C     [illegible] ARRAY IS FILLED
   45 [illegible]
   47 [illegible]
   55 IF [illegible] GO TO 56
```

PROGRAM LANDUSE

```
 50 CONTINUE
C         BEGIN COMPUTATIONS
 65 DO 401 I=1,32
 70 DO  401 J= ,16
    KK=4
 75 DO  400  K=1,KK
C         CHECK LAND USE FOR WATER, URBAN, OR TRANSPORTATION
 80 IF(DS1(I,J,1).GE.75)  GO TO 142
 85 IF(DS1(I,J,2).EQ.100)  GO TO 143
 90 IF(DS1(I,J,6).EQ.100)  GO TO 144
 95 GO TO (100,15 ,150,250)K
100 CONTINUE
C                  BEGIN TRANSFORMATIONS FOR SANITARY LANDFILLS
C      X2 IS DRAINAGE
    X2=1
101 IF(DS1(I,J,18).LE.2)X2=-1
C       X3 IS FLOODING
102 X3 = 1
103 IF(DS1(I,J,25).EQ.3) X3 =-1
C       X4 IS PERMEABILITY
104 X4 =1
105 IF(DS1(I,J,23).GE.4)  X4=-1
C         X5 AND X6 ARE SLOPE
106 X5=1
107 X6=0
108 IF(DS1(I,J,14). EQ.4.OR.DS1(I,J,14).EQ.5)  GO TO 110
109 GO TO 113
110 X5 =0
111 X6=1
112 GO TO 117
113 IF(DS1(I,J,14).EQ.6)  GO TO 115
114 GO TO 117
115 X5=-1
116 X6=-1
C         X7 AND X8 ARE TEXTURE
117 X7=1
118 X8=0
119 IF(DS1(I,J,17).LE.2.OR.DS1(I,J,17).EQ.4)  GO TO 121
120 GO TO 124
121 X7=0
122 X8=1
123 GO TO 128
124 IF(DS1(I,J,17).EQ.5) GO TO 126
125 GO TO 128
126 X7=-1
127 X8=-1
C         X9 IS BEDROCK
128 X9=1
129 IF(DS1(I,J,27).GE.2)  X9=-1
C         X10 AND X11 ARE STONINESS
130 X10=1
131 X11=0
132 IF(DS1(I,J,21).EQ.3)  GO TO 134
133 GO TO 137
134 X10=0
```

PROGRAM LANDUSE

```
      135 X11=1
      136 GO TO 141
      137 IF(DS1(I,J,21).GE.4)  GO TO 139
      138 GO TO 141
      139 X10=-1
      140 X11=-1
          PRINT 11,X2, X3, X4, X5, X6, X7, X8, X9, X10, X11
       11 FORMAT ( 10F4.0 )
      141 DS2(I,J,K)= 1.0 - ((26.637 -4.469*X2-4.469*X3-3.207*X4 -4.025*X5-
         20.059*X6-1.903*X7+1.000*X8-4.538*X9-4.013*X10-0.928*X11)/45)*100
          GO TO 400
      150 CONTINUE
C                        RESIDENTIAL HOMESITE TRANSFORMATIONS
C                        CHECK FOR FLOODING OR ORGANIC SOILS
          IF(DS1(I,J,20).EQ.1) GO TO 145
          IF(DS1(I,J,25).EQ.3) GO TO 146
          X2=1
          X3=0
          X4=0
      154 IF(DS1(I,J,14).EQ.3) GO TO 157
      155 IF(DS1(I,J,14).EQ.4) GO TO 160
      156 IF(DS1(I,J,14).GE.5) GO TO 163
          GO TO 166
      157 X2=0
      158 X3=1
      159 X4=0
          GO TO 166
      160 X2=0
      161 X3=0
      162 X4=1
          GO TO 166
      163 X2=-1
      164 X3=-1
      165 X4=-1
C            SURFACE TEXTURE
      166 X5=1
      167 IF(DS1(I,J,15).LE.2. OR.DS1(I,J,15).EQ.5) X5=-1
C            SUBSOIL TEXTURE
      168 X6=1
      169 IF(DS1(I,J,16).EQ.1) X6=-1
C            NATURAL DRAINAGE
      170 X7=1
      171 X8=0
      172 IF(DS1(I,J,18).EQ.2)  GO TO 174
      173 IF(DS1(I,J,18).EQ.1)  GO TO 176
          GO TO 178
      174 X7=0
      175 X8=1
          GOTO  178
      176 X7=-1
      177 X8=-1
C            ORGANIC MATTER
      178 X9=1
      179 X10=0
      180 IF(DS1(I,J,20).EQ.2.OR.DS1(I,J,20).EQ.4) GO TO 182
```

PROGRAM LANDUSE

```
  181 IF(DS1(I,J,20).EQ.1)GOTO 185
      GO TO 187
  182 X9=0
  183 X10=1
  184 GO TO 1 .
  185 X9=-1
  186 X10=-1
C        STONINESS
  187 X11= 1
      X12= 0
      IF(DS1(I,J,21).EQ.3)  GO TO  188
      IF(DS1(I,J,21).EQ.4)  GO TO  189
      GOTO 190
  188 X11=0
      X12=1
      GO TO   190
  189 X11=-1
      X12=-1
C        FLOODING
  190 X13=1
      IF(DS1(I,J,25).EQ.3) X13=-1
C        DEPTH TO BEDROCK
      X14=1
      X15=0
      IF(DS1(I,J,27).EQ.2) GO TO 191
      IF(DS1(I,J,27).GE.3) GO TO  192
      GO TO 193
  191 X14=0
      X15=1
      GO TO 193
  192 X14=-1
      X15=-1
C        PERMEABILITY
  193 X16=1
      X17=0
      X18=0
      IF(DS1(I,J,23).EQ.3) GO TO 194
      GO TO 195
  194 X16=0
      X17=1
      X18=0
      GO TO 197
  195 IF(DS1(I,J,23).EQ.2) GO TO 196
      GO TO 198
  196 X16=0
      X17=0
      X18=1
      GO TO 197
  198 IF(DS1(I,J,23).EQ.1) GO TO 199
      GO TO 197
  199 X16=-1
      X17=-1
      X18=-1
  197 IF(K.EQ.3) GO TO 200
      DS2(I,J,K)=  100- ((28.07-4.40*X2-1.51*X3+1.48*X4-1.44*X5-1.57*X6
```

```
181 IF(X(I).GT.0.AND.X(I+1).LT.0) GO TO 182
    GO TO 183
182 X(I)=0
183 X(I+1)=1
184 GO TO 1
185 X(I+2)=1
186 X(I+1)=-1
C        ...
187 X(I+1)=1
    X(I)=0
    IF(X(I).LT.0.AND.X(I+1).GT.0) GO TO 188
    IF(X(I).GT.0.AND.X(I+1).LT.0) GO TO 189
    GO TO 190
188 X(I)=1
    X(I+1)=1
    GO TO 1
189 X(I+1)=1
C        ...
190 X(I)=1
    IF(X(I).LT.0.AND.X(I+1).GT.0) X(I+1)=1
C        ...
    X(I+1)=1
    X(I)=1
    IF(X(I).GT.0.AND.X(I+1).GT.0) GO TO 191
    IF(X(I).LT.0.AND.X(I+1).LT.0) GO TO 192
    GO TO 193
191 X(I)=0
    GO TO 193
192 X(I+1)=1
    X(I)=1
193 X(I)=1
C        ...
    X(I+1)=1
    X(I)=0
    IF(X(I).LT.0.AND.X(I+1).GT.0) GO TO 194
    GO TO 195
194 X(I+1)=0
    X(I)=1
    X(I)=0
    GO TO 196
195 IF(X(I).GT.0.AND.X(I+1).GT.0) GO TO 196
    GO TO 197
196 X(I)=0
197 X(I)=1
    X(I+1)=1
    X(I+1)=1
198 IF(X(K).LT.0) GO TO 200
```

PROGRAM LANDUSE

```
     2-3.97*X7-0.98*X8-4.03*X9-0.93*X10-4.02*X11-1.04*X12-4.46*X13-4.10*
     3X14-0.81*X15)/42))*100
      GO TO 400
  200 DS2(I,J,K) = 100- ((33.83-4.39*X2-1.51*X3+1.48*X4-1.42*X5-2.10*X6-
     24.93*X7+0.92*X8-4.04*X9-0.90*X10-4.02*X11-1.04*X12-4.46*X13-4.10*
     3X14-0.81*X15-4.26*X16-1.33*X17+1.89*X18 )/51)*100
      GO TO 400
  145  DS2(I,J,K)=000.
      GO TO 400
  146  DS2(I,J,K)=777.
      GO TO 400
  250 CONTINUE
C                     CONTINUOUS CORN TRANSFORMATIONS
C                     SLOPE
      X2=1
      X3=0
      X4=0
      IF(DS1(I,J,14).EQ.2) GO TO 251
      IF(DS1(I,J,14).EQ.3) GO TO 252
      IF(DS1(I,J,14).GE.4)GO TO 253
      GO TO 255
  251 X2=0
      X3=1
      X4=0
      GO TO 255
  252 X2=0
      X3=0
      X4=1
      GO TO 255
  253 X2=-1
      X3=-1
      X4=-1
      GO TO 298
C                       SURFACE TEXTURE
  255 X5=1
      X6=0
      IF(DS1(I,J,15).EQ.2.OR.DS1(I,J,15).EQ.4) GO TO 256
      IF(DS1(I,J,15).EQ.1.OR.DS1(I,J,15).EQ.5) GO TO 257
      GO TO 259
  256 X5=0
      X6=1
      GO TO 259
  257 X5=-1
      X6=-1
C                     SUBSOIL TEXTURE
  259 X7=1
      X8=0
      IF(DS1(I,J,16).EQ.2.OR.DS1(I,J,16).EQ.4) GO TO 260
      IF(DS1(I,J,16).EQ.1.OR.DS1(I,J,16).EQ.5) GO TO 261
      GO TO 263
  260 X7=0
      X8=1
      GO TO 263
  261 X7=-1
      X8=-1
```

```
PROGRAM      LANDUSE
      C                        TOPSOIL DEPTH
        263 X9=1
            X10=0
            X11=0
            IF(DS1(I,J,19).EQ.3)GO TO 265
            IF(DS1(I,J,19).EQ.4)GO TO 266
            IF(DS1(I,J,19).EQ.5)GO TO 267
            GO TO 269
        265 X9=0
            X10=1
            X11=0
            GO TO 269
        266 X9=0
            X10=0
            X11=1
            GO TO 269
        267 X9=-1
            X10=-1
            X11=-1
      C                        ORGANIC MATTER
        269 X12=1
            X13=0
            IF(DS1(I,J,20).EQ.4) GO TO 270
            IF(DS1(I,J,20).EQ.5) GO TO 271
            GO TO 273
        270 X12=0
            X13=1
            GO TO 273
        271 X12=-1
            X13=-1
      C                        STONINESS
        273 X14=1
            X15=0
            IF(DS1(I,J,21).EQ.3) GO TO 274
            IF(DS1(I,J,21).EQ.4) GO TO 275
            GO TO 277
        274 X14=0
            X15=1
            GO TO 277
        275 X14=-1
            X15=-1
      C                        SOIL DEPTH
        277 X16=1
            X17=0
            X18=0
            IF(DS1(I,J,22).EQ.3) GO TO 278
            IF(DS1(I,J,22).EQ.4) GO TO 279
            IF(DS1(I,J,22).EQ.5) GO TO 280
            GO TO 282
        278 X16=0
            X17=1
            X18=0
            GO TO 282
        279 X16=0
            X17=0
```

PROGRAM LANDUSE

```
      X18=1
      GO TO 282
  280 X16=-1
      X17=-1
      X18=-1
C                         AVAILABLE WATER
  282 X19=1
      X20=0
      X21=0
      IF(DS1(I,J,24).EQ.3) GO TO 283
      IF(DS1(I,J,24).EQ.4) GO TO 284
      IF(DS1(I,J,24).EQ.5) GO TO 285
      GO TO 287
  283 X19=0
      X20=1
      X21=0
      GO TO 287
  284 X19=0
      X20=0
      X21=1
      GO TO 287
  285 X19=-1
      X20=-1
      X21=-1
C                         FLOODING
  287 X22=1
      IF(DS1(I,J,25).EQ.3) GO TO 288
      GO TO 290
  288 X22=-1
C                         TOPOGRAPHIC POSITION
  290 X23=1
      IF(DS1(I,J,26).EQ.1.OR.DS1(I,J,26).EQ.3) GO TO 291
      GO TO 29
  291 X23=-1
C                         FREEZE FREE DAYS
  293 X24=1
      X25=0
      IF(DS1(I,J,11).EQ.2) GO TO 294
      IF(DS1(I,J,11).EQ.1) GO TO 295
      GO TO 297
  294 X24=0
      X25=1
      GO TO 297
  295 X24=-1
      X25=-1
C                         FORMULA FOR CONTINUOUS CORN
  297 DS2(I,J,K)=100.-((35.00-4.12*X2-2.14*X3+1.77*X4-3.08*X5-0.03*X6-
     21.42*X7+0.07*X8-3.14*X9-1.04*X10+1.09*X11-2.52*X12-0.57*X13-3.15*
     3X14-0.19*X15-4.39*X16-1.39*X17+1.50*X18-4.22*X19-2.16*X20+1.84*
     4X21-2.98*X22-1.45*X23-3.94*X24-1.01*X25)/64.1)*100.
      GO TO 400
  298 DS2(I,J,K)=555.
      GO TO 400
  142 DS2(I,J,K) = 111.00
      GO TO 400
```

```
PROGRAM     LANDUSE

            143 DS2(I,J,K) = 222.00
                GO TO 400
            144 DS2(I,J,K) = 666.00
            400 CONTINUE
            401 CONTINUE
          C                   BEGIN PRINT STATEMENTS
                DO 349 K=1,4
                GO TO (310,315,330,345)K
            310 PRINT  300
            300 FORMAT (1H1,/,/,/,/,/,/,
               6         *        THIS TABLE REPRESENTS AN INDEX VALUE FOR SANITARY LI
               2ANDFILLS*,/,*      A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE
               3BASED ON THE NATURAL PHYSICAL FEATURES*)
                GO TO 311
            315 PRINT 316
            316 FORMAT (1H1,/,/,/,/,/,/,
               6         *        THIS TABLE REPRESENTS AN INDEX VALUE FOR RESIDENTIAL
               7 HOMES ON SANITARY SEWERS,WITHOUT BASEMENTS*,/,*       A VALUE OF 1
               300 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL
               4FEATURES*)
                GO TO 31
            330 PRINT 331
            331 FORMAT ( 1H1,/,/,/,/,/,/,
               6         *        THIS TABLE REPRESENTS AN INDEX VALUE FOR RESIDENTIA
               2L HOMES WITH SEPTIC FILTER FIELDS,NO BASEMENTS*,/,*       A VALUE O
               3F 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICA
               4L FEATURES*)
                GO TO 311
            345 PRINT 346
            346 FORMAT ( 1H1,/,/,/,/,/,/,
               6         *        THIS TABLE REPRESENTS AN INDEX VALUE FOR CONTINUOUS
               2 CORN*,/,*      A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BAS
               3ED ON THE NATURAL PHYSICAL FEATURES*)
            311 PRINT 301
            301 FORMAT (*        TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 34,GRAND
               2TRAVERSE COUNTY,MICHIGAN*,//)
                PRINT 302, ((J),J=1,16)
            302 FORMAT (6X,16I5,//)
                PRINT 303,  (I ,       ( DS2(I,J,K),J=1,16),I=1,16)
            303 FORMAT (2X,I2,2X,16F5.0,//)
                PRINT 347
            347 FORMAT (*1 EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5
               2 ACRES*)
                PRINT 304
            304 FORMAT(*0 A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND
               2WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES*,/,
               3*  A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS M
               4ORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED*,/,
               5*  A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS
               6100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED*,/,
               7*  A VALUE OF  555. INDICATES A SLOPE GREATER THAN 12 PER CENT AND
               8THE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN*,/,*  A VALUE OF
               9666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WA
               9S CALCULATED*,/,*  A VALUE OF 777. INDICATES THE SITE IS SUBJECT T
               9O FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES*)
```

PROGRAM LANDUSE

```
      GO TO (306,307,308,309)K
  306 PRINT 300
      GO TO 312
  307 PRINT 316
      GO TO 312
  308 PRINT 331
      GO TO 312
  309 PRINT 346
  312 PRINT 305
  305 FORMAT (*      TOWNSHIP 27 NORTH,RANGE 11 WEST, SECTION 36, GRAND
     2TRAVERSE COUNTY, MICHIGAN*)
      PRINT 302,  ((J),J=1,16)
      PRINT 303 ,    (I ,      (  DS2(I,J,K),J=1,16),I=17,32)
      PRINT 347
      PRINT 304
  399 CONTINUE
      GO TO 904
  899 PRINT 403
  403 FORMAT  (*1 SOIL CARD MISSING*)
  904 CONTINUE
      END
```

APPENDIX D

DATA FOR ROW 3, COLUMN 3, AND SOIL DATA

APPENDIX D

DATA RETRIEVAL

The material included in this appendix illustrates the type and form of data retrieval that is possible with this computer program for any of the parcels of land evaluated; and identifies all of the soil mapping units, with their respective characteristics as listed in Appendix B, that were included in this study.

As an example, the first row of values on the following page is a print of the data submitted to the computer program from the data work sheet (Appendix A) for the land parcel located in row 3 column 3, section 34. The soil mapping unit occurring on this parcel is identified in the last two columns as EYB 1. Each remaining row of values represents a different soil mapping unit and its respective set of characteristics. The soil characteristics for row 3 column 3 can be determined by locating the row beginning with EYB in the left column and a 1 in the second column. (The characteristics are identified consecutively in Appendix B.)

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DATA RETRIEVAL

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As an example, the first row of values on the following page is a print of the data submitted to the computer program from the data work sheet (Appendix A) for the land parcel located in row 3 column 3, section 34. The soil mapping unit occurring on this parcel is identified in the last two columns as EYB 1. Each remaining row of values represents a different soil mapping unit and its respective set of characteristics. The soil characteristics for row 3 column 3 can be determined by locating the row beginning with EYB in the left column and a 1 in the second column. (The characteristics are identified consecutively in Appendix B.)

0 0 0 100 0 0 -0 -0 -0 -0 -0 EYB 1

AFA	1	1	5	5	4	4	4	4	3	3	5	5	1	1	1
AFB	1	2	5	5	4	4	4	4	3	3	5	5	1	1	1
COA	1	1	5	5	5	3	3	5	2	2	5	5	1	1	1
CRA	1	1	5	5	5	3	3	4	1	2	5	5	1	1	1
EMA	1	1	5	5	5	1	3	4	2	3	5	5	1	1	1
EYA	1	1	4	2	4	4	3	4	1	2	4	3	1	1	1
EYB	1	2	4	2	4	4	3	4	1	2	4	3	1	1	1
EYC	1	3	4	4	4	4	3	4	1	2	4	3	1	1	1
EYC	2	3	4	2	4	4	4	5	1	2	4	3	1	1	1
EYD	1	4	4	2	4	4	4	5	2	2	4	3	1	1	1
EYD	2	4	4	2	4	4	4	5	2	3	4	3	1	1	1
EYE	1	5	4	2	4	4	4	5	2	3	4	3	1	1	1
EYE	2	5	4	2	4	4	4	5	2	3	4	4	1	1	1
EYF	1	6	4	2	4	4	4	5	2	3	4	4	1	1	1
EYF	2	6	4	2	4	4	5	5	2	3	4	4	1	1	1
EYB	1	2	4	2	4	4	3	4	1	2	4	3	1	1	1
EXD	1	4	4	2	4	4	4	4	3	2	4	4	1	1	1
EXE	1	5	4	2	4	4	4	5	3	3	4	4	1	1	1
KAF	1	6	5	5	5	4	3	4	1	3	5	5	1	1	1
LKA	1	1	5	3	5	4	4	4	1	2	4	4	1	1	1
LKA	2	1	5	3	5	4	4	4	1	2	4	4	1	1	1
LKB	1	2	5	3	5	4	4	5	1	2	4	4	1	1	1
LKC	1	3	5	3	5	4	4	5	1	3	4	4	1	1	1
LKD	1	4	5	3	5	4	4	5	1	2	4	4	1	1	1
LKD	2	4	5	3	5	4	4	5	1	3	4	4	1	1	1
LKE	1	5	5	3	5	4	4	5	1	3	4	4	1	1	1
LKE	2	5	5	3	5	4	5	5	1	3	4	4	1	1	1
LKF	1	6	5	3	5	4	4	5	1	3	4	4	1	1	1
LKF	2	6	5	3	5	4	5	5	1	3	4	4	1	1	1
MAB	1	2	4	2	5	4	4	4	2	3	4	4	1	1	1
RCA	1	1	4	5	5	2	2	4	1	2	3	3	1	1	1
RHA	1	1	3	5	5	2	3	4	1	2	3	3	1	1	1
RRB	1	1	3	5	1	1	3	3	1	2	3	3	1	4	1
TOA	1	1	4	3	5	1	3	3	1	3	3	3	1	2	1
TPA	1	1	3	2	1	1	2	3	1	2	3	3	1	2	1
UNB	1	2	3	2	2	3	3	4	1	2	2	3	1	1	1
UNC	1	3	3	2	2	3	3	4	1	2	2	3	1	1	1
UND	1	4	3	2	2	3	3	4	1	2	2	3	1	1	1
UNE	1	5	3	2	2	4	3	4	1	2	2	3	1	1	1
UNF	1	6	3	2	2	4	3	4	1	2	2	3	1	1	1
WOD	1	5	5	5	5	5	5	5	1	4	5	5	1	1	1
WOD	3	5	5	5	5	5	5	5	1	4	5	5	1	1	1
000	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX E

PSSI VALUES FOR FOUR LAND USES

APPENDIX E

PSSI VALUES

Two sections of land (640 acres each) and 4 land uses were evaluated in this study and the tables in this Appendix represent the PSSI values calculated for a section and for a specified land use. (The section location and land use are identified at the top of each table.)

Each section was divided into a 16 x 16 row-column grid system making a total of 256 cells of 2½ acres in size. A PSSI value was calculated for every cell in the system and this value was printed in table form according to its row-column location. Lines were drawn around contiguous cells having equal value to illustrate a method of associating larger areas of similar suitability. The lines were placed midway between the values to represent the cell boundaries.

APPENDIX B

PSSI VALUES

Two sections of land (640 acres each) and 4 land uses were evaluated in this study and the tables in this Appendix represent the PSSI values calculated for a section and for a specified land use. (The section location and land use are identified at the top of each table.)

Each section was divided into a 16 x 16 row-column grid system making a total of 256 cells of 2½ acres in size. A PSSI value was calculated for every cell in the system and this value was printed in table form according to its row-column location. Lines were drawn around contiguous cells having equal value to illustrate a method of associating larger areas of similar suitability. The lines were placed midway between the values to represent the cell boundaries.

THIS TABLE REPRESENTS AN INDEX VALUE FOR SANITARY LANDFILLS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 34,GRAND TRAVERSE COUNTY,MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	72.	79.	79.	73.	79.	79.	79.	59.	74.	59.	59.	79.	59.	72.	666.	666.
2	72.	79.	79.	79.	79.	79.	79.	79.	59.	59.	74.	79.	72.	666.	666.	666.
3	72.	79.	79.	79.	73.	79.	79.	79.	79.	79.	79.	74.	72.	666.	666.	666.
4	72.	79.	79.	73.	73.	79.	79.	79.	79.	79.	79.	80.	80.	666.	666.	666.
5	72.	74.	79.	79.	79.	79.	79.	79.	79.	79.	72.	80.	80.	666.	666.	666.
6	67.	79.	79.	79.	79.	79.	79.	79.	79.	79.	72.	80.	80.	666.	666.	666.
7	72.	79.	79.	79.	79.	79.	79.	79.	79.	79.	72.	60.	60.	666.	666.	666.
8	72.	79.	79.	79.	79.	79.	79.	79.	73.	73.	59.	60.	60.	60.	666.	666.
9	72.	79.	79.	80.	79.	79.	73.	73.	79.	73.	59.	59.	72.	72.	666.	666.
10	67.	79.	79.	79.	79.	73.	73.	73.	79.	73.	93.	79.	59.	72.	666.	666.
11	67.	79.	50.	79.	73.	79.	79.	79.	79.	73.	93.	79.	79.	72.	666.	666.
12	67.	79.	79.	79.	79.	80.	79.	79.	79.	79.	93.	79.	59.	72.	666.	666.
13	72.	79.	79.	74.	74.	80.	73.	73.	79.	79.	79.	79.	72.	72.	666.	666.
14	72.	79.	79.	74.	80.	73.	73.	73.	79.	79.	80.	72.	72.	666.	666.	666.
15	72.	79.	80.	74.	80.	72.	93.	93.	80.	80.	80.	72.	666.	666.	666.	666.
16	72.	80.	80.	80.	72.	79.	93.	79.	80.	80.	80.	72.	666.	666.	666.	666.

THIS TABLE REPRESENTS AN INDEX VALUE FOR [illegible]
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 16,GRAND TRAVERSE COUNTY,MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	72.	79.	70.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
2	72.	79.	70.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
3	72.	79.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
4	72.	79.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
5	72.	74.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
7	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
8	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
9	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
13	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.
14	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.
15	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.	888.
16	72.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888.	888.	888.	888.

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR SANITARY LANDFILLS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 27 NORTH, RANGE 11 WEST, SECTION 36, GRAND TRAVERSE COUNTY, MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	73.	80.	80.	80.	60.	80.	93.	80.	93.	59.	72.	72.	72.	72.	80.	80.
18	73.	80.	80.	80.	74.	87.	87.	80.	79.	59.	72.	72.	72.	72.	72.	80.
19	73.	80.	80.	74.	74.	80.	87.	79.	79.	80.	72.	72.	72.	72.	72.	72.
20	73.	80.	80.	80.	80.	80.	80.	73.	73.	80.	72.	72.	72.	73.	80.	79.
21	73.	80.	80.	80.	80.	80.	80.	80.	73.	80.	80.	60.	80.	72.	80.	80.
22	73.	80.	80.	93.	80.	80.	80.	80.	73.	73.	80.	80.	80.	73.	80.	80.
23	73.	74.	79.	79.	79.	79.	80.	65.	65.	73.	80.	80.	60.	80.	80.	80.
24	73.	80.	74.	80.	79.	79.	80.	65.	65.	80.	80.	80.	60.	80.	80.	80.
25	73.	80.	74.	80.	80.	80.	80.	65.	79.	80.	80.	79.	60.	60.	73.	73.
26	73.	80.	80.	60.	80.	80.	80.	73.	80.	80.	79.	79.	79.	79.	73.	73.
27	73.	80.	60.	60.	73.	73.	73.	73.	80.	79.	79.	79.	79.	79.	72.	72.
28	72.	79.	79.	60.	79.	79.	79.	79.	72.	79.	79.	79.	80.	79.	79.	72.
29	72.	79.	79.	79.	79.	72.	79.	79.	79.	79.	79.	79.	72.	72.	72.	72.
30	72.	60.	79.	79.	79.	80.	80.	79.	79.	79.	79.	60.	60.	60.	60.	60.
31	72.	59.	60.	60.	79.	80.	80.	79.	79.	79.	79.	60.	79.	74.	87.	87.
32	72.	59.	80.	60.	80.	80.	80.	79.	79.	79.	60.	79.	72.	72.	87.	87.

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.9 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 888. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 999. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE HEPPFSENTS AN INDEX VALUF FOR RESIDENTIAL HOMES ON SANITARY SEWERS,WITHOUT BASEMENTS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 34,GRAND TRAVERSE COUNTY,MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	79.	86.	92.	79.	92.	92.	92.	79.	79.	79.	79.	93.	79.	78.	666.	666.
2	92.	92.	92.	93.	92.	92.	92.	92.	79.	79.	79.	79.	78.	666.	666.	666.
3	92.	92.	92.	92.	79.	92.	92.	86.	92.	92.	79.	79.	78.	666.	666.	666.
4	92.	92.	92.	79.	79.	92.	92.	86.	79.	92.	79.	86.	86.	666.	666.	666.
5	92.	85.	92.	86.	92.	79.	79.	92.	92.	79.	78.	86.	86.	666.	666.	666.
6	85.	92.	92.	79.	92.	86.	92.	92.	79.	79.	78.	86.	86.	666.	666.	666.
7	92.	92.	86.	79.	92.	86.	86.	92.	92.	79.	78.	64.	64.	666.	666.	666.
8	92.	93.	92.	92.	92.	92.	92.	79.	79.	79.	79.	64.	64.	64.	666.	666.
9	92.	93.	79.	86.	92.	92.	79.	79.	79.	79.	79.	79.	78.	78.	666.	666.
10	85.	93.	79.	86.	92.	79.	79.	79.	79.	79.	92.	92.	79.	78.	666.	666.
11	85.	93.	79.	86.	79.	92.	92.	92.	79.	71.	92.	92.	79.	78.	666.	666.
12	85.	93.	92.	92.	92.	86.	92.	92.	79.	79.	92.	92.	79.	78.	666.	666.
13	92.	93.	92.	79.	79.	86.	79.	79.	79.	92.	92.	92.	78.	78.	666.	666.
14	92.	93.	92.	79.	86.	79.	79.	79.	92.	92.	72.	78.	78.	666.	666.	666.
15	86.	92.	86.	79.	86.	86.	86.	86.	72.	72.	86.	78.	666.	666.	666.	666.
16	92.	86.	86.	86.	86.	92.	86.	92.	72.	86.	86.	78.	666.	666.	666.	666.

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.4 ACRES

A VALUE OF 88. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR RESIDENTIAL HOMES ON SANITARY SEWERS,WITHOUT BASEMENTS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 27 NORTH,RANGE 11 WEST, SECTION 36, GRAND TRAVERSE COUNTY, MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	79.	92.	93.	93.	72.	93.	86.	72.	92.	79.	86.	86.	86.	86.	72.	72.
18	79.	92.	92.	93.	85.	78.	78.	72.	79.	79.	72.	86.	86.	86.	86.	72.
19	92.	92.	92.	85.	85.	93.	78.	93.	79.	72.	72.	72.	86.	86.	86.	86.
20	79.	92.	86.	86.	86.	93.	86.	79.	79.	72.	72.	72.	72.	79.	72.	92.
21	79.	92.	86.	93.	72.	72.	72.	93.	79.	72.	72.	72.	72.	72.	72.	72.
22	79.	92.	93.	71.	72.	72.	72.	72.	79.	79.	72.	72.	72.	79.	72.	72.
23	79.	85.	86.	92.	92.	92.	72.	71.	71.	79.	72.	72.	72.	72.	72.	72.
24	79.	72.	85.	72.	92.	92.	72.	71.	71.	72.	72.	72.	72.	72.	72.	72.
25	79.	72.	85.	72.	72.	72.	72.	71.	79.	72.	72.	86.	72.	72.	71.	71.
26	79.	72.	72.	72.	72.	72.	72.	79.	72.	72.	86.	86.	86.	86.	71.	71.
27	79.	72.	72.	72.	79.	79.	79.	79.	72.	86.	86.	86.	86.	86.	86.	86.
28	86.	86.	86.	72.	86.	86.	86.	86.	86.	86.	86.	86.	93.	86.	86.	86.
29	86.	86.	86.	86.	86.	86.	86.	92.	86.	86.	86.	86.	86.	86.	86.	86.
30	86.	72.	86.	86.	86.	93.	93.	92.	86.	86.	86.	72.	72.	72.	72.	72.
31	79.	79.	72.	65.	86.	93.	93.	92.	92.	86.	86.	72.	92.	85.	78.	78.
32	79.	79.	86.	65.	72.	72.	93.	92.	86.	86.	72.	92.	86.	86.	78.	78.

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 888. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR RESIDENTIAL HOMES WITH SEPTIC FILTER FIELDS,NO BASEMENTS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 34,GRAND TRAVERSE COUNTY,MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	83.	88.	94.	77.	94.	94.	94.	83.	77.	83.	83.	94.	83.	82.	666.	666.
2	94.	94.	94.	94.	94.	94.	94.	94.	83.	83.	77.	83.	82.	666.	666.	666.
3	94.	94.	94.	94.	77.	94.	94.	88.	94.	94.	83.	77.	82.	666.	666.	666.
4	94.	94.	94.	77.	77.	94.	94.	88.	83.	94.	83.	88.	88.	666.	666.	666.
5	94.	76.	94.	88.	94.	83.	83.	94.	94.	83.	82.	88.	88.	666.	666.	666.
6	76.	94.	94.	83.	94.	88.	94.	94.	83.	83.	82.	88.	88.	666.	666.	666.
7	94.	94.	88.	83.	94.	88.	88.	94.	94.	83.	82.	71.	71.	666.	666.	666.
8	94.	94.	94.	94.	94.	94.	94.	83.	77.	77.	83.	71.	71.	71.	666.	666.
9	94.	94.	83.	89.	94.	94.	77.	77.	83.	77.	83.	83.	82.	82.	666.	666.
10	76.	94.	83.	88.	94.	77.	77.	77.	83.	77.	82.	94.	83.	82.	666.	666.
11	76.	94.	83.	88.	77.	94.	94.	94.	83.	64.	82.	94.	83.	82.	666.	666.
12	76.	94.	94.	94.	94.	88.	94.	94.	83.	83.	82.	94.	83.	82.	666.	666.
13	94.	94.	94.	77.	77.	88.	83.	83.	83.	94.	94.	94.	82.	82.	666.	666.
14	94.	94.	94.	77.	89.	83.	83.	83.	94.	94.	77.	82.	82.	666.	666.	666.
15	88.	94.	88.	77.	89.	88.	76.	76.	77.	77.	89.	82.	666.	666.	666.	666.
16	94.	88.	88.	88.	88.	94.	76.	94.	77.	89.	89.	82.	666.	666.	666.	666.

[illegible]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR RESIDENTIAL HOMES WITH SEPTIC FILTER FIELDS,NO BASEMENTS
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 27 NORTH,RANGE 11 WEST, SECTION 36, GRAND TRAVERSE COUNTY, MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	83.	94.	94.	94.	77.	94.	76.	77.	82.	83.	88.	88.	88.	88.	77.	77.
18	83.	94.	94.	94.	76.	70.	70.	77.	83.	83.	77.	88.	88.	88.	88.	77.
19	94.	94.	94.	76.	76.	94.	70.	94.	83.	77.	77.	77.	88.	88.	88.	88.
20	83.	94.	89.	88.	88.	94.	89.	83.	83.	77.	77.	77.	77.	83.	77.	94.
21	83.	94.	89.	94.	77.	77.	77.	94.	83.	77.	77.	77.	77.	77.	77.	77.
22	83.	94.	94.	64.	77.	77.	77.	77.	83.	83.	77.	77.	77.	83.	77.	77.
23	83.	76.	88.	94.	94.	94.	77.	76.	76.	83.	77.	77.	77.	77.	77.	77.
24	83.	77.	76.	77.	94.	94.	77.	76.	76.	77.	77.	77.	77.	77.	77.	77.
25	83.	77.	76.	77.	77.	77.	77.	76.	83.	77.	77.	88.	77.	77.	64.	64.
26	83.	77.	77.	77.	77.	77.	77.	83.	77.	77.	88.	88.	88.	88.	64.	64.
27	83.	77.	77.	77.	83.	83.	83.	83.	77.	88.	88.	88.	88.	88.	88.	88.
28	88.	88.	88.	77.	88.	88.	88.	88.	88.	88.	88.	88.	94.	88.	88.	88.
29	88.	88.	88.	88.	88.	88.	88.	94.	88.	88.	88.	88.	88.	88.	88.	88.
30	88.	77.	88.	88.	88.	94.	94.	94.	88.	88.	88.	77.	77.	77.	77.	77.
31	83.	83.	77.	71.	88.	94.	94.	94.	94.	88.	88.	77.	94.	76.	70.	70.
32	83.	83.	89.	71.	77.	77.	94.	94.	88.	88.	77.	94.	88.	88.	70.	70.

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR CONTINUOUS CORN
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH,RANGE 10 WEST, SECTION 34,GRAND TRAVERSE COUNTY,MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	555.	69.	75.	94.	78.	78.	78.	555.	84.	555.	555.	60.	555.	44.	666.	666.
2	75.	75.	75.	60.	78.	78.	78.	75.	555.	555.	84.	555.	44.	666.	666.	666.
3	75.	75.	75.	78.	87.	78.	75.	69.	75.	75.	555.	84.	44.	666.	666.	666.
4	75.	75.	75.	87.	87.	78.	75.	69.	555.	75.	555.	60.	60.	666.	666.	666.
5	75.	78.	75.	69.	75.	555.	555.	75.	75.	555.	44.	60.	60.	666.	666.	666.
6	78.	75.	75.	555.	75.	69.	75.	75.	555.	555.	44.	60.	60.	666.	666.	666.
7	75.	75.	69.	555.	75.	69.	69.	75.	75.	555.	44.	55.	55.	666.	666.	666.
8	78.	60.	75.	75.	75.	75.	75.	555.	94.	94.	555.	55.	55.	55.	666.	666.
9	78.	60.	555.	47.	75.	75.	87.	87.	555.	94.	555.	555.	47.	47.	666.	666.
10	78.	60.	555.	69.	75.	87.	87.	87.	555.	94.	80.	75.	555.	47.	666.	666.
11	78.	60.	555.	69.	87.	75.	75.	75.	555.	555.	80.	75.	555.	47.	666.	666.
12	78.	60.	75.	75.	75.	67.	75.	75.	555.	555.	80.	75.	555.	47.	666.	666.
13	75.	60.	75.	84.	84.	67.	555.	555.	555.	75.	75.	75.	47.	47.	666.	666.
14	75.	60.	75.	84.	47.	555.	555.	555.	75.	75.	555.	47.	47.	666.	666.	666.
15	555.	75.	67.	84.	47.	555.	73.	73.	555.	555.	47.	47.	666.	666.	666.	666.
16	78.	67.	67.	67.	555.	75.	73.	75.	555.	47.	47.	47.	666.	666.	666.	666.

THIS TABLE REPRESENTS AN INDEX VALUE FOR [illegible]
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 29 NORTH, RANGE 10 WEST, SECTION [illegible]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
A VALUE OF 111. INDICATES THE CURRENT LAND USE OF THE SITE IS MORE THAN 75 PER CENT URBAN AND NO INDEX VALUES WERE CALCULATED
A VALUE OF 222. INDICATES THE CURRENT LAND USE OF THE SITE IS 100 PER CENT TRANSPORTATION AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 555. INDICATES A SLOPE GREATER THAN 12 PER CENT ANDTHE SITE WAS NOT CONSIDERED FOR CONTINUOUS CORN
A VALUE OF 666. INDICATE THE SITE IS 100 PER CENT WATER AND NO INDEX VALUE WAS CALCULATED
A VALUE OF 777. INDICATES THE SITE IS SUBJECT TO FLOODING AND NOT CONSIDERED FOR RESIDENTIAL HOMES

THIS TABLE REPRESENTS AN INDEX VALUE FOR CONTINUOUS CORN
A VALUE OF 100 WOULD BE THE MOST SUITABLE SITE BASED ON THE NATURAL PHYSICAL FEATURES
TOWNSHIP 27 NORTH, RANGE 11 WEST, SECTION 30, GRAND TRAVERSE COUNTY, MICHIGAN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	555.	61.	58.	58.	555.	58.	73.	555.	80.	555.	555.	555.	555.	555.	555.	555.
18	555.	61.	61.	58.	80.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.
19	61.	61.	61.	80.	80.	54.	555.	60.	555.	555.	555.	555.	555.	555.	555.	555.
20	555.	61.	47.	67.	67.	58.	47.	555.	555.	555.	555.	555.	555.	555.	555.	78.
21	555.	61.	47.	58.	555.	555.	555.	54.	555.	555.	555.	555.	555.	555.	555.	555.
22	555.	61.	58.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.
23	555.	78.	69.	75.	75.	75.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.
24	555.	555.	78.	555.	75.	75.	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.
25	555.	555.	78.	555.	555.	555.	555.	555.	555.	555.	555.	69.	555.	555.	555.	555.
26	555.	555.	555.	555.	555.	555.	555.	555.	555.	555.	69.	69.	69.	69.	555.	555.
27	555.	555.	555.	555.	555.	555.	555.	555.	555.	69.	69.	69.	69.	69.	555.	555.
28	69.	69.	69.	555.	69.	69.	69.	69.	555.	69.	69.	69.	58.	69.	69.	555.
29	69.	69.	69.	69.	69.	555.	69.	75.	69.	69.	69.	69.	555.	555.	555.	555.
30	69.	555.	69.	69.	69.	58.	58.	75.	69.	69.	69.	555.	555.	555.	555.	555.
31	555.	555.	555.	555.	69.	58.	58.	75.	75.	69.	69.	555.	75.	78.	555.	555.
32	555.	555.	47.	555.	555.	555.	58.	75.	69.	69.	555.	75.	555.	555.	555.	555.

THIS TABLE REPRESENTS AN INDEX VALUE [illegible]
A VALUE OF 100 WOULD BE [illegible]
TOWNSHIP 27 SOUTH, RANGE 11 WEST, [illegible]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EACH VALUE IN THE ABOVE TABLE REPRESENTS AN AREA OF 2.5 ACRES

A VALUE OF 00. INDICATE THE SITE IS AN ORGANIC SOIL AND WAS NOT CONSIDERED FOR SANITARY LANDFILL OR RESIDENTIAL HOMES
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