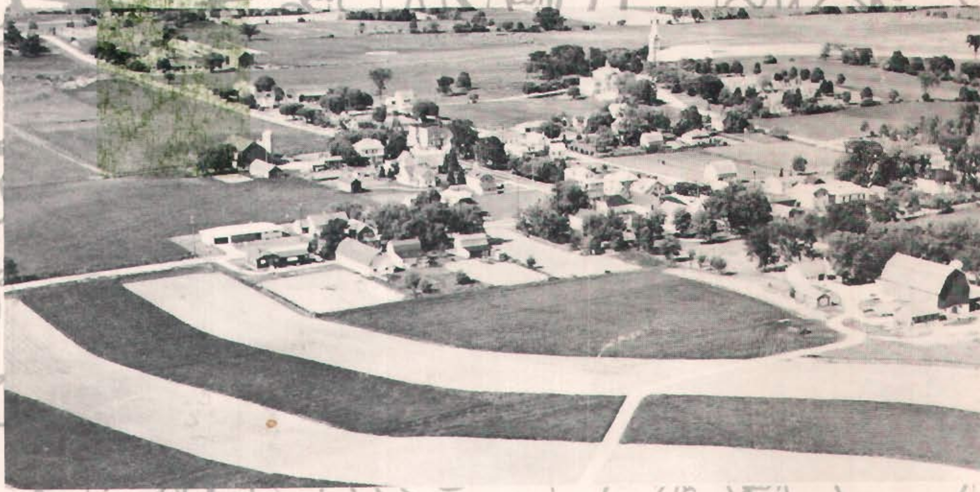
PLANNING GUIDE NO. 6

SOILS DEVELOPMENT GUIDE



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Special acknowledgement is hereby given to William J. Kockelman, former Chief of the SEWRPC Community Assistance Division, for his contribution to this Guide.

PLANNING GUIDE

NUMBER 6

SOILS DEVELOPMENT GUIDE

Prepared by the
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Waukesha, Wisconsin 53186

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PREFACE

This publication is the sixth in a series of planning guides prepared by the Southeastern Wisconsin Regional Planning Commission for distribution to cities, villages, towns, and counties within the seven-county Region. The guides are intended to assist local planning officials in the execution of their important duties. The purpose of this Guide is threefold: first, to provide an understanding of the detailed soil survey and its accompanying interpretive analyses; second, to illustrate how such a survey and its interpretive analyses can be used in local, as well as regional, planning and development; and third, to present suggested land use regulations that may be enacted by local units of government and that utilize and incorporate such survey and interpretations to better adjust both rural and urban development to the ability of the natural resource base to sustain such development.

Accordingly, this Guide contains a discussion of the detailed regional soil survey; an explanation of its interpretations for various uses; a description of how such surveys and interpretations have been used for regional, watershed, community, neighborhood, and farm planning; and suggests special soil-related regulations for incorporation into local zoning, sanitary, land division, and building ordinances.

This Guide is not intended to be applied indiscriminately without regard for local conditions; nor is it intended to be a substitute for necessary professional planning, engineering, and legal advice at the local level. It assumes the existence of duly constituted local zoning, planning, health, and building agencies charged with carrying out the local zoning, planning, sanitation, and building functions and is intended to assist these local agencies in the performance of their duties.

The use of soil surveys in planning and development was approached on a broad scale at a nationwide conference entitled "Soil, Water, and Suburbia," held on June 15 and 16, 1967, and jointly sponsored by the U. S. Department of Agriculture and the U. S. Department of Housing and Urban Development. This Guide builds on the ideas presented at that conference and was jointly prepared by the Commission and the U. S. Department of Agriculture, Soil Conservation Service, with financial assistance from the U. S. Department of Housing and Urban Development. It is the hope of the Commission that this Guide may be a helpful and informative aid to those interested in properly using the soil resources of the Southeastern Wisconsin Region and thereby creating a more healthful, more economical, and more attractive environment for life within the Region.

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Chapter I
INTRODUCTION

The natural resources of a region or a community are vital elements to its economic development and to its ability to provide and sustain a safe, healthful, and pleasant environment for human life. These natural resources not only condition, but are conditioned by, regional growth and urbanization. Any meaningful effort to guide urban and rural development at the state, county, or local level of government in the public interest must recognize the existence of a limited natural resource base to which both urban and rural development must be adjusted if serious environmental and developmental problems are to be avoided. This is particularly true in the Southeastern Wisconsin Region where an increasing number of urbanites are becoming year-round residents of outlying areas of the Region, seeking not only the varied recreational opportunities offered by these areas but also the feeling of open space, which these areas lend to urban development.

The soil resources of an area are one of the most important elements of the natural resource base, influencing both urban and rural development. Much that is of importance to mankind takes place in the soil; and soil is, directly or indirectly, the foothold for much of the life on earth. It is the natural medium for the growth of plants; its properties and life serve to stabilize wastes and purify water; it serves as the foundation for buildings, roads, and all other man-made land-based structures. As one writer has argued: "this slight and superficial and inconstant covering of the earth should receive a measure of care which is rarely devoted to it."[1] If this measure of care is to be provided, the nature of soil and the kinds of soils and their distribution must first be known.

Despite the fact that it is so widely distributed as to be commonplace, soil is highly complex. Each soil body consists not only of a variety of minerals and an assortment of particles of many sizes but also of a collection of dilute solutions and a mixture of gases. Under natural conditions soil harbors immense numbers of microorganisms and is host to numerous plant roots and small animals. The relationships among the components of the soil and between the soil and the life within it are many and varied. Thus, each body of soil is a dynamic, rather than a static, system and one which is open rather than closed.[2]

Soils are an irreplaceable resource; and mounting development pressures upon land are making this resource more and more valuable. The soil resource has been subject to grave misuse through improper land use and transportation facility development. Such misuse has often led to severe environmental problems, which are very expensive to correct, and to the deterioration and ultimate destruction of the resource base itself. To avoid further misuse of this important element of the natural resource base, then, it is necessary to acquire definitive data about this element and then to utilize such data to the greatest extent possible in guiding both urban and rural development.

In 1963 the Southeastern Wisconsin Regional Planning Commission (SEWRPC) negotiated a cooperative agreement with the U. S. Department of Agriculture, Soil Conservation Service, for the completion of detailed operational soil surveys for the entire Region, together with the provision of interpretations for planning and engineering purposes. The work was completed in 1965, and the results were immediately made available, not only for regional planning purposes but also for use by local governments in the Region and by private individuals. The purpose of this Guide is to assist local governmental officials and private citizens within the Region in becoming more familiar with the soil survey and its various applications in local planning and development programs in order that further misuse of the soil resources of the Region can be avoided.

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[1] *N. S. Shaler, U. S. Geological Survey, Annual Report No. 12, 1891.*

[2] *Roy W. Simonson, "Soil Classification in the United States," Science, September 28, 1962, Vol. 137, No. 3535.*

REGIONAL SETTING

The seven-county Southeastern Wisconsin Region is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, this Region has a total land and inland water area of 2,689 square miles. It is the most intensively developed area of the state, encompassing only 5 percent of the area of the state but containing over 40 percent of the state's population, over 50 percent of the state's resident manufacturing employment, and over 46 percent of the state's real property valuation. The population of the Region, estimated at 1,835,000 in 1968, has increased over the past century at a rate greater than that of the state or the nation. The Region contains the twelfth largest city in the nation; and many of the most important industrial areas and heaviest population concentrations in the Midwest are located within 250 miles of the Region, with over 31 million people residing within this radius.

The entire Southeastern Wisconsin Region is rapidly becoming a single metropolitan complex of highly concentrated urban land uses interspersed with large areas of mixed rural-urban uses. Rapid population growth and urbanization within the Region have intensified the demand for the conversion of agricultural and other open lands to urban use as sites for the development of homes, shopping centers, industrial parks, and a variety of other intensive uses. Once converted to, and developed for, urban uses, such lands are irretrievably lost to agricultural use. Moreover, if the conversion is made without careful consideration of the physical, chemical, and biological properties of the soil resource, severe environmental and developmental problems may result. The correction of these problems may entail great public, as well as private, expense and may cause great personal aggravation and inconvenience.

SOIL ABUSE AND MISUSE

Serious health, safety, and pollution problems may be caused by failure to take the capabilities and limitations of soils into consideration during the planning stage of any urban or rural development proposal. Such problems are usually very costly to correct and may create personal hardship out of all proportion to the relatively simple steps required to avoid them. Such problems include malfunctioning on-site soil absorption sewage disposal (septic tank) systems, flood damages, footing and foundation failures, and soil erosion and sedimentation. Knowledge of the soil resource and its ability to sustain development can not only help in avoiding such problems but can also contribute to avoiding or reducing excessive land development costs.

Malfunctioning Septic Tank Systems

Septic tank sewage disposal system filter fields and beds that are located on slopes in excess of 12 percent may cause partially treated sewage effluent to seep onto the downslope surface, thus creating a potential health hazard and an aesthetic nuisance.[3] Where terraces or series systems are used to overcome steep slope limitations, a reduction of ground cover and a loss of a desirable natural setting often result. Filter fields located on floodlands, wetlands, high-water table areas, or on soils with slow permeability may not operate properly during all or part of the year and, thus, may result not only in total system failures and improper ponding and surface runoff of partially treated effluent but also in solids clogging the absorptive soil pores (see Figure 1). Filter fields located near bedrock may result in a lateral flow and an eventual discharge of improperly treated effluent onto the surface at outcroppings. Filter fields located on excessively well-drained soils, over creviced or fractured bedrock, or near ground water level may result in partially treated effluent rapidly reaching and polluting ground water supplies. Filter fields located on tight or slowly permeable soils may result in the effluent rising to, and ponding on, the surface from where it may drain into, and pollute, surface waters.

Malfunctioning septic tank sewage disposal systems may produce an untreated effluent containing coliform bacteria and permit this effluent to seep, drain, wash, or percolate into ground or surface water supplies.

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[3] *See U. S. Department of Agriculture, Soil Conservation Service, Agriculture Information Bulletin No. 243, Soils Suitable for Septic Tank Filter Fields, U. S. Government Printing Office, 1961.*

This contributes to overfertilization of surface waters, with resultant excessive algae growth, turbidity, and impairment of the water quality for various types of recreational uses, and may create a public health hazard, including danger of the transmission of such water-borne diseases as typhoid, paratyphoid, dysentery, and hepatitus. At times malfunctioning septic tank systems are illegally pumped out directly into a stream or lake, onto the surface of the ground so that the effluent flows into surface waters, or into a farm drainage tile or other storm water drains which directly transmit the untreated effluent into surface waters (see Figure 2).

Figure I

FLOODED SEWAGE DISPOSAL FIELD

The public school in this photograph is located within the Region and was constructed since 1960. It is located on soils that have a high water table and a severe flooding hazard. The on-site soil absorption sewage disposal system that is supposed to adequately handle the wastes from the school simply cannot function properly in these soil types. Soil characteristics must be recognized in the location of both public and private land uses that cannot be served by public sanitary sewers.

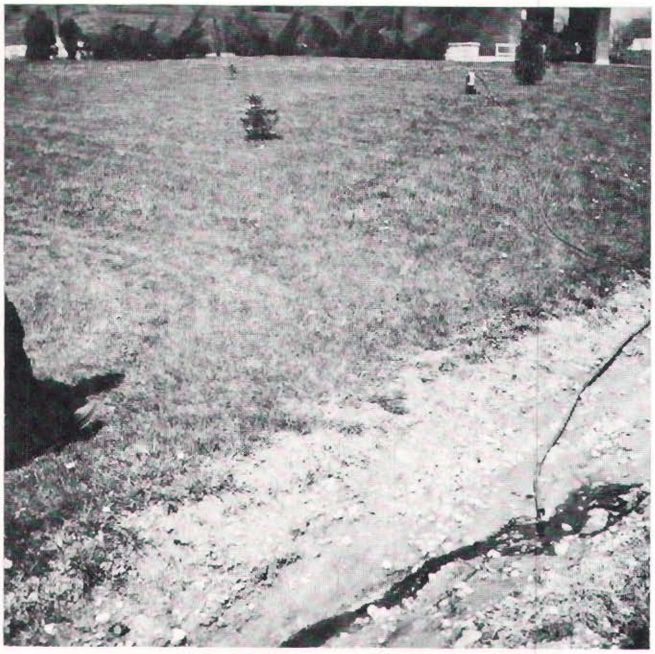

Figure 2

ILLEGAL DISCHARGE OF SEPTIC TANK SEWAGE EFFLUENT

When soil absorption sewage disposal systems fail because of soil limitations, home owners often resort to draining the excess effluent directly into roadside ditches. This photo shows such an operation within the Region, with the hose in the foreground leading directly from the sewage disposal field vent pipe. Soil survey data can be used to prevent the installation of septic tank sewage disposal systems in soils where such systems are bound to malfunction.

Relating the installation of septic tank sewage disposal systems to the soil resource in order to avoid the further creation of malfunctioning systems in the Region is, thus, essential. Certain soils are unsuitable for such use no matter what corrective measures may be undertaken. Other soils require that special care and attention be given to the installation and continued maintenance of septic tank systems in order that hazards to individuals and public health, as well as serious ground and surface water pollution problems, may be avoided. The magnitude of this problem becomes quite evident when the number of such installations each year is considered. In 1968 approximately 1,500 new septic tank installations within the Region were recorded by the Wisconsin Division of Health. It becomes very important, therefore, to properly relate all non-sewered urban development to the soil resource. Failure to do so will create severe areawide health and pollution problems and commit the local units of government to massive expenditures of public funds for corrective measures.

Floodland Damages

Increasing urbanization in southeastern Wisconsin continues to result in urban development being allowed to preempt the natural floodways and floodplains of the streams, often without regard to the periodic flood hazards and concomitant dangers to property, health, and life (see Figure 3). In addition to the inconvenience, hardship, danger, mental anguish, and economic loss inflicted upon occupants of floodlands during floods, floodwaters also cause disruption of utility and transportation services; create public health and safety hazards; damage industries, businesses, residences, and agricultural operations; and result in other economic losses. Flood losses can be caused indirectly by seepage, sanitary sewer or septic tank system backup, erosion, siltation, and water pollution, as well as by direct inundation and by the force of the moving floodwaters. Moreover, the floodlands of streams are often covered by soils poorly suited for urban uses without centralized sanitary sewerage facilities and sometimes are covered by soils unsuited for urban uses of any kind. The use of such soils for urban development may not only serve to escalate direct flood damages but may also create other problems relating to health and safety hazards and utility and transportation disruption.

Foundation Failures

Soils with a high clay content swell when wet and shrink when dry, sometimes expanding up to 20 percent in volume between wet and dry conditions. Urban development on such expansive soils and on soils which have inadequate bearing and shear strength may result in the failure of footings and the cracking of building foundations and in the structural failure of roadway pavements unless special, often expensive provisions are made during construction (see Figure 4). Unstable soils, such as alluvial, peat, and muck soils, may, when drained, decompose or shrink and cause severe settling of foundations.

Figure 3

URBAN DEVELOPMENT ON FLOODLANDS

Natural floodlands are usually covered by soils poorly suited for urban uses without public sanitary sewerage facilities and sometimes covered by soils unsuited for urban uses of any kind. Yet, urban development in the Region continues to preempt the natural floodways and floodplains of streams and rivers. The detailed soils data available for the Southeastern Wisconsin Region provide flood hazard ratings for all soil types.

Figure 4

FOUNDATION FAILURE

Problems such as the residential foundation failure shown in this photograph, which recently occurred within the Region, can be avoided by restricting the placement of structures on soils having severe limitations for such use. The soil in which this basement was placed is characterized by a high shrink-swell potential and a high water table. Thus, this soil swells when wet and shrinks when dry, at times changing up to 10 percent in volume. This change in volume combined with the increased hydrostatic pressure created by the high water table can cause foundation failures such as this.

Erosion and Sedimentation

Perhaps the most flagrant abuse of the natural soil resource is the increasing amount of soil erosion resulting from man's activities on the land. Such erosion contributes to stream bank destruction, silting of culverts and drainage ditches, pollution of surface waters, blocking of storm sewers, and lake and stream sedimentation. Sediment from excessive erosion greatly reduces the attraction of many lakes and ponds for swimming, boating, fishing, and other water-related recreational use. Sedimentation can also destroy the spawning beds of game fish and reduce their food supply. On small streams the sediment can fill deep pools that provide a refuge for fish during winter months and the dry summer season. Sediment can also fill multiple- or special-purpose reservoirs, destroying their ability to fulfill their intended functions for water supply, flood control, low-flow augmentation, and recreation. Sediment can also interfere with the use of both commercial and small pleasure craft harbors and require expensive, recurring dredging operations. These operations are not only costly but may contribute to the further pollution of even such major bodies of water as Lake Michigan.

Soil erosion and consequent sedimentation can result from poor farming practices, such as the tillage of steep slopes or readily erodible soils. Recent studies have concluded, however, that the process of urbanization brings about large increases in sediment production. As urban development proceeds within an area, the soil is usually cleared of its natural cover and left exposed to the rain, often for extended periods of time. As raindrops hit the exposed earth, particles of soil are broken off and carried away, picking up additional sediment along the way. Examples of poor development practices which leave the soil unprotected and exposed abound within the Southeastern Wisconsin Region (see Figure 5). While the problems caused by such poor urban development practices are usually of a transitional nature, the effects in terms of sedimentation are of great impact and long lasting.

Figure 5

SOIL EROSION AND SEDIMENTATION

Soil erodes rapidly when left exposed and unprotected to wind and rain. The sediment from such erosion results in the silting of culverts and drainage ditches, blocking of storm sewers, pollution of surface waters, and the filling in of reservoirs, lakes, ponds, and streams. Erosion and sedimentation are particularly severe and harmful when, as in this photograph of an area within the Region, large areas of land are unnecessarily left without protection after urban development of adjacent lands.

POTENTIAL BENEFITS IN THE USE OF SOILS DATA

Such practices as the placement of streets and highways over peat and muck soils, the excavation of basements and utility trenches in shallow bedrock areas, the development of industrial sites on steep slopes and poorly suited soils, and the construction of underground utilities in high ground water areas, all result in additional construction and site preparation costs in order to overcome the limitations of the soils for the desired use. Such increased construction and site preparation costs may include the costs attendant to the removal of poor soils and their replacement with stable materials; the blasting of rock; extensive grading and terracing; and the use of tight sheathing, dewatering systems, and careful design and construction supervision to avoid ground water interference during construction. The proper use of the soil survey and the interpretive analyses can result in direct savings by reducing initial construction costs and avoiding later corrective measures and costly maintenance problems.

Soil characteristics which affect development costs include: soil texture, depth to water table, depth to bedrock, and slope. When these factors are considered in combination and to varying degrees of refinement, they provide a basis for defining soil development cost relationships. A building of given dimensions, weight, and loading will necessarily require more elaborate and hence more costly foundations if located on organic soils than if located on granular soils having a comparatively high bearing strength. It has been estimated by the Commission,[4] for example, that urban development on soils poorly suited for such development may cost up to 63 percent more than on soils well suited to such development.

Private individuals, as well as builders and developers, can consult the soil maps and analyses before committing land to certain kinds of development that may be entirely improper and result in excessive development costs. Similarly, public agencies, such as school boards, can utilize the soil survey to select sites for public buildings that are well suited for such use. Failure to consult the soil maps and utilize fully the data and analyses available can only result in the further improper use of land and in unnecessarily expensive development costs.

SUMMARY

The importance of the underlying and sustaining soil resource to the sound social, economic, and physical development of the Southeastern Wisconsin Region; the urgent need to protect and conserve that soil resource as urbanization proceeds on an areawide basis throughout the Region; and the rapid intensification of soil and soil-related resource problems within the Region dictate that the counties, towns, villages, and cities comprising the Region give careful consideration in their planning and engineering efforts to the soil resources and the proper use of such resources. The misuse of the soil resources has led to costly problems, such as malfunctioning septic tank sewage disposal systems, flood damages, footing and foundation failures, and soil erosion and sedimentation. By proper utilization of soils data and analyses, not only may these and other related problems be avoided but development, operation, and maintenance costs may also be reduced.

The Southeastern Wisconsin Regional Planning Commission has prepared this Planning Guide to assist the people of the Region and their elected and appointed officials in becoming more aware of the regional soil survey and in becoming more familiar with some of the means by which the soil survey can be used in local planning and development programs. In addition, this Guide is intended to assist those who make private development decisions to make such decisions with full knowledge of any implications varying kinds of development might have for the underlying soil resource. Subsequent chapters of this Guide will discuss the regional soil survey and mapping program; specific soil interpretations; and the use of soils data in regional planning, watershed planning, community planning, neighborhood planning, zoning regulations, health and sanitary regulations, and land subdivision regulations. Consideration will also be given to legal and administrative ramifications.

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[4] *See SEWRPC Technical Report No. 3, A Mathmatical Approach to Urban Design, January 1966.*

Chapter II
THE REGIONAL SOIL SURVEY

INTRODUCTION

The need for a detailed inventory of the soil resources of the Southeastern Wisconsin Region became apparent shortly after recognition of the need for areawide planning within the Region. The Southeastern Wisconsin Regional Planning Commission early realized that, in order to plan intelligently on a local, as well as on an areawide, basis for the proper development of transportation, flood control, pollution abatement, and utility facilities and for the proper use of land, the behavior of the soils of the Region under various uses and circumstances must be known. It was recognized that soil behavior is the result of the response of certain definable soil characteristics to given treatment and use and that these characteristics are, in turn, related to the nature of the soil itself. It was also recognized that intelligent planning and development decisions require knowledge of where bedrock occurs at shallow depths; where water tables are high; where soils are open and pervious and where they are tight and impervious; where soils have a high bearing strength and support structures well and where they cannot; where soils are subject to excessive swelling, shrinkage, and frost action and where they are not; where slopes are steep or where they are gentle; and where accelerated erosion has changed the soil.

This kind of information is provided by the standard soil surveys that are made under the National Cooperative Soil Survey in all parts of the United States. At the time of the creation of the Regional Planning Commission, the necessary detailed operational soil surveys had been completed for about 38 percent of the total area of the Region (see Map 1). About one million acres remained to be mapped. Only agricultural use interpretations, however, were available for the existing surveys, whereas a comprehensive set of interpretations was required for planning purposes. The Regional Planning Commission, therefore, in 1963 entered into a cooperative agreement with the U. S. Department of Agriculture, Soil Conservation Service (SCS) to provide the necessary soil surveys and interpretations under the National Cooperative Soil Survey. The soil survey was completed for the entire seven-county Region in 1966, and the results were published in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.

The regional soil survey represents one of the most important tools ever made available to private investors and public agencies in helping to make day-to-day development decisions. It is continuing to prove to be one of the soundest capital investments that could have been made. Since these soil surveys are a basic scientific inventory, they provide valuable information needed to help ensure the avoidance of future developmental problems and of further destruction of the natural resource base.

SOIL CLASSIFICATION SYSTEMS

The National Cooperative Soil Survey is concerned with the identification, classification, mapping, and interpretation of one of the most important of all natural resources—the soil. This resource has been variously defined by geologists, agronomists, engineers, and others concerned with its study or use. The civil engineer, for example, defines soil broadly as any earth material except imbedded rock. The soil scientists define soil more narrowly. C. F. Marbut, an eminent soil scientist during the early part of this century, restricted soil by definition to: "that layer of the earth's crust lying within reach of those forces which influence, control, and develop organic life."[1] A glossary of special terms published in the 1938 Yearbook of Agriculture, Soils and Men, defines soil as: "The natural medium for the growth of plants on the surface of the earth. A natural body on the surface of the earth in which plants grow, composed of organic and mineral materials."[2] Thus, only within the last century has it been recognized that

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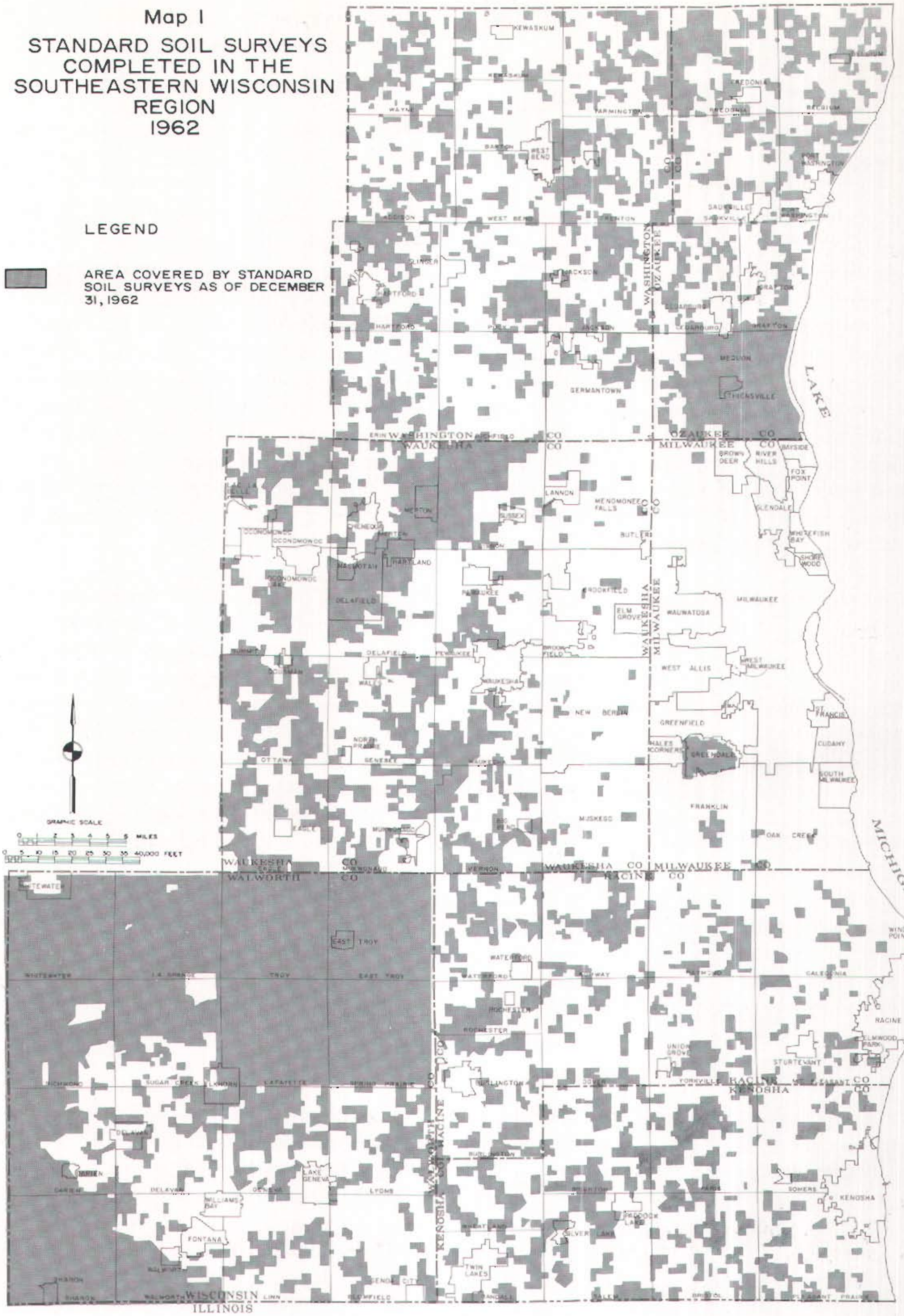
[1] *C. F. Marbut, Soils: Their Genesis and Classification, Soil Science Society of America, Madison, Wisconsin, 1951.*

[2] *Soils and Men, Year Book of Agriculture, U. S. Department of Agriculture, Washington, D. C., 1938.*

Map I

STANDARD SOIL SURVEYS COMPLETED IN THE SOUTHEASTERN WISCONSIN REGION 1962



Detailed soil surveys covering approximately 38 percent of the Region had been completed for farm planning and conservation purposes by the end of 1962. These surveys were accompanied only by agricultural interpretations and were, therefore, inadequate for regional and local comprehensive planning purposes. As part of the Commission's regional land use-transportation planning program, and in cooperation with the U.S. Soil Conservation Service, the remaining areas of the Region, totaling nearly one million acres, were surveyed, and interpretations of the soil properties for planning and engineering applications, made.

a soil is a collection of natural bodies paralleling those of flora, fauna, and rock formations. Before recognition of this fact, construction of systems of soil classification applicable to wide areas was not possible. It is within the confines of the latter definitions that soils have been studied, classified, and mapped for more than 50 years by soil scientists.

The complexity of soil makes it necessary to devise some systematic means for its effective study. The purpose of soil classification is to group individual soil units found in nature so that their properties can be easily understood and used and so that experience about the use of a particular soil can be readily conveyed. Clear distinction in this respect must be made between identification and classification. To identify is to distinguish; to classify is to group. Things must be identified before they can be classified. Identification depends upon factual information; classification, upon interpretation. Soil test data and observed or measured soil behavior constitute factual information about soils accrued as a result of observation or experiment. This information does not change with time but forms a growing body of permanent knowledge about soils. Classification is essentially an inference of expected behavior deduced from interpretation of factual information and must be constantly reevaluated. A good classification system must be simple and concise, minimizing the number of classes required. It must be meaningful and relate to characteristics of the soil of interest to the user. It should be readily applicable from simple examinations and tests. Finally, soil properties should comprise the basis for the classification; and these should be significant to the intended use of the system. It should be noted that it is possible to develop many different classification schemes for natural objects as complex as soils; many have already been constructed, and more can be expected in the future.

It is important that soil classification systems be based upon soil characteristics rather than upon possible explanations for those characteristics. The danger that markedly unlike soils will be classed together and that like soils will be put in separate classes exists with any approach to classification, but it is greater in some approaches than in others. The use of morphology, or the science of form and structure, and composition of soils as criteria for differentiation in soil classification seems to present the smallest risk of error. The selection and weighting of soil characteristics as differentiation criteria are best done in the light of the current understanding of soil genesis; that is, development and evolution. While theories of soil genesis are thus an important part of the background for selecting criteria to be used in a soil classification system, it is important to remember that the criteria themselves must be characteristics which can be observed and measured and not inferences which cannot be rigorously tested.

The principal difficulty in all efforts to classify soils arises from the fact that soil forms a continuum on the land surface. With few exceptions changes within the continuum are gradual in character, although horizontal differences in the soil may be substantial over differences measured only in feet. Despite the existence of differences within the continuum, however, discrete entities, which would be comparable to single plants or animals, do not exist. Thus, one of the basic problems of all soil classification systems is defining the basic entity or entities that are to be grouped into classes in some way.

One comprehensive soil classification system and two specialized soil classification systems are in common use within the United States today. The comprehensive classification system is recognized and used the world over, originally used for agricultural application and more recently for nonagricultural applications. Because this system has been specifically adapted for use by the U. S. Department of Agriculture, Soil Conservation Service, it will be referred to in this Guide as the USDA System. The two specialized classification systems are recognized and used the world over in engineering applications. They are the American Association of State Highway Officials (AASHO) System and the U. S. Army, Corps of Engineers, (Unified) System.

USDA System

The soil classification system used by the U. S. Department of Agriculture is the most important of the three systems in common use today since it increasingly holds the key to the ready and widespread application of the other two. It is known as a pedological system since it has its foundation in the study of the soils themselves rather than, as do the other systems, in the application of soils to specific uses. It identifies soils not only according to such physical characteristics as color, texture, structure, permeability, and reaction but also according to such characteristics as parent material, position in the landscape, slope, depth, and drainage. In effect, the USDA System attempts to identify each significantly different soil as it occurs in the landscape. It groups soils according to the similarity of the properties used in the identification.

The current USDA soil classification system has evolved from earlier soil classification efforts in China and Russia. The earliest attempt to classify soils systematically seems to have occurred in China about 4,000 years ago. The soils of the kingdom were reportedly graded into nine classes at that time, apparently on the basis of their known agricultural productivity. Furthermore, the size of individual landholdings and the tax to be paid to the state were related to the classified soil productivity.[3] Much later, in 1882, an effort took place in Russia that led directly to the establishment of pedology as a separate discipline. At that time a Russian geologist, V. V. Dokuchaiev, began a program for classifying and mapping soils as a basis for tax assessment. Dokuchaiev established a natural classification of soils and than graded those soils according to their agricultural potentiality. This Russian program included field studies of soil morphology, laboratory analyses of soil samples, construction of maps to show distribution of various kinds of soils, and measurement of crop yields on those soils. Dokuchaiev and his followers set out to describe and characterize soils as natural bodies rather than as mantles of weathered rock, giving attention first to exterior characteristics, or to the soil morphology, because it was the most obvious feature. The concept that soil is an independent, natural body possessing a degree of internal organization, expressed in the soil profile with its horizons, was a major contribution of the Russian school of pedology. These soil classification concepts developed in Russia have had an enormous impact on the study of soils throughout the world.[4]

The development of soil science in the United States at first proceeded independently of the Russian work, although an immediate practical objective—the increased production of tobacco—also prompted the first efforts to classify and map soils in the United States. Soon the objectives had been expanded to include increasing the production of other crops and providing information on lands proposed for irrigation. By 1899 the concept of the soil series and type had been developed. Soils were considered solely as a medium for plant growth, and attention was focused primarily on characteristics of soil important for plant growth and on local differences of consequence in crop production. Thus, while in Russia the soils of extensive regions were being classified and mapped as great soil groups, in the United States the soils of small areas important to the individual farmer were being classified and mapped as soil types and series.

A comprehensive scheme of soil classification, one which combined the Russian and American concepts and which was useful worldwide, was proposed by C. F. Marbut, Chief of the Division of Soil Surveys in the U. S. Department of Agriculture, in 1927 to the First International Congress of Soil Science.[5] The present USDA System has evolved from these early efforts, and the USDA has since classified and mapped soils over extensive areas of the United States and expanded the classification system for nonagricultural applications.

The USDA System is based upon the fact that soils which have the same climate, topography, parent material, and drainage characteristics will behave similarly under specific uses wherever found. Thus, a road subgrade comprised of a particular soil series may be expected to perform the same wherever it occurs since such factors as rainfall, frost, depth to the ground water table, and capillarity, as well as texture and plasticity, are all considered in the identification and subsequent classification of the soil in the USDA System. In no other system in use today are all of the important factors relating to soils considered directly in the identification and classification. The USDA System can be widely extended as engineering properties are determined for a particular soil. Moreover, through national correlation, behavior of a soil can be accurately predicted from actual experience with the behavior of similar soils

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[3] *Roy W. Simonson, "Soil Classification in the United States,"* Science, *September 28, 1962, Vol. 137, No. 3535.*

[4] *Ibid.*

[5] *Ibid.*

under actual use in the landscape elsewhere. The pedological approach incorporated in the USDA System provides a systematic approach to understanding land forms and their composition while providing the user with the most reasonably accurate representation of subsurface conditions and enabling him to visualize corrective measures which may be necessary to provide the most practical and economical solution to soil problems.

The soils maps that were made during the progress of the surveys in the seven-county Southeastern Wisconsin Region delineate areas covered by soils that were classified according to the latest USDA Soil Classification System.[6] This latest system has been developing over an 18-year period, beginning about 1951 and has been in official use in the United States since January 1965.[7] The system has received worldwide use and acceptance.

The USDA Soil Classification System seeks first of all to organize, define, and name classes in the lowest category possible. It then groups these classes into progressively broader classes in higher categories and provides names for these classes. The general purpose is to make the characteristics of soils easier to remember, to bring out relationships among soils and between the soils and other elements of the environment, and to provide a basis for developing principles of soil genesis and soil behavior that have predictive value. The USDA System uses six levels of classification: orders, suborders, great groups, subgroups, families, and series. The series are, in practice, further divided into types and phases that reflect characteristics relating to use and management. The first four categories are illustrated in Table 1, using a representative soil series from each subgroup.

The subgroup, family, series, type, and phase are the most important categories of classification to users of soil information. The connotative nature of the system enables a soil scientist or other person familiar with the basic concepts to make relatively accurate interpretations for most uses, given the subgroup and the family designation of any soil in the world. Each syllable of the subgroup name indicates a soil characteristic important to classification or to use and management. For example, a soil in the subgroup Typic Ochraqualf is in the Alfisols Order (alf), which has accumulations of clay in the subsoil, is wet most of the time or has a high water table less than one foot below the soil surface (aqu), and has a light colored surface soil (ochra). Wherever they occur, soils in this subgroup are too wet for use as cropland, unless drained; cannot be used as filter fields for on-site soil absorption sewage disposal systems; and have severe limitations for use as highway subgrades, residential development, or upland wildlife. A Typic Argiudoll has a thick dark surface (oll), is well drained (ud), and has a clay accumulation in the subsoil (argi). Generally, these soils are well suited for cropland. With favorable texture and underlying material, they have few or no limitations for most engineering uses. The family designation, such as fine-loamy, mixed, or mesic, which indicate the texture of the soil profile, the mineralogy, and the climate, respectively, can be used to make more accurate interpretations of the soil. Each soil family may contain several soil series and soil types.

The type and phase are the two most detailed classifications and, because variations in soil characteristics become meaningful for planning and engineering purposes only when a comparatively fine differentiation is made, are the only two classifications of direct concern to planners and engineers. Soil families are composed of groups of soil series having similar texture, mineralogy, soil temperature, reaction, permeability, depth, and consistence. In Wisconsin texture, mineralogy, and soil temperature are the principal factors which affect the family classification. Seven textural classes are used for defining soil families (see Figure 6). Temperature ranges in soils are expressed in Wisconsin as mesic (mean annual temperature 47°-59°F), or frigid (mean annual temperature less than 47°F). All the soils in southeastern Wisconsin are in the mesic temperature range. Most of the soils have a mixed mineralogy. A few are illitic (dominantly clayey soils with relatively high shrink-swell potential) and siliceous (sandy soils that are more than 90 percent quartz or other very hard minerals).

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[6] *Classification of Wisconsin Soils*, *Special Bulletin No. 12, Research Division, College of Agriculture and Life Sciences, University of Wisconsin, in cooperation with the U. S. Soil Conservation Service, 1968.*

[7] *Soil Classification, A Comprehensive System (7th Approximation)* *and subsequent amendments; Soil Conservation Service, U. S. Department of Agriculture, Washington, D. C., 1960.*

Table I

ORDERS, SUBORDERS, GREAT GROUPS, SUBGROUPS, AND REPRESENTATIVE SERIES OF SOILS IN THE SOUTHEASTERN WISCONSIN REGION

Order	Suborder	Great Group	Subgroup	Representative Series
Entisols	Fluvents	Udifluvents	Typic Udifluvents	Juneau
			Aquic Udifluvents	Pistakee
	Psamments	Udipsamments	Alfic Udipsamments	Chelsea
Inceptisols	Aquepts	Haplaquept	Mollic Haplaquepts	Keowns
			Thapto Histic Haplaquepts	Wallkill
	Ochrepts	Eutrochrepts	Typic Eutrochrepts	Hennepin
Mollisols	Aquolls	Argiaquolls	Typic Argiaquolls	Brookston
		Haplaquolls	Typic Haplaquolls	Colwood
			Cumulic Haplaquolls	Otter
	Udolls	Argiudolls	Typic Argiudolls	Varna
			Aquic Argiudolls	Elburn
			Cumulic Argiudolls	Troxel
		Hapludolls	Aquic Hapludolls	Yahara
			Cumulic Hapludolls	Worthen
			Lithic Hapludolls	Ritchey
			Fluventic Hapludolls	Radford
Alfisols	Aqualfs	Ochraqualfs	Typic Ochraqualfs	Auburndale
			Aeric Ochraqualfs	Blount
			Udollic Ochraqualfs	Matherton
	Udalfs	Hapludalfs	Typic Hapludalfs	Miami
			Arenic Hapludalfs	Metea
			Aquollic Hapludalfs	Mequon
			Mollic Hapludalfs	Dresden
Histosols	Incomplete			Adrian

Source: U.S. Soil Conservation Service.

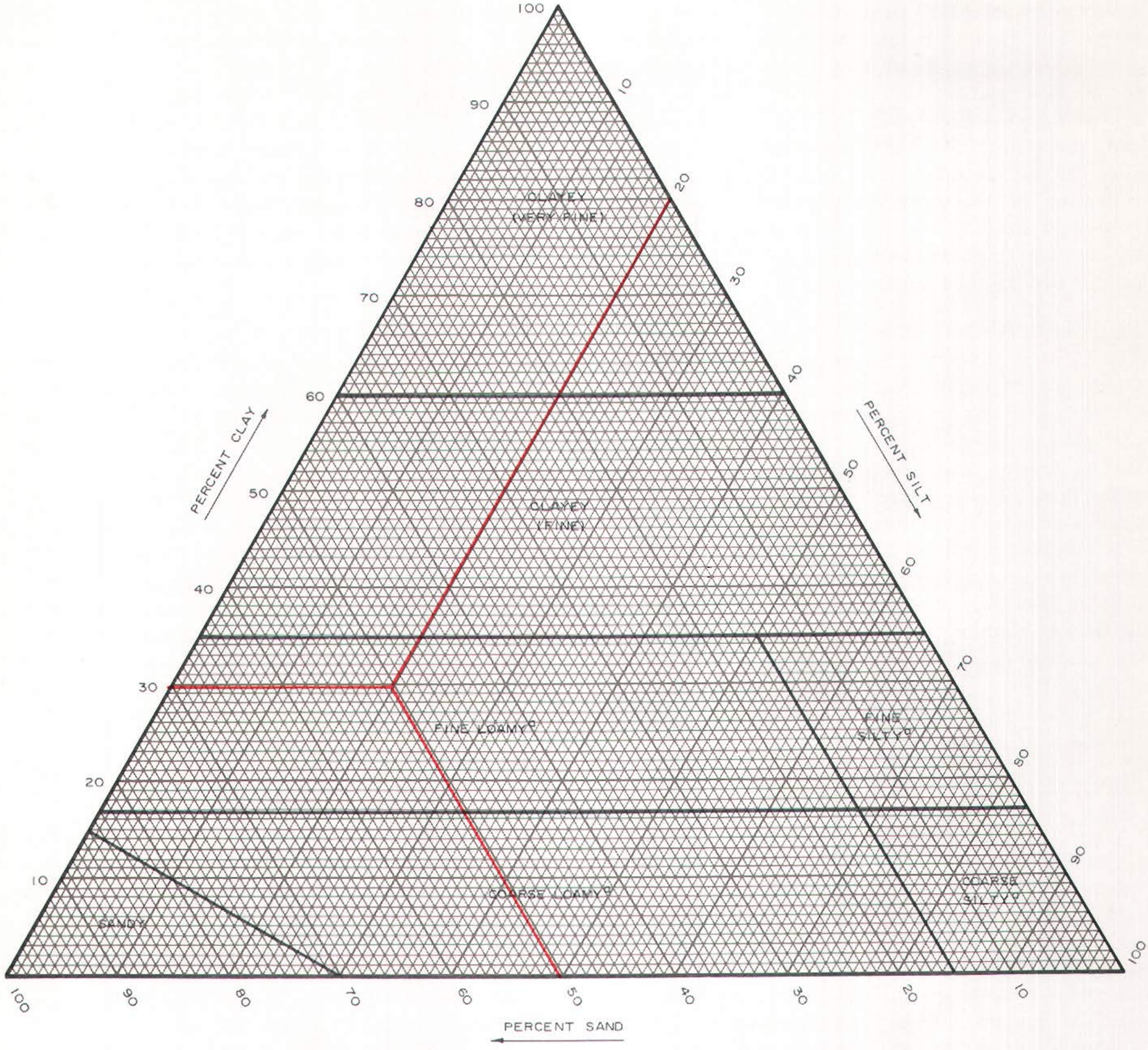
Soil series are comprised of soils having similar kinds and sequences of horizons, or layers, with color, texture, structure, reaction, and other physical properties of the A and B (upper) horizons similar within a narrow range and the characteristics of the C horizons similar in texture and reaction. Each soil series is named for a geographic feature—town, county, stream—near where it was first identified, mapped, and described. It retains this name wherever it occurs.

Soil series are further separated into types on the basis of differences in surface texture. Soil series are thus comprised of soils alike in every respect but the texture of the surface horizons. Soil types are further divided into soil phases based on such characteristics as slope and erosion, and it is the phases which provide the basis for the delineation of soil mapping units.

Criteria for the differentiation of one series from another are based on readily measurable and deduced characteristics. Soil color, texture, reaction, and thickness and kinds of soil horizons can be estimated in the field with sufficient accuracy for separation of soils in mapping. Other features that are commonly used as a basis for series separations are depth and kind of bedrock, depth to ground water or perched water table, length of saturation period for wet soils, and quantity of gravel or stones in the soil. Criteria for the differentiation of one phase from another are based on such readily observable and measurable characteristics as slope and degree of erosion.

Figure 6

GUIDE FOR U.S. DEPARTMENT OF AGRICULTURE
TEXTURAL CLASSIFICATION FOR USE IN SOIL FAMILY DETERMINATION



[a] *Very fine sand (0.05-0.1) is treated as silt for family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between the silty and loamy classes.*

Source: U.S. Soil Conservation Service.

Seven textural classes are used by the U.S. Soil Conservation Service in defining soil families. The various textural classes are determined by the relative amounts of sand, clay, and silt found in the soil series to be grouped into families. The above triangular graph accounts for all possible combinations of sand, clay, and silt and groups these combinations into the seven textural classifications. For example, as shown in red on the above figure, a combination of 50 percent sand, 30 percent clay, and 20 percent silt results in a family textural classification of "fine loamy."

AASHO System

The AASHO System is the most widely used soil classification system for highway engineering purposes. It identifies soils according to the qualities of texture and plasticity and groups them with respect to performance as highway subgrade materials. Originally devised in 1931 by the U. S. Bureau of Public Roads and revised by the Highway Research Board of the National Academy of Sciences in 1945, this system was thereafter adopted by the American Association of State Highway Officials. This classification system groups soils of the same load-carrying capacity into seven basic groups, A-1 through A-7. The best soils for highway subgrades are classified as A-1 and then in descending rank order to the poorest, which are classified as A-7 (see Figure 7). A wide range of load-carrying capacity exists within each soil group; and, therefore, the groups are subdivided into subgroups through the use of an index number ranking from zero for the best subgrade soils to 20 for the poorest. Increasing values of the index number reflect a reduction in load-carrying capacity and the combined effect of an increasing liquid limit and plasticity index and of the increasing percentages of coarse material. The soils under each group classification of this system are further discussed in Chapter III of this Guide under the subsection entitled "Soil Interpretations for Engineering Purposes."

Unified System

The Unified System of soil classification was developed for the U. S. Army, Corps of Engineers, during World War II and subsequently expanded in cooperation with the U. S. Department of the Interior, Bureau of Reclamation, for application to embankment and foundation construction, as well as to roadway and airfield construction. Like the AASHO System, the Unified System identifies soils according to the qualities of texture and plasticity and groups them with respect to performance as engineering construction materials. The following properties form the basis of the soil identification: the proportion of gravel, sand, and fines; the shape of the grain size distribution curve; and the plasticity and compressibility characteristics of the soil. Each soil is given a descriptive name and a letter symbol. Three soil fractions are recognized: gravel, sand, and fines, the latter consisting of silt or clay; and the soils are divided into three major divisions: coarse-grained, fine-grained, and highly organic. The coarse-grained soils are further divided into gravel and sand, and each is in turn further subdivided into four groups (see Figure 8). The fine-grained soils are divided into silt and clay, and each is further subdivided into three groups. The highly organic soils comprise one group. The soils under each group classification of this system are further discussed in Chapter III of this Guide under the subsection entitled "Soil Interpretations for Engineering Purposes."

CONDUCT OF THE REGIONAL SOIL SURVEY

Utilizing the basic USDA Soil Classification System described above, the U. S. Soil Conservation Service proceeded in 1963 to complete the soil survey in the Southeastern Wisconsin Region. The major steps involved were field operations, including mapping, and the preparation of interpretive analyses. The latter is further discussed in Chapter III of this Guide.

Field Operations

The classification of soils is useful mainly in segregating soil characteristics that are relevant to interpretation and use. The people who perform the work of recording soil information for later use are professional soil scientists trained in the science of soil identification, classification, and interpretation, as well as in the art of map making. Operations in the field include soil mapping, measurement of slope, and sampling of soils for soil characterization. Once the actual field work has been completed and preliminary soil maps drawn, descriptions of each distinctive kind of soil are prepared; and, based on these descriptions, the various soils are correlated and classified. Finally, interpretive analyses are made based on the soil descriptions and classifications.

The completion of soil survey mapping for about one million acres in the Region over a two-year period necessarily involved a very significant concentration of effort by the U. S. Soil Conservation Service. An estimated total of approximately 500 man-months were expended on the survey effort, including 250 man-months of actual survey work in the field. Every acre in the Region not previously mapped by soil scientists was mapped in the field during the non-winter months of 1963, 1964, and 1965. A total of 15 soil scientists were assigned to the survey project over the three-year survey period.

Figure 7
THE AASHO SOIL CLASSIFICATION SYSTEM

Fig. 5. Group index charts.

Chart A—Grain Size and P. I. Relations

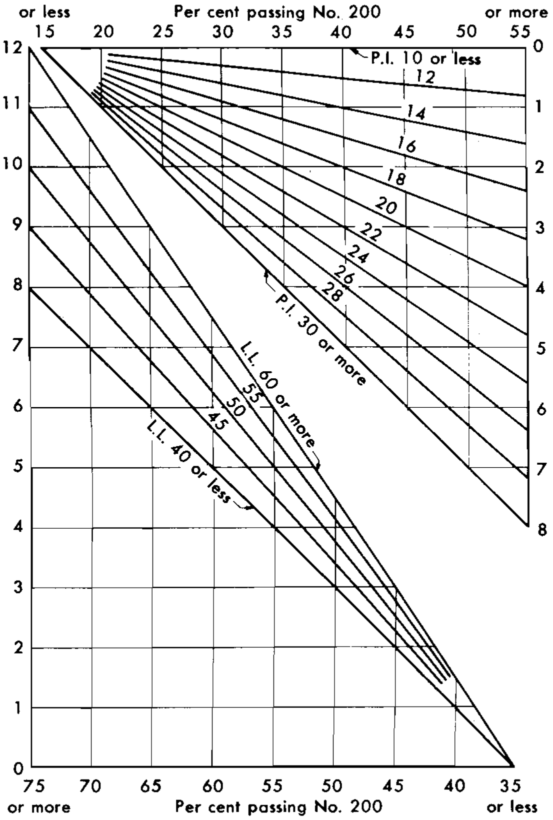


Chart B—Grain Size and L. L. Relations

Group Index Equals Sum of Readings on Both Vertical Scales

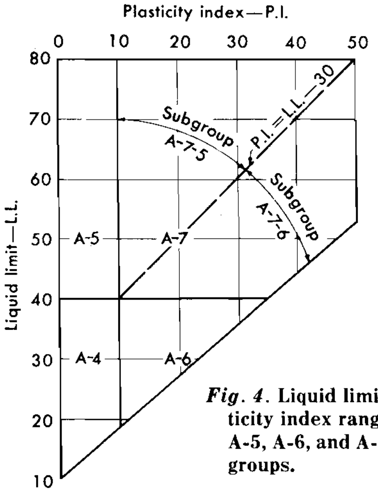


Fig. 4. Liquid limit and plasticity index ranges for A-4, A-5, A-6, and A-7 subgrade groups.

Classification of Highway Subgrade Materials (with Suggested Subgroups)

General classification	Granular materials (35 per cent or less of total sample passing No. 200)							Silt-clay materials (More than 35 per cent of total sample passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve analysis, per cent passing:											
No. 10	50 max.										
No. 40	30 max.	50 max.	51 min.								
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit				40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Group Index**	0		0	0		4 max.		8 max.	12 max.	16 max.	20 max.

Classification procedure: With required test data available, proceed from left to right on chart; correct group will be found by process of elimination. The first group from the left into which the test data will fit is the correct classification.

*P.I. of A-7-5 subgroup is equal to or less than L.L. minus 30. P.I. of A-7-6 subgroup is greater than L.L. minus 30 (see Fig. 4).

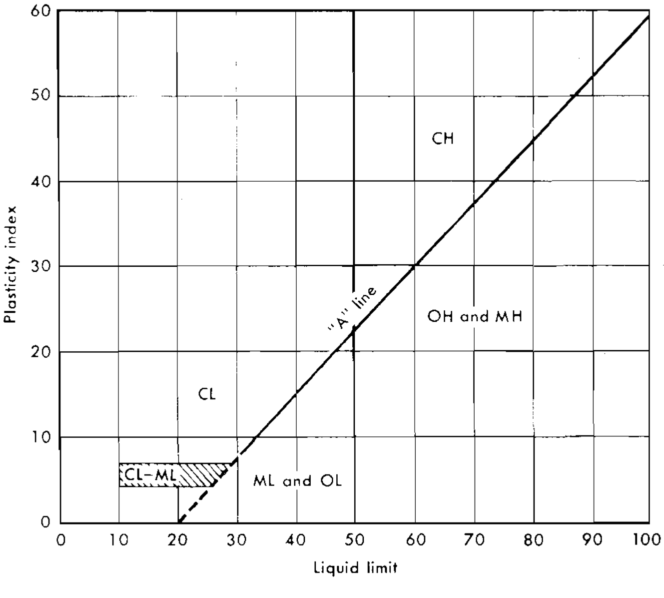
**See group index formula or Fig. 5 for method of calculation. Group index should be shown in parentheses after group symbol as: A-2-6(3), A-4(5), A-6(12), A-7-5(17), etc.

Source: American Association of State Highway Officials; Portland Cement Association.

The AASHO soil classification system groups soils with respect to their performance as highway subgrade materials. The soils are identified by the properties of texture and plasticity. There are seven basic groups, A-1 through A-7, which are further divided into subgroups based on an index number that reflects primarily a reduction in load carrying capacity.

Figure 8

THE UNIFIED SOIL CLASSIFICATION SYSTEM

Major divisions			Group symbols		Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent . . . . GW, GP, SW, SP More than 12 per cent . . . . GM, GC, SM, SC 5 to 12 per cent . . . . Borderline cases requiring dual symbols**	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM*	d u	Silty gravels, gravel-sand-silt mixtures		Atterburg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterburg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM*	d u	Silty sands, sand-silt mixtures		Atterburg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.
			SC		Clayey sands, sand-clay mixtures		Atterburg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity	 **Plasticity Chart**		
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		Pt		Peat and other highly organic soils			

*Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterburg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

**Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

Source: U. S. Army Corps of Engineers: Portland Cement Association.

The Unified soil classification system, like the AASHO system, identifies soils by the properties of texture and plasticity and then groups them with respect to performance as engineering construction materials.

The soil survey in the Southeastern Wisconsin Region was carried out in conformance with the latest standard procedures of the U. S. Soil Conservation Service as set forth in the U. S. Department of Agriculture Soil Survey Manual.[8] In addition to substantive knowledge in the fields of soils, geology, hydrology, and air photo interpretation gained through formal education and through work experience, a soil scientist entering the field to do soil survey work carries with him a kit of tools with which to examine the soil and the landscape. Included in this kit are a spade, an auger, a hand microscope, and a slope-measuring instrument called the Abney hand level (see Figure 9), and small bottles of chemicals used to determine the presence of free carbonates and the soil reaction (acidity-alkalinity). He also carries with him aerial photographs of the area to be mapped. These photographs provide both a base for the mapping and an important aid in the location of soil boundaries. The soil scientist knows, through experience and through careful observation of the surface, vegetation, topography, and road cuts, where to make borings to obtain the specific information he needs to identify the soils to be mapped.

Soil Boring: The soil scientist usually starts a boring with a shovel and deepens it with an auger (see Figure 10). As he bores down through the soil layer by layer, he examines the amount of sand, silt, and clay in the soil by moistening it and rubbing it through his fingers (see Figure 11). He then examines the arrangement of the particles because this arrangement will affect how water, air, and roots move through the soil. Using a lens, he looks at the soil closely to observe the internal fabric or make-up of the soil; and as he digs, he compares the colors of the soil with a standard color chart (see Figure 12).

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[8] *U. S. Department of Agriculture Handbook No. 18, Soil Survey Manual, Washington, D. C., 1951.*

Figure 9

SLOPE MEASUREMENT

The soil scientist measures the slope of the land in the field with the aid of a slope-measuring instrument called the Abney hand level. Slope is an important characteristic bearing on the suitability of soils for various uses. Slope also, of course, has a direct effect on soil erosion and sedimentation. A slope measurement is recorded for each soil mapping unit.

Figure 10

SOIL BORING

A shovel and an auger are basic tools of the soil scientist. A soil boring is usually started with the shovel and deepened with the auger. Soil borings are normally made to a depth of five feet. The soil scientist knows, through experience and careful observation of the land surface and vegetation, where to make borings to obtain the specific information he needs to identify the soils to be mapped.

Figure 11

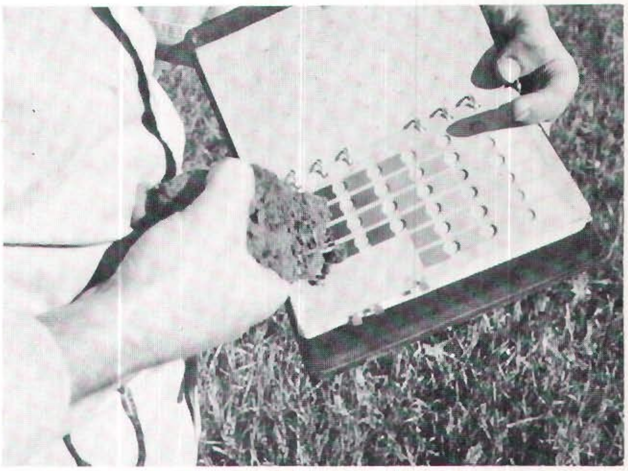
SOIL TEXTURE EXAMINATION

As the soil scientist bores down through the soil layer by layer, he examines the soil by moistening it and rubbing it through his fingers. In this way he can determine the approximate amounts of sand, silt, and clay in the soil. Sand, silt, and clay percentages determine the textural classification of the soil.

Figure 12

SOIL COLOR COMPARISON

Soil color provides an important key to soil classification and soil behavior. The soil scientist compares a soil sample to a standard color chart known as the Munsell Soil Color Chart. Colors of gray, green, or olive in the subsoil are reliable indicators of the degree of wetness and the absence or presence of a high water table. These colors persist in soils even after many years of artificial drainage. Brown, yellowish-brown, and reddish-brown colors are associated with well-drained soils.



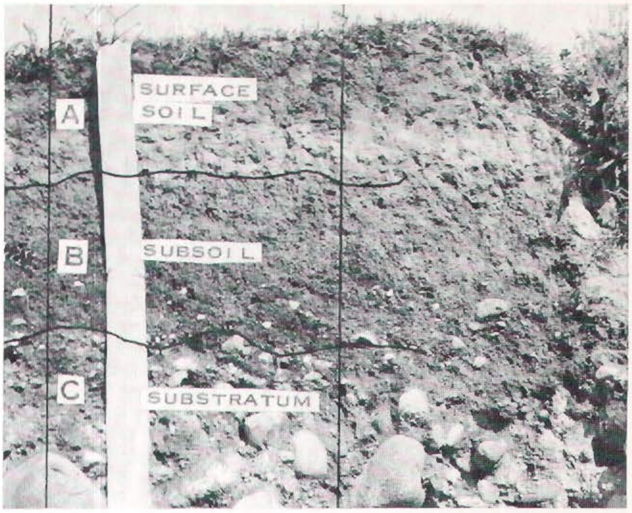
As he digs, he is searching for layers of soil, called horizons (see Figure 13), which give him clues to both how the soil will perform for a given land use and why the soil has the characteristics that he is observing. These properties of the soil, which the soil scientist studies in detail through boring, give him a precise picture of what the soil conditions are in the field as he makes the soil map. In addition to looking at the soil in the field, he will take samples of the soils for testing and measuring in the laboratory. These laboratory tests and measurements supplement those which are made in the field. Proceeding in this way, a soil scientist can survey and map approximately 250 acres on a typical working day, the rate varying with terrain, complexity of the soil pattern, and land ownership patterns.

The quality and accuracy of a soil map reflects, to some extent, the ability of the soil scientist to depict in two-dimensional graphic form the things he sees as he walks across the land. Behind each symbol and line placed on the map are knowledge and appreciation of his surroundings, based on experience and intensive study of the earth's surface. A thorough understanding of the different kinds of soil and their relationship to the landscape can be gained only by experience. A knowledge of the geology of the area can be gained by on-site investigation and by collation and analysis of published data collected by others. Many geologic formations and ice, water, and wind-laid deposits have characteristic land forms that provide clues to the soil scientist. His knowledge of geomorphology, and the topography associated with it, and of plant ecology aids in making extrapolations for similar situations. Thus, although many soil borings must be made to identify the various soil series, the number of borings can be reduced by "reading" the landscape. Examination of the soil profiles by the soil scientist provides most of the information needed for soil identification. The environment surrounding the examined soil profile provides information that can be used to delineate the boundaries of each soil as it occurs in the landscape. Through formal study and experience, the soil scientist acquires the skill and knowledge needed to show the existing conditions on the aerial photographs that he uses as a base map.

Figure 13

SOIL HORIZONS

The soil scientist in his field investigations identifies the various layers of soil, called horizons. These layers give him clues as to the way in which the soil was formed, how the soil will perform for various land uses, and how this performance will vary with depth. As shown in this photograph, three soil horizons are usually observed: the A horizon or surface soil, the B horizon or subsoil, and the C horizon or substratum.



Mapping: When the soil scientist has made his examinations of the soil, studied the different horizons, measured the slope, estimated the erosion, and studied the aerial photographs, he begins to draw lines on aerial photographs used as base maps for this purpose (see Figure 14). These lines delineate areas covered by soils which differ from one another in their important characteristics.

The detailed operational soil survey conducted in southeastern Wisconsin departed from the standard soil survey in one important respect; namely, the type of aerial photograph used as a base map for the field operations. The work specifications prepared by the Commission required that the boundaries of all soil mapping units be identified on prints of current Commission aerial photographs. These photographs were to consist of ratioed and rectified enlargements to a scale of 1" = 1320' of Commission 1" = 6000' scale current (1963) high-altitude photography. Each field sheet base map covered six U. S. Public Land Survey sections. The specifications also required that the Commission be furnished with reproducible half-tone positives of the field sheets on dimensionally stable base material at a scale of 1" = 2000'. The reproducible positives were to be suitable for the preparation of clear blue-line or black-line prints by diazo process and were to show clearly the soil mapping units with delineations and identifying symbols so that the prints could be used in conjunction with the published Commission soils report. The specifications further required that finished photo maps be prepared to accompany the published soil surveys at a scale of 1" = 1320', also using the negatives of current photography provided by the Commission. Key planimetric features, such as major highways, railroads, streams, lakes, cemeteries, and major structures, were to be identified on the finished photo maps, as were all U. S. Public Land Survey township, range, and section lines.

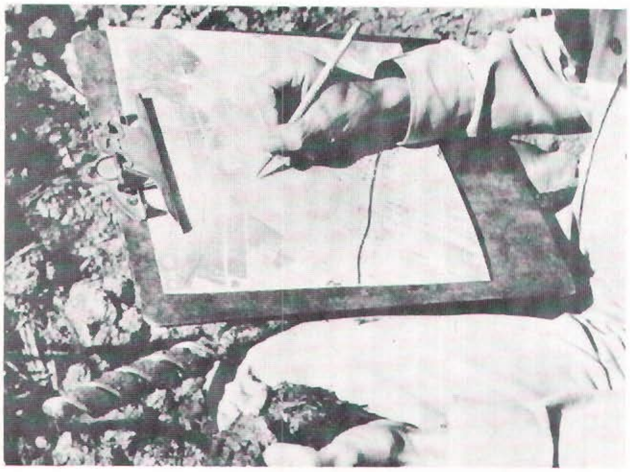


Figure 14

SOIL MAPPING

Once the soil scientist has completed his examination of the soil, measured the slope, and estimated the degree of erosion, he studies aerial photographs of the area being mapped and draws lines on these photographs depicting the boundaries of the soil mapping units. The soil mapping for the Southeastern Wisconsin Region was accomplished on prints of current Commission aerial photographs at a field scale of 1" = 1320', which were subsequently reduced to 1" = 2000' for regional planning purposes.

These base mapping specifications concerning the soils mapping program in southeastern Wisconsin were unique in that the normal U. S. Soil Conservation Service practice up to that time had been to prepare controlled photo mosaics for the soil mapping. The revised base mapping procedure required by the Commission, consisting of the preparation of ratioed and rectified enlargements to eliminate all distortion except that due to relief, provided instead actual photo maps upon which distances and areas could subsequently be accurately scaled and measured. Such distances and areas cannot be reliably obtained on controlled photo mosaics. An example of a six-section soil survey photo map for southeastern Wisconsin is shown in Figure 15.

Correlation: As the initial soil mapping is completed in the field by the soil scientists, a final correlation is made by state and national U. S. Soil Conservation Service personnel to ensure uniformity in soil identification between soil survey areas, such as the Southeastern Wisconsin Region, the remainder of the State of Wisconsin, and the rest of the nation. Reports are prepared that include comments on inspections of soil series and mapping units and recommendations for any changes that should be made in soil identification names.

Soil Map Numbers and Symbols

To save time and space, a code number indicating the kind of soil, the soil gradient, and the degree of erosion is placed in each soil delineation drawn on the soil survey field sheet. The usual code is comprised of a number for the soil type, a number for the percent slope, and a number for the degree of erosion. An example of such a code number would be 297-5-2 (see Figure 15). In the soil survey for southeastern Wisconsin, numbers were used on the field sheets to indicate the actual slope; and capital letters, representing slope ranges, were used for analysis purposes in the soils report.

Soil Type: Knowing the soil type, slope, and degree of erosion, as indicated by the number code 297-5-2, provides a soil map user with the key to all of the information that is necessary to provide a sound basis for determining the suitability and limitations of soils for a given use. The soil type code number 297 identifies the soil type delineated on the soil map, thereby identifying the distinctive color, texture, soil structure, consistence, reaction, and other properties of the soil relevant to its classification for various uses. A numerical listing of each soil number used on the soil maps of the Region and a description of each soil mapping unit occurring within the Region are set forth in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.

Soil Slope: The second group of digits in the code number, the number 5 in the soil code example given above, as already noted, indicates the percent slope on which the mapped soil occurs. The importance of slope cannot be overemphasized. The slope is indicative of the erosion hazard. The operation of on-site sewage disposal filter fields is severely limited and should be curtailed on steep slopes. Residential, commercial, industrial, and even recreational land use development is hindered by steep slopes. Nearly level slopes are difficult to surface drain and if in low areas may be accompanied by high water tables. Indeed, slope conditions enter into determining the suitability of an area for almost every kind of use. Regular and complex slopes have been grouped and classed for analysis purposes, as shown in Table 2.

Soil Erosion: The third group of digits in the code number, the number 2 in the soil code example given above, indicates the degree of erosion for the particular soil mapping unit. The digits 1, 2, and 3 are used to indicate the degree of erosion as follows:

1—none to one-fourth of the original surface soil has been removed by erosion.

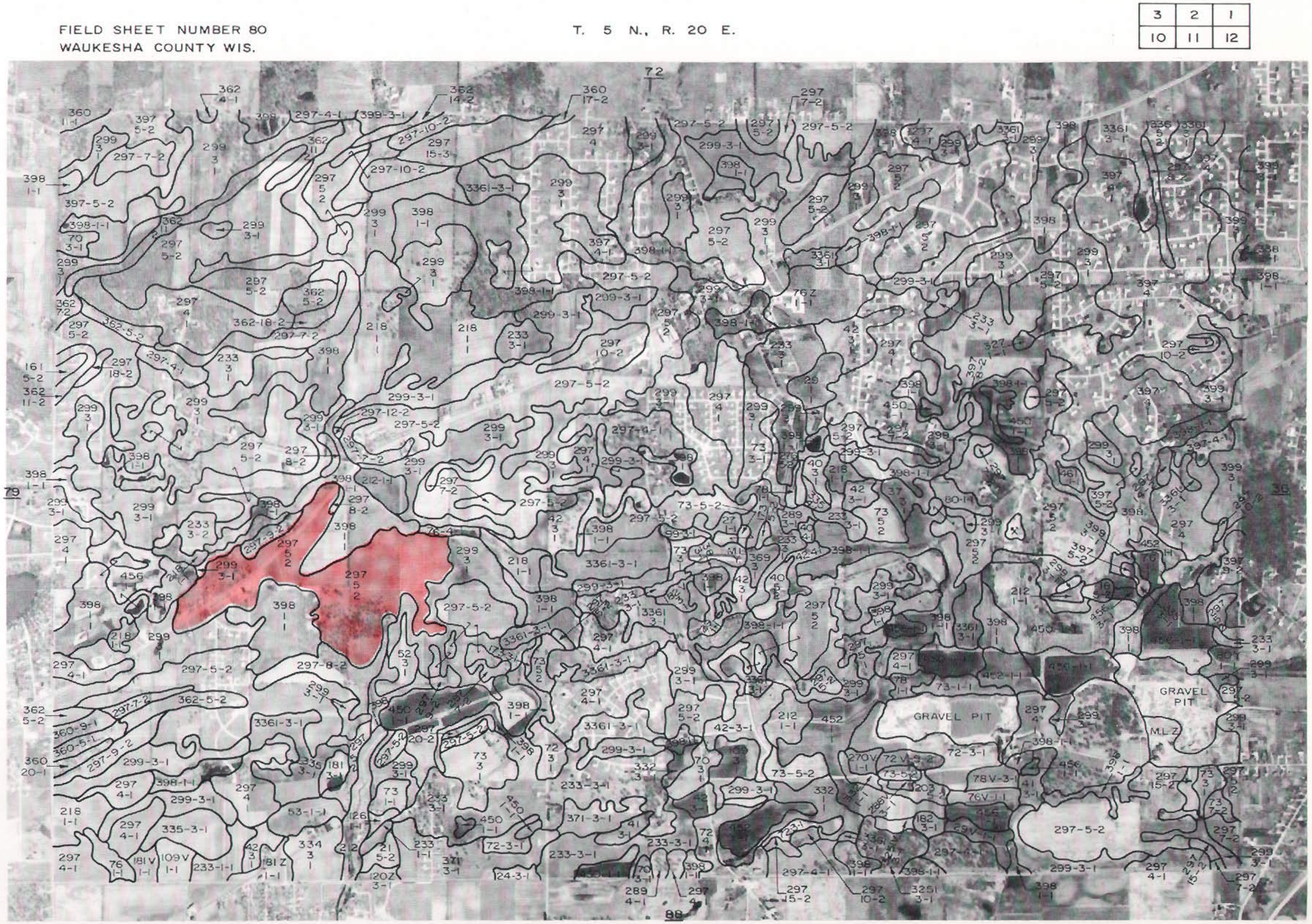
2—one-fourth to three-fourths of the original surface soil has been removed by erosion.

3—three-fourths of the original surface soil to one-fourth of the subsoil has been removed by erosion.

The historical erosion indicated by this digit in the soil mapping code number provides knowledge of the kind of surface soil that remains. For example, a severely eroded loam soil with a clay loam subsoil will

Figure 15

TYPICAL SOIL SURVEY PHOTO MAP IN THE SOUTHEASTERN WISCONSIN REGION



Source: U.S. Soil Conservation Service; SEWRPC.

Soil mapping unit boundaries in southeastern Wisconsin were delineated on prints of ratioed and rectified enlargements of 1963 aerial photographs. It is thus possible to scale distances and measure areas directly on the soil photo maps. Each soil photo map covers six U.S. Public Land Survey sections, or approximately six square miles. Copies of these maps for any portion of the Southeastern Wisconsin Region may be ordered directly

Table 2

SOIL SURVEY SLOPE GROUPS AND CLASSIFICATIONS
IN THE SOUTHEASTERN WISCONSIN REGION

<table>
<tr><td colspan="3">Regular Slopes - Areas with long slopes that have well-defined natural drainage systems.</td></tr>
<tr><td>Percent Of Slope</td><td>Slope Group</td><td>Slope Classification</td></tr>
<tr><td>< 2</td><td>A</td><td>Nearly level</td></tr>
<tr><td>2- 6</td><td>B</td><td>Gently sloping</td></tr>
<tr><td>6-12</td><td>C</td><td>Sloping</td></tr>
<tr><td>12-20</td><td>D</td><td>Moderately steep</td></tr>
<tr><td>20-30</td><td>E</td><td>Steep</td></tr>
<tr><td>30-45</td><td>F</td><td>Very steep</td></tr>
<tr><td colspan="3">Complex Slopes - Areas with gradients in many directions and that have no defined natural drainage system.</td></tr>
<tr><td>Percent Of Slope</td><td>Slope Group</td><td>Slope Classification</td></tr>
<tr><td>< 6</td><td>M</td><td>Gently undulating</td></tr>
<tr><td>6-12</td><td>N</td><td>Undulating</td></tr>
<tr><td>12-20</td><td>K</td><td>Rolling</td></tr>
</table>

Source: U.S. Soil Conservation Service.

have lost all the original surface soil and part of the subsoil. The remaining clay loam has poor tilth, is low in organic matter, is less permeable than the original soil, is low in fertility, and is more erosive because of the lower water intake rate. Soils with slight erosion are generally high in organic matter content, have good tilth, are easier to cultivate, and usually are more productive than those with moderate or severe erosion.

Other Symbols: In addition to the soil mapping unit code numbers just discussed, there are additional conventional map symbols used on the soil maps to indicate various features of the landscape. These map symbols, as shown in Figure 16, aid in understanding the soil survey and in interpretation of the suitability of the soils for various uses.

Soil Characteristics

In identifying and classifying the soil series and types found in the Southeastern Wisconsin Region, the soil scientist must look for several distinguishing characteristics. These characteristics include soil color, soil texture, soil structure, soil consistence, soil reaction, and other features that are relevant to the classification and interpretation of soils. In addition, several laboratory analyses are commonly made.

Soil Color: In the description of each distinctive soil horizon in the soil profile, color is mentioned first. In soil descriptions colors are given according to standard nomenclature and Munsell notations.[9] Where

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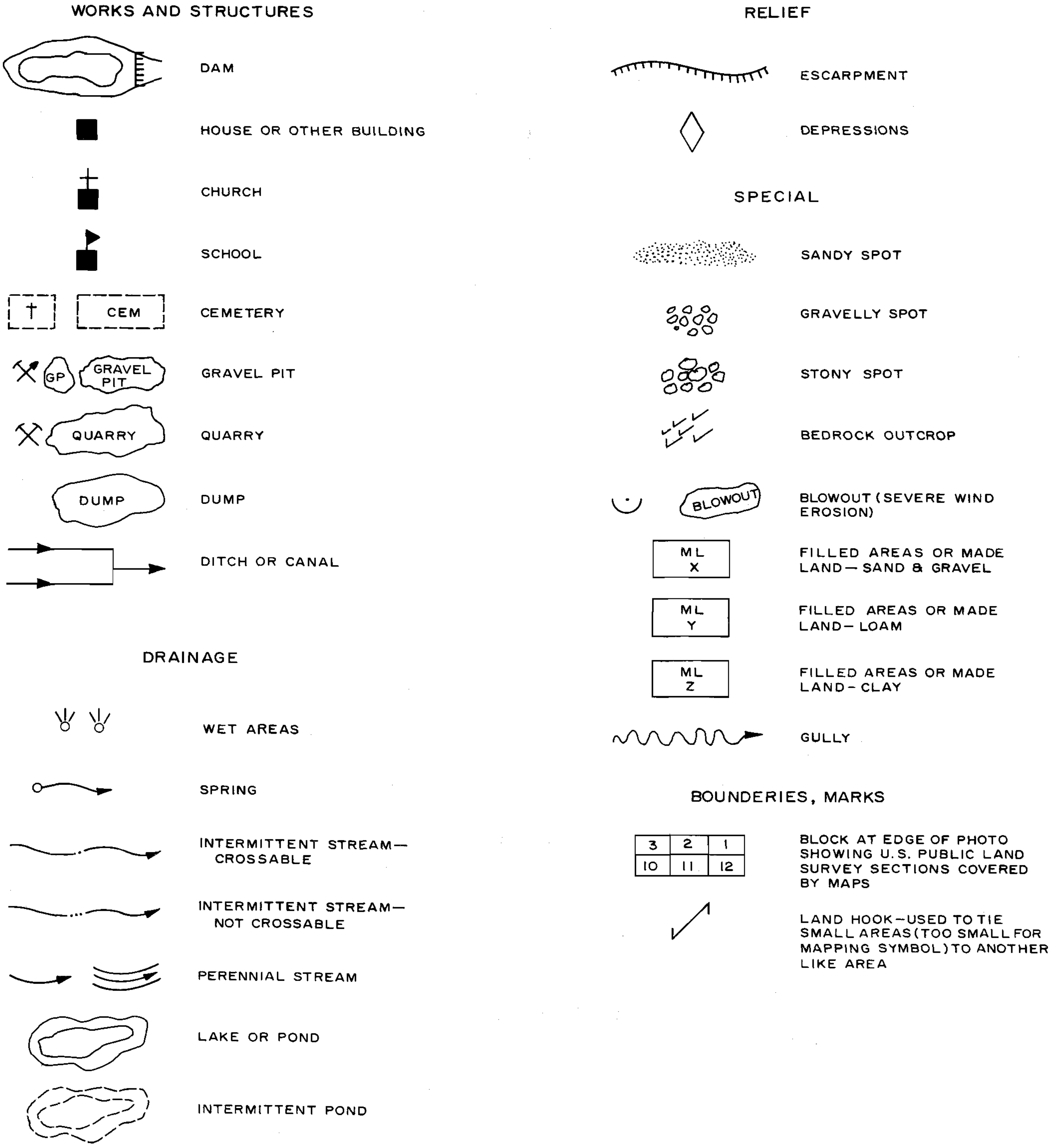
[9] *The Munsell notation is a code indicating, with respect to a standard chart, the precise color and hue of a soil. See Munsell System of Color Notation--Munsell Soil Color Chart, Munsell Color Company, Inc., Baltimore, Maryland.*

Figure 16

CONVENTIONAL SOIL PHOTO MAP SYMBOLS



Source: U. S. Soil Conservation Service.

the soil has a thick, dark surface layer, a large amount of organic matter is usually present; and relatively high fertility is indicated. These soils generally have a high-water-holding capacity and good tilth. Light-colored soils are generally low in organic matter content.

Color in the subsoil is a reliable indicator of the degree of wetness and the absence or presence of a high water table. The gray, green, or olive colors of reduced iron compounds indicate that soils have been saturated for long periods of time each year and have a high water table. These colors persist in soils even after many years of artificial drainage. Mottling with a low percentage of gray color indicates a lesser degree of wetness or probably an intermittent water table that is near the surface during and shortly after rainy seasons. In some areas, certain kinds of parent materials have distinctive colors that remain in the weathered products. In general, brown, yellowish-brown, and reddish-brown colors are associated with well-drained soils.

Soil Texture: Because of its important influence on many soil properties, texture is considered an important criterion for series differentiation, is a part of the soil type name, and is a part of each soil horizon description. Soil textural classes are a reflection of the relative amounts of sand, silt, and clay particles in the soil (see Figure 17). Sand particles range from 0. 05 mm (millimeters) to 2 mm in size. Silt particles range from 0. 002 mm to 0. 05 mm in diameter, and clay particles are less than 0. 002 mm in diameter. Most soils are mixtures of all the particle sizes, and it is the percentage of each particle size in the mixture that determines the textural class. Where there are enough coarse fragments, such as gravel or stones, in the soil to affect appreciably the water-holding capacity, fertility-holding capacity, or other qualities related to use, the soil is said to be gravelly or stony.

Soil texture is the principal characteristic that affects soil permeability. Most sandy soils are rapidly permeable, and most clay soils are slowly or very slowly permeable. Loam soils are generally moderately permeable. The water-holding capacity of soil is controlled mainly by texture and the amount of organic matter present. Water is held in the soil by particle surface tension. Because of the smaller particles in clay soils, the surface exposure per given volume of soil is greater than for other textures; and the water-holding capacity is larger. Thus, sandy soils hold smaller amounts of water per given volume than finer-textured clayey soils. The ability of soils to hold chemical elements that are used by plants in growth and reproduction is also a function of soil texture and organic matter content. In general, the fertility-holding capacity of soils is directly related to organic matter content and the amount of clay in the soil. The clay acts as the anion in the chemical exchange which occurs between fertilizer compounds and the mineral soil. Optimum fertilizer applications can be calculated by using the soil exchange capacity, which is mainly based on the clay content. Excess applications of fertilizer could result in loss of fertilizer by leaching and attendant water pollution problems.

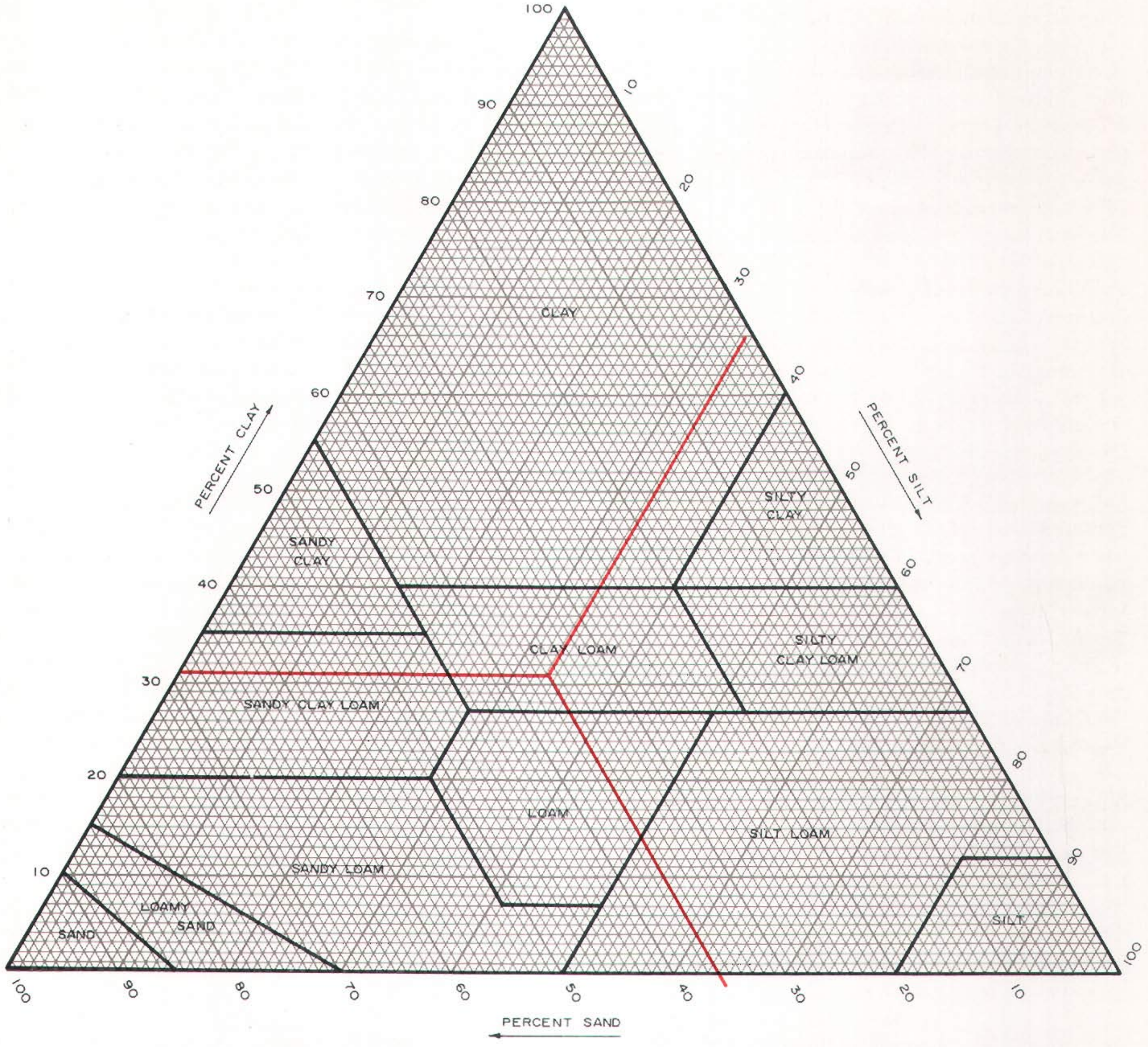
The stability of soils when subjected to stationary or moving loads is related mainly to soil texture. Loamy sand, sandy loam, and sandy clay loam soils have higher stability than other soils. These textures represent a mixture of particle sizes and shapes that complement each other in the soil mass and prevent slippage between particles.

Shrink-swell potential or the change of soil volume with changes in soil moisture is directly related to the amount and kind of clay in the soil. Swelling clays, such as montmorillonite and bentonite, cause high shrink-swell potentials in soils. Their molecular structure permits them to hold large amounts of water, which causes expansion of each particle, as well as increases in the distance between particles. Other clays, such as illite and kaolinite, have moderate or low shrink-swell potential. Silt and sand particles absorb relatively smaller amounts of moisture and, therefore, cause little swelling with moisture increase.

Soil Structure: Soil structure refers to the aggregation of primary soil particles into clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. The surfaces of weakness are commonly called cleavage planes. Four primary types of structure occur in the soils of southeastern Wisconsin: 1) platy, with particles arranged around a plane, generally horizontal; 2) prismlike or prismatic, with particles arranged around a vertical line and bounded by relatively flat vertical surfaces; 3) blocklike or polyhedral, with particles arranged around a point and bounded by flat or rounded

Figure 17

U. S. DEPARTMENT OF AGRICULTURE GUIDE FOR TEXTURAL CLASSIFICATION OF SOILS[a]



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[a] *Using materials less than 2.0 mm in size. If approximately 20 percent or more of the soil material is larger than 2.0 mm, the texture term includes a modifier. For example, ''gravelly sandy loam.''*

Source: U.S. Soil Conservation Service.

Soil textural classes are a reflection of the relative amounts of sand, clay, and silt particles in the soil. Whether a particle is sand, clay, or silt is determined by its size. Most soils are mixtures of all particle sizes. The above triangular graph can be used to identify the textural classification of a soil and accounts for all possible combinations of sand, clay, and silt, grouping these combinations into twelve textural classifications. For example, as shown in red on the above figure, a combination of 35 percent sand, 32 percent clay, and 33 percent silt results in a textural classification of "clay loam."

surfaces, which are casts of the molds formed by the faces of surrounding peds; and 4) spheroidal (granular or crumb), with particles arranged around a point and bounded by curved or very irregular surfaces that are not accommodated to the adjoining aggregates. Subtypes of blocky are subangular blocky, having mixed rounded and plane faces with vertices mostly rounded and angular blocky (blocky) bounded by planes intersecting at relatively sharp angles.

Structure mainly affects soil permeability, which is defined as the ability of soils to transmit water or air. The relative permeability of granular, subangular blocky, blocky, and platy structure is lower in each subsequent listing. Prismatic structure generally occurs as a compound structure that parts to angular or subangular blocks. Relative permeability is about the same as the blocky structure. Erodibility of soils is indirectly affected by soil structure because structure affects permeability, which, in turn, to some extent controls runoff. Soils with granular or subangular blocky structure are generally less erodible than other soils because they can transmit greater amounts of water when saturated.

Structure grades of weak, moderate, and strong are defined in terms of stability of the peds or clustered masses of individual soil particles. Weak structure is usually less permeable than the strong structure because space between peds is more likely to be filled with individual particles. Soil stability under stationary and moving loads is partially a function of soil structure. Where the ped faces overlap, the aggregates act as bricks or building stones to bind each other and prevent slippage under loads. Weak structures with little overlap will support only light loads. The weak structures are also less stable in the presence of water.

Soil Consistence: Soil consistence is expressed in terms that indicate degree of cohesion and adhesion or resistance to deformation or rupture. Soil structure is a function of size, shape, and distinctness of peds, whereas consistence represents the strength of the forces that hold aggregates together. Consistence can be expressed in standard nomenclature for dry, moist, and wet soils. Gradations of dry consistence are loose, soft, slightly hard, hard, very hard, and extremely hard. Moist consistence is expressed as loose, very friable, friable, firm, very firm, and extremely firm. Wet consistence is expressed as nonsticky, slightly sticky, sticky, very sticky, nonplastic, slightly plastic, and plastic. Most soil descriptions for southeastern Wisconsin soils note only the moist consistence. Where significant the wet consistence is given. Dry consistence is generally omitted in soil descriptions because soils in the Region are dry for short periods of time only.

Soil Reaction: Soil reaction is important in soil classification and interpretations mainly because of other soil qualities that can be inferred from it. It is an indication of the degree of acidity or alkalinity of soils and is expressed in terms of pH—the logarithm of the reciprocal of the hydrogen ion concentration. With this notation pH 7 is neutral; lower values indicate acidity; and higher values show alkalinity.

Descriptive terms that correspond to ranges in pH values are shown in Table 3. In southeastern Wisconsin the soils range from very strongly acid through moderately alkaline. Soils with pH above 7 generally contain free carbonates.

Indirectly.soil reaction is an indication of the degree of weathering, the composition of the parent material, the amount of leaching that has occurred, and the kind of vegetation that grew on the soil during early stages of formation. The values can be used to determine crop suitability. A given species of plant usually has a specific range of soil reaction in which it grows best. pH values can be used to indicate the need for lime from which plants extract calcium, one of the elements essential to plant growth. In general, low pH values indicate that plants will respond favorably to applications of lime on a particular soil.

To some extent, the corrosivity of metal and concrete pipe in soils can be predicted with proper interpretation of pH values. Concrete pipe will corrode rapidly in moist soils with low pH values. In Wisconsin observations of metal pipe in soils indicate that corrosion is faster in alkaline soils (pH above 7) than in acid soils (pH below 7).

Special Features: The presence of pebbles or stones in the soil or the underlying material not only provides clues about the origin of the soil but is also a basis for some interpretations. Large amounts of

Table 3

SOIL REACTION CLASSIFICATIONS

Reaction Classification	pH Value Range
Extremely acid	<4.6
Very strongly acid	4.6-5.0
Strongly acid	5.1-5.5
Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	>9.0

Source: U.S. Soil Conservation Service.

gravel or stones in the profile will affect the total capacity of soils to hold water or fertility and, if on the surface, will affect tillage of the soil. Soils underlain by sand and gravel deposits may comprise valuable sources of road building material.

The presence of bedrock within a depth of five feet is indicated in the soil description or by the mapping symbol. Soils underlain by rock at a depth of less than 20 inches are classified and named differently than soils underlain by bedrock at a depth of more than 20 inches. For example, soils of the Knowles series are 20 to 40 inches deep over dolomitic bedrock; but similar soils less than 20 inches deep are in the Ritchie series. Depth to bedrock affects soil interpretations for uses such as farming, road construction, urban development, recreation, and engineering uses.

Laboratory Analyses

In addition to information gathered in the field, representative samples of soils are analyzed in the laboratory. Some physical determinations commonly made are mechanical analysis for texture; bulk density to help estimate the shrink-swell potential, pore space, and soil condition; and percent water at field capacity (1/3 atmosphere) and wilting point (15 atmosphere) to arrive at the available moisture capacity. Analyses for organic carbon and nitrogen content help to determine organic matter content and relative productivity. The amount of carbonates and pH values indicate the degree of leaching and provide valuable clues about parent material. The cation exchange capacity and the amount of extractable bases indicate the fertility potential of the soil and the level of fertility at sampling time. In addition to these, other special analyses can be used to verify or correct field determinations and aid in classification of soils.

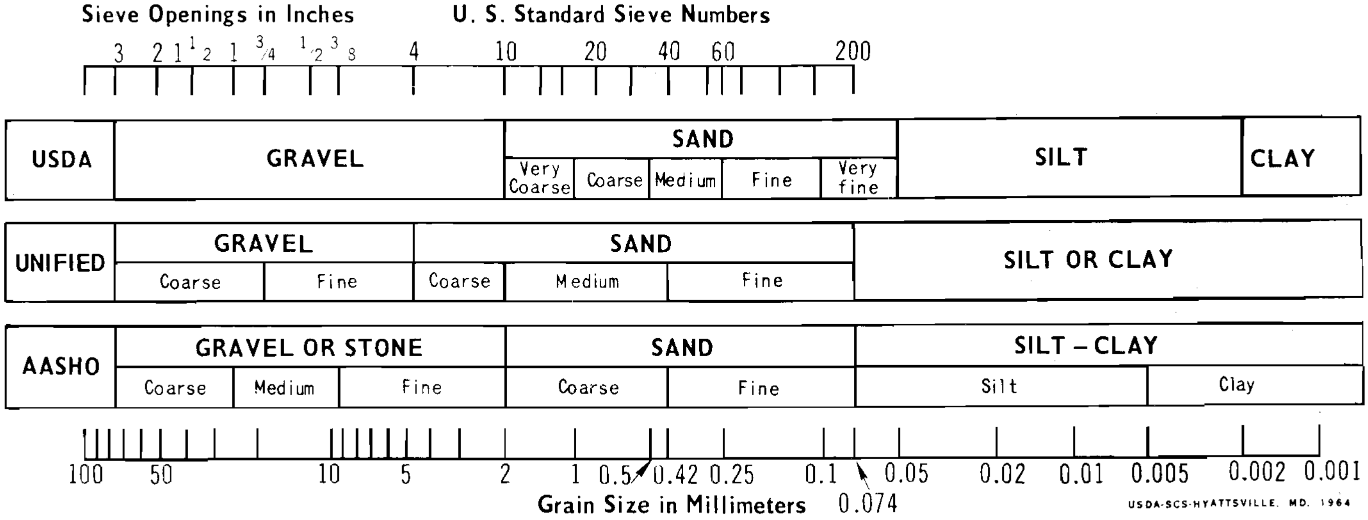
Many soil interpretations can be made from the laboratory studies outlined in the preceding paragraph. In order to learn more about the suitability of the soils for various engineering purposes, however, analyses, such as sieve analysis, liquid limit, plasticity index, optimum moisture, and maximum dry density, must be made. These help to classify the soils into the Unified and AASHO Systems commonly used by engineers (see Figure 18). These two systems are useful as an indication of the potential behavior of soils where used for highway construction, embankments, and other engineering applications.

LIMITATIONS OF THE REGIONAL SOIL SURVEY

The soil survey conducted in the Southeastern Wisconsin Region, like all such soil surveys, has certain limitations that must be recognized in order to avoid misuse of the resulting soils data. It should be emphasized, however, that these limitations are relatively minor; can often be overcome through relatively inexpensive additional field investigation; and, if properly understood, do not detract from the overall validity of the soil survey and its potential usefulness in planning and engineering work programs. It should be clearly understood that the interpretations based on the regional soil survey do not eliminate

Figure 18

COMPARISON OF PARTICLE SIZE SCALES



Source: U. S. Soil Conservation Service.

the need for additional soil sampling and testing where, for instance, the construction of major engineering works involving heavy loads is contemplated or where proposed excavations are deeper than the depths of layers reported in the soil survey.

While soil surveys have certain inherent limitations, it is also important to note that the other major traditional method of obtaining detailed soils information—soil boring—also has certain inherent limitations. Analysis of subsoil conditions by borings alone may be unsatisfactory because the subsoil information, as depicted by boring logs at selected bore hole locations, may be inadequate to represent actual conditions. The boring log provides soils information only for a particular bore hole location. The bore holes can, for economic reasons, be located only at relatively widely separated locations along a defined line or over a defined area. Interpolations between borings may or may not represent true conditions. Furthermore, should an engineer wish to alter the alignment or location of a particular installation, such as a building, road, or sanitary sewer, new borings must be obtained at additional expense. Data from detailed soil surveys can be used instead to prepare soils engineering maps that show conditions in a broad area and not only along a fixed line or in a defined area. Preliminary locations for engineering structures can then be analyzed with the aid of such a map. If borings are then deemed necessary to provide additional information, the locations of the bore holes can be more rationally selected based upon the existing soils data. Thus, soils surveys and soil borings can be used to complement each other.

Based on the definition of soil as set forth earlier in this chapter, the soil scientists in Wisconsin have selected 60 inches as a practical depth to which the soils are sampled. Even though plants, such as trees, send some roots to depths greater than five feet, most of the roots that extract food and water from the soil are located at depths of less than five feet. In addition, most soils in southeastern Wisconsin are underlain, at a depth of less than five feet, by thick, unweathered glacial deposits; outwash materials; or bedrock. For most uses, therefore, investigation to a greater depth is neither necessary nor practical. Given the present level of technology, the soil scientist must be highly mobile and able to carry all necessary sampling equipment with him. The use of heavy boring equipment to achieve a greater depth of investigation would prevent the soil scientist from inspecting many key areas that enable him to study soils in relatively great detail and to map with a higher degree of accuracy.

Because the soil is a continuous layer on the earth's surface that differs with each change in a multitude of factors, including topography, parent material, and drainage, a range of characteristics must be defined for each kind of soil. It is obviously impossible to set up absolutely homogeneous soil mapping units. The soil map represents, therefore, a geographic delineation of the ranges of certain soil characteristics. Even though a soil is mapped correctly according to the classification scheme, it may have weak manifestations of the characteristics for which interpretations are made. Thus, some map delineations may represent soils that could have slightly different interpretations than typical soils of this kind. Where there is any question regarding the proper interpretation of the characteristics of a soil mapping unit, additional on-site investigations should be made.

The scale used in mapping the soils also has considerable influence on the amount of detail that can be shown. Traditionally, the U. S. Soil Conservation Service has compiled soil maps at a scale of 1" = 1320', which scale is convenient for field use and permits sufficient detail to be mapped for most purposes. At this scale, however, it is not practical to delineate areas of less than two acres in size. This means that some delineations on the soil map may contain soils that differ in some manner from the soil identified by the soil code. These soils, termed "inclusions," will usually but not always have properties similar to the coded soil. Again, where inclusions are suspected that may affect the application of the soils data, additional on-site investigations should be made.

Two other limitations in the soil survey should be recognized. The first involves human error on the part of the soil scientist in the field or the cartographer in the drafting room. The soil scientist may misclassify a soil through an error in judgment or interpretation. The cartographer may misread the field survey sheets and notes and, therefore, err in drafting the final soil survey map. Experience has shown that, while these kinds of errors are certainly possible, they occur very infrequently. The second limitation involves possible variations in the actual soil boundary from the boundary shown on the map. Such variations may range up to 50 feet and usually occur because of subsoil irregularity not readily detectable on the surface or through a limited number of borings. Where errors in soil classification or boundary location are suspected and may affect the application of the soils data, additional on-site investigation should be made.

In addition to possible mapping inaccuracies and limitations, the various soil interpretations may, in some instances, contain slight errors because of a lack of research data about a given use or misjudgment concerning the predicted behavior of a soil based on a given set of characteristics. The very nature of the USDA soil survey system, however, which provides for a growing body of permanent knowledge based on observed or measured soil behavior, permits refinements in interpretations to be made over time, with concomitant increasing reliability on the usefulness and validity of the soil survey data.

The afore-described limitations to the regional soil survey represent cautions to be kept in mind during utilization of the survey results. They do not in any way detract from the validity of the surveys or their reliability and value if properly applied. Many communities in the Southeastern Wisconsin Region have used the soil maps and analyses, both through formal zoning, land subdivision, and sanitary ordinances and through informal procedures, in attempting to properly regulate urban growth and development. Questions are often raised by concerned landowners and developers about the accuracy and validity of the soil survey. As warranted, the U. S. Soil Conservation Service has made additional on-site investigations, often with the owner of the land in attendance, to verify the original survey classification; seek out any possible inclusions; and adjust, if necessary, the soil mapping unit boundaries. In this way, the individual landowner is assured of the accuracy and reliability of the soil survey. This continuing experience has shown that, with very few exceptions, the soil surveys are accurate and reliable.

INTERAGENCY SOILS AGREEMENT

While the regional soil survey was initially intended for use in the preparation of regional plan elements by the Commission, it was obvious that the survey could also be of great value to local communities and private individuals in the Region. Through its established community assistance program, the Commission had an ongoing vehicle for extending the soils data and analyses to local officials, for encouraging its full utilization, and for providing assistance in adapting the soils survey to local planning and development programs. In order to provide these services adequately, however, the Commission required the technical and professional assistance available from the U. S. Soil Conservation Service area engineers, area soil scientists, and county work unit conservationists; the educational assistance available from the University of Wisconsin Extension Service; and the aid and assistance available from the seven county soil and water conservation districts.

To obtain assistance from these agencies, the Commission prepared and executed an interagency "Memorandum of Understanding" with the U. S. Soil Conservation Service, the University of Wisconsin Extension Service, and the seven county soil and water conservation districts, designed to achieve the full potential value of the soil survey and analyses. This interagency agreement provides for the extension of technical information and educational services by the signatories to local public officials, citizen groups, and interested individuals on the need for, advantages of, and application of the detailed operational soil survey and its analyses. Under this agreement the U. S. Soil Conservation Service has continued to provide technical services in the application of the soil surveys, including the conduct of on-site soil investigations for additional detailing and refinement of the soils maps, the provision of technical advice on means for overcoming soil limitations for specific uses, and the provision of technical assistance in the application of good soil and water conservation practices. The Extension Service has continued to cooperate in educational programs relating to the use of the detailed soil survey, and the seven districts have continued to maintain local interest in the soil survey and to administer conservation plans. The Commission has cooperated with these agencies in helping to achieve full use and value of the soil survey as an integral part of its community assistance program. This unique agreement is set forth in its entirety in Appendix A.

AVAILABILITY OF SOIL MAPS

As part of the Interagency Soils Agreement, the Commission provides copies of the soil maps at only the nominal cost of reproduction and mailing. Each soil photo map, at a scale of 1" = 2000', covers six U. S. Public Land Survey sections. In addition, the soil maps have been enlarged to a scale of 1" = 1000' for the entire Counties of Kenosha, Racine, Walworth, Washington, and Waukesha and for the Town of Belgium in Ozaukee County. All of these maps may be ordered directly from the Commission Offices by specifying the county and the soil map index number as shown in the series of county index maps in Appendix B.

SUMMARY

Early recognition was given in the regional planning program for southeastern Wisconsin to the need for definitive data about the soil resources of the Region. The soil information needed is provided by the standard soil surveys made under the National Cooperative Soil Survey conducted by the U. S. Soil Conservation Service. Such a survey was completed for the Southeastern Wisconsin Region in 1966 as a result of a cooperative agreement between the U. S. Soil Conservation Service and the Southeastern Wisconsin Regional Planning Commission.

The complexity of the soil resource makes it necessary to devise some systematic means for its effective study. Three soil classification systems are in common use in the United States today. The USDA System differs from the AASHO and Unified Systems in that it is a pedological system having its foundation in the study of the soils themselves rather than in the application of soils to specific uses, such as highway engineering. The USDA System is based upon the fact that soils which have the same climate, topography, parent material, and drainage characteristics will behave similarly under specific uses wherever found.

The USDA Classification System uses six levels of classification: orders, suborders, great groups, subgroups, families, and series. The series and the further subclassifications of types and phases are of most direct concern to planners and engineers. Soil families are composed of groups of soil series having similar texture, mineralogy, soil temperature, reaction, permeability, depth, slope, and consistence. Soil series are comprised of soils having similar kinds and sequences of horizons with color, texture, structure, reaction, and other physical properties of the A and B horizons similar within a narrow range and the characteristics of the C horizons similar in texture and reaction. Each soil series is named for a geographic feature proximal to where it was first identified, mapped, and described.

The regional soil survey conducted in southeastern Wisconsin necessarily involved a very extensive concentration of effort on the part of the U. S. Soil Conservation Service. Over one million acres in the Region remained to be mapped in 1963 when the major effort was begun. The steps involved in the survey were field operations, including mapping, and the preparation of interpretive analyses. All soil mapping in southeastern Wisconsin was done on Commission aerial photographs enlarged to a scale of 1" = 1320'. The photographs were ratioed and rectified to remove distortion, thus making it possible to scale distances and measure areas directly on the photographs. Each field sheet covered six U. S. Public Land Survey sections. The final soil maps furnished the Commission were reproducible half-tone positives of the field sheets on dimensionally stable base material at a scale of 1" = 2000'. In addition to the substantive knowledge gained through formal education and work experience in the fields of soils, geology, hydrology, and air photo interpretation, a soil scientist entering the field to do soil survey work carries with him such tools as a spade, an auger, and an Abney hand level. The soil scientist knows through experience and through careful observation of the surface, vegetation, topography, and road cuts where to dig the holes to obtain the specific soil information he needs to classify the soil and prepare the detailed soil map.

The regional soil survey conducted in southeastern Wisconsin, like soil surveys conducted elsewhere, has some limitations that should be recognized. It is clearly recognized that the interpretations based on the regional soil survey do not completely eliminate the need for additional soil sampling and testing in specific instances. The various minor limitations of the soil survey include a depth of investigation of no greater than five feet, the inclusion in soil mapping units of small areas of up to two acres of a different soil type, human error on the part of the soil scientist in interpretation or on the part of the cartographer in drafting the soil map, and possible variations of up to 50 feet in the actual soil boundary from the boundary shown on the map. These limitations, however, represent only very minor obstacles to full utilization of the survey results and interpretive analyses.

To help ensure full use of the soil survey and analyses throughout the Region, the Commission prepared and executed an interagency "Memorandum of Understanding" with the U. S. Soil Conservation Service, the University of Wisconsin Extension Service, and the seven county soil and water conservation districts. This Interagency Agreement provides for the extension of technical information and educational services by the signatories to local public officials, citizen groups, and interested individuals on the need for, advantages of, and application of the detailed soil survey and its analyses. A particularly important service under this agreement is the provision by the U. S. Soil Conservation Service of technical services by a soil scientist, including the conduct of on-site soil investigations for additional detailing and refinement of the soils maps and for verification of the original survey.

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Chapter III
INTERPRETATIONS OF SOIL SURVEY DATA

INTRODUCTION

The first concerted efforts to apply soil science to practical ends were made by agriculturalists who were interested in increased crop yields, and these efforts were soon broadened to encompass farm planning. Such planning is designed to achieve, in addition to increased crop production, sound soil and water conservation objectives and includes measures relating to erosion and sediment control, as well as to soil improvement, drainage, and crop selection. Farm planning thus requires interpretive analyses of soil properties for agricultural purposes, including the suitability of the various soils for cultivated crops, pasture, and woodlands; crop yield estimates; and drainage requirements.

Sporadic efforts were made in the late 1920's and early 1930's to broaden the application of soil surveys to include engineering uses particularly for highway location and design. Only in recent years, however, has the soil survey been systematically expanded to include interpretive analyses for broad nonagricultural purposes. Rapid areawide urbanization, such as that occurring in the Southeastern Wisconsin Region (see Figure 19), requires planning and engineering programs designed to guide and shape such urbanization in the public interest and thereby to avoid costly developmental and environmental problems. In turn, these planning and engineering programs require not only detailed information on the physical, chemical, and biological properties of the soils but also analyses of the suitability of such soils for residential, commercial, industrial, recreational, transportation, and other urban land uses, as well as for agricultural, conservancy, and other rural land uses.

Such detailed information and analyses for both urban and rural land uses have been prepared by the U. S. Soil Conservation Service for the Commission and have been published in Tables 4 through 19, SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. These tables contain interpretive ratings for each soil mapping unit occurring within the Region for the most important kinds of land uses. The interpretive ratings are given in terms of limitations for the proposed uses. Suitability rather than limitation ratings are given in some instances, as for example, the use of soils as a source of sand, gravel, or topsoil. The five categories of limitations utilized in the interpretive phase of the soil survey for southeastern Wisconsin, together with corresponding suitability ratings and definitions, are shown in Table 4.

Interpretive ratings are usually written in terms of limitations for use. This is because there are few soil limitations that cannot be overcome if the user is willing and able to pay the cost of the measures necessary to overcome the limitations. For example, certain clay soils are considered to have severe limitations for use as a highway subgrade; but these limitations can be overcome by utilizing a granular base course. Even organic soils which may be truly unsuited for use as a highway subgrade can be removed and replaced with granular mineral soils. In either case, the cost may be high or even excessive; but it is not impossible to change the nature of or to replace the soil and thereby overcome the limitations for its use. Where the soil is being investigated for use as topsoil or as a source of sand and gravel, however, there is no possibility of altering the presence or absence of the soil material itself; and, therefore, the interpretive ratings are written in terms of suitability rather than in terms of limitations.

The various interpretive analyses available to users of the soil survey in southeastern Wisconsin are presented and discussed in this chapter. There are four general groups of interpretive analyses that contain useful information for soil survey users. These four groups are:

1. Interpretations for engineering purposes, such as the chemical and physical properties of soils, water management characteristics of soils, and the limitations of soils for road construction and other specific engineering applications.

Figure 19

AREAWIDE URBANIZATION

An increase in the amount of scattered low-density urban development within the Southeastern Wisconsin Region has intensified the pressures placed upon the soil resource base. The sprawling nature of much of this development has often forced reliance upon on-site soil absorption sewage disposal systems. Yet, many soils within the Region are very poorly suited for the absorption of septic tank sewage effluent. Detailed soils data can be extensively and effectively used in planning and engineering programs designed to guide and shape urbanization in the public interest, thereby helping to avoid severe developmental problems and the ultimate destruction of the natural resource base.

2. Interpretations for planning purposes, such as the limitations of soils for residential development with or without public sanitary sewer service; for light industrial and commercial buildings; and for highway, railroad, and airport location.

3. Interpretations for agricultural purposes, such as the limitations of soils for cultivated crops, pasture, and woodlands; the capability of soils for irrigation and drainage; and estimates of cropland and woodland yields.

4. Interpretations for aesthetic and recreational purposes, such as the limitations of soils for wildlife habitat or the maintenance of greens, shade trees, and ornamental shrubs.

As noted above, the basic tables containing this interpretive information can be found in SEWRPC Planning Report No. 8, <u>Soils of Southeastern Wisconsin</u>; and these tables are not reproduced in full here. An

Table 4

DEFINITION OF LIMITATIONS AND SUITABILITY CATEGORIES
AS USED IN SOIL INTERPRETATIONS FOR THE SOUTHEASTERN WISCONSIN REGION

Interpretive Categories		
Limitations	Suitability	Definition
Very slight	Very good or excellent	Few or no limitations for use.
Slight	Good	Slight limitations that are easy to overcome.
Moderate	Fair	Moderate limitations that can normally be overcome with proper planning, careful design, and average management.
Severe	Poor	Limitations that are diffcult to overcome. Careful planning and above average design and management are required.
Very severe	Very poor or unsuitable	Problems and limitations are very difficult to overcome and costs are generally prohibitive. Major soil reclamation work is generally required.

Source: U.S. Soil Conservation Service; SEWRPC.

excerpt from each table has, however, been reproduced for illustrative purposes. In addition, a number of composite analytical tables have been added. The following, then, is a discussion of the various analytical interpretations of soil survey data that are available to the soil survey user, along with a discussion of the preparation of soil suitability or limitation maps.

SOIL INTERPRETATIONS FOR ENGINEERING PURPOSES

Soil characteristics and properties are of special interest to engineers because they affect the construction and maintenance of roads, railways, airports, pipelines, building foundations, embankments, dikes, water storage facilities, erosion control structures, drainage systems, sanitary land fills, sewage disposal systems, and other engineering structures and improvements. Of particular importance to the engineer are the following soil characteristics and properties: permeability, shear strength, compaction, drainage, shrink-swell potential, grain size, plasticity, reaction, depth to water table, location of bedrock, and topography.

Chemical and Physical Properties

The chemical and physical properties of the soils in the Southeastern Wisconsin Region are set forth in tabular form in Table 4 of SEWRPC Planning Report No. 8, an exerpt from which is shown in Figure 20. This table includes the soil code number and name; a brief soil description; depth of each horizon; the USDA, Unified, and AASHO textural classification; the mechanical analysis, or percent of soils passing through various sized sieves; maximum dry density; optimum moisture content; liquid limit; plasticity index; bearing capacity; and shrink-swell potential. In addition, this table contains the estimated percolation rate, permeability, and reaction (degree of acidity or alkalinity) for the surface soil, subsoil, and substratum. Finally, the table also contains, with reference to the whole soil, ratings for the frost hazard and the erosion hazard and estimates of the depth to water table and bedrock.

Figure 20

EXCERPT FROM TABLE 4 OF SEWRPC PLANNING REPORT NO. 8
CHEMICAL AND PHYSICAL PROPERTIES OF SOILS

Soil Number And Soil Name	Brief Description	Soil Horizon		Classification			Mechanical Analysis Percent Passing Sieve			Maximum Dry Density (lbs. per cu. ft.)	Optimum Moisture Content (percent)	Liquid Limit	Plasticity Index	Bearing Capacity (Tons per Sq. Ft.)	Shrink-Swell Potential	Percolation (Estimated, minutes per inch)	Permeability (Estimated, inches per hour)	Reaction (pH Value)	Frost Hazard3/	Water Table (Estimated depth in feet)3/	Bedrock (Estimated depth in feet)3/	Erosion Hazard3/
		Symbol	Depth (Inches)	USDA	UNIFIED	AASHO	No. 4 (4.70mm)	No. 10 (2.00mm)	No. 200 (.07mm)													
153 Lapeer loam2/	Loamy soils over sandy loam till	A	-	-	-	-	-	-	-	-	-	-	-	-	-	31-60	0.8-2.5	5.1-6.5	SLIGHT	5 plus	5 plus	SLIGHT on 0-2%; MODERATE on 2-12%; SEVERE on 12-45% slopes
		B	20-30	sl	SC	A-4	95	94	36	126	10	25	10	1-1/2 to 2-1/2	LOW TO MODERATE	31-60	0.8-2.5	5.1-6.5				
		C	36-48	sl	SM	A-2-4	80	76	28	131	7	1/	NP	1-1/2 to 2-1/2	VERY LOW	31-60	0.8-2.5	7.4-8.4				
154 Same as No. 155, McHenry silt loam																						
155 McHenry silt loam2/	Silty soils over sandy loam till	A	-	-	-	-	-	-	-	-	-	-	-	-	-	31-60	0.8-2.5	5.1-6.5	MODERATE	5 plus	5 plus	SLIGHT on 0-2%; MODERATE on 2-12%; SEVERE on 12-30% slopes
		B	20-30	scl	SC	A-6	93	90	44	111	15	16	19	1-1/2 to 2-1/2	MODERATE	31-60	0.8-2.5	5.1-6.5				
		C	42-54	ls	SM	A-1-b	66	60	21	142	6	1/	NP	1-1/2 to 2-1/2	VERY LOW	31-60	0.8-2.5	7.4-8.4				
1557 Same as No. 16, Rome silt loam																						
156 Lapeer sandy loam2/	Loamy soils over sandy loam till	A	-	-	-	-	-	-	-	-	-	-	-	-	-	10-30	2.5-5.0	5.1-6.5	SLIGHT	5 plus	5 plus	SLIGHT on 0-2%; MODERATE on 2-12% slopes
		B	20-30	sl	SC	A-2-6	90	89	33	119	12	27	12	1-1/2 to 2-1/2	MODERATE	10-30	2.5-5.0	5.1-6.5				
		C	36-48	sl	SM	A-2-4	69	65	18	132	7	1/	NP	1-1/2 to 2-1/2	VERY LOW	10-30	2.5-5.0	7.4-8.4				
157 Same as No. 156, Lapeer sandy loam																						
160 Hochheim-Casco-Sisson loams	Hochheim part -- same as No. 357, Hochheim loam Casco part -- same as No. 173, Casco silt loam Sisson part -- same as No. 266, Sisson silt loam																					
161 Dodge silt loam2/	Silty soils over sandy to gravelly loam till	A	-	-	-	-	-	-	-	-	-	-	-	-	-	31-60	0.8-2.5	5.6-6.5	MODERATE	5 plus	5 plus	SLIGHT on 0-2% MODERATE on 2-12% slopes
		B	20-30	sicl	CH	A-7-6	100	100	92	104	20	50	29	1/2 to 1	MODERATE TO HIGH	61-120	0.2-0.6	5.1-5.5				
		C	36-48	sl	SC	A-4	82	76	36	130	9	20	7	1-1/2 to 2-1/2	LOW	31-60	0.8-2.5	7.4-8.4				
161R Same as No. 204, Knowles loam																						
165 Poygan silt loam2/	Silty soils over reddish clay	A	-	-	-	-	-	-	-	-	-	-	-	-	-	31-60 4/	0.8-2.5	6.6-7.3	VERY SEVERE	0 to 1	5 plus	SLIGHT on 0-2%; MODERATE on 2-6% slopes
		B	10-18	cl	CL	A-7-6	100	100	76	101	19	42	22	1 to 2	MODERATE TO HIGH	121-300	0.2-0.8	6.6-7.3				
		C	24-48	sicl	CL	A-6	100	100	82	105	17	35	20	1 to 2	MODERATE TO HIGH	300 plus	.05-0.2	7.4-8.4				

Source: U. S. Soil Conservation Service; SEWRPC.

Textural Classification: The USDA textural classification is an expression of the amount of clay (less than 0.002 mm in diameter), silt (0.002 mm to 0.05 mm in diameter), and sand (0.05 mm to 2.0 mm in diameter) in the soil mass. Almost all soils are a mixture of various size particles. Although some soils appear to be comprised of only one kind of particle, such as silt or clay, a mechanical analysis will, in most soils, reveal the presence of a wide range of particle size. Class names are based on the proportion of each particle size present in the total soil. As shown in Table 5, an example of a sandy loam soil is one containing a mixture of 75 percent sand, 15 percent silt, and 10 percent clay. Sandy loam soils, however, can contain 53 to 85 percent sand, up to 50 percent silt, and as much as 20 percent clay. A soil in the clay textural class can contain as much as 45 percent sand, and a sand can contain as much as 10 percent clay. The kind of mixture in the soil affects other properties from which predictions of soil behavior can be made.

Table 5

PROPORTION OF SAND, SILT, AND CLAY IN THE USDA
TEXTURAL CLASSIFICATION SYSTEM

Texture Class		Percentage Ranges			
Name	Abbreviation[a]	Sand	Silt	Clay	Examples[b]
Sand	s	>85	< 15	< 10	90- 6- 4
Loamy sand	ls	70-90	< 30	< 15	80-12- 8
Sandy loam	sl	43-85	< 50	< 20	75-15-10
Loam	l	23-52	28-50	7-27	45-40-15
Sandy clay loam	scl	45-80	< 28	20-35	65-10-25
Clay loam	cl	20-45	15-53	27-40	32-33-35
Silt loam (1)	sil (1)	20-50	50-80	12-27	25-55-20
Silt loam (2)	sil (2)	<50	50-80	< 12	15-75-10
Silt	si	<20	> 80	< 12	5-90- 5
Silty clay loam	sicl	<20	40-73	27-40	10-55- 35
Sandy clay	sc	45-65	< 20	35-55	45-10-45
Silty clay	sic	<20	40-60	40-60	10-40-50
Clay	c	<45	< 40	> 40	10-30-60

[a] *As used in Table 4 of SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *Examples of sand, silt and clay percentages representative of the named textural class.*

Source: U.S. Soil Conservation Service.

As noted in Chapter II of this Guide, the Unified System of soil classification has been developed and expanded for application to roadway, airfield, embankment, and foundation construction. This system is based primarily on the texture, that is, the percentages of gravel, sand, and fines (principally silt and clay) in the soils, and the plasticity characteristics of the soils. Properties can be estimated for approximate placement of soils into the various classes of the system where the USDA textural class is known. In order to accurately place fine-textured soils in the system, however, laboratory determinations should be made of the liquid limit and plasticity index. As indicated by the plasticity chart (see Figure 8), the class name of fine-textured soils is determined by the liquid limit and plasticity index of the soil.

Also, as noted in Chapter II of this Guide, the AASHO System of soil classification uses texture and plasticity to identify and group soils with respect to performance as highway subgrade materials. Soils are grouped according to their load-carrying capacity and service as road subgrades. The best soils are classified as A-1 and the poorest as A-7. The seven subgroups have been subdivided to accommodate observed differences within the broad groups. As shown in Figure 7, the system is divided into two general classifications. Soils in the granular class contain less than 36 percent of soil passing the 200-mesh sieve. (The term granular in this classification refers to size of particles rather than a kind of soil structure as used by soil scientists.) Subgroups A-1, A-2, and A-3 are said to be granular. A-4, A-5, A-6, and A-7 are in the silt-clay group and have more than 35 percent of soil passing the 200-mesh sieve. Table 4 of SEWRPC Planning Report No. 8 (see Figure 20) contains the Unified and AASHO textural classification for each soil type.

Mechanical Analysis: The mechanical analysis information presented in Table 4 of SEWRPC Planning Report No. 8 is the estimated proportion of a soil sample passing the No. 4, No. 10, and No. 200 sieves and represents the separation of coarse gravel, fine gravel, sand, and fines (silt and clay). The No. 4 sieve retains pebbles, termed coarse gravel, that are more than 4.70 mm in diameter. Fine gravel, 2.0 mm to 4.70 mm in diameter, passes the No. 4 sieve but is retained on the No. 10 sieve. The fraction passing the No. 10 sieve but retained on the No. 200 sieve represents sand that is more than 0.07 mm in diameter. The soil passing the No. 200 sieve includes all the silt and clay in a sample and some very fine sand ranging in diameter from 0.05 mm to 0.07 mm. This part of the very fine sand fraction is classified as "fines" for engineering purposes. Neither the Unified nor the AASHO Systems separate the clay fraction of soils from the silt fraction.

Dry Density and Moisture Content: The maximum dry density and optimum moisture content values shown in Table 4 of SEWRPC Planning Report No. 8 can be used by engineers to predict the degrees of compaction that can be expected with a given textural class of soil. Maximum dry density is given in lbs. per cubic feet; optimum moisture content, in percent.

Liquid Limit and Plasticity Index: Liquid limit and plasticity index values, as shown in Table 4 of SEWRPC Planning Report No. 8, are used as an indication of the stability and bearing capacity of fine-textured soils. The liquid limit number represents the percent moisture at which a soil passes from a plastic to a liquid state. The plastic limit is the moisture content at which a soil changes from a semisolid to a plastic state. The plasticity index is defined as the numerical difference between liquid limit and the plastic limit. A small plasticity index, such as 5, indicates that a small increase in moisture content will change the soil from a semisolid to a liquid condition. A large plasticity index, such as 20, means that considerable water can be added before the soil becomes liquid.

Bearing Capacity: Judgments about the bearing capacity or bearing value of soils are useful in the design of footings or foundations. The bearing values shown in Table 4 of SEWRPC Planning Report No. 8 are not based upon actual tests but rather represent an estimate of bearing capacity. As such, they should not be used in the design of important structures without additional engineering investigations. The bearing value of the substratum of most soils in southeastern Wisconsin is more important to building construction than the bearing value of the subsoil because almost all buildings are built with basements. The bottom of the subsoil, therefore, is normally above the base of the foundation and is not important in most construction. In general, gravelly and sandy soils have higher bearing values than loamy or clayey soils. In road construction the bearing value of both the subsoil and substratum must be considered in design.

Shrink-Swell Potential: The shrink-swell potential, expressed in basic categories of very low, low, moderate, high, and very high, is a measure of the amount of volume change that occurs in soils with changes in moisture content. The volume change can be expressed as linear expansion. This provides one means of measurement and a basis of comparison between soils. In general, soils with high clay content have a higher shrink-swell potential than soils that contain low amounts of clay. The kind of clay in soils also affects the shrink-swell potential. Many of the soils in southeastern Wisconsin contain a mixture of clays with enough montmorillonite to cause a relatively large change of volume with changes in moisture content. The shrink-swell potential of these soils is not as high as soils with very high shrink-swell potential, but it is sufficient to exert great pressure when subjected to increasing amounts of water. Building foundations or basements constructed in soils with high shrink-swell potential have, in some instances, been pushed out of place and cracked with the addition of moisture to the soil. Wide cracks may occur in these soils during long periods of dry weather due to excessive shrinkage.

Percolation: Percolation rates are commonly used as a basis for determining the suitability of soils for septic tank filter fields. It is expressed as the time, in minutes, required for water in a bore hole to move downward one inch into a saturated soil. Percolation rates can be estimated as a function of pore space, soil texture, and soil structure but, for purposes of designing land subdivision plats or developing individual lots, are generally determined by on-site tests. In addition to internal soil characteristics, the depth to the water table affects percolation rates. During the wet season, percolation rates in soils with high-water tables will be very slow. During the dry season, the rate may be rapid. Interpretations based on field tests made during the dry season are deceptive because they do not indicate that a septic tank system will not function during the wet season when the water table is near the soil surface.

Permeability: Soil permeability is defined as the rate at which saturated soils transmit water and is expressed in inches per hour. In the laboratory it is determined by allowing water to pass through an undisturbed core. Like percolation, it is a function of pore space, soil texture, and soil structure. Because the method used to determine percolation rates differs from the method used to determine permeability, one rate cannot be directly converted to another.

In most interpretive publications, a range of permeability rates or a corresponding descriptive term is given for each soil horizon. SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin, contains permeability rates that were developed and used mainly for agricultural interpretations. The permeability class range in rates has been subsequently adjusted to meet the needs of engineers and others in determining the limitations of soils for septic tank filter fields and for other uses. Table 6 presents the permeability classes with the old and revised permeability rates. Users of the permeability data in SEWRPC Planning Report No. 8 should consult this table to determine if a change in classification is warranted. Permeability rates are especially critical when using soils data for septic tank filter fields, irrigation systems, artificial drainage, and farm pond reservoirs.

Table 6

PERMEABILITY CLASSIFICATION OF SOILS IN THE SOUTHEASTERN WISCONSIN REGION

Permeability Value Ranges In SEWRPC Planning Report No. 8 (inches per hour)	Permeability Classification	Revised Permeability Value Ranges (inches per hour)
< 0.05	Very slow	< 0.06
0.05 - 0.20	Slow	0.06 - 0.20
0.20 - 0.80	Moderately slow	0.20 - 0.63
0.80 - 2.50	Moderate	0.63 - 2.00
2.50 - 5.00	Moderately rapid	2.00 - 6.30
5.00 - 10.00	Rapid	6.30 - 20.00
> 10.00	Very rapid	> 20.00

Source: U.S. Soil Conservation Service; SEWRPC.

Reaction: Soil reaction in soil descriptions, data, and interpretive reports is presented in terms of pH values which indicate the degree of acidity or alkalinity. In interpretations for farming, the values are used mainly to determine whether applications of lime to cropland or pasture will be beneficial. The benefits are primarily in the form of higher crop yields partially because of a greater supply of calcium and magnesium for plant use.[1] The occurrence of calcium in soils, mainly as a carbonate, has led to the practice of estimating the amount of lime (calcium carbonate) needed for optimum plant growth by use of pH values. A pH below 6.0 indicates that applications of crushed limestone or other calcium-carrying compounds will increase growth and yield of crops. Some plants grow well only in a definite range of pH values. Where the soil pH and plant requirements are known, the suitability of soils for a given plant can be determined. Where soils are acid (low pH) and the plants to be grown require higher pH values, liming the soil will help raise the pH and create a more favorable soil environment for bacterial and plant activity. The pH values in a few soils in the Region are low enough to restrict the growth of some plants and soil bacteria. Applications of large amounts of lime to these soils will not only increase the calcium available to plants but also correct the acidity.

The pH values can also be used to estimate the relative corrosivity of metal and concrete conduit in soils. Metal pipe will corrode rapidly in wet, somewhat poorly or poorly drained soils with high pH values (alkaline). Metal pipe also corrodes in wet soils with very low pH values (very strongly acid). Concrete pipe corrodes rapidly in wet soils with low pH values (acid soils) but has a long life in soils with high pH values (alkaline soils). The various reaction classifications and their corresponding pH value ranges are shown in Table 3.

Frost Hazard: Frost hazard ratings indicate the susceptibility of soils to frost action or frost heaving (see Figure 21). Silty, somewhat poorly drained soils are more susceptible to frost action than are other soils. Sandy and gravelly soils are least susceptible to frost action. A system of classification developed by the Wisconsin Department of Transportation[2] relates the AASHO Classification System to frost susceptibility. Table 7 presents this system, together with the corresponding value ratings as given in Table 4 of SEWRPC Planning Report No. 8.

Water Table: Water tables in or below soils are relevant to soil classification, interpretation, and use mainly where the water is less than five feet below the surface of the soil. Gray, olive, or green colors indicate wetness in soils except in a few small areas of the Region where the parent material is characterized by one of these colors. A high percentage of these colors in the soil mass near the surface indicates that the water table is at or near the surface during most of the year. These soils are classified as poorly drained or very poorly drained. They are generally located in nearly level areas with a lower elevation than surrounding soils (see Figure 22).

Where the water table is near the surface, mainly during rainy seasons, the gray, olive, and green colors occur as mottles in the brighter colored soil mass. The mottles generally occur relatively deep in the profile. These are somewhat poorly drained soils that are also located in nearly level areas, but some are gently sloping. In some areas the seasonal water table is caused by the presence of a slowly or very slowly permeable soil layer that restricts the downward flow of water.

Interpretations and use of soils for cropland, irrigation, highway construction, on-site sewage disposal systems, residential development, recreational developments, and wildlife habitat are affected by shallow water tables. For most of these uses, a permanent high water table imposes severe limitations. For wildlife habitat the shallow water table confines soil use to wetland species. The limitations for cropland and irrigation can be overcome with relative ease by artificial drainage; but for most other uses, the limitations are very difficult to overcome. The estimated average depth in feet to the water table during the wet season of the year is indicated in Table 4 of SEWRPC Planning Report No. 8.

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[1] *K. Lawton and L. T. Kurtz, ''Soil Reaction and Liming,'' Soil - 1957 Yearbook of Agriculture, U. S. Department of Agriculture.*

[2] *Soils Manual, Wisconsin Department of Transportation, Madison, Wisconsin, 1964.*

Figure 21

FROST HAZARD ACTION

Frost action or frost heaving can destroy roadbeds and disrupt transportation. Frost hazard ratings are available for all soil types in the Southeastern Wisconsin Region. Silty, somewhat poorly drained soils are highly susceptible to frost action: sandy and gravelly soils are least susceptible to frost action.

Bedrock: Bedrock affects classification, use, and interpretations by controlling in some soils the effective depth for uses such as growth of plants, engineering applications, and sewage disposal. The regional soil survey indicates depth to bedrock only where it is less than five feet deep. At these depths most soil uses are affected. The amount of water available for plant use is much lower in soils that are shallow to bedrock than in similar soils underlain by bedrock at greater depths. Where the proposed engineering use requires excavation, bedrock causes severe limitations. Where a given depth of soil is needed as a filter, such as for septic tank filter fields, it is virtually impossible to use soils that are shallow over bedrock.

Erosion Hazard: The danger of accelerated erosion in soils is related mainly to the soil slope and permeability. Soil texture has some effect on the erosion hazard because of a difference in detachability in the presence of running water. Texture, as the principal cause of permeability differences, causes differences in runoff that, in turn, affect the erosion hazard. Soil slope, however, is the most important factor. Erosion, whether geologic or accelerated, occurs faster where soil slopes are steep than where they are gentle or nearly level. The degree of erosion hazard then is directly related to the steepness of slope within the range of a given soil. The erosion hazard is rated for bare soils. Vegetative cover, such as grass or trees, alters the amount of erosion that will occur but will not alter the rated hazard (see Figure 23).

Water Management Characteristics

The soil properties and interpretations that are closely related to the water content of the soil and to water-related uses, such as for impoundments, are grouped together in Table 5 of SEWRPC Planning Report No. 8, an excerpt from which is presented in Figure 24. To facilitate use of this data, the following soil characteristics, which were discussed above in relation to physical and chemical properties, were repeated in Table 5: the estimated percolation rates, permeability rates, depth to water table, and

Table 7

FROST HAZARD CLASSIFICATIONS AND RATINGS

Rating In Table 4 Of SEWRPC Planning Report No. 8	Wisconsin Department Of Transportation Classification	General Definition	Relationship To AASHO Classification System
Very slight	F-0	Nonfrost susceptible materials.	Generally the better A-1 and A-3 groups.
Slight	F-1	Gravelly soils containing between 3 and 15 percent finer than 0.02 mm.	Generally the finer A-1 group.
Moderate	F-2	Sand containing between 3 and 15 percent finer than 0.02 mm.	Generally the A-1 sand, finer textured A-3 sand, and better A-2 sand.
Severe	F-3	Gravelly soils containing more than 20 percent finer than 0.02 mm.	
		Sand, except fine silty sand, containing more than 15 percent finer than 0.02 mm.	Generally the A-2 group and A-4 material bordering on the A-2 group.
		Clay with a plasticity index of more than 12.	Generally the medium-to-heavy A-6 and A-7 groups.
		Varved clay existing with uniform subgrade conditions.	
Very severe	F-4	All silt, including sandy silt.	Generally the A-4 and A-5 groups.
		Very fine silty sand containing more than 15 percent finer than 0.02 mm.	
		Lean clay with plasticity indexes of 12 or less.	Generally the light A-6 group.
		Varved clay with nonuniform subgrade conditions.	

Source: U. S. Soil Conservation Service; Wisconsin Department of Transportation; SEWRPC.

the rated frost and erosion hazards. In addition, Table 5 presents ratings and interpretations for the hydrologic soil group; available water capacity; flooding hazard; drainage requirements; and limitations for irrigation, reservoir areas, and embankments.

Hydrologic Soil Group: Hydrologic soil groups are based on the amount of runoff from bare soil after prolonged wetting. Soils with rapid permeability rates generally yield less runoff than soils with slow permeability rates. Soils with a rapid water intake rate and transmission rate permit small amounts of

Figure 22
HIGH WATER TABLE

The location of the water table in a soil is an extremely important soil characteristic. A very shallow water table exists in many areas of the Region. This characteristic affects the use to which land can effectively be put. The home basement excavation in this photograph is in a land subdivision within the Region where existing homes are plagued with high water table problems, such as poor drainage, wet basements, and inoperative septic tank sewage disposal systems. Fortunately, construction was never completed on the homesite in this photograph.

Figure 23
SOIL EROSION HAZARD

Soil slope, permeability, and texture are directly related to the danger of accelerated erosion of soils. Erosion, whether natural or accelerated by man's activities, occurs faster where soil slopes are steep than where they are gentle or nearly level. Soil erosion, such as that shown in this photograph, results in the pollution of surface waters and the filling in of drainage ditches, streams, ponds, and lakes. An erosion hazard rating is available for every soil type in the Southeastern Wisconsin Region.

Figure 24
EXCERPT FROM TABLE 5 OF SEWRPC PLANNING REPORT NO. 8
WATER MANAGEMENT CHARACTERISTICS OF SOILS

Soil Number & Soil Name		Hydrologic Soil Group	Soil Horizon[1]		Percolation (Estimated) (Minutes Per Inch)	Permeability (Estimated) (Inches Per Hour)	Available Water Capacity (in/in.)	Water Table (Depth) in ft.)	Frost Hazard	Erosion Hazard	Flooding Hazard	Drainage Requirements	Limitations of Soils for		
			Symbol	Depth (Inches)									Irrigation	Reservoir Areas	Embankments
44	Jericho silt loam	B	A B C	0- 9 9- 30 30-60+	31-60 121-300 300 plus	0.8-2.5 0.2-0.8 .05-0.2	.24 .18 .16	3 to 5	SEVERE	SLIGHT on 0-2%; MODERATE on 2-6% slopes.	None	None	MODERATE on 0-6% slopes.	SLIGHT - semi-pervious; bottom may need to be compacted.	SLIGHT TO MODERATE - medium stability; high shrink-swell potential.
45	Same as No. 46, Yahara silt loam														
457	Same as No. 370, Mosel sandy loam														
46	Yahara silt loam	C	A B C	0-10 10-16 16-60+	31-60[4] 31-60 31-60	0.8-2.5 0.8-2.5 0.8-2.5	.22 .18 .18	1 to 3	SEVERE	SLIGHT on 0-2%; MODERATE on 2-6% slopes.	MODERATE - occasional flooding.	Surface drainage is beneficial.	MODERATE on 0-6% slopes.	MODERATE TO SEVERE - pervious to semi-pervious; bottom needs to be scarified and compacted; suitable for dug-out ponds.	MODERATE TO SEVERE - low stability; low shrink-swell potential; susceptible to piping; banks very erosive.
47	Same as No. 46, Yahara silt loam														
477	Same as No. 371, Mosel loam														
48	Keowns silt loam	D	A B C	0-12 12-20 20-60+	31-60[4] 31-60 31-60	0.8-2.5 0.8-2.5 0.8-2.5	.24 .18 .18	0 to 1	VERY SEVERE	SLIGHT on 0-2%; MODERATE on 2-6% slopes.	MODERATE - ponding and occasional flooding.	Surface drainage is needed.	MODERATE on 0-6% slopes.	MODERATE TO SEVERE - pervious to semi-pervious; high water table; suitable for dug-out ponds with low side slopes.	MODERATE TO SEVERE - low stability; low shrink-swell potential; susceptible to piping; banks very erosive.
487	Same as No. 340, Navan silt loam														

Source: U. S. Soil Conservation Service; SEWRPC.

runoff because much of the water goes into the soil and is transmitted to the substrata. Soils with a slow intake and transmission rate take in very little water. This forces most of the rainfall to move to lower areas in the form of runoff. There is generally less runoff from well-drained soils than from poorly drained soils. During the wet season, poorly drained soils are almost always saturated with water and cannot store or transmit additional water. The well-drained soils, even though sometimes saturated during wet seasons, can always transmit some water into the substrata.

Soil scientists place soils in four broad classes—A, B, C, and D—that represent ranges of runoff to be expected from a given soil. Knowledge of the kind of soil in a watershed and placement of the soils into hydrologic soil groups enable planners, hydrologists, and engineers to estimate the amount of runoff from the watersheds. The use of hydrologic soil groupings for comprehensive watershed planning in southeastern Wisconsin is discussed in Chapter IV of this Guide, and the use of such groupings for urban storm water drainage planning and storm sewer design is discussed in Chapter V of this Guide. The hydrologic soil groupings are set forth in Appendix C.

Group A includes soils from which there is very little runoff. Because of a high intake rate and rapid or very rapid permeability (transmission) rate, much of the rainfall that falls on the soil moves into and through it. These are generally sandy or gravelly, well-drained, or excessively drained soils. Except in very high-intensity storms, the amount of water that moves off the soil as runoff is relatively low. In southeastern Wisconsin soils, such as Rodman gravelly loam, Spinks loamy sand, and Vilas loamy sand, are examples of soils in Group A.

Group B includes soils from which there are moderate amounts of runoff. The moderate water intake rate and permeability permit absorption and transmission of part of the water that falls on the soil. Because of the somewhat slower intake rate, less water is taken into the soil; and more water runs off than from soils of Group A. These soils are generally loamy or silty, well-drained soils. In southeastern Wisconsin soils, such as Fox loam, Lapeer loam, and Dodge silt loam, are examples of soils in Group B.

The soils in Group C yield large amounts of runoff water. They have slow water intake rates and slow permeability rates. Most of the soils are somewhat poorly drained or moderately well drained, with seasonal fluctuating high water tables or with perched water tables that are generally caused by heavy clay layers in the lower part of the soil. Most of these soils are in positions in the landscape that cause moderate wetness. In addition, some have clayey subsoils. Soils, such as Aztalan loam, Kibbie silt loam, and Saylesville loam, are examples of soils in Group C.

Group D includes soils from which there are large amounts of runoff. Most of the water that falls on them moves to other soils as runoff. In southeastern Wisconsin all the soils in Group D are poorly drained. Many are moderately permeable but, because of position in the landscape, are saturated with water almost continuously. Runoff is high because there is very little unused storage capacity in the soil or below it. Rainfall becomes excess water that cannot be absorbed by the soil but must seek a lower level on some other soil or in a drainageway or stream. Soils of the Colwood, Granby, and Wallkill series are examples of poorly drained soils in Group D.

Available Water Capacity: The term available water capacity, as applied to soils, refers to the ability of soils to supply moisture to plants. It represents the amount of water that soils can hold at field capacity minus the amount of water that is held at wilting percentage. The amount of water held in the soil after being filled with water and permitted to drain for several hours is known as field capacity. The soil moisture percentage at which plants cease to extract water from the soil is known as the wilting percentage. In Table 5 of SEWRPC Planning Report No. 8, values for available water are expressed as inches of water per inch of soil. These terms actually represent volumetric measurements of acre-inches of water per acre-inch of soil. The amount of available water in each soil layer can be determined by multiplying the value for inches per inch of water by the thickness of the layer in inches. The sum of these calculations, to a depth of five feet, represents the amount of water available for plant use. These values can be used to compare the ability of soils to sustain crops between rains or to determine how often soils should be irrigated. Thus, a shallow or sandy soil that holds three inches of available water or less can sustain a crop, such as corn, for less than 10 days, while a deep loamy soil will hold about nine inches of available water that will sustain a corn crop for more than 20 days. The irrigation cycle for the two soils will have the same relationship; that is, nine days versus 20 days.

In soil descriptions the available water capacity is generally expressed as low, medium, high, or very high. These terms can be given numerical ratings in terms of the water held in the soil to a depth of five feet. They are as follows: low, less than three inches; medium, three to six inches; high, six to nine inches; and very high, more than nine inches. Spinks fine sand and Hackett loamy sand are examples of soils with low available water capacity. Ozaukee silt loam and Pecatonica silt loam are examples of soils that have very high available water capacity.

Flooding Hazard: The flood hazard for a soil is related to the frequency and intensity of flooding. Most of the soils occurring on bottom land are subject to relatively frequent flooding. Some soils occurring on low terrace or in bench positions are flooded only occasionally. Some soils are subject not to flooding, that is, inundation, from high water levels in nearby streams and watercourses but to ponding due to poor surface or subsurface drainage.

Soils that flood relatively frequently are said to have a severe flood hazard and are almost always located within the natural floodplains of a stream or watercourse. The actual extent of the floodplain area, however, cannot be determined from the soil survey interpretations alone. This is so because the activities of man within a watershed and particularly the conversion of land from natural to agricultural and from agricultural to urban use may change both the amount and rate of storm water runoff and modify river system performance. This results in larger peak flood flows and shorter times of concentration. The larger peak flows may cause flooding of some soils that did not under natural conditions have a flood hazard.[3]

The flood hazard has a strong influence on soil use. Frequently flooded soils cannot be safely used for foundations for residential development, on-site soil absorption sewage disposal systems, commercial development, highway location, and certain types of recreational developments. The effects of flood hazards on land use have been recognized in the floodplain zoning provisions included by the Wisconsin Legislature in the State Water Resources Act of 1965. This Act requires counties in unincorporated areas and cities and villages in incorporated areas to adopt reasonable and effective floodplain zoning ordinances within their respective jurisdictions. The flood hazard rating of soils cannot be used alone as a basis for the delineation of floodland zoning districts. Such ratings can, however, in the absence of engineering studies be used, in conjunction with good topographic maps and historic flood inundation records, to delineate the approximate limits of floodlands for zoning purposes.

Drainage Requirements: As used in Table 5 of SEWRPC Planning Report No. 8, drainage requirements refer to the need to remove excess water that limits the use of soils for cropland. The soils listed as somewhat poorly drained and poorly drained, with seasonal or permanent high water tables, have severe limitations for crop production because saturation of the soil with water excludes air from plant roots and permits the growth of only water-tolerant plants. The feasibility of tile drainage or open ditch drainage is indicated in the table. The very close spacing of tile lines required in slowly and very slowly permeable soils because of the slow lateral movement of water in these soils may make the use of drain tiles in these soils impractical. In some soils with fine sand and silt substrata, the tile openings become clogged and cease to function soon after installation.

Irrigation: The limitations of soils for irrigation are based mainly on the available water capacity, water intake rate, soil slope, and natural drainage. Where sprinkler irrigation is used, as in Wisconsin, all unfavorable factors except drainage can be easily overcome (see Figure 25). In some areas, a combination of artificial drainage and irrigation is used to control the water content of soils for crops with a

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[3] *The use of soil surveys to determine and delineate floodlands is further discussed in Chapter VII of SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, November 1968.*

narrow range of moisture tolerance. Soils with low available water capacity require frequent applications of water to maintain a rapid rate of plant growth. Slowly permeable soils are somewhat difficult to irrigate because water must be applied very slowly to allow the water to soak into the soil and avoid runoff. The various soil features affecting sprinkler irrigation are shown in Table 8.

Reservoir Areas: The permeability of undisturbed soil and the depth to bedrock or sand and gravel are important factors in determining the degree of limitations of a soil for use as a reservoir area of a farm pond or other water impoundment area (see Figure 26). In order to prevent excessive loss of water by seepage, the permeability of the reservoir area should be slow or very slow. Moderately slow or moderately permeable soils can be readily treated to prevent seepage. It is more difficult to treat soils with moderately rapid permeability and very difficult to treat rapidly or very rapidly permeable sandy or gravelly soils to prevent excessive seepage. It is almost impossible to use shallow soils over fissured or pervious bedrock for water impoundment purposes. Deep soils over bedrock can be sealed if the soil tex-

Figure 25
SPRINKLER IRRIGATION

Sprinkler irrigation is used in Wisconsin to provide needed crop moisture during drouth periods. The limitations of soils for irrigation are primarily based on the characteristics of available water capacity, water intake rate, slope, and drainage. An interpretive rating for sprinkler irrigation is available for each soil type.

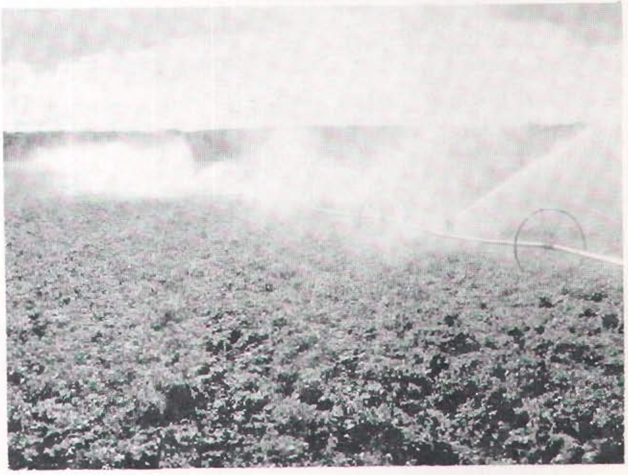


Table 8
SOIL LIMITATIONS FOR SPRINKLER IRRIGATION

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Available water capacity (inches) [a]	> 6	4-6	<4
Water intake rate	Very rapid Rapid Moderately rapid Moderate	Moderately slow	Slow Very slow
Soil slope (percent)	< 2	2-12	>12
Effective soil depth (inches) [b]	>30	20-30	<20

[a] *Based on soil depth to three feet or depth to bedrock if less than three feet.*

[b] *Depth to layer that restricts root or water movement (bedrock, clay layer, gravel, fragipan).*

Source: U.S. Soil Conservation Service.

ture is favorable. It is very difficult to seal reservoir areas that are relatively shallow over sand and gravel or excavated in sand and gravel. Soil slope is critical because the ratio of surface area of the reservoir to the size of embankment is smaller on steep slopes than on nearly level or gentle slopes. Some poorly drained soils in low positions on the landscape can be used for dugout ponds that require little or no embankment. Soil permeability is not a factor in the limitations of these soils for reservoir areas. The various soil characteristics affecting the suitability for reservoir areas are shown in Table 9.

Embankments: Soils that are useful for reservoir embankments should be almost impervious when compacted. They should be stable when subjected to hydrostatic pressure from impounded water. Loamy soils with a balanced mixture of particle sizes generally have slight limitations for embankments. Clayey soils with high shrink-swell potential and low stability or sand soils that are pervious even when compacted have severe limitations for embankment use. Table 5 in SEWRPC Planning Report No. 8 (see Figure 24) presents the ratings for embankment use. Table 10 in this Guide relates general embankment criteria to the Unified Classification System.

Road Construction

Ratings and limitations of soils for road location; for use as a subgrade, that is, foundation for road; and for actual use as a road construction material are given in Table 7 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced as Figure 27. The kinds of soil occurring along a proposed highway

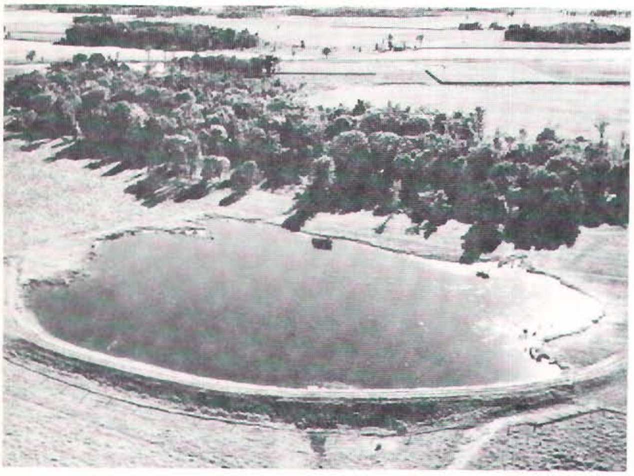


Figure 26

WATER IMPOUNDMENT AREA

The selection of a suitable site for a water impoundment area is governed by the factors of soil permeability and the depth to bedrock or sand and gravel. The permeability of the reservoir area should be slow or very slow so as to prevent excessive loss of water by seepage. Interpretive ratings are available for the use of each soil type in the Southeastern Wisconsin Region as a reservoir or water impoundment area.

Table 9

SOIL LIMITATIONS FOR RESERVOIR AREAS OF EMBANKMENT PONDS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Permeability rate [a]	Slow Very slow	Moderate Moderately slow	Moderately rapid Rapid Very rapid
Depth to bedrock (inches) [b]	>60	40-60	<40
Soil slope (percent)	< 6	6-12	>12

[a] *Subsoil, substratum, or both.*

[b] *Fractured or pervious bedrock.*

Source: U.S. Soil Conservation Service.

route will determine the kind of subgrade available, in part; the structural design of the pavement and its cost; and may even affect the location and alignment of the road itself. In Table 7 of SEWRPC Planning Report No. 8, the soils are appraised in terms of their limitation for use by pedestrian and vehicular traffic in the absence of any pavement; the limitations imposed on winter grading operations; and the effects of their properties on compaction, surface stabilization with additives, use as a road base material, and as a backfill material.

Table 10

GENERAL EMBANKMENT CRITERIA AS RELATED TO THE UNIFIED SOIL CLASSIFICATION SYSTEM

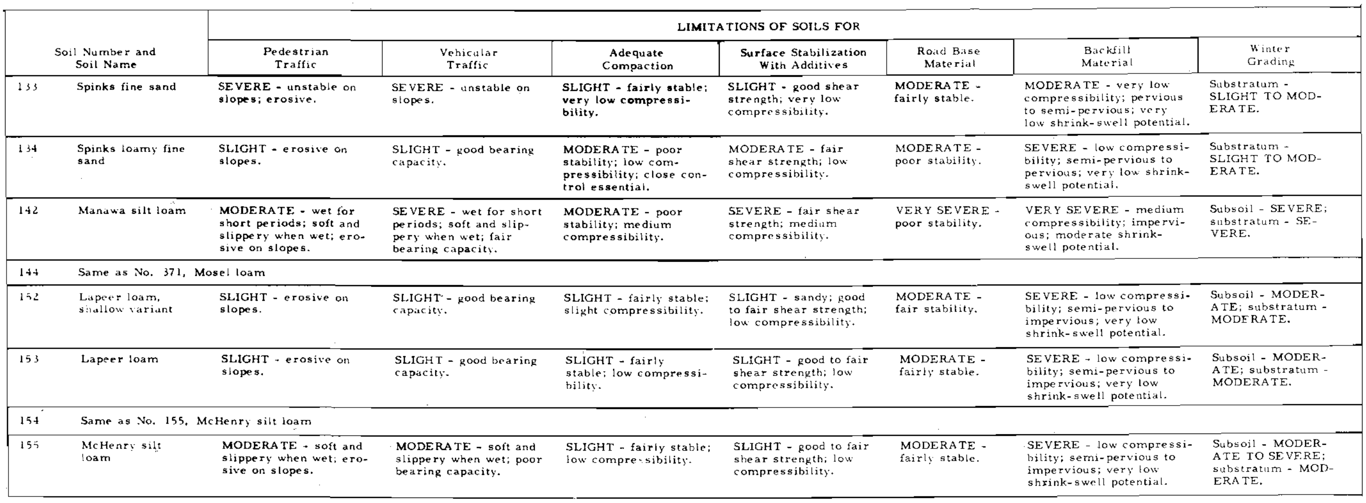
Unified Classification [a]	Soil Features Affecting Use				
	Stability	Compaction Characteristics	Permeability When Compacted	Compressibility	Resistance To Piping
GW	Good	Good	High	Very slight	Good
GP	Fair	Good	High	Very slight	Good
GM	Fair	Fair-to-good	Moderate	Slight	Poor
GC	Fair	Good	Low	Slight	Good
SW	Good	Good	High	Very slight	Fair
SP	Poor	Fair	High	Very slight	Fair-to-poor
SM	Fair	Fair-to-good	Moderate	Slight	Poor
SC	Fair	Good-to-fair	Low	Slight	Good
ML	Poor	Poor	Moderate	Medium	Poor
CL	Fair-to-good	Fair-to-good	Low	Medium-to-high	Good
MH	Poor	Poor-to-very poor	Low	Very high	Fair-to-poor
CH	Fair-to-poor	Fair-to-poor	Low	High	Good

[a] *Soils classed as OL, OH, or Pt are not suitable for embankments.*

Source: U.S. Soil Conservation Service.

Figure 27

EXCERPT FROM TABLE 7 OF SEWRPC PLANNING REPORT NO. 8
THE USE OF SOILS FOR ROAD CONSTRUCTION



Soil Number and Soil Name		LIMITATIONS OF SOILS FOR						
		Pedestrian Traffic	Vehicular Traffic	Adequate Compaction	Surface Stabilization With Additives	Road Base Material	Backfill Material	Winter Grading
133	Spinks fine sand	**SEVERE - unstable on slopes; erosive.**	SEVERE - unstable on slopes.	**SLIGHT - fairly stable; very low compressibility.**	**SLIGHT - good shear strength; very low compressibility.**	**MODERATE - fairly stable.**	MODERATE - very low compressibility; pervious to semi-pervious; very low shrink-swell potential.	Substratum - SLIGHT TO MODERATE.
134	Spinks loamy fine sand	**SLIGHT - erosive on slopes.**	SLIGHT - good bearing capacity.	**MODERATE - poor stability; low compressibility; close control essential.**	MODERATE - fair shear strength; low compressibility.	MODERATE - poor stability.	SEVERE - low compressibility; semi-pervious to pervious; very low shrink-swell potential.	Substratum - SLIGHT TO MODERATE.
142	Manawa silt loam	**MODERATE - wet for short periods; soft and slippery when wet; erosive on slopes.**	SEVERE - wet for short periods; soft and slippery when wet; fair bearing capacity.	**MODERATE - poor stability; medium compressibility.**	SEVERE - fair shear strength; medium compressibility.	VERY SEVERE - poor stability.	VERY SEVERE - medium compressibility; impervious; moderate shrink-swell potential.	Subsoil - SEVERE; substratum - SEVERE.
144	Same as No. 371, Mosel loam							
152	Lapeer loam, shallow variant	SLIGHT - erosive on slopes.	SLIGHT - good bearing capacity.	SLIGHT - fairly stable; slight compressibility.	SLIGHT - sandy; good to fair shear strength; low compressibility.	MODERATE - fair stability.	SEVERE - low compressibility; semi-pervious to impervious; very low shrink-swell potential.	Subsoil - MODERATE; substratum - MODERATE.
153	Lapeer loam	SLIGHT - erosive on slopes.	SLIGHT - good bearing capacity.	SLIGHT - fairly stable; low compressibility.	SLIGHT - good to fair shear strength; low compressibility.	MODERATE - fairly stable.	SEVERE - low compressibility; semi-pervious to impervious; very low shrink-swell potential.	Subsoil - MODERATE; substratum - MODERATE.
154	Same as No. 155, McHenry silt loam							
155	McHenry silt loam	MODERATE - soft and slippery when wet; erosive on slopes.	MODERATE - soft and slippery when wet; poor bearing capacity.	SLIGHT - fairly stable; low compressibility.	SLIGHT - good to fair shear strength; low compressibility.	MODERATE - fairly stable.	SEVERE - low compressibility; semi-pervious to impervious; very low shrink-swell potential.	Subsoil - MODERATE TO SEVERE; substratum - MODERATE.

Source: U. S. Soil Conservation Service; SEWRPC.

Pedestrian Traffic: Few roads within the Region are without all-weather surface, and few are used by pedestrians. Where roads are used in this manner, however, the limitations of some soils are very real. Ideally, pedestrian traffic requires soils that drain quickly after rain, provide good traction when moist, and are not dusty when dry. For these reasons poorly drained soils and silty soils cannot be considered ideal. The permanent high water tables in soils, such as Brookston silt loam, Keowns fine sandy loam, and Pella (Ehler) silt loam, severely restrict their use for pedestrian traffic. Soils such as Fox sandy loam and Boyer sandy loam are well suited for this purpose.

Vehicular Traffic: The appraisal of soils for vehicular traffic without all-weather surface is similar to interpretations for pedestrial traffic except that bearing strength and soil stability must be considered. Slippery conditions when moist and dusty conditions when dry are undesirable. Well-drained sandy loam soils, such as Fox and Boyer sandy loam, are relatively free of limitations for this purpose. In general, soils in the A-2-4 AASHO grouping are probably best suited for this purpose. Soils in the A-6 and A-7-6 groups, such as Kewaunee silt loam and Morley silt loam, are soft and slippery when wet and have fair bearing strength. Poorly drained soils in the same AASHO group are generally too wet for vehicular traffic. They are usually slippery and unstable.

Adequate Compaction: Road builders are keenly interested in the compaction characteristics of soils upon which roads are being built because these properties will determine the durability of the all-weather surface under pressure of traffic, as well as the cost of its construction. In Table 7 of SEWRPC Planning Report No. 8, the soil limitations for adequate compaction are appraised for the soil substratum after it has been moved to the point of use. In most road building operations, the surface soil and subsoil are removed.

The soil substratum that has low compressibility is most desirable because it will remain compacted after being rolled or tamped. Most soils in southeastern Wisconsin, except the organic soils, will compact readily and adequately. Substrata of soils such as Sebewa, Warsaw, Lapeer, and Casco are in the A-1, A-2-4, or A-3 AASHO groups and have fewer limitations for compaction than do the substrata of soils such as Hebron, Briggsville, Blount, and Colwood that are in the AASHO groups A-4, A-6, or A-7-6.

Surface Stabilization with Additives: In some areas where heavy traffic is not anticipated and suitable soils are available, the soil can be stabilized by addition of small amounts of asphalt or cement. Only the soil substratum has been considered for this purpose in southeastern Wisconsin because most soils have silty or clayey surface soils and subsoils that have severe limitations for this use. According to the American Society for Testing Materials,[4] the soil should contain at least 8 percent of particle sizes that pass the 200-mesh sieve. Gravel in the mixture should not exceed one inch in diameter. Percentages passing other sieve sizes should be about evenly distributed between the 3/8-inch size and the No. 10 and No. 40 sieve. This kind of soil material mixed with asphalt or cement can be used as a road surface for light traffic.

Soils with substrata in the A-2 AASHO group are best suited for surface stabilization with additives. Substrata of the Spinks, Lapeer, Hochheim, and Hennepin series are in this group.

Roadbase Material: Roadbase or subgrade soil material consists, in most places, of the soil substratum in place or soil that has been moved from its substratum position to a fill to be prepared for a subgrade. In either case, bearing strength, stability, compaction characteristics, and shrink-swell potential are factors to consider.

Soils in the A-1, A-2, or A-3 AASHO groups have satisfactory properties for this purpose. The Sisson, Colwood, and Briggsville soils are examples of A-4, A-6, and A-7 AASHO soil groups that have low stability and bearing strength and poor compaction characteristics and which, therefore, are poorly suited for roadbase material.

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[4] *ASTM Standards, Part 3, American Society for Testing Materials, 1952.*

Backfill Material: Soils that contain large amounts of sand and gravel in the substratum, such as those underlain by outwash materials in the A-1, A-2, or A-3 AASHO groups, are good sources of backfill material. These soils have low shrink-swell potential values. The lacustrine soils or soils with high shrink-swell potential have severe limitations for this use.

Winter Grading: There are very few soils in southeastern Wisconsin that are friable or loose enough in winter to permit road construction or grading when frozen. The exceptions are the sandy soils or the sand and gravel outwash material under some soils. Silty, loamy, or clayey soils are generally frozen and cannot be worked successfully in winter. The sand and gravel material could be graded if exposed. The removal of 20 to 40 inches of frozen soil would be very difficult, however. Soils of the Spinks, Lapeer, and Oshtemo are among the few soil series that are satisfactory for winter grading.

Other Engineering Purposes

Suitability and limitations of soil types for specific engineering purposes are given in Table 6 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in Figure 28. This table includes interpretations for use of the soil as a source of topsoil or sand and gravel, road subgrades, and foundations for low buildings. It also contains ratings for soil corrosivity for metal and concrete conduits. The depth to bedrock soil feature is repeated in this table because of its pertinence to the other interpretations.

Figure 28

EXCERPT FROM TABLE 6 OF SEWRPC PLANNING REPORT NO. 8
THE USE OF SOILS FOR SPECIFIC ENGINEERING PURPOSES

Soil Number and Soil Name		Suitability as a Source of		Depth to Bedrock (in ft.)	Limitations For		Soil Corrosivity For Conduits
		Topsoil	Sand & Gravel		Road Subgrades	Foundations for Low Buildings	
343	Celina silt loam, sloping to moderately steep	Same as No. 362, Theresa silt loam					
344	Ashford silt loam	Surface soil - GOOD - thin. Subsoil - FAIR TO POOR - clayey; thin; lower part gravelly in places.	POOR - substratum contains pockets of well graded sand and gravel.	5 plus	Subsoil - VERY SEVERE - high shrink-swell potential; low bearing capacity. Substratum - MODERATE - low shrink-swell potential; fair stability when wet.	SLIGHT TO MODERATE - low compressibility; easy to compact; good bearing capacity; good to fair shear strength.	Metal - MODERATE Concrete - LOW
345	Nenno silt loam	Surface soil - GOOD. Subsoil - FAIR TO POOR - may be gravelly in the lower part; water table 1 to 3 feet.	POOR - may have pockets of well graded sand and gravel in the substratum; high water table.	5 plus	Subsoil - VERY SEVERE - high shrink-swell potential; low bearing capacity. Substratum - MODERATE - low shrink-swell potential; fair stability.	SLIGHT - low compressibility; fair shear strength; moderate to good bearing capacity.	Metal - HIGH Concrete - LOW
346	Kane loam	Surface soil - GOOD - dark; thick. Subsoil - POOR - clayey; water table - 1 to 3 feet.	GOOD - substratum is poorly graded stratified sand and gravel at less than 40 inches; high water table.	5 plus	Subsoil - VERY SEVERE - high shrink-swell potential; low bearing capacity. Substratum - VERY SLIGHT - very stable.	SLIGHT - very low compressibility; low shrink-swell potential; good shear strength; high water table, seepage, or both.	Metal - MODERATE Concrete - LOW

Source: U. S. Soil Conservation Service; SEWRPC.

Topsoil: Soil layers that are used for topsoil are removed from their natural location and subsequently spread in a thin layer over lawns, vegetable gardens, or cuts and fills for new roadways. The upper 6 to 12 inches, or surface layer, of most soils have the qualities that are desirable for this purpose. These soils should have good tilth and high water-holding capacity. They must not disperse easily or form a hard crust when spread on a ground surface and artificially watered or subjected to rainfall. Soil texture, structure, and consistence are very important characteristics that contribute to the suitability ratings for topsoil. Because of poor accessibility and the probability of increasing the erosion hazard on steep slopes, the nearly level, gently sloping, and sloping soils are most suitable as a source of topsoil. Loamy surface soils with moderate or strong granular structure and a friable consistence are most desirable for this purpose. These kinds of soils will hold large amounts of water, do not disperse easily (puddle and form a crust), will hold relatively large amounts of fertilizer, and are not subject to severe water or wind erosion. The silt loam and loam surface layers of most of the soils in southeastern Wisconsin are good soils for this purpose where other factors, such as structure and consistence, are favorable. The surface layer of soils such as Ockley silt loam, Warsaw silt loam, and Hebron loam are good sources of topsoil.

Clayey soils that are low in organic matter generally disperse easily and when used for topsoil form hard crusts that inhibit the growth of grass, flowers, or shrubs. Sandy (loamy sand and sand) soils, on the other hand, are very friable and do not form crusts but have a low available water capacity and are subject to wind erosion. Soils that contain enough organic matter to maintain good structure and tilth are most desirable for use as topsoil. Where other factors are favorable, however, a deficiency in organic matter can be corrected by the addition of compost, manure, or other forms of partially decomposed plant residue.

In some places it may be advantageous to use subsoil as a source of topsoil. This can be done where texture and structure are favorable. Almost all subsoils have very little organic matter. Unless some form of organic residue is added to most subsoils before or after spreading, the topsoil is likely to crust or erode readily. With proper treatment the upper subsoils of soils such as Sisson fine sandy loam and Symerton (Rome) silt loam can be used as a source of topsoil. Some soils, such as Tichigan silt loam, Fox loam, and Dodge silt loam, have surface soils that are well suited for use as topsoil and subsoils that are poorly suited.

The presence of a high water table affects the accessibility of the topsoil during wet seasons. Most of the somewhat poorly drained and poorly drained soils with surface soils that have favorable textural and structural properties can be used successfully for this purpose. Because of their position in the landscape and rank vegetative growth during early stages of soil formation, the wet soils generally contain large amounts of organic matter and are very desirable as a source of topsoil. The subsoils of most of these soils, however, are a poor source of topsoil because most of them are clayey or sandy and few of them have favorable structure. The surface layers of wet soils, such as Matherton silt loam, Brookston silt loam, and Mussey silt loam, are well suited for use as topsoil; but the subsoils are poorly suited.

The availability of soil for topsoil is affected by the presence of bedrock. Where the depth to bedrock is less than 20 inches, the removal of the soil would render the area unsuitable for most urban and rural land uses. Soils that are very shallow to sand and gravel are poor sources of topsoil because of the probability of mixing some of the gravel with the topsoil. A composite analysis of the suitability of soils as a source of topsoil is presented in Table 11.

Sand and Gravel: Soil maps can be used to indicate the probable location of deposits of sand or gravel, or both, that are suitable for road construction or for use as concrete aggregate (see Figure 29). The maps will not indicate such sources where the upper boundary of the deposit is more than five feet deep. The potential user of these areas is usually looking for thick deposits of clean sand or gravel in well-drained positions with a minimum of soil cover. The term "clean" refers to the absence of fine soil particles, such as silt, clay, and organic matter, in the sand or gravel. Well-drained soils are desirable. The necessary excavation in somewhat poorly and poorly drained soils would result in water-filled ponds that make the use of the trucks and other machinery needed to mine and haul the sand and gravel difficult.

The fine particles have been removed from clean sand or gravel in one of two ways. In some places the sand or gravel has been transported from glacial drift deposits by running water. During the transportation fine particles of clay and silt have been removed by running water. In other areas the fine particles in the glacial drift have been removed by water leaving the coarser sand and gravel in place. Heavy rains and melting ice, during recession of the glaciers many thousands of years ago, provided the water necessary to clean thick deposits of sand and gravel.

The glacial drift underlying many soils of the Region is a mixture of all soil particle sizes and, along with lacustrine deposits of fine sand, silt, or clay, is a poor source of sand or gravel, or both. The substrata of soils of the Fox, Casco, or Boyer series are good sources of sand or gravel. A composite analysis of the suitability of soils as a source of sand and gravel is presented in Table 12.

Road Subgrades: Soils with slight limitations for road subgrades must be stable under both moving and stationary loads, have a high bearing capacity, and have a relatively low shrink-swell potential. Only the subsoil and substratum are considered as a road subgrade, since the surface soil generally is removed

Table 11
THE SUITABILITY OF SOILS AS A SOURCE OF TOPSOIL

Soil Features Affecting Use	Degree Of Suitability		
	Very Good And Good	Fair	Poor And Very Poor
Texture (classification[a])	l, sil, scl	cl, sicl, sl	ls, c, sic, s, si, sc
Available water capacity (inches per inch)	>0.14	0.10-0.14	<0.10
Consistence, tilth (moist rating)	Very Friable Friable	Loose Firm	Very firm Extremely firm
Erodibility (erosion hazard)	None to slight	Moderate	Severe
Fertility-holding capacity (rating)	High	Moderate	Low
Thickness (inches)	>12	6-12	< 6
Coarse fragments (percent)[b]	0	< 5	> 5
Depth to bedrock (inches)	>30	20-30	< 20
Soil slope (percent)[c]	< 6	6-12	>12

[a] *See code of textural abbreviations in Table 5.*

[b] *Includes pebbles, cobblestones, and stones.*

[c] *Soil slope and high water table affect accessibility.*

Source: U.S. Soil Conservation Service.

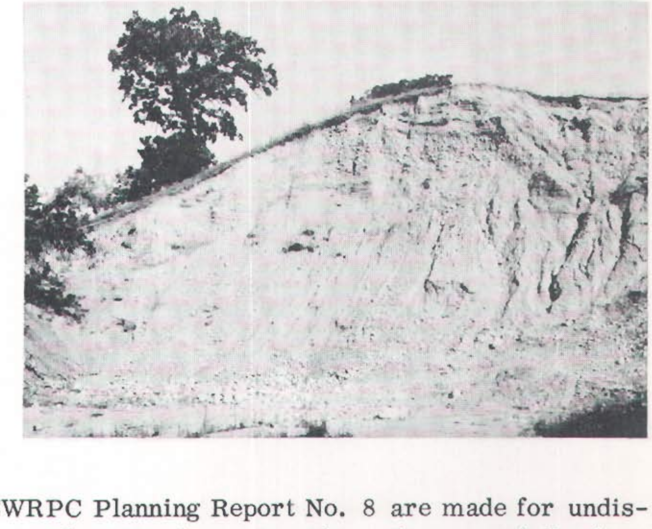

Figure 29
SAND AND GRAVEL DEPOSITS

The probable location of deposits of sand and gravel can be found through an examination of the detailed soil maps and of the accompanying interpretive analyses. This photograph shows typical Rodman soils, which are a good source of sand and gravel for road base material.

during construction. The ratings given in Table 6 of SEWRPC Planning Report No. 8 are made for undisturbed soils and, therefore, are applicable mainly to secondary road construction. Because of the low-gradient design criterion of most primary highways and the sloping and steeply sloping topography in much of southeastern Wisconsin, relatively large cuts and fills are generally encountered in construction; and subgrades are comprised of either disturbed soils (fills) or deep substrata (cuts). Secondary roads, however, often are built on undisturbed subsoil or substratum. Sandy soils, such as Spinks, have few limitations for road subgrades in both subsoil and substratum because they are relatively stable, have high bearing capacity, and a very low shrink-swell potential. The clayey subsoils of soils such as Sebewa, Matherton, or Casco are relatively unstable and have low bearing values; but the sand and gravel substrata have high bearing capacity, good stability, and very low shrink-swell potential. The subsoil and substrata of soils such as Morley and Navan are clayey with low bearing capacity and relatively high shrink-swell potential. A composite analysis of soil limitations for road subgrades is presented in Table 13.

Foundations for Low Buildings: Low buildings, as used in Table 6 of SEWRPC Planning Report No. 8, refer to buildings with three stories or less in height. The interpretations are based on the assumption that foundations will be placed deep enough to prevent heaving by frost action and reduce the effects of shrink-swell action. To accomplish this, the bottom of the foundation should be about five feet below ground surface. Soil ratings, therefore, are made only for the substratum because most foundations rest on the undisturbed layer below the soil. The principal factors that affect limitations of soils for foundations are shrink-swell potential, consolidation characteristics, depth to bedrock, depth to water table, and shear strength.

Table 12

THE SUITABILITY OF SOILS AS A SOURCE OF SAND AND GRAVEL[a]

Soil Features Affecting Use	Degree Of Suitability		
	Very Good And Good	Fair	Poor And Very Poor
Amount of fines (percent)	< 5	5-15	>15
Thickness of deposit (feet)	>15	5-15	< 5
Stones and boulders (percent)	0	< 3	> 3
Thickness of overburden (feet)	< 5	5-10	>10
Depth to permanent water table[b]	Below deposit	--	Above deposit

[a] Substratum only.

[b] No intermediate rating needed.

Source: U.S. Soil Conservation Service.

Table 13

SOIL LIMITATIONS FOR ROAD SUBGRADES

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Shear strength (rating)	High	Medium	Low
Shrink-swell potential (rating)	Low	Medium	High
Susceptibility to frost action (rating)	Low	Moderate	High
Stones (percent of soil mass)	<5	5-15	>15
Compaction characteristics (rating)	Good	Fair	Poor

Source: U.S. Soil Conservation Service.

Although the shrink-swell potential in the substrata of soils in southeastern Wisconsin is not extremely high, it can affect structures during exceptionally wet or dry seasons. Shrink-swell potential indicates the relative volume change of soils upon wetting and drying. Most of the soil substrata have low or moderate shrink-swell potential, which would have little effect on foundations. A few soils, such as Morley, Blount, and Elliott, have substrata with sufficient volume change upon wetting and drying to exert pressure on foundation walls and bottoms. The pressure thus exerted can cause cracking of the foundation because of uneven stress on different parts of the structure. Soils with a high percent of clay generally have a higher shrink-swell potential than soils with a low percent of clay.

Consolidation characteristics refer to the amount of settlement that can be expected when a load, such as a building foundation, is transmitted to the soil. If the building overlaps two or more soil areas that have different consolidation characteristics, it can be expected to settle more in one part than another. The resulting crack in the foundation could greatly reduce the usefulness and value of the building.

Few soils are stable or will bear heavy loads when saturated with water. Where a permanent high water table exists, the limitations are severe for use as a base for a foundation. A seasonal high water table imposes severe limitations even though the soil may be saturated for a short time only. In soils that liquify at very high water content, the effects of water tables are slightly less than in other soils; but many soils will liquify at relatively low water content and lose their stability and bearing capacity. Gravelly and sandy soils retain their high bearing capacity at high moisture contents. Thus, with the exception of Fox, Casco, and other soils underlain by sand and gravel, a high water table means poor support for foundations.

Shear strength is an expression that indicates the strength of the internal friction and cohesion of the soil. A high shear strength resists the tendency of one part of a soil column to slide across another. This characteristic could determine whether a building placed on a hillside will move downward or be held in place. In southeastern Wisconsin clayey substrata in soils such as Morley or Kewaunee have fair shear strength.

As a base for foundations, dolomite bedrock, such as that under soils of the Knowles series, is the most desirable material that can be used in southeastern Wisconsin. Where bedrock is near the surface, however, it is very difficult to excavate for foundations, footings, or basements for buildings.

The sand and gravel substrata of many soils formed over sand and gravel outwash deposits have high stability, high bearing capacity, low shrink-swell potential, and favorable consolidation characteristics. The substrata of soils such as Rodman gravelly loam, Warsaw silt loam, and Matherton silt loam are examples of this kind of material. Some soils underlain by sandy loam glacial till are well suited as foundations for low buildings because of the presence of gravel and a low content of clay. Soils of the Theresa and Mayville series have this kind of substratum. Soils, such as Sisson fine sandy loam and Aztalan loam, underlain by sand, silt, and clay of lacustrine origin generally have low bearing capacity, poor consolidation characteristics, and poor stability. A composite analysis of soil limitations for low building foundations is presented in Table 14.

Soil Corrosivity: Soil corrosivity evaluations, as shown in Table 6 of SEWRPC Planning Report No. 8, are based mainly on observations of the corrosion of metal and concrete conduits in different kinds of soils. The corrosion of metal conduits is often attributed to the total acidity or the salt content of soils. In most areas a rapid rate of corrosivity most often is associated with wet, loamy, or clayey soils with a relatively low pH (high acidity). In southeastern Wisconsin, however, the most rapid corrosion of metal conduits occurs in somewhat poorly and poorly drained soils that are alkaline (pH 7.4 to 8.4) and that generally have free carbonates in the substratum.

Five causes of corrosion of buried ferrous metal conduit can be listed: 1) differences in alloys and surface conditions, 2) differences in soils, 3) differences in oxygen concentrations, 4) anaerobic bacteria, and 5) man-made electrical earth currents. It appears that in southeastern Wisconsin anaerobic bacteria are an unlikely cause of corrosion because of the absence in the soils of the sulfates required by the bacteria.

Table 14

SOIL LIMITATIONS FOR LOW BUILDING FOUNDATIONS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Consolidation characteristics (rating)	Good	Fair	Poor
Shrink-swell potential (rating)	Low	Moderate	High
Shear strength (rating of susceptibility to Sliding)	High	Medium	Low
Depth to water table (feet)[a]	>5	3-5	<3
Depth to bedrock (feet)	>5	3-5	<3
Flood hazard (rating)	None	Moderate	Severe

[a] *Sand or sand and gravel excepted.*

Source: U. S. Soil Conservation Service.

Differences in metals and surface conditions are the result of the conduit manufacturing or construction process and can occur in any soil and result in corrosion. This leaves differences in soil and differences in oxygen concentrations as probable soil-associated causes of ferrous metal corrosion in southeastern Wisconsin. Although streetcars and electric railways, which use the soil as a ground return for direct current, no longer operate within the Region, there are other sources of electrical currents that could contribute to corrosion.

As indicated by the soil descriptions and soil reaction data found in Table 4 of SEWRPC Planning Report No. 8 (see Figure 20), all soils, except those in the Houghton and Lawson series, have calcareous substrata with pH ranges of 7.4 to 8.4. It would appear that the substrata are uniform. These substrata, however, are, or originally were, glacial till. This means that they are a mixture of different kinds of stones, cobbles, gravel, and finely ground rock that have different chemical activity. Metal conduits are generally buried about five feet deep. With the introduction of metal conduit into a wet soil, a potential battery system is set up between components of the soil mixture and the metal. In addition, the exclusion of oxygen, where the lower part of the soil is saturated with water in poorly drained and somewhat poorly drained soils, apparently accounts for the rapid corrosion in some soils. In southeastern Wisconsin the prediction can be made that, in most of the somewhat poorly and poorly drained soils, metal conduits will corrode rapidly unless protected. Soils of the Keowns, Colwood, Blount, Aztalan, and Pella (Ehler) series are examples of soils in which particularly rapid corrosion of metal conduit can be expected.

The corrosion of concrete conduit in southeastern Wisconsin is mainly a chemical exchange between acid soils and the alkaline compounds of which concrete is made. The soils, of course, must be moist for corrosion to occur. With the absence of significant concentrations of sulfates or chlorides, soils can be rated according to their pH values. Slightly acid to alkaline soils with pH values of more than 6.0 are in the low corrosivity class. Medium acid and strongly acid soils with pH values of 5.0 to 6.0 are in the moderate class, and very strongly and extremely acid soils are classed as high. The substrata of most soils of the Region are alkaline and can be classed as low corrosivity. Most subsoils will be classed as moderate or low. The probability of concrete conduit corrosion will depend, therefore, on the soil layer in which it is buried and on the type of concrete used.

SOIL INTERPRETATIONS FOR PLANNING PURPOSES

Almost all soil properties and their limitations for various urban and rural uses are of substantial interest to regional and local planning agencies engaged in comprehensive planning for the physical development of new urban areas and for the conservation of natural resources. Particularly tailored to the regional and local planners' needs are the limitations of soils for certain urban and rural uses given in Table 8 of SEWRPC Planning Report No. 8. An excerpt of that table is reproduced in this Guide as Figure 30. Included are limitations of the soils for crops, pasture, and trees; for residential development with public sanitary sewer service; for residential development with on-site soil absorption sewage disposal systems; for light industrial and commercial buildings; and for highway, railroad, and airport development. Although not included in Table 8 of SEWRPC Planning Report No. 8, this section of the Guide also includes discussions of soil limitations for sewage lagoons and sanitary land fill operations.

This soil limitations information is an invaluable guide, not only for the regional and local planner but also for land developers, real estate brokers, managers of financial institutions, utility engineers, highway engineers, and local sanitarians. The information can be used on a very large scale, as for regional land use planning, and on a very small scale, as for specific site selection and design for a given land use. Subsequent chapters of this Guide will discuss and illustrate the use of such soils information in regional, watershed, community, and neighborhood planning and in site development.

Figure 30

EXCERPT FROM TABLE 8 OF SEWRPC PLANNING REPORT NO. 8
SELECTED RURAL AND URBAN USES OF SOILS

		LIMITATIONS OF SOIL FOR					
Soil Number and Soil Name		Cultivated Crops, Pasture and Trees	Residential Development With Public Sewer Service	On-site Soil Absorption Sewage Disposal Systems for Lots		Light Industry and Commercial Buildings	Highway, Railroad and Airport Development
				Less than 1 acre	1 acre or more		
3267	Same as No. 212, Ehler silt loam						
327	Wallkill silt loam	SLIGHT for crops when drained and protected from overflow; SLIGHT for pasture and MODERATE for trees; frequent overflow.	VERY SEVERE - low bearing capacity; subject to shrinkage on drying; high water table; frequent overflow.	VERY SEVERE - systems will not operate when flooded.	VERY SEVERE - systems will not operate when flooded.	VERY SEVERE - high water table; high compressibility and instability; frequent overflow.	VERY SEVERE - high compressibility and instability; frequent overflow; low bearing capacity; high water table.
328	Pistakee silt loam	SLIGHT for crops when drained and protected from overflow; SLIGHT for pasture and trees; occasional overflow.	SEVERE - low bearing capacity; frost heave; high water table; occasional overflow.	VERY SEVERE - high water table; systems will not operate.	VERY SEVERE - high water table; systems will not operate.	SEVERE - high water table; low bearing capacity; piping; occasional overflow.	SEVERE - high water table; low bearing capacity; piping; frost heave; occasional overflow.
330	Navan loam	SLIGHT for crops when drained; SLIGHT for pasture and MODERATE for trees.	SEVERE - substratum has low bearing capacity; high shrink-swell potential; high water table; wet basements.	VERY SEVERE - high water table; slow permeability; systems will not operate.	VERY SEVERE - high water table; slow permeability; systems will not operate.	SEVERE - high water table; high compressibility; low shear strength; high shrink-swell potential; low bearing capacity.	SEVERE - high water table; substratum has moderate compressibility and shrink-swell potential and low bearing capacity.
331	Markham-Elliott silt loams	Markham part - Same as No. 336, Markham silt loam Elliott part - Same as No. 3251, Elliott silt loam					
332	Kane silt loam	SLIGHT for crops when drained; SLIGHT for pasture and trees; high water table.	MODERATE - high water table.	VERY SEVERE - high water table; systems will not operate.	SEVERE - high water table; systems will not operate.	MODERATE - high water table; frost heave.	MODERATE - high water table; frost heave.

Source: U. S. Soil Conservation Service; SEWRPC.

Cropland, Pasture, and Trees

The limitations of soils for cropland are based on the capacity of the soil to produce, without excessive erosion or soil deterioration, economically acceptable yields of crops commonly grown in the survey area. In southeastern Wisconsin, corn, oats, and alfalfa are important crops by which the limitations of soils can be measured. These plants grow best on deep, well-drained soils with good tilth, moderate permeability, relatively high available water capacity, relatively low gradient, and high fertility. Soils with these characteristics have few, if any, limitations for use as cropland and receive the rating of slight. A similar soil with a high water table would have severe limitations where artificial drainage has not been installed. With drainage, however, the limitations are slight because the restrictive property for crop production has been removed.

The erodibility of soils is closely related to the soil slope. Some soils, even though fertile, are too steep to use properly for cropland because the rapidity of rainfall runoff causes accelerated erosion. These soils have severe or very severe limitations for cropland. Where other factors are favorable, the nearly level and gently sloping soils have little or no erosion hazard and slight limitations for use as cropland.

The available moisture capacity of soils can control the growth and yield of crops unless irrigation is used. Where rainfall is the only source of moisture, soils with low available water capacity cannot continuously supply adequate amounts of water for optimum plant growth in the climate that prevails in southeastern Wisconsin. For example, sandy soils of the Spinks series hold about 0. 04 inch of moisture per inch of soil. The total amount of available water to a depth of 5 feet for Spinks loamy sand is 2. 4 inches. Table 10 of SEWRPC Planning Report No. 8 indicates that corn will use about 0. 30 inch of water per day. Thus, even if corn were able to extract all of the available water to a depth of 5 feet, the supply in the soil would last only 8 days after the soil moisture was fully replenished. If roots were only 3 feet deep, water would be exhausted in less than 5 days. In a nearby area of Boyer sandy loam that holds about 4. 7 inches of water to a depth of 5 feet, moisture could last about 15 days after the soil was filled with water. If roots were only 3 feet deep, water would sustain plant growth for about 12 days. In a similar manner, the available water capacity is affected by shallow depth of soils. A silt loam soil, such as Knowles, shallow variant, in which bedrock is about 15 inches deep, holds about 2. 5 inches of water when full. The available water capacity of these soils compares with that of Spinks soils. Actually, crops will suffer before all of the available moisture is used. A deficiency of water at any time during the growing season will adversely affect crop yields. This is one of the principal limitations of shallow soils or sandy soils.

The capacity of soils to hold fertility is almost parallel to their ability to hold water. Deep, silty, and loamy soils are capable of holding large amounts of fertility. Sandy and shallow soils generally have low fertility-holding capacity. Compensation for this deficiency can be made by applying fertilizer to sandy and shallow soils more often than to deep, silty, and loamy soils where plant nutrients have been depleted.

Soil permeability, rather than being a direct limitation for the use of soils for cropland, can be used to indicate the absence or presence of certain limitations. For example, the growth of plant roots is slow in slowly or very slowly permeable soils. These soils are generally poorly aerated in the lower part of the soil profiles because of little or no soil structure or weak blocky or platy structure. Moderately permeable to rapidly permeable soils are generally well aerated.

Tilth in soils is closely related to structure and texture. Sandy and coarse loamy soils with sand, loamy sand, sandy loam, and light silt loam textures are generally easy to cultivate because of the low content of clay that acts as a binding agent. With a minimum of care, these soils are friable and crumble easily when plowed. At the other extreme, clayey soils with clay, silty clay, sandy clay, and heavy clay loam and silty clay loam textures puddle easily and are hard when dry unless the organic matter content is maintained at a high level. Where moderate or strong granular or subangular blocky structures are maintained in clayey soils, they generally have good tilth and are easy to plow and cultivate.

Many soils with slight limitations for cropland also have slight limitations for pasture or trees. Most soils with high water tables are not artificially drained to grow pasture or trees. This limits the species to be grown to water-tolerant plants. Many sloping and steeply sloping soils, with moderate or severe limitations for cropland, have slight limitations for pasture or trees. The presence of vegetative cover that reduces erosion causes the differences in the ratings. Where soils are used for cropland, they are exposed to erosion at least part of the growing season. Some soils, such as Rodman gravelly loam, have very severe limitations for cropland because they are both shallow and steep. These soils have only moderate limitations for pasture. A composite analysis of soil limitations for cropland is presented in Table 15.

Residential Development (Public Sanitary Sewer)

Interpretations for residential development include appraisal of the area surrounding a house, as well as the area occupied by the building foundation. The probability of wet basements and the flooding hazard are important factors. Landscaping of the grounds surrounding a residence is to be considered in making interpretations. Soil erosion and the ability of the soil to produce grass and shrubs are important. Sandy soils are generally subject to wind erosion and are drouthy. They have, however, only slight limitations for foundations. Poorly drained soils have severe limitations because use for residential development will result in wet basements or will require very expensive treatment and equipment to prevent water

Table 15

SOIL LIMITATIONS FOR CROPLAND

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Available water capacity (inches) [a]	>8	4-8	<4
Soil slope (percent)	<6	6-12	>12
Soil consistence, tilth (moist rating)	Very friable Friable	Loose Firm	Very firm Extremely firm
Erodibility (rating)	None to slight	Moderate	Severe
Natural drainage (undrained rating)	Well Moderately well	Excessive Somewhat poorly	Poorly Very poorly
Effective soil depth (inches) [b]	>40	20-40	<20
Permeability (rating)	Moderately rapid Moderate Moderately slow	Very rapid Rapid Slow	Very slow
Flood hazard (rating)	None	Moderate	Severe
Stones (percent of ground cover)	< 0.01	0.01-0.10	> 0.10
Gravel and cobblestones (percent of soil mass)	< 5	5-15	>15

[a] *Based on depth to five feet or depth to bedrock if less than three feet.*

[b] *Depth to layer that restricts root or water movement (bedrock, clay layer, gravel fragipan).*

Source: U.S. Soil Conservation Service.

from seeping into the basements. Soils that flood occasionally or frequently have severe limitations for residential development. Well-drained, deep loam or silt loam soils have fewer limitations than other soils for residential development. Lapeer loam and Dodge silt loam, on nearly level topography, are examples of soils with no limitations for residential development. Poorly drained soils, such as Brookston silt loam or Mussey loam, have severe limitations for residential development mainly because ground water is less than a foot below the soil surface most of the time. A composite analysis of the limitations of soils for residential development, assuming construction with basements and the availability of public sanitary sewer service, is shown in Table 16.

On-Site Soil Absorption Sewage Disposal

The successful use of the soil for on-site soil absorption sewerage systems is dependent on the ability of the soil to remove harmful substances and transmit sewage effluent. The relative amelioration of substances harmful to human and animal life by reduction of bacteria and filtering is the basis for determining the limitations of soils for septic tank filter fields. Until recently the operation of septic tanks and septic tank filter fields was considered successful if the soil transmitted effluent away from the soil surface. With increased use of septic tanks in lieu of public sewerage systems in many urban expansion areas in the Region and in resort areas near lakes and streams, it has been found that rapid passage of sewage effluent through the soil contributes to pollution of ground water. Conversely, very slow move-

Table 16

SOIL LIMITATIONS FOR RESIDENTIAL DEVELOPMENT[a]

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Consolidation characteristics (rating)	Good	Fair	Poor
Shrink-swell potential (rating)	Low	Moderate	High
Shear strength (rating of susceptibility to sliding)	High	Medium	Low
Depth to water table (feet)	>5	3-5	<3
Depth to bedrock (feet)	>5	3-5	<3
Soil erodibility (erosion hazard rating)	Low	Moderate	High
Available water capacity (rating)	High	Moderate	Low
Flood hazard (rating)	None	None	Severe

[a] *Assuming construction with basements and public sanitary sewerage systems.*

Source: U.S. Soil Conservation Service.

ment of effluent through the soil will result in saturation of the soil. The effluent ponds on the soil surface or flows across it and eventually enters and pollutes surface waters. In either event, the presence of effluent on the surface of the soil causes a public nuisance and is hazardous to the public health. The danger of ground water contamination where sandy, rapidly permeable soils are used for septic tank filter fields is recognized as a moderate limitation. Slow or very slow permeability, however, is considered a severe and very severe limitation because most households produce more effluent than this kind of soil can transmit. Well-drained, moderately slowly permeable soils, such as Briggsville silty clay loam, have moderate limitations for on-site sewage disposal. The moderate and moderately rapid permeability classes impose no soil limitation for sewage disposal because effluent is transmitted rapidly enough to prevent surface flow but slow enough to remove harmful substances by filtering.

The estimated percolation rates given in Table 4 of SEWRPC Planning Report No. 8 (see Figure 20) were calculated as reciprocals of the permeability rates. This kind of calculation can be theoretically made because permeability rates are given as inches per hour and percolation rates are given as minutes per inch. Because the test for one of the values is a laboratory test and the other a field test, however, the two values cannot be considered as truly reciprocal in nature. Permeability rates are determined mainly by allowing water to pass through a core sample of soil in the laboratory. Except for a slight disturbance in taking the core sample, it is representative of the soil as it occurs naturally. The site disturbance may change the permeability slightly. The laboratory results provide soil scientists with a basis for estimating permeability rates in other soils. Such estimates cannot be made as accurately for percolation rates because tests must be made in the field and standardization of conditions is difficult. Field determinations, therefore, are not always reliable because of unnoticed differences in moisture and temperature of the soil or because of failure to make the test in a bore hole fully representative of the soil area in question. For these reasons, soil scientists prefer to base interpretations for on-site sewage disposal systems on the kind of soils that are shown on the soil map and the estimated permeability rates for each soil, rather than on percolation test results alone. Appraisals for on-site sewage disposal, such as found in Table 8 of SEWRPC Planning Report No. 8, can be made on the basis of permeability only, provided other soil characteristics and properties are favorable. Unfavorable factors, such as high water tables, shallow bedrock, steep slopes, or flooding, will, however, override seemingly favorable permeability rates.

Soils in the suborders Aquolls, Aquepts, and Aqualfs that have permanent high water tables do not permit the filtering action necessary to successful operation of septic tank filter fields. The filtering action in these soils is not adequate for removal of harmful substances. A filter field in these kinds of soils is almost equivalent to running untreated effluent directly into the surface and ground water. Sewerage systems built in such soils have a very small capacity for absorption and transmission (see Figure 31). That is why soils such as Colwood silt loam or Brookston silt loam have very severe limitations for on-site sewage disposal.

Figure 31

SOIL ABSORPTION SEWAGE DISPOSAL

The house in this photograph is being constructed on an Ashkum silty clay loam soil. This soil is characterized by a high water table, as can be seen in the shallow excavation to the right of the house. Septic tank filter fields cannot operate successfully in such soils.

Proximity to bedrock poses severe problems for septic tank sewage disposal systems. Where soils are shallow, there is insufficient depth for the necessary filtering action. Effluent from septic tanks in shallow soils over bedrock passes into or over the bedrock in a relatively raw state. Where bedrock is solid, the effluent flows over the upper surface until it finds a crack in the rock or until it comes to the surface at a lower point on the slope. In either event, it becomes a danger to the public health and a source of ground or surface water pollution. Where bedrock is fractured, the relatively raw effluent passes into the ground water and contributes to ground water pollution. Soils underlain by bedrock should be sufficiently deep to allow adequate filtering action and destruction of bacteria and pathogens. The limitations of shallow soils over bedrock for on-site sewage disposal are rated as being very severe.

Where septic tank filter fields are placed on steep slopes, the effluent usually moves to the surface a short distance below the field. Soil occurring on slopes of more than 12 percent is considered as being too steep for septic tank filter fields. These soils have severe limitations for on-site sewerage systems. Soils occurring on slopes of 6 to 12 percent are rated as having moderate limitations.

Septic tanks located in areas subject to flooding are a public health hazard and a source of water pollution. In some floodland areas, the systems may function properly during periods of normal streamflow. With flooding, however, the septic tank fills with water; the soil and filter field become saturated; and untreated sewage is carried downstream. For this reason, it has been proposed that on-site soil absorption sewage disposal systems be prohibited in floodplains in Wisconsin.[5]

A composite analysis of soil limitations for the proper operation of on-site soil absorption sewage disposal systems is presented in Table 17.

<u>Sewage Lagoons</u>

In evaluating the degree of limitation for soils forming a sewage lagoon impoundment site, four general factors must be considered: 1) permeability; 2) soil depth, slope, and relief; 3) organic matter; and 4) coarse fragments. Federal Housing Administration specifications for sewage lagoons state that the

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[5] *See draft of Section H 62.20, Wisconsin Administrative Code, Wisconsin Division of Health, dated April 7, 1969.*

Table 17

SOIL LIMITATIONS FOR ON-SITE SOIL ABSORPTION SEWAGE DISPOSAL SYSTEMS[a]

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Permeability (class)	Upper end of moderate	Lower end of moderate Moderately rapid Rapid	Moderately slow Slow
Hydraulic conductivity rate[b] (inches per hour)	> 1.00	1.00-0.63	< 0.63
Percolation rate[c] (minutes per inch)	< 45	45-75	>75
Depth to seasonal or normal water table (feet)	> 5	3-5 (Seasonal water table)	< 3 (Normal water table)
Flood hazard (rating)	None	Moderate	Severe
Slope (percent)	< 6	6-12	>12
Depth to hard rock, bedrock, or other impervious materials (feet)	> 6	4-6	< 4

[a] *The criteria contained in this table are those used by the U. S. Soil Conservation Service in their preparation of the interpretive analyses set forth in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. Local sanitary ordinances governing the installation of on-site soil absorption sewage disposal facilities may, as recommended by the SEWRPC in its Model Sanitary Ordinance, be made more restrictive with respect to individual specific soil features, such as depth to water table, depth to bedrock, or percolation rate. Chapters H 62 and H 65 of the Wisconsin Administrative Code are more restrictive with respect to depth to water table and percolation rate.*

Source: U. S. Soil Conservation Service.

liquid depth should not be less than two feet and generally not more than five feet and that the lagoon floor should be sufficiently impervious to preclude excessive liquid loss.[6]

It is important that the impervious soil material be at least one foot thick. Lagoon floors must be impermeable because of the potential for contamination of ground water supplies that are often tapped by shallow wells. The slope and relief of the lagoon floors must be low enough and the soil material over bedrock thick enough so that the smoothing required to obtain the specified uniformity in depths of the liquid body is practical. Where the soil material is over 60 inches deep, a greater slope is allowable, although it is generally impractical to consider slopes of more than 7 percent. Where the soils are nearly level, the thickness of suitable soil material generally can be 40 to 60 inches. Surface runoff and floodwater must be kept from entering the lagoon. Moderate to high amounts of organic matter are unfavorable in the lagoon floor even though it is underlain by suitable soil material since organic matter promotes aquatic plant growth, which is detrimental to proper functioning of the lagoon. Fragments more than six inches in diameter interfere with manipulation and compaction of the soil material in the process of smoothing the basin floor and are, therefore, undesirable in sewage lagoon sites. A composite analysis of soil limitations for sewage lagoon sites is presented in Table 18.

Light Industrial and Commercial Buildings

Soil interpretations for light industrial and commercial buildings are similar to those for foundations for low buildings (see discussion under "Other Engineering Purposes," this chapter), except that somewhat larger areas are considered. The buildings are generally less than three stories high with a minimum area of 2,500 square feet in each floor. As in foundations for low buildings, the bearing capacity, stability, shrink-swell potential, and consolidation characteristics are the principal factors that affect the interpretations.

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[6] *Community Sewage Systems, ''Design Guides for Sewage Stabilization Basins,'' Series No. 1833, December 8, 1960, Federal Housing Administration.*

Table 18

SOIL LIMITATIONS FOR SEWAGE LAGOONS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Permeability (inches per hour)	< 0.63	0.63-2.00	> 2.0
Depth to bedrock (inches)	>60	40-60	<40
Slope (percent)	< 2	2-6	> 6
Reservoir site material (Unified classes)	GC, SC, CL, and CH	GM, ML, SM, and MH	GP, SW, SP, SW, OL, and OH
Coarse fragments less than 6'' in diameter (by volume-percent)	<20	20-50	>50
Surface area covered by coarse fragments over 6'' in diameter (percent)	< 3	3-15	>15
Organic matter (percent)	< 2	2-15	>15
Flood hazard (rating)	None	Moderate	Severe

Source: U.S. Soil Conservation Service.

Highway, Railway, and Airport Development

The interpretation of soils for use in the location of transportation systems, such as highways, railways, and airfields, involves appraisal of the bearing capacity, frost hazard, flooding hazard, compaction characteristics, and shrink-swell potential of the soil. The depth to bedrock, depth to water table, and soil slope are also important in arriving at limitations for this use. One of the principal applications of soils data in transportation system development is in the route location studies for highway and railway transportation facilities and in site selection for airport facilities. The interpretations for airports have been designed to be applied to runways intended for use only by light aircraft. Bearing capacity must be high to withstand the weight of trucks on highways or the impact of landing aircraft. The frost hazard is important because frost heave can crack concrete pavement and cause surface flaking and formation of holes in asphalt pavement. Silty, wet soils are most susceptible to frost heave.

A high shrink-swell potential will cause bumps and a washboard effect in roads and runways. Most roads and runways are constructed on compacted soils. The well-graded sandy and loamy soils have good compaction characteristics. Soils underlain by sand and gravel generally have slight limitations for transportation systems. The silty and clayey soils in lacustrine deposits have severe limitations because they have a low bearing capacity and high frost heave hazard.

The depth to bedrock affects the difficulty of road construction. Most bedrock in southeastern Wisconsin will provide good foundations for transportation systems. Excavation is difficult and costly where it is necessary to make cuts that extend into bedrock.

Soils with permanent high water tables have severe limitations for highways and airport runways. Most of the soils are unstable, have a low bearing capacity, and high frost hazard when wet. This means that most of the time the roads and runways will not support the trucks and airplanes that use them. A composite analysis of the limitations of soils for transportation system development is presented in Table 19.

Table 19

SOIL LIMITATIONS FOR TRANSPORTATION SYSTEMS

Soil Features Affecting Use	Degree Of Limitation: Very Slight And Slight	Moderate	Severe And Very Severe
Depth to bedrock (inches)	>40	20-40	<20
Depth to water table (feet)	> 3	1-3	< 1
Frost hazard (Unified classes)	GW, GP, GM, SW, and SP	C, GC, SM, SC, ML, (loam) CH	ML (silt and silt loam) CL, MH
Flood hazard (rating)	None	Moderate	Severe
Topography	Nearly level Gently sloping	Sloping Moderately steep	Steep Very Steep
Stones and boulders (percent of surface area)	<3	3-15	>15
Stability (rating)	High	Medium	Low
Shrink-swell potential (rating)	Low	Medium	High

Source: U.S. Soil Conservation Service.

Sanitary Land Fill

As already noted, SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin, does not contain interpretations for solid waste disposal through the use of soils for sanitary land fill operations. This method of disposing of solid waste has greatly increased in recent years and is becoming an important consideration in the use of soil survey data. Solid waste is aesthetically offensive. The objective of waste disposal is the disposal of the unwanted material without generation of undesirable or harmful by-products, such as offensive odors, smoke, rodent and insect pests, and blowing paper and debris. Careless disposal of solid waste can result in serious problems of air and water pollution.

Sanitary land fill is the method of solid waste disposal that utilizes burial in soil on a day-to-day basis. Soil is used as the covering and sanitizing material that, if properly manipulated, helps eliminate the undesirable features of certain other methods of disposal. After use for land fill, most areas can be restored to agriculture, forestry, or recreational use. Reuse for land fill is also a possibility after the lapse of many years. Table 20 presents a composite analysis of the soil features that can be used to determine the soil limitations for sanitary land fill operations.

Slope is an important factor in appraising soils for sanitary land fill. Slopes steeper than 12 percent are considered too steep for land fill. Steep slopes are erosive and may expose the land fill core after spreading of the final cover. It is desirable, however, for the final cover to be gently sloping to reduce leaching through the land fill.

Drainage and depth to water table can influence selection of a land fill site. The high water tables that are generally associated with poorly drained soils will cause the leachate to break out of the land fill without sufficient filtration and renovation by extended contact with the soil. The leachate then becomes a pollutant for both ground and surface water.

Table 20

SOIL LIMITATIONS FOR SANITARY LANDFILL OPERATIONS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Slope (percent)	<6	6-12	>12
Natural drainage (rating)	Well Moderately well	Somewhat poorly	Poorly
Depth to water table (feet)	>12	6-12	<6
Depth to bedrock (feet)			
Hard (unfractured)	> 6	3- 6	<3
Limestone (fractured)	>12	6-12	<6
Sandstone (semipervious)	>12	6-12	<6
Flood hazard (rating)	None	Moderate	Severe
Soil texture (class[a])	sl, l, sil, scl	ls, si, cl, sicl	s, sic, sc, c, plus organic soils
Stones (rating)	None	Very stony	Extremely stony

[a] *See code of textural abbreviations in Table 5.*

Source: U.S. Soil Conservation Service.

Depth to bedrock is also a determining factor in site selection. There should be sufficient soil in the land fill over bedrock to leach out harmful substances. Leachate that enters fissured or pervious bedrock substratum without sufficient amelioration becomes a pollutant.

Flooding severely restricts the use of the soil for land fill. Flooding of the land fill by overflow or ponding of surface water increases leaching and the release of leachate to waterways without renovation by the soil. There is also a risk of erosion of the land fill by an overflowing stream. For these reasons, floodplains should not be used as sites for sanitary land fill operations.

Soil texture is very important to proper operation of land fill. Loamy soils that can be placed and compacted in all kinds of weather are the most desirable textures for sanitary land fill. Coarse textures will allow leachate to pass through the soil too rapidly for proper amelioration. Silt is unstable when wet and very erodible on finished surfaces. Sticky and plastic clay with a high shrink-swell potential will shrink and crack when dry and allow the escape of gases and the entrance of rodents and insects. Stones seldom prevent proper operation of the sanitary land fill but can interfere with covering operations.

SOIL INTERPRETATIONS FOR AGRICULTURAL PURPOSES

Soil surveys can be used as a guide to the suitability of soils for cropland, the kind of crops the soils can support, and the management needed to maintain their productivity from year to year. To simplify the information being collected and to promote understanding of soil problems, a system of land capability groupings was devised. The system is based on the limitations of soils for use as cropland. Yield information and woodland suitability groupings also aid in determining the best agricultural use for soils. Drainage and irrigation guides are helpful in solving problems of excess water or inadequate water supply.

Capability Groups of Soils

The soils of southeastern Wisconsin have been classified into capability groupings that indicate their general suitability for most kinds of farming. These are practical groupings based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. In this system all soils are grouped at three levels: the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by roman numerals I through VIII. In Class I are the soils that have few limitations, the widest range of use, and the least risk of damage when used. The soils in the other classes have progressively greater natural limitations. In Class VIII are soils and land forms so rough, shallow, or otherwise limited that they do not produce economically worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most classes there are up to four subclasses. The subclass is indicated by the addition of a lower case letter, e, w, s, or c, to the class numeral, as for example IIe. The letter e indicates that the main limitation to the use of the soil for cultivated crops is risk of erosion; w indicates that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s indicates that use of the soil for cultivated crops is restricted because it is shallow, drouthy, stony or has some other soil induced limitation; and c indicates that the use of the soil for cultivated crops is limited by climate that is too cold or too dry for optimum plant growth. In southeastern Wisconsin climate is not a limiting factor for soil use. There are no subclasses in Class I because the soils in this class have few or no limitations. Class V can contain only subclasses w and s because the soils in this class have little or no erosion hazard but have other limitations that restrict their use mainly to pasture, woodland, or wildlife.

Each subclass is further divided into capability units. These consist of groups of soils that are very similar and, therefore, suited to the same kind of crop and pasture plants, require similar management, and have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping of soils for management purposes. Capability units are identified by the addition of an arabic numeral code to the class and subclass code, as for example IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations, but without consideration of major and generally expensive land-forming practices that would change the slope, depth, or other characteristics of the soil and without consideration of possible but unlikely major reclamation projects. Most of the deep, well-drained, moderately permeable loamy soils are classified as Class I where they are nearly level. Theresa silt loam, 0 to 2 percent slope, for example, is classified as Class I-1. Sloping soils are susceptible to erosion because of runoff. The erosion hazard is primarily related to steepness of slope, and the soils are classed accordingly. Thus, Theresa silt loam, 2 to 6 percent slope, is classified as IIe-1; Theresa silt loam, 6 to 12 percent slope, is classified as IIIe-1; and Theresa silt loam, 12 to 20 percent slope, is classified as IVe-1. Slowly permeable and very slowly permeable soils generally restrict root growth and are poorly aerated in the lower part of the soil. This restriction is considered a soil or "s" factor. For this reason, soils such as Morley silt loam, 0 to 2 percent slope, are classified as IIs-7. Other soils, such as the sandy Spinks fine sand, 0 to 2 percent slope, that have low available water capacity and are subject to wind erosion are classified as IVs-3. Shallow soils, such as Knowles silt loam, shallow variant, 0 to 2 percent slope, have low water-holding capacity because they are less than 20 inches deep over bedrock. These soils are classified as IIIs-8. Most wet soils with high water tables have neither an erosion hazard nor available water deficiency. The excess water in these soils places them in IIw-1, IIw-2, or IIIw-3 after drainage.

Estimated Crop Yields

In most soil surveys, crop yields are given in terms of bushels per acre or tons per acre for two kinds of management programs. One kind of management represents an average for the survey area. The other represents better than average management. Both values represent yields under the state of agricultural technology existing at the time the interpretations were made and may become obsolete because of changing technology, including major improvement in seed varieties, cultural methods, and methods of weed and insect control. The estimated yields are most useful in comparing the productivity of different soils. Crop yields for soils in southeastern Wisconsin are given in Table 9 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide as Figure 32. As indicated in this excerpt, the corn yield to be expected at the time the survey was made in 1965 from Soil No. 2, Stinson silt loam, with average management is 60 bushels per acre. Soil No. 12, Wea silt loam, however, could be expected to yield 85 bushels per acre with the same kind of management. With improved management the yields from both soils increased about 60 percent. This indicates that, with further improved technology, the comparative yields would probably have the same ratio as the average yields. Thus, we can say that Wea soils will probably yield more corn than Stinson under any kind of management or technology. The value of soils for cropland, then, can validly be compared by examining the estimated crop yields. The various agricultural practices that represent the two kinds of management, "high" and "average," are discussed in SEWRPC Planning Report No. 8.

Figure 32

EXCERPT FROM TABLE 9 OF SEWRPC PLANNING REPORT NO. 8

ESTIMATED CROP YIELDS

Soil Number and Soil Name1/		Corn				Oats Grain-Bushels Per Acre		Alfalfa-Brome Hay-Tons Per Acre3/	
		Grain-Bushels Per Acre		Silage Tons Per Acre					
		High	Average	High	Average	High2/	Average	High	Average
2	Stinson silt loam	95	60	16	12	65	45	4.0	2.0
5	Same as No. 54, Lawson silt loam								
5W	Sawmill silt loam4/	110	5/	18	5/	5/	5/	5/	5/
7	Dorchester silt loam4/	110	80	18	13	70	50	4.5	3.5
7W	Same as No. 54, Lawson silt loam								
12	Wea silt loam	125	85	19	14	75	60	4.5	3.0
16	Rome silt loam	105	80	17	13	70	55	4.5	3.0
18	Same as No. 266, Sisson silt loam								

Source: U. S. Soil Conservation Service; SEWRPC.

Sprinkler Irrigation

Table 10 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide as Figure 33, is a sprinkler irrigation guide for soils, which contains soil information that provides a basis for the design and operation of a sprinkler irrigation system. The available water capacity and the water intake rate are important soil properties that affect the frequency and rate of water application. A system that successfully supplies water to crops as they need it, and at the same time conserves soil and water, must be designed to fit the crops and the soils that are being irrigated. Only those soils suitable for sprinkler irrigation systems are given consideration in Table 10. Soils that have similar physical characteristics have been grouped by capability units in the first column of the table. The capability unit for each soil in southeastern Wisconsin is listed at the end of the particular soil description found in Chapter IV of SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.

The description of the soils in the capability units summarizes the physical soil characteristics that are important to irrigation. Soil depth refers to the mean depth of each major soil horizon in successive order of occurrence below the surface. These are average depths of all the soils in the capability unit. The available moisture capacity given for each horizon, in inches per inch, is the average available moisture capacity of all the soils in the capability unit. The maximum water application rate is based on the average rate of water intake into the soil for bare and covered conditions. Bare soil condition refers to land planted in row crops where the land is exposed to compaction and the sealing effect of rainfall impact. On soils with grass cover, the vegetation or mulch absorbs the raindrop energy; and there is little or no surface sealing. The application rates given are for nearly level to gently sloping soils and do not apply to soils with slopes of 5 percent or more.

Figure 33

EXCERPT FROM TABLE 10 OF SEWRPC PLANNING REPORT NO. 8
SPRINKLER IRRIGATION GUIDE FOR SOILS

SOILS				CROPS					IRRIGATION SPECIFICATIONS				
Soil Capability Units	Description of Capability Units	Soil Depth (inches)	Available moisture capacity (inches per inch of soil depth)	Maximum water application rate (inches per hour)		Crop[1] Groups	Depth of soil to be irrigated (inches)	Peak moisture use rates (inches per day)	Total available moisture capacity of soil depth to be irrigated (inches)	Water to be applied at each irrigation (inches)	Water application time based on maximum water application rate (hours)		Maximum time to cover irrigated area based on peak-use rate (days)
				Bare Soil	With vegetative cover						Bare	Cover	
I-1 IIe-2	Deep, moderately permeable loam and silt loam soils with permeable substrata.					1	6	0. 10	1. 32	0. 79	1. 6	1. 0	6
		0-7	0. 22	0. 5	0. 8	2	12	0. 20	2. 64	1. 58	3. 2	2. 0	6
						3	18	0. 20	3. 72	2. 23	4. 5	2. 8	8
		7-12	0. 22			4	24	0. 20	4. 80	2. 88	5. 8	3. 6	11
						5	18	0. 25	3. 72	2. 23	4. 5	2. 8	7
		12-30	0. 18			6	24	0. 20	4. 80	2. 88	5. 8	3. 6	11
						7	24	0. 30	4. 80	2. 88	5. 8	3. 6	7
						8	36	0. 30	6. 90	4. 14	8. 3	5. 2	10
						Tobacco	12	0. 25	2. 64	1. 58	3. 2	2. 0	5
IIe-2	Moderately deep, moderately permeable, loam and silt loam soils with sand and gravel on dolomite bedrock substrata.					1	6	0. 10	1. 08	0. 65	1. 3	0. 8	5
		0-7	0. 18	0. 5	0. 8	2	12	0. 20	2. 16	1. 30	2. 6	1. 6	5
						3	18	0. 20	3. 00	1. 80	3. 6	2. 3	7
		7-12	0. 18			4	24	0. 20	3. 84	2. 30	4. 6	2. 9	9
						5	18	0. 25	3. 00	1. 80	3. 6	2. 3	5
		12-30	0. 14			6	24	0. 20	3. 84	2. 30	4. 6	2. 9	9
						7	24	0. 30	3. 84	2. 30	4. 6	2. 9	6
						8	30	0. 30	4. 68	2. 81	5. 6	3. 5	7
IIe-5 IIw-11	Deep, moderately permeable loam and silt loam soils on alluvial flood plains subject to occasional overflow.					1	6	0. 10	1. 20	0. 72	1. 4	0. 9	5
		0-7	0. 20	0. 5	0. 8	2	12	0. 20	2. 25	1. 35	2. 7	1. 7	5
						3	18	0. 20	3. 27	1. 96	3. 9	2. 5	7
		7-15	0. 17			4	24	0. 20	4. 29	2. 58	5. 2	3. 2	10
						5	18	0. 25	3. 27	1. 96	3. 9	2. 5	6
		15-42	0. 17			6	24	0. 20	4. 29	2. 58	5. 2	3. 2	10
						7	24	0. 30	4. 29	2. 58	5. 2	3. 2	6
						8	36	0. 30	6. 33	3. 80	7. 6	4. 8	10
						Tobacco	12	0. 25	2. 25	1. 35	2. 7		4

Source: U. S. Soil Conservation Service; ***SEWRPC.***

The crop groups represent a grouping of crops with similar root depths and similar peak moisture use rates. The depth of soil to be irrigated is given for each crop group. This depth is related to rooting characteristics of crops in each group and the purpose for which the crop is grown. The peak water-use rate for each crop group provides a basis for estimating the amount of water that must be supplied to the plant. The total available moisture in the soil depth to be irrigated provides a basis for calculating the amount of water that must be replaced in each irrigation. It may be calculated by multiplying the available moisture capacity for the various soil horizons by the appropriate depths to be irrigated.

The recommended amount of water, in inches, to be applied at each irrigation is based on irrigation efficiency of 75 percent. Irrigation efficiency is affected by evaporation losses, uneven distribution, and interception by foliage. It is also based on the assumption that irrigation is begun when 45 percent of the available moisture has been depleted from the soil depth to be irrigated. The application time, in hours, required to supply the necessary water by sprinkler irrigation for bare soil groups and for soils with cover is based on the total water to be applied at a selected rate of application. The maximum irrigation frequency, in days, or the maximum length of time between irrigations, in days, is based on the peak use rate of the crop being grown.

Drainage

The design of soil drainage systems requires some knowledge of the soil characteristics and how they will respond to drainage improvements (see Figure 34). Table 11 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide as Figure 35, is a drainage guide for soils. This table provides guidelines for the design and installation of farm drainage systems for capability units which include soils that normally benefit from drainage. The soil capability unit designation of each soil mapped in the Region can be found at the end of each soil description in Chapter IV of SEWRPC Planning Report No. 8. Capability units comprised of soils that do not need drainage or are not suitable for drainage are not listed in this table. The information provided in this table is not intended for use in designing urban drainage systems that are installed to lower water tables or to provide storm water drainage.

Woodlands

The soil survey can be used to determine the suitability of the soils for use as woodlands, for selecting suitable species, for predicting productivity, and for recognition of special hazards related to the soils.

Figure 34

SOIL DRAINAGE

Knowledge of soil characteristics and how they will respond to drainage improvements is necessary to the design of farm soil drainage systems. This photograph shows how ditching, diking, and a tile drainage system are being used to drain peat and muck soils.

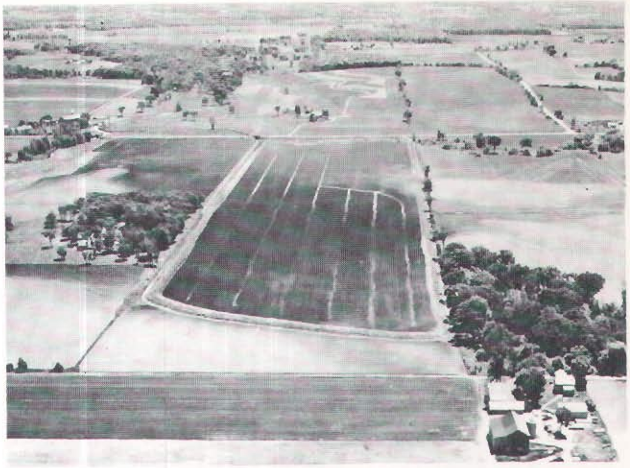


Figure 35

EXCERPT FROM TABLE II OF SEWRPC PLANNING REPORT NO. 8

DRAINAGE GUIDE FOR SOILS

Soil[4/] Capability Units	Description of Capability Units	Subsurface Drains[1/]		Surface Field Ditches Spacing[3/] (feet)	Remarks
		Depth (feet)	Spacing[2/] (feet)		
IIw-1	Deep, poorly drained, nearly level to sloping, moderate to slowly permeable loamy soils.	Tile Drain 3.0-4.0	Tile Drain 60-80	200-400	Divert upland runoff where possible. Surface drains needed to supplement tile. Land smoothing is usually beneficial.
IIw-2	Deep, somewhat poorly drained, nearly level to sloping, moderate to slowly permeable loamy to clayey soils.	Tile Drain 3.0-4.0	Tile Drain 60-80	200-400	Use random tile lines in complex topography. Divert upland runoff where possible. Surface drains needed to supplement tile. Land smoothing is usually beneficial. (See "IIIe-8" for "C" slopes.)
IIw-3	Moderately deep, somewhat poorly to poorly drained, nearly level to sloping moderately permeable loamy soils overlying dolomite bedrock.	Tile Drain 2.5-3.0	Tile Drain 60-90	200-400	May be tiled if sufficient depth over bedrock exists. Surface drainage is recommended. Land smoothing is beneficial.
IIw-5	Moderately deep, somewhat poorly to poorly drained, nearly level to sloping, moderately permeable, loamy soils overlying sand and gravel.	Open Ditch 2.5-3.0	Open Ditch 330-440	200-450	Tiling is questionable. If tiled, take precautions to prevent sand from entering tile system. Land smoothing is beneficial. Surface drainage is satisfactory for meadow and pasture crops. Use open ditch for subsurface drainage.

Source: U. S. Soil Conservation Service; SEWRPC.

Table 12 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide as Figure 36, indicates the limitations of soils for woodlands. Soils which respond similarly to use and management and are suitable for the same species have been classified together into woodland suitability groups. Factors such as soil drouth, plant competition, soil wetness, erosion hazard, equipment limitations, and wind-throw hazards are rated as having slight, moderate, or severe limitations for woodland development. A description of each woodland suitability group is given in Chapter VII of SEWRPC Planning Report No. 8. The particular woodland suitability group to which each soil type belongs is indicated at the end of the soil description in Chapter IV of SEWRPC Planning Report No. 8.

The estimated yields of selected species of trees on various soils of the Region are given in Table 13 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide in Figure 37. These data represent the estimated average annual production in gross board feet of lumber per acre. The yields are for fully stocked, unmanaged areas with enough trees to fully utilize the site. No deduction is made for culls or defective trees. Yields for white pine and red pine are for areas that are being managed intensively and where trees are harvested at optimum age. Material cut in thinning is included in white and red pine yields.

Figure 36

EXCERPT FROM TABLE 12 OF SEWRPC PLANNING REPORT NO. 8
THE USE OF SOILS FOR WOODLAND

Woodland Suitability Group	Description	Hazards Affecting Seedling Survival			Erosion Hazard	Windthrow Hazard	Equipment Limitation for		Species Suitability	
		Drouth	Plant Competition	Wetness			Tree Planting	Timber Harvest	Natural Stands	Plantations
1	Moderately deep and deep, well to moderately well drained, medium textured soils, with less than 12 percent slopes.	Slight	Severe	Slight	Slight	Slight	Slight	Slight	Maple, basswood, red oak, white pine	White pine, Norway pine, white spruce
	Soils in Group 1 but with slopes of 12 percent or more.	Slight on northeast; moderate on southwest	Severe	None	Moderate	Slight	Moderate to Severe	Moderate to Severe	Same as above	Same as above
2	Moderately deep and deep, moderately well to well drained fine textured soils with less than 12 percent slopes.	Slight	Severe	Slight	Slight	Slight	Moderate	Moderate	Maple, basswood, white oak, red oak, white ash	White pine, white spruce
	Soils in Group 2 with slopes of 12 percent or more.	Moderate	Severe	Slight	Moderate	Slight	Severe	Severe	Same as above	Same as above
3	Moderately deep and deep, moderately coarse textured, somewhat excessively drained soils with less than 12 percent slopes.	Moderate	Moderate	None	Moderate	Slight	Slight	Slight	White pine, Norway pine, red oak	White pine, Norway pine
	Group 3 soils with slopes of 12 percent or more.	Moderate on north slopes; Severe on south slopes	Moderate (brush on north slopes)	None	Severe	Slight	Moderate to Severe	Moderate to Severe	Same as above	Same as above

Source: U. S. Soil Conservation Service; SEWRPC.

Figure 37

EXCERPT FROM TABLE 13 OF SEWRPC PLANNING REPORT NO. 8
WOODLAND YIELDS

Soil Name [1]	Woodland Suitability Group	Lumber Yield in Board Feet per Acre			
		Mixed Hardwood	Oak	Red Pine	White Pine
Adrian muck	10	100-200	-	-	-
Adrian muck, clay substratum	10	100-200	-	-	-
Adrian mucky peat	10	100-200	-	-	-
Alluvial land	1	200-275	-	-	-
Alluvial land, rock substratum	9	50-100	-	-	-
Alluvial land, wet	9	100-200	-	-	-
Argyle silt loam	1	-	160-190	-	-
Ashford silt loam	5	200-250	160-190	-	-
Ashkum silty clay loam	7	-	80-120	-	-
Beecher silt loam	7	-	160-190	-	-

Source: U. S. Soil Conservation Service; SEWRPC.

SOIL INTERPRETATIONS FOR AESTHETIC AND RECREATIONAL PURPOSES

The limitations and capabilities of soils for various plantings, park and recreational uses, and wildlife habitat are of great interest to those desiring to control erosion, conserve water and moisture, improve water quality, promote beauty, protect wildlife, screen unsightly developments, and develop recreational facilities. SEWRPC Planning Report No. 8 contains several interpretive tables showing these limitations and capabilities.

Plant Materials for Beautification and Soil Stabilization

Before disturbance of the soil by man, trees, shrubs, and grass grew in locations most favorable to them. Their very survival or return from year to year indicated that they were suitable to the environment in which they were growing. Man has, however, upset the ecology by disturbing the soil in various ways. In the early history of the use of soils for cropland, trees were removed to make way for the plow. Then roads were built to provide access to markets. Superhighways were built to allow easy travel between cities. Cities expanded to areas that once were farmland, now devoid of the original trees. With this expansion came urban dwellers looking for the trees that were removed a hundred years ago. Failing to find trees, shrubs, and grass, they turned to planting. The architect and the planner recognize the erosion reducing value and aesthetic value of vegetative soil cover; but it remains for the agronomist, plant ecologist, and forester to name the species best suited for a particular purpose and soil.

Herbaceous Planting Guide: Table 14 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in Figure 38 of this Guide, is a herbaceous planting guide and includes recommended plants suitable for use in critical areas, open areas, golf course roughs, lawns, golf course fairways, and play areas. The soils are grouped by soil capability units and according to drainage class, texture, and depth. The first group listed is described as moderately deep to deep, moderately well to well drained, medium textured soils, with good moisture-supplying capacity for plant growth. Soils such as those in the Dodge,

Figure 38

EXCERPT FROM TABLE 14 OF SEWRPC PLANNING REPORT NO. 8
HERBACEOUS PLANTING GUIDE

Soil Capability Units	Brief Descriptions of Soils in Units	SUITABLE MIXTURES AND SUGGESTED SEEDING RATES FOR						
		Stabilization of Critical Areas 1/	Open Areas; Permanent Vegetation	Golf Course Roughs	Lawns	Golf Course Fairways	Extensive Play Areas 2/	Intensive Play Areas 3/
					SUNNY EXPOSURES			
IIw-1 IIw-2 IIw-3 IIw-5 IIw-8 IIw-13 IIIe-8 IIIw-1 IIIw-3 IIIw-5 IIIw-6 IIIw-8 IIIw-9 IVe-8 IVw-3 IVw-5 IVw-7 Vw-7 Vw-14	Somewhat poorly to poorly drained soils with high moisutre supplying capacity for plant growth and with adequate artificial drainage.	*NOT SPRAYED FOR WEED CONTROL* 10 lbs. of seed per acre comprised of 8 lbs. Empire birdsfoot trefoil 2 lbs. Kentucky bluegrass 18 lbs of seed per acre comprised of 6 lbs. Empire birdsfoot trefoil 4 lbs. Smooth brome 8 lbs. Tall fescue *SPRAYED FOR WEED CONTROL* 33 lbs of seed per acre comprised of 22 lbs. Smooth brome 11 lbs. Tall fescue 25-30 lbs. per acre of smooth brome	8 lbs. of seed per acre comprised of 6 lbs. Empire birdsfoot trefoil 2 lbs. Timothy or bluegrass 8-11 lbs. of seed per acre comprised of 4-5 lbs. Alsike clover 4-6 lbs. Smooth brome	18 lbs. of seed per acre comprised of 12 lbs. Kentucky bluegrass 6 lbs. Creeping red fescue	22-1/2 lbs. of seed per acre comprised of 15 lbs. Kentucky bluegrass 7-1/2 lbs. Creeping red fescue *Home Owners:* Without proper seeding equipment, 1-1/4 to 1-3/4 lbs. of mixture (2 parts Kentucky bluegrass, 1 part Creeping red fescue) per 1,000 square feet.	27 lbs. of seed per acre comprised of 18 lbs. Kentucky bluegrass 9 lbs. Creeping red fescue	33 lbs. of seed per acre comprised of 22 lbs. Kentucky bluegrass 11 lbs. Creeping red fescue	39 lbs. of seed per acre comprised of 26 lbs. Kentucky bluegrass 13 lbs. Creeping red fescue 29 lbs. per acre of Kentucky bluegrass
					PARTIAL SHADE			
		21 lbs. of seed per acre comprised of 7 lbs. Smooth brome 14 lbs. Tall fescue 24 lbs. of seed per acre comprised of 8 lbs. Kentucky bluegrass 16 lbs. Creeping red fescue	18 lbs. of seed per acre comprised of 6 lbs. Kentucky bluegrass 12 lbs. Creeping red fescue	21 lbs. of seed per acre comprised of 7 lbs. Kentucky bluegrass 14 lbs. Creeping red fescue	24 lbs. of seed per acre comprised of 8 lbs. Kentucky bluegrass 16 lbs. Creeping red fescue *Home Owners:* 1-1/4 - 1-3/4 lbs. of mixture (1 part Kentucky bluegrass, 2 parts Creeping red fescue) per 1,000 square feet.	Condition not probable	33 lbs. of seed per acre comprised of 11 lbs. Kentucky bluegrass 22 lbs. Creeping red fescue	39 lbs. of seed per acre comprised of 13 lbs. Kentucky bluegrass 26 lbs. Creeping red fescue

Source: U. S. Soil Conservation Service; SEWRPC.

Flagg, Lapeer, McHenry, and Miami series are included. Another group is described as shallow or sandy, somewhat excessive to excessively drained soils, with low moisture-supplying capacity for plant growth. This includes soils of series such as Boyer, Casco, Hochheim, Lorenzo, Rodman, and Spinks. A third group is described as somewhat poorly to poorly drained soils, with high moisture-supplying capacity for plant growth and with adequate artificial drainage. This group includes soils series such as Ashkum, Blount, Brookston, Lamartine, Lawson, Matherton, and Mussey. Another group is described as poorly drained soils with high moisture-supplying capacity for plant growth without adequate drainage. Soils in this group include the Ashkum, Brookston, Colwood, Granby, Keowns, Mussey, and other series.

The relative proportion of seeds for different uses has been varied according to the kind of cover that is needed. The mixtures suggested for critical areas, such as road cuts and fills, drainage ditches, and gully banks, are designed to control accelerated erosion. These areas receive very little traffic; but because of generally steep slopes, they are subject to rapid runoff and severe erosion hazard. The plants used for this purpose must be able to put down roots rapidly and withstand the erosive action of running water. Empire birdsfoot trefoil, Kentucky bluegrass, and creeping fescue or a combination of trefoil, smooth brome, and tall fescue have been suggested for these areas. For open areas where permanent vegetation is needed, a combination of vernal alfalfa and smooth brome or birdsfoot trefoil and timothy or Kentucky bluegrass can be used in sunny exposures. Creeping red fescue is used in some mixtures where the site is partially shaded or soils are somewhat poorly or poorly drained. For golf course roughs, lawns, golf course fairways, and extensive play areas, combinations of Kentucky bluegrass and creeping red fescue are suggested. Heavier seeding is suggested for areas such as lawns, golf course fairways, and intensive play areas that receive more foot traffic than golf course roughs and extensive play areas.

General Shrub and Vine Planting Guide: Table 15 in SEWRPC Planning Report No. 8, an excerpt from which is reproduced in Figure 39 of this Guide, is a general shrub and vine planting guide. The soil groupings in this table are similar to those used for the herbaceous planting guide. Shrubs and vines suitable for each soil group are listed. Ornamentals, plants for cover and wildlife food, and screens and windbreaks have also been listed. In addition, the shade tolerance uses, growth form, and aesthetic value of each plant are indicated. The uses are mainly concerned with urban landscaping or farm homesteads.

Figure 39

EXCERPT FROM TABLE 15 OF SEWRPC PLANNING REPORT NO. 8
GENERAL SHRUB AND VINE PLANTING GUIDE

Soil Capability Units	Brief Description of Units	Plant Species	Shade Tolerance	USES					GROWTH FORM				AESTHETIC VALUE			Remarks
				Landscape	Hedges Screens Windbreaks	Wildlife Food & Cover	Roadsides	Ground cover	Height (feet)	Type	Thorny	Thicket former	Flower	Fruit or Berry	Fall Color	
I IIe-1 IIe-2 IIe-5 IIe-6 IIe-7 IIs-1 IIs-7 IIw-11 IIIe-1 IIIe-2 IIIe-5 IIIe-6 IIIe-7 IVe-1 IVe-2 IVe-6 IVe-7 VIe-1 VIe-2 VIe-6 VIe-7 VIIe-1 VIIe-2 VIIe-6 VIIe-7	Moderately deep to deep, moderate to well drained, medium textured soils with good moisture supplying capacity for plant growth.	Arborvitae (shrub types) (Thuja species)	Some	x	x	x			3-7	Shrub					x	Conifer
		Barberry, Japanese (Berberis thunbergi)	x	x	x	x			6	Shrub	x			x	x	Colorful
		*Bittersweet (Celastrus scandens)	x	Some		x	x	x	Climbs	Vine				x	x	Male and female plants--can injure trees.
		*Blackberry, dewberry blackcap, raspberry (Rubus species)				x	x	x	1-5	Bramble	x	x	x	x	x	Many species-edible.
		*Chokeberry, black (Aronia melanocarpa)	x	x		x	x	x	1-3	Shrub		x		x	x	
		Cotoneaster (Cotoneaster species)		x	x	x			4-8	Shrub				x	x	Usually glossy foliage--sun lovers
		Crabapple (Malus species)		x	x	x	x		Up to 25	Shrub			x	x	x	Much used large shrub.
		Current, Alpine (Ribes alpinum)	x	x	x				6-7	Foliage shrub			x			Leafs out early--especially
		*Dogwood, gray (Cornus racemosa)	x			x	x		6-10	Shrub			x	x	x	
		*Dogwood, Pagoda (Cornus alternifolia)	x			x	x		10-15	Shrub			x	x	x	
		*Dogwood, redosier (Cornus stolonifera)	x	Some					3-9	Shrub		x	x	x	x	Attractive red twigs.
		*Dogwood, roundleaf (Cornus rugosa)	x			x	x	x	3-9	Shrub			x	x	x	
		*Dogwood, silky (Cornus amomum)	x		x	x	x		6-10	Shrub			x	x	x	
		*Elder, American (Sambucus canadensis)				x	x		3-10	Shrub		x	x	x		
		*Filbert (hazelnut) (Corylus americana)	x			x	x		5-8	Shrub		x		x	x	Bears edible nuts.
		Forsythia (Forsythia species)	x	x					4-8	Shrub			x			Early yellow blooms.

Source: U. S. Soil Conservation Service; SEWRPC.

Landscaping, hedges, screens, windbreaks, cover and food for wildlife, roadside plantings, and plants for ground cover are included. The list of plants for somewhat poorly and poorly drained soils is much shorter than that for well-drained soils, since only water tolerant plants are listed for the wet soils. The indicated growth form and height will enable users to determine whether a given species is suitable for the use intended. The aesthetic value as flowers, fruit, or for fall color is also indicated for each plant.

Tree Plantings and Selection Guide: A general landscape guide for the planting and selection of various trees is given by woodland suitability group in Table 16 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in Figure 40 of this Guide. With the expansion of urban areas, the use of trees for ornament and shade has become increasingly important. Differences in size, shape, and suitability for different soil conditions should be considered when selecting trees for landscaping or windbreaks. Some trees are more satisfactory for street trees than others. Some are suitable for shade and lawn trees and others for hedges and windbreaks.

The tree planting guide recommends suitable species for sheltered coves, north and east slopes, exposed ridges, south and west slopes, shade, streets, lawns, hedges, screens, and windbreaks. The first letter in parentheses indicates height: S, less than 30 feet; M, 30 to 60 feet; and C, more than 60 feet. The second letter indicates shape: C, columnar; O, oval; P, pyramidal; Pe, pendulus; R, round; and U, umbrella. The decisions to plant a given tree will no doubt be affected by the tree shape and the availability of suitable trees. As an example in using this tree planting guide, assume that an urban dweller has built his house on Spinks fine sand. This soil is in Woodland Group 4. He wants to plant a tree for shade, and he prefers a tree of medium height. According to the guide, scarlet oak, hackberry, and green ash are satisfactory for this purpose on this group of soils. His choice will depend on the shape he prefers.

Figure 40

EXCERPT FROM TABLE 16 OF SEWRPC PLANNING REPORT NO. 8
TREE PLANTING AND SELECTION GUIDE

Brief Description of Soils in the Woodland Suitability Group	WOODLANDS		TREES FOR LANDSCAPE PLANTING			
	Sheltered Coves N & E Slopes	Exposed Ridges S & W Slopes	Shade Trees	Street Trees	Lawn Trees	Hedges, Screens & Windbreaks
1 Moderately deep to deep, moderately well to well drained medium textured upland soils	Sugar Maple Basswood White Ash Black Walnut White Pine White Spruce White Cedar Red Pine	Red Pine White Pine	SUNNY SITES			
			American Beech (LO) Sugar Maple (LO) Red Maple (MO) Red Oak (LR) White Oak (LR) Basswood (LO) Hackberry (MR) White Ash (LO) Sycamore (LO) Bur Oak (LR) Norway Maple (MR) Silver Maple (LO) Thornless Honey Locust (MO)	Norway Maple (MR) S. Pin Oak (MP) Thornless Honey Locust (MO) Basswood (LO) White Ash (LO) Sugar Maple (LO) Hackberry (MR) Red Maple (MO)	Flowering Crab (SR) Mt. Ash (SO) Blue Beech (SR) Paper Birch (MO) River Birch (MO) Russian Olive (SR) S. Pin Oak (MP) Serviceberry (SR) Horse Chestnut (LR) Norway Spruce (LP) Red Pine (LP) White Pine (LP) White Spruce (MP) Black Cherry (LO) Blue Spruce (LP) Norway Spruce (LP) Hawthorn (SR)	Red Cedar (SP) White Cedar (MC,P) White Pine (LP) White Spruce (MP) Lombardy Poplar (LC) Russian Olive (SR) Upright Yew (SP)
			PARTIAL SHADE			
			American Beech (LO) Sugar Maple (LO) Red Maple (MO) Red Oak (LR) Hackberry (MR) White Ash (LO) Basswood (LO)	Norway Maple (MP) White Ash (LO) Basswood (LO) Sugar Maple (LO)	Blue Beech (SP) Serviceberry (SR) White Pine (LP) White Spruce (MP) Blue Spruce (LP) Norway Spruce (LP)	White Cedar (MC) White Pine (LP) White Spruce (MP) Upright Yew (SP)

Source: U. S. Soil Conservation Service; SEWRPC.

Recreational Developments

The suitability of soils for various park and recreational developments is given in Table 17 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide in Figure 41. These park and recreation developments include playgrounds, athletic fields, and other intensive play areas; picnic areas, parks, and other extensive use areas; bridle, nature, and hiking trails; golf course fairways; cottages and service and utility buildings; and camping sites.

Figure 41

EXCERPT FROM TABLE 17 OF SEWRPC PLANNING REPORT NO. 8
THE USE OF SOILS FOR RECREATIONAL DEVELOPMENTS

Map Number and Soil Name	Playgrounds, Athletic Fields and Other Intensive Play Areas	Picnic Areas, Parks and Other Extensive Use Areas	Bridle Paths, Nature and Hiking Trails	Golf Course Fairways	Cottages, Service and Utility Buildings	Tent and Trailer Camp Sites
47 Yahara loam	MODERATE - seasonal high water table; needs water management; erosive on slopes.	MODERATE - seasonal high water table; needs water management; heavy foot traffic may damage sod in wet seasons.	SLIGHT - trails and paths remain wet for short periods during seasonal high water table; sloping areas have an erosion hazard.	MODERATE - will support a firm turf; low relief; seasonal high water table; needs water management.	VERY SEVERE - sewage disposal questionable due to periodic high water table; low bearing capacity when wet; liquefies easily.	MODERATE - surface tends to remain wet for short periods; areas may need drainage.
47Z Same as No. 370, Mosel sandy loam						
48 Keowns silt loam	SEVERE - high water table; needs drainage; limited in vegetation it will support; compacts easily when wet.	SEVERE - high water table; needs drainage; limited in vegetation it will support.	SEVERE - trails and paths are often wet for long periods due to high water table; muddy and slippery when wet; may need surfacing.	SEVERE - high water table; needs drainage; very low relief; turf easily damaged when wet.	VERY SEVERE - high water table; sewage disposal difficult; liquefies easily; low bearing capacity when wet.	SEVERE - high water table; sites remain wet and soft for long periods; poor trafficability when wet; walk and roads need surfacing.
48Z Same as No. 340, Navan silt loam						
49 Keowns fine sandy loam	SEVERE - high water table; needs drainage; limited in vegetation it will support.	SEVERE - high water table; needs drainage; sod is easily damaged unless soils are drained; limited in vegetation it will support.	MODERATE - trails and paths are often wet for long periods due to high water table.	SEVERE - high water table; needs drainage; heavy traffic during periods of high water table may damage turf; very low relief.	VERY SEVERE - high water table; sewage disposal difficult; liquefies easily; low bearing capacity when wet.	SEVERE - high water table; sites remain wet for long periods; areas need drainage or fill.
49Y Same as No. 49, Keowns fine sandy loam						
51 Aztalan loam	MODERATE - seasonal high water table; needs water management; erosive on slopes.	MODERATE - seasonal high water table; needs water management; heavy foot traffic may damage sod in wet seasons unless drained.	MODERATE - trails may be wet during periods of seasonal high water table.	MODERATE - seasonal high water table; needs water management; low relief; turf easily damaged when wet.	VERY SEVERE - sewage disposal is difficult; seasonal high water table; high shrink-swell potential.	MODERATE - surface tends to remain wet for short periods; areas may need drainage.
52 Aztalan sandy loam	MODERATE - seasonal high water table; needs water management; erosive on slopes.	MODERATE - seasonal high water table; needs water management; heavy foot traffic may damage sod in wet seasons unless drained.	SLIGHT - trails may be wet during periods of seasonal high water table.	MODERATE - low relief; seasonal high water table; needs water management; erosive on slopes.	VERY SEVERE - sewage disposal is difficult; seasonal high water table; high shrink-swell potential.	MODERATE - surface tends to remain wet for short periods; areas may need drainage.

Source: U. S. Soil Conservation Service; SEWRPC.

Intensive Play Areas: A distinction is made between intensive play areas and extensive play areas. Playgrounds and athletic fields are examples of intensive play areas (see Figure 42). These areas are used mainly for organized games. They are subject to relatively heavy foot traffic. They should be nearly level with no rocks, stones, or gravel on the soil surface. Soils used for this purpose should be well drained, with the texture and structure usually associated with moderate or moderately rapid permeability. Preferably the soils should not be subject to overflow, but occasional overflow during periods of nonuse can be tolerated. Examples of soils with few or no limitations for use as intensive play areas are nearly level Fox loam, Warsaw loam, Lapeer sandy loam, and Knowles loam. Gently sloping (2 to 6 percent) areas of these soils are somewhat limited for use. Slopes of 6 to 12 percent are too steep for playgrounds or athletic fields. Colwood silt loam, Sebewa silt loam, and Poygan silt loam are examples of soils with high water tables that restrict their use for intensive play areas. Rodman gravelly loam is undesirable because it is drouthy, steep, and has stones and gravel on the soil surface. Well-drained soils, such as Kewaunee silt loam or Saylesville silt loam, dry slowly because of moderately slow permeability. A composite analysis of soil limitations for playground development is presented in Table 21.

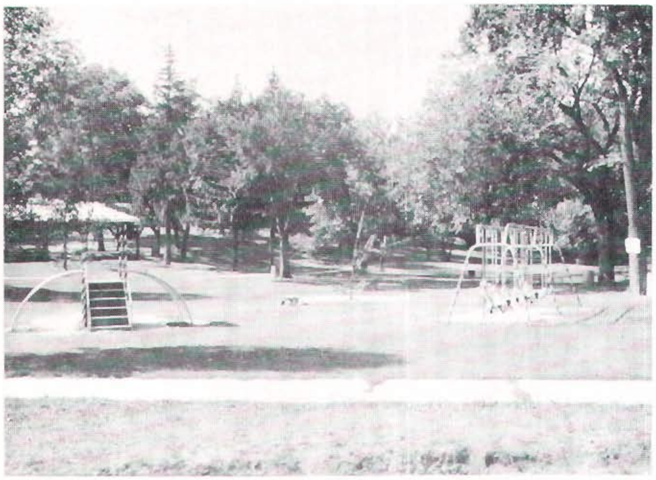


Figure 42

INTENSIVE PLAY AREAS

Intensive play areas in parks and playgrounds are subject to relatively heavy foot traffic. Soils data can help in the site selection for such areas. Soils used for intensive play areas should be well drained with rapid permeability and nearly level slope. Each soil type in the Southeastern Wisconsin Region is rated for intensive play use.

Table 21
SOIL LIMITATIONS FOR PLAYGROUNDS

	Degree Of Limitation		
Soil Features Affecting Use	Very Slight And Slight	Moderate	Severe And Very Severe
Wetness (rating)	Excessive, somewhat excessive, well, and moderately well drained soils. Water table below 30'' during season of use.	Moderately well and somewhat poorly drained soils. Water table below 20'' during season of use.	Somewhat poorly, poorly, and very poorly drained soils. Water table above 20'' during season of use.
Flood hazard (recurrence)	None during season of use.	Floods once in two years during season of use.	Floods more than once in two years during season of use.
Permeability (rating)	Very rapid to moderate, inclusive.	Moderately slow and slow.	Very slow.
Slope (percent)	< 2	2-6	> 6
Surface soil texture (class[a])	sl, l, sil	cl, scl, sicl, ls	sc, sic, c, plus organic soils, sand subject to blowing.
Depth to bedrock (inches)	>40	20-40	<20
Coarse fragments on surface[b] (percent)	Relatively free	20	>20
Stoniness[c] (percent of surface area)	< 0.01	0.01-3.0	> 3.0
Rockiness[d] (percent of surface area)	< 2	2-10	>10

[a] *See code of textural abbreviations in Table 5.*

[b] *Includes all rock fragments such as pebbles, cobblestones, stones, channery, and flags that are larger than sand size grains (more than 2 mm in diameter).*

[c] *Rounded fragments more than 10 inches in diameter.*

[d] *Bedrock exposure above soil surface.*

Source: U.S. Soil Conservation Service.

Extensive Play Areas: Extensive play areas include picnic areas and parks that normally receive much less foot traffic than athletic fields and playgrounds. Deep, well-drained, loamy, moderately permeable soils have slight limitations for this use because vegetative cover is relatively easy to maintain, the surface soil is usually dry, and water does not pond on the surface soil after rains. Occasional flooding is not a severe hazard in the well-drained soils because use of the areas will be lost for a short time only. Gentle slopes have slight limitations because gradients up to 6 percent do not restrict activities related to picnic areas and parks.

A comparison of interpretations for soils used as examples for intensive play areas show that there are few or no limiting factors for use of gently sloping soils of the Fox, Warsaw, Lapeer, and Knowles, as well as the nearly level soils, as extensive play areas. Sloping soils of these series are moderately limited for extensive use, such as picnic areas, but are severely limited for intensive play areas. High water tables in poorly drained soils restrict use of these soils for both intensive and extensive play areas. Sloping soils of the Kewaunee, Saylesville, and Lorenzo series have moderate limitations for extensive play areas. Occasional flooding somewhat limits use of soils for extensive play areas but is not a serious problem. A composite analysis of the soil limitations for picnic areas is presented in Table 22.

Table 22

SOIL LIMITATIONS FOR PICNIC AREAS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Wetness (rating)	Excessive, somewhat excessive, well, and moderately well drained soils. Water table below 20" during season of use.	Moderately well and somewhat poorly drained soils. Water table during season of use above 20" for short periods.	Poorly and very poorly drained soils. Water table above 20" and often near the surface for a month or more during season of use.
Flood hazard (recurrence)	None during season of use.	Floods up to two times for short periods during season of use.	Floods more than two times during season of use.
Slope (percent)	<8	8-15	>15
Surface soil texture (class[a])	sl, l, sil	cl, scl, sicl, ls, and sand other than loose sand.	sc, sic, c, loose sand, organic soils, and soils subject to severe blowing.
Coarse fragments on surface[b] (percent)	<20	20-50	>50
Stoniness[c] (percent of surface area)	<3	3-15	>15
Rockiness[d] (percent of surface area)	<10	10-25	>25

[a] *See code of textural abbreviations in Table 5.*

[b] *Includes all rock fragments such as pebbles, cobblestones, stones, channery, and flags that are larger than sand size grains (more than 2 mm in diameter).*

[c] *Rounded fragments more than 10 inches in diameter.*

[d] *Bedrock exposure above soil surface.*

Source: U.S. Soil Conservation Service.

Bridle Paths and Nature and Hiking Trails: Criteria for determining limitations of soils for bridle paths and nature and hiking trails include soil texture, natural drainage, flood hazard, erosion hazard, and presence of stones. Ideally, the paths and trails are located in well-drained areas that are not slippery when wet, that do not have a severe erosion hazard, and in which there are few stones and rock outcrops. The gradient should be less than 12 percent for both paths and trails.

Soil texture is the principal factor that affects trafficability of soils when wet. Silty surface soils usually are slippery and wet after rains and dry more slowly than do loam or sandy loam soils. Silty soils are also dusty when dry. Steep gradients usually are not satisfactory for either paths or trails because most users prefer less than 12 percent slopes. Where soil slopes are steep, the paths and trails can be placed on contour or near contour lines to prevent excessive erosion. A path or trail with excessive gradient could be the beginning of a gully if not properly maintained. Occasional flooding of short duration, although a limitation, is not severe because use of the facility can generally be resumed within a short time after recession of the water. Frequent flooding, however, will severely restrict use of the paths or trails. Stones and rock outcrops are undesirable. Poorly drained soils are generally too wet for satisfactory use for hiking or riding. Somewhat poorly drained sandy loam soils with seasonal high water tables have slight limitations because they usually are dry during the peak use period. The somewhat poorly drained soils with silt loam and loam surface soils have moderate limitations. A composite analysis of soil limitations for path and trail development is presented in Table 23.

Table 23

SOIL LIMITATIONS FOR PATHS AND TRAILS[a]

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Wetness (rating)	Excessive, somewhat excessive, well, and moderately well drained soils. Water table below 20" during season of use.	Somewhat poorly drained soils. Water table during season of use above 20" for short periods.	Poorly and very poorly drained soils. Water table above 20" and often near surface during season of use.
Flood hazard (recurrence)	Floods once a year during season of use.	Floods up to three times during season of use.	Floods more than three times during season of use.
Slope (percent)	<15	15-25	>25
Surface soil texture (class[b])	sl, l, sil	sicl, scl, cl, ls	sc, sic, c, sand and organic soils
Coarse fragments on surface[c] (percent)	<20	20-50	>50
Stoniness[d] (percent of surface area)	< 0.1	0.1-3.0	> 3.0
Rockiness (percent of surface area)	<10.0	10.0-25.0	>25.0

[a] *This guide sheet applies to soils to be used for local and cross-country footpaths and trails and for bridle paths. It is assumed that these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled). Soil features that affect trafficability, dust, design, and maintenance of trafficways are given special emphasis in this Guide.*

[b] *See code of textural abbreviations in Table 5.*

[c] *Includes all rock fragments such as pebbles, cobblestones, stones, channery, and flags that are larger than sand size (more than 2 mm in diameter).*

[d] *Rounded fragments more than 10 inches in diameter and bedrock exposure.*

Source: U. S. Soil Conservation Service.

Golf Course Fairways: Golf course fairways require well-drained, nearly level, or gently sloping soils with no stones or gravel and little flood hazard during the period of use. Soils that provide firm footing and will grow good turf are most desirable. Sandy loam, loam, or silt loam soils have less limitations than other soils because they are generally relatively firm and hold sufficient moisture and fertility to grow good turf. Slopes greater than 6 percent are excessive because they could cause erratic ball action and difficult walking. Well-drained soils with moderate or moderately rapid permeability are desirable for golf course fairways. These kinds of soils dry quickly after rains and provide a high percentage of playing time during the season. Occasional flooding can be tolerated on the well-drained bottom land soils. Frequently flooded soils, however, have severe limitations. Stones or rocks are undesirable because of the possibility of diverting the direction of the roll of the ball. Soils such as nearly level or gently sloping Warsaw loam, Dodge silt loam, Sisson silt loam, and Mayville silt loam have few limitations for golf course fairways. Soils such as Keowns fine sandy loam, Sebewa sandy loam, and Brookston silt loam have severe limitations because of the wetness that accompanies a high water table. Soils of the Spinks and Boyer series have a low available water capacity, are drouthy, and will not grow adequate turf without supplemental irrigation. A composite analysis of the soil limitations for golf course fairways is presented in Table 24.

Table 24

SOIL LIMITATIONS FOR GOLF COURSE FAIRWAYS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Wetness (rating)	Excessive, somewhat excessive, well, and moderately well drained soils. Water table below 20" during season of use.	Somewhat poorly drained soils. Water table during season of use above 20" for short periods.	Poorly and very poorly drained soils. Water table above 20" during season of use.
Flood hazard (recurrence)	Floods once a year during season of use.	Floods up to three times during season of use.	Floods more than three times during season of use.
Slope (percent)	< 6	6-12	>12
Surface soil texture (class [a])	sl, l, sil	sicl, scl, cl, ls	sc, sic, c, sand, and organic soils
Coarse fragments on surfaces[b] (percent)	< 1	1-5	>5
Stoniness[c] (percent of surface area)	<0.01	0.01-3.0	>3.0
Rockiness[d] (percent of surface area)	< 2	2-10	>10
Permeability (rating)	Very Rapid Rapid Moderately rapid Moderate	Moderately slow Slow	Very slow

[a] *See code of textural abbreviations in Table 5.*

[b] *Includes all rock fragments such as pebbles, cobblestones, stones, channery, and flags that are larger than sand size grains (more than 2 mm in diameter).*

[c] *Rounded fragments more than 10 inches in diameter.*

[d] *Bedrock exposure above soil surface.*

Source: U. S. Soil Conservation Service.

Cottages and Service and Utility Buildings: The interpretations for the buildings connected with recreational development include limitations for septic tank filter fields because many such developments do not have access to public sewerage systems. The interpretations for septic tank filter fields for soils near the buildings have been combined with interpretations for soils upon which building foundations are resting. Some soils may have favorable characteristics for building foundations but, because of high water tables or steep slopes, have severe limitations for on-site sewerage systems. In addition to factors that affect sewage disposal, such as natural drainage and flood hazard, the interpretations include factors such as bearing capacity, stability, shrink-swell potential, and frost heave at the building site.

Examples of soils with few limitations for buildings in recreational developments include nearly level and gently sloping soils of the Casco, Warsaw, and Miami series. The permanent high water tables in poorly drained soils, such as Navan silt loam, Ashkum silty clay loam, Matherton silt loam, and Brookston silt loam, severely restrict the use of on-site sewage disposal systems and construction of buildings. Some soils, such as Boyer loamy sand and Spinks fine sand, are drouthy; and ground water contamination from on-site sewage is likely.

Tent and Trailer Campsites: Campsites that are suitable for either tents or trailers should be located on nearly level, relatively deep, well-drained soils that are free of stones and do not flood (see Figure 43). The presence of gravel is a limitation for tent campsites but can be tolerated for trailer campsites. These sites are appraised in their natural conditions without benefit of a hard surface cover. The soils should not be slippery when wet. Vegetative cover should be easy to maintain. Wetness or flooding are severe limitations because these factors prevent use of the sites during part of the use season. Silty soils with surface soils such as McHenry silt loam, Dodge silt loam, or Warsaw silt loam have moderate limitations because the surface is slippery when wet and very dusty when dry. Loam or sandy loam soils do not have

Figure 43
CAMPSITE AREAS

Nearly level, relatively deep, well-drained soils that are free of stones make the best campsite areas for either tents or trailers. In addition, the soils should not be slippery when wet. The detailed soils data available in the Southeastern Wisconsin Region can assist in the selection of suitable campsite areas.

this limitation. Examples of soils with few or no limitations are Casco sandy loam, Sisson fine sandy loam, and Lapeer sandy loam. Wetness severely restricts the use of soils of the Colwood, Sebewa, and Poygan series for campsites. A composite analysis of soil limitations for camp development is presented in Table 25.

Wildlife Habitat Development

Most species of wildlife range over a wide land area that includes several kinds of soils. The kinds and amounts of wildlife on a soil are closely related to the kinds and amount of vegetation, its distribution over a given area, the topography of the soil areas, the flood hazard, the degree of wetness, and the availability of water (see Figure 44). Although tracking tests indicate that most species of wildlife occupy a definite area and are equipped for a special kind of habitat, they do make use of a wide variety of soils. They often feed in one area and nest or find protective cover in another. A variety of soils, within the home range of a given species, usually provides the most productive habitat.

Table 25

SOIL LIMITATIONS FOR CAMP AREAS

Soil Features Affecting Use	Degree Of Limitation		
	Very Slight And Slight	Moderate	Severe And Very Severe
Wetness (rating)	Excessive, somewhat excessive, well, and moderately well drained soils. Water table below 30" during season of use.	Moderately well and somewhat poorly drained soils. Water table below 20" during season of use.	Somewhat poorly, poorly, and very poorly drained soils. Water table above 20" during season of use.
Flood hazard (recurrence)	None	None during season of use.	Floods during season of use.
Permeability (rating)	Very rapid to moderate, inclusive.	Moderately slow Slow	Very slow
Slope (percent)	<8	8-15	>15
Surface soil texture (class[a])	sl, l, sil	cl, scl, sicl, ls, and sand other than loose sand.	Organic soils, sc, sic, loose sand, and soils subject to severe blowing.
Coarse fragments on surface[b] (percent)	<20	20-50	>50
Stoniness[c] (percent of surface area)	<0.01	0.1-3.0	>3.0
Rockiness[d] (percent of surface area)	<2	2-10	>10

[a] *See code of textural abbreviations in Table 5.*

[b] *Includes all rock fragments such as pebbles, cobblestones, stones, channery, and flags that are larger than sand size grains (more than 2 mm in diameter).*

[c] *Rounded fragments more than 10 inches in diameter.*

[d] *Bedrock exposure above soil surface.*

Source: U. S. Soil Conservation Service.

Figure 44

WILDLIFE HABITAT DEVELOPMENT

Vegetation, topography, wetness, and the availability of water are the key factors in the development of wildlife habitat. A variety of soils within the home range of a given species of wildlife usually provides the most productive habitat. This photograph shows wildlife area development adjacent to cropland, with substantial plantings on the steep slopes.

Appraisal of the limitations of a single soil for a specific kind of wildlife is difficult. It is possible, however, to appraise a specific kind of soil for wildlife on the basis of the degree that it provides habitat (food, shelter, and nesting area) for a given species. This has been done in Table 18 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide in Figure 45. The ratings for each soil are based on major habitat requirements for the species in question. Only the major limitations and hazards for different kinds of wildlife are listed for each soil.

A wide range of habitat has been separated into habitat elements that represent different kinds of food, cover, denning, and nesting areas required by animals and birds. These include grain and seed crops; grasses and legumes; herbaceous upland plants; woody plants, hardwood; woody plants, conifers; herbaceous wetland plants; and water developments. Each soil has been appraised for its ability to furnish the kind of habitat needs for a specific wildlife group. The importance of each kind of habitat to different kinds of wildlife has been considered in assigning a degree of limitations to a soil. As an example, consider soils of the Casco series, a well-drained loamy soil underlain by sand and gravel. The limitations for migratory waterfowl, such as ducks and geese, and fur bearing animals, such as muskrat, are severe because it is very difficult to provide open water for these water-oriented animals and birds and wetland herbaceous plants do not grow on the soil. The limitations for upland game birds, such as grouse, quail, and pheasants; song birds; small game, such as rabbits and squirrels; and big game, such as deer, are slight because the soils are capable of furnishing adequate food, cover, and nesting areas for these

Figure 45

EXCERPT FROM TABLE 18 OF SEWRPC PLANNING REPORT NO. 8
LIMITATIONS OF SOILS FOR PRODUCTION OF SELECTED WILDLIFE SPECIES

Soil number; Soil name; & Native Vegetation	Migratory Waterfowl (Ducks - Geese)	Upland Game Birds (Grouse-Quail-Pheasants)	Song Birds	Small Game (Rabbits-Squirrels)	Big Game (Deer)	Fur Bearers (Beaver-Mink-Muskrat)
82 Juneau silt loam (Southern Hardwood)	MODERATE on 0-6% and SEVERE on 6-12% slopes. Poorly suited for wetland food and cover plants; nesting sites may flood; poorly suited for intensive production of grain and seed crops on slopes.	MODERATE on 0-6% and SEVERE on 6-12% slopes for quail and pheasants; frequent overflow restricts production of grain and seed crops; nesting sites may flood.	MODERATE on 0-6% and SEVERE on 6-12% slopes. Sloping areas erosive when cultivated; nesting sites may flood.	MODERATE-burrows and nests may flood; mast trees scarce; poor reproduction of woody plants.	SLIGHT-overflow hazard restricts production of grain.	MODERATE on 0-6% and SEVERE on 6-12% slopes. Water habitat hard to provide.
84 Ockley silt loam (Southern Hardwood)	MODERATE on 0-6% and SEVERE on 6-12% slopes. No wetland food and cover plants; poorly suited for intensive production of grain and seed crops on slopes.	SLIGHT on 0-6% and MODERATE on steeper slopes. Sloping areas erosive when cultivated and poorly suited for intensive production of grain and seed crops.	SLIGHT on 0-6% and MODERATE on steeper slopes. Sloping areas erosive when cultivated.	SLIGHT-no major soil limitation.	SLIGHT-no major soil limitation.	MODERATE on 0-6% and SEVERE on steeper slopes. Water habitat hard to provide.
84R Same as No. 204, Knowles loam.						
84V Same as No. 266, Sisson silt loam.						
84Z Same as No. 21, Hebron loam.						
86 Thackery silt loam (Southern Hardwood)	MODERATE on 0-6% and SEVERE on 6-12% slopes. Poorly suited for wetland food and cover plants; poorly suited for intensive production of grain and seed crops on slopes.	SLIGHT on 0-6%; MODERATE on 6-12% slopes. Poorly suited for intensive production of grain and seed crops on slopes.	SLIGHT on 0-6% and MODERATE on 6-12% slopes. Sloping areas erosive when cultivated.	SLIGHT-no major soil limitations.	SLIGHT-no major soil limitations.	MODERATE on 0-6% and SEVERE on 6-12% slopes. Water habitat hard to provide.

Source: U. S. Soil Conservation Service; SEWRPC.

species. Water developments are not essential for these species. Poorly drained soils, such as Colwood or Brookston, have slight limitations for waterfowl and water-oriented animals because water developments are easy to provide and wetland plants thrive in these areas. The limitations for upland game birds and animals on Colwood and Brookston soils are moderate because the animals will utilize these soils to some extent during dry seasons and with artificial drainage the soils will produce grain, seed, and legumes for food.

Because of the large number of species in the Region, it is impractical to rate each soil for each species. Kinds of wildlife, therefore, have been grouped as migratory waterfowl, upland game birds, songbirds, small game, big game, and fur bearers.

Migratory Waterfowl: Such migratory waterfowl as ducks and geese need nearly level soils that are well suited for intensive production of grain, seed crops, grasses, legumes, and wild herbaceous food plants (see Figure 46). The soils should not be subject to frequent overflow, to erosion, or to drouthiness. Shallow water developments should be relatively easy to provide, and maintenance of desired water levels should not be difficult. Good production of a variety of wetland food and cover plants may be expected on such soils. Wood ducks generally need nesting boxes or trees in addition to the other habitat elements. Woodcock, herons, bitterns, and cranes are marsh and shore birds that require about the same habitat as migratory waterfowl.

Figure 46
MIGRATORY WATERFOWL HABITAT

Migratory waterfowl, such as ducks and geese, need nearly level soils that are well suited for intensive production of grain, grasses, legumes, and wild herbaceous food plants. This photograph shows a marshland providing an excellent duck habitat. In the development of such habitat, it is often necessary to provide some open water through the construction of water impoundments.

Although food for ducks and geese can be grown easily on well-drained soils, such as Fox, Casco, Saylesville, and Kewaunee soils, it is difficult to provide open water. Water impoundments can be constructed on soils such as Kewaunee and Saylesville, but soils such as Casco are underlain by sand and gravel that is very pervious and very difficult to seal. Soils of the Ashkum, Brookston, and Pella (Ehler) series are examples of soils that have few limitations for waterfowl. Open water can be provided easily, and wetland food and cover plants grow well on these soils.

Upland Game Birds: Such upland game birds as grouse, quail, and pheasants grow best on nearly level or gently sloping soils that are well suited to the production of grain, seed crops, legumes, and wild herbaceous and woody plants. Although soil requirements are similar for all species in this group, pheasants and quail generally need more open areas, while grouse can tolerate more heavily wooded areas. The soils should not be subject to frequent overflow or severe erosion and should not be drouthy. They should have good natural drainage and be relatively free of stones or bedrock obstructions. Hungarian partridge and prairie chicken require about the same habitat as quail and pheasants, while sharp-tailed grouse require habitat that includes elements for both prairie chicken and ruffed grouse.

Kewaunee, Saylesville, Miami, and Fox soils provide adequate food and cover and nesting areas for upland game birds. Little or no soil manipulation is required. With drainage adequate food and cover can be grown on Ashkum, Brookston, and Pella soils; but nesting is somewhat restricted by wetness.

Songbirds: Songbirds are treated collectively; and the most productive soils are those which can provide suitable habitat for large numbers, as well as for many species. Soils with good natural drainage on slopes of less than 6 percent capable of growing good grain, seed crops, and wild herbaceous and woody plants are the most desirable. The soils should not be excessively wet, drouthy, erosive when cultivated, stony, or subject to overflow or flooding.

Small Game: Such small game as rabbits and squirrels do best on nearly level to sloping soils (less than 12 percent slopes). The soils should have good natural drainage and be moderately fertile and productive of cover and natural food plants. Good growth of a variety of shrubs, thickets, and mast and den trees is needed. The soils should not be drouthy, excessively stony, poorly drained, or subject to frequent and prolonged overflow or flooding.

Cottontail rabbits and squirrels are the two types of small game for which the soils in Table 18 were rated. Jackrabbits and snowshoe rabbits were not considered even though they are quite numerous in some parts of the state. In general, jackrabbits range over the heavily farmed areas; snowshoe rabbits inhabit brushy areas of conifer and hardwood stands. Both jackrabbits and snowshoe rabbits utilize many of the same food plants as those used by the cottontail rabbit.

The wide range of soils that are used by small game is indicated by limitation ratings in Table 18. Sandy soils, such as Spinks and Vilas, are among the few soils that grow insufficient food and cover for rabbits. Few squirrels live on Mollisols, such as Lorenzo, Warsaw, Mussey, and Navan soils, because trees seldom grow naturally. All small game are severely restricted on frequently flooded or very wet areas, such as alluvial land, wetland, or marsh.

Big Game: Big game, such as deer, generally range on nearly level to sloping soils (less than 12 percent slopes). The soils should have fair to good natural soil drainage. They should produce good yields of grain, grasses, legumes, and woodland food plants. The soils should not be drouthy, poorly drained, erosive when cultivated, or excessively stony.

Because of the ranging habits of deer, they use many kinds of soils for their food and cover. Deer feed in the open fields by night and rest in the woods by day. They utilize almost all kinds of habitat and soils for food and protection in different seasons of the year.

Fur Bearers: Such fur bearers as beaver, mink, and muskrat require a dependable water supply, as well as a source of food. Soils with less than 6 percent slopes, where a suitable water habitat is easy to provide, have the best potential. They should also have a moderate, natural fertility level and produce a wide range of aquatic food, cover, and woody plants. Mink, raccoon, and skunk, although not dependent entirely on water habitat, quite frequently find their best habitat in the vicinity of water areas.

Poorly drained soils, such as Sawmill silt loam, Lawson silt loam, and Pella (Ehler) silt loam, provide good habitat for beaver, mink, and muskrat that need open water for their activities. Water impoundments are very difficult to construct on soils such as Spinks, a sandy soil, and Knowles, shallow variant, that is underlain by limestone. In spite of seasonal or perched water tables, it is difficult to provide open water throughout the year on somewhat poorly drained soils, such as Beecher silt loam and Lamartine silt loam.

Herbaceous Plantings for Wildlife Habitat Improvement: Wildlife habitat can be improved in areas that have been stripped of natural food and cover or where food and cover are naturally scarce by planting grain crops, grasses, and legumes in soils suitable to their growth habits. Table 19 of SEWRPC Planning Report No. 8, an excerpt from which is reproduced in this Guide in Figure 47, is a guide to wildlife plantings on various soil groups and the kind of benefit that may be expected for wildlife. The soils are arranged in four groups and listed by capability units. The groupings are based on drainage characteristics and soil texture. Plants and wildlife species common to the Region are listed. The symbols F for food and C for cover indicate the kind of benefit that can be expected from a given plant to given wildlife species. For example, corn growing in well-drained soils will furnish food and cover for quail, pheasants, rabbits, and deer; food for ducks and geese; and is not applicable to songbirds. In contrast, wild rice growing in flooded areas of poorly drained soils provides food for songbirds, ducks, and geese and is not applicable to other species of wildlife.

Figure 47

EXCERPT FROM TABLE 19 OF SEWRPC PLANNING REPORT NO. 8
HERBACEOUS PLANTINGS FOR WILDLIFE
HABITAT IMPROVEMENT

Groupings of Land Capability Units for Wildlife	Plant Species	Bobwhite Quail	Ringneck Pheasants	Song Birds	Cottontail Rabbits	Whitetail Deer	Migratory Waterfowl	
							Ducks	Geese
Well to moderately well drained soils with good moisture-holding capacity and moderate to high productivity I IIe-1 IIe-2 IIe-5 IIe-6 IIe-7 IIs-1 IIs-7 IIw-11 IIIe-1 IIIe-2 IIIe-5 IIIe-6 IIIe-7 IVe-1 IVe-2 IVe-6 IVe-7	GRAINS							
	Barley	F	F	F	F	F	F	F
	Buckwheat	F	F	F	F	F	F	F
	Corn	F-C	F-C	-	F-C	F-C	F	F
	Oats	F	F	F	F	F	F	F
	Rye	F	F	F	F	F	F	F
	Sorghum	C	F-C	-	-	F	-	-
	Wheat	F	F	F	F	F	F	F
	GRASSES							
	Kentucky bluegrass	C	C	C	F-C	-	-	-
	Orchard grass	C	C	-	-	-	-	-
	Redtop	C	C	C	C	-	-	-
	Smooth brome	C	C	C	F-C	F	-	-
	Switchgrass	F-C	F-C	F-C	F-C	-	F	-
	Tall fescue	C	C	C	F-C	F	-	-
	Timothy	C	C	F-C	F-C	F	-	-
	LEGUMES							
	Alfalfa	F-C	F-C	C	F-C	F	F	F
	Birdsfoot trefoil	F-C	F-C	C	F-C	F	F	F
	Cowpeas	F	F	-	-	F	-	-
	Crownvetch	F-C	F-C	C	F-C	F	F	F
	Ladino clover	-	C	F	F	F	-	-
	Red clover	-	C	F	F	F	-	-
	Sweet clover	C	F-C	F	C	F	-	-

Source: U. S. Soil Conservation Service; SEWRPC.

INTERPRETIVE SOIL MAPS

The foregoing soil interpretations for engineering, planning, agricultural, aesthetic, and recreational applications can be graphically displayed through the preparation of interpretive soil maps. Interpretive soil maps can be made directly on the soil photo maps, on enlargements of such maps, or on specially prepared base maps on which the soil mapping unit boundaries have been delineated. Often the interpretive maps are initially made on prints of the soil photo maps and then are transferred to a reproducible base map. Interpretive soils maps are based upon the limitation or suitability categories as found in the series of interpretive tables in SEWRPC Planning Report No. 8. While interpretive soil maps are usually made for a single interpretation, such as the limitations for development utilizing on-site soil absorption sewage disposal systems, attempts have been made to prepare composite interpretive soil maps where several interpretations are combined into a single rating scheme.

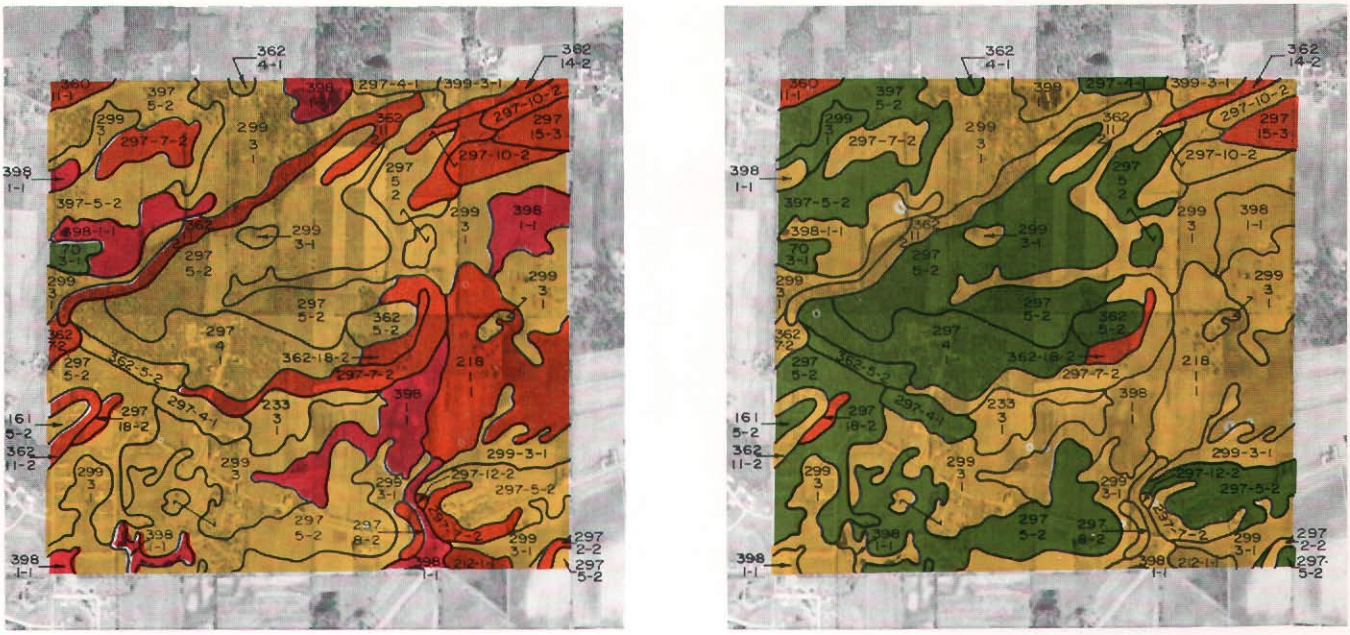
Interpretive soil maps usually utilize a color code to designate the various limitation or suitability categories. Examples of single-purpose interpretive soil maps are shown in Figure 48. In these examples, a "stop-go" color coding system has been used. Blue and green coded soils indicate that few soil limitations exist for the particular use under consideration ("go"), while orange and red coded soils indicate

Figure 48

SELECTED EXAMPLES OF INTERPRETIVE SOIL MAPS

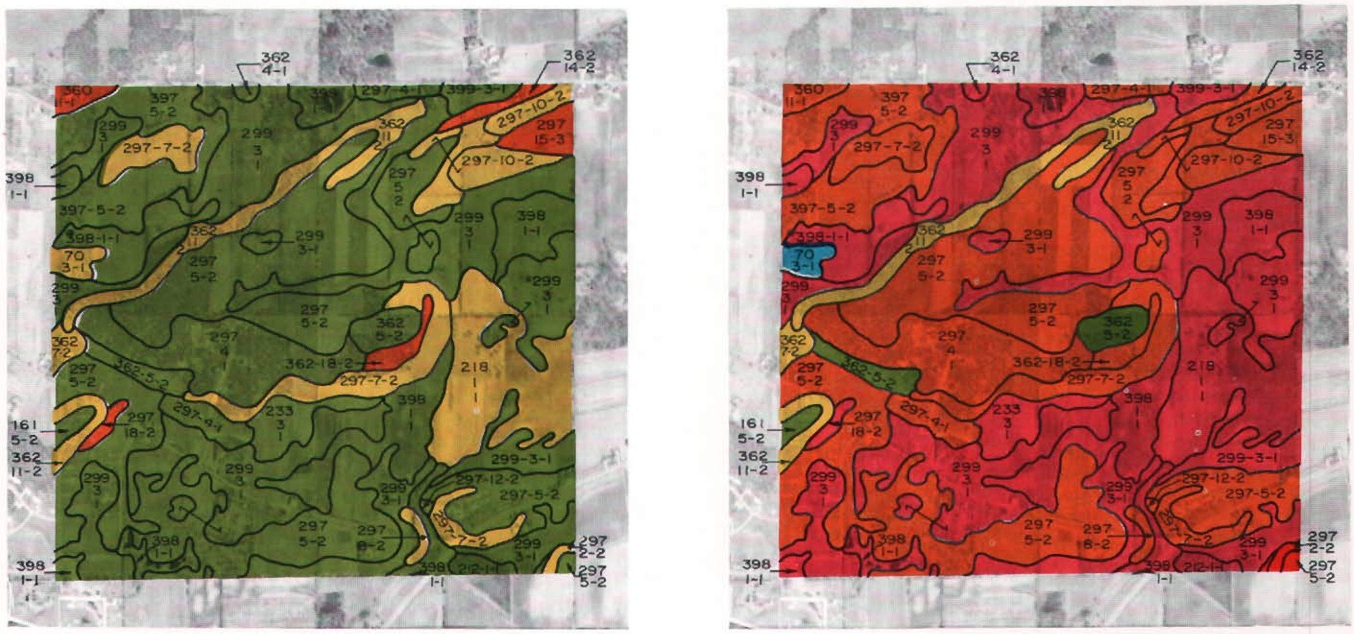
LIMITATIONS OF SOILS FOR THE DEVELOPMENT OF TENT AND TRAILER CAMPSITES

LIMITATIONS OF SOILS FOR THE PRODUCTION OF UPLAND GAME BIRDS



LIMITATIONS OF SOILS FOR CULTIVATED CROPS, PASTURE, AND TREES

LIMITATIONS OF SOILS FOR ON-SITE SOIL ABSORPTION SEWAGE DISPOSAL SYSTEMS



LEGEND

🟦 VERY SLIGHT LIMITATIONS	🟧 SEVERE LIMITATIONS
🟩 SLIGHT LIMITATIONS	🟥 VERY SEVERE LIMITATIONS
🟨 MODERATE LIMITATIONS	

Source: U.S. Soil Conservation Service; SEWRPC.

The above examples of interpretive soil maps illustrate the use of a "stop-go" color coding system. The same geographical area (Section 3, T5N, R20E) has been interpreted for four selected land uses. In each instance, the blue and green coded soils indicate that few limitations exist (go), the yellow coded soils indicate that moderate limitations exist (caution), and the orange and red coded soils indicate that many limitations exist (stop). Interpretive soil maps such as these can be prepared for many other specific uses and provide an important and useful input to the planning process.

that severe and very severe limitations exist ("stop"). The use of such interpretive soil maps in regional, watershed, community, and neighborhood planning and development will be discussed in subsequent chapters of this Guide.

As noted above, attempts have been made to prepare soil interpretive maps that combine several specific soil interpretations into a single capability interpretation for a given project. A noteworthy example of this technique is one developed by John R. Quay, a Barrington, Illinois, architect.[7] Mr. Quay has developed a project capability interpretation for residential development that takes into consideration single interpretations for the following soil properties: percolation rate, flood potential, water table, bearing strength, corrosion potential, shrink-swell potential, AASHO classification, erosion hazard, frost action, trees, shrubs, grasses, and wildlife. All of these separate interpretations were then used to prepare, based on the knowledge of a soil scientist and a land use planner, a subjective project capability interpretation. This composite interpretation was then mapped in a "stop-go" color pattern as discussed above. The final interpretive map was utilized in preparing the recommended subdivision design. Similar rating schemes could be developed for numerous land uses utilizing the several composite analytical tables presented earlier in this chapter. In effect, also, certain interpretations presented in this chapter, such as the one for light industrial and commercial buildings, represent a composite interpretation of several soil characteristics and properties.

SUMMARY

Soil survey data and analyses were first used in a practical manner by agriculturalists interested in increasing crop yields. These efforts were broadened to encompass farm planning, including measures relating to erosion, sediment control, soil improvement, drainage, and crop selection. Only in recent years has the soil survey been expanded to include interpretive analyses for nonagricultural purposes. Rapid areawide urbanization, such as that occurring in the Southeastern Wisconsin Region, requires planning and engineering programs designed to guide and shape such urbanization in the public interest and thereby to avoid costly developmental and environmental problems. These planning and engineering programs require not only detailed information on the physical, chemical, and biological properties of the soils but also analyses of the suitability of such soils for residential, commercial, industrial, and other urban land uses.

A series of interpretive tables containing detailed information and analyses for both urban and rural land uses has been prepared and published in SEWRPC Planning Report No. 8, Soils in Southeastern Wisconsin. In most instances, these tables contain interpretive ratings given in terms of limitations. The five categories of limitations utilized in southeastern Wisconsin are the following: very slight, slight, moderate, severe, and very severe. It should be noted that interpretive ratings are written mainly in terms of limitations for use because there are few soil limitations that cannot be overcome by soil removal or compensation if the user is willing and able to pay for such operations.

Four general groups of interpretive analyses have been prepared for users of the soil survey in southeastern Wisconsin. These four groups are: interpretations for engineering purposes, such as the suitability of soils for road construction; interpretations for planning purposes, such as the suitability of soils for residential development utilizing on-site soil absorption sewage disposal facilities; interpretations for agricultural purposes, such as the suitability of soils for cultivated crops and pasture; and interpretations for aesthetic and recreational purposes, such as the suitability of soils for intensive recreational use areas.

Soil characteristics and properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, water storage facilities, erosion control structures, pond embankments and dikes, drainage systems, sanitary land fill areas, sewage

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[7] *''Use of Soil Surveys in Subdivision Design,'' Soil Surveys and Land Use Planning, Soil Science Society of America and American Society of Agronomy, Madison, Wisconsin, 1966.*

disposal systems, and other engineering structures and improvements. Of particular importance to the engineer are the following soil characteristics and properties: permeability, shear strength, compaction, drainage, shrink-swell potential, grain size, plasticity, reaction, depth to water table, location of bedrock, and topography. The foregoing soil characteristics and properties are contained in Tables 4 through 7 of SEWRPC Planning Report No. 8.

Almost all soil properties and their limitations for various urban and rural uses are of substantial interest to regional and local planning agencies engaged in comprehensive planning for the development of new urban areas and for the conservation of natural resources. Particularly important to planners are the limitations of soils for certain urban and rural uses found in Table 8 of SEWRPC Planning Report No. 8. Included in this table are limitations of soils for crops, pasture, and trees; for residential development with public sanitary sewer service; for residential development with on-site soil absorption sewage disposal systems; for light industrial and commercial buildings; and for highway, railroad, and airport development. In addition, the soils limitations for sewage lagoons and sanitary land fill operations are of importance to regional and local planners. Such soil limitations are also an invaluable guide for land developers, real estate brokers, bankers, utility engineers, highway engineers, and local health officials.

Soil surveys can be used as a guide to the suitability of soils for cropland, the kind of crops the soils can support, and the management needed to maintain their productivity from year to year. To simplify the information being collected and to promote understanding of soil problems, a system of land capability groupings was devised. The system is based on the limitations of soils for use as cropland. Yield information and woodland suitability groupings also aid in determining the best agricultural use for soils. Drainage and irrigation guides are helpful in solving problems of excess water or inadequate water supply. The foregoing soil interpretations are contained in Tables 9 through 13 of SEWRPC Planning Report No. 8.

The limitations and capabilities of soils for various plantings, park and recreation uses, and wildlife habitat are of great interest to those desiring to control erosion, conserve water and moisture, improve water quality, promote beauty, protect wildlife, and develop recreational facilities. Tables 14 through 19 contain interpretations for uses related to planting, recreation, and wildlife development. Included are a herbaceous planting guide, a general shrub and vine planting guide, and a tree planting and selection guide. Also included are interpretations for such recreational developments as intensive play areas, extensive play areas, bridle paths, golf course fairways, and tent and trailer campsites.

Most soil interpretations for engineering, planning, agricultural, planting, recreational, and wildlife purposes are capable of being graphically displayed through interpretive soil maps. Such interpretive soil maps utilize the limitation or suitability categories found in the series of interpretive tables. These interpretive maps usually utilize a color code to designate the degree of limitation or suitability. Such maps are usually made for a single soil interpretation but can also be made for composite interpretations relating to a given specific project. The use of such suitability interpretive soil maps in regional, watershed, community, and neighborhood planning will be discussed in subsequent chapters of this Guide.

Chapter IV
THE USE OF SOILS DATA IN REGIONAL AND WATERSHED PLANNING

INTRODUCTION

As noted earlier in this Guide, one of the important reasons for undertaking the regional soil survey in southeastern Wisconsin and for obtaining interpretive analyses for nonagricultural, as well as agricultural, land uses was to provide data essential to the preparation of the regional land use, transportation, and watershed plans. Many of the areawide environmental and developmental problems which contributed to the need for areawide planning and which require expensive corrective measures are linked to the misuse of soils. If further intensification of these problems is to be avoided, regional development will have to be adjusted to the soil capabilities within the Region.

Of the 536 soil types occurring within the seven-county Southeastern Wisconsin Region approximately 40 percent, covering almost one-half of the total area of the Region, have severe and very severe limitations for the application of on-site soil absorption sewage disposal facilities. Urban development undertaken on such soils without public sanitary sewer service has in the past created severe public health hazards and environmental problems within the Region, with the result that the State Division of Health has placed restrictions on the development of new subdivision plats in certain areas of the Region and has issued orders for the installation of public sanitary sewerage facilities in other areas originally developed with septic tank sewage disposal systems. It should also be noted that soils having severe limitations for urban development even if served by public sanitary sewer are also widespread throughout the Region. These include wet soils, which either have a high water table or are poorly drained and organic soils which are poorly drained and provide poor foundation support, and soils which have a flood hazard. Failure to consider soil properties during the planning stages of any physical development will usually result in higher initial construction costs and severe continuing maintenance problems. It should be emphasized, however, that soil limitations are only one of the many important factors to be considered in making urban development decisions. At times other considerations will outweigh the soil limitations, and decisions will be made to expend additional monies to overcome the soil limitations.

Since the process of plan design is essentially a problem of finding the least costly way to meet stated development objectives, it is necessary to link geographic location with development costs. In this way, alternatives can be explored and the least costly alternative selected. Detailed soil surveys provide a means for relating development costs to geographic location, since development costs vary with soil type and since the soil types have been geographically mapped. Thus, the detailed soil surveys provide an essential data input not only for the design of regional plan elements but also for the design of community and detailed site plans.

The purpose of this chapter is to show how the regional soil survey has been utilized to date in the comprehensive planning program for the Southeastern Wisconsin Region to prepare a regional land use plan and comprehensive watershed plans.

PLANNING OBJECTIVES AND STANDARDS

Planning has been defined by the Commission as a rational process for formulating and meeting objectives. Before plans can be prepared, therefore, objectives must be formulated. In the regional planning program for southeastern Wisconsin, this task was initially undertaken in the regional land use-transportation planning program. Subsequent regional or subregional planning programs, such as the series of comprehensive watershed studies, have refined and extended the objectives initially formulated, as appropriate, to additional and more specific subject areas. Objectives are defined as goals or ends toward the attainment of which plans and policies are directed. In turn, standards are defined as criteria used as a basis of comparison to determine the adequacy of plan proposals to attain the stated objectives.

Several objectives and standards formulated and adopted by the Commission in its land use-transportation planning program relate directly to the use of the regional soil survey and its interpretive analyses. In addition to the general objective of protecting, wisely using, and soundly developing the natural resource base of the Region, the Commission has adopted the following specific development standards that are based upon the regional soil survey and its interpretive analyses:

1. Urban development, particularly for residential use, shall be located only in those areas which do not contain significant concentrations of soils rated in the regional detailed operational soil survey as having severe or very severe limitations for such development. Significant concentrations are defined as follows:[1]

   a. In areas to be developed for low-density residential use, no more than 2.5 percent of the gross area should be covered by soils rated in the regional soil survey as having severe or very severe limitations for such development.

   b. In areas to be developed for medium-density residential use, no more than 3.5 percent of the gross area should be covered by soils rated in the regional soil survey as having severe or very severe limitations for such development.

   c. In areas to be developed for high-density residential use, no more than 5.0 percent of the gross area should be covered by soils rated in the regional soil survey as having severe or very severe limitations for such development.

2. Rural development, principally agricultural land uses, shall be allocated primarily to those areas covered by soils rated in the regional soil survey as having only moderate, slight, or very slight limitations for such uses.

3. Land developed or proposed to be developed without public sanitary sewer service should be located only in areas covered by soils rated in the regional soil survey as having moderate, slight, or very slight limitations for such development.

4. New industrial development should be located in planned industrial districts in areas which contain soils rated in the regional soil survey as having only moderate, slight, or very slight limitations for such development.

5. New regional commercial development, which would include activities primarily associated with the sale of shopper's goods, should be concentrated in regional commercial centers in areas which contain soils rated in the regional soil survey as having only moderate, slight, or very slight limitations for such development.

6. All prime agricultural areas, defined as those areas which contain soils rated in the regional soil survey as having only slight or very slight limitations for agricultural uses and which occur in concentrated areas over five square miles in extent that have been designated as exceptionally good for agricultural production by agricultural specialists, should be preserved.

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[1] *These standards are based upon development of neighborhood units utilizing conventional land subdivision design layouts, with lot sizes throughout the neighborhood unit uniformly approximating the average lot size required to meet the desired neighborhood population level and gross population density. If larger areas of a potential neighborhood unit than those specified above are covered by poor soils and are placed in open-space use without varying the lot size and subdivision layout, the population level and gross population density of the neighborhood unit may be adversely affected, as may the quality of the urban services provided. If variations in the subdivision layout design and lot size are permitted, such as cluster subdivision, minimum population levels necessary to sustain a desirable level of urban services may be achieved in areas covered by much higher percentages of poor soils than recommended in the standards; up to 75 percent of low-density neighborhoods, up to 50 percent of medium-density neighborhoods, and up to 44 percent of high-density neighborhoods. For a discussion of the neighborhood unit development concept, see Chapter V of this Guide.*

7. All agricultural lands surrounding adjacent high-value scientific, educational, or recreational resources and covered by soils rated in the regional soil survey as having moderate, slight, or very slight limitations for agricultural use should be preserved.

8. An attempt should be made to preserve agricultural areas which are covered by soils having moderate limitations for agricultural uses if these soils occur in concentrations greater than five square miles and surround, or lie adjacent to, areas which qualify as prime agricultural areas or occur in areas which may be designated as desirable open spaces for shaping urban development.

In its comprehensive watershed planning programs, the Commission has also adopted objectives and standards that relate to the regional soil survey and its interpretive analyses. To achieve the general objective of reducing storm water runoff, soil erosion, and stream sedimentation and pollution, the following standards have been formulated:

1. A minimum of 50 percent of the area of the watershed in agricultural use should be under district cooperative soil and water conservation agreements and planned conservation treatment.

2. A minimum of 25 percent of the area of the watershed in agricultural use should be under conservation treatment.

To achieve the general objective of ensuring certain specified stream and lake water quality standards, the following standard has been formulated:

1. All urban residential development, except single-family residences on lots of five acres or more in area and located on soils rated in the regional soil survey as suitable for the soil absorption method of sewage disposal, shall be served by public sanitary sewerage facilities conveying liquid wastes to a sewage treatment plant.

The foregoing examples demonstrate the incorporation of soils data and interpretations directly into statements of regional planning development objectives and standards. Once stated, these objectives and standards become the guidelines for plan design, test, and evaluation.

REGIONAL LAND USE PLAN

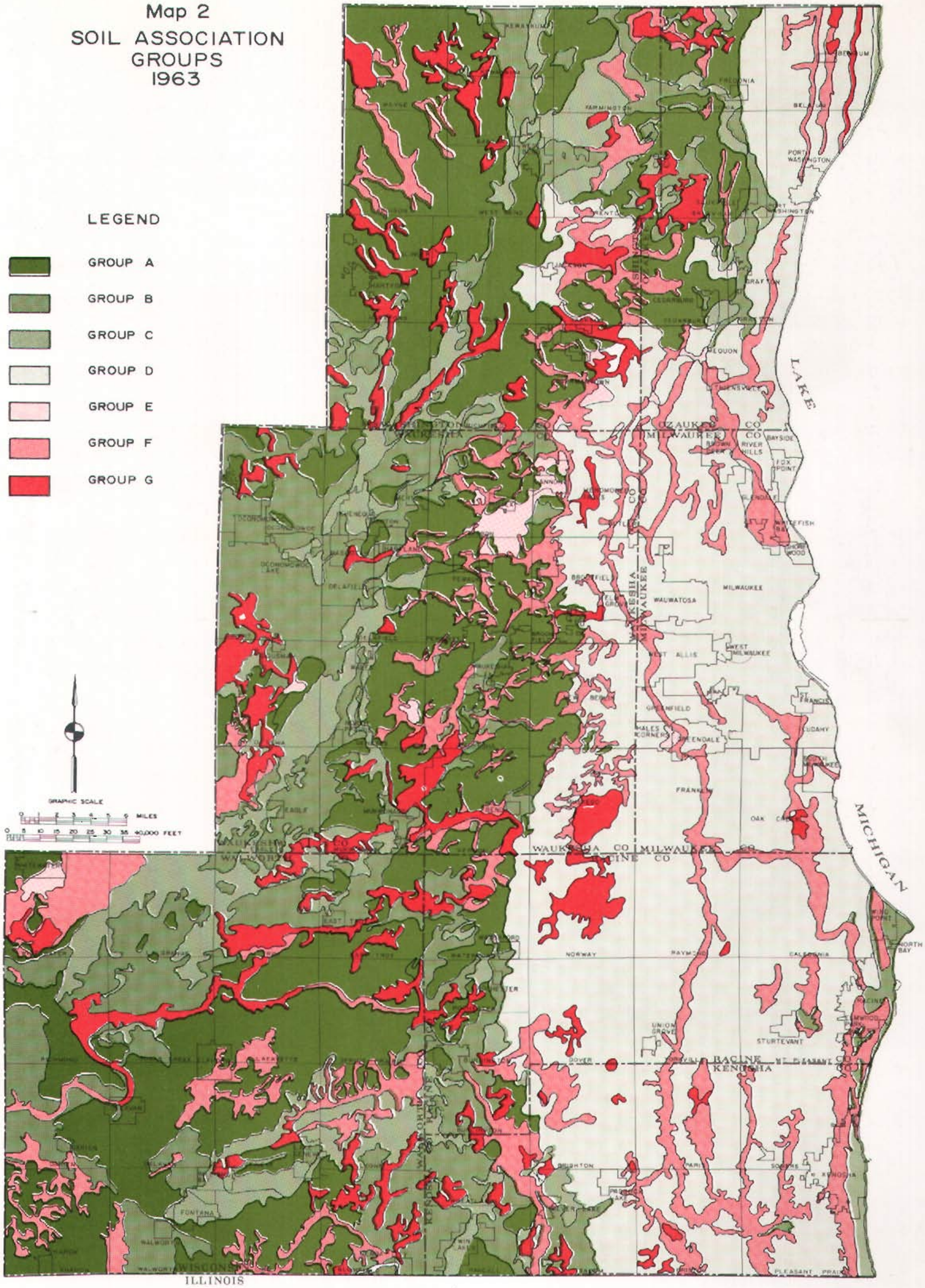
The soil survey data provided a particularly important input to the preparation and design of the adopted regional land use plan. The use of detailed soils data in such a large-scale regional land use planning effort was unprecedented. Three alternative regional land use plans were prepared—a controlled existing trend plan; a satellite city plan; and a corridor plan. The controlled existing trend plan was recommended for adoption and, after public hearings, was refined and ultimately adopted. In the preparation of each of the alternative land use plans, the Commission utilized information about the physical features of the Region, including data on topography and drainage patterns; on surface and ground water; on recreational resource areas, including wildlife habitat, woodlands, wetlands, and historic sites; on existing and potential park and related open-space sites; and on soils.

Plan Design Methodology

As already noted, the detailed soils inventory of the Region revealed that soils having questionable characteristics for on-site soil absorption sewage disposal systems are widespread throughout the Region, covering nearly one-half of the total area of the Region. Moreover, these poorly suited soils are concentrated in the rapidly urbanizing eastern portion of the Region. This large area of soils poorly suited for urban development utilizing on-site soil absorption sewage disposal systems is shown on Map 2.

Primarily for the foregoing reason, it was determined that the alternative regional land use plans would be designed based on the standards noted above; namely, that all medium- and high-density residential development would be placed in areas capable of being served by public sanitary sewer systems. The gravity drainage areas tributary to existing and proposed sewage treatment plants, along with the peren-

Map 2
SOIL ASSOCIATION GROUPS
1963



As shown on this generalized soil map of the seven-county Southeastern Wisconsin Region, nearly one-half of the 2,689 square mile Region is covered by soils which are generally poorly suited for development with on-site soil absorption sewage disposal systems (Soil groups D, E, F, G). The detailed soil survey completed for the Region in 1966 provides definitive data for use in local, as well as regional, planning and development.

nial stream network and subwatershed pattern of the Region, thus provided important inputs to the regional land use plan design process.

Given the criterion that most future urban development in the Region would be so planned as to be served by public sanitary sewer systems, interpretive soil maps at a scale of 1" = 2000' were prepared for those areas of the Region that were as yet undeveloped but that had potential for future service by public sanitary sewer systems. These interpretive soil maps, using the "stop-go" color coding system discussed in Chapter III of this Guide, were based on the ratings given in Table 8 of SEWRPC Planning Report No. 8. The particular interpretation chosen for this application was, necessarily, the interpretation for residential development served by public sanitary sewer systems. A portion of this interpretive soil map of the Region is shown in Figure 49. Interpretive soil maps were also prepared for other urban and rural land uses, including agriculture, residential development without public sanitary sewer on lots less than one acre in area, residential development without public sanitary sewer on lots one acre or more in area, commercial and industrial development, and transportation system development. Portions of these interpretive soil maps are also shown in Figure 49.

Once the interpretive soil maps were prepared, it was possible to measure and thus quantify the amount of land in each U. S. Public Land Survey quarter section that had severe and very severe limitations for urban development even if served by public sanitary sewer. By subtracting this poorly suited area from the gross area of the quarter section and by further subtracting areas committed to existing urban development, primary environmental corridor (less any poor soils in such corridor), and water, it was possible to arrive at a "net" land area for each quarter section. This "net" land area was termed "developable land" and was assumed to be available for future urban development. Once this process was completed, the alternative regional land use plans were prepared using well-developed techniques for balancing on the gross basis the forecast demand for, and supply of, land for the various uses and for spatially distributing these land uses within the planning area.

It should be noted that the poorly suited soils as defined above were also important inputs to the delineation of environmental corridors. These corridors are defined as elongated areas encompassing the best remaining elements of the natural resource base, including, in addition to soils ill-suited for urban development, all major bodies of surface water and their associated floodlands; wetlands; woodlands; wildlife habitat areas; rough topography; significant geological formations; and several other features related to the natural resource base, including existing and potential outdoor recreation and related open-space sites, historic sites and structures, and significant scenic areas or vistas.

Plan Elements

The adopted regional land use plan (see Map 3) represents a conscious continuation of historic development trends within the Region. Urban development would, in general, continue to occur in roughly concentric rings along the full periphery of, and outward from, existing urban centers. The plan proposes, however, to regulate, in the public interest, the urban land market in order to provide for a more orderly and economical regional development pattern, thus avoiding the intensification of areawide developmental and environmental problems. In so doing the adopted regional land use plan, designed in the manner described above, relied extensively on the detailed soils data and interpretive analyses.

Residential Development: The adopted regional land use plan provides for the conversion of more than 71,000 acres of vacant and agricultural lands to residential use in the 27-year period from 1963 to 1990. This new residential development would take place in three density categories—low, medium, and high. Because so much of the urbanizing portion of the Region consists of soils that have severe and very severe limitations for the proper operation of on-site soil absorption sewage disposal systems, the adopted plan proposed to serve all of the new medium- and high-density residential development, shown on Map 3, with public sanitary sewerage facilities. This would mean that by 1990 over 95 percent of the total urban area within the Region would be served by public sanitary sewerage facilities. All new low-density residential development, shown on Map 3, which could not be economically and feasibly served by public sanitary sewerage facilities was placed in the regional land use plan on soils which have only very slight, slight, or moderate limitations for development utilizing on-site soil absorption sewage disposal facilities.

Figure 49

TYPICAL INTERPRETIVE SOIL MAPS PREPARED AS PART OF THE COMPREHENSIVE PLANNING PROGRAM FOR THE SOUTHEASTERN WISCONSIN REGION

AGRICULTURE

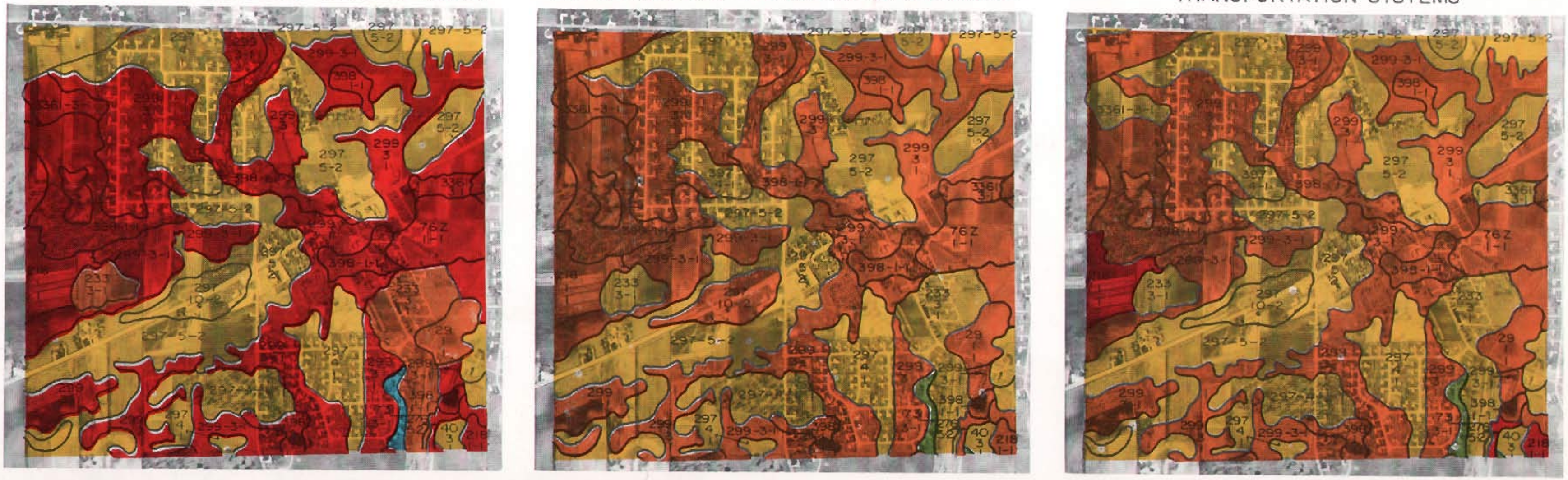
RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER

RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER (LESS THAN ONE ACRE LOTS)

RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER (ONE ACRE LOTS OR MORE)

COMMERCIAL AND INDUSTRIAL DEVELOPMENT

TRANSPORTATION SYSTEMS



LEGEND

🟦 VERY SLIGHT LIMITATIONS

🟩 SLIGHT LIMITATIONS

🟨 MODERATE LIMITATIONS

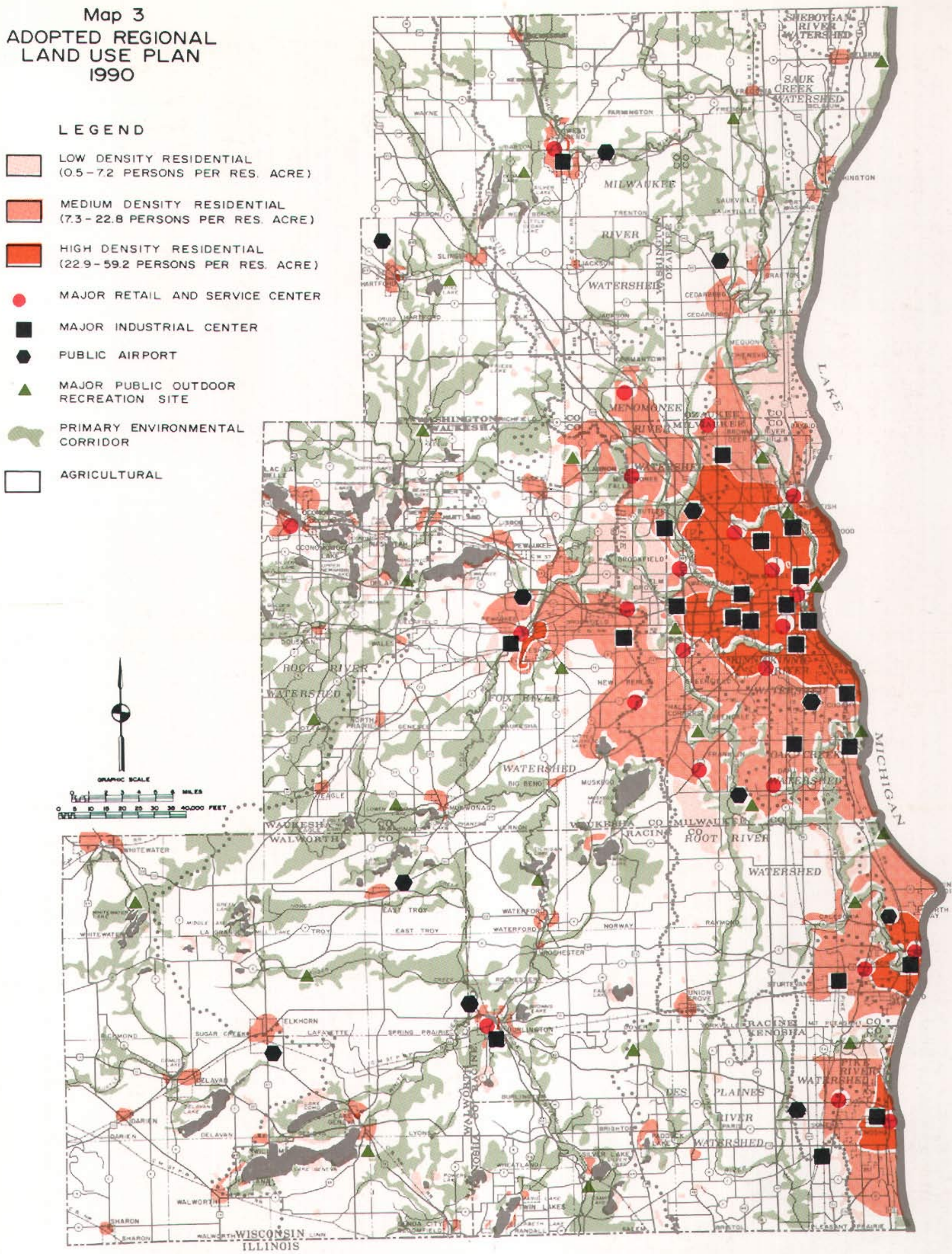
🟧 SEVERE LIMITATIONS

🟥 VERY SEVERE LIMITATIONS

Source: U.S. Soil Conservation Service; SEWRPC.

These interpretive soil maps are examples of those prepared under the regional land use planning program for the Southeastern Wisconsin Region. The suitability ratings for various urban and rural land uses established by the soil survey were used to prepare this series of soil maps. This graphic portrayal of the detailed soils data and interpretive analyses continues to provide important inputs to the Commission's work program.

Map 3
ADOPTED REGIONAL LAND USE PLAN 1990



Extensive reliance was placed on the detailed soils data and interpretive analyses in the preparation of the adopted regional land use plan. The soils data were used to determine the amount and spatial location of "developable" land, an important consideration in the land use plan design process. In addition, the soils data were very useful in the delineation of the primary environmental corridors. Urban development in accordance with this land use plan would assure the protection of the best remaining elements of the Region's natural resource base and of the overall quality of the environment within the Region.

Within the areas shown for residential development by 1990, there are numerous small pockets of soils unsuited for development even with public sanitary sewers. These small areas can be avoided in most cases through proper subdivision design and placed in minor drainageways and local parks and open spaces. This design process is further discussed in Chapters V and VII of this Guide.

Agricultural Land: Of the more than 1,085,000 acres of land used for agriculture in 1963, over 40 percent, or about 444,000 acres, was classified as prime agricultural land. The delineation of prime agricultural land, as noted above, was based on the regional soil survey. Urban expansion by 1990 within the Region will require the conversion of more than 102,000 acres of agricultural land to urban use. The adopted regional land use plan places all remaining agricultural lands into a recommended exclusive agricultural zone. In accordance with the regional development objectives and standards set forth above, nearly 423,000 acres, or about 95 percent, of the prime agricultural lands have been recommended for retention in agricultural use at least through 1990.

Environmental Corridors: As noted above, the regional soils data provided an important input to the delineation of the primary environmental corridors. These high-value natural resource corridors were incorporated into the adopted regional land use plan as a major plan element. The plan recommends that these corridors be refined as urban development continues in the Region and that they be preserved and protected from encroachment by incompatible types of urban development. These corridors will also serve to provide the communities within the Region with additional park and outdoor recreation areas.

COMPREHENSIVE WATERSHED PLANS

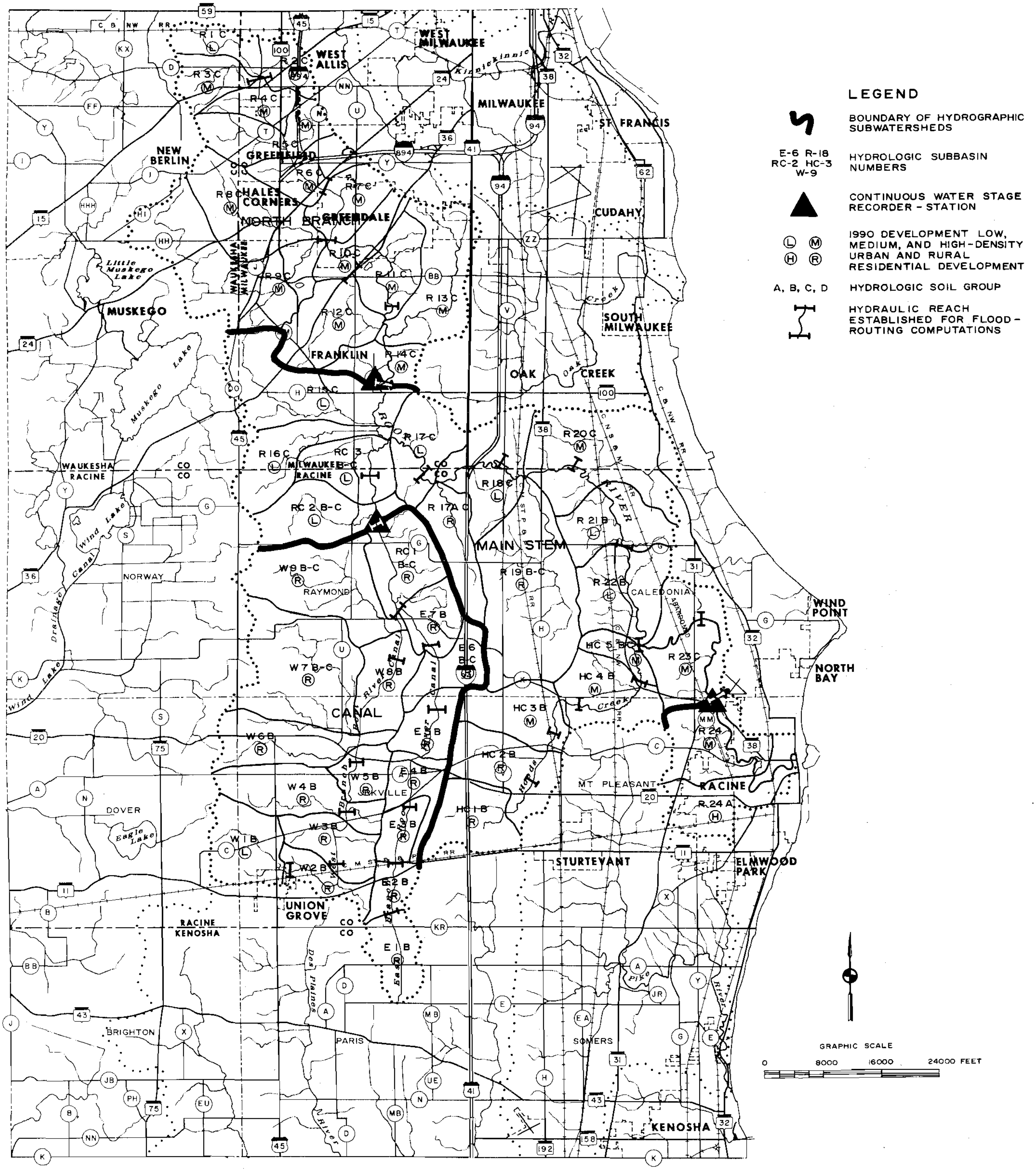
The regional soil survey data and interpretive analyses have also been extensively utilized in the Commission's series of comprehensive watershed studies. To date the Commission has prepared or currently has under preparation comprehensive watershed planning programs for three important watersheds in the Region: the Root River, Fox River, and Milwaukee River watersheds. Comprehensive watershed studies are designed to produce for each watershed a long-range plan for the development of water-related community facilities, including integrated proposals for pollution abatement, drainage and flood control, land and water use, and park and public open-space reservation. As such they are fully integrated into the ongoing regional planning program for land use, transportation facilities, and other public facilities and utilities.

An important part of each Commission watershed study is the development of a mathematical model, used to simulate the hydrologic and hydraulic performance of the river system under study. Each such simulation model is constructed from available information on the climate, topography, soils, land use, and hydraulic characteristics of the watershed. These factors are combined in the model through established hydrological and hydraulic relationships. The model, once formulated, is calibrated to the specific watershed by using data on actual river performance, including high-water marks and stream gaging records. As the model is thus refined, a basic understanding of the specific hydrologic relationships of the watershed is obtained. The model then becomes a tool for forecasting river system performance given, for example, a proposed or forecast change in one of the hydrologic input factors, such as land use. In the Commission's watershed studies, the hydrologic simulation model is used to simulate flood flows corresponding to selected recurrence intervals of 10, 50, and 100 years for conditions of present and planned future land use in the particular watershed under consideration. In this way floodlands can be delineated for use in conjunction with such public land regulatory devices as zoning and subdivision control.

Soils data are an important input to the development of a hydrologic simulation model. For example, in the Commission's Root River watershed study, the watershed was divided into 52 hydrologic sub-basins. Detailed soils maps were used to determine the predominant hydrologic soil group in each sub-basin. All soil types occurring in the Region have been classified into one of four hydrologic soil groups, A through D, as indicated in Appendix C and as discussed in Chapter III of this Guide under the subheading "Water Management Characteristics." The sub-basins in the Root River watershed are shown, together with the hydrologic soil group and the general type of planned land use on Map 4. The various hydrologic soil groups indicate the infiltration characteristics of the sub-basin soils, the Group A soils having the highest infiltration rate and Group D the lowest.

Map 4

HYDROGRAPHIC SUBWATERSHEDS AND HYDROLOGIC SUBBASINS IN THE ROOT RIVER WATERSHED



Detailed soils data provide an important input to the development of hydrologic simulation models in the Commission's comprehensive watershed planning programs. The predominant hydrologic soils group is determined for each sub-basin by examination of the detailed soil survey maps. These hydrologic soil groups indicate the infiltration characteristics of the sub-basin soils, an important determinant of the ratio of runoff to rainfall. This ratio is a key factor in the hydrologic model.

The hydrologic soil classification is used to determine the ratio of runoff to rainfall and thus assists in building the hydrologic model. As noted, the existing and proposed land uses also affect the amount of runoff. In view of the availability of the detailed soils data, the U. S. Soil Conservation Service Runoff-Curve-Number System[2] was selected in the Root River watershed study as the most suitable method for calculating runoff resulting from a rainfall of given depth and duration. This method assigns runoff curve numbers to a range of hydrologic soil-cover complexes made up of combinations of hydrologic soil groups and agricultural land uses. The runoff curve number classifications are shown in Table 26. Weighted

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[2] *Engineering Handbook*, *Section 4, ''Hydrology,'' U. S. Department of Agriculture, Soil Conservation Service, 1957.*

Table 26

RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL COVER COMPLEXES[a]
(For Watershed Moisture Condition II)[b]

Land Use or Cover	Treatment or Practice	Hydrologic Condition[c]	Runoff Curve Numbers by Hydrologic Soil Group			
			A	B	C	D
Fallow	Straight Row	--	77	86	91	94
Row Crops	Straight Row	Poor	72	81	88	91
	Straight Row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured & Terraced	Poor	66	74	80	82
	Contoured & Terraced	Good	62	71	78	81
Small Grain	Straight Row	Poor	65	76	84	88
	Straight Row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured & Terraced	Poor	61	72	79	82
	Contoured & Terraced	Good	59	70	78	81
Close-Seated Legumes or Rotation Meadows[d]	Straight Row	Poor	66	77	85	89
	Straight Row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured & Terraced	Poor	63	73	80	83
	Contoured & Terraced	Good	51	67	76	80
Pasture or Range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow (permanent)		Good	30	58	71	78
Woods (farm woodlots)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		--	59	74	82	86
Roads[e] (dirt)		--	72	82	87	89
(hard surface)		--	74	84	90	92

[a] *Engineering Handbook, Section 4, "Hydrology," U.S. Department of Agriculture, Soil Conservation Service, 1957.*

[b] *Moisture Condition II is defined as 1.4 to 2.1 inches of rainfall in the preceding five days.*

[c] *Hydrologic condition is defined as the rainfall retention characteristics of the land use or cover and the treatment or practice.*

[d] *Close-drilled or broadcast.*

[e] *Including right-of-way.*

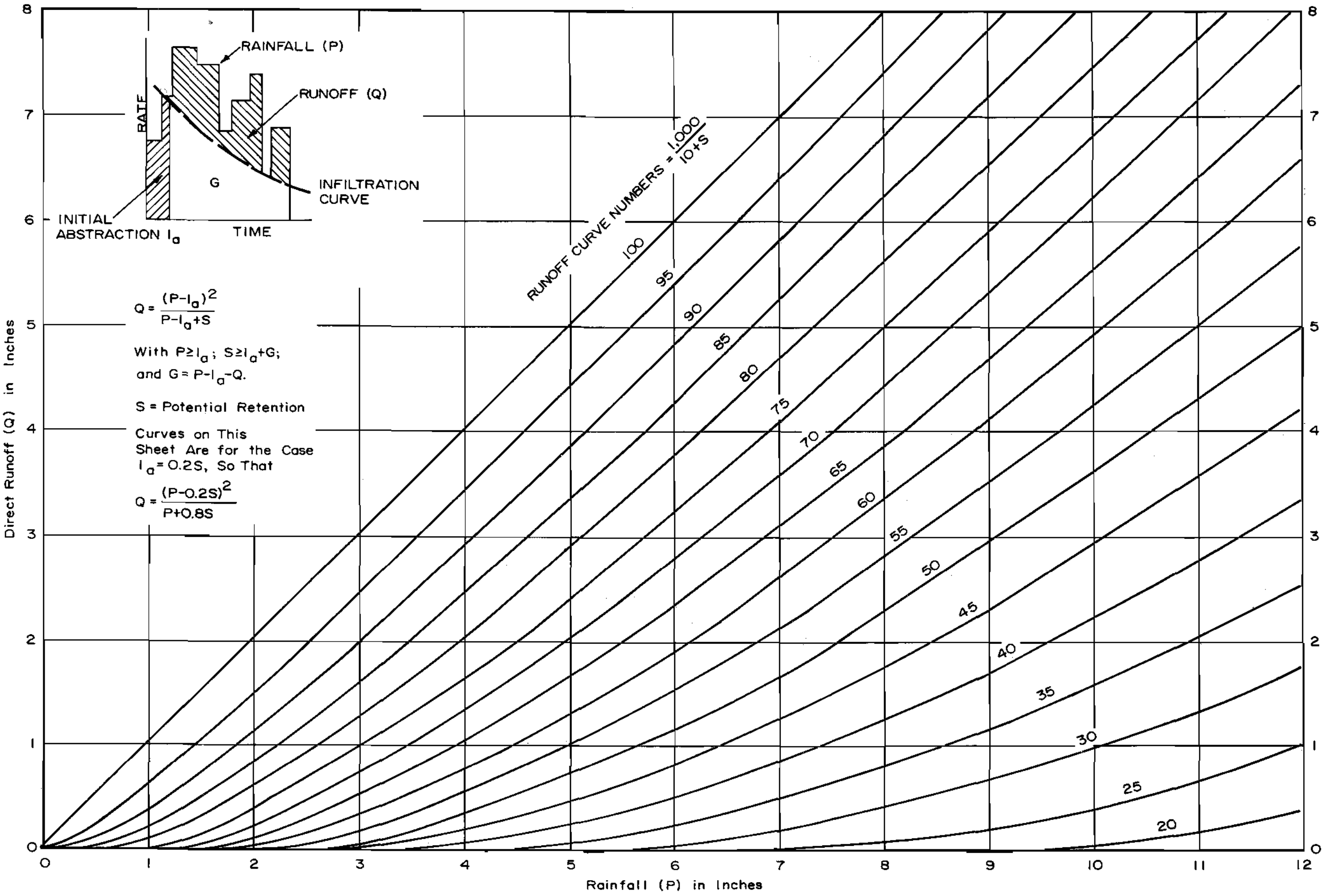
Source: U.S. Soil Conservation Service.

average runoff curve numbers were prepared for those sub-basins having mixed land use. Curves relating the runoff to rainfall are shown in Figure 50. These curves were prepared by the U. S. Soil Conservation Service on the basis of field experience and infiltration tests. Once established for each sub-basin, primarily through the use of soils and related data, the rainfall-runoff relationships formed a necessary input to the hydrologic simulation model. Further description of this model can be found in Chapter VI of SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed.

The detailed soils data has at least two additional applications in comprehensive watershed planning as conducted by the Commission. The soils data, in terms of its interpretations for flood hazard, are used in conjunction with the mathematical hydrologic simulation model to delineate accurately the 10-year recurrence interval flood inundation line along a stream system. Experience has shown that a strong correlation exists between such soil interpretations and the predictive 10-year recurrence interval flood. The soils can thus be used in a supplemental way. In addition, the detailed soils data are often used to assist in estimating the costs of proposed utility services. For example, in the Commission's Fox River watershed study, the soil maps and interpretive analyses were consulted in preparing cost estimates for the installation of several recommended public sanitary sewer systems. Where the proposed installations traversed soils having severe and very severe limitations for urban development utilizing sanitary sewers, higher unit cost factors were applied in preparing the estimate.

Figure 50

RAINFALL-RUNOFF RELATIONSHIPS
FOR HYDROLOGIC SOIL-COVER COMPLEX RUNOFF CURVE NUMBERS



Source: U. S. Soil Conservation Service.

REGIONAL SANITARY SEWERAGE SYSTEM PLAN

The regional soil survey data and interpretive analyses will also be utilized in the regional sanitary sewerage system planning program being undertaken by the Commission at the writing of this Guide. A major work element in this planning program is a technical analysis of the soils data with particular respect to that soils information having relevance for sanitary sewerage system planning. In particular, the areas proposed in the regional land use plan to be developed for urban use and covered by soils suitable for septic tank sewage disposal system application and areas proposed to be developed for urban use and covered by soils unsuitable for septic tank sewage disposal system application will be mapped, measured, and tabulated by county, civil division, and subwatershed area. In addition, areas of bedrock outcrop, shallow bedrock, and high ground water table will be mapped and analyzed as these factors may relate to the planning, design, and provision of sanitary sewerage facilities. This data will not only serve as an aid in the system design but will also be utilized in the preparation of cost estimates of various plan elements. Thus, the detailed soils data continue to be invaluable to ongoing regional planning efforts. Proposed future regional planning programs, including programs designed to prepare a regional airport plan, a regional water supply system plan, and a regional park and outdoor recreation plan, will also have to utilize extensively the detailed soils data.

PLAN IMPLEMENTATION RECOMMENDATIONS

Each Commission planning report that recommends for adoption a regional or subregional plan element contains specific plan implementation recommendations to those federal, state, areawide, and local units of government that have the legal powers and financial means to implement most effectively the particular plan element under consideration.[3] Certain of these plan implementation recommendations relate directly to, and often incorporate, the regional soil survey and its accompanying interpretive analyses.

Soil and Water Conservation Practices

It is recommended that counties supplement exclusive agricultural and conservancy zoning district regulations of comprehensive county zoning ordinances by special land use regulations adopted for the purpose of conserving soil and water resources, controlling erosion, reducing stream pollution, and promoting good soil and water conservation practices. The latter may include the construction of upland water control structures, such as terraces, terrace outlets, grassed waterways, erosion control dams, dikes, ponds, and diversion channels, and the application of good land management practices, such as contour cultivating, reforestation, contour strip cropping, and the seeding and planting of lands to special plants, trees, and grasses.

Therefore, it is recommended in the cited planning reports that all county soil and water conservation districts, except Milwaukee County, formulate proposed soil and water conservation regulations pursuant to Section 92.09(1) of the Wisconsin Statutes; that all county boards, except Milwaukee County, adopt such proposed regulations pursuant to Section 92.09 of the Wisconsin Statutes; enforce such regulations; and, if necessary, have the work performed by the district supervisors pursuant to Sections 92.10 and 92.11 of the Wisconsin Statutes. It is further recommended that the State Soil Conservation Board apportion appropriate state and federal funds to the county soil and water conservation districts within the Region to enable implementation of the necessary conservation programs.

Special Soil Restrictions

The regional soil survey delineates and the interpretive analyses classify those soils which have severe and very severe limitations for urban development utilizing on-site soil absorption sewage disposal systems. In Section 144.025(2)(q) of the Wisconsin Statutes, the Wisconsin Legislature has given to the State Department of Natural Resources the power to prohibit the installation or use of septic tanks in any area

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[3] *For example, see Chapter VII of SEWRPC Planning Report No. 7, Volume III, Recommended Regional Land Use and Transportation Plans - - 1990; Chapter XIV of SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed; and Chapter IX of SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume II, Alternative Plans and Recommended Comprehensive Plan.*

of the state where water quality would be impaired through such installation and use. It is, therefore, recommended in the cited planning reports that the State Department of Natural Resources prohibit further septic tank system installations on soils within the Region that are rated in the regional soil survey as having very severe limitations for such use or where ground or surface waters would be subject to contamination and to further prohibit septic tank system installation on soils rated in the regional soil survey as having severe limitations for such use, unless such limitations are demonstrated to have been overcome.

It is also recommended in the cited planning reports that the State Division of Health amend Chapters H 62 and H 65 of the Wisconsin Administrative Code relating to sewage disposal systems so as to prohibit the installation of septic tank systems on soils rated in the regional soil survey as having very severe limitations for such use and to further prohibit septic tank system installations and subdivision of land on soils rated in the regional soil survey as having severe limitations for such use, unless such limitations are demonstrated to have been overcome.

It is further recommended that all counties, except Milwaukee County, pursuant to Section 59. 07(51) or Section 140. 09 of the Wisconsin Statutes, adopt sanitary ordinances regulating private water and sewage disposal systems that are related to the soil survey and interpretive analyses and that all counties, except Milwaukee County, and all cities, villages, and towns within the Region, pursuant to Section 236. 45 of the Wisconsin Statutes, amend existing or adopt new subdivision regulations containing an appropriate soil restriction clause.

Public Development Policies

It is recommended in the cited planning reports that all metropolitan and municipal utilities design and install public water supply and sanitary sewer systems so as to preclude the provision of such services to urban development proposed to be located on those soils designated in the regional soil survey as having severe and very severe limitations for such urban development.

SUMMARY

The regional soil survey and its companion interpretive analyses have been a basic data input in the various regional and watershed programs conducted by the Commission. The soils data and analyses are utilized directly by the Commission in the formulation of planning objectives and standards and in plan design, test, and evaluation.

The soil survey data provided a particularly important input to the preparation and design of the adopted regional land use plan. Because a large area of the Region was found to be unsuited for future development utilizing on-site soil absorption sewage disposal systems, it was determined that the alternative regional land use plans that were prepared in the regional land use-transportation study should place all future medium- and high-density residential development in areas capable of being served by public sanitary sewer systems. By analyzing interpretive soil maps, it was possible to quantify the soils poorly suited for urban development even with public sanitary sewer service and thus determine the amount of land that was suitable for future urban development. This suitable land was termed "developable land." Knowing the amount of developable land, it was then possible to use traditional land use plan design techniques in preparing the regional land use plan. The soils data were also very important in the determination and ultimate delineation of the environmental corridors in the Region.

The regional soil survey data and interpretive analyses have also been extensively utilized in the Commission's comprehensive watershed studies. The soils data and, in particular, the hydrologic soil groupings are an important input to the development of a mathematical hydrologic simulation model, which is principally used to evaluate possible flood characteristics of the particular river system under study. The soils data are also important in the watershed studies in determining the 10-year recurrence interval flood inundation line and in estimating the cost of proposed utility services, such as a public sanitary sewer system.

Additional Commission work programs will also extensively use the detailed soils data. A regional sanitary sewerage system planning program currently underway will extensively analyze the soils data for use as an aid in the sewerage system design and for use in preparing preliminary cost estimates of various plan elements. Proposed future regional planning programs designed to prepare a regional airport plan, a regional water supply system plan, and a regional outdoor and recreation plan will also extensively utilize the detailed soils data.

A number of regional and watershed plan implementation recommendations relate directly to and often incorporate the regional soil survey and interpretive analyses. The Commission has recommended, for example, that the Wisconsin Department of Natural Resources and the Wisconsin Division of Health and each county in the Region, except Milwaukee County, utilize the detailed soils data to prohibit further septic tank system installations on soils rated as having very severe limitations for such use. The Commission has also recommended that all municipal utilities design and install public water supply and sanitary sewer systems so as to preclude the provision of such service to areas designated in the regional soil survey as having severe and very severe limitations for urban development.

Chapter V
THE USE OF SOILS DATA IN COMMUNITY AND NEIGHBORHOOD DEVELOPMENT PLANNING

INTRODUCTION

Just as the detailed soils data continue to provide an important input to the preparation of regional and watershed plan elements, so also can the soils data be effectively utilized in planning at the community and neighborhood levels. In applying the soil survey and interpretive analyses to community and neighborhood planning, the local planner and engineer are concerned with the properties, capabilities, and suitabilities of soils for various land uses; with the spatial location of and areal extent of the various soil types; and with their effect upon utility service areas, proper locations for residential, commercial, and industrial land uses, and upon the location of streets and drainageways and block and lot layouts. Thus, the local planner or engineer is concerned about the same general influences of soil patterns and properties upon sound land use development as the regional planner or engineer. The basic difference is one of scale and detail in that the local planner and engineer can utilize the soils data more intensively in the planning process because of the reduced area of geographic responsibility. Moreover, the local planner and engineer can bring the soils data to bear most effectively in day-to-day working relationships with public and private land developers. Indeed, it is at this level that the soils data has proven to be truly invaluable in the Southeastern Wisconsin Region.

This chapter will discuss and illustrate, by way of examples drawn from within the Region, the use of detailed soils data and analyses in the preparation by local planners and engineers of community and neighborhood development plans. Three local planning efforts will be noted: the preparation of a comprehensive community plan for the Kenosha Planning District, the preparation of a storm water drainage plan for the City of Mequon, and the preparation of precise neighborhood unit development (subdivision layout) plans for the Village of Germantown.

COMPREHENSIVE COMMUNITY PLANNING

Soils data can be used in the preparation of a comprehensive community plan in much the same manner as described in Chapter IV for the preparation of regional plan elements. The basic process involved is an analysis of the suitability of the soils for the various categories of land uses expected to occur in the community. These suitability analyses can then be used as an input to the preparation of a community land use plan and supporting public utility and community facility service plans. The following discussion will serve to illustrate the use of soils data in preparing an actual comprehensive community development plan.

Kenosha Planning District

In 1963 the local units of government having jurisdiction over all that part of Kenosha County lying easterly of IH 94 determined to undertake a cooperative planning program designed to provide a comprehensive plan for the area, which was subsequently called the Kenosha Planning District. The District, which has an area of about 85 square miles and a population (1964) of about 96,000 persons, is comprised of three local units of government: the City of Kenosha and the Towns of Pleasant Prairie and Somers. The District represents a rational urban planning unit encompassing all of the City of Kenosha and the surrounding areas into which the Kenosha-oriented urban growth is expected to expand over the next 20 to 25 years. The Planning District was intended to provide the basis for the preparation of areawide development plans in greater depth and detail than practical at the regional level. As such, the District planning program provided a single, integrated comprehensive community development plan for the three constituent local units of government. The planning program was administered by the Regional Planning Commission, with the actual planning work being carried out by the firm of Harland Bartholomew and Associates, city planners, under the general guidance of a local intercommunity Citizens Advisory Committee.

Planning Objectives and Principles: The comprehensive planning program for the District included the preparation of development objectives relating to sound land use development within the District. In addition to the specific objective of allocating sufficient land in each of the various urban land use categories to house and serve an estimated 1990 District population of 181,000, the program recommended the following development objectives relating to the soil resource:

1. The proper allocation of land uses to the capabilities of the land so as to avoid or minimize hazards to health and safety.

2. The proper relation of urban and rural land use development to the underlying soils so as to avoid environmental problems, aid in the establishment of better development patterns, and promote the wise use of an irreplaceable resource.

3. The proper relation of land uses to the supporting utility systems in order to assure the economical provision of utility services, particularly sewerage and water supply facilities.

4. The preservation of land for agricultural use.

Soil Suitability Maps: Special soil suitability maps were prepared as part of the initial work effort under the District planning program. In all, six such suitability maps were prepared, one for agricultural, three for residential, one for industrial, and one for recreational land uses. The interpretive analyses used to prepare the suitability maps were taken from Table 8 of SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin, as described in Chapter III of this Guide. A modified, three-category "stop-go" color coding system was utilized to provide the graphic representation necessary for analytical purposes.

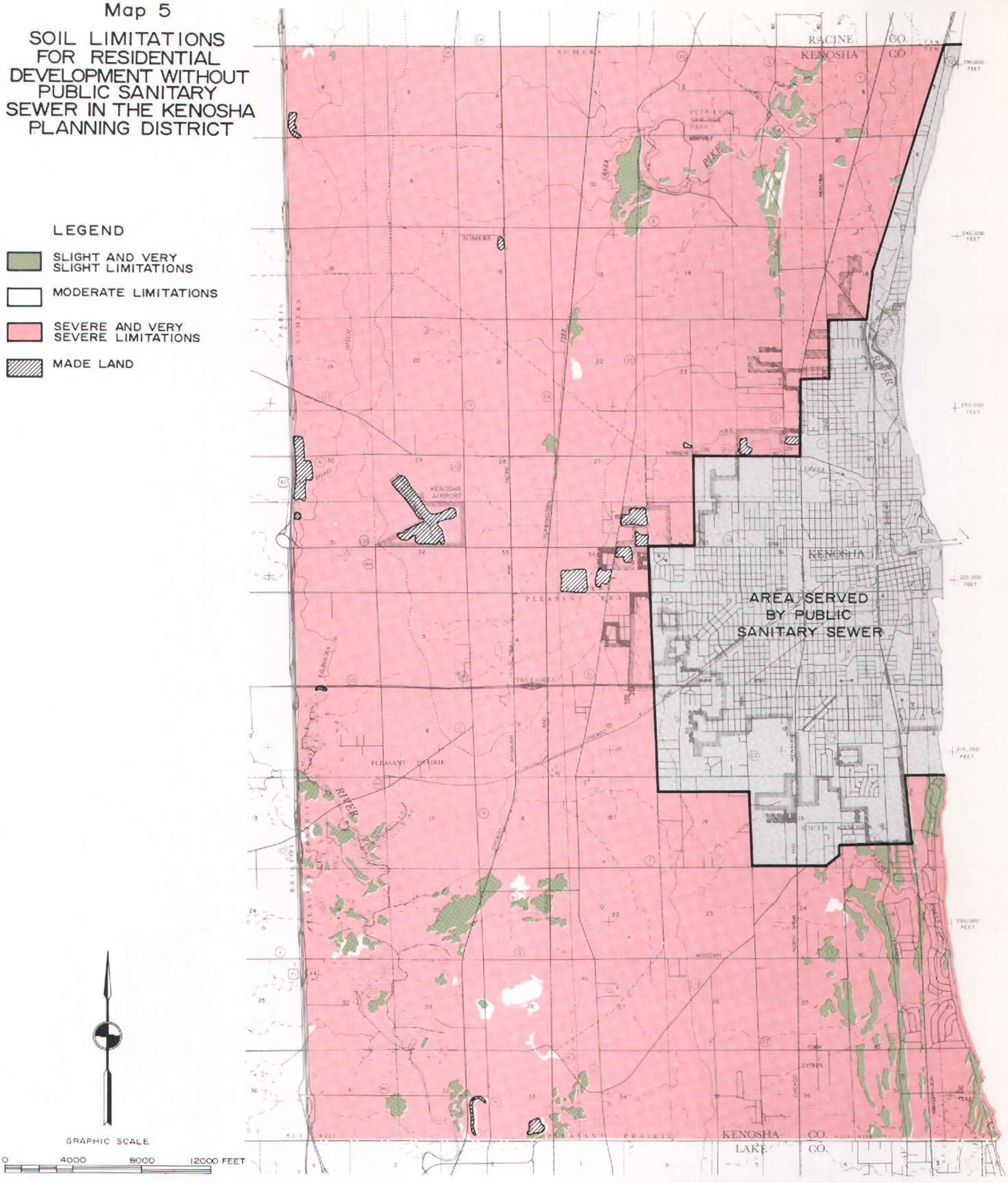
Two of the series of soil suitability maps prepared for the District planning program are reproduced in this Guide as Maps 5 and 6. The large amount of the land in the District outside the already urbanized area that has severe and very severe limitations for residential or other intensive urban development utilizing on-site soil absorption sewage disposal systems is shown on Map 5. This can be contrasted with the relatively large amounts of land in the District that have only moderate, slight, or very slight limitations for such development when served by public sanitary sewerage facilities, as shown on Map 6. These soils analyses made it evident that the Kenosha Planning District could not be developed in a sound and orderly manner without the provision of adequate public sanitary sewerage service. This fact, in turn, was a major influence in selecting and recommending desirable overall population densities for various portions of the District. The soils analyses also provided much valuable information that was used in the plan design process to spatially distribute the various land uses within the District.

District Plans: The comprehensive planning program for the Kenosha Planning District was designed to produce a land use plan, together with supporting transportation, utility, and community facility service plans. In the preparation of the plan, many inventories and analyses were conducted in addition to the soils analyses noted above; and it should be stressed that the District plan, as finally recommended for adoption, is based upon a thorough understanding and careful consideration of many factors, in addition to the soils.

Reproduced on Maps 7 and 8 are the District land use plan and the District sanitary sewerage system plan. These plan elements have been designed to accomplish or comply with the aforementioned District development objectives and are based in part upon the results of the soils analyses. The District land use plan provides for the conversion of a total of almost 17,500 acres of land from rural to urban residential use within the District by 1990, the target year of the plan. Because of the demonstrated severe and very severe limitations of the soils in the District for utilization of on-site soil absorption sewage disposal systems, all of the proposed high- and medium-density residential development and those low-density residential areas lying in the extreme northern section of the District are proposed to be served by centralized public sanitary sewerage facilities.

Map 5

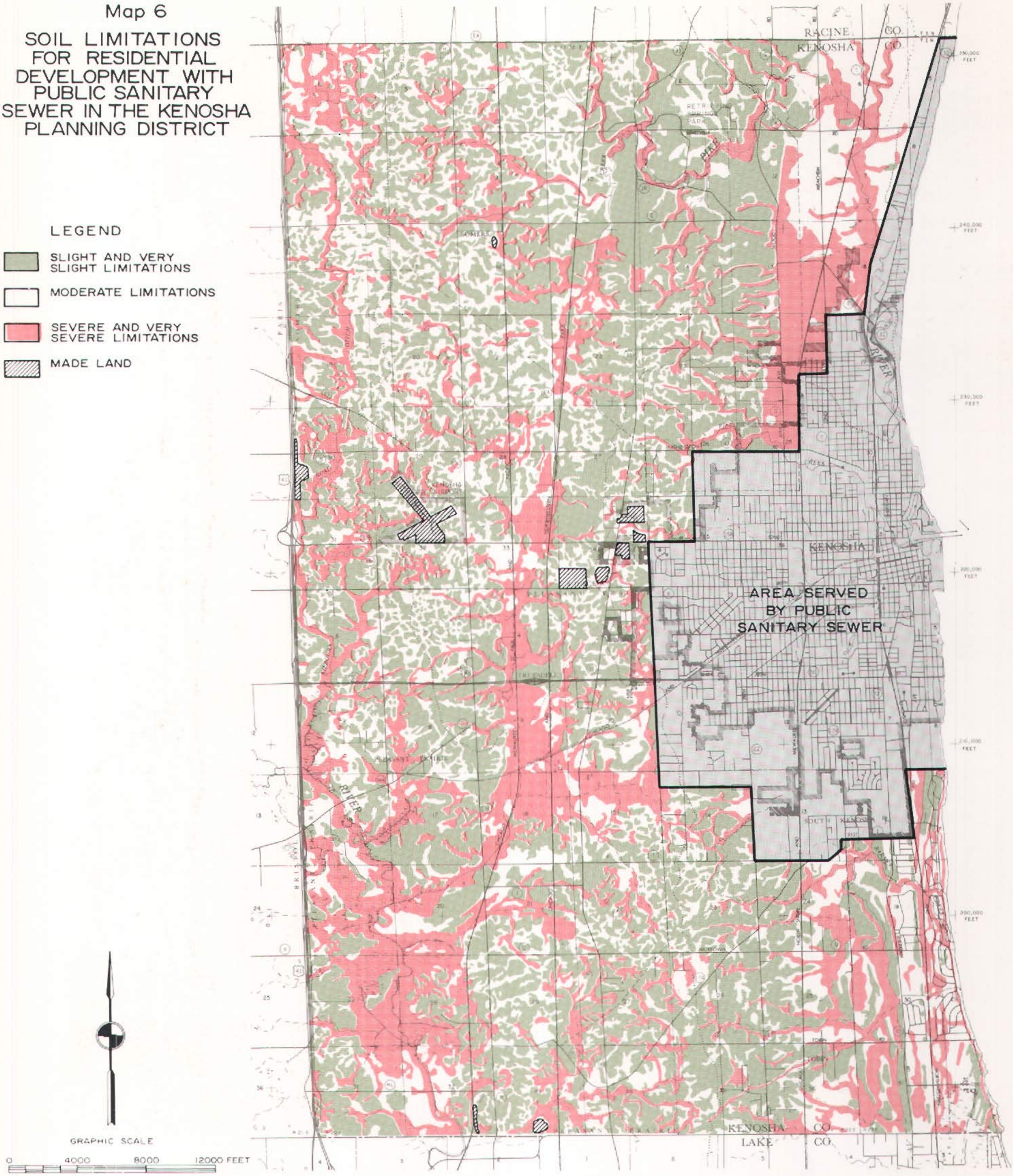
SOIL LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER IN THE KENOSHA PLANNING DISTRICT



The above map of the 85-square mile Kenosha Planning District depicts the widespread unsuitability of the soils for the proper absorption of on-site sewage disposal (septic tank) effluent. The development of such lands without public sanitary sewer service inevitably results in malfunctioning septic tank systems which produce an untreated effluent that can lead to severe environmental health problems.

Map 6

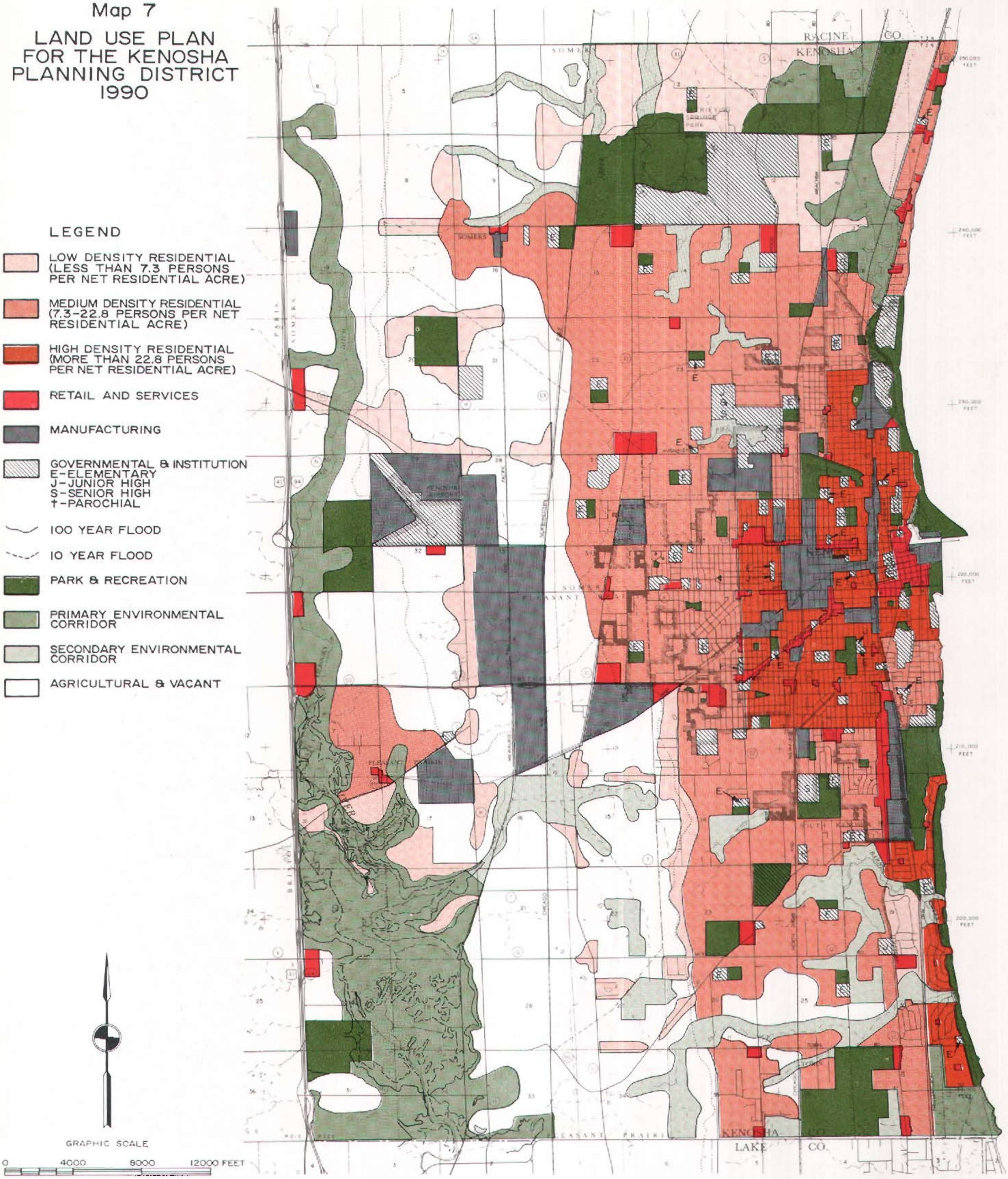
SOIL LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER IN THE KENOSHA PLANNING DISTRICT



The vast majority of the land available for development in the Kenosha Planning District has only very slight, slight, or moderate limitations as long as a public sanitary sewer system serves the area. Those areas which have severe and very severe limitations for development even with public sanitary sewer offer, in many cases, opportunities for development as parks and open spaces in the urban environment. Soils analyses such as this provide an invaluable input to the planning process.

Map 7

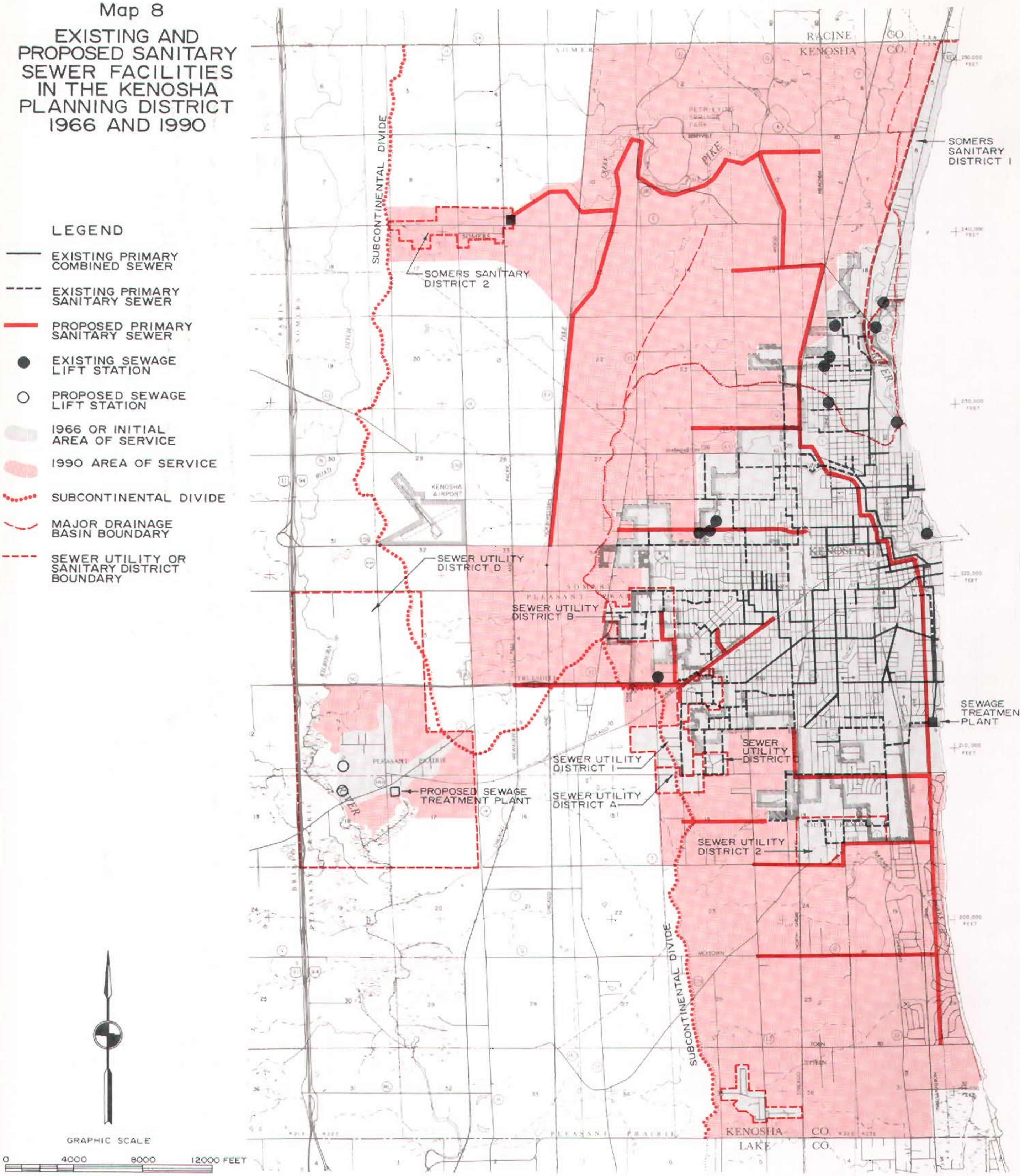
LAND USE PLAN FOR THE KENOSHA PLANNING DISTRICT 1990



The Kenosha Planning District represents a rational planning unit that provides the basis for the preparation of areawide development plans in substantial depth and detail. The above land use plan for 1990 represents an attempt to adjust urban development to the underlying and sustaining natural resource base and because of soil conditions is premised on the provision of public sanitary sewer service over most of the District.

Map 8

EXISTING AND PROPOSED SANITARY SEWER FACILITIES IN THE KENOSHA PLANNING DISTRICT 1966 AND 1990



Because of the extremely poor suitability of the soils in the Kenosha Planning District for the absorption of septic tank sewage effluent, the recommended District comprehensive plan calls for the provision of sanitary sewer service to nearly all of the 1990 developed areas of the District. Construction of the above system will ensure orderly and economic development of the District through 1990.

The District plan proposes to retain in agricultural or other open uses until 1990 large areas of the District not needed to fulfill the forecast urban land use demands within the District. These areas cannot be economically served by public utility systems and contain soils that have excellent agricultural suitability. These District plans, as well as the basic District inventories and analyses and the recommendations for implementing the plans, are set forth in SEWRPC Planning Report No. 10, A Comprehensive Plan for the Kenosha Planning District, issued in two volumes in 1967.

Having the detailed soil survey information available during the conduct of the Kenosha Planning District comprehensive planning program enabled the planners and the Advisory Committee to formulate more effectively the recommended District plan elements. In particular, application of the soils data and interpretive analyses resulted in a spatial allocation of the recommended industrial, commercial, and recreational areas that are closely related to the capabilities of the underlying and sustaining soil resource base and in sound recommendations to service nearly all proposed urban development in the District with public sanitary sewer and public water supply. Detailed soil surveys thus provided another very important input to the community planning and development process.

STORM WATER DRAINAGE PLANNING

The provision of adequate storm water drainage facilities poses a recurrent problem in community planning and development. Soils data can be useful to engineers in the preparation of storm water drainage system plans designed to alleviate existing drainage problems and to avoid the creation of new problems as development proceeds. Since urban storm water drainage systems are among the most expensive of all public works and since they directly affect the public health, safety, and welfare, the design of such systems deserves careful attention.

Determination of Storm Water Runoff

One of the most difficult problems encountered in the design of urban storm water drainage systems is the determination of storm water runoff; that is, the quantity of water that must be carried by the drainage system. The amount of storm water runoff is not susceptible to precise determination and must, therefore, be estimated by the design engineer. One of the more common design methods used in the calculation of storm water runoff is known as the rational method. This method recognizes that a direct relationship exists between rainfall and runoff. The key factor in this design method is a dimensionless coefficient of runoff representing the ratio between the maximum rate of runoff from the area under consideration and the average rate of rainfall on the area during the time of concentration. It is in the determination of this coefficient of runoff that detailed soils data can be especially useful.

The Commission, as a part of its overall work program, has prepared a series of weighted coefficients of runoff related to varying conditions of slope, soil permeability, and land use for use within the Region in conjunction with the rational method of storm water runoff determination. The infiltration characteristics of the soils were a significant consideration in the determination of these composite coefficient of runoff values. The hydrologic grouping of soils, as discussed in Chapter III and presented in Appendix C, was selected as an important input to the determination of the coefficient of runoff. There are four hydrologic soil groups: A, B, C, and D; the A soils group exhibiting the highest, and the D soils group the lowest, infiltration capacity. The hydrologic soil group information, together with slope data that are also available through the detailed soil survey, together with existing and proposed land use information, was then used to calculate recommended weighted coefficient runoff values. These values of the coefficient of runoff, C, for composite land use, slope, and soil conditions are presented in Table 27 as ranges and in Figure 51 as curves. This facilitates the selection of appropriate coefficients of runoff storm drainage facility design, as well as providing a sounder basis for the selection by recognizing the effects of soil type and slope on runoff.

Application in the City of Mequon

A recent storm water drainage planning program was carried out in the City of Mequon utilizing the soils data in the above recommended manner. The City of Mequon comprises a geographic area of approximately 50 square miles bordering Lake Michigan in southern Ozaukee County. The City is characterized

Table 27

WEIGHTED RUNOFF COEFFICIENTS FOR USE IN THE RATIONAL FORMULA

Hydrologic Soil Group	A			B			C			D		
Slope Range	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Land Use												
Industrial	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High-Density Residential	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Medium-Density Residential	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low-Density Residential	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agricultural	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways and Expressways	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Source: SEWRPC.

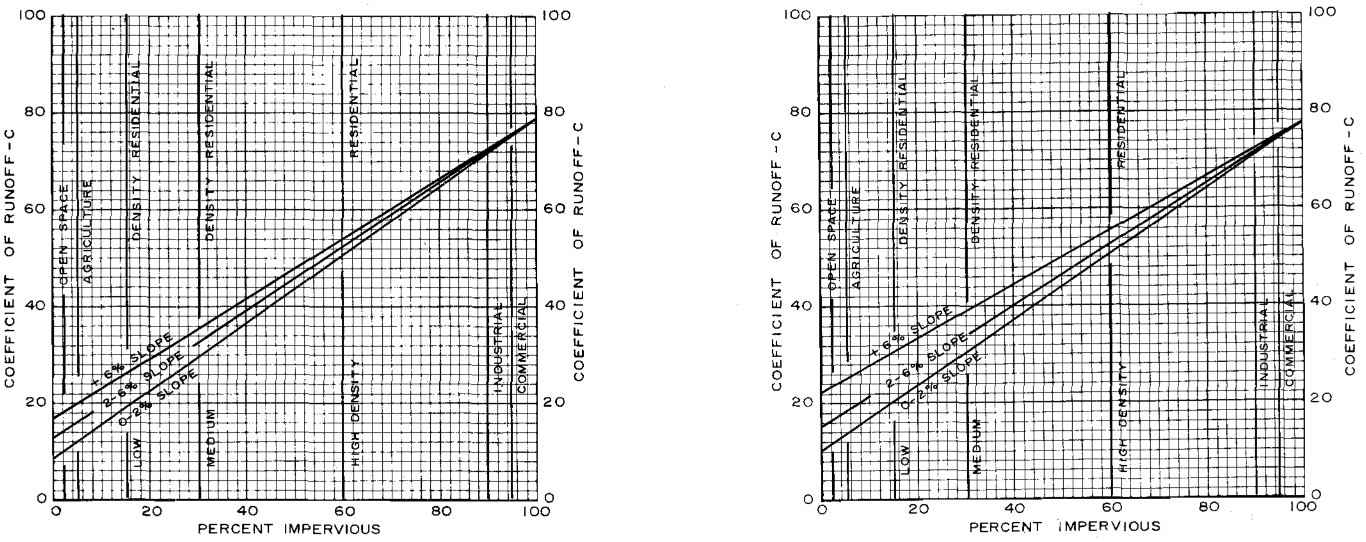
by primarily low-density residential development and is currently experiencing a rapid rate of urbanization. As in other rapidly urbanizing communities, the problem of storm water drainage grew to the point where the local officials retained an engineering consultant to recommend a plan and program which would permit the City to provide an adequate system of storm water drainage facilities.

Because of the low-density characteristics of the community, the design standards selected by the engineering consultant were premised on the use of storm water drainage facilities consisting of open, smooth-graded earth channels with sodded bottom and banks and occasional natural stone check dams to restrict velocities and control erosion, instead of storm sewers. The rational method of flood flow computation was selected for use in the system planning and design. To determine the coefficient of runoff, the consultant utilized topographic base maps upon which were delineated the City's zoning districts, which represented existing and proposed land uses, and the soils in the form of the various hydrologic soil groups. A composite hydrologic soil grouping map of the City of Mequon is shown on Map 9.

Considering the topographic information, the land use data, and the soils data displayed on the base map, the consulting engineer was able to quickly derive a composite coefficient of runoff for each drainage subarea. The storm water runoff coefficients selected for use are shown in Table 28. Once the design flood flow for each reach of each major channel was computed, a typical channel cross section was designed and the needed right-of-way for each reach established. The final storm water drainage master plan, then, contains recommendations for the location, cross section, and right-of-way requirement for each major storm water drainage channel in the City.

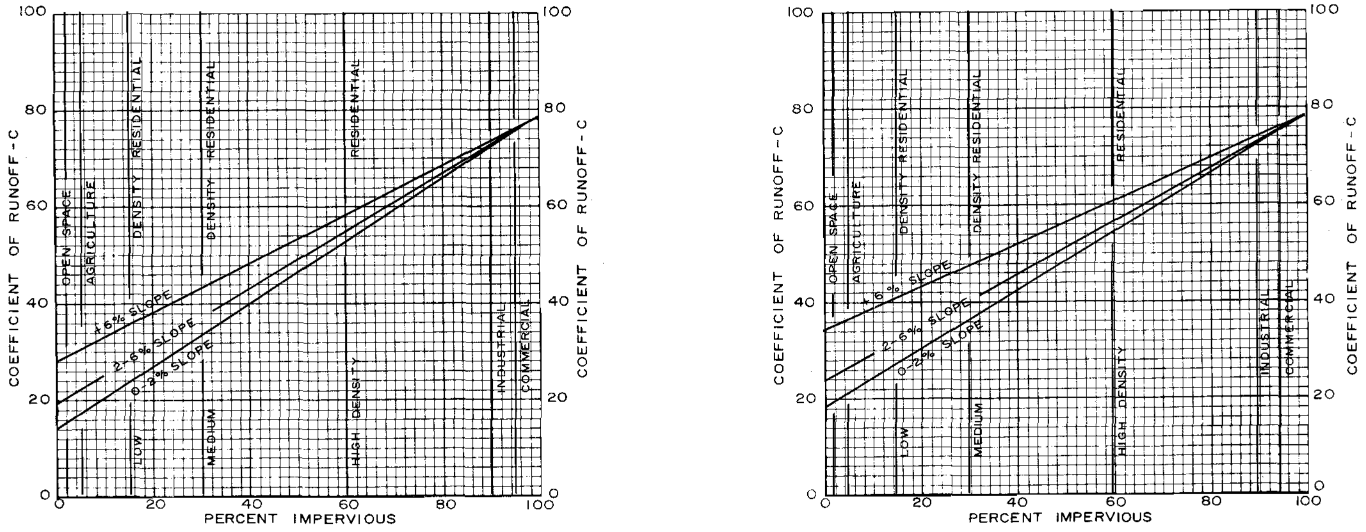
The preparation of a storm water drainage master plan in advance of urban development enables a community to take action to avoid the severe drainage problems which may result from improper subdivision

Figure 51
COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUPS



COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUP "A"

COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUP "B"



COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUP "C"

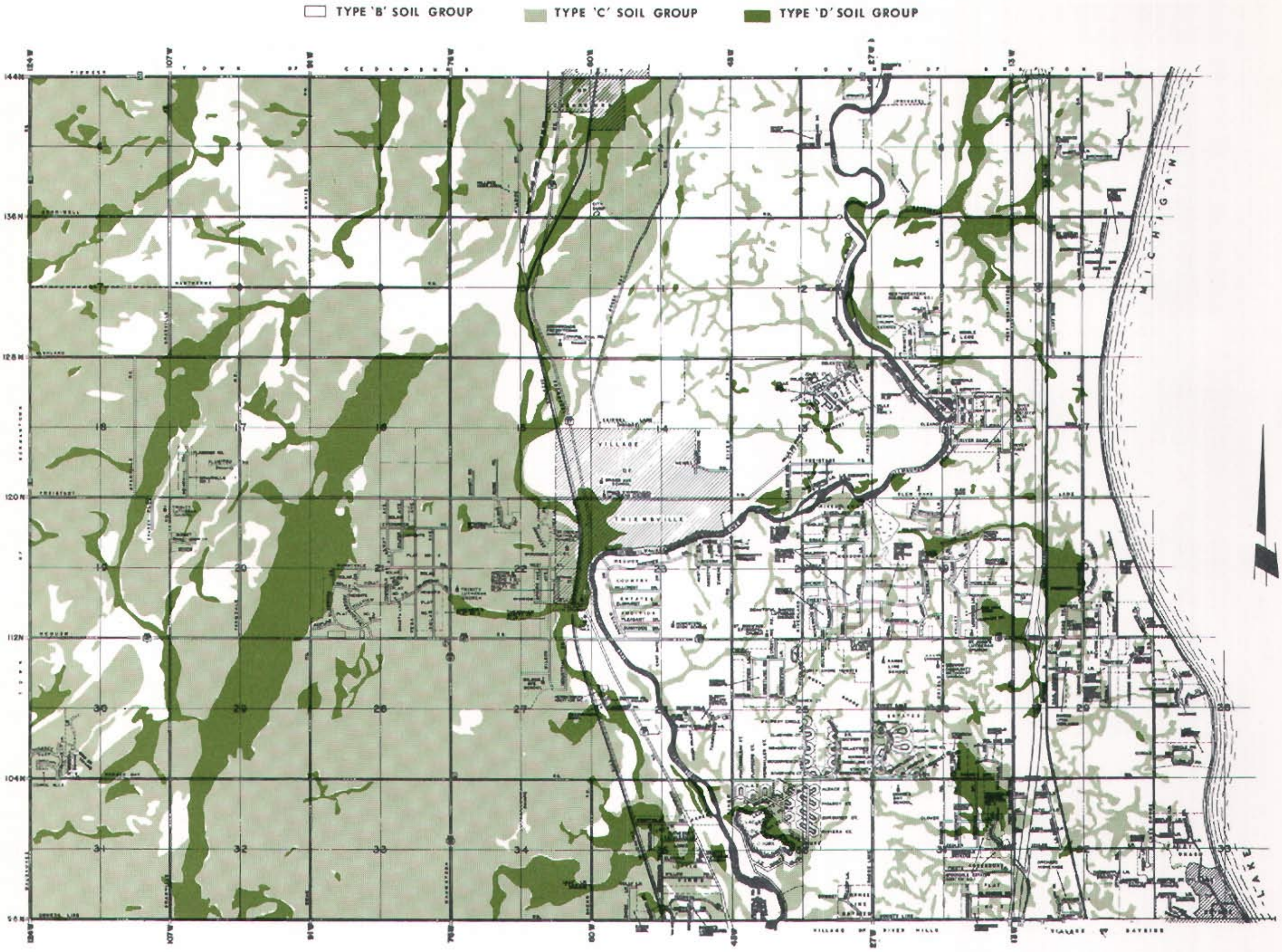
COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUP "D"

Source: SEWRPC.

Map 9

CITY OF MEQUON, WISCONSIN

HYDROLOGIC SOIL GROUPING MAP



Source: J.C. Zimmerman Engineering Corporation.

Hydrologic soil data play an important role in the determination of rainfall-runoff coefficients used in the computation of estimated flood flows for small drainage areas. Such data was effectively used in a master storm water drainage planning program for the City of Mequon in Ozaukee County. As shown on the above map, hydrologic soil groups C and D predominate in the western and relatively undeveloped portion of the City.

layout. In addition, such a drainage plan, if properly implemented, can assist in avoiding the expenditure of large sums of public funds to build expensive drainage improvements, such as concrete-lined channels and deep storm sewers, required to overcome storm water drainage problems once such problems have been allowed to develop. Of particular importance in a program like that carried out for the City of Mequon is the establishment of the necessary rights-of-way for all drainage channels. These rights-of-way can then be protected during urban development through the subdivision review process by requiring the dedication or reservation of the needed rights-of-way for eventual public use. The use of the detailed soils data to arrive at these storm water drainage recommendations represents another major application of the soils data and analyses in sound, long-range community planning.

NEIGHBORHOOD PLANNING

The Commission has recommended that communities within the Region take steps to ensure that future urban development will take place in individual neighborhood units rather than as a formless mass. This

Table 28

CITY OF MEQUON
COEFFICIENTS FOR STORM WATER RUNOFF

ZONING	HYDROLOGIC SOIL GROUPING						ALL CASES
	B		C		B&C		
	2%-6%	6% +	2%-6%	6% +	2%-6%	6% +	
RCE	.28	.34	.32	.40	.30	.37	
RRE	.28	.34	.32	.40	.30	.37	
RLE	.28	.34	.32	.40	.30	.37	
R-1	.28	.34	.32	.40	.30	.37	
R-2	.28	.34	.32	.40	.30	.37	
R-3	.28	.34	.32	.40	.30	.37	
RSE	.28	.34	.32	.40	.30	.37	
RS1	.28	.34	.32	.40	.30	.37	
RS2	.28	.34	.32	.40	.30	.37	
RS3	.28	.34	.32	.40	.30	.37	
RM1	.39	.44	.42	.49	.41	.47	
RM2	.39	.44	.42	.49	.41	.47	
C-1							.89
C-2							.89
C-3							.89
I-1							.86
I-2							.86
OH							.89
OGP	.28	.34	.32	.40	.30	.37	
O1P	.58	.60	.64	.64	.59	.62	
OA	.28	.34	.32	.40	.30	.37	
OPS	.28	.34	.32	.40	.30	.37	
WF							.22
FREEWAYS							.70

Source: J.C. Zimmerman Engineering Corporation.

can be done at the community level through the institution and implementation of a precise neighborhood unit development planning program. Insofar as possible, each neighborhood unit should be a relatively self-contained unit with respect to the day-to-day living requirements of the family, bounded by arterial streets, major parks and parkways, institutional lands, bodies of water, or other natural or cultural features which would serve to physically separate each unit from the surrounding units. Such neighborhood units should be of such size and development density as to provide housing for that population for which, by prevailing standards, one elementary school is required. Each unit is further intended to provide, within overall density limitations, a full range of housing types and lot sizes; a full complement of public and semipublic facilities needed by the family within the immediate vicinity of its dwelling, such as church, local park, and local shopping facilities; and ready access to the arterial street system. The internal street pattern of planned neighborhood units should be designed not only to facilitate vehicular and pedestrian circulation within the unit but also to discourage penetration by through traffic. In building communities through this concept, local public officials promote not only an environment designed to achieve a sense of physical unity but also one that leads to greater personal identity in an urban area.

Within the Southeastern Wisconsin Region, several local communities are attempting to utilize the precise neighborhood unit development concept in directing and guiding future development. The Village of Greendale and the City of Oak Creek in Milwaukee County were among the first communities within the Region to prepare such plans. The Commission is now working with the City of Franklin in Milwaukee County, the City of Cedarburg in Ozaukee County, and the City of West Bend and the Village of Germantown in Washington County in preparing precise neighborhood unit development plans. The following example of neighborhood unit planning in the Village of Germantown will serve to illustrate how the detailed soils data is utilized in such precise planning programs.

Application in the Village of Germantown

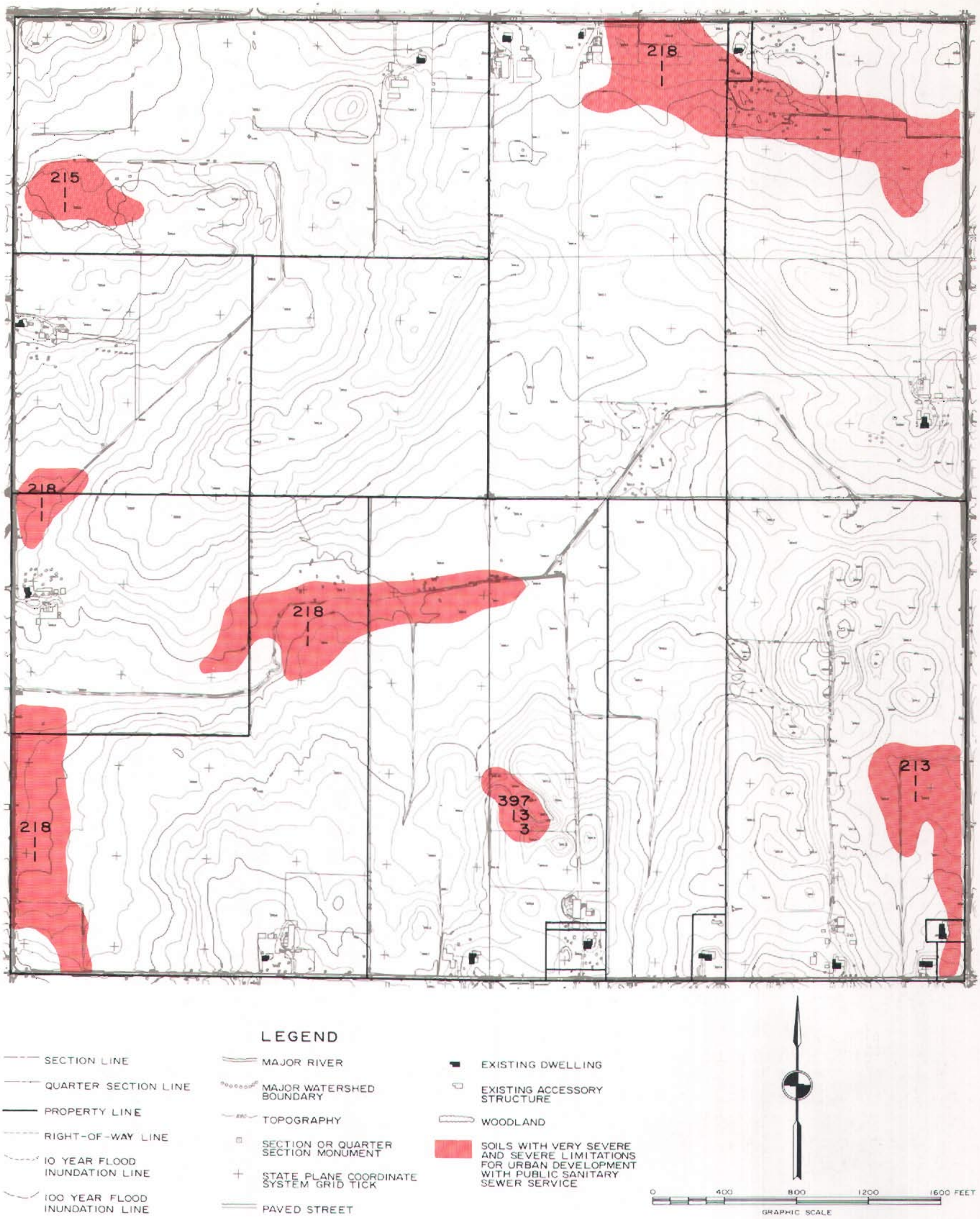
The Village of Germantown consists of a 35 square mile area lying in the southeasterly corner of Washington County in a rapidly urbanizing area adjacent to the City of Milwaukee. During the preparation of a comprehensive community plan for the Village in 1967, the Village officials requested the Regional Planning Commission staff to prepare detailed neighborhood unit development plans for the approximately six square mile area designated for extensive urban development on the adopted regional land use plan. Such precise neighborhood unit development plans were to provide for the identification and delineation of public school and park sites to be preserved for ultimate acquisition; the delineation of required rights-of-way for arterial highways, collector and minor streets, and drainageways so that these rights-of-way could be preserved for ultimate dedication or acquisition at a minimum cost and with a minimum disruption of existing development; and a recommended platting layout based upon existing development, topography, soils, parcel ownership, and the land use pattern recommended in the Village plan. The objective was to achieve for each delineated neighborhood the best development design possible, given the constraints of existing land uses, topography, soil conditions, and parcel ownership. The use of soils data in land development design and regulation will be further discussed in Chapter VII of this Guide. Attention here will be focused on the use of soils data in designing the overall neighborhood unit development plan.

The Village had already prepared the topographic base maps and cadastral (property boundary) maps necessary to properly conduct the neighborhood unit planning program. The next step was to identify those soils in the neighborhood areas that had severe and very severe limitations for development even with public sanitary sewer service. These soils were then delineated on the topographic base map, along with property boundary lines. Map 10 shows the topographic base map for the Jefferson Park Neighborhood with the poor soils and property boundary lines delineated on it.

In the Jefferson Park Neighborhood, seven separate soil mapping units were identified as having very severe and severe limitations for development. These seven mapping units included three different soil types. These three types and their limitations for development are as follows:

Map 10

LARGE-SCALE TOPOGRAPHIC BASE MAP JEFFERSON PARK NEIGHBORHOOD VILLAGE OF GERMANTOWN



Soundly prepared topographic cadastral and soils maps provide an essential basis for beginning a neighborhood unit development planning program. Such a program recognizes that communities should develop in meaningful cellular units rather than as a formless mass. The above map of a future neighborhood in the Village of Germantown, Washington County, depicts not only topography but also property boundary lines and those soils having severe and very severe limitations for urban development even with public sanitary sewer service. This information is vital to the preparation of sound precise neighborhood unit development plans.

Soil Code Number	Limitation
213-1-1 and 215-1-1	Liquifies easily; has low bearing capacity, frost heave susceptibility, and high water table; generally results in wet basements and flotation of pipes.
218-1-1	Has low bearing capacity, high shrink-swell potential, and high water table; generally results in wet basements.
397-13-3	Erosive on slopes; has low bearing capacity and high shrink-swell potential.

Given knowledge about the Jefferson Park Neighborhood, including existing land use; soils data; topography; property boundaries; and the land use, utility, transportation facility, and community facility recommendations available from the Village comprehensive development plan, it was then possible to design a recommended precise neighborhood unit development plan for the Jefferson Park Neighborhood. This recommended plan is shown on Map 11.

The plan provides for the ultimate urban development of the entire approximately one square mile neighborhood. A neighborhood school site and neighborhood park site have been centrally located along collector streets. The exact distribution of future land uses within the neighborhood is shown on Map 11. Provision has been made for about 300 acres of single-family residential development, 25 acres of two-family residential development, and 65 acres of multi-family residential development. In addition, a 54-acre tract of land in the northeast corner of the neighborhood, containing the largest area covered by unsuitable soils in the neighborhood, has been recommended for residential planned unit development. In this way, the residential structures can be grouped or "clustered" around courts in those parts of the tract having suitable soils, while the unsuitable soil area remains in common open space to benefit the entire development.

An additional large area of unsuitable soils, leading southwest from the school site, has been primarily recommended for dedication as an open drainageway. Not only will such dedication result in additional open space in the neighborhood, but the ultimate construction of expensive public works to improve drainage will be avoided. It was not considered feasible to include the remaining smaller areas of poor soils in parcels designated for permanent open space. Lot sites located on these small pockets of poor soils will pose some problems for potential home builders and buyers. In such cases, efforts should be made to educate potential lot buyers with respect to the problems associated with these soils. In addition, home builders should be encouraged to take additional precautions against potential problems, such as undertaking special foundation construction, drainage, and waterproofing measures. On steep slopes special erosion-control measures should be considered. These will be discussed more fully in Chapter VII of this Guide.

Precise neighborhood unit planning offers an opportunity for a community to take the lead in encouraging and requiring sound design in the land development process. Through such a program, a local plan commission does more than simply react to developers' proposals, since detailed, precise plans have been prepared in advance and are available for use in evaluating the merits of each development proposal as it arises. As we have seen, the detailed soils data can provide, once again, an important input to the planning and land development process.

SUMMARY

The detailed soil survey and interpretive analyses can be applied a variety of ways in planning and engineering at the community level. The local planner or engineer is concerned with the properties, capabilities, and suitabilities of soils for various land uses and with the spatial location of soil types and their areal extent.

Map 11

PRECISE NEIGHBORHOOD UNIT DEVELOPMENT PLAN JEFFERSON PARK NEIGHBORHOOD VILLAGE OF GERMANTOWN

LEGEND

LAND USE	NUMBER OF ACRES	PERCENT OF TOTAL
▭ SINGLE-FAMILY RESIDENTIAL	311.43	48.65
🟥 TWO-FAMILY RESIDENTIAL	26.60	4.15
🟥 MULTI-FAMILY RESIDENTIAL	65.20	10.18
▦ RESIDENTIAL PLANNED UNIT DEVELOPMENT	53.60	8.38
▨ GOVERNMENTAL OR INSTITUTIONAL	11.06	1.73
🟩 RECREATIONAL, OPEN SPACE, OR DRAINAGEWAYS	32.52[a]	5.08[a]
|130'| STANDARD ARTERIAL STREET OR HIGHWAY	33.04	5.16
|80'| COLLECTOR STREET	18.36	2.87
|60'| MINOR STREET	88.34	13.80
NEIGHBORHOOD TOTAL	640.15	100.00

|| EXISTING STREET SURFACE

▨ SOILS HAVING SEVERE OR VERY SEVERE LIMITATIONS FOR URBAN DEVELOPMENT WITH PUBLIC SANITARY SEWER

[a] DOES NOT INCLUDE OPEN SPACE IN RESIDENTIAL PLANNED UNIT DEVELOPMENT

The above precise neighborhood unit development plan for a neighborhood in the Village of Germantown seeks, insofar as possible, to retain in public or private open space those large areas having soils with severe and very severe limitations for urban development. One such large area has been placed in a drainageway to be dedicated at the time of subdivision. Another large poor soil area has been recommended for open space use within a planned unit development where the structures are clustered on the better soil types. Severe drainage and foundation problems can be avoided through this kind of neighborhood unit planning process.

Soils data can be used in the preparation of a comprehensive community plan through an analysis of the suitability of soils for the various categories of land uses expected to occur in the community. An example of a comprehensive community plan prepared in part upon the basis of soils data is that for the Kenosha Planning District, lying in eastern Kenosha County. Special soil suitability maps were prepared as part of the comprehensive planning program for the District. These maps provided a graphic representation of the suitability of the soils in the District for agricultural, residential, industrial, and recreational land uses. The study revealed that most of the land in the District outside the already urbanized area had severe or very severe limitations for development with on-site soil absorption sewage disposal systems. Through these soils analyses, it became evident that the area could not develop in a sound and orderly manner without the provision of public sanitary sewer systems. The District land use and supporting utility and facility service plans were based in part upon the results of the soils analyses. Nearly all of the residential areas proposed in the plan are recommended to be served by a public sanitary sewer system. In addition, certain areas containing soils that have excellent agricultural suitability are recommended to be retained in agriculture or open use at least through 1990.

Soils data can be extremely useful in the preparation of a storm water drainage plan designed to alleviate existing drainage problems and to avoid the creation of additional problems as development proceeds in an area. The soils data are particularly useful in the design of urban storm water drainage systems as an input to the determination of storm water runoff; that is, of the quantity of water that must be carried by the drainage system. The hydrologic grouping of soils can be used to assist in determining the coefficient of runoff, which is, in turn, used to calculate storm flows. Once these values are available, the engineer can proceed with the hydraulic design of the storm drainage system.

Soils data are also extremely useful in the preparation of precise neighborhood unit development plans. Such plans, currently being prepared by several communities in the Region, provide for the delineation of public school and park sites, of required rights-of-way, and of a recommended platting layout based upon parcel ownership. An important step in the neighborhood planning process is the identification of those soils unsuitable for most urban development. In designing the precise neighborhood unit development plan, the planner may be able to recommend the placing of the poor soil areas in either public or private open space. Such open space can often be dedicated to the local unit of government for drainageways. In certain instances, the planned unit development concept can be used on large parcels to cluster structures around courts located on soils suitable for development, while retaining the poor or unsuitable soil areas in permanent open-space use, and thereby achieve not only the objective of avoiding the erection of structures in unsuitable soil areas but also the objective of creating open space in urban neighborhoods while achieving a desired overall development density.

Chapter VI
THE USE OF SOILS DATA IN ZONING REGULATIONS

INTRODUCTION

Of all the land use controls available to assist local public officials in guiding and shaping development in the public interest, the most readily available, the most important, and the most versatile is zoning. A properly prepared zoning ordinance consists of a text setting forth regulations which apply to the use of land in various zoning districts and a map delineating the boundaries of the various districts or areas to which the regulations apply. A thorough discussion of this plan implementation device is set forth in SEWRPC Planning Guide No. 3, Zoning Guide, 1964.

The soil survey and accompanying interpretive analyses can be used in conjunction with, and directly incorporated into, local zoning ordinances in the following ways:

1. Through the creation of special zoning districts related to certain kinds of soils.

2. Through the incorporation of special use regulations relating to certain kinds of soils.

3. In the delineation of district boundaries.

4. In the determination of special hazard areas, such as floodlands.

This chapter will consider these applications of soils data and analyses to zoning, discuss the administration and enforcement of zoning provisions relating to soils, and present an example of how the soils data were actually used in the preparation of a zoning ordinance and district map for a community within the Southeastern Wisconsin Region. In any consideration of the following discussion of the use of soils data in zoning, it must always be remembered that soils are only one consideration, albeit an important consideration, in any zoning action. Due consideration must also always be given to other factors involved, including the existing land use pattern, land use demand forecasts, community and neighborhood unit development plans, relationship to public utilities, relationship to transportation facilities, property ownership patterns, and economic development, as well as to soils.

ZONING DISTRICTS AND SOILS DATA

The detailed soil survey and interpretive analyses may be used in the creation of special zoning districts appropriate to the capability and suitability of soils for specific uses, as well as a basis for the application of conventional zoning districts. Of particular importance in this respect are agricultural, conservation, and residential zoning districts.

Agricultural Districts

Exclusive agricultural districts may be created for the purpose of preserving prime agricultural lands. These districts can then be applied to selected areas covered by soils particularly well suited to agricultural use. Special agricultural soil suitability maps, as discussed in Chapter III of this Guide, can provide the basis for delineating such districts. The exclusive agricultural districts would permit all types of general and special types of farming but would permit only farm dwellings for those residential owners and laborers actually engaged in the principal permitted uses. The use of such districts can assist in controlling or preventing urban sprawl and the costly problems attendant thereto and in protecting the soil resources from destruction by urban development. In addition, exclusive agricultural districts, combined with proper tax relief policies,[1] can serve to preserve and protect prime agricultural land in close proximity to major metropolitan markets; can provide the rural open space needed to complement increasing massive urbanization; and can serve as effective holding zones in the public interest to prevent premature, scattered, and undesirably mixed urban development, thus providing the opportunity to develop urban areas in a sound, orderly, and logical fashion. Examples of these types of exclusive agricultural districts are presented in Appendix D.

Conservation Districts

A resource conservation district may be created for the purpose of protecting the community's soil, water, wetland, woodland, and wildlife resources and then be applied to selected areas covered by soils which are steep, wet, subject to severe erosion, subject to flooding, or have a high water table. Special soil suitability and slope maps can provide the basis for delineating such districts. Resource conservation districts should prohibit dumping, filling, and tillage; mineral, soil, or peat removal; or any other use that would substantially disturb or be detrimental to the natural flora, fauna, water regimen, or topography. Such resource conservation districts may also serve to preserve historic, recreational, scenic, geological, scientific, and mineral resource areas. In addition, a special farm conservation district may be created in an attempt to reduce or control soil erosion and sedimentation. Such a farm conservation district might be applied as an "overlay" district to lands which are generally steep, have lost most or all of their topsoil, have low agricultural capabilities, or have been severely mismanaged. Examples of these types of conservation districts are presented in Appendix D.

Residential Districts

The regulations contained in conventional residential zoning districts should be adjusted to reflect the soil capabilities. Where lands are steep, subject to severe erosion, or covered by soils having certain other limitations for residential use with relatively small inclusions of suitable soils, residential lot areas should be increased substantially so as to provide the largest possible area for the selection and development of suitable building sites. In this way problems, such as soil erosion, foundation failures, wet basements, and malfunctioning on-site sewage disposal systems, can be avoided. Where the soils have moderate limitations for on-site soil absorption sewage disposal facilities, consideration should be given to increasing the residential lot areas to provide room for adequate filter fields.

In undeveloped and sparsely developed areas covered by soils with severe and very severe limitations for soil absorption sewage disposal facilities and where the limitations are due primarily to the slow permeability of the soils, the lot areas for proposed residential development should be increased substantially so as to provide for large absorption areas, dual filter fields, and for eventual expansion and replacement of the filter field. Where such poor soils have already been developed utilizing relatively small lots, such as one-third to one-half acre, and where such development has created health and sanitation problems, then the zoning district regulations should be so drafted as to require public sanitary sewer service for any additional development or redevelopment. Examples of these types of residential districts are presented in Appendix D.

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[1] *One of the valid criticisms often leveled against the use of exclusive agricultural and conservancy districts is that in an urbanizing area the assessed valuation may be so high as to preclude the maintenance of the land in rural uses. Section 70.32 of the Wisconsin Statutes directs assessors to value all real estate at the full value which could ordinarily be obtained at a private sale. This implies that the development potential must be considered in the assessment of open lands. Where such open lands are adjacent to, or within, a rapidly urbanizing area and particularly so where poor land use regulations have permitted highly dispersed urban development, assessments may reflect the public's exaggerated estimate of development potential. Under present Wisconsin Constitution and statutory law, the most satisfactory way to relieve the owner of lands zoned for exclusive agricultural or conservancy use from unrealistically high property assessment and taxation is to remove the development potential. This may be accomplished in one of three ways:*

1. *The property owner may voluntarily grant an easement to a governmental unit prohibiting development for a period of at least 20 years.*
2. *The property owner may voluntarily place restrictive covenants upon the lands enforceable by a governmental unit in perpetuity or for some substantial period of time.*
3. *A governmental unit may purchase the development rights.*

All of these private or governmental actions will serve to permit the local assessor to assess open lands at their fair market value for agricultural and conservancy uses and not on their potential value for urban type uses.

Other Districts
The selection and application of commercial, industrial, park, and recreation zoning districts should also, insofar as possible, be related to the suitability of the soils for such uses. Special soil suitability maps can be prepared for these uses and then used to define more precisely areas suitable for the particular use under consideration.

SPECIAL SOIL REGULATIONS

The detailed soil survey and interpretive analyses may be used to develop general or specific substantive land use regulations related to the proper use of soils which would be applicable throughout the local community and which would be in addition to, or would overlay, any zoning district regulations. An example of such a special soil regulation is the general land suitability clause set forth in Section 2.4 of Appendix E. This clause prohibits the use of land or the erection of structures in areas where, by a specific finding of the local plan commission, the soils are unsuitable for the proposed use or structure. The reasons for such unsuitability can be determined through utilization of the soil survey and interpretive analyses, as discussed in Chapter III of this Guide, and include a severe flooding hazard; high water table; inadequate surface water drainage; shallow depth to bedrock; adverse soil types, such as peat or muck; extremely unfavorable topography; low percolation rate; low bearing strength; and susceptibility to severe erosion.

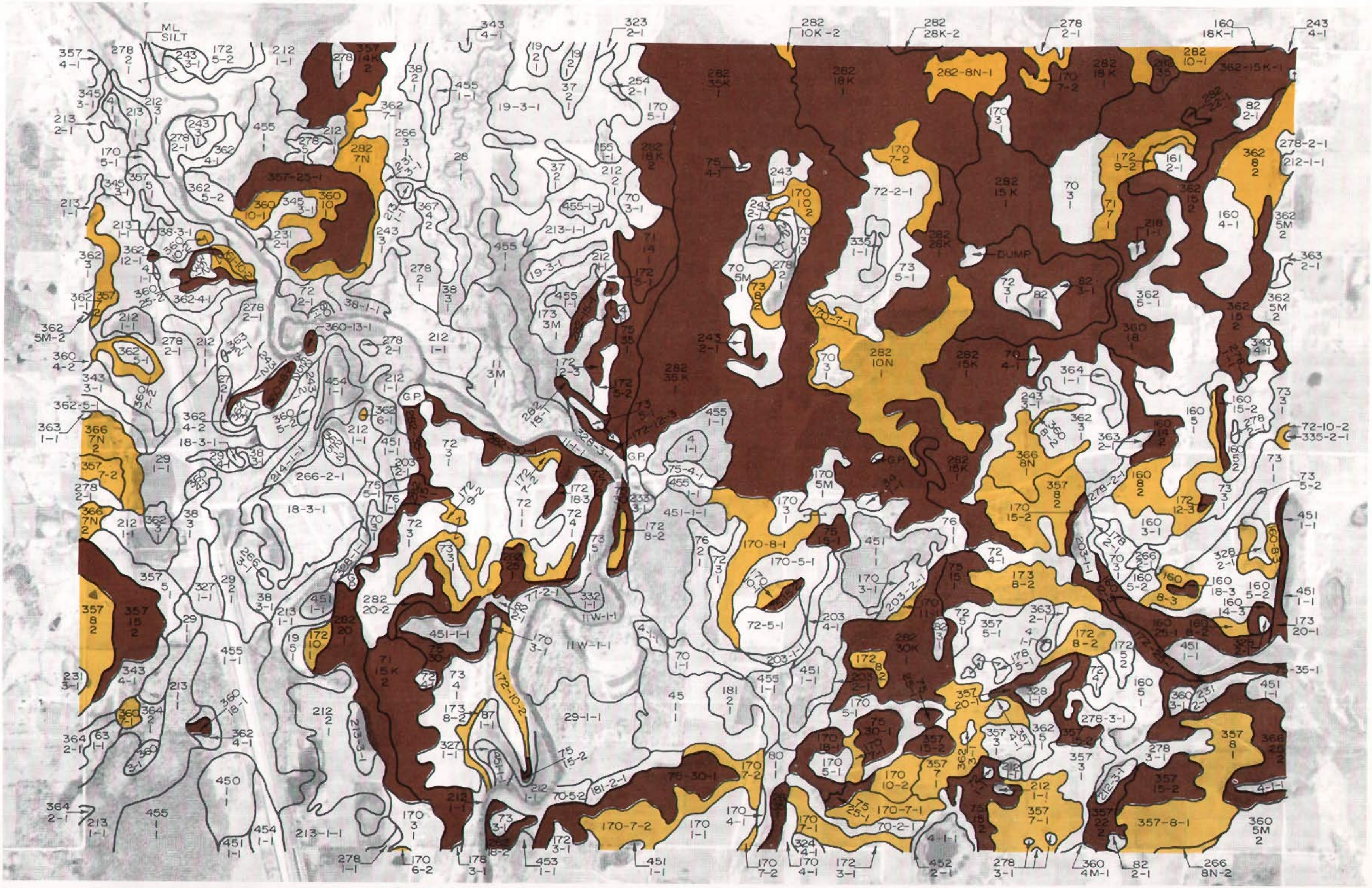
The soil survey and interpretive analyses may also be effectively used to preclude specific land uses in areas covered by certain enumerated soils incapable of supporting the land uses. Examples of this type of regulation as applied to steep lands, erodible lands, and lands with very low agricultural capabilities are presented in Sections 2.6, 2.7, and 2.8 of Appendix E. Steep land regulations might be applied to all lands having slopes of 12 percent or more, as shown on a composite soil survey slope map of a community. An example of such a slope map is shown on Map 12. On such steep lands, the soil regulations may provide for special design and construction of roads and attendant storm water drainage facilities to prevent erosion, for the prohibition of tillage and grazing unless conducted in accordance with accepted soil conservation standards, and for special review of tree cutting and shrubbery clearing so as to prevent soil erosion and sedimentation.

Erodible land regulations are designed to prohibit improper farm management practices on certain slopes and soil types (see Figure 52). Intensive farming, such as truck farming, should be prohibited on lands

Figure 52
IMPROPER FARM MANAGEMENT PRACTICE

The detailed soil survey can be used as an aid in achieving good farm management practices on steep and erodible slopes. This photograph shows a badly eroded slope caused primarily by overgrazing. Such poor farm management practices can be controlled through special erodible land regulations incorporated into rural zoning ordinances.

Map 12
TYPICAL SLOPE MAP FOR ZONING REGULATION PURPOSES



LEGEND

🟨 DENOTES SOIL MAPPING UNITS WITH A SLOPE OF 6-11 PERCENT

🟫 DENOTES SOIL MAPPING UNITS WITH A SLOPE OF 12 PERCENT OR MORE

Source: U.S. Soil Conservation Service; SEWRPC.

Zoning ordinances may include special-use regulations relative to steep lands. The above soil map of a six-square mile area in Washington County has been interpreted for two steep slope categories. On such steep lands, special soil regulations may be provided for roadside erosion control, for the control of tillage and grazing, and for special review of tree cutting and shrubbery clearing so as to prevent soil erosion and sedimentation.

having slopes of 6 percent or more unless such intensive farming is conducted in accordance with accepted soil conservation standards. Similarly, lands subject to blowing (wind erosion) should have all tillage and grazing prohibited except as conducted in accordance with sound soil conservation standards. In addition, lands having an erosion factor of 3 should have all tillage or grazing prohibited except as conducted in accordance with sound conservation standards.

Special agricultural soil capability regulations would include prohibiting tillage on enumerated rough, broken, sandy, stoney, or escarpment soil types because of their erodibility; prohibiting farm drainage systems on certain enumerated soil types unless installation is conducted in accordance with sound conservation standards; and prohibiting grazing on certain enumerated soil types because of their severe limitations for pasturing.

In lieu of the preparation and adoption of special sanitary regulations, as discussed in Chapter VIII of this Guide, zoning ordinances may include sanitary provisions prohibiting or regulating on-site soil absorption sewage disposal facilities on certain enumerated soil types. An example of this type of sanitary regulation, designed for inclusion in a zoning ordinance, is set forth in Section 2.5 of Appendix E. Soil absorption sewage disposal facilities should be prohibited on those soils rated as having very severe limitations for the absorption of septic tank sewage effluent. Where the rating designates moderate or severe limitations, an applicant should be required to demonstrate that the specific limitations can be overcome.

ZONING DISTRICT BOUNDARY DELINEATION

The delineation of zoning district boundaries may be based, in part, upon consideration of the boundaries of the type of soils shown on the detailed soil survey maps. An example of the delineation of a zoning district, which should closely follow soil mapping unit boundaries, is the resource conservation district, where boundaries generally follow marshes, peat, and muck soils or high water table soils along drainageways. Other considerations, such as road rights-of-way, minimum distances from streams, property lines, and existing land uses, of course, are also considerations which affect or constrain the delineation of zoning district boundaries, so that such boundaries cannot always reflect precisely the soil pattern.

In those cases where adequate base maps upon which to place zoning districts are not available, the soil survey map may be used as a substitute base map. The normal scale of the soil survey maps, the nature of the field inventory, and the range of variable conditions within soil mapping units, however, limit the utility of soil survey maps for such purposes. The soil survey map prepared by the U. S. Soil Conservation Service for the Commission at a scale of 1" = 2000' (1:24000)[2] is not large enough to show precise locations of zoning district boundaries in highly urbanized areas, although they may be perfectly adequate in rural areas. Large-scale insert maps may be needed to supplement the soil maps if they are used as zoning base maps. Enlargement of photo mosaic soil maps can be made if the aerial photographs have been fully ratioed and rectified, but enlargements may create a false sense of reliability if the soil map user is not familiar with the limitations of the soil mapping methodology.

FLOODLAND DELINEATION

A good community zoning ordinance should contain special zoning regulations or special zoning districts that apply to floodlands. While the determination and delineation of floodways and floodplains, which together comprise the floodlands, are best accomplished through comprehensive watershed planning programs that include hydrologic and hydraulic engineering studies, the soil survey and analyses may be used in an interim delineation of flood hazard areas.

When soil surveys are used in this way, they should be supplemented with available topographic maps, historic flood records, and field investigations. In general, where the soil surveys indicate that a soil is

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[2] *The soils mapping in southeastern Wisconsin was done in accordance with specifications prepared by the Commission and designed to integrate the soils maps with the Commission's base mapping program. Normally, the soils maps are prepared at a scale of 1'' = 1320' (1:15840).*

subject to flooding, the soil almost always lies within the generally recognized floodway. Some soils in terrace or upland positions are not given a flood hazard rating in the soil survey because of the observed soil characteristics. Yet, historical records often indicate that these soils are occasionally flooded and, therefore, lie within the floodplain. In addition, flooding of these soils may have resulted partially from man-made changes in the watershed that have increased flood flows substantially.

In general, soil surveys can be very useful in delineating areas subject to inundation by floods of relatively high frequency, such as a 10-year recurrence interval flood. Areas subject to inundation by floods of a relatively low frequency, such as a 100-year recurrence interval flood, cannot be accurately determined by the use of soil maps alone. In addition, floodland delineations based on soil maps are not apt to reflect accurately the true situation in heavily urbanized watersheds where development has altered the streamflow regimen so that it no longer conforms to natural patterns. Further discussion of the use of soil maps to determine and delineate floodland zoning districts or special floodland regulatory areas can be found in SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, 1968.

ADMINISTRATION AND ENFORCEMENT

The detailed soil survey and interpretive analyses can be readily incorporated into the Model Zoning Ordinance set forth in Appendix A of SEWRPC Planning Guide No. 3, Zoning Guide, 1964, or into other properly prepared zoning ordinances by creating special zoning districts, adding special soil-related regulations to the district or general regulations and provisions of the ordinance, delineating district boundaries, and identifying special hazard areas. The proper administration and enforcement of such zoning ordinance provisions, however, require that several additional provisions be added to the ordinance. These include: a soil intent subsection, which should clearly state that the objectives of the zoning ordinance include the prevention and control of soil erosion and consequent sedimentation, as well as the promotion of the wise use, conservation, development, and protection of the community's soil, wetland, woodland, wildlife, and water resources, and the attainment of a balance between land uses and the ability of the natural resource base to support and sustain such uses; a non-liability clause disclaiming any guarantee that only those soil types listed as being unsuited for specific uses are the only unsuitable soils within the community for those uses; a requirement that the soil mapping units be shown on the plat of survey required for a zoning permit; a clause to the effect that district boundaries shall, in some instances, be construed to follow soil mapping unit boundaries; appeal procedures geared toward rectifying any errors in soil type classification, slope, erosion factor, mapping unit boundaries, or analyses; and definitions of soil-related terms, such as erosion factor, soil mapping units, and conservation standards. Appendix E contains several model subsections designed to fulfill these requirements.

APPLICATION OF SOILS DATA IN THE TOWN OF BELGIUM

One of the earliest applications of the regional soil survey to a zoning ordinance within the Southeastern Wisconsin Region occurred in the Town of Belgium, Ozaukee County. The Town of Belgium is a 37 square mile town located in the northeasterly corner of Ozaukee County along the Lake Michigan shoreline. The soil survey showed that the Town of Belgium generally was covered by soils with high agricultural capabilities. Other natural resource inventories in the Town revealed the existence of a large, high-value, potential park site; significant areas of prime wildlife habitat; and several areas with stands of commercially significant timber.

Most of the soils in the Town of Belgium, however, have severe or very severe limitations for residential development either with private sewage disposal systems or public sanitary sewer systems because of high or fluctuating water tables, slow permeability, overflow hazards, or occasional steep slopes along the Lake Michigan shoreline. The residents of the Town wanted to maintain the existing highly productive farm operations, protect their community land and water resources, and prevent indiscriminate home building that would result in the problems attendant to inoperative sewage disposal systems. The two major factors contributing to the adoption of the Town's first zoning ordinance were, then, recognition of the disorder and costs connected with urban sprawl together with recognition that many soils in the town which were highly productive for agriculture had very severe limitations for urban development.

Suitability Map

As part of the Town's planning and zoning program, a soil suitability map was prepared showing those soils in the Town which have very severe limitations for on-site soil absorption sewage disposal facilities because they are subject to overflow or flooding; have a fluctuating or high water table; or have a ponding, overwash, or runoff hazard and showing those soils which have severe limitations for on-site soil absorption disposal facilities because of slow permeability. This suitability map was prepared by coloring soil survey field sheets that had been enlarged to a scale of 1" = 1000' (1:12000). A portion of this map with the accompanying legend is shown on Map 13.

Town Zoning District Map

The locations of those soils with very severe limitations were transferred directly to the Town zoning map, which is reproduced in this Guide as Map 14. These soil boundaries were used as an aid in delineating areas subject to relatively frequent flooding, wildlife habitat areas, and wetlands that had not been drained and cultivated. As shown on Map 14, these areas were placed in resource conservation districts for protection and preservation. Existing residential, commercial, industrial, and recreational uses were placed in appropriate zoning districts. The Town's farm land was placed in an exclusive zoning district, which permits only agricultural uses. Farm dwellings are permitted in this district only as an accessory use to the principal agricultural use, thereby avoiding unplanned, uneconomical, inefficient, and scattered residential development. In addition, the Town prohibits on-site soil absorption filter fields on those soils that have very severe limitations for such systems. Soils that have severe limitations for such sewage disposal systems are carefully regulated, since applicants must show that the severe limitations can be overcome.

In developing this zoning ordinance and district map, and in so doing utilizing the soils data, the Town of Belgium has achieved a far better means of guiding and shaping the future development of the Town than previously existed. Not only will scattered, inefficient residential development be discouraged through the use of an exclusive agricultural zone but prime agricultural land will be protected from the encroachment of incompatible urban uses. In addition, the drainageways, wildlife habitat, and wetlands will largely be conserved and protected through a resource conservation zone. These major steps will help to ensure sound growth and development of the Town.

SUMMARY

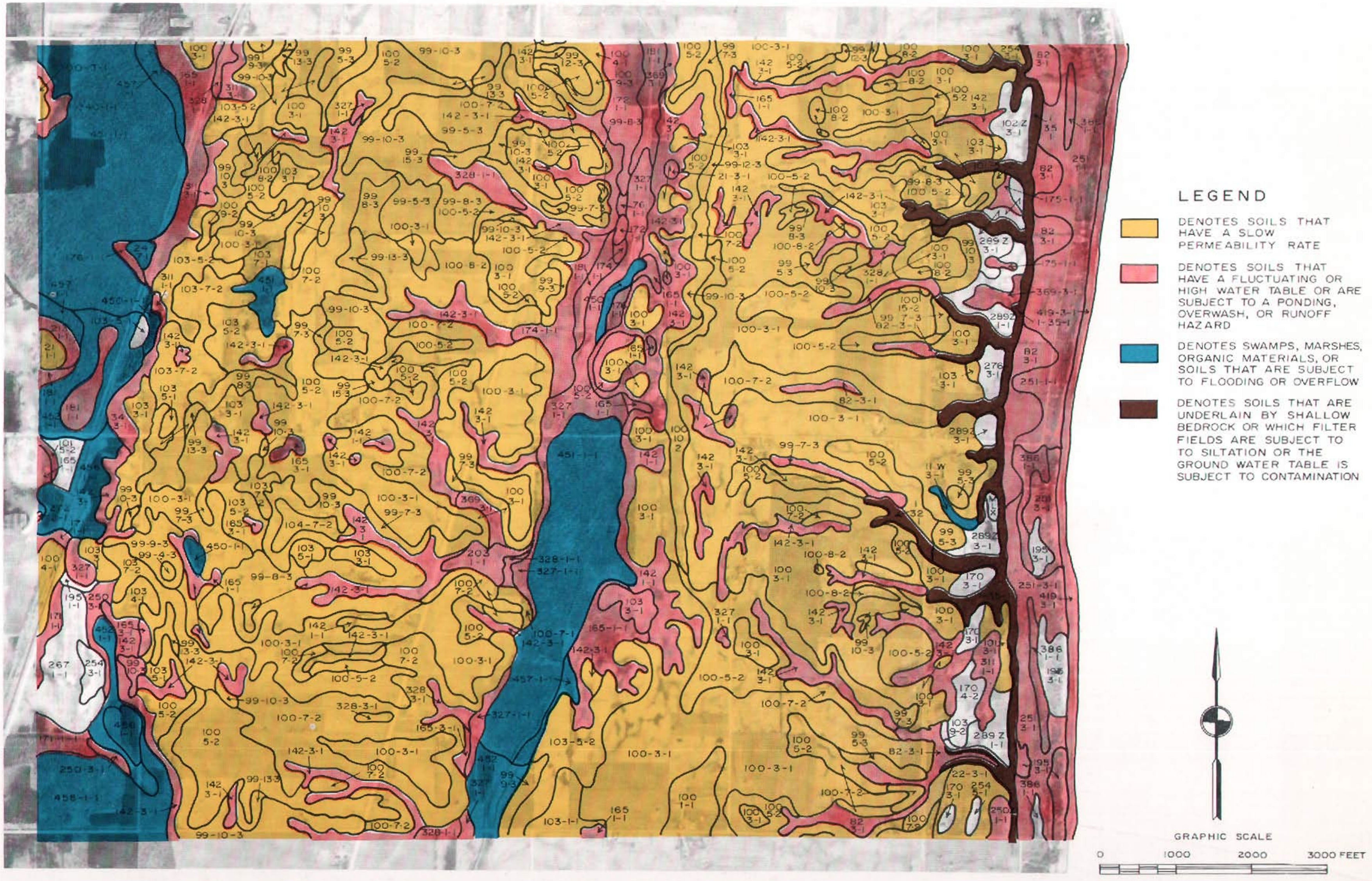
One of the most important land use controls is the community zoning ordinance. The detailed soil survey and interpretive analysis may be used in the creation of special zoning districts appropriate to the capability and suitability of soils for specific uses. Of particular importance are agricultural, conservation, and residential zoning districts. Special agricultural soil suitability maps can provide the basis for delineating exclusive agricultural districts. Such districts would be created for the purpose of preserving prime agricultural lands. Resource conservation districts are intended to provide for the protection of the community's soil, water, wetland, woodland, and wildlife resources. Such districts should be applied to those soils which are steep, wet, subject to flooding, or have a high water table. Residential districts should also be related to the capability of the soils to support such development. In particular, large estate-type lots should be provided where soils have questionable soil suitability for the absorption of sewage effluent from septic tank systems.

The detailed soil survey and analyses may also be used to develop specific land use regulations that would be in addition to any zoning district regulations. Such specific soil regulations suitable for inclusion in a zoning ordinance include a general land suitability clause, steep land regulations, erodible land regulations, and regulations for lands with very low agricultural capabilities. In addition, zoning ordinances may include sanitary provisions regulating on-site soil absorption sewage disposal facilities on certain enumerated soil types.

The determination and delineation of zoning district boundaries and special zoning regulatory areas may be based upon the boundaries of the type, slope, and erosion of soils shown on the detailed soil survey maps. For example, the resource conservation districts should closely follow soil mapping unit bound-

Map 13

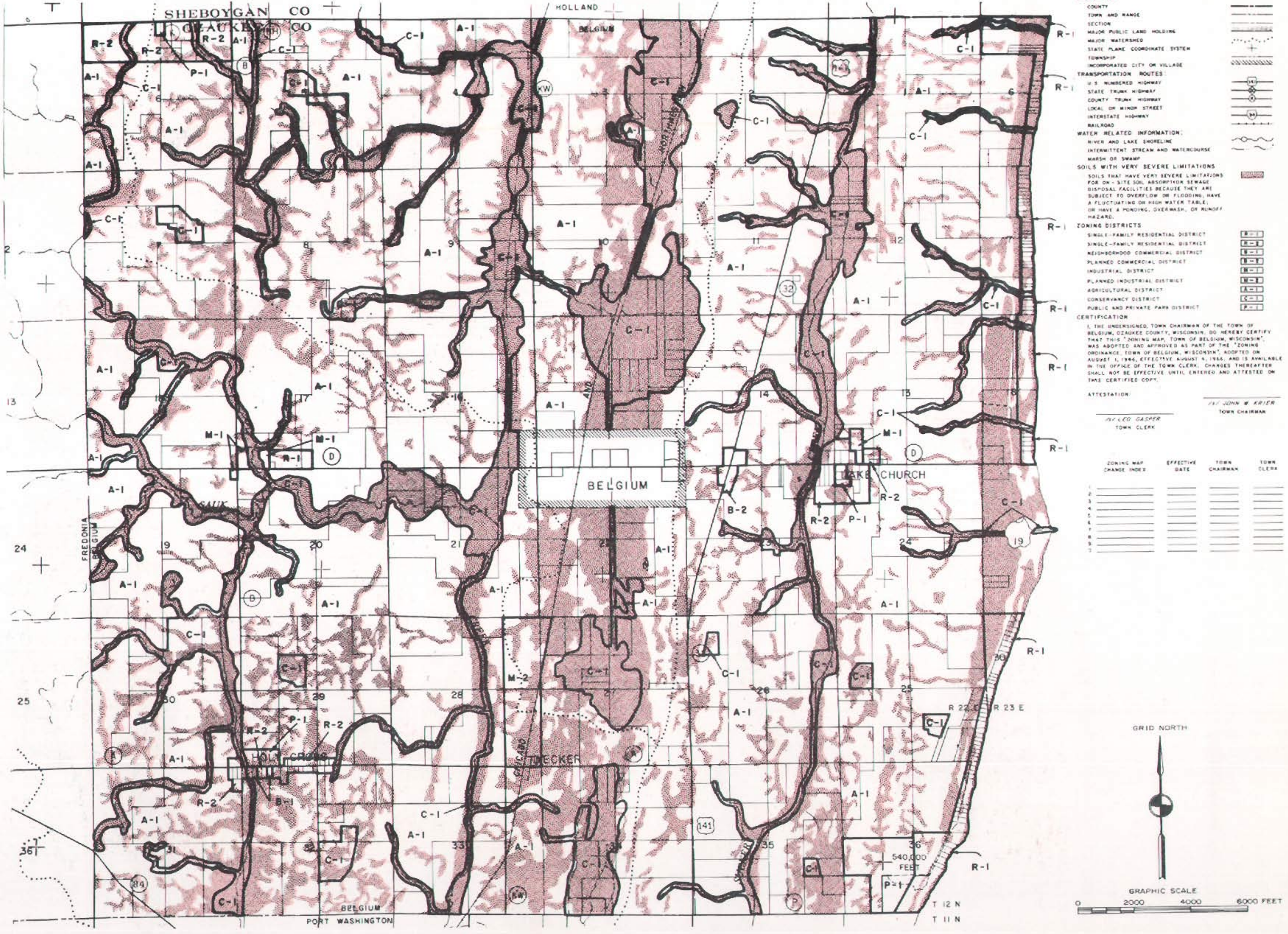
PORTION OF A SOIL SUITABILITY MAP RELATED TO ON-SITE SOIL ABSORPTION SEWAGE DISPOSAL FACILITIES



Soil suitability maps, such as this one for the Town of Belgium, are prepared on request by the Commission for local units of government. These maps are designed to help the local officials in preparing and administering zoning ordinances. The maps are prepared by color coding soil survey field sheets that have been enlarged to a scale of 1" = 1000' (1:12000).

Map 14

ZONING MAP
TOWN OF BELGIUM
1966



I, THE UNDERSIGNED, TOWN CHAIRMAN OF THE TOWN OF BELGIUM, OZAUKEE COUNTY, WISCONSIN, DO HEREBY CERTIFY THAT THIS "ZONING MAP, TOWN OF BELGIUM, WISCONSIN", WAS ADOPTED AND APPROVED AS PART OF THE "ZONING ORDINANCE, TOWN OF BELGIUM, WISCONSIN", ADOPTED ON AUGUST 1, 1966, EFFECTIVE AUGUST 4, 1966, AND IS AVAILABLE IN THE OFFICE OF THE TOWN CLERK. CHANGES THEREAFTER SHALL NOT BE EFFECTIVE UNTIL ENTERED AND ATTESTED ON THIS CERTIFIED COPY.

ATTESTATION:

/s/ JOHN W. KRIER
TOWN CHAIRMAN

/s/ LEO GASPER
TOWN CLERK

Soils data can be effectively used in community zoning programs. In the above zoning district map of the Town of Belgium, Ozaukee County, the relationship of the C-1 Conservancy District to the soils is clearly evident. The Conservancy District has been utilized to preserve and protect drainageways, wildlife areas, and remaining wetlands. The soils data was also useful in delineating the prime agricultural areas in the Town. These lands were then placed in an exclusive zoning district which permits only agricultural uses.

aries. The boundaries of special regulatory areas, such as erodible or steep lands, should also be directly related to the detailed soil survey maps. Finally, soil surveys can be useful in delineating areas subject to inundation by floods of a relatively high frequency, such as a 10-year recurrence interval flood. Areas subject to inundation by floods of a relatively low frequency, such as a 100-year recurrence interval flood, cannot be accurately determined using soil maps alone.

The proper administration and enforcement of zoning ordinance regulations and districts built upon the regional soil survey require that several additional provisions be added to the ordinance. These include a soil intent subsection; a requirement that soil mapping units be shown on a plat of survey; appeal procedures geared to rectifying errors that may be uncovered in the soil survey itself; and definitions of soil-related terms.

Chapter VII

THE USE OF SOILS DATA IN LAND DEVELOPMENT REGULATIONS AND PRACTICES

INTRODUCTION

The process of land division and development is far more than a means of marketing land; it is the first step in the process of building a community. Much of the form and character of a community are determined by the quality of its land subdivisions and the standards which are built into them. Once land has been divided into blocks and lots, streets established, and utilities installed, the development pattern is permanently established and unlikely to be changed. For generations the entire community, as well as the individuals who occupy such subdivisions, will be influenced by the quality and character of their design. Hence, the regulation and control of land subdivision has become widely accepted as an important function of municipal, county, and state government.

Land division regulations and controls are necessary to:

1. Ensure that land subdivision will fit into the existing land use pattern and general plan for the physical development of the community.
2. Ensure that adequate provision will be made for necessary community and neighborhood facilities—parks, schools, churches, shopping centers—so that a harmonious and desirable environment will result.
3. Provide for uniformly high standards in the development of land subdivisions, with particular attention to such design and improvement factors as utilities, drainage, street widths, street layouts and grades, lot sizes and arrangements, and other improvements.
4. Provide a basis for clear and accurate official property boundary line records.
5. Promote the public health, safety, and welfare of all citizens.

A thorough discussion of this type of implementation device is set forth in SEWRPC Planning Guide No. 1, Land Development Guide, 1963.

Land subdivision regulations and related development practices can also be very useful in preventing certain problems relating to abuse of the soil resource, such as erosion, foundation failures, and siltation. Desecration of the soil and natural landscape need not be the rule in urban expansion activities. Soil limitations can be recognized in subdivision layout and design; and erosion can be controlled during development, with existing stands of trees being carefully preserved to form a setting for the new urban development, particularly residential development. The key to achieving such results lies in the establishment of sound local regulations governing land development, including land division ordinances and building codes or ordinances, and in the development of erosion control techniques and practices during construction. This chapter will examine the use of soil survey data and analyses in land subdivision design and in land development regulations and will discuss the various practices being developed to control soil erosion during urban expansion activities.

SUBDIVISION DESIGN

The design of land subdivisions is a complex process requiring considerable technical skill and a full realization of the importance of the design to the various interests involved. A subdivision design seeks to create building sites which meet the requirements of modern family life; which are not only presently marketable but which can compete favorably with future developments, thereby presenting a stable and liquid investment; and which are so arranged in relation to the rest of the community as to provide the best possible urban environment.

Design Principles

Sound subdivision design can be achieved through the effective application of four basic design principles.[1] While relatively easy to enumerate, these four design principles are very difficult to apply. The first principle of good subdivision design is that the design must provide for certain external factors of community-wide concern which affect the proposed subdivision, such as major arterial streets, school sites, park sites and parkways, and major drainage channels. The second principle of good subdivision design is that the design must be properly related to proposed and existing land uses. The third principle of good subdivision design is proper attention to internal detailing, including the proper layout of streets, lots, and blocks. The last, and most important, principle of good subdivision design is achievement of unity in design. In this respect, the subdivision should, depending on its size, either constitute a complete neighborhood unit, as discussed in Chapter V of this Guide, or an integral part of such a unit.

Soils Data and Design Principles

The detailed soil survey can provide invaluable inputs to the subdivision design process and can contribute toward the sound application of each of the four above-named design principles. The first principle cited above, that of providing for external factors of community-wide concern, is directly related to the soils data. For example, the soils data and survey maps can be used as an aid in delineating drainageways for preservation in open-space uses; in delineating parkways for dedication or future public acquisition; in locating and delineating both neighborhood and possible community park sites; and in routing the location of major arterial streets. Even when the proposed subdivision is to be served by public sanitary sewer and water supply, there are likely to be areas of soils in most parts of the Southeastern Wisconsin Region that have severe and very severe limitations for development because of high water table (see Figure 53), excessive slope, low bearing capacity, high shrink-swell potential, and proximity to bedrock. Once these areas are identified, whether consisting of relatively small isolated pockets or relatively large areas, they can become, at least in part, the basis for the design of an integrated system of drainageways, parkways, parks, and related open-space uses that are of concern not only within but also without individual subdivision developments.

Detailed soils data can also contribute to application of the second subdivision design principle noted above—that of properly relating the design to proposed, as well as existing, land uses. The very nature of the soil may provide guidance as to what land uses should be allowed. Certain soil types may not be capable of supporting unsewered residential development, yet may lend themselves well to sewered residential development. Other soil types may provide an excellent base for recreational development while being wholly unsuitable for residential development. Desirably, the community land use plan, into which the subdivision being designed must fit, has already considered the relationship between soil conditions and land use. But the subdivision design process allows for a much more detailed examination of the soil conditions and for potential refinement of the land use plan. The larger the subdivision area being designed, of course, the greater the chance there is of fully utilizing the soils data to provide for suitable land uses while achieving sound subdivision design.

Proper application of the third design principle, that of proper attention to the internal detailing of streets, blocks, and lots, also requires detailed soils data. The internal street pattern determines in large part the shape, size, and orientation of the individual building sites. Insofar as possible, the streets, which also provide for the location of the supporting utilities, such as sewer lines, water and gas mains, and, sometimes, power and communication cables, should not be routed through large areas of highly unsuitable soils. It must be recognized, however, that other design considerations will, at times, make it impossible to avoid poor soil areas. Soils data must also be taken into account when shaping and sizing the development lots, with each lot encompassing enough area covered by suitable soils so as to provide a good,

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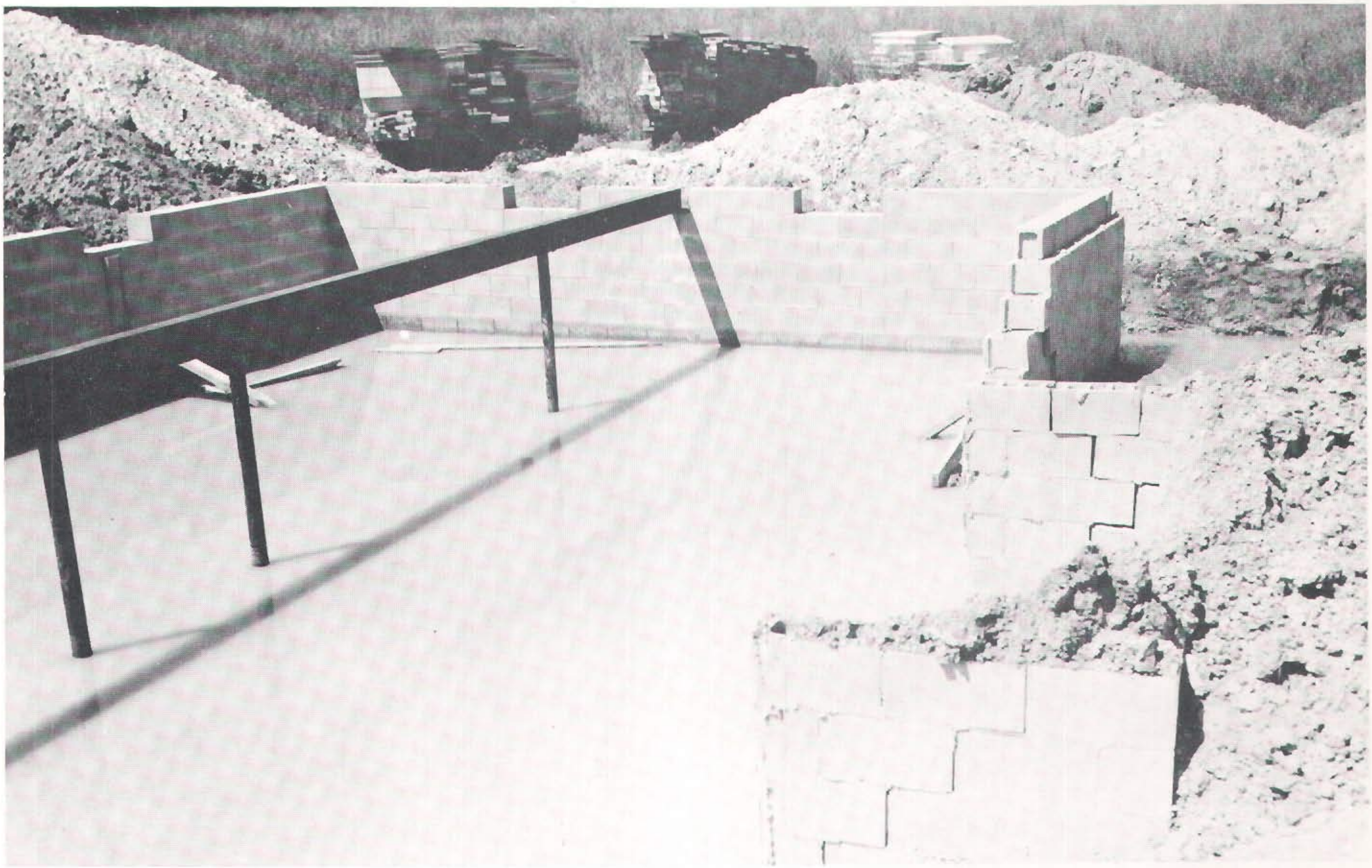
[1] *These basic design principles are fully discussed in Chapter IV of SEWRPC Planning Guide No. 1, Land Development Guide, 1963.*

Figure 53

DEVELOPMENT ON HIGH WATER TABLE SOIL



Many of the soils of the Region have severe and very severe limitations for urban development because of high water table characteristics. The foundation shown in this photograph, taken within the Region, illustrates the type of problems encountered when residential development takes place on wet soils. Not only will the basement of this home be wet and require the almost constant operation of a sump pump but the foundation walls have already begun to fail. Sound subdivision design would preclude the placement of building sites on areas covered by such poorly suited soils.

buildable site. Soils data are particularly important in the sizing of lots for a subdivision not served by public sanitary sewer. In this case, each lot must contain sufficient area covered by suitable soils to accommodate properly the necessary on-site soil absorption sewage disposal system.

Finally, the detailed soils data can assist in proper application of the fourth subdivision design principle noted above; namely, that of achieving unity in design. By using the soils data as an aid in delineating an integrated system of drainageways, parkways, parks, and other open spaces; in determining the location of multiple-family residential structures; in laying out the street and utility network; and in the shaping and sizing of blocks and lots, greater assurance is given that the subdivisions and the larger neighborhood of which it should normally be a part will be efficiently and soundly organized, convenient to the conduct of the day-to-day activities of the family in proximity to its home, and aesthetically pleasing. All of these design considerations, then, contribute toward achieving unity in design.

Application of Soils Data to Subdivision Design

In order to illustrate the use of soils data in subdivision design, the following discussion will present several examples of both hypothetical and real subdivision developments within the Southeastern Wisconsin Region. In each case, the soils data have been recognized and used to advantage in the design process.

Soils Demonstration Site: In order to demonstrate the use of the detailed soil survey and interpretive analyses in local development practice, a soils educational program utilizing a demonstration site was jointly prepared and sponsored by the U. S. Department of Agriculture, Soil Conservation Service; the University of Wisconsin; the Waukesha County Extension Service, County Institutions, and County Park and Planning Commission; and the Southeastern Wisconsin Regional Planning Commission. This site is located on the Waukesha County Institutions grounds.[2] Map 15 is a combined topographic base and soils map of the demonstration site modified by the removal of certain cultural features and the addition of hypothetical topographic and control survey data as necessary to make the map conform to good engineering practice. Five hypothetical alternative development plans were prepared for this demonstration site, two of which are presented in this chapter. Later chapters will examine three additional development plans.[3] It is important to note that the illustrative examples in this Guide relating to the soils demonstration site are not intended to demonstrate the use of soils data in site selection, for some of the soils on the site are clearly not well suited to the illustrated uses. Rather, the use of these examples is intended to show that any particular given site may have soil limitations for any given land use and that these limitations should be recognized in the design process. Furthermore, it is recognized that nearly all soil limitations can be overcome in order to develop a parcel for a given land use, if there is the desire and the financial ability to do so.

Map 16 shows the soil limitations of the demonstration site for residential development served by public sanitary sewer. Less than one-fourth of the site is covered by soils having severe or very severe limitations for sewered residential development. The Ehler (212 and 213), Brookston (231), and Pistakee (328) silt loams have high water tables, frost heave hazards, poor drainage, and low bearing capacity characteristics and, if used extensively for residential development, would tend to result in wet basements and foundation problems. For these reasons, these soil types should be avoided, if possible, in the creation of lots during the subdivision design process.

A suggested sewered residential development for the soils demonstration site, along with appropriate neighborhood shopping, park and open space, and school sites, is shown on Map 17. This development plan recognizes the existence of the poor soil areas noted in the foregoing soil limitations map. Although many of the residential lots created contain some areas covered by unsuitable soils, nearly every lot contains enough area covered by suitable soils to permit proper building placement. One relatively large area of unsuitable soils has been accommodated by including it in a larger area designated for multi-family residential development. In this way, the residential structures can be grouped or clustered on the suitable soils; and the unsuitable soils can be retained in open-space use, while at the same time achieving the overall desired density pattern. A second large area of unsuitable soils has been suggested for use as a private recreation area. A third large area of unsuitable soils has been recommended for inclusion in a parkway and in an adjoining school site. It should be noted that there is sufficient suitable soil area on the school site to permit building placement.

The limitations of the soils of the demonstration site for light industrial and commercial development are shown on Map 18. About one-fourth of the site is covered by soils having severe or very severe limitations for such development. The Tichigan (42), Ehler (212 and 213), Brookston (231), and Pistakee (328) silt loams have a high water table, a high shrink-swell potential, and a low-bearing capacity. Several other soil types on the site have slopes in excess of 12 percent. Such slopes become a limiting factor for development of modern one-story industrial plant layouts.

Map 19 shows a suggested industrial-commercial development layout for the soils demonstration site that has been designed, in part, upon recognition of the soil limitations. The lots have been so sized and laid out as to provide a sufficient area covered by suitable soils on each lot for proper structure placement. Very large lots are suggested for areas of unsuitable soils. That portion of a lot covered by unsuitable

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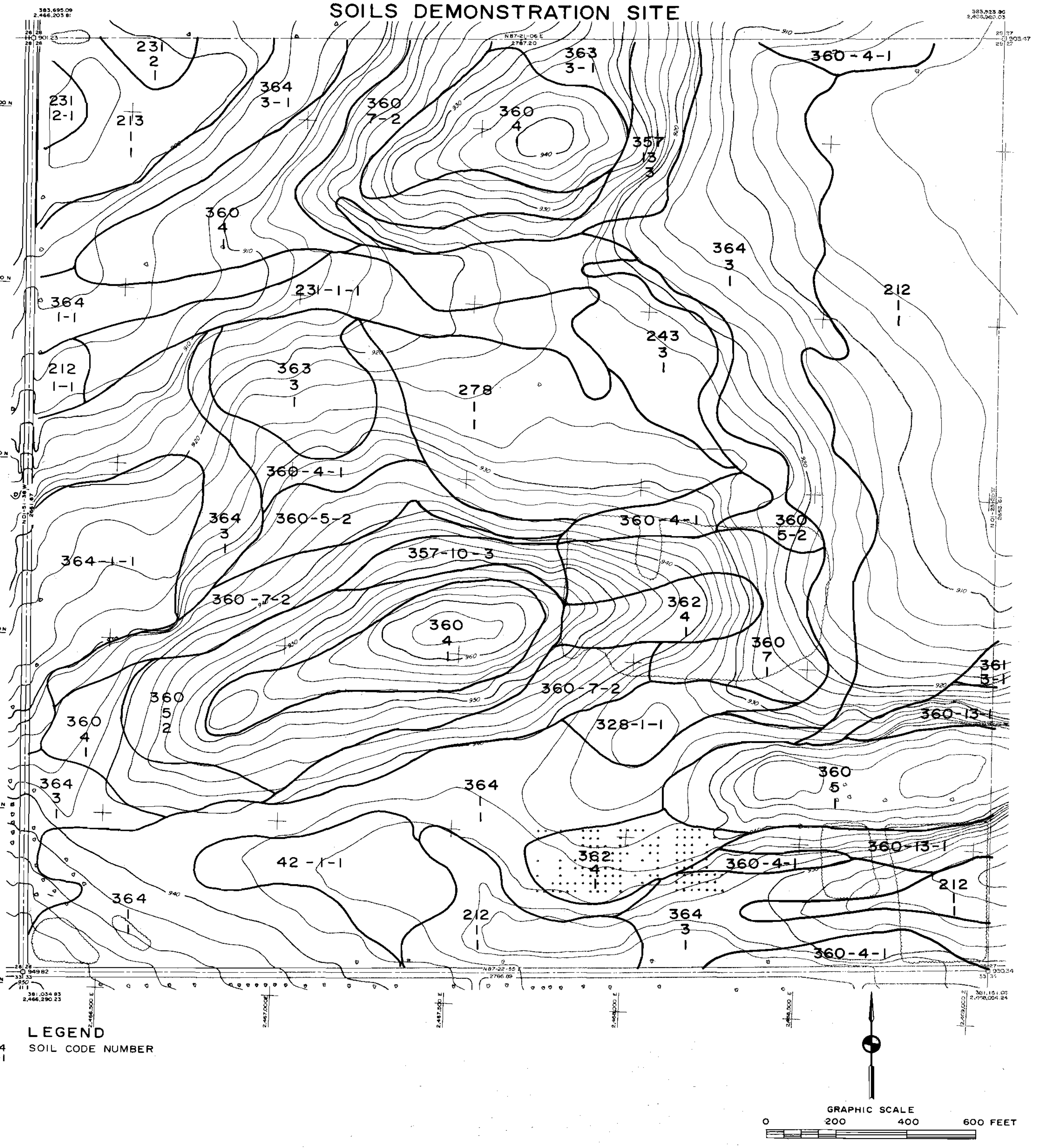
[2] *Further information about the soils demonstration site is presented in Appendix J of this Guide.*

[3] *The development plans presented in this Guide differ slightly from those originally prepared under the educational program. See Appendix J.*

Map 15

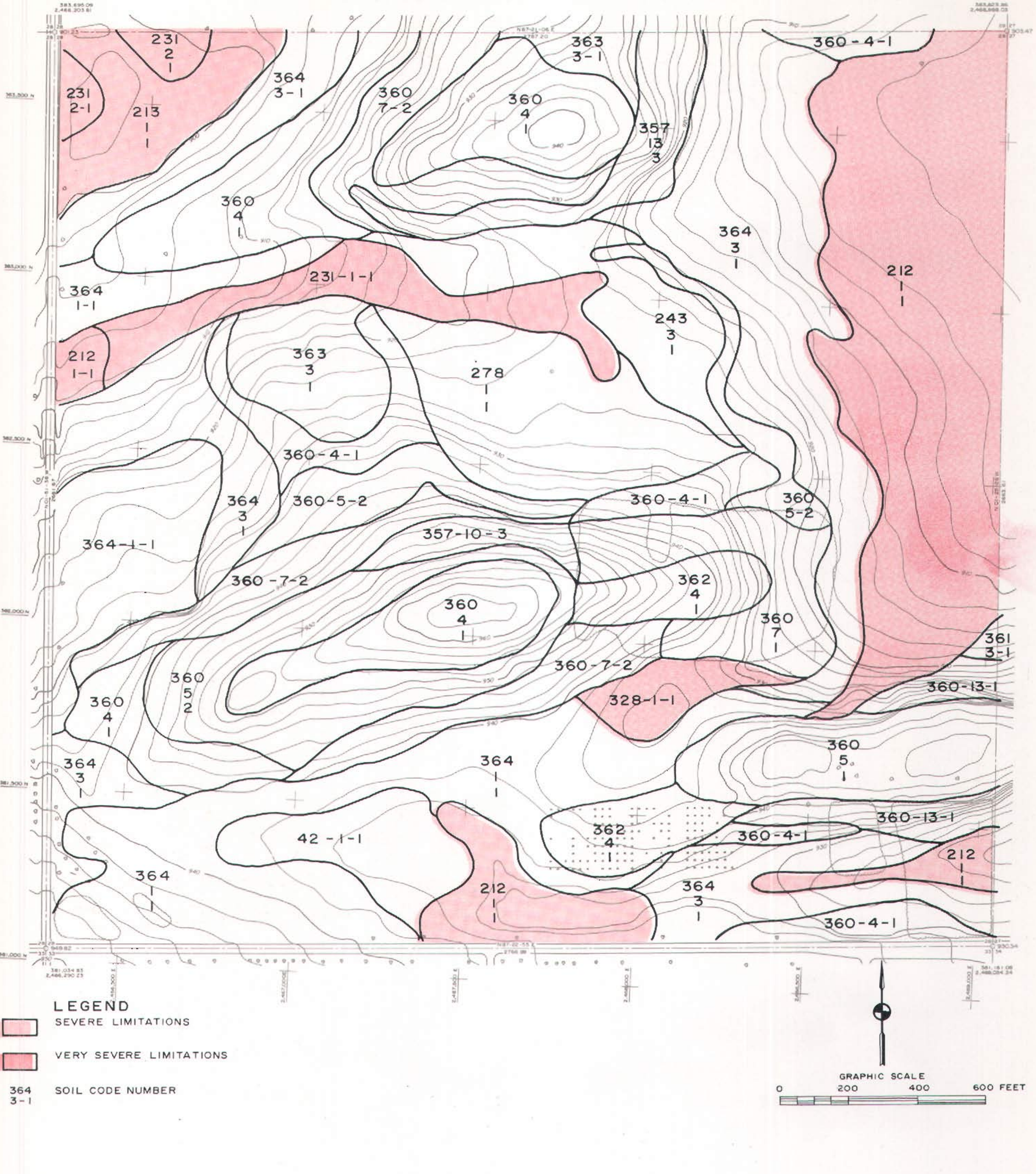
BASE AND SOILS MAP SOILS DEMONSTRATION SITE



Acting under an Interagency Soils Agreement, an educational program dealing with soils data and utilizing a demonstration site was established for southeastern Wisconsin. The detailed soil mapping unit boundary lines and soil code numbers have been placed on the topographic base map of the soils demonstration site shown above.

Map 16

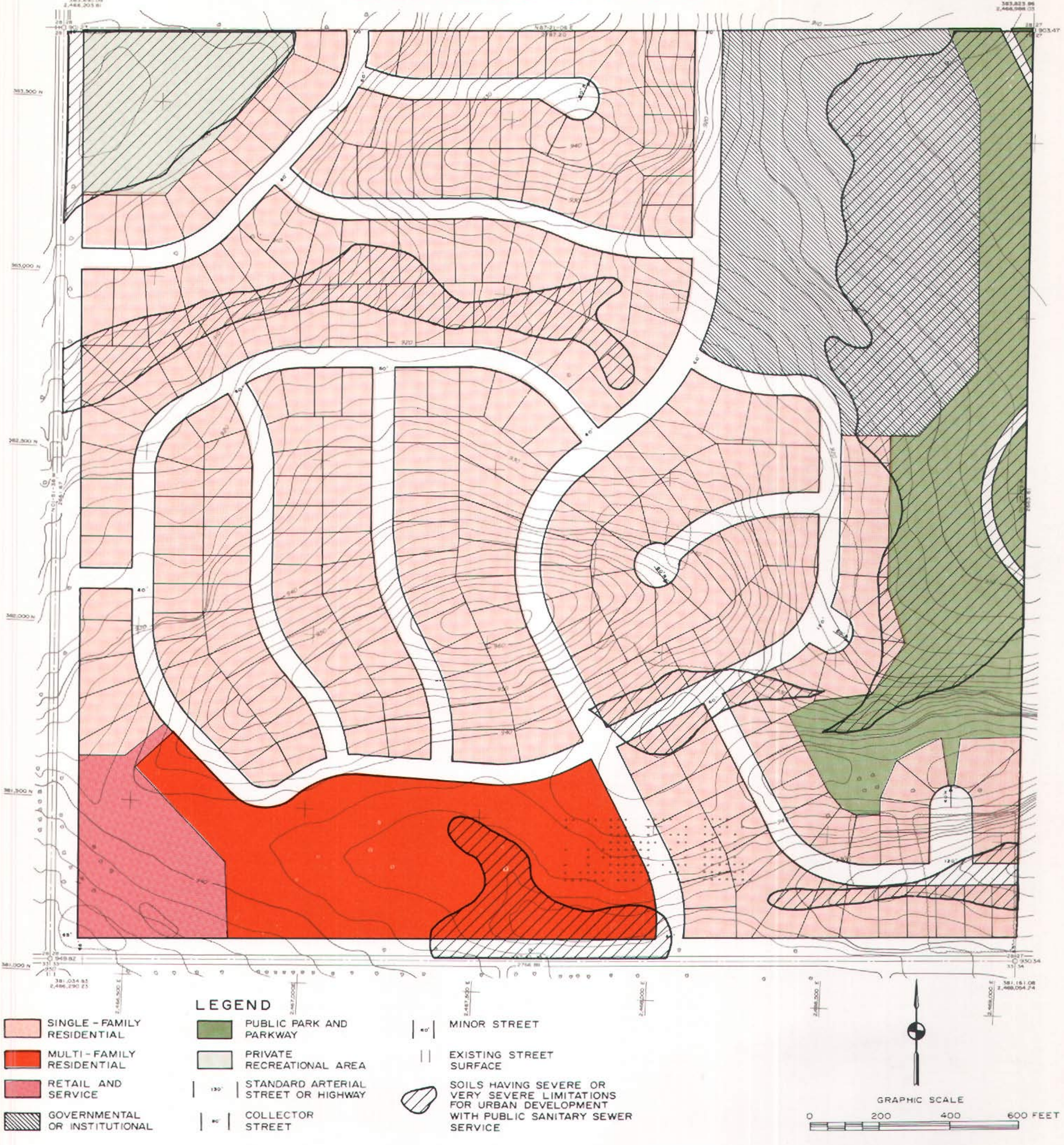
SOIL INTERPRETATIONS FOR SEWERED RESIDENTIAL DEVELOPMENT SOILS DEMONSTRATION SITE



Most of the soils demonstration site is covered by soils having only moderate, slight, and very slight limitations for sewered residential development. The soils having severe limitations generally have problems associated with high water tables and must be carefully considered in the subdivision design process.

Map 17

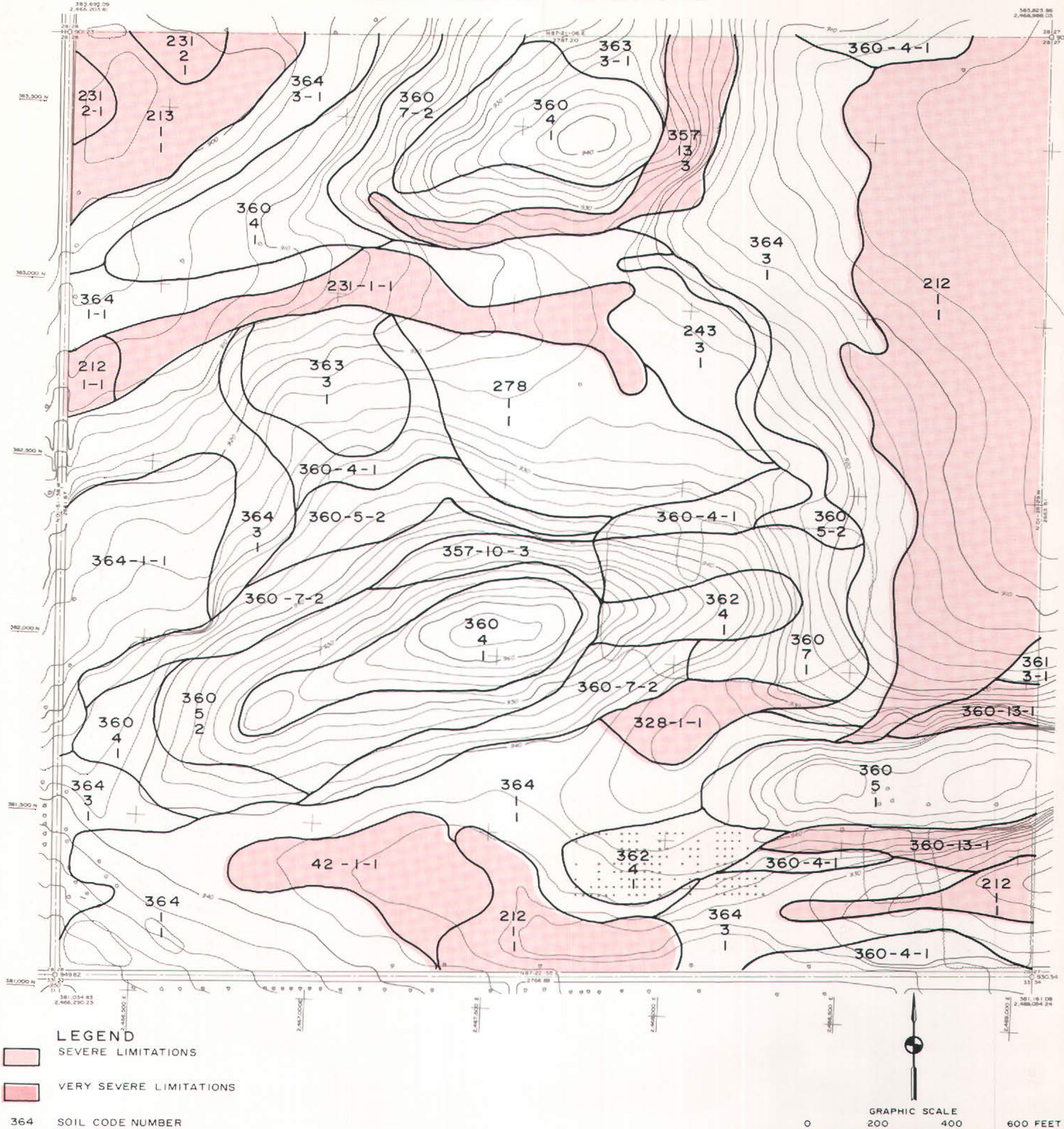
SEWERED RESIDENTIAL DEVELOPMENT PLAN SOILS DEMONSTRATION SITE



The above residential subdivision design for the soils demonstration site recognizes the existence of pockets of soils that have severe and very severe limitations for development even with public sanitary sewer service. In most instances, it is possible to design a subdivision layout that will result in the avoidance of the placement of structures on unsuitable soils.

Map 18

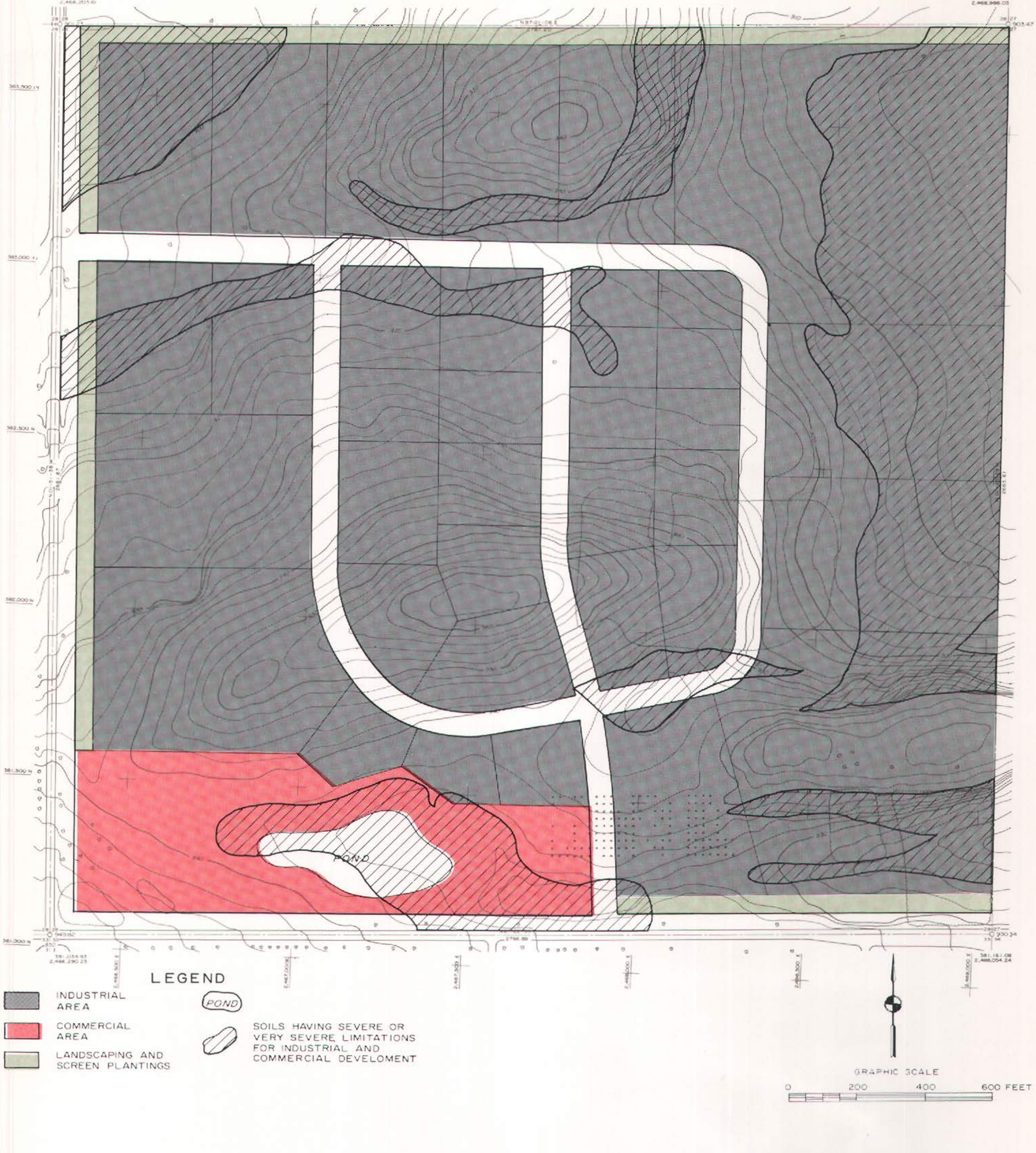
SOIL INTERPRETATIONS FOR INDUSTRIAL AND COMMERCIAL DEVELOPMENT
SOILS DEMONSTRATION SITE



About one-fourth of the soils demonstration site is covered by soils having severe limitations for light industrial and commercial development. Most of the problems of these soil types are due to such soil characteristics as high water table, high shrink-swell potential, and low bearing capacity. In addition, slopes in excess of 12 percent become a limiting factor when industrial and commercial development is proposed.

Map 19

INDUSTRIAL - COMMERCIAL DEVELOPMENT PLAN
SOILS DEMONSTRATION SITE



A suggested industrial-commercial development layout for the soils demonstration site is shown on the above map. Design considerations relating to soil conditions in this instance included the proper sizing of lots and the construction of a pond. In addition, steep slope limitations would be overcome through cutting, grading, and terracing.

soils should be used for nonstructural purposes, including such industrial-related activities as aeration facilities, drying yards, testing grounds, water storage, settling and cooling basins, and other similar storage activities. A commercial service area has been proposed for the southwest corner of the site at the intersection of the two arterial streets. The soil limitations in this area can, in part, be overcome through drainage and pond construction. The additional soil limitations imposed by steep slopes can be overcome through proper cutting, grading, and terracing.

City of Brookfield: A recent subdivision development within the City of Brookfield, Waukesha County, provides an interesting example of the use of soils data in subdivision design. The site involved covers nearly 150 acres and is strategically located at the interchange of Moorland Road, an important north-south arterial street in Waukesha County, with IH 94, a major east-west freeway serving the Milwaukee metropolitan area. As shown in Figure 54, much of the site is covered by soils having very severe and severe limitations for development even with public sanitary sewer service. The very poor soils include substantial areas of Houghton mucky peat (450 and 454), which is characterized by susceptibility to erosion and shrinkage, low-bearing capacity, instability, and a high water table. Such soils simply cannot support structural development. Better soils suitable for development are found on hillsides within the site boundaries.

The development plan proposed for this site is shown in Figure 55. The development, called Brookfield Hills, utilizes a cluster concept of residential structure placement, along with a motel and golf course, to achieve an economically feasible, as well as aesthetically pleasing, development package. The residential structures have been placed on the suitable soils located on the hillsides. The unsuitable soils have been utilized for the golf course development. Brookfield Hills is currently under construction, with the final site plan differing only slightly from that shown in Figure 55. This development is an excellent example of the recognition of soils data in subdivision design.

Village of Wind Point: Another example of the proper use of soils data in subdivision design is the development known as Wind Meadows in the Village of Wind Point, Racine County. This particular site totals slightly over 200 acres and is shown in Figure 56. The site is characterized by a low meadow area containing soils poorly suited for development because of a high water table and poor natural drainage. Further on-site soils investigation revealed a perched water table trapped in a layer of sand above an impervious stratum of clay. Thus, the soils became a major factor in the design of the Wind Meadows development.

The proposed development plan for the Wind Meadows site is shown in Figure 57. The plan is primarily based upon the cluster design concept and, therefore, includes substantial areas of poor soils in permanent open-space use. A series of ponds has been proposed to help overcome some of the high water table limitations through drainage. Wind Meadows represents another development that has been successfully designed utilizing soils data as a major factor in the design process.

Village of Elm Grove: A proposed subdivision of 40 acres in the Village of Elm Grove, Waukesha County, represents an example of a smaller-scale subdivision wherein the soils data contributed to the design solution. As shown in Figure 58, much of the site is covered by soils poorly suited for development. Houghton mucky peat, characterized by instability and a high water table, is found in both the southwest and northwest corners of the site.

The proposed subdivision design for this site is shown in Figure 59. A large pond has been proposed to assist in draining the site. The two areas of extremely poor soils have been largely reserved in permanent open-space use through the use of the cluster design concept, whereby overall densities remain the same as if the entire 40-acre site were developed with typical single-family suburban lots.

Subdivision Design—Concluding Remarks

The foregoing examples of hypothetical and actual subdivision developments within the Southeastern Wisconsin Region have demonstrated that detailed soils data, as an essential element in the design process, can contribute toward the achievement of better subdivision developments. Not only can recognition of the soils data assist in avoiding severe developmental and environmental problems in the land division and development process, such as poor and inadequate drainage conditions, wet basements, and structural failures, but very often recognition of the soil conditions leads to greater unity in design, including the preservation of adequate drainageways, the construction of ponds and retention reservoirs, the creation of parkways and parks, and the establishment of a reasonable mixture of residential structure types. It is essential, then, that soils data be recognized in land subdivision design.

LAND DIVISION ORDINANCES

Sound land division regulations are necessary to ensure that land subdivisions will fit into the land use pattern and general plan for the physical development of the community and that adequate provision will be made for necessary community facilities, such as parks, schools, churches, and shopping centers, so that a harmonious and desirable environment will result. More specifically, land division ordinances are intended to assist in achieving good subdivision design and in providing adequate information about the proposed development, as well as directly providing uniformly high standards in the actual development of land, with particular attention to such factors as utilities, drainage, street widths, street layouts and grades, lot sizes and arrangements, and improvements. In addition, properly prepared land division regulations can provide a basis for clear and accurate property boundary line records. Finally, land division regulations can assist in the prevention of certain problems related to abuse of the soil resource, such as erosion, sedimentation, and foundation failures. A thorough discussion of the land division ordinance as a plan implementation device is set forth in SEWRPC Planning Guide No. 1, Land Development Guide, 1963.

Special Soil Regulations

In general, the detailed soil survey and analyses may be used to regulate the design of land subdivisions and the conduct of subdivision development operations by the incorporation of special regulations and prohibitions into local land division ordinances. In this respect, such land division ordinances should be designed to accomplish the following:

1. Require the design of lot, block, and street layouts to minimize disruption of the natural terrain, tree removal, and shrubbery clearing and to be related to the capability of the soil resource.

2. Require the provision of soil and water conservation structures to retard the rate of storm water runoff and the observance of grading and excavating practices that will minimize erosion and sedimentation.

3. Reduce the exposure of soils without vegetative covering between the time of grading and the time of final planting.

The latter two objectives have recently received greater emphasis in land development regulations. Heavy grading during subdivision development, cutting and filling during road construction, and removal of natural cover during building site preparation all cause soil erosion and sedimentation. Construction sites are especially vulnerable to erosion, and large housing development and major construction projects may keep an area bare and vulnerable to erosion for periods as long as three years. The period of greatest erosion hazard on individual homesites usually lasts from three to 12 months.[4]

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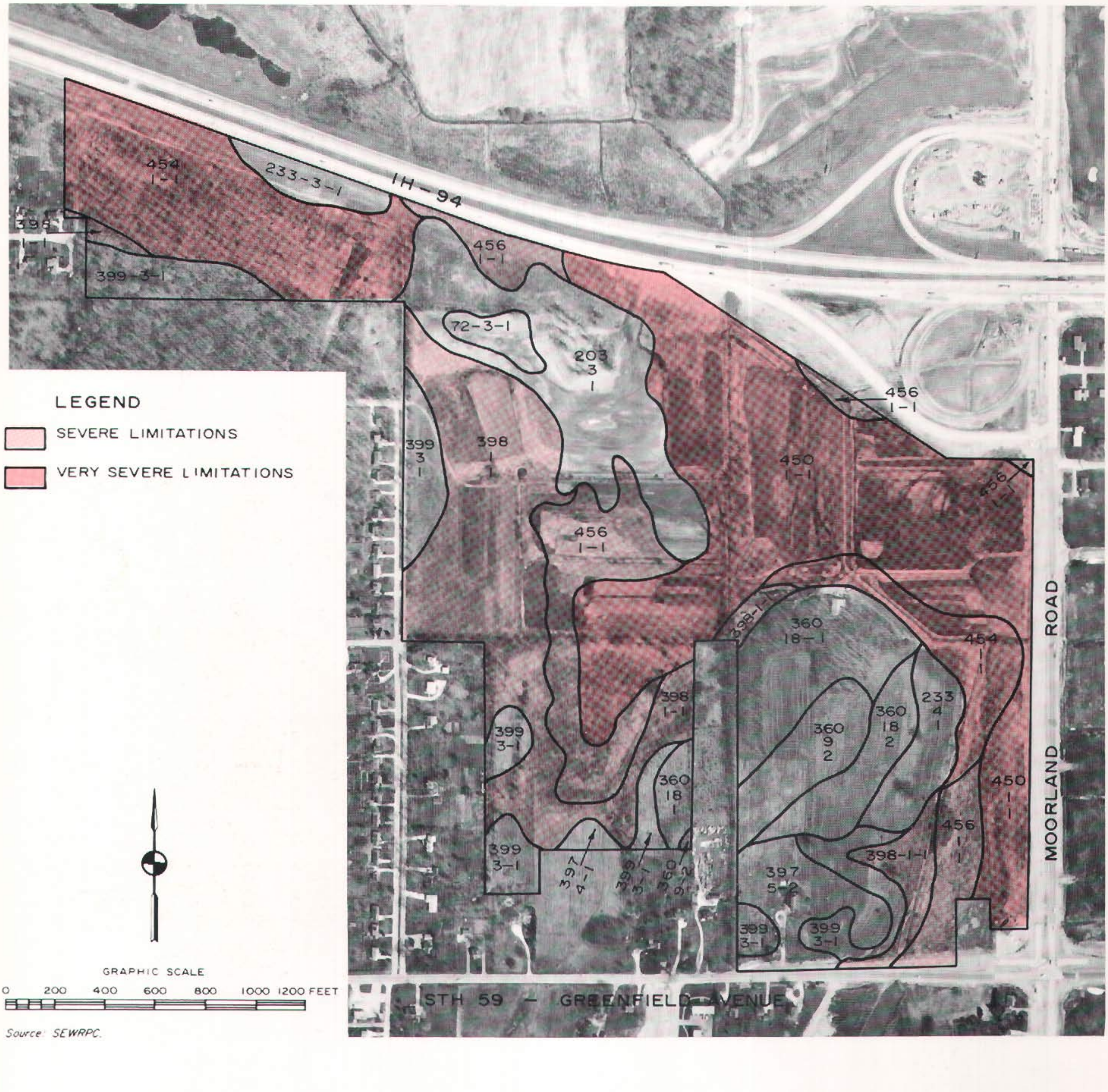
[4] *Sediment, It's Filling Harbors, Lakes and Roadside Ditches, U. S. Soil Conservation Service, Agricultural Bulletin No. 325, 1967.*

Figure 54

SOIL INTERPRETATIONS FOR SEWERED RESIDENTIAL DEVELOPMENT BROOKFIELD HILLS, CITY OF BROOKFIELD WAUKESHA COUNTY, WISCONSIN



Source: SEWRPC.

Figure 55

SITE DEVELOPMENT PLAN
BROOKFIELD HILLS, CITY OF BROOKFIELD
WAUKESHA COUNTY, WISCONSIN

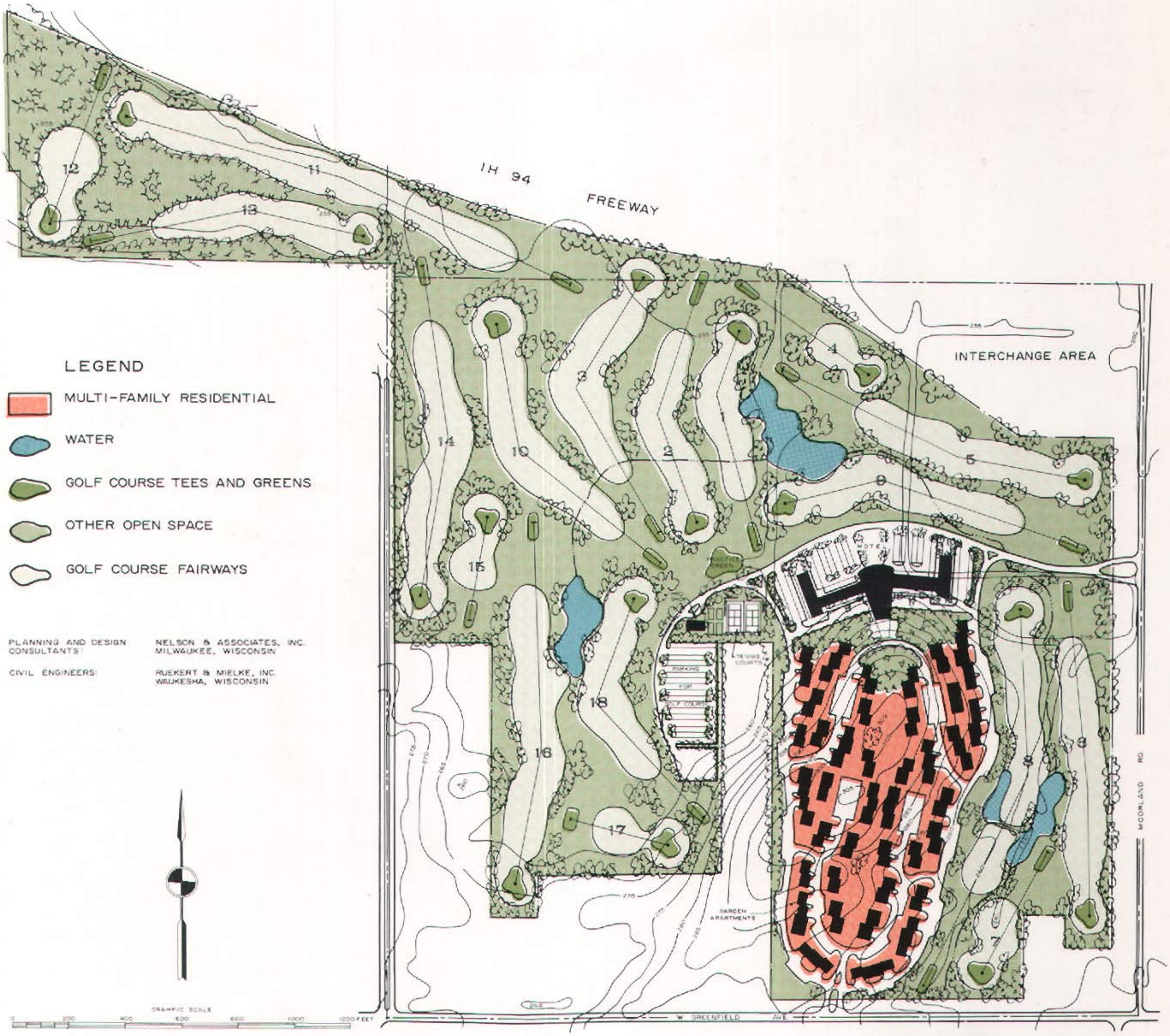
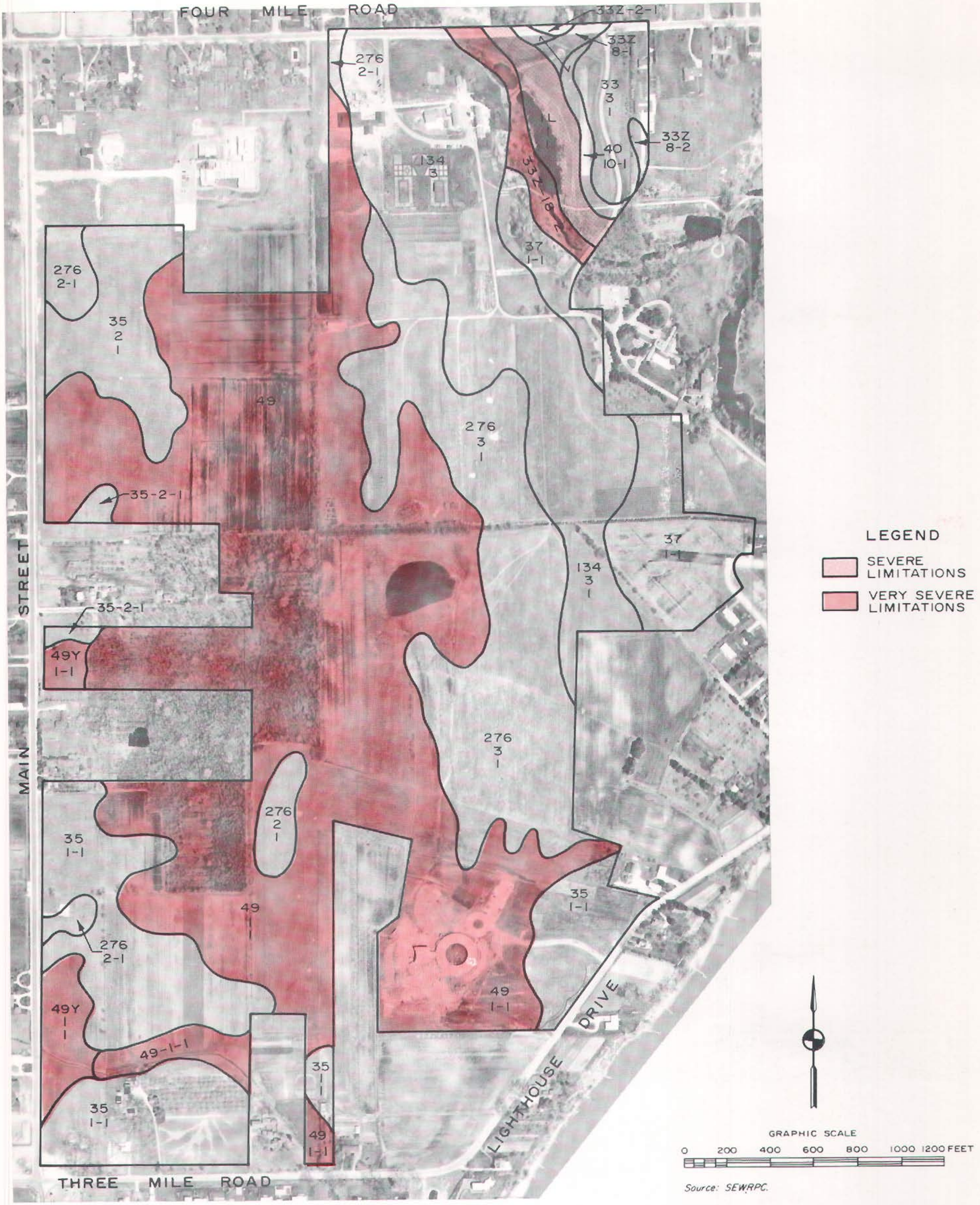


Figure 56

SOIL INTERPRETATIONS FOR SEWERED RESIDENTIAL DEVELOPMENT WIND MEADOWS, VILLAGE OF WIND POINT RACINE COUNTY, WISCONSIN



Source: SEWRPC.

Figure 57

SITE DEVELOPMENT PLAN WIND MEADOWS, VILLAGE OF WIND POINT, RACINE COUNTY, WISCONSIN

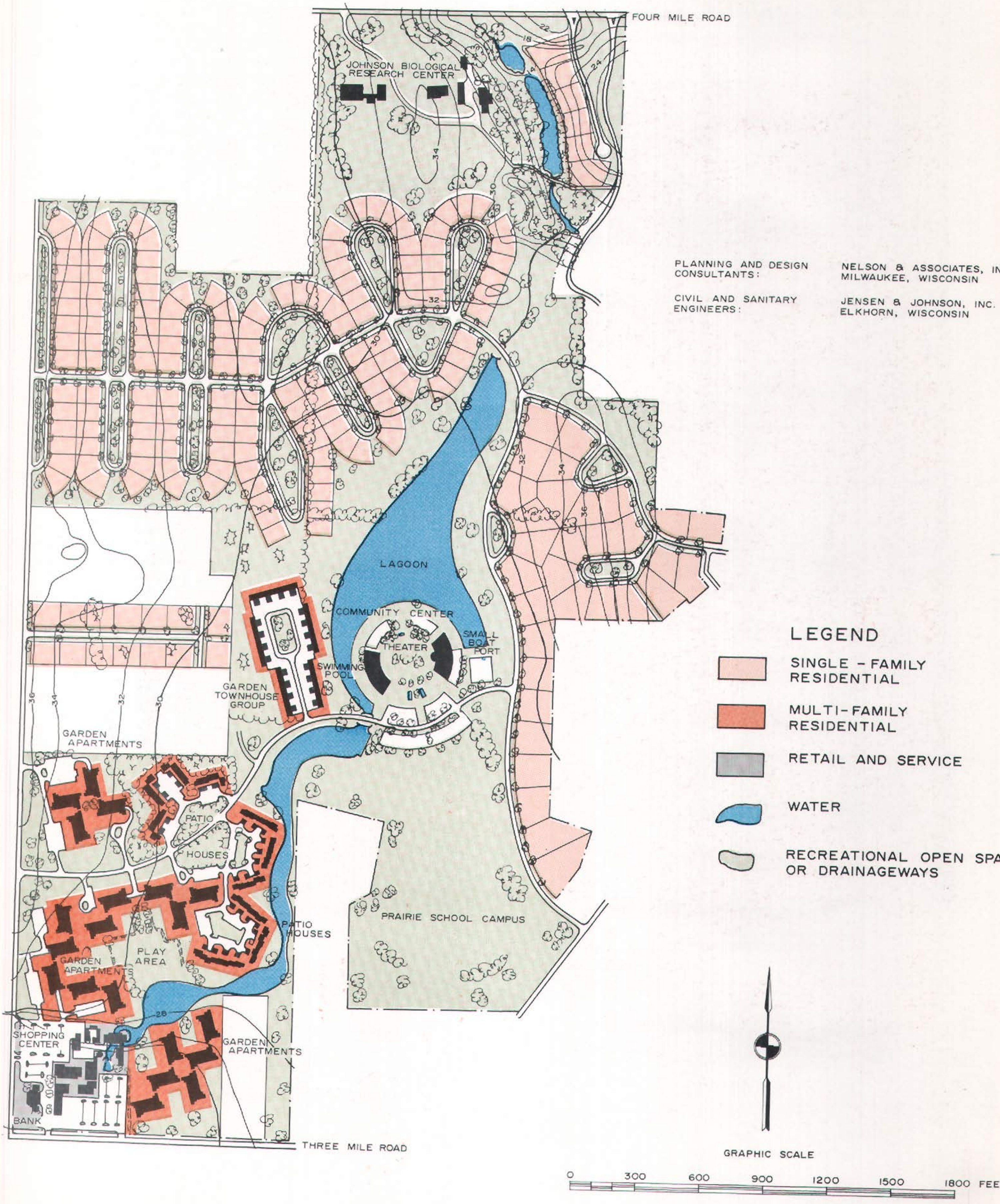
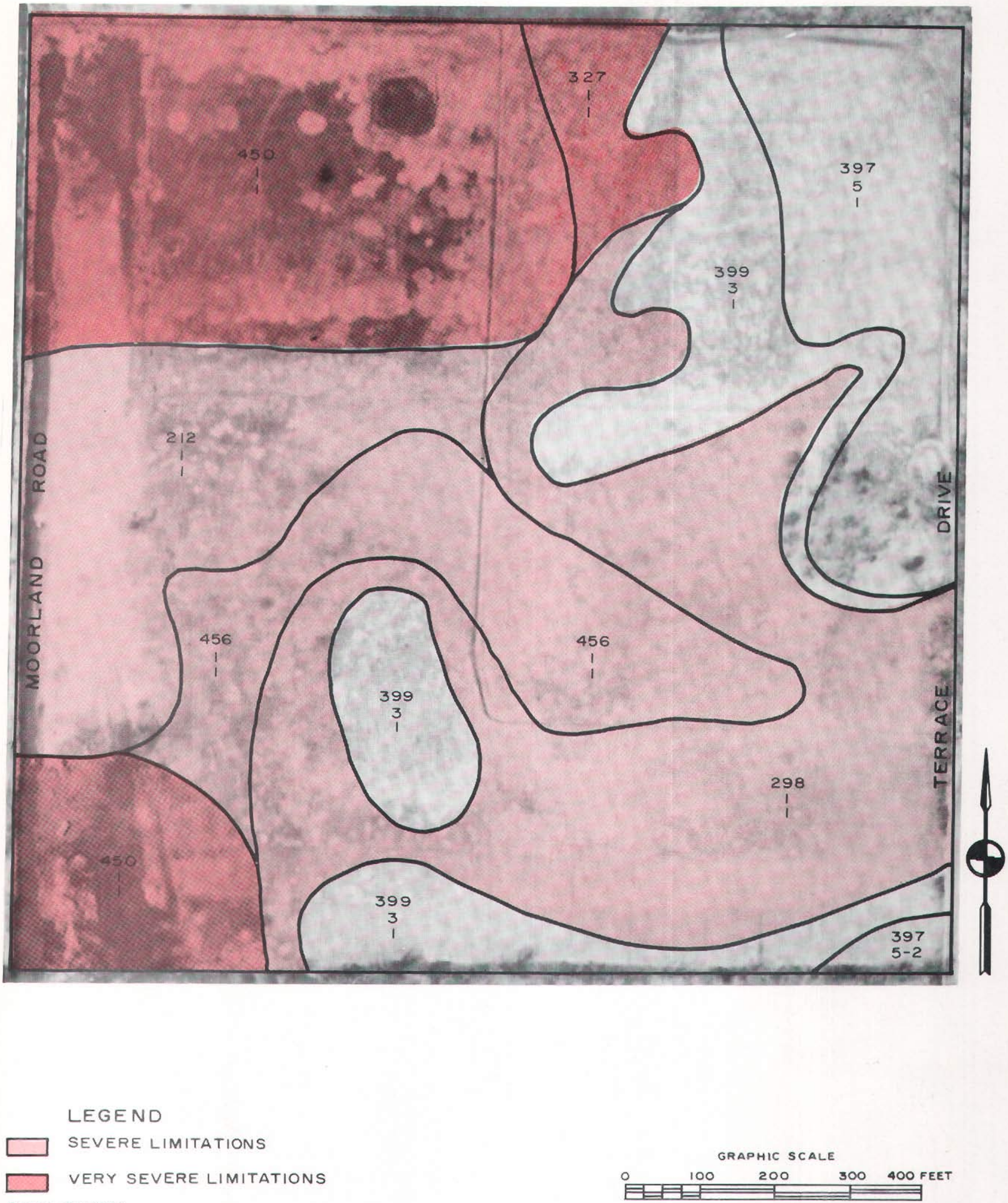


Figure 58

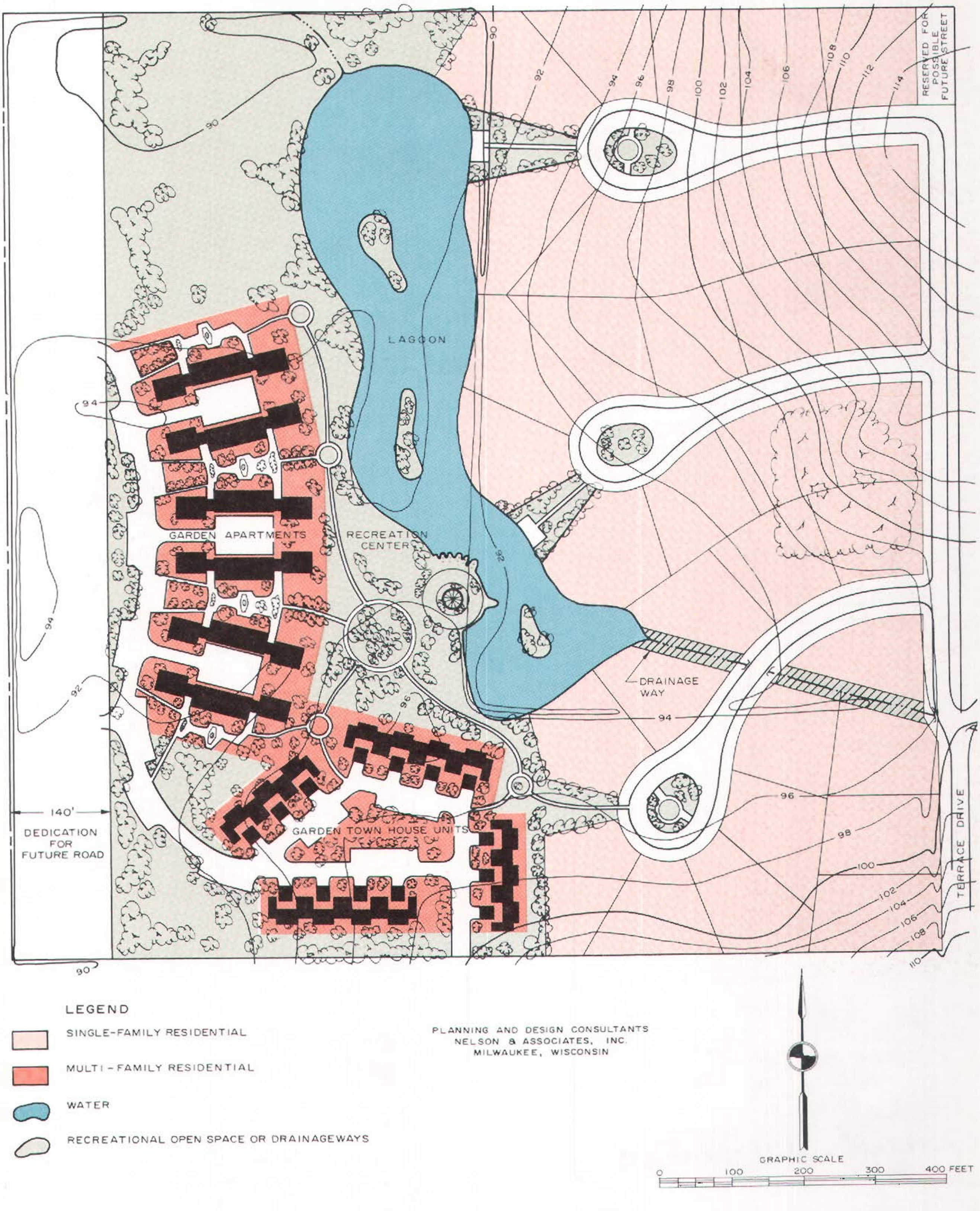
SOIL INTERPRETATIONS FOR SEWERED RESIDENTIAL DEVELOPMENT
LAND INVENTORY, INC. PROJECT, VILLAGE OF ELM GROVE
WAUKESHA COUNTY, WISCONSIN



Source: SEWRPC

Figure 59

SITE DEVELOPMENT PLAN
LAND INVENTORY, INC. PROJECT, VILLAGE OF ELM GROVE
WAUKESHA COUNTY, WISCONSIN



Appendix F contains suggested regulations designed to be incorporated into sound land subdivision ordinances and to achieve the aforementioned objectives. Section 4.7 of Appendix F provides for soil and water conservation considerations at the time of the filing of the preliminary plat. In that section the local engineer is given the authority to require the subdivider to provide soil erosion and sedimentation control plans and specifications. In addition, tree cutting, shrubbery clearing, path and trail development, and all types of earthwork operations may be subject to review by appropriate soil and water conservation agencies and officials. Sections 7.1 and 7.2 provide for consideration of soil characteristics and limitations in the subdivision design process. Section 8.8 provides for the provision of adequate storm water drainage facilities, including water retention structures, settling basins, and sodded waterways. Section 8.14 specifically provides for special sediment control measures, such as planting of grasses, trees, and vines and installation or provision of retaining walls, sloping, seeding, brush mats, and grade stabilization structures. Sections 9.3, 9.5, and 9.6 deal with the actual construction of erosion and sediment control structures and improvements.

In addition, special soil regulations in land division ordinances may take the form of a general suitability clause, such as the clause discussed in Chapter VI (Section 2.4 of Appendix E), which prohibits the use of lands or the erection of structures in areas where the soils have specific and severe limitations for certain uses or structures. Finally, the soil survey and analyses may also be used in land division ordinances to preclude the division or development of lands for specific purposes that are beyond the capabilities of certain enumerated soil types. An example of this type of regulation as applied to soils which have severe and very severe limitations for soil absorption sewage disposal systems is presented in Section 2.6 of Appendix F.

Administration and Enforcement

The proper administration and enforcement of special soil-related land division regulations require that several additional provisions be added to the ordinance. These include the following: a soil intent subsection, making it clear that the major objectives of a land division ordinance include attaining an adjustment of the land development design to the supporting and sustaining natural resource base, the prevention and control of soil erosion and sedimentation, and the prohibition of the creation of building sites on those soils poorly suited for development; a non-liability clause disclaiming any guarantee that the soils listed as being unsuited for specific uses are the only such unsuited soils within the community; a requirement that the soil mapping units be shown on any preliminary plat; a requirement that erosion and sedimentation control plans be submitted and approved before construction of any improvement commences; a modification clause to the effect that a subdivider may contest the soil type classifications, analyses, and boundary locations; and a definition of the soil mapping unit. Suggested provisions to meet these requirements are set forth in Appendix F.

BUILDING ORDINANCES

Building codes or ordinances are public laws adopted by local units of government under their police power to ensure the erection of safe, liveable, and substantial structures. A poorly prepared building ordinance can do much to diminish the effect of other properly prepared and administered land use control ordinances, such as zoning and land division ordinances.

Special Soil Regulations

If properly prepared and administered, building ordinances can be used to require adequate site development practices and landscaping and drainage improvements so as to assist in preventing soil erosion. More specifically, building ordinances should be designed to accomplish the following:

1. Require building sites to be so developed as to minimize the disruption of the terrain and protect existing trees.

2. Require that necessary disruption of the site be protected from erosion and that adequate drainage be provided.

3. Require that special foundation construction or stabilization practices be used on fill materials.

Appendix G contains suggested regulations designed to be incorporated into sound building ordinances and to achieve the above objectives. Section 2. 6 of Appendix G provides for a general land suitability clause that could be used to prevent the erection of structures on soil found unsuitable for certain uses. Section 2. 7 specifies those extremely poor soils that should be categorized as unbuildable. Section 2. 8 provides for special design considerations on steep lands. Sections 3. 1 through 3. 4 provide for site improvement practices relating to erosion control, the protection of existing flora, and drainage improvements. Section 4. 2 calls for special design considerations on disturbed soils. The soil survey and analyses, then, may be integrated into building regulations so as to control building site developments or to require that special safeguards or treatment be taken so as to prevent certain problems related to soil suitability, such as erosion, foundation failure, and siltation.

Administration and Enforcement

The proper administration and enforcement of special soil-related building regulations require that several additional provisions be added to the building ordinance. These include the following: a soil intent subsection, making it clear that the major objectives of a building ordinance include the prevention and control of erosion and sedimentation and the protection of existing terrain, flora, and fauna; a non-liability clause disclaiming any guarantee that the soils listed as being unsuited for specific building uses are the only unsuitable soils within the community; a requirement that the soil mapping units be shown on the plat of survey required for a building permit; a provision that a building permit applicant may contest the soil classification, analyses, and boundary locations; and a definition of the soil mapping unit. Suggested provisions to meet these requirements are set forth in Appendix G.

EROSION AND SEDIMENTATION CONTROL

A particularly common and serious problem accompanying the conversion of land from rural to urban uses is soil erosion and concomitant sedimentation. Erosion may be defined as the process by which soil is removed through the action of moving water, wind, or gravity. Sedimentation may be defined as the process by which mineral or organic matter is deposited and accumulated through the action of water, wind, or gravity. Eroded soil constitutes the bulk of all sediment; and, therefore, erosion and sedimentation are inextricably interrelated problems. Although erosion takes place upon, and affects, specific geographic locations and can in this respect be considered primarily a local problem, the sediment produced is mobile and may inflict severe damages at locations far removed from the original source. Any effective efforts to control sedimentation must, therefore, seek to control the erosion in which the sedimentation has its source; and both erosion and sedimentation thus become problems of areawide concern.

Five factors affect the degree or severity of erosion:

1. Climate, including temperature, wind, and the erosive amount, intensity, and frequency of rainfall, which determine the intensity of the forces acting on the soil.

2. Soil characteristics, which determine the ease with which water, wind, and gravity may displace particles of soil and which also determine the volume and intensity of runoff as an erosive force.

3. Degree of slope and the direction in which the slopes face, with the dry south facing slopes being more susceptible to erosion than others.

4. Vegetation, which reduces the erosion potential by mechanically holding the soil in place, by protecting the surface of the ground, and by reducing the volume and intensity of runoff.

5. Land use development which may serve to both temporarily and permanently increase the volume and intensity of runoff and which may temporarily at least increase the area of soil surface exposed to erosive forces.

Erosion may be classified as natural, man-made agricultural-related, and man-made urban-related. The abuse of the soil resource during the development or construction of residential subdivisions, shopping centers, industrial parks, streets and highways, and utility facilities through careless development operations can cause particularly severe soil erosion and subsequent deposit of detrimental sediment in drainageways and structures and in streams, lakes, and reservoirs (see Figures 60, 61, and 62). In any land development process, it is necessary to disturb the surface soil and to remove the vegetative cover, such cover being a natural deterrent to accelerated soil erosion. The usual result is erosion and sedimentation at some point below the place of soil removal. The amount of erosion and sedimentation, however, can be greatly reduced through careful attention to the properties of the soils involved and to the construction practices applied.

Figure 60

SOIL EROSION DURING LAND DEVELOPMENT

The conversion of land from rural to urban uses can present serious problems of soil erosion and sedimentation. The waterway shown in this photograph, taken within the Region, is in an expanding industrial park and needs treatment to protect it from continuing erosion. Land development plans must include measures, such as the rapid establishment of permanent vegetation in waterways, dealing with soil erosion and sedimentation problems.

Figure 61

SOIL EROSION DURING HIGHWAY CONSTRUCTION

The construction of highway facilities often contributes substantially to soil erosion and stream and lake sedimentation. Earthwork operations are, of course, essential to highway construction. Great care should be taken, however, to ensure that the soil is left exposed to the elements for as short a period of time and over as small an area as possible.

Figure 62

HILLSIDE EROSION

Gullies are formed very rapidly on soils having a severe erosion hazard and steep slopes if care is not taken to control surface water runoff. In this photograph of a hilltop home within the Region, an extensive gully has been created because of concentrated runoff from the house roof through the rain gutter and downspout collection system. Great care must be taken to control high-velocity runoff on steep slopes so that situations such as this can be avoided.

The extent to which land development processes contribute to the total soil erosion and sedimentation problem is not well documented. There are indications, however, that sediment produced through the processes of urbanization far exceeds that resulting from poor farm management practices. A recent study of sedimentation in Pennsylvania concluded that an increase in sediment production is the first major change in the hydrologic and hydraulic regimen of a watershed brought about by urbanization.[5] For typical rural and for established urban areas, the soil erosion rate is estimated to range from 50 to 100 tons per square mile per year. In large-scale urban land use developments under construction, however, this rate is estimated to rise rapidly to as high as 50,000 tons of soil per square mile per year.[6]

The discussion in the foregoing sections of this chapter concerning the utilization of soils data and analyses in land development regulations, such as land division ordinances and building ordinances, provides the basis for the strengthening of such land use controls to require better subdivision design and development in an attempt to control costly soil erosion and sedimentation. These strengthened ordinances, however, must be supplemented with a greater awareness on the part of land developers and builders of the specific site development practices needed to achieve the objectives set forth in the ordinances. Most of the efforts to date at encouraging better site development practices and at promulgating guides for conducting such practices have been made by the U. S. Soil Conservation Service, and the role of the soil conservation technicians in the urban environment should become an increasingly important one. In most counties direct technical assistance from U. S. Soil Conservation Service soil technicians is available to land developers and builders at no direct cost.

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[5] *The Plan and Program for the Brandywine, Institute for Environmental Studies, University of Pennsylvania, Philadelphia, 1968.*

[6] *''Urban Sediment Can Be Controlled,'' Proceedings, Interstate Commission on the Potomac River Basin, Winter Meeting, Washington, D. C., 1966.*

It is clear that erosion caused by construction operations in areas being urbanized cannot be entirely prevented. Soil that is torn and agitated by heavy earth-moving equipment will be subject to some erosion until the area can be stabilized. What is needed are attempts to prevent unnecessary or controllable erosion and consequently prevent, to the maximum extent possible, costly sediment damage.

Specific Erosion Control Practices

There are many site development practices that will result in the prevention and reduction of soil erosion and sedimentation, that will avoid or overcome soil limitations, and that will contribute toward attractive landscaping in the urban environment. Concentrated running water causes most of the severe erosion problems; and, therefore, the first concern is to control the abnormal runoff from buildings, paved areas, and compacted earth and guide this runoff water into an adequately designed and properly constructed storm water drainage system. Running water may be kept from cutting up the ground by keeping it spread out and moving slowly enough so that it does not scour the soil; by diverting it away from areas it could damage; or by making it flow on erosion-resistant surfaces, like dense sod or concrete.

The following 10 practices that contribute to good urban land conservation and reduce soil erosion and sedimentation have been identified:[7]

1. Choose the land that has the suitable natural drainage and soils for the intended development.
2. Waterways and floodplain land should be considered for park and other open-space uses.
3. Save natural vegetation and trees wherever possible. These enhance the beauty of the subdivision, which increases the dollar value and helps control erosion.
4. Plan for the safe disposal of increased water runoff caused by rooftops, pavement, and straightened waterways.
5. Plan streets to fit the contour of the land, avoiding long stretches of steep grade.
6. Provide adequate drainage to and from streets, to storm sewers or other runoff disposal practices that do not erode the land or flood property below.
7. Hold the amount of land area graded at any one time to a minimum and stockpile the topsoil for re-use in preparing the final seedbed.
8. During and after grading, plant a temporary vegetative cover which will protect the bare soil surface.
9. Build sediment basins to remove sediment from runoff waters during development.
10. Install drainage structures and plant permanent vegetation compatible with future turf as soon as possible.

More specifically, the U. S. Soil Conservation Service has promulgated the following urban land conservation practices:[8]

Site Layout: The site area should be of adequate size so as to permit flexibility in the arrangement of structures and uses. Runoff problems can be minimized by locating driveways, walks, and yard and garden edges to follow level contours and gentle slopes. Water flowing directly downhill has maximum

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[7] *The Land Developer's Guide to Handling Surface Runoff*, Douglas Soil and Water Conservation District, Omaha, Nebraska, 1969.

[8] *Soil Conservation at Home*, Agricultural Information Bulletin No. 244, U. S. Soil Conservation Service, 1963.

speed and cutting power; and, therefore, site layouts which permit cross slope locations of driveways, walks, and garden edges are preferable to layouts which require up-and-down-hill locations; however, on small lots where complicated contour patterns are not possible, drainage down the slope may become necessary.

Grading: On small lots it may become necessary to reshape the ground surface by grading. Cuts and fills should be so planned as to give a maximum area of gentle slopes and to dispose of runoff water safely. Wide bench terraces with the intervening banks protected by vegetation or retaining walls are often the most practical treatment for steep slopes around buildings. Good topsoil should be removed and stockpiled before excavating or grading so it can be replaced on the final surface.

Diversions: Diversions can be used to turn water away from a critical area and lead it to a pond or drainageway. Runoff from sloping land above the site may be diverted or directed to a waterway and guided carefully through the site. A diversion is a ridge with a channel above it, following the approximate contour to a safe outlet, and is usually kept covered with turf to prevent erosion. For all but the smallest diversions, careful design is required to fit each individual situation. The height of the ridge and size of the channel must be adequate to carry the amount of water coming from the drainage area; and the grade or slope along the channel must be correct to keep the water moving steadily, so it will not pile up and overtop the ridge. Technical assistance to design a diversion is available from the U. S. Soil Conservation Service.

Waterways: Concentration of water at any point requires a waterway to carry it to a stream, street gutter, or storm water system. The little draws and valleys in the landscape are natural waterways. When they are forced to carry increased amounts of water because of the additional runoff from developed areas, their channels are likely to be scoured into gullies. Such natural waterways can be protected by shaping and smoothing the bottom and establishing a dense sod on it. Artificial waterways can be created by shaping a wide-bottomed ditch down the slope and sodding it. In some situations it may be more practical to line a small ditch with concrete or use a tile or pipeline. Waterways, like diversions, need to be carefully designed to carry and discharge the amount of water they will receive.

Drainage: Wet basements, seepy spots, or waterlogged soils require waterproofing and the installation of tile lines or other means of drainage. Building sites may be drained by laying a line of fiber pipe or tile around the foundation a few inches below the level of the basement floor. Every drain must have a suitable outlet or a sump pump to remove the excess water.

Guides for Erosion Control

The Milwaukee and Waukesha Soil and Water Conservation Districts, cooperating with the U. S. Soil Conservation Service, have taken the lead in the Southeastern Wisconsin Region in preparing actual technical guides for several practices designed to control erosion and sedimentation and to preserve existing vegetation in the urban development process. These practices are designed to prevent erosion by establishing and maintaining vegetative cover in the construction area during the construction period. They are also designed to prevent escape of sediment to adjoining areas or to waters of streams and lakes.

A brief summary of the objectives and specifications of each of these technical guides follows. The guides are reproduced in full in Appendix I.

Topsoiling: The technical guide for topsoiling has the objective of providing for a sufficient supply of topsoil upon completion of rough grading activities. The primary purpose of this practice is to secure topsoil to be used upon exposed surfaces of graded areas. This helps ensure a favorable environment for shrubs and grass after construction of the home is complete. The upper five to seven inches of the surface soil is removed before construction or excavation begins and stockpiled for future use after construction is complete. Removal of the surface layer of soil exposes subsoil that is more suitable for fill material than the surface soil. Once construction is completed, the stockpiled surface soil can be spread over the lot in preparation for seeding or sodding.

Protection of Existing Trees: The technical guide for protection of healthy disease-free trees suggests means of ensuring the survival of desirable trees for shade, beautification, and erosion control. The guide suggests tiling at the original ground level where fills are made around trees, boxing in trees to prevent mechanical injury, painting of damaged trunks or roots, and removal of damaged limbs by cutting flush at the trunk and painting the cut. No boards should be nailed to trees, and major feeder roots should not be cut. Damage to existing tree trunks and roots can be reduced by avoiding use of heavy equipment near desirable trees. Removal of waste concrete from the area is also desirable.

Establishing Temporary Vegetative Cover on Critical Areas: The technical guide for establishing temporary vegetative cover has the objective of reducing the exposure of unprotected soil to wind and water elements. This practice is designed to provide cover for a 6-to-12 month period for soils that are being converted from cropland or idle land to urban development. The planting of rye or oats with heavy applications of fertilizer is suggested as a means of getting rapid temporary cover. Where permanent seedings are planned, a straw mulch anchored with asphalt or netting can be used in lieu of live cover.

Establishing Permanent Vegetation on Critical Areas: The technical guide for establishing permanent vegetative cover has the objective of stabilizing sediment-producing or highly erodible areas resulting from construction activities. This is done by establishing legumes and grasses by seeding or by sodding grass. The areas should first be covered by four inches of topsoil, and where possible storm water should be diverted. Heavily fertilized seedings of mixed grasses and legumes, such as smooth brome grass, tall fescue, birdsfoot trefoil, and vernal alfalfa, are suggested. A heavy straw mulch or jute netting is suggested to hold the soil until adequate live cover is established. Where mulching is not practicable, a stabilizing crop of oats can be planted.

Establishing Cover by Sodding: The technical guide for sodding has the objective of providing a permanent, attractive cover where possible early in the stages of development activities. This practice is suggested where hazardous erosion conditions make it desirable to get quick permanent cover or where other methods are questionable or impossible because of steep slopes or other conditions. Soil preparation includes heavy applications of fertilizer and tillage of the top three inches of soil. The sod is cut in strips about two inches thick, pressed tightly together on the soil and smoothed with a roller. Rapid and successful growth can be assured by sprinkler irrigation, especially if sodding is done during the normally dry part of the growing season.

Jute Thatching for Waterways: The technical guide for jute thatching has the objective of providing for a mechanical aid to protect the exposed soil during the critical period of vegetative establishment. Jute thatching can be used in lieu of a mulch. It consists of placing an open mesh web, woven of jute twine, on the soil surface during the period of vegetation establishment. The web is generally in rolls 225 feet long and 4 feet wide. The thatching is laid on the surface soil and anchored with staples and soil. In critical areas the mesh may be folded for increased erosion control effect.

Open and Closed Storm Drains: The technical guide for storm drains is intended to provide for the design and construction of open or closed conduits to carry excess water in order to prevent unnecessary erosion. Where there is a constant flow of water that prohibits growth of vegetation for protection, the installation of lined drains is suggested. The drains can be open or closed as conditions dictate and can be lined with metal, concrete, and other durable material.

Temporary Debris Basins: In some areas, even though temporary vegetative practices have been installed, it may be evident that some erosion will occur in urban development areas. Where erosion cannot be adequately controlled, the resulting sediment can be prevented from damaging other areas or streams and lakes by construction of temporary catch basins. These should be built on suitable sites below high sediment source areas. The basins should consist of embankments constructed according to specifications that assure adequate water storage and sediment-holding areas. A pipe spillway should be installed to handle normal flow of water and to drain flood runoff from the sediment pool.

SUMMARY

The detailed soil survey and interpretive analyses can provide an important input to the land subdivision design process. The soils data and survey maps can be used as an aid in delineating drainageways, in delineating parkways, and in locating and delineating neighborhood and possible community park sites. In addition, the detailed soils data can provide, in the subdivision design process, the potential for refinement of a community land use plan. Also, soils data must be taken into account in shaping and sizing the blocks and lots since each lot must contain suitable soils for site development. This consideration becomes particularly important when a proposed subdivision development is not to be served by public sanitary sewer. Several recent residential and commercial developments within the Southeastern Wisconsin Region have not only recognized the assistance of soils data in the design process but have utilized such data to a great extent in developing superior residential and commercial development layouts.

Severe soil erosion and detrimental stream and lake sedimentation are caused through careless urban development operations. Studies have shown that sediment produced through the processes of urbanization far exceeds that resulting from poor farm management practices. In large-scale developments that are under construction, the soil erosion rate has been estimated to reach 50, 000 tons of soil per square mile per year.

The key to achieving sound subdivision design and erosion and sedimentation control lies in the establishment of appropriate local regulations for land development, including land division and building ordinances. The soil survey and analyses may be incorporated into local land division ordinances in the form of special soil erosion and sediment control regulations. Sound land division ordinances should require the design of lot, block, and street layouts so as to minimize disruption of the natural terrain, require the erection of soil and water conservation control structures to reduce the velocity of runoff waters and trap sediment, require the observance of sound grading and excavating practices that will prevent erosion and sedimentation, and require the reduction of the time in which soils without vegetative covering are exposed to the elements during construction periods.

Building codes or ordinances are intended to assure the erection of safe, liveable, and substantial structures. Special regulations can also be prepared to utilize the soils data in building codes. Building codes should require building sites to be so developed as to minimize the disruption of the terrain, require that necessary disruption of the site be protected from erosion and that adequate drainage be provided, and require that special foundation construction or stabilization practices be used on field materials.

In addition to the inclusion of special soil regulations in land division and building ordinances, an educational effort is needed to bring about a greater awareness of erosion and sedimentation control practices on the part of land developers and builders. Direct technical assistance in such matters is available from the county offices of the U. S. Soil Conservation Service. Several guides for erosion control have been prepared by the Milwaukee and Waukesha Soil and Water Conservation Districts. These practices are designed to prevent erosion by establishing and maintaining vegetative cover in the construction area during the construction period. These guides include topsoiling, the protection of existing trees, the establishment of temporary vegetative cover on critical areas, the establishment of permanent vegetation on critical areas, the establishment of cover by sodding, jute thatching for waterways, open and closed storm drains, and temporary debris basins.

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Chapter VIII

THE USE OF SOILS DATA IN HEALTH AND SANITARY REGULATIONS

INTRODUCTION

Much of the recent urban development in the Southeastern Wisconsin Region has taken place in a highly diffused manner beyond the existing and proposed limits of public sanitary sewerage systems. This development, therefore, has been commonly serviced by private on-site soil absorption sewage disposal systems, called "septic tank systems." These private sewage disposal systems have been altogether too often underdesigned, improperly installed, or located on soils which are poorly suited for the absorption of sewage effluent. As a result these systems often malfunction and result in great inconvenience to the homeowner, severe health hazards to the community, and serious deterioration of the community's land and water resources. Malfunctioning septic tank systems within the Region have resulted in foul-smelling stream and lake shores; stream, lake, and ground water pollution; contaminated wells; and yards and road ditches saturated with sewage effluent that poses a definite health problem. This chapter will discuss the use of soils data in sanitary regulations designed to prevent the installation of soil absorption sewage disposal systems in areas unsuited to the use of such systems.

OPERATION OF SOIL ABSORPTION SEWAGE DISPOSAL SYSTEMS

The function of a septic tank, which in its simplest form consists of a water-tight container with an inlet and an outlet (see Figure 63), is to condition the sewage so that it may be more readily percolated into the subsoil. Some of the suspended solids in the influent sewage are settled out and retained in the tank forming a sludge deposit in the bottom of the tank that must be removed from time to time. This sludge deposit, as well as some of the dissolved solids in the influent sewage, is biologically decomposed in the septic tank by anaerobic bacterial action; that is, by the action of bacteria living in the absence of air or free oxygen. Contrary to popular belief, septic tanks are not very effective in the removal of microorganisms from the sewage. Thus, although the sewage undergoes partial stabilization in passing through the tank, this does not mean that disease-producing agents are removed; hence, septic tank effluents cannot be considered "safe" from a health standpoint.[1] The effluent contains a variety of suspended and dissolved solids, various chemicals, and a large and varied microbial population.

The sewage effluent which leaves the septic tank is discharged into the soil by means of a seepage trench, seepage bed, or seepage pit (see Figure 63). The effluent is further treated by passage through the soil, which absorbs and adsorbs certain pollutants, as well as assists in further removing any suspended solids by filtration. The soil will not remove certain dissolved solids nor microorganisms. Some disease-producing microorganisms which require special conditions for life, such as the warmth found within a human or other warm-blooded animal host, will, however, die given enough time. The rate at which the soil absorbs the effluent is, therefore, critical to the proper operation of the sewage disposal system. If the effluent is not absorbed rapidly enough, it may back up or rise to the surface of the ground over the seepage area and be carried off into ditches and drainageways and eventually into streams and lakes as a pollutant. If the effluent drains through the soil too rapidly, it may travel unfiltered into, and contaminate, ground water supplies. The filtering action through the soil is thus essential to the proper operation of the system. Clearly, then, the soil characteristics present in the filter field are the singularly most important element to the proper operation of septic tank sewage disposal systems.

The permeability of the soil is one of the most important soil characteristics affecting proper absorption. There are indications that soil permeability decreases over time at an increasingly rapid rate when the

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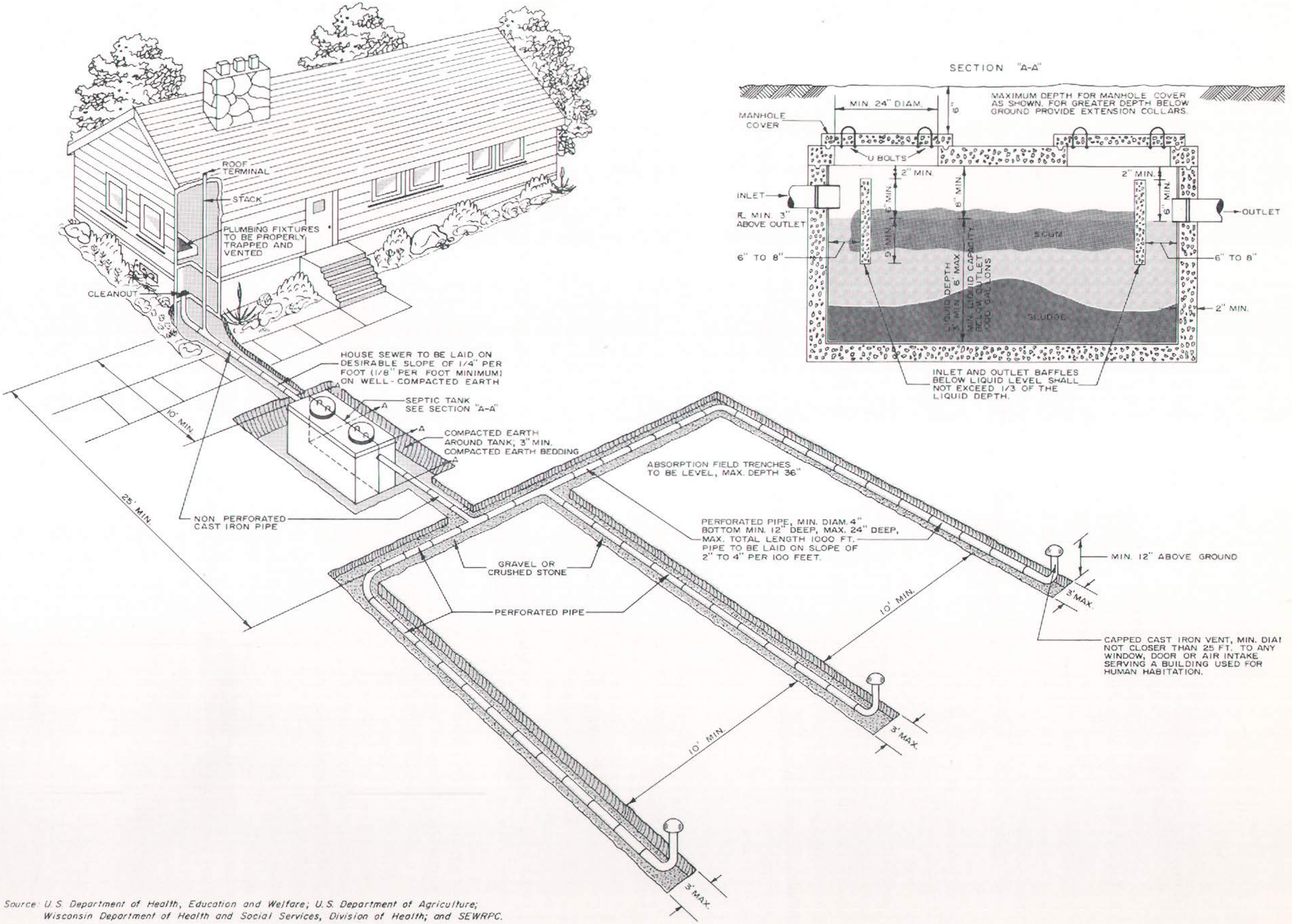
[1] *Manual of Septic Tank Practice*, *U. S. Department of Health, Education, and Welfare, Public Health Service, Publication No. 526, revised 1967.*

Figure 63

ON-SITE SOIL ABSORPTION SEWAGE DISPOSAL SYSTEM



Source: U.S. Department of Health, Education and Welfare; U.S. Department of Agriculture; Wisconsin Department of Health and Social Services, Division of Health; and SEWRPC.

soil receives septic tank effluent.[2] This decrease in permeability is the result of soil clogging. This clogging process can be divided into three interrelated types: physical, chemical, and biological. Physical clogging occurs when solid material carried in the effluent is deposited in the pores of the soil. Clogging may also be caused by chemicals in the effluent that are able to alter the composition of the soil and break down the natural soil structure. Biological materials, however, appear to be the most important cause of soil clogging. Research efforts have not as yet determined the exact nature of the clogging material formed by biological activity. It is believed, however, that such biological clogging takes place mainly under anaerobic (absence of air or free oxygen) conditions, which conditions exist in the soil below the water table. To minimize soil clogging. therefore, the soil absorption system should be located as high above the water table as possible. Thus, the depth to the water table is another important soil characteristic affecting the proper operation of septic tank systems.

The proper operation of on-site soil absorption sewage disposal systems requires, therefore, soil suitable for the absorption of septic tank sewage effluent. Furthermore, because of the decreasing soil permeability over time, which results from soil clogging, sufficient lot area should be provided to allow periodic relocation of the soil absorption area. Clearly, the septic tank system of sewage disposal, even when properly located, sized, installed, operated, and maintained, is often a poor solution to the disposal of wastes. Such systems should always be considered a temporary measure in urban areas.

SOIL PROBLEMS

On-site soil absorption sewage disposal systems have in numerous instances within the Region been improperly located in areas covered by soils having severe or very severe limitations for the safe and efficient operation of such systems. The following types of soils are not well suited for the installation of septic tank systems:

1. Floodland and wetland soils and soils having a high water table, which cause malfunctioning of the system for all or for part of the year and rapid clogging of the absorptive soil pores.

2. "Tight" or slowly permeable soils, which do not permit the septic tank effluent to percolate properly and result in the effluent rising to the surface where it may pond or drain into roadside ditches, streams, and lakes.

3. Excessively well-drained soils or soils over creviced or fractured bedrock, which may result in partially treated effluent rapidly reaching ground water supplies.

4. Soils on slopes in excess of 12 percent, which may result in partially treated effluent seeping to the surface and draining into roadside ditches, streams, and lakes.

Enterprising developers and misinformed public officials often believe that by simple filling, low-lying wetlands can be made suitable for soil absorption sewage disposal systems. That this can be a dangerous misconception was demonstrated by a recent survey of private sewage disposal systems located in selected shoreland areas throughout the state, including two lakes in southeastern Wisconsin, conducted by the Wisconsin Department of Health and Social Services.[3] This survey found that all areas surveyed which had been developed by placing fill over peat or muck soils contained malfunctioning septic tank sewage disposal systems. Some land developers also suggest larger lots when the capability of a soil to handle sewage effluent is questionable. Larger lots, however, will not in themselves ensure the proper operation of soil absorption sewage disposal systems if the soils covering the lots are unsuited to the proper operation of the system. Often, "solutions," such as filling and larger lot sizes, are only temporary in nature since the basic problem of poor permeability or high water table remains and causes systems to fail after

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[2] *"Disposal of Septic Tank Effluent in Soils," J. M. Cain and M. T. Beatty, Journal of Soil and Water Conservation, Vol. 20, No. 3, May-June 1965.*

[3] *Wisconsin Department of Health and Social Services, Summary Report of a Survey of Private Sewage Disposal Systems Serving Water Front Properties, 1967.*

a relatively short period of operation. Rather than attempting to seek ways to make soil absorption disposal systems temporarily operable in such areas, local public officials should seek to prevent the installation of systems on unsuitable soils and encourage future urban growth to take place in such areas only if public sanitary sewer service can be provided.

Map 20 shows the location of malfunctioning septic tank sewage disposal systems as recorded by the Waukesha County Health Department from 1966 to 1969. Except in a few instances around the shorelines of lakes in the County where the Department conducted areawide field inspections, all of the recorded malfunctioning systems were brought to the attention of the Department by concerned neighbors and, in a few cases, by the landowner himself. Because of the reluctance to report malfunctioning septic tank systems and because of the lack of knowledge by the general public about proper system operation, it can be safely assumed that these recorded malfunctioning systems represent only a small proportion of such problems existing in the County. Maps 21 and 22 are the soil survey maps for two areas of the County, color-interpreted for the installation of soil absorption sewage disposal systems. The locations of malfunctioning systems, as recorded by the County Health Department, have been superimposed on the soil maps. As shown on Map 21, most of the system failures occurred on soils rated as having very severe limitations for the absorption of sewage effluent. In addition, a large number of failures occurred on filled or "made" land. As shown on Map 22, failures also occurred on soils rated as having severe limitations. In this particular area, the soils are very "tight" or impermeable. These examples serve to demonstrate that septic tank sewage disposal systems should not be considered a permanent solution to the problem of sewage disposal in areas covered by soils that are ill-suited for the absorption of effluent.

HEALTH HAZARDS AND WATER POLLUTION

Malfunctioning septic tank sewage disposal systems produce an untreated or partially treated effluent containing a large number of bacteria and other microorganisms, as well as various suspended and dissolved solids, and permit such effluent to seep, drain, or wash into ground or surface water supplies. The phosphates and nitrates in such effluent may contribute to fertilization of surface waters, excessive algae growths, turbidity, and general impairment of the water quality for various types of recreational uses. The microorganisms may result in a public health hazard. Often such systems are illegally pumped or piped directly into a stream or lake or onto the surface of the ground (see Figure 2) so that the effluent flows directly into surface waters or are connected to an agricultural or other drain tile, which directly transports the untreated effluent into roadside ditches, which, in turn, drain into streams and lakes. It is important that the detailed soils data be utilized to assist in the prevention of the installation of additional septic tank sewage disposal systems in those areas unsuited for such use, so that severe health hazards can be avoided and water pollution abated.

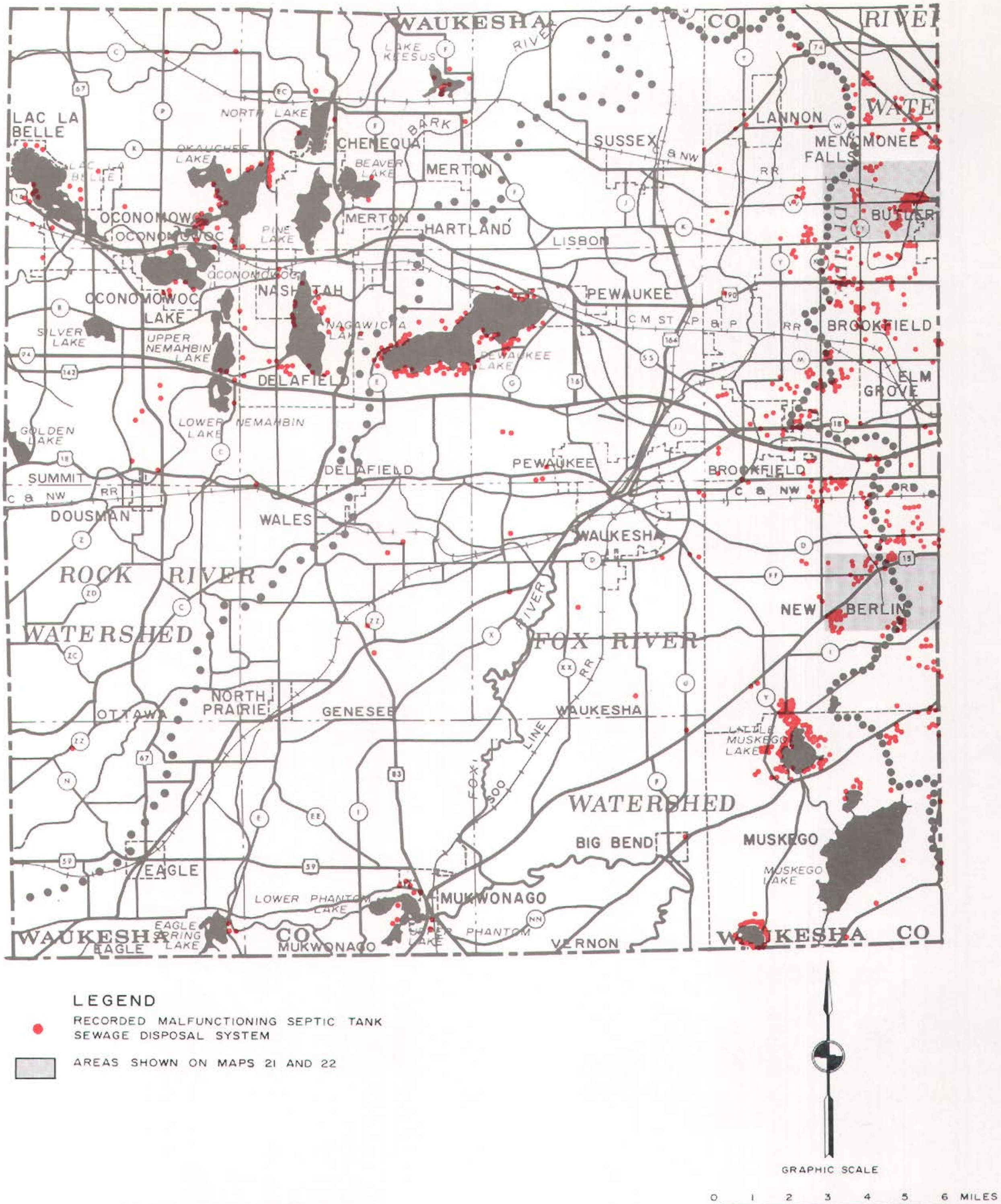
SANITARY ORDINANCES

Sanitary ordinances are public laws adopted by local units of government under the police powers to protect the health of their citizens. Such ordinances, stringently enforced, can effectively prevent the health problems occasioned by the disruption of private soil absorption sewage effluent disposal systems or the contamination of private water supply systems that may be caused by the malfunctioning of such systems. For example, on-site soil absorption sewage disposal system components, such as septic tanks, absorption fields, seepage beds, and seepage pits, do not function properly on certain soils; and, as noted above, the transmission of sewage solids into soil absorption areas results in the eventual clogging and disruption of such systems. The proper location and construction of such sewage disposal systems can best be regulated by a sanitary ordinance similar to the Model Sanitary Ordinance set forth in Appendix K of SEWRPC Planning Guide No. 5, <u>Floodland and Shoreland Development Guide</u>, 1968. This Model Sanitary Ordinance has been designed, in part, to accomplish the following:

1. Require a permit prior to the installation of any septic tank sewage disposal system, with the application for such permit showing such pertinent features of the site under consideration as topography, soils, percolation test holes, shoreland and floodland boundaries, drainage ditches, and farm drainage tile systems.

Map 20

RECORDED MALFUNCTIONING SEPTIC TANK SEWAGE DISPOSAL SYSTEMS IN WAUKESHA COUNTY: 1966 - 1969

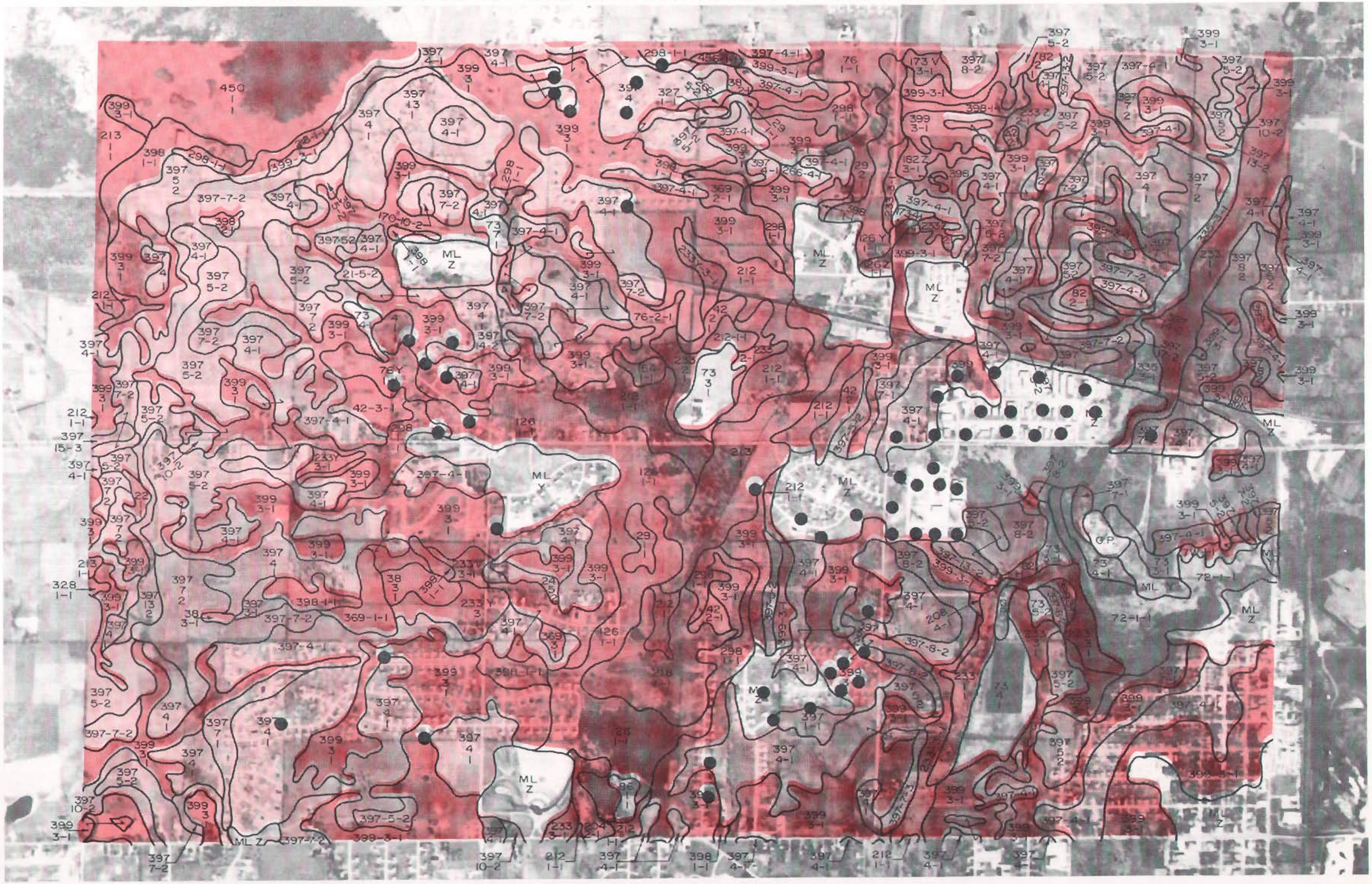


Source: Waukesha County Health Department.

The proper operation of on-site soil absorption sewage disposal systems is of great concern to public health officials. The above map is a geographical log of malfunctioning systems as recorded by the Waukesha County Health Department from 1966 to 1969. Except in a very few instances where the Department conducted areawide field inspections around lakes, the recorded system failures were brought to the attention of Department officials by neighbors and landowners. The widespread occurrence of system failures emphasizes the need to use soils data in the location and proper construction of such systems.

Map 21

RELATIONSHIP BETWEEN SOILS DATA AND RECORDED MALFUNCTIONING SEPTIC TANK SEWAGE DISPOSAL SYSTEMS SECTIONS 25, 26, 27, 34, 35 AND 36, T8N, R20E, WAUKESHA COUNTY



LEGEND

▭ DENOTES SOILS WITH SEVERE LIMITATIONS

▨ DENOTES SOILS WITH VERY SEVERE LIMITATIONS

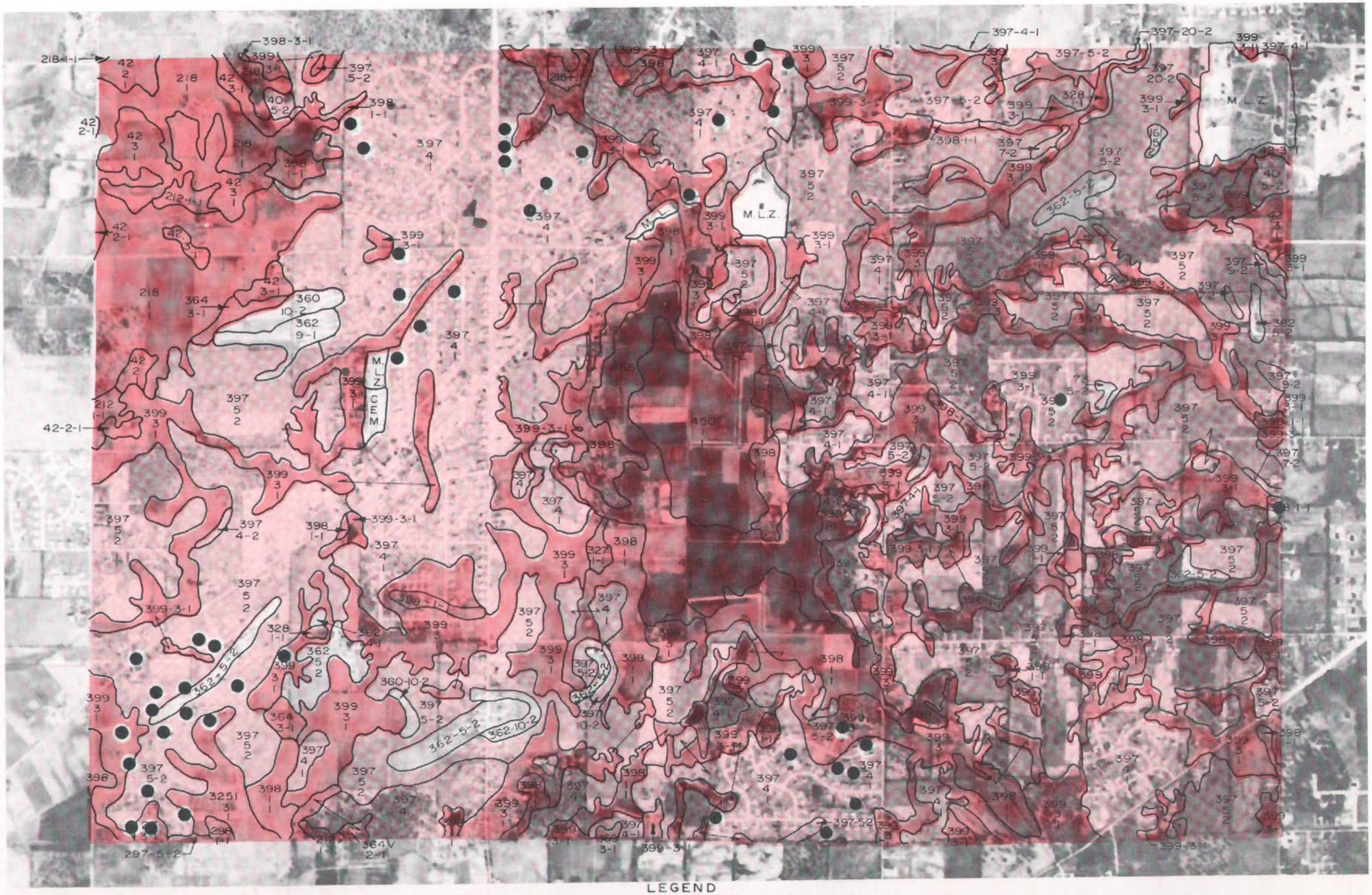
● DENOTES RECORDED MALFUNCTIONING SEPTIC TANK SEWAGE DISPOSAL SYSTEM

Source: Waukesha County Health Department; SEWRPC

The recorded septic tank system failures for this particular six-square mile area in Waukesha County have been superimposed on a soils map interpreted for the absorption of sewage effluent. Most of the system failures occurred on soils rated as having very severe limitations for such use. In addition, a large number of failures occurred in an area that had been "made" or filled in an attempt to overcome the natural limitations.

Map 22

RELATIONSHIP BETWEEN SOILS DATA AND RECORDED MALFUNCTIONING SEPTIC TANK SEWAGE DISPOSAL SYSTEMS SECTIONS 13,14,15,22,23 AND 24, T6N, R20E, WAUKESHA COUNTY



LEGEND

▨ DENOTES SOILS WITH SEVERE LIMITATIONS

🟥 DENOTES SOILS WITH VERY SEVERE LIMITATIONS

● DENOTES RECORDED MALFUNCTIONING SEPTIC TANK SEWAGE DISPOSAL SYSTEM

Source: Waukesha County Health Department; SEWRPC

In another six-square mile area of Waukesha County, a large number of septic tank sewage disposal system failures were found to occur on soils that are "tight" or have a slow permeability rate. Within this particular area, there have been a number of attempts to "improve" the operation of the systems by illegally draining the sewage effluent into roadside ditches and drainageways through pipes and hoses.

2. Prohibit on-site soil absorption waste disposal systems in areas covered by excessively well-drained soils, on steep slopes, in areas where creviced or fractured bedrock is near the surface, or where high or fluctuating water tables are in evidence and require corrective measures where land is steep or has slow permeability.

3. Specify certain minimum distances that septic tanks and soil absorption areas must be located from wells, stream and lake banks, ground water tables, and bedrock.

4. Require the correction of malfunctioning sewage disposal systems or their replacement with alternative systems, such as holding tanks or public sanitary sewerage systems.

The regulations contained within the SEWRPC Model Sanitary Ordinance are equal to, or exceed, the minimum standards applicable to soil absorption sewage disposal facilities and private well water supply systems required or recommended by the State Division of Health, the State Department of Natural Resources, the Federal Housing Administration, the U. S. Department of Agriculture, and the U. S. Public Health Service.

Pertinent sections from this Model Sanitary Ordinance are reproduced in Appendix H and in lieu of adoption of the Model Sanitary Ordinance, as set forth in full in SEWRPC Planning Guide No. 5, previously referenced, may be incorporated into other health, sanitation, and plumbing ordinances. The Model Ordinance was designed for adoption by counties, pursuant to Section 59.07(51) of the Wisconsin Statutes, and contains regulations applicable to private water supply and waste disposal systems. Other health and sanitation regulations concerning the operation of public bathing beaches, swimming pools, restaurants, tourist camps, schools, and hotels were not included. Similar sanitary ordinances can be adopted by towns, villages, and cities pursuant to Section 60.18(12), 61.34(1), and 62.11(5) of the Wisconsin Statutes. In addition, sanitary provisions governing the installation of private sewage disposal systems can be included in county health codes adopted by county boards of health pursuant to Section 140.09 of the Wisconsin Statutes.

Administration and Enforcement

The proper administration and enforcement of sanitary regulations based on soils data and governing the installation of private on-site soil absorption sewage disposal systems require that several additional provisions be added to the code or ordinance. These include a soil intent subsection, wherein it is clearly stated that the objectives of the health or sanitary ordinance include the protection of the community's soil and water resources; a non-liability clause disclaiming any guarantee that the soils listed as having limitations for soil absorption sewage disposal systems are the only unsuitable soils within the community; a requirement that the soil mapping units be shown on the plat of survey required for a sanitary or health permit; and a provision that an applicant may contest the soil classification, analyses, and boundary locations. Appendix H contains several model subsections designed to fulfill these requirements.

Percolation Tests

The Wisconsin Department of Health and Social Services is charged by Chapters 140 and 145 of the Wisconsin Statutes with general public health responsibilities, including the proper installation and maintenance of private waste disposal systems. To this end, Chapters H 62 and H 65 of the Wisconsin Administrative Code require that soil percolation tests be conducted prior to state approval of any land subdivision plat not served by public sanitary sewerage facilities and prior to the installation of an individual septic tank sewage disposal system on any particular parcel of land. The enactment of a sound local sanitary code incorporating the soil survey data and governing the location and construction of private on-site sewage disposal systems will not, therefore, eliminate the need for soil percolation tests. The Wisconsin Department of Health and Social Services utilizes the soil percolation tests, along with soil survey data, to determine the ability of the soil to absorb sewage effluent. Minimum lot areas and minimum soil absorption field areas are determined by the Department according to formulae which relate these areas to percolation test results; that is, the greater the number of minutes required in the test for the water to fall one inch, the greater the lot and absorption area required (see Tables 29 and 30).

In theory the soil percolation test is supposed to estimate soil permeability and by inference the ability of the soil to discharge adequately through the soil various amounts of sewage effluent. There are, however,

Table 29

DETERMINATION OF LOT AREA REQUIRED FOR SUBDIVISIONS NOT SERVED BY PUBLIC SANITARY SEWER

Percolation Rate (Minutes[a])		Minimum Lot Area (Square Feet)	
Shallow Absorption Systems	Deep Absorption Systems	Private Water Supply Systems	Public Water Supply Systems
< 3	< 2	20,000	10,000
3 - 30	2 - 10	15,000	12,000
30 - 45	10 - 30	20,000	15,000
45 - 60	30 - 60	40,000	30,000

[a] *Minutes required for water to fall one inch.*

Source: *Wisconsin Department of Health and Social Services; Chapter H 65, Wisconsin Administrative Code.*

Table 30

DETERMINATION OF MINIMUM ABSORPTION AREA FOR RESIDENTIAL SOIL ABSORPTION SEWAGE DISPOSAL SYSTEMS

Percolation Rate (Minutes[a])	Minimum Absorption Area (Square Feet Per Bedroom)			
	Normal Plumbing Fixtures	With Garbage Grinder	With Automatic Washer	With Both Garbage Grinder And Automatic Washer
< 3	50	65	75	85
3 - 10	100	120	135	165
10 - 30	150	180	205	250
30 - 45	180	215	245	300
45 - 60	200	240	275	330

[a] *Minutes required for water to fall one inch.*

Source: *Wisconsin Department of Health and Social Services; Chapter H 62, Wisconsin Administrative Code.*

several theoretical and practical limitations of the percolation test. Two writers on the subject have stated these limitations as follows:[4]

1. Data from the tests are not applicable if there is a fluctuating water table near the soil surface or if there are abnormal situations, such as root channels, large soil cracks, or small animal burrows in the test area.

2. The test cannot be performed on frozen ground and is not reliable when run on dry soil.

3. There is considerable variation in the techniques used in performing the test; often, it may be run improperly.

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[4] *Cain and Beatty, op. cit.*

4. There is no valid reason for assuming that the percolation rate from a carefully prepared test hole will be the same as that from an absorption area constructed on the same soil with heavy machinery.

5. It is quite likely that there may be no relationship between the ability of the soil to accept water for a short period of time and its ability to accept sewage effluent over a long period of time.

These limitations serve to make the soil percolation test alone an unreliable method of determining the suitability of soils to adequately absorb sewage effluent. The very fact that local public health and other officials in the Region have repeatedly uncovered malfunctioning septic tank systems that have been in operation for only a very short period of time, that were properly designed and installed, and that presumably met at the time of installation all the percolation test requirements makes the test an unreliable one at best. For this reason, the SEWRPC Model Sanitary Ordinance recommends utilizing the detailed soil survey data as the primary basis for regulating the installation of septic tank sewage disposal systems. Thus, the soils data are used as a basis for prohibiting the installation of septic tank sewage disposal systems on certain soils unsuited to this application. The percolation test is used in conjunction with the soils data and in areas covered by soils suitable for the use of septic tanks in determining the type and size of the waste disposal system to be used. By coordinating the percolation test with the soils data, the chances that public officials and prospective lot or home buyers will be misled by percolation test results into buying or building in areas where septic tank systems will not function properly will be greatly reduced.

SOILS DEMONSTRATION SITE APPLICATION

Map 23 shows the soil limitations for the 160-acre soils demonstration site discussed in Chapter VII of this Guide as interpreted for residential development with on-site soil absorption sewage disposal systems on lots of one acre or less. Over 50 percent of the site contains soils having very severe or severe limitations for the absorption of sewage effluent. The Tichigan (42), Ehler (212 and 213), Clyman (278), Pistakee (328), Lamartine (364), and Brookston (231) silt loams all have a high water table, with the result that soil absorption sewage disposal systems will not operate properly during all or part of the year. The Hochheim (357) loams have slopes in excess of 12 percent, and the installation of soil absorption disposal systems on these soil types may cause partially treated effluent to seep to the surface and run off into the land. The balance of the site is covered by soils having only moderate or slight limitations for soil absorption sewage disposal systems.

Map 24 shows a suggested subdivision plat layout if the site were to be developed without public sanitary sewer service. The home sites and soil absorption sewage disposal areas shown are carefully located so as to avoid the poor soils, even though many of the lots include a small proportion of poor soils. That portion of each lot fronting on the public street is generally located on high ground so the homes and wells can be elevated above the disposal areas to the rear. The soil absorption disposal areas are sized to cover an area of 1,000 square feet so as to provide an adequate filter field for a 3-bedroom home with all modern appliances, including a dishwasher and garbage grinder. The lots are sized at a minimum of 30,000 square feet so as to accommodate adequately the disposal area, in addition to large ranch-type homes. Most of the lots include at least 15,000 square feet of area covered by suitable soils, allowing for the possible relocation of the disposal field. Those portions of the site covered by soils unsuited for soil absorption sewage disposal facilities have been designated for conservancy, park, drainage, or other open space use.

SUMMARY

Rapid urban development within the Region has resulted in urban growth taking place beyond the existing and proposed service limits of public sanitary sewer systems. Such development is forced to rely on private on-site soil absorption sewage disposal systems, commonly called "septic tank systems." In many instances, these private sewage disposal systems have been underdesigned, poorly installed, and located on soils that are ill-suited for absorption of sewage effluent. As a result these systems often malfunction and create serious health and sanitation problems in the community.

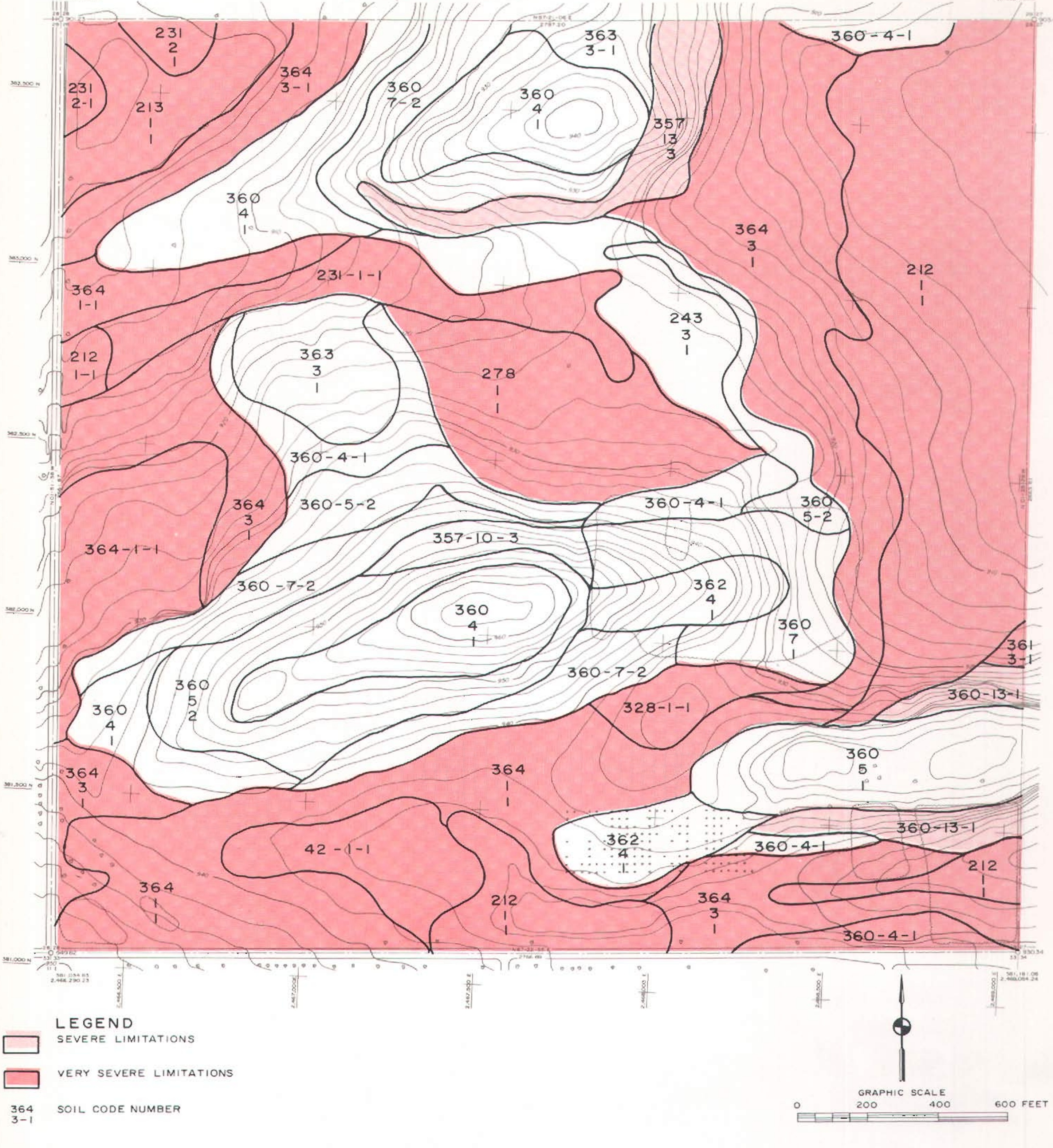
Certain soil types are not well suited for the installation of septic tank systems. These include floodland and wetland soils, high water table soils, "tight" or slowly permeable soils, excessively well-drained soils, soils over creviced or fractured bedrock, and soils on slopes in excess of 12 percent. The simple filling of floodland and wetland areas will not necessarily form a suitable site for soil absorption sewage disposal systems. Neither are larger lots necessarily the answer to operation of septic systems. These "solutions," such as filling and larger lot sizes, are generally only temporary in nature since the basic problem of poor permeability remains and causes systems to fail after a relatively short period of time.

Sanitary ordinances and their enforcement can be effective in avoiding the health problems occasioned by improperly located and constructed on-site soil absorption sewage disposal systems. Sanitary ordinances can be used to regulate the location and construction of all private sewage disposal systems. Sound sanitary ordinances should require a sanitary permit; prohibit or curtail on-site soil absorption sewage disposal systems on soils having severe and very severe limitations for the absorption of sewage effluent; specify minimum distances that septic tanks and soil absorption areas must be located from stream and lake banks, ground water tables, and bedrock; and require the correction of malfunctioning sewage disposal systems. Wisconsin counties, cities, villages, and towns may adopt sanitary ordinances such as set forth in Appendix K to SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, 1968. Alternatively, sanitary provisions may be incorporated into county and local health codes and local plumbing codes.

Finally, the sanitary ordinance to be effective must be stringently enforced. This requires the employment of knowledgeable staff to assure that all requirements of the ordinance are met. Without competent staff to administer the sanitary ordinance through consultation and inspection, the ordinance will fail in its basic intent—prevention of improperly located and constructed private sewage disposal systems.

Map 23

SOIL INTERPRETATIONS FOR UNSEWERED RESIDENTIAL DEVELOPMENT
SOILS DEMONSTRATION SITE



Soil characteristics provide the key elements in the operation of on-site soil absorption sewage disposal systems. The above interpretive soil map reveals that over 50 percent of the 160-acre soils demonstration site is covered by soils having very severe and severe limitations for the absorption of sewage effluent. The particular limitations on this site include steep slopes and soils with a high water table. These soil limitations must be taken into account if development is to take place without public sanitary sewer service.

Map 24

UNSEWERED RESIDENTIAL DEVELOPMENT PLAN SOILS DEMONSTRATION SITE

The above suggested residential subdivision plat layout illustrates the use of soils data in the design process when the development must occur without the benefit of public sanitary sewer service. Each residential structure and soil absorption sewage disposal area in the design layout has been placed in areas covered by soil types not having very severe or severe limitations, for septic tank systems although such soil types have been used in some instances as additional lot area. Because of the extent of unsuitable soils in this site, a large portion must remain undeveloped until such time as public sanitary sewer service becomes available.

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Chapter IX

THE USE OF SOILS DATA IN SOIL AND WATER CONSERVATION PLANNING IN THE SOUTHEASTERN WISCONSIN REGION

INTRODUCTION

As noted earlier in this Guide, the detailed soil surveys were originally undertaken in the United States by the U. S. Department of Agriculture, Soil Conservation Service, for the purpose of providing the basis for agricultural interpretations to be used in farm planning and other rural soil and water conservation efforts. While the use of the soil survey has been expanded to include applications for urban development purposes, a need exists to continue to apply and to expand the application of soils data in rural development activities. Proper agricultural practices will reduce soil erosion and sedimentation, conserve the soil and water resource base, and contribute toward making the rural environment not only economically productive but attractive and healthful as well.

This chapter will consider the various agricultural conservation practices that are related to the soil resource; discuss briefly the financial and technical assistance programs concerned with soil conservation; and review the various means of promoting, encouraging, and requiring agricultural soil conservation practices.

AGRICULTURAL CONSERVATION PRACTICES

Certain agricultural operations contribute to soil erosion and sedimentation. Poor farm management practices, such as overgrazing of pasture and woodlands and tillage of steep slopes, erodible lands, or soils with limited capabilities, may contribute, unless accompanied by application of proper soil and water conservation measures, to stream bank destruction, silting of drainage ditches, erosion, and stream sedimentation. The result is not only a waste of soil resources but also a reduction in surface water quality and the destruction of the beauty of a well-husbanded landscape. Conservation practices that are used to control erosion, improve the soil, prevent sedimentation and water pollution, and maintain soil productivity can be divided into practices for cropland, pasture and hay land, woodland, recreation, and wildlife and special practices for water impoundment and sediment control.

All of the conservation practices applicable to rural development activities are directly related to the detailed soil survey and accompanying interpretive data. Each enumerated practice needs the soil survey map and interpretive analyses in order to be properly applied to a particular geographical area. The farm conservation planning program that has been carried on over the years by the U. S. Soil Conservation Service has always recognized the need for definitive information about soils and, indeed, has provided much of the impetus for the soil survey program itself. Of particular relevance to farm conservation planning are several of the soil interpretations and guides discussed in Chapter III of this Guide, including certain chemical and physical properties of soils, such as texture, reaction, permeability rates, water table, and erosion hazard; water management characteristics, such as available water capacity, drainage requirements, and irrigation capability; capability groups of soils; estimated crop yields; sprinkler irrigation guide; drainage guide; and the various tree, shrub, and other planting guides.

Cropland Practices

Cropland soil and water conservation practices include vegetative practices, such as a conservation cropping system, contour farming, cover and green manure crops, crop residue use, wheel track planting, stripcropping, and stubble mulching; and mechanical practices, such as gradient terraces, parallel terraces, diversions, grassed waterways, artificial drainage, and irrigation.

Conservation Cropping System: The purpose of conservation cropping is to maintain or improve the physical condition of the soil and to protect the soil during periods when erosion usually occurs. The practice includes the use of crop rotation sequences that contain grasses and legumes or sequences in which the desired benefits can be achieved without the use of grasses or legumes. Cropping systems usually consist of a definite number and sequence of years each in row crops, small grain, and meadow. For example, a cropping system could consist of two years of row crops, one year of small grain, and two years of meadow.

Contour Farming: Contour farming consists of conducting farming operations for sloping cropland in level rows along the natural contours of the lands. The operations include plowing, land preparation, planting, and cultivation. This practice is designed to reduce soil and water losses and to aid in the maintenance of other practices.

Cover and Green Manure Crops: Cover and green manure crops consist of the growth of close-growing grasses, legumes, or small grains that act as summer or winter protection and aid in soil improvements. The practice is used mainly to reduce soil loss by wind or water erosion, reduce runoff and overflow damage, and help maintain soil organic matter and soil structure. The plants generally are on the soil for a year or less and usually remain over the winter.

Crop Residue Use: Crop residue use consists of leaving plant residues in cultivated fields by incorporating them into the soil or leaving them on the surface during critical periods of the year when erosion usually occurs. The practice is designed to reduce soil blowing (wind erosion), water erosion, conserve moisture and plant nutrients, maintain soil organic matter, and maintain or improve the physical condition of the soil. On cropland where sufficient crop residue is produced to satisfy the purpose of the practice, it is implemented by leaving all unharvested parts of grain crops on the soil surface until time to seed the next crop. The residues cannot be burned, and grazing is limited to utilization of grain lost in harvesting operations.

Wheel Track Planting: Wheel track planting consists of planting a crop at the time the land is plowed or soon thereafter without additional tillage operations to prepare a seedbed. The seed is placed in the firm soil or wheel track that has been compressed by the tractor wheel. The soil between the tracks remains loose to conserve moisture and retard early weed growth. The practice reduces soil and water losses by permitting more rapid water intake and reducing deterioration of soil structure by tillage.

Contour and Field Stripcropping: Stripcropping consists of systematically alternating strips of grass or close growing crops with strips of clean tilled crops. In contour stripcropping, the strips are planted along the contours (see Figure 64), while in field stripcropping the strips are planted generally across the slope but not necessarily along the contours. The purpose of both contour and field stripcropping is to control water erosion by using close growing crops as a vegetative barrier and to stabilize the soil for efficient use of seed, commercial fertilizers, lime, and manure. The width of strips ranges from 100 feet on gently sloping (2 to 6 percent) soils to 60 feet on moderately steep (12 to 20 percent) soils. The crops on the strips are often rotated to help maintain the physical condition of the soil.

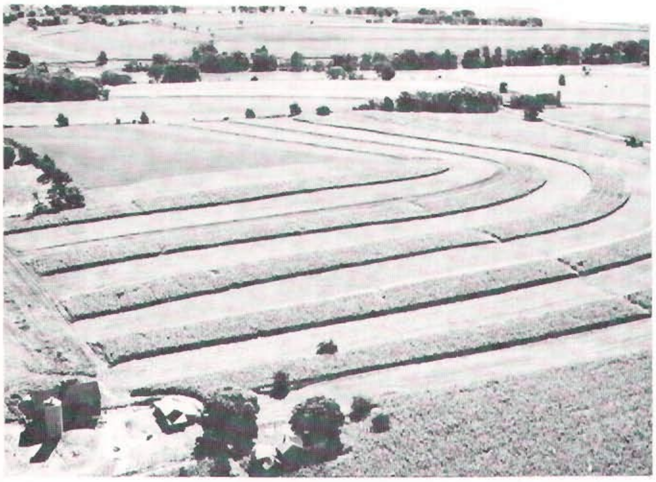


Figure 64
CONTOUR STRIPCROPPING

Contour stripcropping involves the planting along the contours of the ground of strips of crops so arranged that a strip of grass or close growing crop is alternated with a strip of clean tilled crop. This soil and water conservation cropland practice utilizes crops as a vegetative barrier to water erosion and, in addition, helps to stabilize the soil. The crops on the strips are also often rotated to help maintain the condition of the soil.

Contouring has been most widely accepted in areas of deficient rainfall where holding additional water on the fields increases crop yields. The crooked rows and the many point rows required for contouring have, with the advent of larger and less maneuverable farming equipment and with the use of narrower rows, made contouring more difficult for, and less acceptable to, the farmer.

Wind stripcropping consists of alternate strips of wind resistant crops with row crops arranged in a direction perpendicular to the direction of the prevailing winds. The object of this kind of strip is to reduce soil blowing and damage to crops by reducing wind velocities at the soil surface.

Stubble Mulching: Stubble mulching consists of maintaining plant residues on the surface of the soil on a year-round basis. The residue is left on the surface by careful manipulation during planting, tilling, and harvesting operations. The practice aids in reducing wind and water erosion, helps to improve the physical condition of the soil, and contributes to maximum water intake rates of soils. Application is by use of special tillage tools designed to leave residues on the soil surface.

Gradient Terraces: Gradient terraces consist of constructing an earth embankment or series of suitably spaced ridges and channels across the slope (see Figure 65). The ridges and channels help reduce erosion by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity. The practice is limited to use on cropland. The benefits from gradient terraces on deep sand or loamy sand soils, stony soils, shallow soils, or on very steep slopes are not sufficient to compensate for the difficulties of installation and maintenance. Terrace channels are difficult to maintain in deep sand or loamy sand soils. Construction is difficult in stony soils and shallow soils. The ridges must be very close together on steep soils, and it would make the carrying out of farming operations difficult.

Figure 65

GRADIENT TERRACES

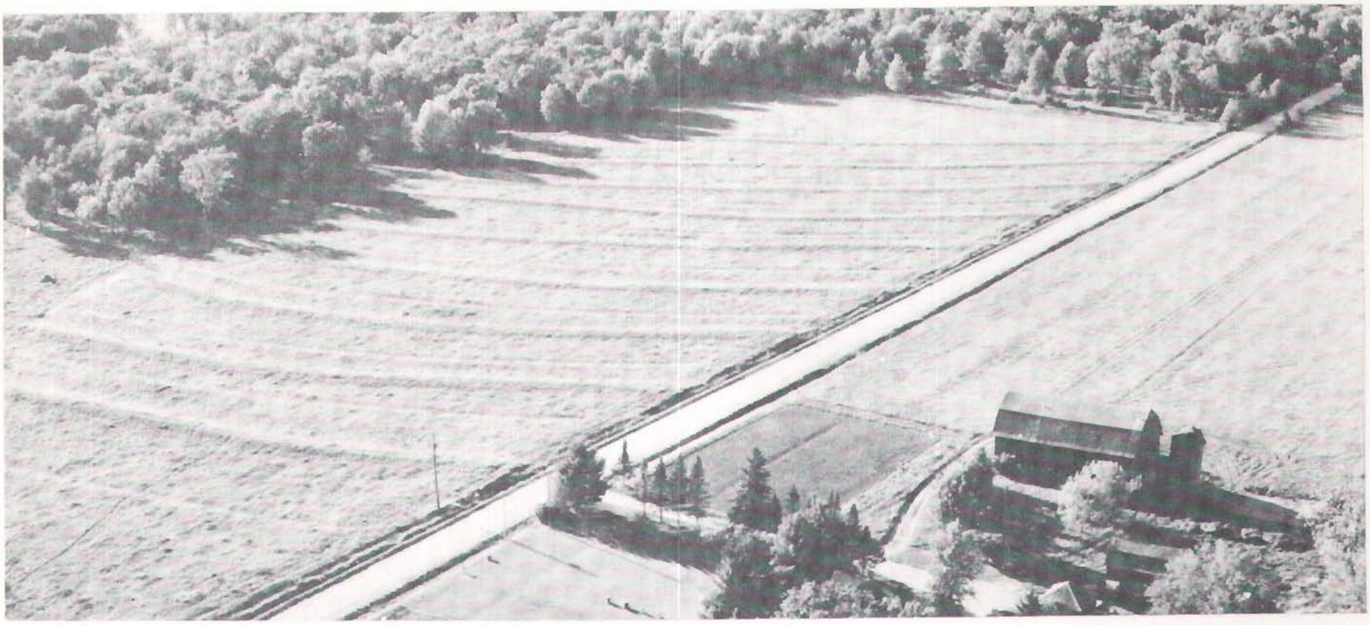
Gradient terraces are earth embankments constructed along the contours and across the slope of the ground. Construction of such terraces, as shown in this photograph, helps reduce soil erosion by intercepting surface water runoff and conducting it to a more stable outlet at a slow, non-erosive velocity.

Parallel Terraces: Parallel terraces are built for the same purpose as gradient terraces. The terraces help reduce erosion by intercepting runoff and channeling it to a stable outlet at a non-erosive velocity. Parallel terraces have a uniform horizontal spacing throughout their length (see Figure 66), whereas gradient terrace spacing is dependent on the vertical spacing interval selected. This causes variations in the horizontal spacing with differences in soil slope. There are no point rows between parallel terraces; and, therefore, farming soils with parallel terraces is less difficult than farming soils with gradient terraces.

Diversions: Diversions consist of grading or digging a channel with a supporting ridge on the lower side (see Figure 67). The channel and ridge are constructed across the slope. Diversions are used to divert excessive runoff water to sites where it can be used or disposed of safely. They are generally installed where runoff from higher-lying areas is damaging cropland, pasture land, farmsteads, or conservation measures, such as terraces or stripcropping.

Grassed Waterways: Grassed waterways are designed to provide for the disposal of excess surface water without damage by erosion or flooding (see Figure 68). Grassed waterways are defined as natural or constructed waterways or outlets, shaped or graded, and established in suitable vegetation as needed for the

Figure 66
PARALLEL TERRACES



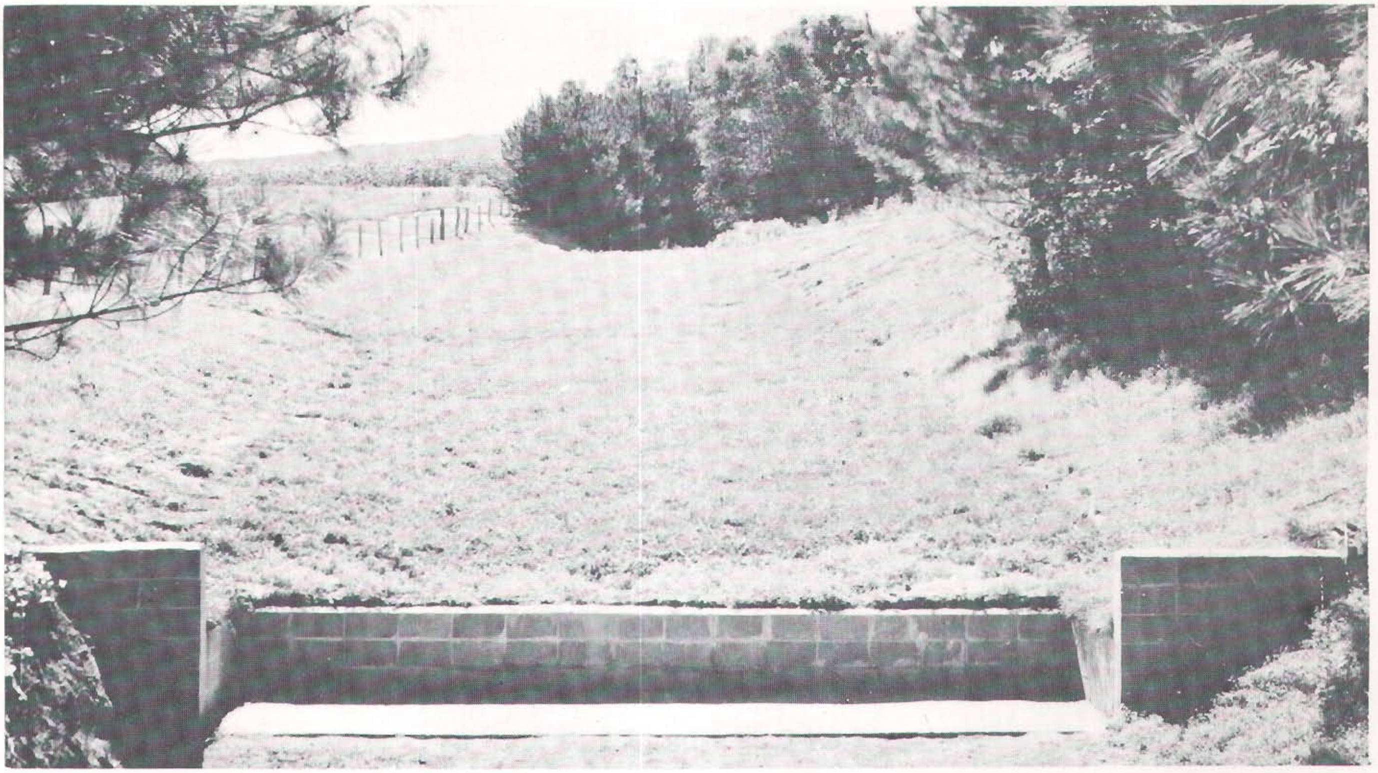
Parallel terraces are earth embankments constructed across the slope but not along the contours of the ground. Such parallel terraces have a uniform horizontal spacing throughout their entire length, making farming less difficult than with gradient terraces. The construction of parallel terraces, as illustrated in this photograph, helps reduce soil erosion by intercepting surface water runoff and channeling it to a stable outlet at a non-erosive velocity.

Figure 67
DIVERSIONS

A diversion consists of grading or digging a channel with a supporting ridge on the lower side. Such a diversion can be seen in this photograph along the near side of the stand of corn. Diversions are used to divert excess runoff water to points where it can be disposed of safely and without contributing to soil erosion.

Figure 68

GRASSED WATERWAYS



A grassed waterway is a shaped and graded channel with suitable vegetation constructed as needed for the safe disposal of runoff from a field or a terrace system. The sod waterway pictured in this photograph was constructed to control an erosive gully and includes a grade stabilization structure in the foreground.

safe disposal or runoff from a field, diversion, terrace system, or other structure. The practice is beneficial to areas where added capacity or vegetative protection or both are needed to control erosion resulting from concentrated runoff and where erosion control can be accomplished by waterways alone or in combination with other practices. The waterways should be large enough to confine the peak runoff expected from a storm having a 10-year recurrence interval.

Artificial Drainage: The principal purpose of installing an artificial drainage system in poorly drained soils is to prevent or remove excess water by lowering of the ground water table. The natural drainage in such soils is too slow to prevent saturation of the plant root zone. Artificial drainage permits soil aeration, deep root development, and growth of crops that cannot tolerate saturated soil conditions. Specific practices used in the artificial drainage of wet soils are drainage mains and laterals, drainage field ditches, tile drains, and land smoothing.

Drainage Mains and Laterals: Drainage mains and laterals are open drainage ditches designed to dispose of excess surface or subsurface water, intercept ground water, or lower ground water levels. The practice includes open ditches for disposal of surface and subsurface drainage waters mainly collected by surface field ditches and tile lines.

Drainage Field Ditches: Drainage field ditches are defined as shallow, graded ditches, usually having flat side slopes designed to collect water within a field. They are installed mainly to drain surface basins or depressional areas and collect or intercept excess runoff, such as sheet flow from natural and graded land surfaces or channeled flow from natural depressions and furrows, for removal to an outlet. The ditches are used only on arable soils.

Tile Drains: Tile drains consist of tile pipe or other covered drains installed below the ground surface (see Figures 69 and 70). They are designed to lower the water table, intercept water moving into an area, relieve artesian pressures, remove surface runoff, and serve as an outlet for other tile drains. The practice can be installed in soils suitable for cropland. The spacing in slowly and very slowly permeable soils may be too close for feasible installation. Fine sands and silts may clog tile lines.

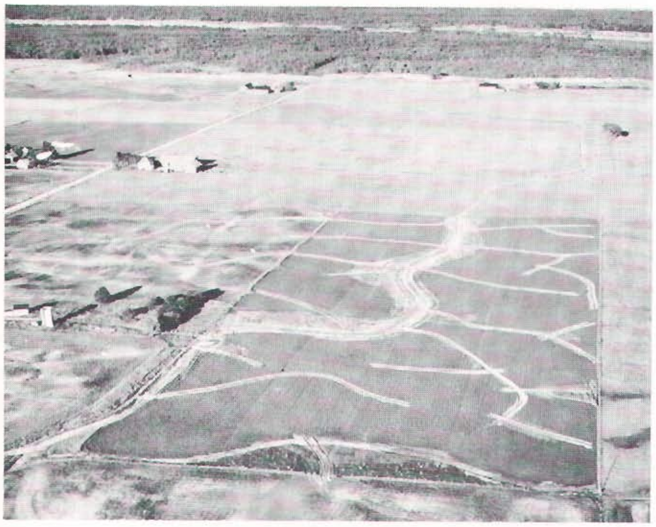


Figure 69

TILE DRAINS

Artificial drainage systems are often installed to remove excess water by lowering the ground water table. This photograph shows a random tile drain system under installation. Tile drains consist of pipe installed below the ground surface in such a way as to permit the ground water to enter the pipeline. The entrance of the water may be achieved by using short lengths of clay or concrete tile laid with open joints or by using longer lengths of tile perforated around its lower portion. Many farms in the Southeastern Wisconsin Region have had such drainage systems installed.

Figure 70

DRAIN TILE INSTALLATION

Machines, such as shown in this photograph, are used to install agricultural drain tile. The machine lays the tile, as well as digs the trench. Drain tile systems are used to carry off excess water and lower ground water tables so that agricultural productivity can be increased.

Land Smoothing: The purpose of land smoothing is to improve surface drainage, to provide for more effective management of water, to help obtain more uniform planting depths, to provide for more uniform cultivation and crop maturity, to improve the efficiency of equipment operation, and to facilitate contour cultivation. The practice consists of removing minor irregularities of the soil surface without altering the general topographic pattern. Special equipment, such as a land plane or leveler, is needed. Use of the practice on shallow or steep soils is questionable. The practice does not include "floating" that is done as regular maintenance on irrigated land or "planing" that is done as the final step in a land leveling or land grading job.

Sprinkler Irrigation: This practice provides for application of irrigation water by means of perforated pipes or nozzles operated under pressure. The systems are installed to apply irrigation water efficiently and uniformly without excessive erosion. The systems are used to maintain soil moisture within the optimum range for plant growth. The systems can also be used to provide frost protection to certain fruit and truck crops and to control wind erosion on soils subject to blowing. The practice can be used on soils that are suitable for irrigation provided that good quality water is available.

Pasture and Hay Land Practices

Pasture and Hay Land Management: Pasture and hay land management is designed to ensure the proper treatment and use of pasture land or hay land. Its purpose is to provide soil protection and reduce water loss, to maintain or improve the quality and quantity of forage, and to prolong the life of desirable forage species. The objective can be accomplished by delaying grazing in the spring until soil is firm and vegetative growth is at least four inches high and by controlling grazing to maintain growth that will sustain vigorous plants.

Pasture and Hay Land Planting: Pasture and hay land planting consists of establishing or reestablishing long-term stands of suitable species of perennial, biennial, or reseeding forage plants for pasture or hay land. Production of high-quality forage and reduction of soil erosion are a part of the benefits. Successful establishment of the plantings can be assured by selecting soils suitable for the purpose, using proper kinds and amounts of fertilizer, and using species suitable for the soils in the proposed site. Vernal alfalfa, orchard grass or brome grass, ladino clover, and birdsfoot trefoil are suitable for moderately well-drained soils. Alfalfa and brome grass are suggested for well-drained soils. Somewhat poorly drained soils are suitable for mixtures of red clover or ladino clover and timothy, brome grass, or birdsfoot trefoil. Reed canary grass, ladino clover, or timothy can be planted on poorly drained soils.

Woodland Practices

Field Windbreak: Windbreaks are used on cropland that is subject to wind erosion. The practice is generally applied on medium- and coarse-textured soils and on peat and muck soils. It consists of planting strips of trees or shrubs in rows perpendicular to the direction of the prevailing winds to reduce wind velocity on the soil surface (see Figure 71). The strips are spaced at a horizontal distance equal to 15 to 20 times the expected height of the plants in the windbreak. They generally contain three rows of plants. Single rows may be used if plants are spaced close together. Trees commonly used for this purpose are white pine, red pine, jack pine, and red cedar. White spruce can be used in loam and silt loam soils. Norway spruce can be used in all soils except loamy sand or sand. Poplar and willow can be used in peat and muck soils.

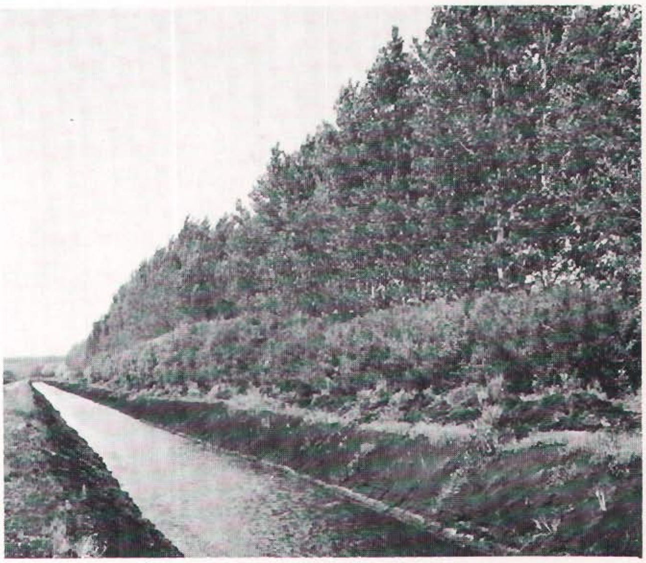


Figure 71
FIELD WINDBREAKS

A windbreak consists of strips of trees or shrubs planted in rows perpendicular to the direction of the prevailing winds. The construction of such a windbreak as shown in this photograph acts to reduce the wind velocity on the soil surface, and thereby to reduce wind erosion. Windbreak strips are spaced at a horizontal distance equal to 15 to 20 times the expected height of the plants in the windbreak.

Tree Planting: The planting of trees in open fields or open areas suitable for production of wood crops is a means of establishing stands of forest trees. The trees are planted for conservation of soil and moisture, for watershed protection, and for production of wood crops (see Figure 72). The trees can be planted as seedlings or cuttings. Species of plantings suitable for the soils in the proposed site should be used.

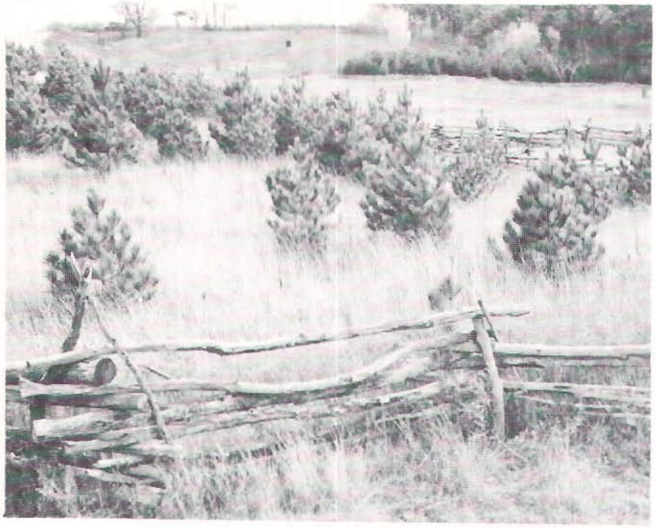


Figure 72
TREE PLANTING

The planting of trees can assist in the prevention of erosion problems, such as gullying and sheet erosion on steep morainic topography. Tree planting programs, such as that pictured in this photograph, can contribute substantially to the protection of an entire watershed.

Recreation-Related Practices

Recreation Area Planting: Recreation area planting consists of establishing grasses, legumes, vines, shrubs, trees, or other plants in recreational developments. Plantings are established to prevent soil erosion; to provide durable plant cover for heavy-use areas; to provide vegetative screens, shade, and barriers; and to enhance the beauty of the landscape and improve wildlife habitat. Mixtures of Kentucky bluegrass and fescue are suggested for sports areas, picnic areas, camping areas, walkways, and trails. Grasses suitable for use on various parts of golf courses are also suggested. Kentucky bluegrass can be used as a part of mixture suggested for tees, fairways, and roughs. Fescue, brome grass, and alsike clover can also be used for roughs. Trees and shrubs should be selected according to soils on the proposed sites.

Recreation Land Grading and Shaping: The topography of some sites that are proposed for recreational development must be altered to meet the requirements of the proposed recreational facilities. This practice provides for shaping or reshaping an area to improve the recreation site on soils that are suitable for recreational development. The practice is designed to save the natural setting by avoiding damage to trees and other vegetation and provide for erosion control and surface drainage where needed.

Recreation Trail and Walkway: Recreation trails and walkways provide pathways prepared especially for pedestrian, equestrian, and bicycle travel. The practice is applicable where it is necessary or desirable to concentrate the movement of people from one point to another in order to facilitate recreational use of the area. The objective is to provide access to points of interest and prevent erosion. The practice consists of laying out trails to provide for a maximum variety of scenery. Such trails should follow the natural contours of the land where possible. Soil limitations for this use are an essential consideration in both the location and design of the pathways.

Wildlife Practices

Fishpond Management: Fishpond management is designed to improve fish habitat by fertilizing, liming, or other means. The soils in the drainage area of a fishpond affect the pH or acidity-alkalinity of the pond water. In addition, many ponds in bog areas contain tannin colored water that is not well suited for fish production. Liming can be used to correct both conditions.

Wildlife Wetland Development: Wildlife wetland development is intended to create or improve the habitat for waterfowl, furbearers, or other wildlife associated with wetlands. Development can be accomplished by diking or ditching and planting. It is used in areas covered by soils that will support wildlife food and cover and where the quantity and quality of water is suitable for development. Water impoundments with water controls in the form of dikes and water level control structures, impoundments without water level controls, pits or dugout ponds, level ditches, and blasted pits can be used under this practice. Soil limitations must be considered for each practice before installation.

Wildlife Habitat Development: Wildlife habitat development is designed to improve the habitat for wildlife other than wetland wildlife and fish. Such habitat improvement can be accomplished by establishing perennial, biennial, or annual plants on suitable soils. In southeastern Wisconsin the plantings are generally made to attract animals and birds, such as ringneck pheasants, Hungarian partridges, songbirds, cottontail rabbits, squirrels, and whitetail deer. Selection of the kind of plants to be used is dependent on the soil characteristics as shown on the soil survey maps, the kind of wildlife desired, and the requirements of the wildlife.

Water Control Structures for Wildlife Habitat: The provision of water control structures for wildlife habitat includes installation of water control structures to control the stage, discharge, distribution, delivery, and direction of flow in open channels. For wildlife habitat management, the practice is used to control water levels in wetland areas. The practice is also used to control water in cranberry bogs or in wild rice production. Water level control structures, pipe drop inlets, and box inlets are commonly used in this practice.

Water Impoundment and Sediment Control Practices

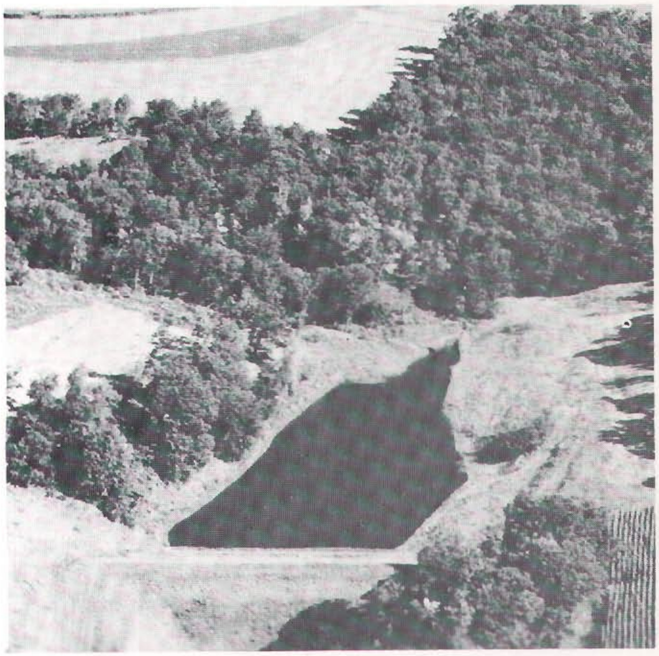
Multiple-Purpose Dams: A multiple-purpose dam is designed to provide distinct and specific water storage for two or more purposes. These uses may include floodwater retardation; irrigation; recreational use, such as fishing, hunting, boating, and swimming; improved environment or habitat for fish and wildlife; municipal uses; industrial uses; or other uses. The dam is constructed across a natural watercourse, providing the desired reservoir storage. Although many of the dams are constructed for floodwater retardation and another purpose, such as recreation or municipal use, they can be and often are designed for any two or more of the uses listed, provided a specific storage allocation is made for each purpose.

Farm Pond: Farm ponds are used where additional water supply on the farm is needed and are defined as water impoundments made by constructing a dam or embankment or by excavating a pit. These ponds are constructed to provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and related uses (see Figure 73).

The pond can only be located in predominantly rural or agricultural areas. Location and size are limited by stipulations that failure of the structure would not endanger people or property or interrupt use of service of the utilities. Size is limited by a formula which states that the storage in acre-feet multiplied by

Figure 73
FARM POND

Farm ponds may be constructed for a variety of purposes. These include the provision of water for livestock, for fish and wildlife, for fire control, and for crop and orchard spraying. In addition, farm ponds provide aesthetics and recreational benefits.



effective height will not exceed 3,000 and the vertical distance between the lowest point along the centerline and the crest of the emergency spillway will not exceed 20 feet. Embankments are constructed with soil material that is impervious after compaction. Reservoir areas should be impervious enough to prevent excessive seepage losses. Where the pond has been constructed in soils with slow-to-moderately rapid permeability, excessive seepage can be corrected by sealing the reservoir with linings of plastic membranes, bentonite, or chemical soil dispersants.

Grade Stabilization Structures: Where water concentration and flow velocity are high, the use of a grade stabilization structure may be necessary to stabilize the soil grade and control head cuttings in natural or artificial channels. The structure can be constructed of concrete, rock, masonry, steel, glass-fused steel plate, or treated wood (see Figure 74). The structures are designed to permit rapid flow of water over a sharp, almost vertical drop constructed of non-erosive materials. The unprotected part of the channel, between the structures, is set at a very low gradient. The structure should be built on soils that have good supporting strength, are resistant to sliding or piping, and have uniform consolidation characteristics.

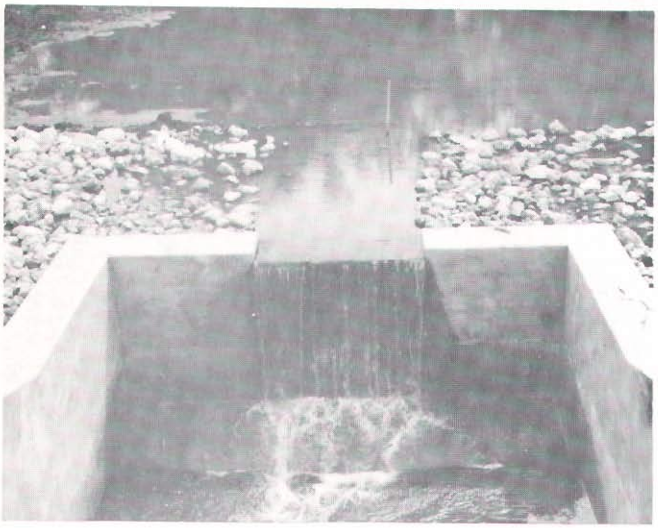


Figure 74
GRADE STABILIZATION STRUCTURE

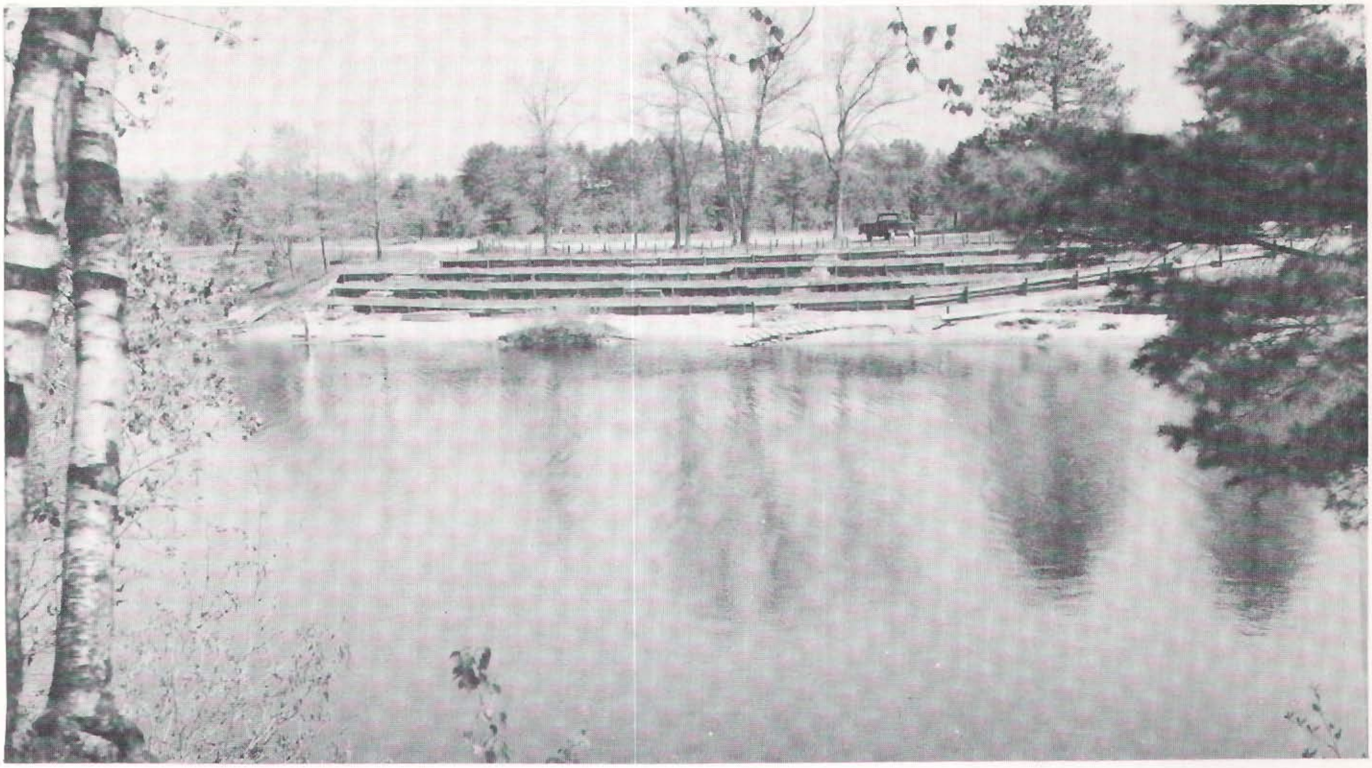
The use of a grade stabilization structure, such as shown in this photograph, may be necessary where water concentration and flow velocity in channels and drainage ditches are high. Such structures can be constructed of concrete, rock, masonry, glass-fused steel plate, or treated wood. Grade stabilization structures permit a rapid flow of water over the vertical drop constructed of non-erosive materials.

Streambank Protection: Streambank protection is defined as the protection of streambanks from erosion by the use of vegetation and structures. It consists of protecting streambanks from grazing; planting streambanks with grass, woody plants, or both; and installing such structures as may be necessary to control streambank erosion (see Figure 75). Streambanks can be protected from grazing by building fences capable of excluding farm livestock from the upper edge of the streambank. Causes of meandering can be corrected by removing fallen trees or deposits of sediments. At critical points on curves where streambank cutting occurs, erosion can be reduced by strategically placed obstructions consisting of jacks, willow pole jetties or rock willow pole jetties, or jetties of piling. The jetties or jacks are placed near streambanks subject to cutting to reduce water flow to a non-erosive velocity.

Critical Planting Areas: Critical planting areas are designed to stabilize sediment-producing or severely eroded areas and are intended to reduce erosion and protect lower-lying areas from sediment resulting from erosion. The practice is accomplished by establishing vegetative cover, such as trees, shrubs, vines, grasses, or legumes, in sediment-producing areas. The practice is used on erodible or severely eroded areas, such as dams, dikes, levees, roadsides, or gullied areas where vegetation is difficult to establish with normal seeding methods. In urban areas combinations of emerald crownvetch, birdsfoot trefoil, Kentucky bluegrass, and creeping red fescue are suggested. For rural areas smooth brome, tall fescue, and timothy are added to the list. The soils are heavily fertilized and heavily seeded to ensure good stands and quick growth. Mulching is beneficial, and sodding is required in areas of water concentration.

Figure 75

STREAMBANK PROTECTION



Through the use of vegetation and structures of various types, streambanks can be protected from erosion. Fencing to exclude farm livestock from the bank is also an important part of any streambank protection effort.

TECHNICAL AND FINANCIAL ASSISTANCE

Technical and financial assistance in the carrying out of sound soil conservation measures in rural areas is available through several federal, state, and local agencies of government. Many of the programs providing such assistance are cooperative ventures involving two or more public agencies, along with the private landowner. In many cases, the assistance is rendered through the local soil and water conservation districts, whose boundaries in Wisconsin are coterminous with county boundaries.

Soil and Water Conservation Districts

County soil and water conservation districts are created pursuant to the provisions of Chapter 92 of the Wisconsin Statutes. Each district is self-governing and has authority to enter into working agreements with other governmental agencies and with private individuals and groups to carry out its responsibilities for the promotion of soil and water conservation within its area. The districts usually enter into basic and supplemental memoranda of understanding with various units of the U. S. Department of Agriculture, such as the Soil Conservation Service, whereby the agencies provide the needed technical assistance to individuals and groups of landowners.

Technical Assistance

The U. S. Soil Conservation Service is the U. S. Department of Agriculture's technical arm of action for the promotion of soil and water conservation. The Service brings together the various disciplines needed to solve land and water conservation problems. Its staff includes soil scientists; economists; agricultural, irrigation, hydraulic, drainage, and cartographic engineers; specialists in biology, agronomy, range management, woodland management, plant materials, geology, and sedimentation; and the skilled professionals developed by the Service—the soil conservationists.

The U. S. Soil Conservation Service provides on-site technical assistance to individuals in preparing a conservation plan for their land. As noted above, this assistance is rendered through the county soil and water conservation districts. Assistance to individual land users includes:

1. Preparing a soil and land-capability map based on the detailed operational soil survey of the farm or other land unit.

2. Helping to prepare a farm or other land conservation plan. The landowner and a U. S. Soil Conservation Service technician consider suitable alternatives for using and treating the land within its needs and capability as shown by the interpretive soil map. The plan outlines needed action to conserve and develop soil, water, plant, and wildlife resources and includes a timetable for accomplishing these actions.

3. Helping to apply the more difficult practices called for in the conservation plan, such as layouts for contouring, stripcropping, and income-producing recreation areas, and helping to design and supervise construction of drainage and water disposal systems, irrigation systems, farm ponds, terrace systems, diversions, and waterways.

4. Giving guidance for maintaining the measures and practices after they have been applied.

A farm conservation plan has been prepared for the soils demonstration site referenced in Chapter VII of this Guide. Map 25 shows the limitations of the soils on this site for agricultural uses. Only a few acres of this tract of land have severe limitations for cropland use. The Hochheim (357 and 360) loams have severe limitations because they have slopes in excess of 12 percent. Some of the other soil types represented, such as the Tichigan (42), Ehler (212), Clyman (278), and Lamartine (364) silt loams can have their slight limitations overcome by the installation of farm drainage systems.

Map 26 shows a farm conservation plan for the demonstration site. This plan has been designed so as to illustrate that almost all soil limitations—from slight to severe—can be overcome for crop production by proper soil and water conservation practices and proper management. As shown on the plan, grassed waterways, drain tile, and a pond have been used to overcome the limitations imposed by high water table soils; diversion terraces leading out to waterways or drains have been used where concentrated runoff may occur on steep slopes; rotation crops of corn, hay, and grain have been used for soil rebuilding and to achieve a balanced annual farm production; and contour plowing and stripcropping have been used for prevention of erosion.

Financial Assistance

Several programs have been established by state and federal agencies to provide financial assistance for sound soil and water conservation projects on agricultural lands. These programs include the following:

1. The state Soil and Water Conservation Program administered by the State Soil Conservation Board provides grants in amounts up to 50 percent, but not to exceed $1,000, toward the cost of approved district soil and water conservation projects.

2. The federal Agricultural Conservation Program (ACP) administered by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, provides grants to rural landowners in amounts up to 50 percent of the total project cost of carrying out approved soil, water, woodland, and wildlife conservation practices. The major categories of conservation practices included in the ACP program are as follows:

   a. Vegetative Cover

   Seedbed preparation, seeding, liming, fertilizing, and other measures needed in the establishment or improvement of grass and legume cover for soil protection.

b. Forestry

The planting of trees and shrubs for erosion control and the improvement of established stands of trees by such measures as thinning, pruning, and the control of competing and undesirable vegetation.

c. Establishment of Conservation Systems of Farming

The construction of terraces and the performance of farming operations on the contour or in strips for the prevention of wind or water erosion.

d. Water Impoundment

The construction of dams, pits, or ponds for erosion control, livestock watering, irrigation, or other agricultural purposes.

e. Disposal of Excess Water

The construction of sod waterways and the installation of farmland drainage systems.

f. Conservation and More Effective Use of Water

The lining of irrigation ditches, leveling of land, and the installation of structures to conserve water, prevent erosion, and permit more efficient use of irrigation water.

g. Wildlife Conservation

The establishment of vegetative cover which will provide food, cover, and habitat for wildlife, as well as soil protection, and for the impoundment of water for fish and other wildlife.

h. Beautification—Conservation

The performance of measures which will enhance the appearance of areas visible to the public and at the same time provide substantial soil and water conservation benefits.

3. The federal Resource Conservation and Development Program (RC&D) administered by the U. S. Department of Agriculture, Soil Conservation Service, which provides cost-sharing up to 100 percent for flood control works and up to 50 percent for construction of water conservation works and improved land use measures.

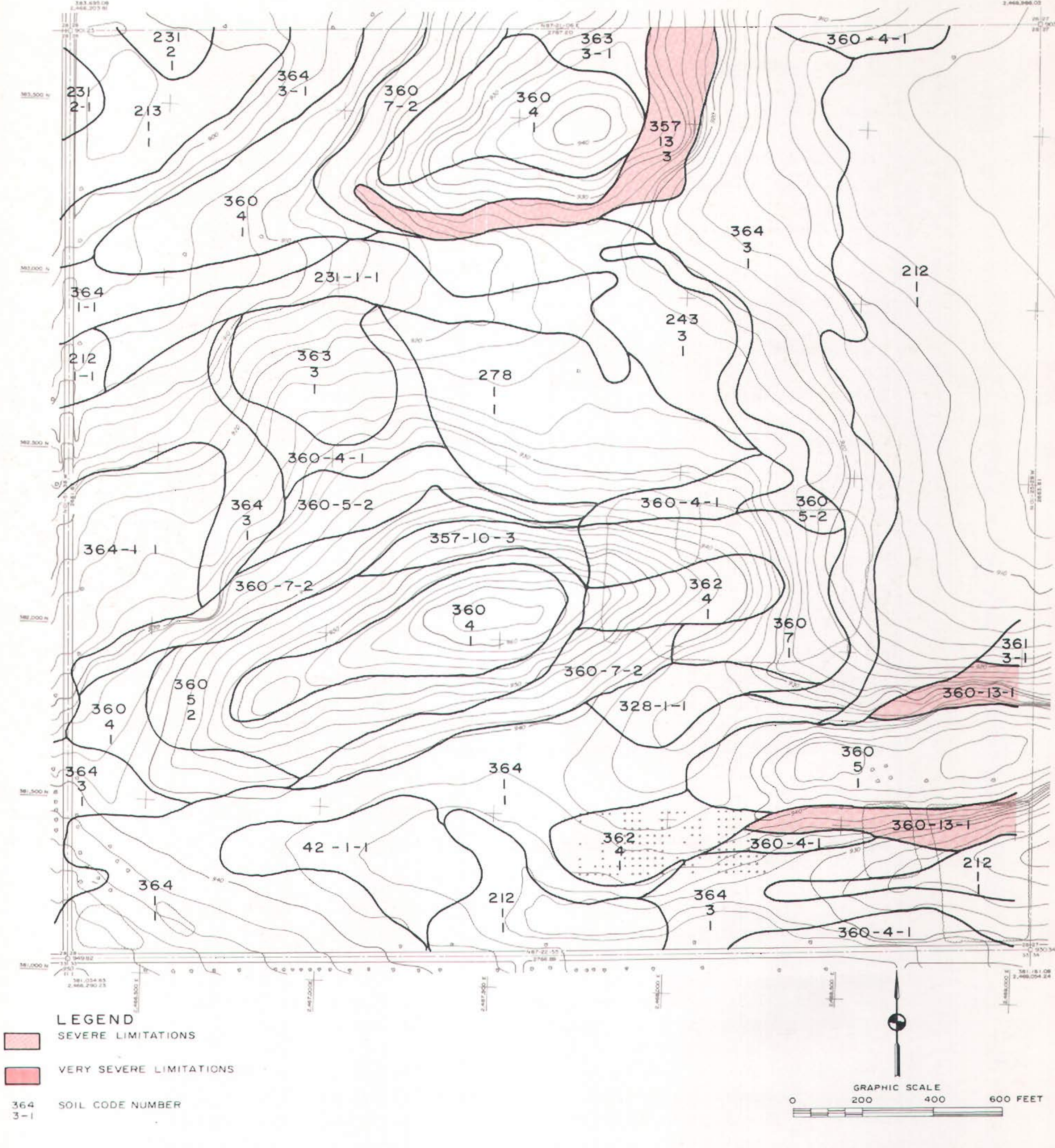
4. The federal Cropland Adjustment Program (CAP) administered by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, which provides grants in amounts up to 50 percent of the cost, based upon the value of the crops which would be produced, to farmers to divert cropland to protective conservation uses for five-to-ten year periods. This program also provides cost-sharing up to 50 percent toward the cost of carrying out sound conservation practices, such as establishment of vegetative cover, forest cover, and good wildlife habitat.

5. The federal Multiple-Purpose Watershed Program administered by the U. S. Department of Agriculture, Soil Conservation Service, through the State Soil Conservation Board, provides cost-sharing up to 100 percent to qualified sponsors, such as soil and water conservation, flood control, drainage, or irrigation districts, for flood prevention works and up to 50 percent towards water management, public recreation, fish and wildlife development, acquisition of certain recreational land rights, and agricultural land planning and treatment.

6. Various loan and grant programs administered by the U. S. Department of Agriculture, Farmers Home Administration, which may include soil and water conservation measures.

Map 25

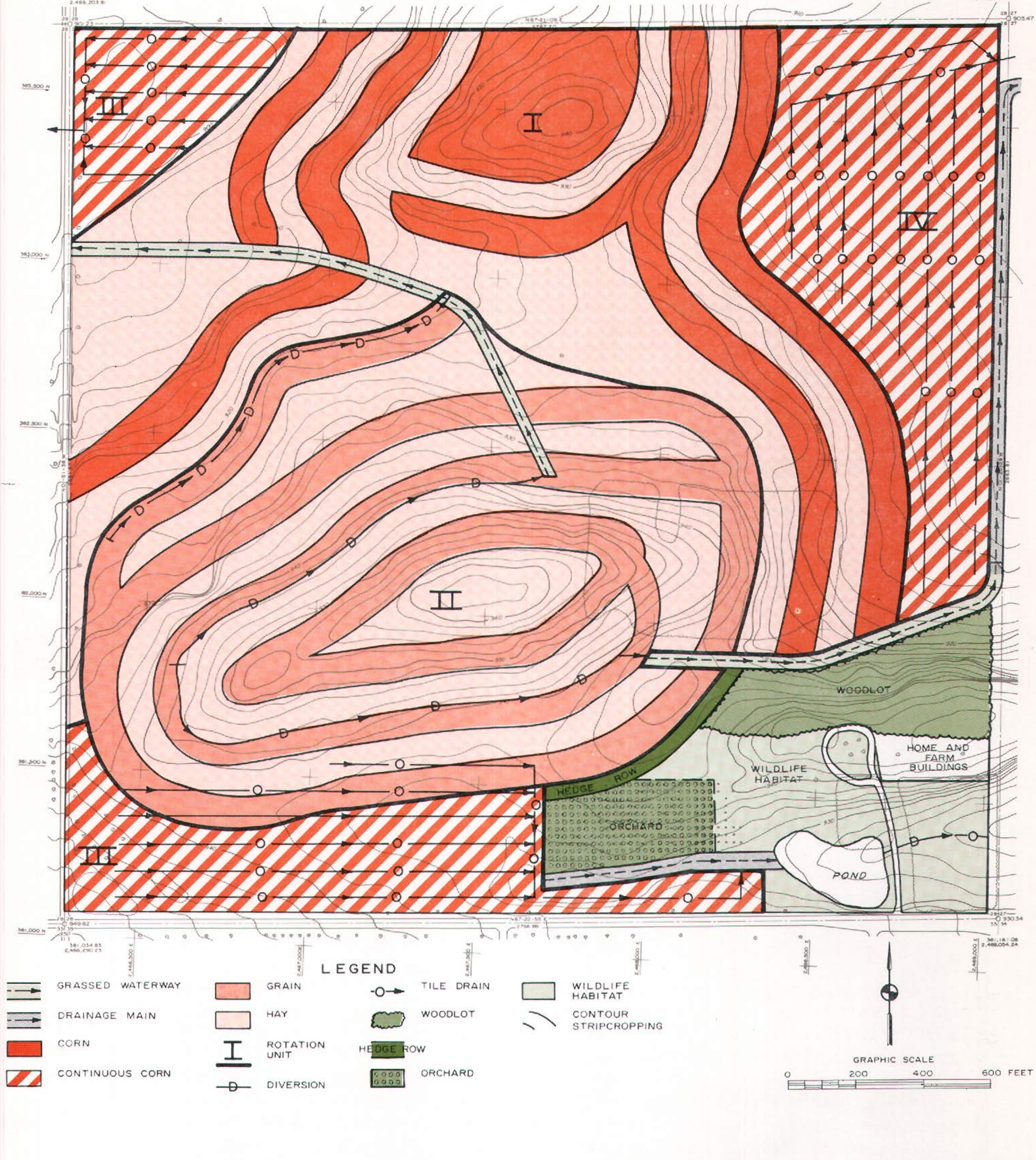
SOIL INTERPRETATIONS FOR AGRICULTURAL DEVELOPMENT
SOILS DEMONSTRATION SITE



Most of the soil types in the soils demonstration site are rated as having only slight limitations for agricultural use and development. A few acres have severe limitations because of slopes in excess of 12 percent. The installation of farm drainage systems can remove most of the limitations indicated.

Map 26

FARM CONSERVATION PLAN
SOILS DEMONSTRATION SITE



The above farm conservation plan for the soils demonstration site illustrates the use of sound soil and water conservation practices to overcome certain limitations and achieve proper farm management. Practices included in this plan are grassed waterways and drain tile, diversion terraces, crop rotation for soil rebuilding, and stripcropping along with contour plowing.

PROMOTING, ENCOURAGING, AND REQUIRING SOIL CONSERVATION PRACTICES

Three basic means are available to local units of government for the promotion of sound soil and water conservation practices: the conduct of educational programs; the enactment of special rural land use regulations; and the enactment of special soil regulations designed to be included in zoning ordinances.

Educational Programs

The University of Wisconsin Extension Service, the county soil and water conservation districts, and the U. S. Soil Conservation Service have for many years cooperated in the conduct of a soil conservation educational program. The University of Wisconsin Extension Service, pursuant to the Smith-Lever Act of 1914, carries out a variety of problem-oriented educational programs as the educational arm of the U. S. Department of Agriculture in cooperation with the University of Wisconsin, the county boards, and the soil and water conservation districts. The districts, under basic and supplemental memoranda of understanding with the U. S. Soil Conservation Service, have the responsibility to arouse local interest in the necessity for attaining soil conservation objectives and to administer conservation plans for farms, watersheds, natural areas, and other land units. The U. S. Soil Conservation Service provides technical and professional assistance available through the engineers, soil scientists, and soil conservationists as originally authorized by the U. S. Soil Conservation Act of 1935. The interagency soils agreement in the Southeastern Wisconsin Region, as set forth in Appendix A, is an example of such an educational effort. These efforts must continue and be strengthened if soil conservation objectives are to be achieved in southeastern Wisconsin.

Special Land Use Ordinances

Soil and water conservation districts have been authorized by the Wisconsin Legislature, pursuant to Chapter 92 of the Wisconsin Statutes, to formulate special land use regulations for unincorporated lands in the county for the purpose of conserving soil resources and controlling erosion. Such regulations may include: provisions requiring the carrying out of necessary engineering operations, including the construction of terraces, terrace outlets, soil saving dams, dikes, ponds, and diversion channels; provisions requiring observance of particular methods of cultivation; specifications of cropping program and tillage practices to be observed; and provisions requiring the retirement from cultivation of highly erosive areas. These regulations may apply to all or part of a district. Public hearings and a referendum of affected land occupiers are required. Two-thirds of such occupiers must approve the proposed regulations. If two-thirds approval is obtained, the county board of supervisors may enact the special regulations into law.

Special Zoning Regulations

Special zoning districts may be created and special regulations related to soil capabilities may be added to general zoning ordinances adopted pursuant to zoning enabling legislation. The soil survey and analyses may be used to develop special soil-related districts, such as a farm conservation district, and special regulations which would be in addition to the usual agricultural, conservation, and residential districts and regulations. Steep land, erodible land, and special soil capability regulations can be designed to achieve soil conservation objectives by requiring adherence to sound soil conservation practices. These special districts and regulations are discussed in Chapter VI of this Guide and are set forth in model form in Appendices D and E.

SUMMARY

Detailed soil survey data remain of great importance in rural development activities. Proper agricultural practices will reduce soil erosion and sedimentation, conserve the soil resource base, and contribute toward the making of an economical rural environment.

There are a number of agricultural conservation practices all directly related to soil properties that are of importance in proper rural development. These include cropland practices, such as a conservation cropping system, contour farming, cover and green manure, proper crop residue use, wheel track planting, stripcropping, and stubble mulching. Proper cropland conservation practices also include such mechanical practices as gradient terraces, parallel terraces, diversions, grassed waterways, artificial drainage, and irrigation.

Other agricultural conservation practices include pasture and hay land management and planting; woodland practices, such as field windbreaks and tree planting; recreation-related practices, such as recreation area planting, recreation land grading and shaping, and trail and walkway construction; and wildlife practices, such as fishpond management and wildlife habitat development.

Additional agricultural practices deal with water impoundment and sediment control. These include multi-purpose dams, agricultural ponds, grades, stabilization structures, streambank protection, and the planting of critical areas.

Technical and financial assistance is available for the carrying out of sound soil conservation measures in rural areas. In many cases, such assistance is rendered through the county soil and water conservation districts, which are charged with the responsibility for soil and water conservation. Each such county district has working memoranda of understanding with various federal agencies, such as the U. S. Soil Conservation Service, whereby the agencies provide the needed technical assistance to individuals and groups of landowners.

The U. S. Soil Conservation Service, through its multi-disciplinary staff, gives on-site technical assistance to individuals in preparing a conservation plan for their land. Once the farm conservation plan is prepared, the Service also provides technical assistance in applying the more difficult practices often called for in the plan, such as stripcropping and the construction of drainage facilities.

Financial assistance programs available to individuals concerned with proper soil conservation in rural areas include: the state Soil and Water Conservation Program; the federal Agricultural Conservation Program; the federal Resource Conservation and Development Program; the federal Cropland Adjustment Program; the federal Multiple-Purpose Watershed Program; and various loan and grant programs administered by the U. S. Department of Agriculture, Farmers Home Administration.

The objectives of sound soil and water conservation in rural areas can be achieved through educational programs, such as those carried out cooperatively by the University of Wisconsin Extension Service, the county soil and water conservation districts, and the U. S. Soil Conservation Service; by special land use ordinances as authorized by the Wisconsin Legislature to be formulated by the soil and water districts; and special zoning regulations, including special soil-related zoning districts and specific regulations dealing with steep and erodible lands.

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Chapter X
OTHER USES OF SOILS DATA

INTRODUCTION

The foregoing chapters of this Guide have illustrated how the detailed soil survey and interpretive analyses can be effectively utilized in planning at the regional, watershed, community, and neighborhood level; in promoting better urban land development through zoning, land division, building, and sanitary ordinances; and in achieving sound rural development through good soil and water conservation practices. In addition to these basic applications, the detailed soil survey data and interpretive analyses can be used in a variety of ways and for many purposes in the day-to-day operations of both public and private enterprise concerned with the land and its use. This chapter will describe a number of such additional applications of the soils data. The descriptions are intended only as selected examples, however, and are by no means exhaustive of the many potential applications.

LAND APPRAISAL

The appraisal of real property involves the estimation of the fair market value of land and appurtenant improvements, the term "fair market value" being defined as the most probable selling price negotiated between a willing buyer and a willing seller. Several methods of estimating the fair market value are in common use by appraisers, including a method which establishes this value from comparable market data for a total real property ownership, both land and buildings; a method which establishes this value separately for the land, using comparable market data, and for the buildings, using unit construction costs and depreciation rates; and a method which capitalizes the net income which a real property holding may be returning. The first two methods, which are commonly employed in the appraisal of residential and industrial property but which may also be applied to commercial and agricultural property, are empirical methods which include for the property being appraised analyses of such factors as the topography and soil characteristics; the availability of essential public utilities and services, or the potential for the provision of private on-site water supply and sewage disposal facilities; location characteristics, including the relationship to other land uses; the accessibility of commercial, civic, and social facilities; the level of taxes and special assessments; use restrictions in the form of zoning and subdivision regulations, building codes, and private deed restrictions; title considerations and existing encroachments; and improvements. The third method, which is commonly used for commercial property and which may be used for farmland where the annual net income can be readily determined, capitalizes this net income at a current rate of return. Knowledge of soil characteristics and their effect upon the suitability of a site for existing and potential uses can provide important inputs to the equitable appraisal of land values by all three of these methods. Soil surveys can provide valuable data upon which to form a sound basis for establishing comparative land value, such as interpretive ratings for various urban and rural land uses; capabilities for irrigation; capabilities for land reclamation by drainage; woodland and cropland yield estimates; and potential as a source for topsoil, sand, and gravel. Soil surveys can provide data upon which the feasibility of on-site water supply and sewage disposal facilities can be determined and can provide a basis for estimating cropland yield estimates for capitalizing current rates of return on agricultural land.

Farmland Appraisal

The appraisal of land for agricultural use involves consideration of a combination of factors, including location, improvements, and soil productivity. Productivity at the time of appraisal may be misleading in comparing values of sites with differing levels of management on similar soils if the full productive potential of the soil is not readily known. The soil survey, with its accompanying crop yield predictions for a given level of management, as described in Chapter III, provides a means of arriving at the comparative productivity of farms and, therefore, at an equitable basis for appraisal. The percent slope and degree of erosion as shown on the detailed soil maps affect the value of land by limiting the consecutive years that high-value row crops can be safely grown without excessive erosion.

As an example of farmland appraisal based on soils data, consider a farm 50 percent of which is covered by Fox loam, 25 percent by Casco loam, and 25 percent by Matherton silt loam. This farm should be valued at a lower per acre figure than a farm 50 percent of which is covered by Warsaw silt loam, 25 percent by Lorenzo loam, and 25 percent by Kane silt loam, given similar slopes and degrees of erosion. Yield data indicate that the average yield with a high level of management for the Fox, Casco, Matherton farm is about 80 bushels of corn per acre. The average predicted yield for the Warsaw, Lorenzo, Kane farm with similar management is about 89 bushels of corn per acre. This simple comparison indicates that the value of the latter farm should reflect the capital value represented by the 10 percent higher yields available on that farm. Similarly, a farm covered by nearly level Fox silt loam is more valuable than a farm covered by steep Fox silt loam because higher-value crops can be safely grown more often in a rotation.

It is not known precisely to what extent appraisers within the Region utilize soils data in their work dealing with the appraisal of farmland. Certainly, appraisers have always incorporated into their appraisal some judgment as to land productivity. The availability of the detailed soils data and the interpretive analyses, particularly the yield estimates, along with the slope data, should enable appraisers to reflect land productivity more accurately and equitably.

Residential Development Appraisal

The soil survey data can also assist in the making of appraisals of land values for potential residential development. Such appraisals are quite complex because of the number of factors influencing the potential of the site for residential development and the difficulty of placing a monetary value on the individual factors. Nevertheless, the interpretive ratings for residential use provided as a part of the soil survey—very slight, slight, moderate, severe, and very severe limitations—can provide an excellent guide to the proportion of a given site that can be economically developed for residential purposes, and hence at ultimately arriving at a realistic and equitable appraisal.

Where public sanitary sewerage service is not available, and consequently where on-site soil absorption sewage disposal systems must be relied upon, soils data can play a particularly important role in land appraisal. As discussed in Chapter VII, many severe environmental and developmental problems can be created where such on-site septic tank systems are installed in soils poorly suited for the absorption of sewage effluent. It follows, then, that sites covered by soils having severe and very severe limitations would be much less valuable for residential development utilizing septic tank sewage disposal systems than soils with only slight limitations for such use. The soil limitations will not only affect the minimum size and, therefore, the number of residential building sites which can be developed on a tract but also the market value of the finished sites.

There are indications that appraisers are using the detailed soils data in making residential appraisals within the Region. The Commission has received many requests from appraisers for soil maps and interpretive analyses for specific parcels of land. Particular interest appears to be shown in the limitations of soils for residential development without public sanitary sewer service, indicating the appraisers are specifically recognizing these limitations in the appraisal of existing and potential residential land.

LAND ASSESSMENT

As in land appraisal, the detailed soil surveys can be effectively utilized in land assessment for property taxation purposes. The characteristics of different soils affecting their utilization for different purposes are relatively stable. When knowledge of these characteristics is combined with practical land development experience and with knowledge of such other information as location; transportation service; and the type, number, and use of buildings, a sound basis for establishing the relative values of various tracts of land is established.

Agricultural land valuations should be based upon productive capacity rather than on current land returns so that the careful, hardworking farmer is not penalized for his ability, industry, and foresight. Erosion and other forms of land deterioration should be also taken into account in preparing farmland assessments.

One method of arriving at relative farmland values utilizing soils data was developed in South Dakota in 1954.[1] This method compares the productivity of various soil types within a county to the most productive soil. This comparison is expressed as a percent of the yield of the most productive soil. As an example, the net annual income (1954) from 100 acres of the most productive soil was $2,040.00. The net annual income from 100 acres of the second most productive soil was $1,439.25, or 70 percent of that for the most productive soil. A relative economic rating of 70 was thus assigned to this second soil type, and each soil type was similarly assigned an economic rating. Utilizing a detailed soil survey, the number of acres of each soil type occurring on any given farm can be computed. Based on these acreage figures and the economic ratings for each soil type, an average economic rating for a farm can be calculated. This average rating can then be converted to an unadjusted assessed value through the use of a constant derived by comparing sales with the relative economic ratings of the land that was sold. Once the unadjusted assessed value is obtained, it must be adjusted by considering such other factors as buildings, other improvements, and proximity to markets.

In a more recent effort in Wisconsin, several local assessors in the western portion of the state are using soil survey data combined with yield data as a basis for determining the value of land for tax assessment purposes.[2] In this method the soils are grouped according to their relative productivity as influenced by soil characteristics. Yields are based on a 20-year average. The total digestible nutrients produced in a 20-year period are used as a basis for comparing soil groups. A crop rotation suitable for soils in each group is assumed in the calculations. Using yield data and estimated costs of production, a net return can be determined for the soils in each group. Soil surveys are used to determine the acreage of each soil in a farm unit. By comparing the calculated net income to the current level of land values, an equitable evaluation for individual farms can be determined.

Soils data can also be useful in areawide equalization of locally derived tax assessments. In addition, several rural property tax assessment review boards in Ohio have used the soil survey and analyses to assist them in reviewing an appeal of the local assessor's valuation and in raising or lowering such valuation. An often overlooked advantage of using soils data in making assessments is that of being able to satisfy the taxpayer that his assessment is equitable when related to the soils and to value of his neighbor's property.

LAND DEVELOPMENT COST ESTIMATING

The detailed soil survey and analyses can be useful in estimating land development costs, such as the cost of constructing storm and sanitary sewers, water mains, curb and gutter, and street pavements and the costs of street and site grading and of seeding, sodding, and topsoiling. The costs of grading, excavating, trenching, and tunneling associated with such improvements, as well as the design and, therefore, costs of the facilities themselves, are directly related to soil conditions. Adverse soil conditions will determine the character and affect the cost of earthwork operations, including both the costs of excavation of cuts and the costs of compaction of fills, and may require the application of special construction practices, such as the use of tight sheeting and of well points for dewatering trenches and other excavations. In some cases, certain kinds of soils may have to be removed entirely from an area proposed to be occupied by a structure and replaced with more suitable material. The physical characteristics of the soils will also determine the actual design of improvements, such as the need to incorporate base courses under street and highway pavements, provide special bedding for pipe, or otherwise structurally strengthen facilities to guard against poor foundation conditions and excessive settling. Thus, the regional soil survey and its interpretive data can be applied in the preparation of development cost estimates for specific sites.

The detailed operational soil survey can also be used in areawide applications of development cost estimations, since it not only relates land development costs to specific geographic locations within a planning area but also covers the entire area. The detailed soil survey, therefore, provides an important basis for

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[1] *A. J. Klingelhoets and F. C. Westin,* Soil Survey and Land Evaluation for Tax Purposes, *Circular 109, Agricultural Experiment Station, South Dakota State College, 1954.*

[2] *U. S. Department of Agriculture, Soil Conservation Service,* Soil Survey of Dunn County, An Interim Report, *1969.*

the application of both conventional land use planning techniques and newer mathematical model techniques to the synthesis of rural and urban land use plans, wherein the purpose of the plan synthesis or design is to minimize public and private development costs while meeting agreed-upon development objectives. Unit land development cost estimates which relate such costs to soil types have been prepared by the Commission staff for use in an urban land use plan design model being developed under contract with the U. S. Department of Housing and Urban Development. Land development cost estimates were prepared for five selected residential development densities and three soil suitability classes, including the costs of providing not only the necessary street and utility improvements but also the associated neighborhood school, park, and shopping center facilities. These cost estimates were based on analyses of the costs of constructing each of the necessary individual municipal improvements, relating these costs to both the land uses to be served and to the type of soils involved. The estimated improvement costs in 1967 dollars are set forth in Table 31. This table illustrates the substantial differences in development costs that can be expected with different soil types.

STREET AND HIGHWAY LOCATION AND DESIGN

Detailed soil surveys are used by highway design engineers in two ways: 1) as an aid in highway route location, and 2) as an aid in detailed design, including drainage, earthwork, and pavement design (see Figure 76). Highways wherever practicable, in view of the many considerations involved, are routed to avoid areas covered by soils having very severe and severe limitations for highway use in order to reduce the cost of road maintenance, as well as of initial construction. With the aid of the detailed soil surveys and maps, highway location engineers can readily identify and attempt to avoid large areas of unfavorable soils, such as highly organic, very fine, or poorly drained soils. Similarly, with the aid of a detailed soil map, highways can be routed through areas covered by favorable soils underlain by sands and gravels. For convenience a general soil map containing broad delineations consisting of soil associations that contain two or more soil types grouped on the basis of suitability for highway location can be used for this purpose.

In route location it is usually impractical to avoid all areas covered by soils with unfavorable characteristics. These areas, however, are shown on the detailed soil survey map; and further study of the detailed soil map will indicate the location of areas covered by soils with poor stability, low bearing capacity, high water table, areas of shallow bedrock, or other unfavorable conditions. The design engineer, in preparing final route locations, can then plan to compensate for these conditions in the detailed drainage, earthwork, and pavement design by the removal and replacement of unfavorable soils, the provision of special drainage facilities, or the use of base courses. In addition, detailed soil surveys show the location of soils that are a good source of fill, of sand and gravel, and of topsoil. Thus, the general soil association map can be used for initial routing of the arterial highway, while detailed soil survey maps can be used as a basis for final design of various segments of the road.

Figure 76

IMPROPER DRAINAGE DESIGN

Transportation facilities, such as highways, if improperly designed and constructed, can contribute substantially to the problem of soil erosion and consequent stream and lake sedimentation. This photograph shows an improperly designed roadside ditch on a newly constructed road. Because the ditch has not been properly shaped, graded, and stabilized with permanent vegetation, the ditch has eroded severely, not only contributing to soil erosion but also increasing highway maintenance costs.

Table 31

ESTIMATED LAND IMPROVEMENT COSTS BY LOT TYPE

IMPROVEMENT	COSTS ON		
	Very Good and Good Soils	Fair Soils	Poor Soils
Street and Utility Improvement			
Lot Size			
Under 9,000 sq. ft.	$3,560.00/lot	$3,945.00/lot	$5,050.00/lot
9,000 to 11,999 sq. ft.	4,345.00/lot	4,805.00/lot	6,149.00/lot
12,000 to 19,999 sq. ft..	5,443.00/lot	6,003.00/lot	7,682.00/lot
20,000 sq. ft. to 1 acre	3,640.00/lot	4,827.00/lot	6,477.00/lot
Over 1 acre	5,608.00/lot	5,894.00/lot	7,298.00/lot
Neighborhood School Construction			
Lot Size			
Under 9,000 sq. ft.	$ 769.00/lot	$ 772.00/lot	$ 822.00/lot
9,000 to 11,999 sq. ft.	658.00/lot	661.00/lot	707.00/lot
12,000 to 19,999 sq. ft..	442.00/lot	449.00/lot	478.00/lot
20,000 sq. ft. to 1 acre	687.00/lot	696.00/lot	745.00/lot
Over 1 acre	659.00/lot	661.00/lot	711.00/lot
Neighborhood Park Improvement			
Lot Size			
Under 9,000 sq. ft.	$ 76.00/lot	$ 82.00/lot	$ 106.00/lot
9,000 to 11,999 sq. ft.	83.00/lot	89.00/lot	118.00/lot
12,000 to 19,999 sq. ft..	97.00/lot	104.00/lot	135.00/lot
20,000 sq. ft. to 1 acre	87.00/lot	106.00/lot	141.00/lot
Over 1 acre	143.00/lot	146.00/lot	185.00/lot
Neighborhood Commercial Center Construction			
Lot Size			
Under 9,000 sq. ft.	$ 572.00/lot	$ 631.00/lot	$ 707.00/lot
9,000 to 11,999 sq. ft.	377.00/lot	416.00/lot	466.00/lot
12,000 to 19,999 sq. ft..	534.00/lot	589.00/lot	660.00/lot
20,000 sq. ft. to 1 acre	460.00/lot	515.00/lot	576.00/lot
Over 1 acre	605.00/lot	666.00/lot	737.00/lot
Total (Combined Improvements)			
Lot Size			
Under 9,000 sq. ft.	$4,977.00/lot	$5,430.00/lot	$6,685.00/lot
9,000 to 11,999 sq. ft.	5,463.00/lot	5,971.00/lot	7,440.00/lot
12,000 to 19,999 sq. ft..	6,516.00/lot	7,145.00/lot	8,955.00/lot
20,000 sq. ft. to 1 acre	4,874.00/lot	6,144.00/lot	7,939.00/lot
Over 1 acre	7,015.00/lot	7,367.00/lot	8,931.00/lot

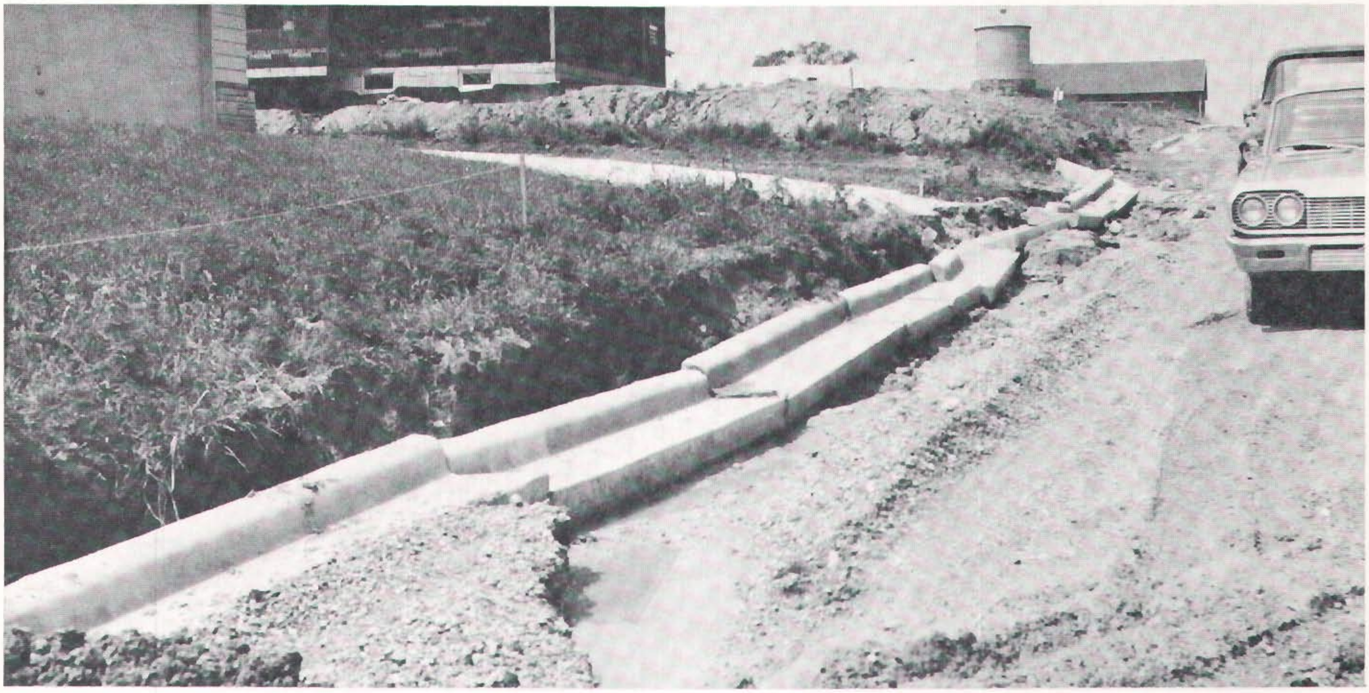
Source: SEWRPC.

Pavement Design

The load bearing capacity of the soil is one of the important factors which must be considered in the design of street and highway pavements, affecting both the thickness of the pavement itself and whether or not a base course or courses must be used between the pavement and the natural subgrade (see Figure 77). The ability of a soil to support a pavement structure is quantitatively estimated by design engineers in terms of a factor known as the modulus of subgrade reaction, or k value. This modulus is expressed in pounds per square inch of load per inch of subgrade deflection (pounds per cubic inch) and will vary with

Figure 77

NEGLECT OF SOIL CHARACTERISTICS
IN RESIDENTIAL STREET DESIGN



Soil characteristics are one of the important factors which must be considered in the design of urban street pavements, including appurtenant curb and gutter sections. This photograph, taken within the Region, shows new concrete curb and gutter displaced by the erosion of the Ozaukee silt loam soil on which it was constructed. Soils having a low bearing capacity, high susceptibility to frost action, and high shrink-swell potential, as well as a high erosion hazard, may also severely damage urban street pavements and appurtenant drainage structures if not compensated for in the design of these pavements and structures.

the soil type and moisture content. Because design pavement thickness is not sensitive to small changes in k value, the design engineer needs only to estimate the approximate range of k values associated with the soils involved rather than to determine the precise and absolute value involved. Because an exact k value is not required, the relationships shown in Figure 78 are often used for pavement design and can be readily estimated with the aid of the detailed soil survey data.

Relatively short periods of reduced subgrade support during spring thaw conditions have little effect on the required thickness of rigid pavements (Portland cement concrete pavements); and in the design of such pavements, normal k values are used. Allowances for seasonal changes in subgrade support may be necessary in the design of flexible pavements (bituminous concrete pavements). Base courses may be used to increase k values and may consist of untreated granular materials, as well as of Portland cement or bituminous treated materials.

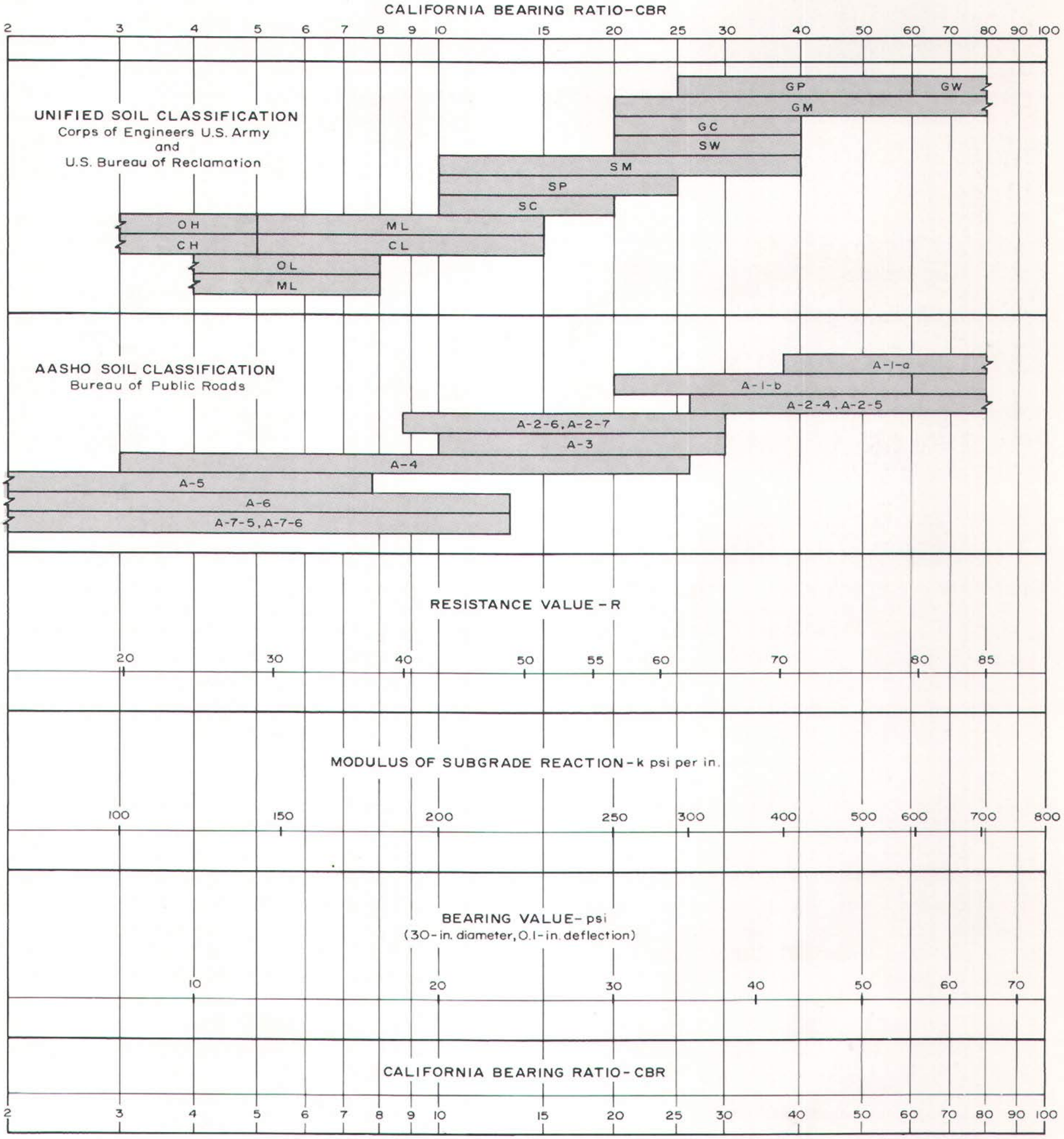
Subgrade support conditions have for many years been carefully considered by the State Highway Commission of Wisconsin in the design of highway pavements. Such conditions have not been, however, commonly considered in the design of urban street pavements, with many local communities utilizing standard pavement cross sections for urban streets regardless of soil conditions. Economies in both the construction and maintenance of urban street pavements could be achieved by more careful consideration of subgrade conditions, and the detailed soil survey data could assist in such consideration.

SPECIFIC SITE LOCATION

Detailed soil surveys can be extremely useful in the process of site selection for a specific use, such as site selection for farm ponds, for light industrial and commercial buildings, for public buildings, for

Figure 78

APPROXIMATE INTERRELATIONSHIPS OF SOIL CLASSIFICATIONS AND BEARING VALUES



Source: Adapted from American Society of Civil Engineers, Transportation Engineering Journal.

recreational developments, and for sanitary land fill operations. The careful examination of soil survey maps for the particular geographical area under consideration for the location of a specific use will result in better site selection and the avoidance of future site-related development problems, such as excessive settlement.

Ponds

In searching for a suitable site for a farm or recreational pond, a location should be sought that is covered by soils suitable for reservoir construction. The detailed soil survey provides this kind of information by showing the types of soils within a proposed reservoir area and the limitations of each soil for reservoir use, as discussed in Chapter III of this Guide. The soil survey also indicates sources of soil material suitable for construction of embankments. Borings may be necessary at some sites to detail or expand the information recorded in the soil survey. The soil survey, however, can be used to select alternative feasible sites and to save much time and expense in the site selection process.

Light Industrial, Commerical, and Public Buildings

The interpretation of soil survey data to indicate the limitations of soils for the construction of foundations for low buildings, as discussed in Chapter III, can be used to select sites for commercial, light industrial, and public buildings. The shear strength, bearing capacity, shrink-swell potential, depth-to-bedrock and depth-to-water-table characteristics, as given for each soil type in the survey, enable the user to accept, reject, or further investigate a proposed site on the basis of the limitations of the soils on the site. Where there is flexibility in the location of a building, soil surveys can indicate areas covered by soils with sufficient bearing capacity and shear strength to support light buildings. The surveys will also indicate soils that have unfavorable characteristics, such as high shrink-swell potential or shallow depths-to-water table or to bedrock. Where location dictates use of a soil with one or more limitations, the builder may wish to disregard or compensate for an unfavorable soil feature. Where all possible locations have some limitations, the soil survey can be used to indicate the site with the fewest and least objectionable features.

Recreational Developments

The selection of sites for recreational developments can best be accomplished with the assistance of detailed soil surveys, especially in areas near new residential developments or where part of a farm is to be converted to recreational use. The high cost of land, the need to place homes on the most favorable sites, and the less demanding requirements of areas to be used for recreational purposes make the soil survey a valuable tool in selection of sites. The soil surveys indicate areas subject to occasional flooding that are suitable for playgrounds or areas with severe limitations for some uses that can be used for paths and trails, camp areas, or other recreational uses. Although a greater latitude of limitations can be permitted for most recreational developments, certain requirements should be met. Soil surveys can be used to determine how well an area meets the needs of a particular recreational development by showing the kind of soils in the area and the limitation of the soil for the proposed use.

Map 27 shows the soil limitations for the 160-acre soils demonstration site discussed in Chapter VII of this Guide as interpreted for outdoor recreational development. Nearly one-third of the site is covered by soils having severe or very severe limitations for certain types of intensive and extensive recreational uses, such as parks, playgrounds, athletic fields, picnic areas, and golf courses. The remainder of the site is covered by soils with moderate limitations for such development. The Ehler (212 and 213) and Brookston (231) silt loams have a high water table, require drainage, remain wet for long periods after rains, and have low trafficability. The Lamartine (364) silt loam is subject to sod damage during wet periods from intensive foot traffic. The Tichigan (42) silt loam is subject to sod damage unless drained.

A suggested park development layout for the soils demonstration site is shown on Map 28. The detailed soils data have been used in the design of this layout, in that certain poorly suited soils have been proposed for recreational uses within their capabilities, such as wildlife areas, ponds, arboreta, and park drives. In such recreational planning, the soils analyses may be used in at least the following ways:

1. The selection of arboretum areas may be based upon a consideration of the suitability of soils for woodlands.

2. The location of park drives and trails may be based upon a consideration of the limitation of soils for vehicular and pedestrian traffic; such soil analyses may also indicate the need for removal of certain soils and replacement with more stable materials.

3. The use of certain soil types for wildlife areas may be based upon a consideration of their limitations for the production of habitat for selected wildlife species.

4. The selection of tree species for arboretum areas and herbaceous plantings for wildlife habitat improvement may be based upon a consideration of woodland suitability groups and wildlife land capability units.

5. The decision to use certain on-tract roadbed materials may result from a consideration of the potential of the soils as a sand and gravel source.

All of the foregoing soil analyses related to recreational developments are discussed in Chapter III of this Guide.

Sanitary Land Fills

Sites for sanitary land fills are often selected almost entirely on the basis of location in relation to the community served, with little consideration for the consequences to other communities or to damage to the soil, the landscape, or to ground water resources. The soil survey can be used to select favorable sites that are suited to the needs of a relatively continuous operation. Slope, natural drainage, depth-to-water table, depth-to-bedrock, flood hazard, soil texture, and presence of stones are criteria for selection of a site for sanitary land fills that are indicated by the soil survey. Generally, a well-drained, deep, loamy soil that does not flood is the kind of site that is most desirable.

OTHER SOILS DATA USES AND USERS

The detailed soils data have the potential for useful application in many additional ways. Civil engineers can use soils data in airport site location and design; landscape architects can use soils data for site layout and design, park design, and plant material selection and location; highway engineers and grading contractors can use soils data for the location of sources of sand and gravel, topsoil, and fill material and for earthwork calculation; and game managers and game farm operators can use soils data for wildlife area selection and wildlife habitat improvement. In fact, the list of potential users of soils data is almost endless; and rightly so, since the soil resource base forms the foundation for nearly all the activities in our inhabited world.

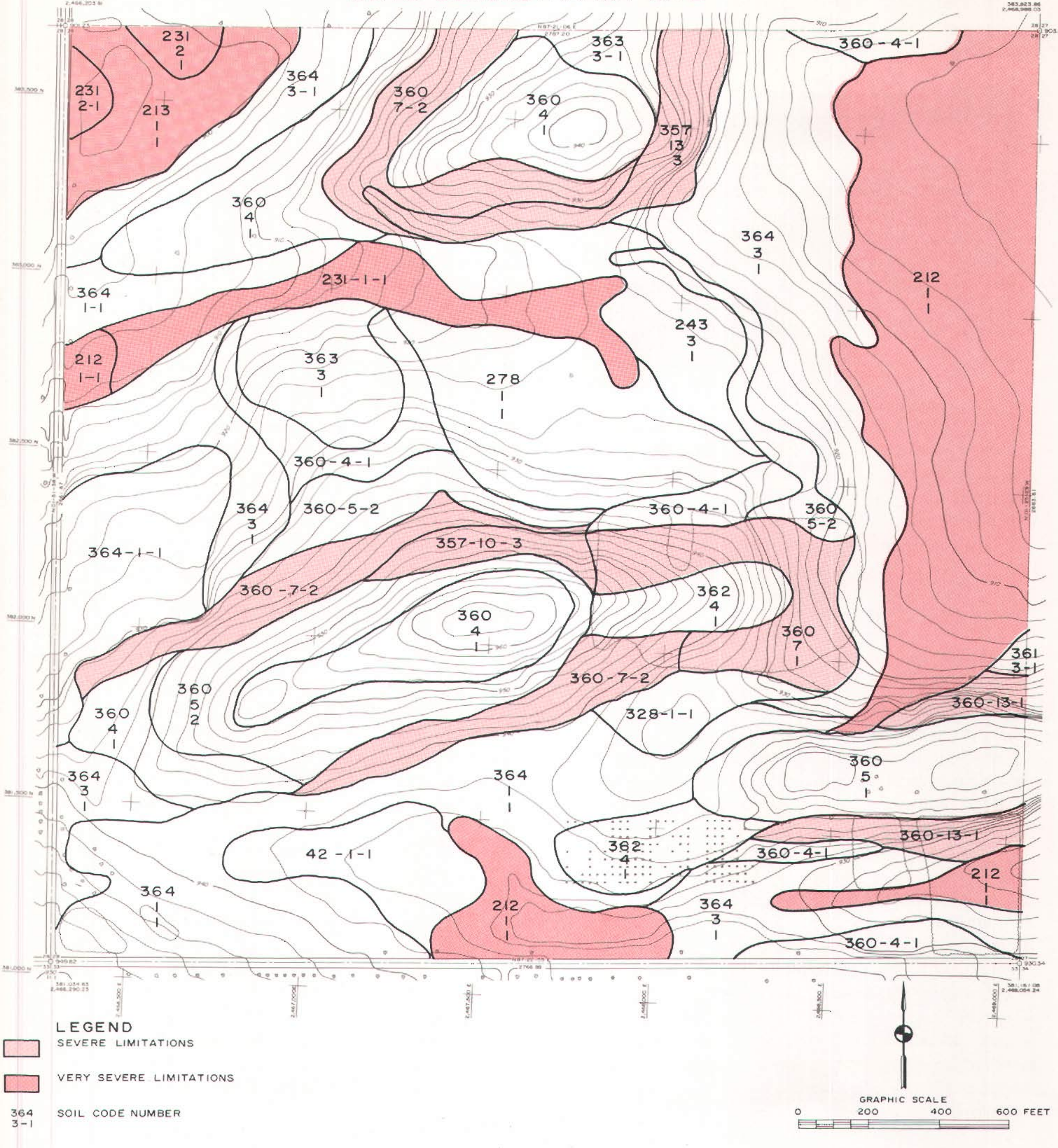
SUMMARY

The detailed soils survey and interpretive analyses can have many applications beyond urban and rural planning. For example, soils data can be used by appraisers as an aid in determining the fair market value of land. In agricultural appraisals the soils data, along with accompanying yield predictions, provide a means at arriving at comparative productivity of farms. In residential appraisals the soils data, along with accompanying yield predictions, provide a means of arriving at comparative productivity of farms. In residential appraisals the soils data have interpretive ratings of the suitability for development with septic tank sewage disposal systems which can be helpful in arriving at fair and equitable land appraisals. In similar ways the detailed soils data can be used in land assessment for property tax purposes.

The preparation of estimates of land development costs is another area in which soil survey data can be useful. The costs of grading, excavating, trenching, and tunneling operations associated with the construction of various types of improvements are directly related to soil conditions. Such land development costs can be prepared utilizing soils data not only for development proposals on specific sites but also for development cost estimates over large geographical areas. The soil survey map provides a ready means of relating land development costs to specific geographical locations within a planning area.

Map 27

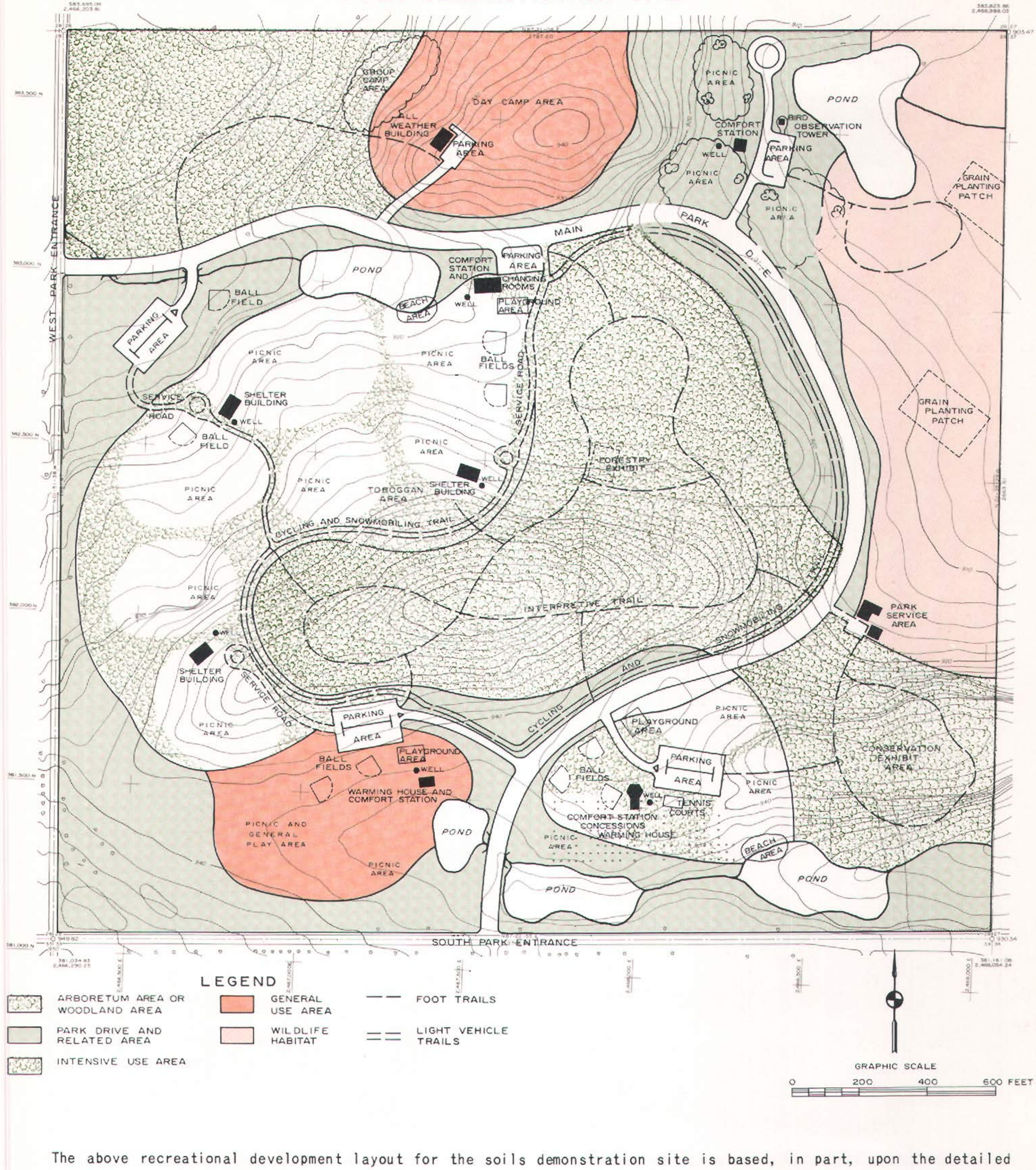
SOIL INTERPRETATIONS FOR RECREATIONAL DEVELOPMENT
SOILS DEMONSTRATION SITE



Nearly one-third of the soils demonstration site is covered by soils having very severe or severe limitations for development for outdoor recreational purposes, including such uses as parks, playgrounds, and picnic areas. Most of the soil problems involve such characteristics as high water table, extended surface wetness after rain, and low trafficability. Such limitations must be recognized in the development of an outdoor recreational plan for the site.

Map 28

RECREATIONAL DEVELOPMENT PLAN
SOILS DEMONSTRATION SITE



The above recreational development layout for the soils demonstration site is based, in part, upon the detailed soils data and interpretive analyses. Certain soil limitations, such as high water table, surface wetness, permeability, and soil texture, should be recognized in the design of park and other outdoor recreation areas. Woodland suitability ratings can be used in the development of arboreta, while the planting guides can be used in the improvement of wildlife habitat areas.

Detailed soils surveys are used by highway design engineers not only as an aid in highway route locations but also in detailed design, including drainage, earthwork, and pavement design. Not only do the detailed soil survey maps aid highway design engineers in avoiding large areas of unfavorable soils but they also can provide the basis for design considerations whereby the design engineer can compensate for whatever soil conditions exist in the detailed drainage, earthwork, and pavement design.

Those concerned with specific site locations for various special land uses can also effectively utilize the detailed soils survey and interpretive analyses. Soils are particularly important in the initial site location studies for ponds; for light industrial, commercial, and public buildings; for recreational developments; and for sanitary land fills.

Chapter XI

ADMINISTRATIVE AND LEGAL CONSIDERATIONS IN THE USE OF SOILS DATA

INTRODUCTION

The foregoing chapters in this Guide have included recommendations that local units of government within the Region utilize directly the detailed soil survey and accompanying interpretive analyses, completed for the Region by the U. S. Department of Agriculture, Soil Conservation Service, in various land use control measures, including zoning and land division ordinances, building codes, and sanitary or health ordinances. Such direct utilization of soils data in regulatory measures requires, however, attention to certain administrative and legal considerations. Of particular concern are such administrative considerations as the familiarity of the local public employees charged with the responsibility of administering soil-related ordinances with the technical details of the soil survey, its interpretations, and its applications; the maps and other materials used in administering the ordinances; and the procedures for rectifying any errors in the soil survey and for handling appeals. In addition, a local government may be faced, as it may be in the enforcement of any land use control ordinance, with legal challenges to the use of the soil survey and interpretive analyses. This chapter of the Guide discusses such administrative and legal considerations.

ADMINISTRATIVE CONSIDERATIONS

Personnel

The proper application and use of soils data in regulatory ordinances, such as zoning and sanitary codes, require that the local public employees charged with the responsibility of administering such codes acquire at least a working knowledge of the detailed soil survey, its interpretations, and its application. This would include a basic understanding of the soil survey field procedures, of soil characteristics, of the relevant soil interpretations based upon these characteristics, and of the limitations of the soil survey. For each local unit of government to employ a soil scientist or soils engineer to assist in administering soils-related codes and in explaining the soil survey and interpretive analyses to local citizens and public officials would be highly inefficient, entailing needless duplication of staff. A better approach would be for local units of government to utilize the extensive skills already available through existing county, state, and federal agencies concerned with the proper use of the soil resource base.

To assist local officials in obtaining a working knowledge of the soils data and to overcome the need to provide resident soils specialists, the various units and agencies of government concerned with the actual use of soils data in the Southeastern Wisconsin Region, as well as with the promotion of the use of this data, have jointly executed an interagency soils agreement. This agreement was briefly discussed in Chapter II of this Guide and is set forth in full in Appendix A. Under this agreement qualified and experienced technical personnel, including soil scientists, soil conservationists, and engineers employed by the U. S. Soil Conservation Service, are made available upon request and at no cost to all local units of government in the Region. These technical personnel can thus assist local public employees in applying the soils data and interpretive analyses through sound land use regulatory measures. Of particular importance in this respect is the availability of a resident U. S. Soil Conservation Service regional soil scientist to make on-site soil investigations and interpretations where soil conditions may be questionable or where soil mapping unit boundary lines need refinement. Also important in this respect are the educational services available through the University of Wisconsin Extension Service. Through these educational efforts, local public officials and interested citizens can achieve a greater understanding of the soil survey itself and of its various applications.

Materials

The basic working material in the utilization of soils data is the detailed operational soil survey map itself. In the Southeastern Wisconsin Region, these maps, as noted in Chapter II of this Guide, were originally prepared in the field at a scale of 1" = 1320' and were made available to the Commission in a form suitable for multiple reproduction at a scale of 1" = 2000' (1:24000) (see Figure 15). While this scale lends itself well to regional and watershed planning, larger-scale maps are necessary to utilize soils data effectively at the local community level. For this reason some communities in the Region[1] have photographic enlargements of the regional soil survey maps made to a scale of 1" = 1000' (1:12000). The City of Oak Creek in Milwaukee County has had the soil survey maps enlarged to a scale of 1" = 400' (1:4800) so as to correspond to the Commission's aerial photos. In dealing with detailed development proposals, such as subdivision layouts and site plans for individual parcels, it may be desirable to enlarge the soil survey map to scales of 1" = 200' (1:2400) or even 1" = 100' (1:1200). It must be recognized, however, that such enlargements tend to give a false sense of precision concerning the location of a soil mapping unit boundary line. Greater precision in locating a boundary line can only be achieved by remapping the soils data at larger scales. For this reason it is important that a soil scientist be consulted when attempting to utilize the regional soil survey data at greatly enlarged scales.

Some communities within the Region have found it very useful to prepare special base map overlays that delineate those soil types, in composite form, that have severe and very severe limitations for the safe absorption of septic tank sewage effluent, as discussed in Chapter VIII of this Guide.[2] In this way the desired soils information is readily at hand when planning, zoning, and development decisions are being considered. It is also useful for a community to have available for public inspection soils maps of the community that are color-coded by interpretation for the particular land use activity that is being regulated,[3] such as the installation of septic tank sewage disposal systems. The Commission will prepare at cost any such mapping materials for local units of government within the Region.

Procedures

In the discussion in Chapter II on the limitations of the soil survey, it was pointed out that despite the care with which the survey was executed certain errors were possible. Such errors may include misclassification of a soil unit; boundary variations; and minor inclusions, ranging up to two acres in area, of different soil types within larger soil mapping units. For this reason it is necessary whenever the soil survey and

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[1] *These communities include to date: The Towns of Brighton, Bristol, Paris, Pleasant Prairie, Randall, Salem, Somers, and Wheatland in Kenosha County; the City of Franklin in Milwaukee County; the Towns of Belgium, Cedarburg, and Grafton in Ozaukee County; the Towns of Burlington, Caledonia, Dover, Mt. Pleasant, Norway, Raymond, Rochester, Waterford, and Yorkville in Racine County; The Towns of Bloomfield, Darien, Delavan, East Troy, Geneva, LaFayette, LaGrange, Linn, Lyons, Richmond, Sharon, Spring Prairie, Sugar Creek, Troy, Walworth, and Whitewater in Walworth County; the Towns of Addison, Barton, Erin, Farmington, Germantown, Hartford, Jackson, Kewaskum, Polk, Richfield, Trenton, Wayne, and West Bend and the Village of Germantown in Washington County; and the Towns of Brookfield, Delafield, Eagle, Genesee, Lisbon, Merton, Mukwonago, Oconomowoc, Ottawa, Pewaukee, Summit, Vernon, and Waukesha and the City of New Berlin in Waukesha County.*

[2] *These communities include to date: The Towns of Brighton, Bristol, Paris, Pleasant Prairie, Randall, Salem, Somers, and Wheatland in Kenosha County; the City of Franklin in Milwaukee County; the Towns of Belgium and Cedarburg in Ozaukee County; the Towns of Burlington, Caledonia, Dover, Mt. Pleasant, Norway, Raymond, Rochester, Waterford, and Yorkville in Racine County; the Towns of Bloomfield, Darien, Delavan, East Troy, Geneva, LaFayette, LaGrange, Linn, Lyons, Richmond, Sharon, Spring Prairie, Sugar Creek, Troy, Walworth, and Whitewater in Walworth County; the Town of Polk in Washington County; and the Town of Merton and the City of New Berlin in Waukesha County.*

[3] *Such color-coded interpretive maps for septic tank sewage disposal systems have been done by the following communities, to date: The Towns of Brighton, Bristol, Paris, Pleasant Prairie, Randall, Salem, Somers, and Wheatland in Kenosha County; the Towns of Belgium and Cedarburg in Ozaukee County; the Towns of Burlington, Caledonia, Dover, Mt. Pleasant, Norway, Raymond, Rochester, Waterford, and Yorkville in Racine County; the Towns of Bloomfield, Darien, Delavan, East Troy, Geneva, LaFayette, LaGrange, Linn, Lyons, Richmond, Sharon, Spring Prairie, Sugar Creek, Troy, Walworth, and Whitewater in Walworth County; the Towns of Addison, Barton, Erin, Farmington, Germantown, Hartford, Jackson, Kewaskum, Polk, Richfield, Trenton, Wayne, and West Bend and the Village of Germantown in Washington County; and the Town of Merton in Waukesha County.*

analyses are directly incorporated into regulatory ordinances to provide for an administrative appeal procedure whereby any claims of classification or mapping errors can be heard and any errors subsequently rectified. This procedure will avoid, in most cases, the need for and resort to any actual court challenges of the accuracy of the soil survey and the financial burden, delays, and hardships which such unnecessary challenge may place upon both the private and public parties involved. Of substantial help in this connection is the aforementioned interagency soils agreement, under which the U. S. Soil Conservation Service will provide, upon request of local units of government, such technical assistance as is necessary to carefully review claims of soil misclassification and soil map inaccuracy.

Coordinated Ordinances

The suggested soil regulations to be incorporated into zoning, land subdivision, building, and sanitary or health ordinances, as set forth in Appendices E, F, G, and H, are similar to, compatible with, and supplement one another. All of these regulations are necessary and important in order to ensure the best possible development and the least abuse of the soil resource. Not only is this important from the standpoint of effective, logical, and consistent administration by local officials but, if all such ordinances are in effect, it will have the added advantage of effectively protecting the community in case of poor enforcement of, modification of, variance to, repeal of, or invalidity of any one of the individual ordinances.

LEGAL CONSIDERATIONS

Any regulation which substantially restricts the freedom of a landowner to develop his land may be subjected to legal challenge. Examples of regulations which are intended to protect the natural resource base, which utilize the detailed soils data in so doing, and which, therefore, may sometimes be considered restrictive and consequently apt to be challenged in the courts, include: exclusive agricultural and conservancy use districts; large lot zoning; the prohibition of on-site soil absorption sewage disposal systems in areas covered by soils having very severe limitations for the absorption of sewage effluent; the prohibition of land division and development on certain soil types; and the creation of special agricultural and building regulations for steep and erodible lands. It should be noted in this context that, in general, the test of the legality of regulations limiting the freedom of the landowner is whether, in the judgment of the court, the overall benefit to public health, safety, and welfare resulting from the restriction is greater than the economic loss to the private landowner caused by the restriction.[4]

The use of soils data in regulatory ordinances involves relatively new concepts. Even the precedents necessary for the routine acceptance by the courts of the detailed soil survey itself as providing, in general, sound and accurate information germane to a particular land use control problem have not as yet been developed. It is probable, therefore, that a local government utilizing the soils data in regulatory ordinances may find itself in the initial position of having to defend, if challenged, the entire concept of the soil survey and its applicability to land use development decisions, as well as its accuracy with respect to the particular site involved. Courts are apt for a period of time to be completely unfamiliar with the principles and concepts underlying the soil survey, the practices involved in its conduct, and its reliability and validity. Therefore, one of the basic steps in defending soils data in regulatory ordinances against legal attack would necessarily be establishing the accuracy and relevance of the soils survey itself. Once the accuracy and relevance of the soil survey is established, then the issue would concern only the legality of the specific application of the ordinance to the particular site in question.

Because the application of soil survey data to land use regulation is so new, there have been very few court cases which deal with such application. One relevant case involves the challenge in circuit court of the use of soils data in a local regulatory ordinance by a northern Illinois county.[5] The zoning authority had concluded, in part, that the detailed soils data warranted requiring in a certain area large estate-type

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[4] See Zoning Law and Practice in Wisconsin, Richard W. Cutler, Board of Regents of the University of Wisconsin, 1967.

[5] Citizens Bank & Trust Company of Park Ridge, Trust 407, v. County of Lake, 19th Judicial Circuit Court of Lake County, Illinois (1965).

residential lots (five-acre minimum) on which there would most probably be sufficient area covered by suitable soils to permit installation and later relocation, if necessary, of on-site soil absorption sewage disposal systems. An attempt to rezone an 80-acre parcel to a one-acre minimum lot size district was unsuccessful, and the petitioner brought suit to have the five-acre minimum zoning requirement declared an arbitrary and unreasonable use of the police power. The zoning authority defended in court its position that the five-acre minimum was justified, in part, because of the character of adjacent land use and, in part, because of the detailed soils data. One observer has described this case as follows:

> The developer presented testimony from a professional engineer that the soil was suitable for on-site sewage disposal systems on lots of 1 acre. Percolation tests certified by the engineer varied from 15 to 60 minutes per inch and averaged about 30 minutes per inch. The engineer's note describing the soil stated that it was a light brown clay sand and silt mixture to the bottom of an 8-foot-deep test hole and that there was no water standing in the hole after three days. The date on the engineer's report is given as December 29, 1962. The county health department, at the request of the county's attorney, attempted to perform percolation tests in the same area on February 18, 19, and 20, 1963, and could not do so in six of nine locations because of the fact that ground water infiltrated into the percolation test holes and flooded them. In three other locations, percolation rates averaged about 120 minutes per inch. Information from a soils map was overlayed on the proposed 1-acre zoning plat to clarify the contradictory position of the developer's consulting engineer and the county health department's findings. It was rather obvious that percolation tests by themselves alone would have been of no help in this situation. By combining the percolation test results with the soil map, the county was able to resolve the apparent contradiction and strengthen its argument that the soils were unsuitable for on-site sewage disposal on 1-acre tracts. To further its point, the county introduced a sketch plat which showed how zoning with 5-acre lots can provide proper distribution of soils so that more desirable soils for on-site sewage disposal may be found, thus avoiding the creation of unsatisfactory conditions.[6]

Although this is only one case, it is probable that the legal principles governing the use of soils data in land use controls, when more fully developed through additional case law, will be similar to those principles applicable to the use of other forms of scientific data to measure the harm to the public interest arising from certain unregulated land use practices as opposed to the public benefit arising from the regulation of these uses. Examples of such application of scientific data include the use of hydrologic and hydraulic engineering studies in delineating flood hazards for floodplain zoning; the use of performance standards in building codes that depend upon the scientific determination of the relevant facts; and the use of traffic engineering studies to determine the need for, and extent of, visual clearance triangles at street and highway intersections.

FAILURE TO USE SOILS DATA

Where the detailed soil survey and analyses have been completed and are available, elected and appointed officials should be aware that such data, while being of great constructive use to the community through proper application in regulatory ordinances, can also be used against local officials, their adopted plans, and implementation ordinances when they have failed to use such soils data properly. For example, to place lands unsuited for home construction in residential zoning districts, to permit on-site soil absorption sewage disposal systems to be installed in areas where such systems cannot function properly, or to assess various farmlands with no relationship to their particular agricultural capabilities is not only irrational but may conceivably, if challenged, be found to be illegal as well. Indeed, the basic zoning enabling act in Wisconsin, Section 62.23(7)(c) of the Wisconsin Statutes, requires that zoning regulations shall be made "... with a view to ... encouraging the most appropriate use of land ...." It would be both logical and obvious to argue that determination of the "appropriate use of land" would include consideration not only of its location, vegetation, and topography but also of its soil capabilities as well. For local

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[6] *Morris, John G., "The Use of Soils Information in Urban Planning and Implementation,"* *__Soil Surveys and Land Use Planning__, Soil Science Society of America and American Society of Agronomy, 1966.*

officials not to make intelligent use of the soil survey and analyses for the planning, regulation, and development of land in their community would be an error in judgment and would most probably appear as a politically irresponsible and possibly legally liable act to those interested and informed citizens who must later cope with the health hazards and assume the added corrective costs in the form of expensive public works improvement. The law with regard to liability for governmental and other actions previously regarded immune has been developing rapidly in recent years, and no one can now foresee how far liability for public action will go. However, a rational scientific basis for action is always a good defense.

SUMMARY

The use of the soil survey and interpretive analyses in local land use regulatory measures raises certain administrative considerations. It is important that the public employees charged with the administration of the land use ordinances have a working knowledge of the soil survey, its interpretations, and its application. Expert technical assistance is available from the U. S. Soil Conservation Service and the University of Wisconsin Extension Service to assist local units of government in properly administering regulatory ordinances that incorporate the soils data. Administrative procedures must also be established whereby the soils data may be routinely challenged and any errors in the soil survey rectified. Each regulatory ordinance that includes soils data should have a specific appeal procedure whereby the soils data or its application can be challenged. In this way, any question about the accuracy of the survey itself with respect to a particular geographical location can be resolved through an administrative rather than a judicial procedure.

It must be recognized that, because the use of detailed soils data in land use control ordinances and assessments if a relatively new concept, the use of the soils survey and analyses in regulatory devices and in the preparation of assessments may be subject to legal attack on the basis of unreasonableness in general or on the basis of the specific manner in which the soil regulations were applied to a particular parcel of land. There has not as yet developed in the judicial system the precedent that is necessary for routine acceptance by courts of the overall validity of even the concept of the soil survey itself.

It should also be recognized that failure to utilize the detailed soils data through its application in regulatory ordinances may be used against local officials and their adopted plans and implementation ordinances. For example, the failure to prohibit on-site soil absorption sewage disposal systems in areas where such systems cannot function properly is not only an irrational and perhaps costly lack of action but may also be a politically irresponsible and possibly legally liable lack of action given the requirement in the state enabling legislation that land use regulations should encourage the most appropriate use of land.

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Chapter XII
SUMMARY AND CONCLUSIONS

INTRODUCTION

The rapid population growth and urbanization which is occurring within the Southeastern Wisconsin Region is making great demands upon the limited natural resource base of the Region. The soils of the Region are one of the most important elements of that natural resource base, and both urban and rural development should be carefully adjusted to the ability of the soils to sustain such development. The soil resource has been subject to grave misuse through improper land use and facility development, leading to costly problems, such as malfunctioning septic tank sewage disposal systems, footing and foundation failures, and greatly increased soil erosion and sedimentation. It is imperative that local governmental officials and concerned citizens within the Region understand the importance of the underlying and sustaining soil resource to the sound social, economic, and physical development of the Region and recognize the urgent need to protect and conserve that soil resource as urbanization proceeds on an areawide basis throughout the Region.

THE REGIONAL SOIL SURVEY

Proper recognition and use of the soil resource of the Region require definitive knowledge about the types of soils occurring within the Region, their spatial distribution, and their properties as these properties relate to their use for various kinds of rural and urban development. To provide this knowledge for the Southeastern Wisconsin Region, a detailed operational soil survey was carried out in 1966 by the U. S. Soil Conservation Service as a result of a cooperative agreement between the U. S. Soil Conservation Service and the Commission. The soil classification system used by the U. S. Soil Conservation Service in the conduct of the regional soil survey is a pedological system having its foundation in the study of the soils themselves rather than in the application of soils information in specific pursuits, such as agriculture or engineering. The system is based upon the fact that soils which have the same climate, topography, parent material, and drainage characteristics will behave similarly under specific uses wherever found.

Two basic operations were involved in conducting the regional soil survey in the Southeastern Wisconsin Region: field surveys, including mapping; and the preparation of interpretive analyses. All soil mapping was done in the field on enlarged SEWRPC aerial photographs, which were ratioed and rectified during enlargement to produce, in effect, photo maps free from all major sources of distortion and displacement. The soil scientists in conducting the field survey employed many tools, of which the most important was the body of substantive knowledge about soils in their possession gained both through formal education and years of experience and careful observation of soil behavior. Certain limitations of the soil survey must be recognized. These include a normal depth of investigation of about five feet; the possible inclusion in soil unit delineations of small areas of different soil types; human error in soil identification, classification, and map drafting; and possible soil map boundary variations. These limitations, however, represent only very minor obstacles to full application of the soil survey and its interpretive analyses in both rural and urban planning and development.

INTERPRETATIONS OF SOIL SURVEY DATA

While originally applied primarily to farm planning, application of the soil survey has in recent years been expanded to include many nonagricultural purposes. A series of interpretive tables containing ratings in terms of limitations of given soil types for given uses have been prepared and published in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. The tables are grouped under four general categories of interpretive analyses: interpretations for engineering purposes, such as the chemical and physical properties of soils, water management characteristics of soils, and the suitability of soils for road construction and other specific engineering applications; interpretations for planning purposes, such as the suitability of soils for residential development with or without public sanitary sewer service, for light industrial and commercial buildings, and for transportation facility location; interpretations for agricultural purposes, such as the suitability of soils for cultivated crops and pasture; the capability of soils for irrigation and drainage and estimates of cropland and woodland yields; and interpretations for aesthetic and recreational purposes, such as the capability of soils for wildlife habitat or the maintenance of greens, shade trees, and ornamental shrubs. These interpretations provide the key for relating the regional soil survey to urban and rural development activities within the Southeastern Wisconsin Region.

REGIONAL AND WATERSHED PLANNING

The regional soil survey and interpretive analyses have provided invaluable basic data inputs to various regional and watershed planning programs conducted by the Commission. Of particular importance has been the use of the soils data in the design of the adopted regional land use plan. The soil survey was used in the land use plan preparation to identify land suitable for various types of development and as an aid in delineating the primary environmental, or high-value natural resource, corridors. In the Commission's comprehensive watershed studies, the detailed soils data and, in particular, the hydrologic soil groupings have been extensively utilized in the development of hydrologic simulation models used to evaluate possible flood characteristics of river systems. Implementation recommendations relating to the regional and watershed plans also extensively utilize the soils data.

COMMUNITY AND NEIGHBORHOOD DEVELOPMENT PLANNING

The detailed soil survey and interpretive analyses can be applied in a variety of ways in planning and engineering at the community level. Soil suitability analyses are extremely useful in community land use planning. In addition, soils data can be utilized in the preparation of storm water drainage plans, including the design of urban storm water drainage systems, and in the preparation of precise neighborhood unit development plans. Soils unsuitable for urban development can be identified and placed in the design process in public and private open space through the use of "cluster" and "planned unit development" techniques.

ZONING REGULATIONS

One of the most important land use controls available to a local unit of government is the community zoning ordinance. The detailed soil survey and interpretive analyses may be used to create special zoning districts appropriate to the capability and suitability of soils for specific uses. In addition, special soil-related zoning regulations may be prepared for inclusion in a zoning ordinance, such as a general land suitability clause, steep land regulations, erodible land regulations, and sanitary regulations. Soil survey maps may be used as an aid in delineating zoning districts, special regulatory areas, and flood-prone areas.

LAND DEVELOPMENT REGULATIONS AND PRACTICES

The detailed soil survey and interpretive analyses can provide an important input to the land subdivision design process. Soils data can be used to assist in delineating drainageways, parkways, and park sites. Soils data must also be taken into account in the shaping and sizing of blocks and lots so that each lot contains suitable soils for site development. Land division ordinances should contain special soil-related regulations designed not only to require that soils data be considered in the design process but also that special erosion and sedimentation control practices be followed in the actual land development process. Direct technical assistance in the development of specialized erosion control practices is available from the U. S. Soil Conservation Service.

HEALTH AND SANITARY REGULATIONS

Rapid urban development within the Region has resulted in substantial urban growth taking place beyond the existing and, often, proposed service limits of public sanitary sewer systems. Such development is consequently forced to rely on private on-site soil absorption sewage disposal systems, commonly called "septic tank systems." In many instances, these systems have been located on soils that are ill-suited for the absorption of sewage effluent, with the result that these systems often malfunction and create serious health and sanitation problems. The detailed soil survey and interpretive analyses can be used to delineate those soils on which septic tank systems should not be placed, including floodland and wetland soils, high water table soils, "tight" or slowly permeable soils, rapidly permeable soils or soils over creviced or fractured bedrock, and soils on slopes in excess of 12 percent. Sanitary ordinances based on the soils information can be effectively utilized to avoid the problems created by malfunctioning septic tank systems by prohibiting or curtailing the installation of such sewage disposal systems on soils having severe and very severe limitations for the absorption of sewage effluent.

SOIL AND WATER CONSERVATION PLANNING

The detailed soil survey data remain of great significance to farm planning and other rural soil and water conservation efforts. Proper agricultural and other rural development practices will reduce soil erosion and sedimentation, conserve the soil resource base, and contribute toward the making of an economical rural environment. Sound agricultural conservation activities include cropland practices, such as contour farming and stripcropping; pasture and hay land management and planting practices; woodland practices, such as field windbreaks; recreation-related practices, such as trail construction; and practices dealing with water impoundment and sediment control. Technical and financial assistance is available for the carrying out of sound soil conservation measures in rural areas.

OTHER USES OF SOILS DATA

In addition to being very useful in local planning activities and in rural soil and water conservation activities, the detailed soils data can be applied in various other areas. Land appraisers and assessors can use the soils data to develop comparative values of land parcels. Soils data can be useful in estimating land development costs, such as the cost of constructing storm and sanitary sewers and water mains. Highway design engineers find the soils data helpful in highway route location and in detailed highway design, including drainage, earthwork, and pavement design. Finally, the soils data and analyses can be effectively used in the site selection process for such uses as water impoundment areas, recreation areas, and sanitary land fill areas.

ADMINISTRATIVE AND LEGAL CONSIDERATIONS

The use of the soil survey and interpretive analyses in local land use control measures has important administrative and legal ramifications. Public employees charged with the administration of land use regulatory ordinances that incorporate the soils data must gain a working knowledge of the soil survey, its interpretations, and its application. Expert technical assistance in properly administering such regulatory ordinances is available to local units of government in southeastern Wisconsin from various agencies under an intergovernmental Memorandum of Understanding between the U. S. Soil Conservation Service, the University of Wisconsin Extension Service, the seven county soil and water conservation districts, and the Commission. Administrative procedures must be established whereby the soils data may be routinely challenged and any errors in the soil survey rectified. At times it may be necessary to defend the use of soils data in legal proceedings. Since the use of soil surveys in regulatory devices is a relatively new concept, the soil survey has not as yet been routinely accepted by the courts as a valid concept and technique for obtaining and applying data. Therefore, the first step in defending the use of soils data would probably have to be the establishment of the validity of the soil survey itself.

CONCLUSION

The detailed soil survey and its accompanying interpretive analyses represent one of the most important and valuable tools available for use by planners, engineers, and other technicians concerned with sound planning and development. It is proving to be one of the soundest investments of public funds that has been made within the Region.

Soil surveys and suitability studies of the type undertaken in southeastern Wisconsin show the geographic locations of the various kinds of soils; identify their physical, chemical, and biological properties; and interpret these properties for land use and public facilities planning. The resulting comprehensive knowledge of the character and suitability of the soils is indispensable to the adjustment of urban development to the supporting and sustaining natural resource base. If properly applied, the detailed soil survey data can provide the basis for many important day-to-day community development decisions by federal, state, and local units of government and by private investors.

Definitive soils data are essential to intelligent zoning, subdivision control, building control, and sanitation control at the local level of government within the Region. The model regulations set forth in the appendices to this Guide provide the basis for incorporating the detailed soil survey and interpretive analyses directly into the traditional local zoning, subdivision, building, and sanitary ordinances.

If soil properties as revealed by a detailed soil survey are ignored in the process of land development and its control by local units of government, irreparable damage may be done to the land and water resources of the local community and the Region. Failure to effectively utilize the soils data in the making of development decisions not only constitutes irresponsibility but also demonstrates a lack of concern over the intensification of environmental problems in the Region and the concomitant further deterioration and destruction of the natural resource base. Such destruction can only lead to a reduction in the standard of human life within the Region.

APPENDICES

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Appendix A
MEMORANDUM OF UNDERSTANDING ON THE USE AND ADAPTATION OF SOILS INFORMATION FOR LOCAL PLANNING IN THE SOUTHEASTERN WISCONSIN REGION

SECTION 1.1 Participants

This Memorandum of Understanding was entered into this 19th day of January, 1966, by and between the Southeastern Wisconsin Regional Planning Commission (hereinafter referred to as the ‘‘Commission’’), the U. S. Department of Agriculture, Soil Conservation Service (hereinafter referred to as the ‘‘Service’’), the Wisconsin Co-operative Extension Service (hereinafter referred to as the ‘‘Extension’’), and the undersigned Soil and Water Conservation Districts (hereinafter referred to as the ‘‘Districts’’).

SECTION 1.2 Introduction

The Commission, pursuant to Section 66.945 of the Wisconsin Statutes, is performing areawide research and preparing areawide development plans, such as a regional land use-transportation plan, a Root River watershed plan, a Fox River watershed plan, and a comprehensive development plan for the Kenosha Planning District.

The Service, by cooperative agreement with the Commission, is performing an operational soil survey and analysis for the Southeastern Wisconsin Region, composed of the counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha. This survey and analysis is not only being utilized for regional and watershed planning but is being used and adapted to local planning and development programs by many local units of government throughout the Region.

The Extension, pursuant to the Smith-Lever Act of 1914, is carrying out a variety of problem-oriented educational programs as the educational arm of the U. S. Department of Agriculture, in cooperation with the University of Wisconsin, the local county boards, and the Districts.

The Districts, under a basic and supplemental ‘‘Memorandum of Understanding’’ with the Service, have the responsibility to arouse local interest with the necessity for attaining soil conservation objectives and administering conservation plans for farms, watersheds, natural areas, and other land units.

To ensure that the Commission's basic planning data and materials and other information, such as the operational soil survey, will be used and adapted at the local level, the Commission has provided for a community assistance program and has received partial financial support from the Housing and Home Finance Agency for an educational, advisory, and review services program. This project has as one of its purposes the extension of the soils data to local officials and communities, encouragement of its use, and assistance in adapting the soils data to local planning and development programs.

SECTION 1.3 Need

The 153 local units of government comprising the service area of the Southeastern Wisconsin Regional Planning Commission, in order to properly utilize and adapt the operational soil survey and analysis to their local planning and development programs, require the educational, advisory, and review services offered by the Commission's community assistance program.

In providing these services, the Commission requires technical and professional assistance available from the Service's engineers, soil scientists, and work unit conservationists, as authorized by the U. S. Soil Conservation Act of 1935 (Public Law No. 46--74th Congress, 49 Stat. 163) and other acts, and educational assistance available from the Extension's field staff and state specialists.

In providing this assistance, the Service requires the aid and assistance available from the Districts' supervisors, as authorized by Section 92.08(2) of the Wisconsin Statutes.

SECTION 1.4 Purpose

The purpose of this memorandum is to provide for an understanding between the Commission, the Service, the Extension, and the Districts as to the type of assistance each can render to the local units of government in the Region on a continuing basis so as to extend, encourage, and ensure the use and adaptation of the soil survey and analysis to local planning and development programs. This purpose can only be achieved through the full and active cooperation of all of the participants to this agreement.

SECTION 1.5 Educational Services

Under this memorandum the participants propose to provide technical information and educational services to local officials, citizen groups, and interested individuals on the need for, advantages of, and uses of the operational soil survey and analysis.

The Commission will:

a. Assist and cooperate in the preparation of course outlines, detailed lectures, and display materials; contact speakers; and sponsor or participate in soil education programs, such as conferences and workshops.

b. Assist and cooperate in the preparation of educational materials containing articles announcing or explaining soils data, such as newsletters, press releases, and fact sheets.

c. Attend, participate, and cooperate at meetings with local planning agencies and local governing bodies where soils data is presented and explained and the relationship of the soils data to community planning and development programs is illustrated.

d. Provide soil maps and interpretative data to local units of government for the cost of reproduction and mailing.

The Service will:

a. Assist, participate, and cooperate in soil educational programs.

b. Attend, participate, and cooperate at meetings with local planning agencies and local governing bodies where the availability and use of soils data and soil and water conservation assistance is presented.

The Extension will:

a. Develop and initiate, in cooperation with the other participants, educational programs, including the preparation of educational plans (project plans), course outlines, detailed lectures, and display materials; provide speakers for, and sponsor and participate in, soil education programs, such as conferences and workshops.

b. Identify soil survey user groups within the Region which may require special educational programs and efforts.

c. Schedule and conduct meetings, demonstrations, conferences, and workshops for special user groups, including the preparation of a calendar, assembly of resource persons and educational materials, and extension of invitations.

d. Generally carry on the educational phases of the soil program through the media of meetings, demonstrations, personal and mimeograph letters, circulars, bulletins, weekly and daily press, radio, and television.

The Districts will:

a. Assist and cooperate in the sponsoring and coordination of educational programs.

b. Generate the active interest of local planning agencies and local governing bodies in attaining the goals of soil and water conservation.

c. Advise local units that such soils data and assistance are available.

SECTION 1.6 Advisory Services

The participants propose to provide basic technical information, limited professional assistance, and general assistance to local officials in the use and adaptation of the operational soil survey and analysis to local planning and development problems.

The Commission will:

a. Arrange meetings where Service personnel can explain the soil survey methodology, limitations, and suitability ratings.

b. Advise on the incorporation, adjustment, and adaptation of the soil survey to community planning and development programs.

c. Prepare planning programs and planning work specifications that include soils data.

d. Prepare model and suggested plan implementation devices that utilize soils data.

The Service will:

a. Attend and participate at meetings with local planning agencies and governing bodies for the purpose of providing advice on the use and adaptation of the soil survey.

b. Provide qualified persons to make on-site soil investigations and interpretations where soils are questionable or perform more detailed soil surveys on occasional areas for interpretative purposes.

c. Provide technical assistance in the application of soil and water conservation practices to land and water resources, such as grass waterways and impoundments.

d. Provide technical advice as to the methods and works necessary to overcome soil limitations for specific uses.

e. Provide municipal engineers and planners with technical information concerning the design and construction of flood control, water quality protection, erosion prevention and sedimentation prevention facilities, and sound soil and water conservation management practices.

f. Provide municipal park and recreation bodies with assistance and advice on the proper development of conservation and recreation areas.

The Extension will:

a. Attend and participate with local planning agencies and governing bodies for the purpose of providing advice on the use and adaptation of the soil survey.

b. Assist and cooperate in the processing of requests for materials to the Commission and Service.

The Districts will:

a. Assist and cooperate in the processing of requests to the Commission, the Service, and the Extension from local units for advisory services.

b. Canvass the local governing bodies and keep themselves, the Commission, the Service, and the Extension advised as to local planning and development problems relating to the misuse of soils in accordance with Section 92.07(3) of the Wisconsin Statutes.

SECTION 1.7 Review Services

The participants propose to provide certain limited reviewing services to local officials on their use and adaptation of the operational soil survey and analysis to local plans and plan implementation devices.

The Commission will upon request:

a. Review the contents of all ''701'' urban planning programs to ensure that such programs provide for the use of the soils data.

b. Review all studies, plans, and implementation devices prepared under ''701'' urban planning programs to ensure that such studies, plans, and devices reflect the use of soils data.

c. Review plans and implementation devices prepared by local, state, and federal agencies as to incorporation and adaptation of soils information.

The Service will upon request:

a. Review and comment on soil maps, plans, and implementation devices prepared by the Commission or local communities to ensure that such materials are accurate and reflect the proper use and adaptation of the soil data.

The Districts will upon request:

a. Review and comment on all plans as they relate to district soil and water conservation development plans prepared in accordance with Section 92.08 of the Wisconsin Statutes.

b. Review and comment on all implementation devices as they relate to soil and water conservation regulations adopted pursuant to Section 92.09 of the Wisconsin Statutes.

SECTION 1.8 Materials and Personnel

The Commission, Service, Extension, and Districts further agree that:

a. All data and reports prepared under this memorandum will be made available or accessible to each of the participants and the local units of government within the participating districts. The Commission, however, reserves the right to withhold its data and its assistance from those local units of government not participating in the Commission.

b. All expenses incurred in providing the educational, advisory, and review services contemplated by this memorandum will be absorbed by those agencies furnishing the services but only to the extent that they determine that their staff or budgetary resources will permit.

SECTION 1.9 Renewal and Withdrawal

This memorandum is effective until June 30 of each year, with annual renewal by the Service and automatic renewal by all other signatories for each subsequent year; however, any participant may withdraw from this memorandum by giving written notice to all the other signatories sixty (60) days prior to such withdrawal. Such withdrawal shall not affect the memorandum as between the other signatories.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION OF WISCONSIN
Date 12/24/65 By /s/ George Berteau
Chairman

SOIL CONSERVATION SERVICE OF THE U. S. DEPARTMENT OF AGRICULTURE
Date 1/3/66 By /s/ W. W. Russell
State Conservationist

WISCONSIN COOPERATIVE EXTENSION SERVICE
Date 1/6/66 By /s/ Henry L. Ahlgren
Associate Director

SOIL AND WATER CONSERVATION DISTRICTS
KENOSHA COUNTY
Date 1/13/66 By /s/ Earl W. Hollister
Chairman, Governing Body

MILWAUKEE COUNTY
Date 1/27/66 By /s/ Herbert G. Froemming
Chairman, Governing Body

OZAUKEE COUNTY
Date 1/19/66 By /s/ Ray F. Blank
Chairman, Governing Body

RACINE COUNTY
Date 1/19/66 By /s/ William J. Rohan
Chairman, Governing Body

WALWORTH COUNTY
Date 1/19/66 By /s/ Franklin E. Walsh
Chairman, Governing Body

WASHINGTON COUNTY
Date 1/19/66 By /s/ E. M. Romaine
Chairman, Governing Body

WAUKESHA COUNTY
Date 1/19/66 By /s/ Lloyd G. Owens
Chairman, Governing Body

SUBSEQUENT SIGNATORY SHEET
FOR ANNUAL RENEWAL BY THE
SOIL CONSERVATION SERVICE OF THE
U. S. DEPARTMENT OF AGRICULTURE

June 30, 1966 By /s/ W. W. Russell
State Conservationist

June 30, 1967 By /s/ W. W. Russell
State Conservationist

June 30, 1968 By /s/ W. W. Russell
State Conservationist

June 30, 1969 By /s/ W. W. Russell
State Conservationist

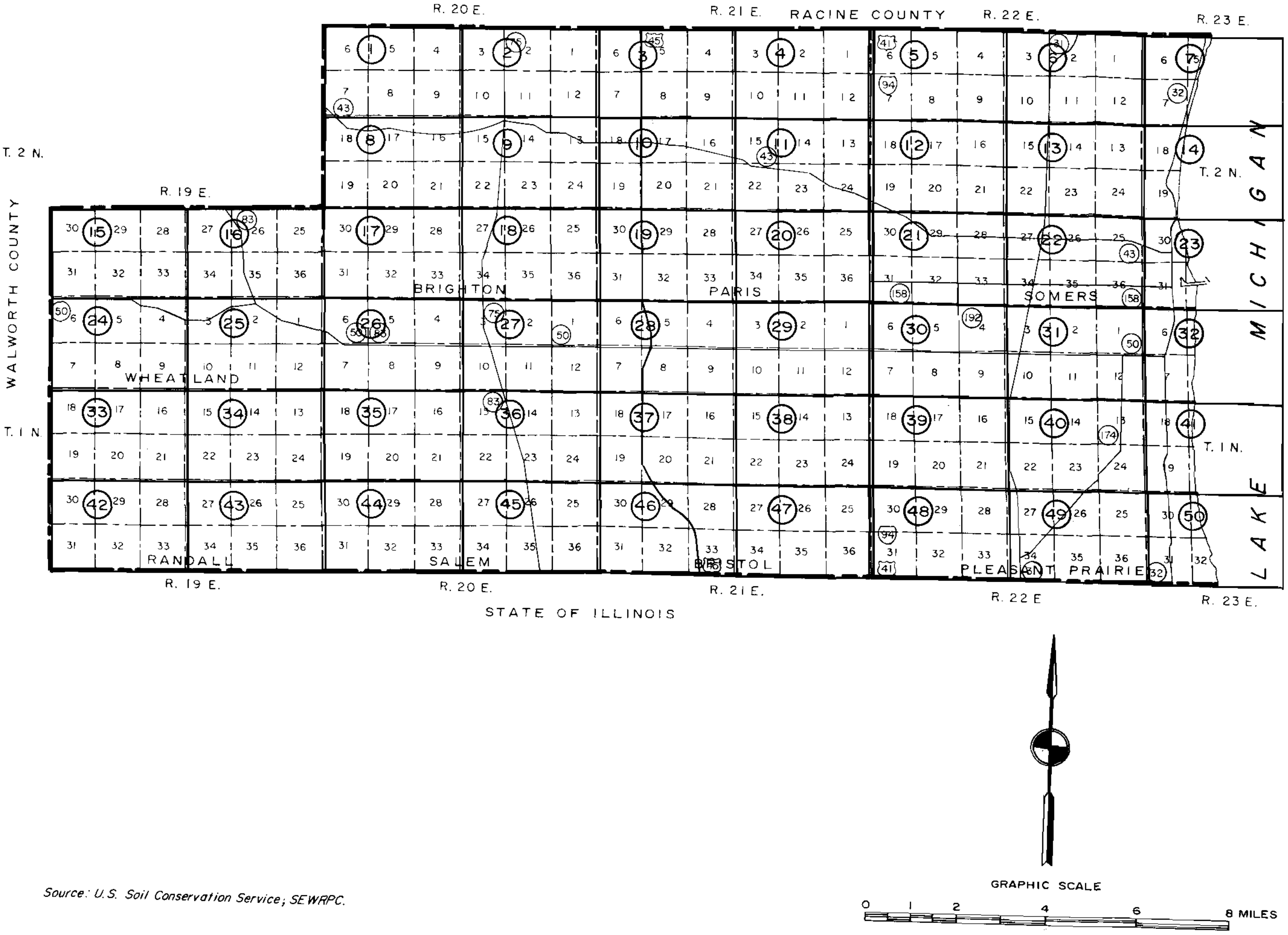
June 30, 1970 By /s/
State Conservationist

Appendix B
SOIL PHOTO MAP INDEX

Copies of soil photo maps may be ordered directly from the Commission offices. The following nine county index maps provide the basis for identifying the particular soil photo map desired. By locating the particular county, town, and U. S. Public Land Survey section number desired, the appropriate soil photo map number can be determined. Each map covers six sections, or six square miles. Maps at a scale of 1" = 2000' are available for the entire Region and for those portions of Dodge, Fond du Lac, and Sheboygan Counties lying within the Milwaukee River Watershed; maps at a scale of 1" = 1000' are available for all of Kenosha, Racine, Walworth, Washington, and Waukesha Counties. Orders for soil photo maps may be placed by telephone or by addressing a request to:

Administrative Officer
Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
Waukesha, Wisconsin 53186

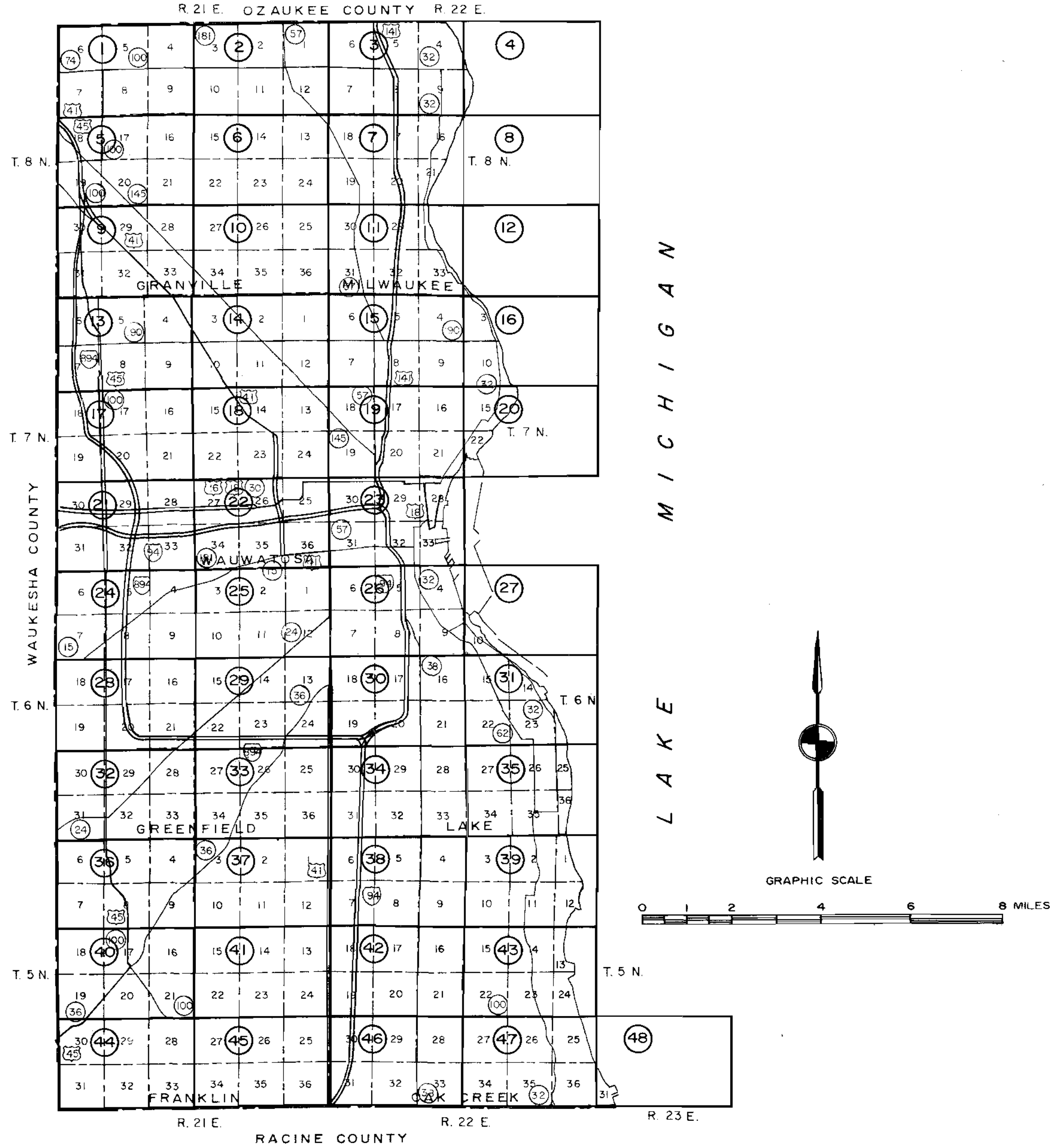
Map B-1
KENOSHA COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

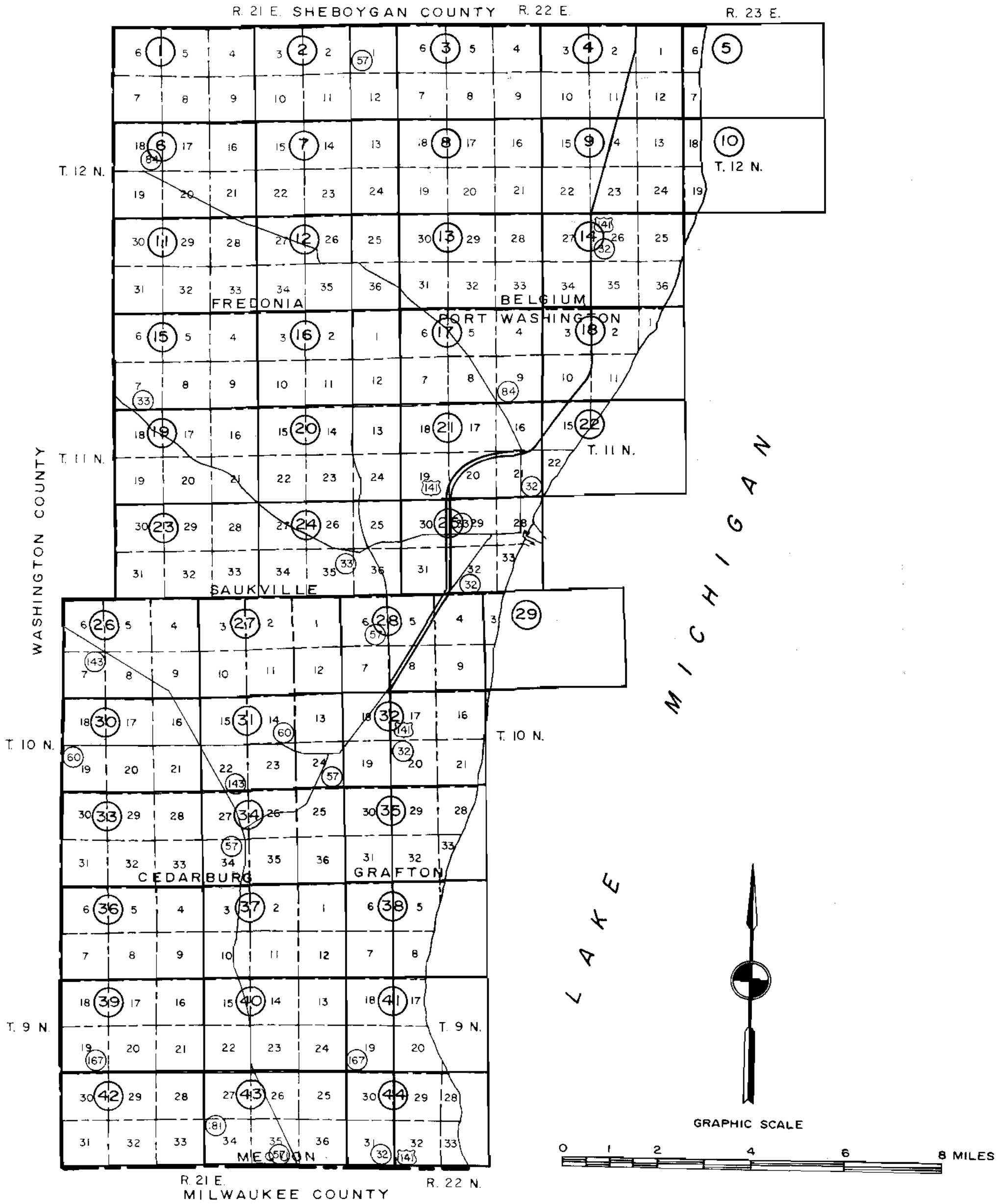
Map B-2

MILWAUKEE COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

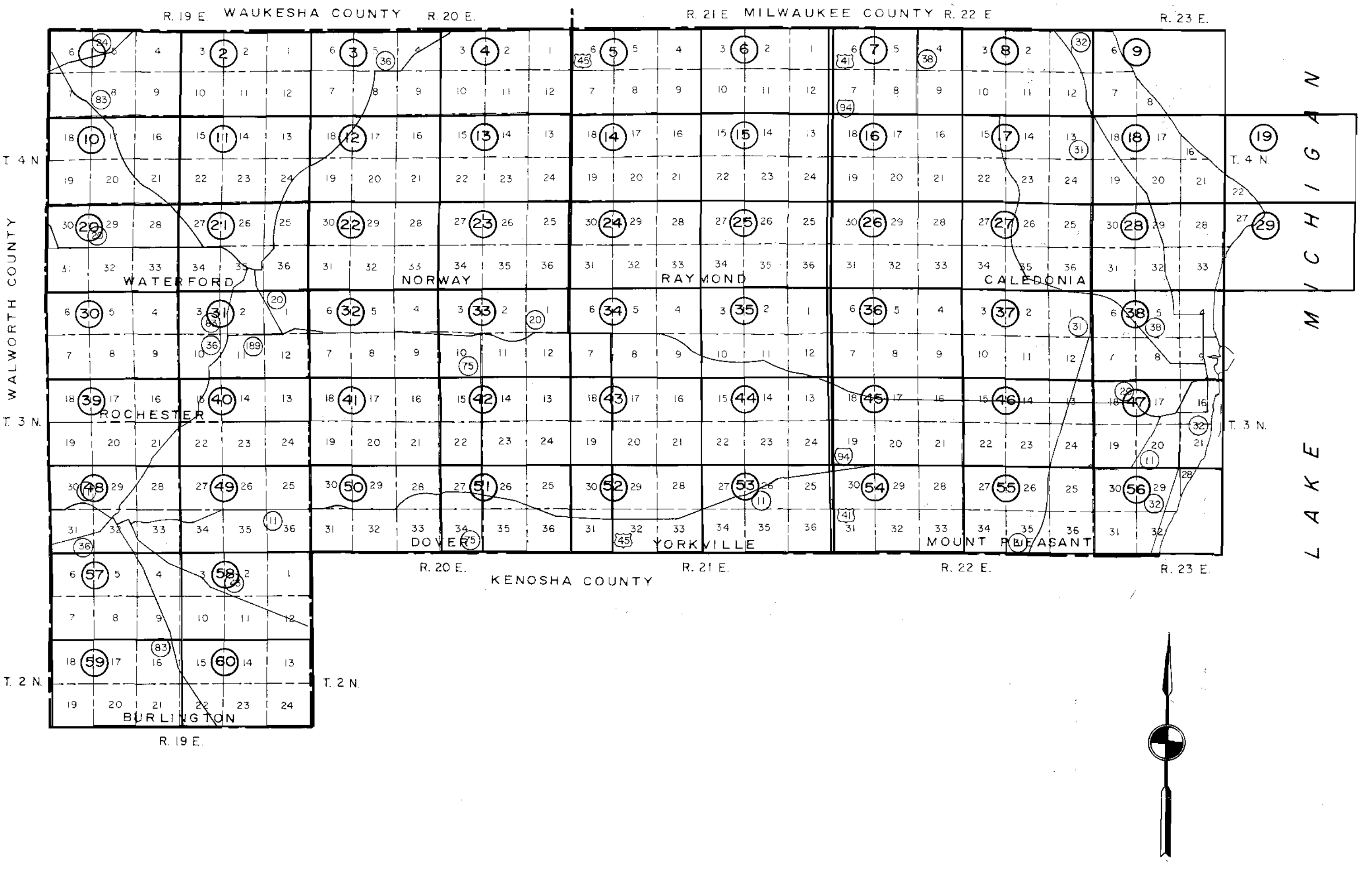
Map B-3
OZAUKEE COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

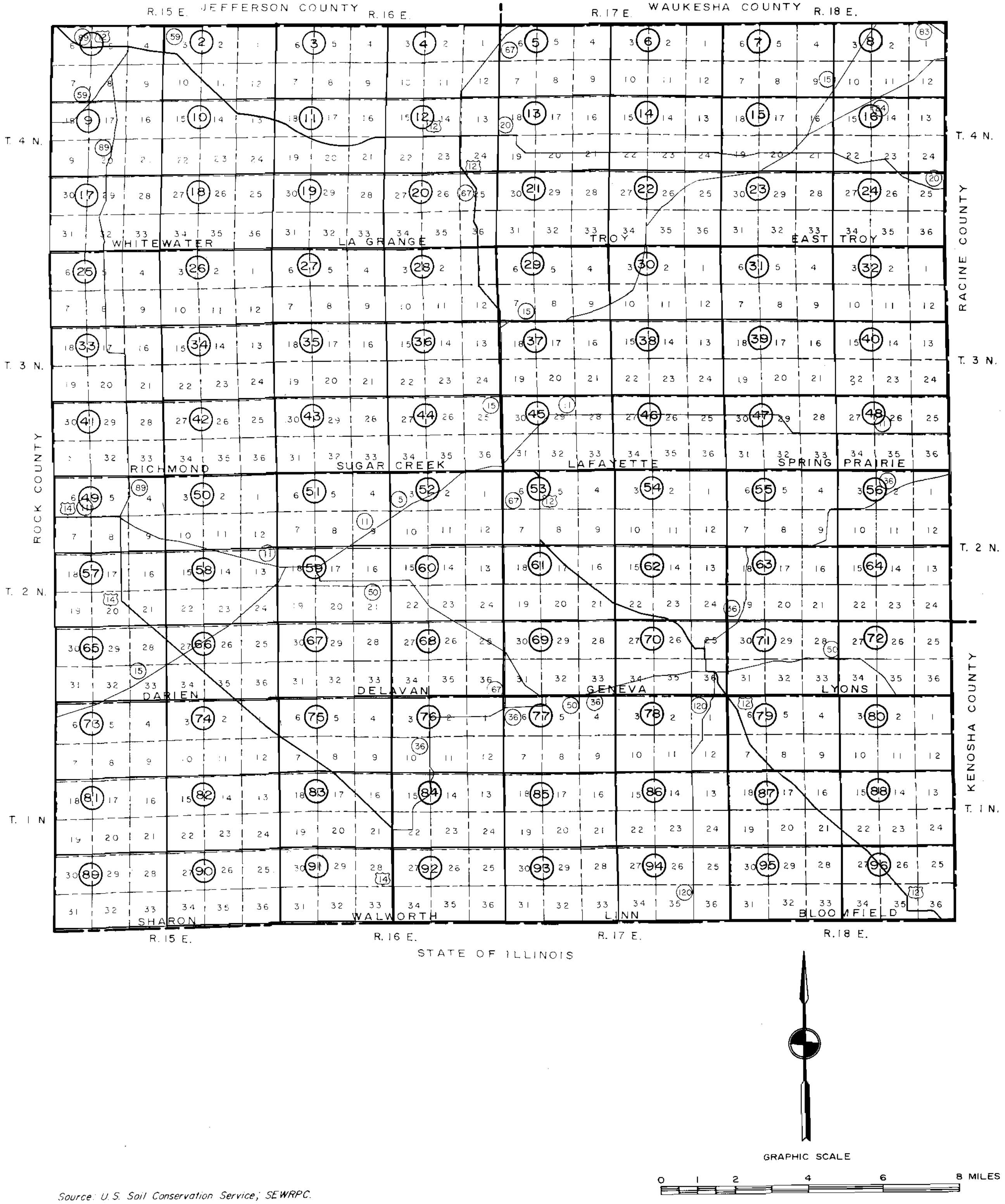
Map B-4

RACINE COUNTY
SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

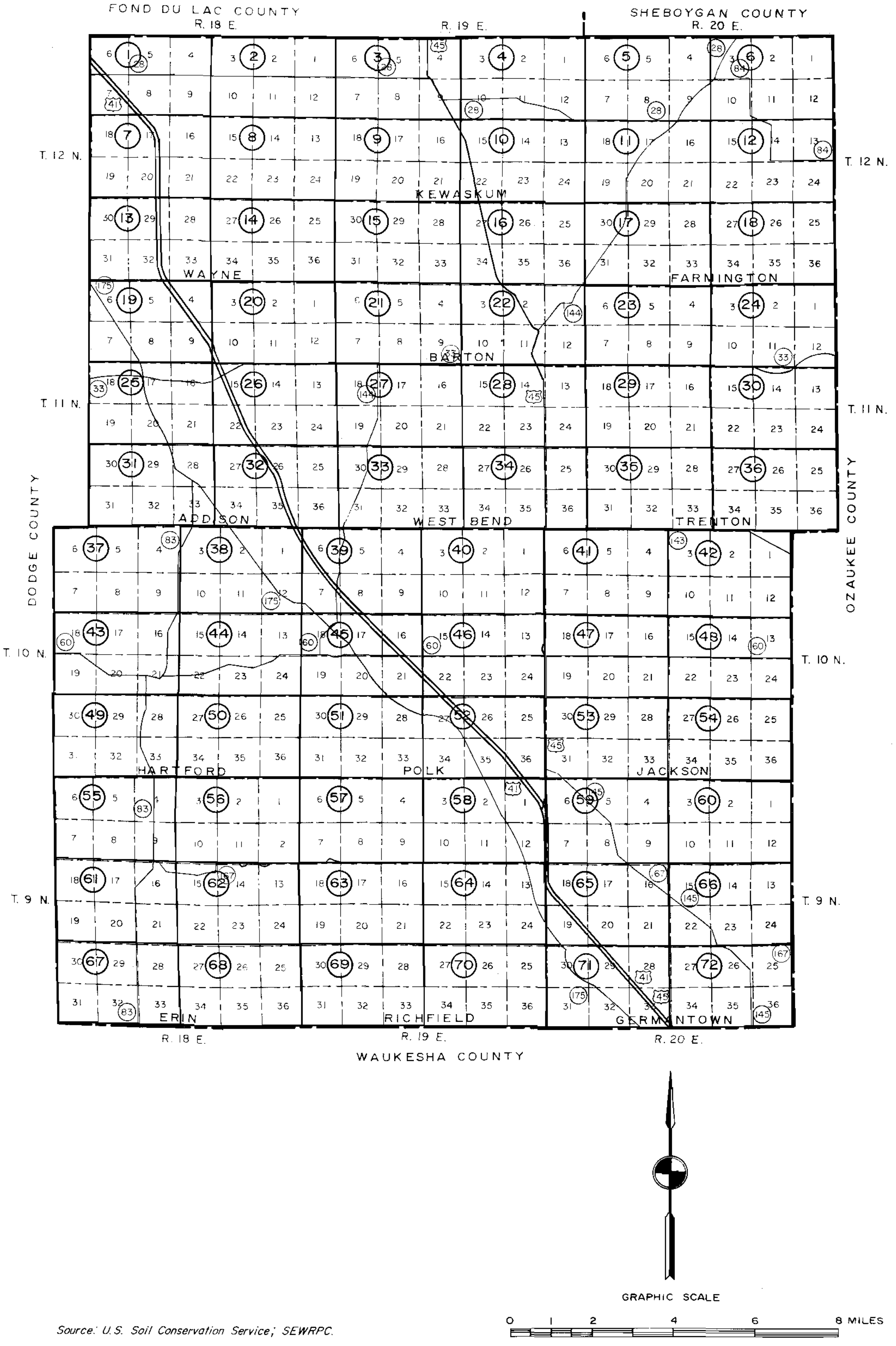
Map B-5
WALWORTH COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

Map B-6

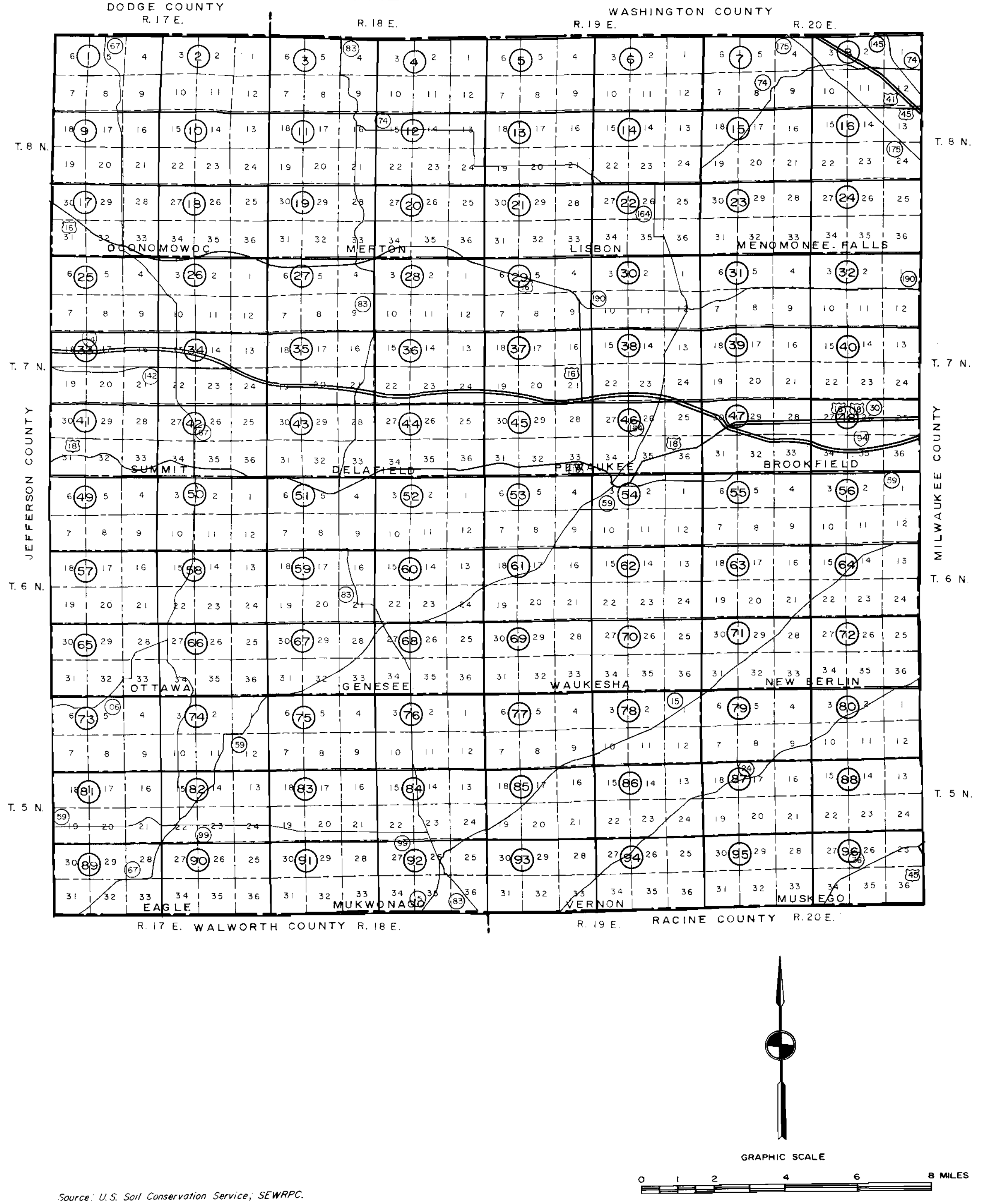
WASHINGTON COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

Map B-7

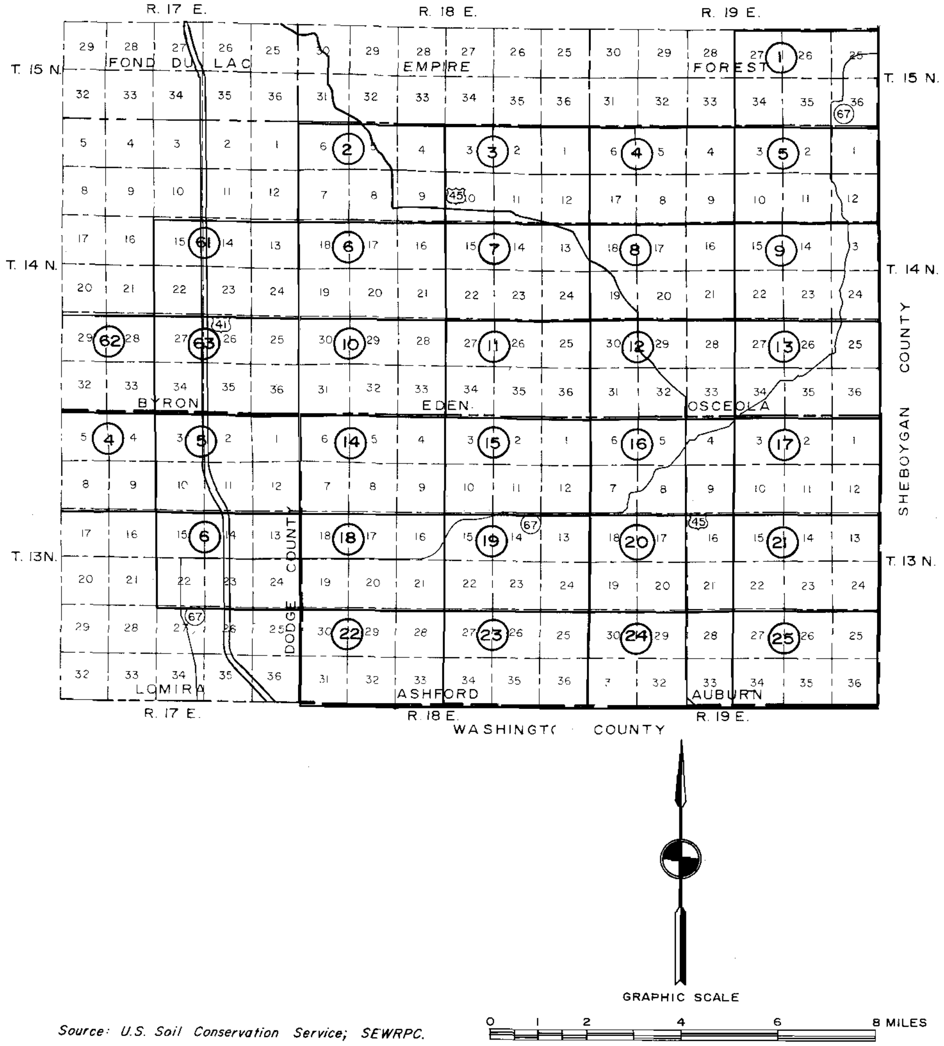
WAUKESHA COUNTY SOIL PHOTO MAP INDEX



Source: U.S. Soil Conservation Service; SEWRPC.

Map B-8

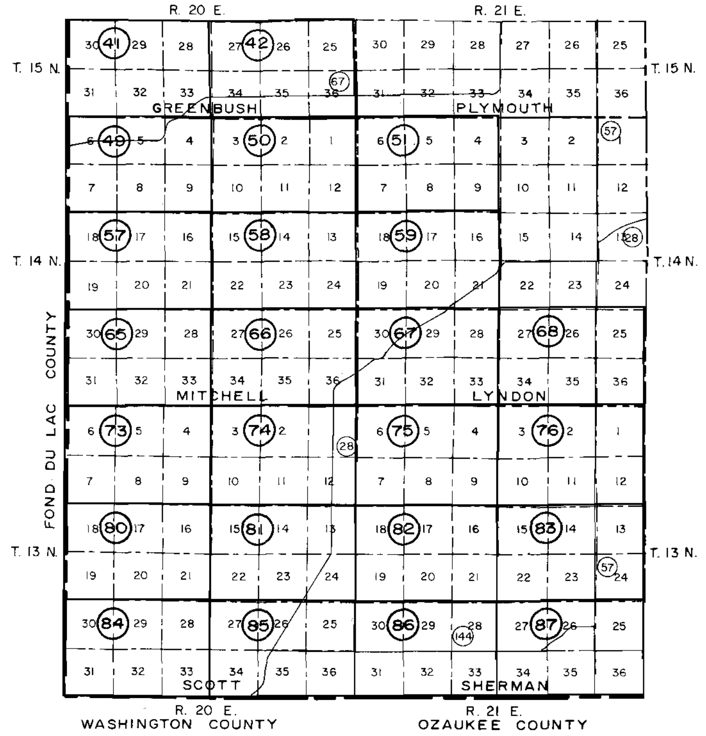
DODGE AND FOND DU LAC COUNTIES SOIL PHOTO MAP INDEX

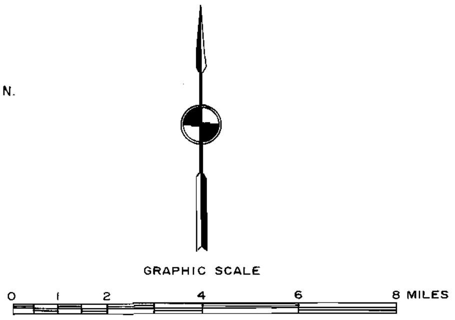


Source: U.S. Soil Conservation Service; SEWRPC.

Map B-9

SHEBOYGAN COUNTY
SOIL PHOTO MAP INDEX





Source: U. S. Soil Conservation Service; SEWRPC.

Appendix C
HYDROLOGIC GROUPING OF SOILS IN THE SOUTHEASTERN WISCONSIN REGION

HYDROLOGIC GROUP A

Soil Mapping Number	Soil Type (Wisconsin)
14	Crestview Loamy Fine Sand
75	Rodman Gravelly Loam
95	(See No. 75, Rodman Gravelly Loam)
96	(See No. 75, Rodman Gravelly Loam)
97	Hackett Loamy Sand
102	Vilas Loamy Sand
108	Lorenzo-Rodman Loams (Rodman Gravelly Loam)
133	Spinks Fine Sand
133Z	(See No. 411, Spinks Fine Sand, Silty Substratum)
134	Spinks Loamy Fine Sand
195	Hackett Loamy Sand
250	Tedron Sandy Loam
250V	Tedron Sandy Loam, (Silt & Fine Sand Substratum)
250Y	Tedron Sandy Loam, Loam Substratum
251	Tedron Loamy Sand
251Y	Tedron Loamy Sand, Loam Substratum
270	Hackett Sandy Loam
271	Hackett Loamy Sand
281	Hackett Loam
282	Casco-Rodman Loams (Rodman Gravelly Loam)
288	Hackett Loamy Sand
289	Hackett Sandy Loam
410	Spinks Loamy Fine Sand
411	Spinks Fine Sand, Silty Substratum
413	Crestview Fine Sandy Loam
414	Crestview Loamy Fine Sand
419	Beach Sand

HYDROLOGIC GROUP B

Soil Mapping Number	Soil Type (Wisconsin)
3	Stony Colluvium
7	Dorchester Silt Loam
10	Alluvial Land
11	Alluvial Land
12	Wea Silt Loam
16	Rome Silt Loam
16Z	(See No. 362, Theresa Silt Loam)
18	Sisson Silt Loam
18Y	Sisson Silt Loam, Loam Substratum
19	Sisson Fine Sandy Loam
20	(See No. 120, Warsaw Loam)

HYDROLOGIC GROUP B (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
21	Hebron Loam
21Y	Hebron Loam, Loam Substratum
22	Hebron Sandy Loam
24	Hebron Silt Loam
31	Rome Loam
32	Rome Sandy Loam
33	Sisson Fine Sandy Loam
33Z	Sisson Fine Sandy Loam (Clay Substratum)
34	Sisson Silt Loam
39X	Saylesville Loam, Gravelly Substratum
40R	(See No. 208, Knowles Silt Loam)
40V	Saylesville Silt Loam (Silt & Fine Sand Substratum)
40X	Saylesville Silt Loam (Gravelly Substratum)
40Y	Saylesville Silt Loam (Loam Substratum)
43	(See No. 206, Knowles Silt Loam, Shallow Variant)
43R	(See No. 206, Knowles Silt Loam, Shallow Variant)
44	Jericho Silt Loam
56	(See No. 357, Hochheim Loam)
69	Casco-Fox Silt Loam
70	Fox Sandy Loam
70V	Fox Sandy Loam (Silt & Fine Sand Substratum)
70Y	Fox Sandy Loam, Loam Substratum
70Z	Fox Sandy Loam, Clay Substratum
71	Casco-Fox Loams
72	Fox Loam
72R	Fox Loam, Rock Substratum
72V	Fox Loam, Silt & Fine Sand Substratu
72Y	Fox Loam, Loam Substratum
72Z	Fox Loam, Clay Substratum
73	Fox Silt Loam-Walworth County only
73R	Fox Silt Loam, Rock Substratum
73V	Fox Silt Loam, Silt & Fine Sand Substratum
73Y	Fox Silt Loam, Loam Substratum
73Z	Fox Silt Loam, Clay Substratum
74	(See No. 70, Fox Sandy Loam)
84	Ockley Silt Loam
84V	Ockley Silt Loam, Silt & Fine Sand Substratum
84R	Ockley Silt Loam, Rock Substratum
84Z	Ockley Silt Loam, Clay Substratum
86	Thackery Silt Loam

HYDROLOGIC GROUP B (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
86V	Thackery Silt Loam, Silt & Fine Sand Substratum
90	(See No. 91, Parr Silt Loam)
91	Parr Silt Loam
91D	Parr Silt Loam
91N	(See No. 91, Parr Silt Loam)
92	Parr Loam
92N	Parr Loam
93	(See No. 73, Fox Silt Loam)
99	Kewaunee Soils
100	Kewaunee Silt Loam
101	Kewaunee Sandy Loam
102Z	(See No. 254, Tustin Sandy Loam)
103	Kewaunee Silt Loam (12-20% slopes)
103	(See No. 100, Kewaunee Silt Loam, 12-20% slope moderately eroded)
106	Lorenzo Silt Loam
106Z	Lorenzo Silt Loam, Clay Substratum
108	Lorenzo-Rodman Loam
110	Lorenzo Loam
110R	Knowles Silt Loam
110Y	Lorenzo Loam, Loam Substratum
110Z	Lorenzo Loam, Clay Substratum
111	Dodge Silt Loam
112	Calamus Silt Loam
114	Miami Silt Loam
116	Celina Silt Loam
119	Warsaw Silt Loam
119V	Warsaw Silt Loam, Silt & Fine Sand Substratum
119Y	Warsaw Silt Loam, Loam Substratum
119Z	Warsaw Silt Loam, Clay Substratum
120	Warsaw Loam
120V	(See No. 267, Sisson Fine Sandy Loam)
120Y	Warsaw Loam, Loam Substratum
120Z	Warsaw Loam, Clay Substratum
121	Lorenzo-Rodman Loams
122	Lorenzo Loam
123	Tippecanoe Silt Loam
123V	Tippecanoe Silt Loam, Silt & Fine Sand Substratum
123Z	Tippecanoe Silt Loam, Clay Substratum
125	Knowles Silt Loam, Shallow Variant
151	(See No. 100, Kewaunee Silt Loam)
152	Lapeer Loam, Shallow Variant
153	Lapeer Loam
154	McHenry Silt Loam
155	McHenry Silt Loam
156	Lapeer Sandy Loam
157	Lapeer Sandy Loam
158	(See No. 152, Lapeer Loam, Shallow Variant)
160	Hochheim-Casco-Sisson Loams
161	Dodge Silt Loam
161R	Dodge Silt Loam, Rock Substratum
162	(See No. 362, Theresa Silt Loam)

HYDROLOGIC GROUP B (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
170	Casco Sandy Loam
170V	Casco Sandy Loam, Silt & Fine Sand Substratum
170Y	Casco Sandy Loam, Loam Substratum
170Z	Casco Sandy Loam, Clay Substratum
172	Casco Loam
172R	Casco Loam, Rock Substratum
172V	Casco Loam, Silt & Fine Sand Substratum
172Y	Casco Loam, Loam Substratum
172Z	Casco Loam, Clay Substratum
173	Casco Silt Loam
173V	Casco Silt Loam, Silt & Fine Sand Substratum
173Y	Casco Silt Loam, Loam Substratum
173Z	Casco Silt Loam, Clay Substratum
191	Parr Silt Loam, Shallow Variant
195V	Hackett Loamy Sand, Silt & Fine Sand Substratum
195Y	Hackett Sandy Loam, Loam Substratum
195Z	Hebron Sandy Loam
204	Knowles Loam
206	Knowles Silt Loam, Shallow Variant
208	Knowles Silt Loam
226	Keyser Silt Loam
226B	(See No. 91, Parr Silt Loam)
226D	Keyser Silt Loam
226N	(See No. 91, Parr Silt Loam)
226W	(See No. 91, Parr Silt Loam)
235	(See No. 73, Fox Silt Loam-Walworth County only)
243	Calamus Silt Loam
254	Tustin Sandy Loam
258	(See No. 510, Pecatonica Silt Loam)
260	(See No. 360, Hochheim Silt Loam)
261	Hackett Sandy Loam, Wet Variant
262	Hackett Loamy Sand, Wet Variant
262R	(See No. 208, Knowles Silt Loam)
265	(See No. 266, Sisson Silt Loam)
266	Sisson Silt Loam
266R	Sisson Silt Loam, Rock Substratum
266X	Sisson Silt Loam, Sand & Gravel Substratum
266Y	(See No. 266, Sisson Silt Loam)
266Z	Sisson Silt Loam, Clay Substratum
267	Sisson Fine Sandy Loam
268	Sisson Loam
269	Warsaw Sandy Loam
269Y	(See No. 119, Warsaw Silt Loam)
270V	Hackett Sandy Loam
271Z	(See No. 22, Hebron Sandy Loam)
272	Tustin Loamy Fine Sand
276	Boyer Sandy Loam
276V	(See No. 267, Sisson Fine Sandy Loam)
276Y	Boyer Sandy Loam, Loam Substratum
276Z	Boyer Sandy Loam, Clay Substratum
277	Sumner Sandy Loam
277Y	Sumner Sandy Loam, Loam Substratum

HYDROLOGIC GROUP B (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
277Z	Sumner Sandy Loam, Clay Substratum
279	Boyer Sandy Loam
280	Boyer Loamy Sand
281Y	(See No. 254, Tustin Sandy Loam)
282	Casco-Rodman Loams (Casco part)
288V	Hackett Loamy Sand, Silt & Fine Sand Substratum
289Y	Hackett Sandy Loam, Loam Substratum
289Z	Hackett Sandy Loam, Clay Substratum
293	(See No. 243, Calamus Silt Loam-Washington County only)
297V	Morley Silt Loam, Silt & Loam Sand Substratum
297X	Morley Silt Loam, Gravelly Substratum
304	(See No. 206, Knowles Silt Loam, Shallow Variant)
305	Knowles Silt Loam
308	Knowles Silt Loam, Shallow Variant
314	Sumner Loamy Sand
315	Oshtemo Loamy Sand
316	Boyer Loamy Sand
316Y	Boyer Loamy Sand, Loam Substratum
316Z	Boyer Loamy Sand, Clay Substratum
317	Oshtemo Loamy Fine Sand
317Y	(See No. 276, Boyer Sandy Loam, Clay Substratum)
318	(See No. 22, Hebron Sandy Loam)
320	Oshtemo Sandy Loam
323	Ionia Sandy Loam
323V	Ionia Sandy Loam
323Y	(See No. 22, Hebron Sandy Loam)
324	Ionia Loam
324V	Ionia Loam, Silt & Fine Sand Substratum
324Y	Ionia Loam, Loam Substratum
324Z	Ionia Loam, Clay Substratum
325	Varna Silt Loam
333	Eagle Silt Loam
333Y	Warsaw Silt Loam, Loam Substratum
333Z	Warsaw Silt Loam, Clay Substratum
334	Warsaw Loam
335	Ionia Silt Loam
335V	(See No. 266, Sisson Silt Loam)
335Y	Ionia Silt Loam, Loam Substratum
335Z	Ionia Silt Loam, Clay Substratum
343	Celina Silt Loam (on 0-6% slope)
343	Theresa Silt Loam (over 6% slope)
344	Ashford Silt Loam
346V	(See No. 266, Sisson Silt Loam)
348	(See No. 323, Ionia Sandy Loam)
348	(See No. 343, Theresa Silt Loam-Washington County only)
352	Lapeer Loam
355	Lapeer Sandy Loam

HYDROLOGIC GROUP B (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
356	Lapeer Sandy Loam
357	Hochheim Loam
357R	Hochheim Loam, Rock Substratum
357X	Hochheim Loam, Gravelly Substratum
358	Miami Loam
359	Hennepin Loam
360	Hochheim Silt Loam
360R	Hochheim Silt Loam, Rock Substratum
360V	Hochheim Silt Loam, Silt & Fine Sand Substratum
360X	Hochheim Silt Loam, Gravelly Substratum
360Y	(See No. 360, Hochheim Silt Loam)
361	Miami Silt Loam
362	Theresa Silt Loam
362R	Theresa Silt Loam, Rock Substratum
362V	Theresa Silt Loam, Silt & Fine Sand Substratum
362X	Theresa Silt Loam, Gravelly Substratum
362Z	Theresa Silt Loam, Clay Substratum
363	Mayville Silt Loam
363X	Mayville Silt Loam, Gravelly Substratum
363Y	Mayville Silt Loam
363Z	Mayville silt Loam, Clay Substratum
365	Hochheim-Hennepin Loams
365X	Hochheim-Hennepin Loams, Gravelly Substratum
366	Hochheim-Theresa Loams
367	Hochheim Fine Sandy Loam
377	(See No. 276, Boyer Sandy Loam)
380	Sumner Loamy Sand
380Z	(See No. 254, Tustin Sandy Loam)
391	Wea Sandy Loam
392	Ockley Loam
393	Ockley Sandy Loam
394	Parr Sandy Loam
397R	Ozaukee Silt Loam, Rock Substratum
397X	Ozaukee Silt Loam, Gravelly Substratum
413Z	Crestview Fine Sandy Loam, Clay Substratum
417	Terrace Escarpment Outwash
420	Miami Silt Loam
421	Dodge Silt Loam
431	Knowles Stony Silt Loam, Shallow Variant
502	Flagg Silt Loam
504	Flagg Silt Loam
504	(See No. 84, Ockley Silt Loam)
508	Pecatonica Silt Loam
510	Pecatonica Silt Loam
512	(See No. 516, Westville Silt Loam)
514	Westville Silt Loam
516	Westville Silt Loam
557	Miami Loam
560	Miami Silt Loam

HYDROLOGIC GROUP C

Soil Mapping Number	Soil Type (Wisconsin)
2	Stinson Silt Loam
11WR	(See No. 306, Knowles Silt Loam, Wet Variant)
23	(See No. 82, Juneau Silt Loam)
26	Wauconda Fine Sandy Loam
27	Wauconda Silt Loam
27Y	(See No. 27, Wauconda Silt Loam)
27Z	Wauconda Silt Loam, Clay Substratum
35	Yahara Very Fine Sandy Loam
35Z	Yahara Very Fine Sandy Loam, Clay Substratum
36	Yahara Silt Loam
37	Kibbie Fine Sandy Loam
37Z	Kibbie Fine Sandy Loam, Clay Substratum
38	Kibbie Silt Loam
38R	Kibbie Silt Loam, Rock Substratum
38X	(See No. 233, Matherton Silt Loam)
38Z	Kibbie Silt Loam, Clay Substratum
39	Saylesville Loam
40	Saylesville Silt Loam
41	Tichigan Silt Loam
41N	(See No. 42, Tichigan Silt Loam)
42	Tichigan Silt Loam
42R	Tichigan Silt Loam, Rock Substratum
42V	Tichigan Silt Loam, Silt & Fine Sand Substratum
42X	Tichigan Silt Loam, Gravelly Substratum
42Y	Tichigan Silt Loam, Loam Substratum
45	Yahara Silt Loam
45Z	Yahara Very Fine Sandy, Clay Loam, Clay Loam Substratum
46	Yahara Silt Loam
47	Yahara Loam
47Z	Yahara Loam, Clay Substratum
51	Aztalan Loam
52	Aztalan Sandy Loam
53	Aztalan Silt Loam
59Z	Dousman Sandy Loam, Clay Substratum
60	Dousman Loam
60Z	Dousman Loam, Clay Substratum
77Z	Dousman Sandy Loam, Clay Substratum
78	Dousman Loam
78V	Dousman Loam, Silt & Fine Sand Substratum
78Y	Dousman Loam, Loam Substratum
82	Juneau Silt Loam
83	(See No. 82, Juneau Silt Loam)
87	Sleeth Silt Loam
87Z	Sleeth Silt Loam, Clay Substratum
89	Briggsville Silty Clay Loam
109	Fabius Loam
109R	(See No. 306, Knowles Silt Loam, Wet Variant)
109V	Fabius Silt Loam, Silt & Fine Sand Substratum

HYDROLOGIC GROUP C (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
109Y	Matherton Loam, Clay Substratum
109Z	Fabius Silt Loam, Clay Substratum
113	Clyman Silt Loam
118	Crosby Silt Loam
124	Crane Silt Loam
124V	(See No. 38, Kibbie Silt Loam)
142	Manawa Silt Loam
143	(See No. 142, Manawa Silt Loam)
144	Matherton Loam, Clay Substratum
174	Fabius Loam
174V	(See No. 38, Kibbie Silt Loam)
174Y	(See No. 174, Fabius Loam)
175	Fabius Sandy Loam
175V	(See No. 37, Kibbie Fine Sandy Loam)
175Z	Fabius Sandy Loam, Clay Substratum
178	Crosby Silt Loam
182	Fabius Silt Loam
182V	Fabius Silt Loam, Silt & Fine Sand Substratum
182Y	Fabius Silt Loam, Loam Substratum
182Z	Fabius Silt Loam, Clay Substratum
184	(See No. 182, Fabius Silt Loam)
188	Crosby Silt Loam
189	Bristol Silt Loam
198	(See No. 178, Crosby Silt Loam)
203	Matherton Loam
203V	Matherton Loam, Silt & Fine Sand Substratum
203Y	Matherton Loam, Loam Substratum
203Z	Matherton Loam, Clay Substratum
223	(See No. 233, Matherton Silt Loam)
233	Matherton Silt Loam
233V	Matherton Silt Loam, Silt & Fine Sand Substratum
233Y	Matherton Silt Loam, Loam Substratum
233Z	Matherton Silt Loam, Clay Substratum
234	Matherton Sandy Loam
234V	Matherton Sandy Loam, Silt & Fine Sand Substratum
234Y	Matherton Sandy Loam, Loam Substratum
234Z	(See No. 51, Aztalan Loam)
235	(See No. 233, Matherton Silt Loam)
238	(See No. 328, Pistakee Silt Loam)
241	(See No. 46, Yahara Silt Loam)
250Z	Tedrow Sandy Loam, Clay Substratum
251Z	Tedrow Loamy Sand, Clay Substratum
261Z	(See No. 51, Aztalan Loam)
263	(See No. 45, Yahara Silt Loam)
278	Clyman Silt Loam
283	Mosel Sandy Loam
284	Mosel Sandy Loam
293	(See No. 297, Morley Silt Loam)
294	(See No. 297, Morley Silt Loam)
295	Morley-Beecher Silt Loams
297	Morley Silt Loam
297S	Morley Sandy Loam

HYDROLOGIC GROUP C (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
297Y	Morley Silt Loam
299	Blount Silt Loam
300	Ashkum-Beecher Silt Loams
306	Knowles Silt Loam, Wet Variant
307	Knowles Silt Loam, Wet Variant
311	Manawa Loam
328	Pistakee Silt Loam
328W	(See No. 328, Pistakee Silt Loam)
328Y	(See No. 328, Pistakee Silt Loam)
328Y	Pistakee Silt Loam
331	Markham-Elliott Silt Loam
332	Kane Silt Loam
332V	Kane Silt Loam, Silt & Fine Sand Substratum
332Y	Kane Silt Loam, Loam Substratum
332Z	Kane Silt Loam, Clay Substratum
336	Markham Silt Loam
340R	(See No. 306, Knowles Silt Loam, Wet Variant)
345	Nenno Silt Loam
345X	(See No. 233, Matherton Silt Loam)
346	Kane Loam
346Y	Kane Loam, Loam Substratum
363R	Mayville Silt Loam, Rock Substratum
364	Lamartine Silt Loam
364V	Lamartine Silt Loam, Silt & Fine Sand Substratum
364X	Lamartine Silt Loam, Gravelly Substratum
364Z	Lamartine Silt Loam, Clay Substratum
369	Mosel Silt Loam
369Z	(See No. 51, Aztalan Loam)
370	Mosel Sandy Loam
371	Mosel Loam
387V	Granby Loamy Sand, Silt & Fine Sand Substratum
397	Ozaukee Silt Loam
397V	Ozaukee Silt Loam, Silt & Fine Sand Substratum
397Y	Ozaukee Silt Loam, Loam Substratum
399	Mequon Silt Loam
416	Terrace Escarpment Till
501	(See No. 505, Flagg Silt Loam, Wet Variant)
505	Flagg Silt Loam, Wet Variant
511	Flagg Silt Loam, Wet Variant
3251	Elliott Silt Loam
3251V	Elliott Silt Loam, Silt & Fine Sand Substratum
3261	(See No. 3361, Beecher Silt Loam)
3361	Beecher Silt Loam
3975	(See No. 397, Ozaukee Silt Loam)

HYDROLOGIC GROUP D

Soil Mapping Number	Soil Type (Wisconsin)
4	Marsh
5	Lawson Silt Loam
5W	Sawmill Silt Loam
7W	Lawson Silt Loam
9	(See No. 450, Houghton Muck)
10W	Alluvial Land, Wet
11W	Alluvial Land, Wet
15	Hillside Seepage
23	Lawson Silt Loam
28	Colwood Fine Sandy Loam
28Z	Colwood Fine Sandy Loam, Clay Substratum
29	Colwood Silt Loam
29C	(See No. 29, Colwood Silt Loam)
29V	Colwood Silt Loam
29X	Colwood Silt Loam, Gravelly Substratum
29Z	Colwood Silt Loam, Clay Substratum
30	Colwood Silt Loam
48	Keowns Silt Loam
48Z	Keowns Silt Loam, Clay Substratum
49	Keowns Fine Sandy Loam
49Y	Keowns Fine Sandy Loam, Loam Substratum
50	(See No. 48, Keowns Silt Loam)
54	Lawson Silt Loam
59	Dousman Sandy Loam
63	Brookston Silt Loam
63V	(See No. 29, Colwood Silt Loam)
63W	(See No. 231, Brookston Silt Loam)
64	Brookston Silt Loam
66	Granby Fine Sandy Loam
67	Granby Fine Sandy Loam
76	Sebewa Silt Loam
76R	Sebewa Silt Loam, Rock Substratum
76V	Sebewa Silt Loam, Silt & Fine Sand Substratum
76W	(See No. 76, Sebewa Silt Loam)
76Y	Sebewa Silt Loam, Loam Substratum
76Z	Sebewa Silt Loam, Clay Substratum
77	Dousman Sandy Loam
79	Waukechon Loam
79Z	(See No. 330, Navan Loam)
80	Sebewa Loam
80V	Sebewa Loam, Silt & Fine Sand Substratum
80W	(See No. 80, Sebewa Loam)
80Y	Sebewa Loam, Loam Substratum
80Z	Sebewa Loam, Clay Substratum
81	Sebewa Sandy Loam
81Z	(See No. 330, Navan Loam)
126	Westland Silt Loam
126V	Westland Silt Loam, Silt & Fine Sand Substratum

HYDROLOGIC GROUP D (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
126Y	Westland Silt Loam, Loam Substratum
126Z	Westland Silt Loam, Clay Substratum
127	(See No. 126, Westland Silt Loam)
128	(See No. 126, Westland Silt Loam)
165	Poygan Silt Loam
171	Poygan Silty Clay Loam
176	Mussey Loam
176V	Mussey Loam
176Z	Mussey Loam, Clay Substratum
179	Brookston Silt Loam
180	Mussey Sandy Loam
181	Mussey Silt Loam
181V	Mussey Silt Loam, Silt & Fine Sand Substratum
181Y	Mussey Silt Loam, Loam Substratum
181Z	Mussey Silt Loam, Clay Substratum
212	Ehler Silt Loam
212R	Ehler Silt Loam, Rock Substratum
212X	Ehler Silt Loam, Gravelly Substratum
212Y	Ehler Silt Loam
213	Ehler Silt Loam
213C	(See No. 212, Ehler Silt Loam)
213R	Ehler Silt Loam, Rock Substratum
213V	Colwood Silt Loam
213W	(See No. 212, Ehler Silt Loam)
213Y	(See No. 212, Ehler Silt Loam)
214	Ehler Silt Loam
215	Ehler Silt Loam
215C	(See No. 212, Ehler Silt Loam)
216	Ehler Silt Loam
217	Bono Silty Clay Loam
217Y	(See No. 217, Bono Silty Clay Loam)
218	Bono Silty Clay Loam
218V	Bono Silty Clay Loam
218Y	Bono Silty Clay Loam
228	Rollin Muck, Shallow Phase
228C	(See No. 458, Rollin Muck, Shallow
231	Brookston Silt Loam
231Z	Brookston Silt Loam, Clay Substratum
232	(See No. 231, Brookston Silt Loam)
285	Mussey Loam
286	Mussey Silt Loam
287	Mussey Loam
290	(See No. 29, Colwood Silt Loam)
290X	(See No. 76, Sebewa Silt Loam)
296	(See No. 298, Ashkum Silty Clay Loam)
298	Ashkum Silty Clay Loam
300	Ashkum-Beecher Silt Loam

HYDROLOGIC GROUP D (Cont.)

Soil Mapping Number	Soil Type (Wisconsin)
302	Rollin Muck
303	Alluvial Land, Rock Substratum
326	Abington Silt Loam
326C	(See No. 326, Abington Silt Loam)
326W	(See No. 326, Abington Silt Loam)
326Z	Abington Silt Loam, Clay Substratum
327	Wallkill Silt Loam
329	(See No. 340, Navan Silt Loam)
330	Navan Loam
338	Ashkum Silty Clay Loam
339	Abington Silty Clay
340	Navan Silt Loam
340W	(See No. 330, Navan Loam)
340Z	(See No. 330, Navan Loam)
368	(See No. 386, Granby Fine Sandy Loam)
386	Granby Fine Sandy Loam
386Y	Granby Fine Sandy Loam, Loam Substratum
386Z	Granby Fine Sandy Loam, Clay Substratum
387	Granby Loamy Sand
398	Ashkum Silty Clay Loam
449	Houghton Mucky Peat
450	Houghton Muck
450C	(See No. 450, Houghton Muck)
450W	(See No. 450, Houghton Muck)
451	Houghton Mucky Peat
451W	(See No. 451, Houghton Mucky Peat)
452	Adrian Muck
452C	(See No. 452, Adrian Muck)
452Z	Adrian Muck, Clay Substratum
453	Adrian Mucky Peat
454	Palms Muck
454C	(See No. 454, Palms Muck)
454W	(See No. 454, Palms Muck)
455	Palms Mucky Peat
455V	(See No. 455, Palms Mucky Peat)
456	Ogden Muck
456C	(See No. 456, Ogden Muck)
456W	(See No. 456, Ogden Muck)
457	Ogden Mucky Peat
458	Rollin Muck, Shallow
459	Rollin Muck
460	Rollin Mucky Peat
461	Muskego Muck
461Y	(See No. 454, Palms Muck)
462	Houghton Peat, Acid Variant
465	(See No. 456, Ogden Muck)
550	Ehler Silt Loam, Rock Substratum
1151	(See No. 451, Houghton Mucky Peat)

Introduction to Appendices D through H

Where the local unit of government, governing body, its agencies, or officials appear in italics in the following suggested zoning districts and special soil regulations, the appropriate unit, body, agency, or official should be substituted to meet the needs and desires of the local community. Other words, numbers, terms, or paragraphs appearing in italics are provided as examples only and may be changed or omitted to best meet the needs and desires of the individual community.

These districts and regulations are set forth in a section and subsection *form convenient* for incorporation into the SEWRPC Model Zoning and Land Division Ordinances or other properly prepared ordinances.

The district regulations in Appendix D should be supplemented by the special soil regulations in Appendix E, which are to be applied in addition to the regulations of the basic underlying comprehensive zoning district.

It is extremely important to note that the suggested districts and regulations are intended only as guides to be used by local units of government in the formulation of their local development ordinances. Competent legal, engineering, and planning assistance should be obtained in conjunction with the use of these suggested regulations by local communities in the formulation of actual regulations carefully fitted to the local needs.

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Appendix D
ZONING DISTRICT REGULATIONS RELATED TO SOIL CAPABILITIES

The following zoning district regulations have been designed to replace or be added to those districts listed in the Model Zoning Ordinance set forth in Appendix A of SEWRPC Planning Guide No. 3, Zoning Guide, 1964, or to other properly prepared zoning ordinances. These district regulations should be supplemented by the special soil regulations set forth in Appendix E of this Guide so as to preserve and protect soil and water resources. The use of additional soil regulations along with appropriate zoning districts obviates the necessity for special soil hazard zoning districts.

A-1 General Farming District (Replacement)

Principal Uses Apiculture; dairying; floriculture; forestry; grazing; greenhouses; hay; livestock raising with herds of less than twenty-five (25) head; orchards; paddocks; pasturage; plant nurseries; poultry raising of flocks of less than five hundred (500) birds; raising of cash grain crops, mint, grass, seed crops, silage, tree fruits, nuts and berries, and vegetables; stables; truck farming; and viticulture. Farm dwellings for those resident owners and laborers actually engaged in a principal use are accessory uses to the farm operation but shall comply insofar as practicable with the provisions of the Rural Residential District. Existing dwellings not accessory to any farm operation and farm dwellings remaining after consolidation of neighboring farms are permitted but shall comply with all the lot, building, and yard provisions of the Rural Residential District. Not more than one (1) roadside stand on any one farm shall be permitted as an accessory use.

Conditional Uses Airports; airstrips; animal hospitals; commercial egg production; commercial raising of animals, such as dogs, foxes, goats, mink, pigs, and rabbits; condenseries; creameries; farm drainage tile; feed lots; hatching or butchering of fowl; landing fields; livestock raising with herds of twenty-five (25) head or more; migratory laborer housing; poultry raising with flocks of five hundred (500) birds or more; and sod farming.

Farm	Width	Minimum	*1,000* ft.
	Area	Minimum	*40* acres
Structure	Height	Maximum	*50* ft.
Yards	Street	Minimum	*100* ft.
	Rear	Minimum	*100* ft.
	Side	Minimum	*100* ft.

A-2 Truck Farming District (Addition)

Principal Uses Apiculture, floriculture, greenhouses, horticulture, nurseries, orchards, paddocks, raising of cash crops, raising of horses not to exceed three (3) head for each five (5) acres, truck farming, and viticulture. Farm dwellings for those resident owners and laborers actually engaged in a principal use are accessory uses to the farm operation but shall comply insofar as practicable with the provisions of the Rural Residential District. Existing dwellings not accessory to any farm operation or dwellings remaining after consolidation of neighboring farms are permitted but shall comply with all the lot, building, and yard provisions of the Rural Residential District. Not more than one (1) roadside stand on any one farm shall be permitted as an accessory use.

Farm	Width	Minimum	*300* ft.
	Area	Minimum	*10* acres
Structure	Height	Maximum	*50* ft.
Yards	Street	Minimum	*100* ft.
	Rear	Minimum	*100* ft.
	Side	Minimum	*100* ft.

C-1 Resource Conservation District (Replacement)

Principal Uses Fishing: flood overflow and floodwater storage; hunting; navigation; pedestrian and equestrian trails; preservation of scenic, historic, and scientific areas; public fish hatcheries; soil and water conservation practices; sustained yield forestry; stream bank and lakeshore protection; water retention ponds; and wildlife areas.

Conditional Uses Boating, drainageways, game farms, grazing, orchards, shooting preserves, swimming, truck farming, utilities, water measurement and water control facilities, and wildcrop harvesting. The above uses shall not involve drainage; dumping; filling; tilling; mineral, soil, or peat removal; or any other use that would substantially disturb or impair the natural fauna, flora, watercourses, water regimen, or topography.

Structures None permitted except accessory to the principal or conditional uses.

C-2 Farm Conservation District (Addition)

Principal Uses All General Farming District principal uses that are conducted in accordance with the County Conservation Standards.

Conditional Uses All General Farming District conditional uses that are conducted in accordance with the County Conservation Standards.

Farm	Width	Minimum	*1,000* ft.
	Area	Minimum	*40* acres
Structure	Height	Maximum	*50* ft.
Yards	Street	Minimum	*100* ft.
	Rear	Minimum	*100* ft.
	Side	Minimum	*100* ft.

R-1 Country Residential District (Addition)

Principal Use One-family dwellings on estate lots where land is generally steep and wooded.

Conditional Uses Stables, grazing, forestry, nurseries, orchards, shrubbery clearing, and tree cutting.

Lot	Width	Minimum	*300* ft.
	Area	Minimum	*5* acres
Building	Height	Maximum	*35* ft.
	Area	Minimum	*1,800* sq. ft. with at least *1,200* sq. ft. on first floor
Yards	Street	Minimum	*100* ft.
	Rear	Minimum	*100* ft.
	Side	Minimum	*50* ft.

Appendix D (continued)

R-2 Rural Residential District (Addition)

Principal Use — One-family dwellings where the soils are generally suitable for on-site soil absorption sewage disposal facilities.

Lot	Width	Minimum	150 ft.
	Area	Minimum	40,000 sq. ft.
Building	Area	Minimum	1,500 sq. ft. with at least 1,000 sq. ft. on first floor
	Height	Maximum	35 ft.
Yards	Street	Minimum	50 ft.
	Rear	Minimum	50 ft.
	Side	Minimum	30 ft.

R-3 Suburban Residential District (Addition)

Principal Use — One-family dwellings where the soils generally have slow permeability characteristics.

Lot	Width	Minimum	200 ft.
	Area	Minimum	80,000 sq. ft.
Building	Area	Minimum	1,200 sq. ft. with at least 1,000 sq. ft. on first floor
	Height	Maximum	35 ft.
Yards	Street	Minimum	50 ft.
	Rear	Minimum	50 ft.
	Side	Minimum	20 ft.

R-4 Sewered Residential District (Replacement)

Principal Use — One-family dwellings on lots to be served by public sanitary sewer systems.

Lot	Width	Minimum	75 ft.
	Area	Minimum	10,000 sq. ft.
Building	Area	Minimum	1,200 sq. ft. with at least 1,000 sq. ft. on first floor
	Height	Maximum	35 ft.
Yards	Street	Minimum	30 ft.
	Rear	Minimum	50 ft.
	Side	Minimum	20 ft.

Appendix E
SPECIAL SOIL REGULATIONS TO BE INCORPORATED INTO ZONING ORDINANCES

The following sections and subsections have been designed to replace or be added to those regulations found in the Model Zoning Ordinance set forth in Appendix A of SEWRPC Planning Guide No. 3, Zoning Guide, 1964, or to other properly prepared zoning ordinances. These soil regulations are in addition to the zoning district regulations set forth in Appendix D of this Guide.

SECTION 1.0 INTRODUCTION

SECTION 1.3 Intent (Addition)

Obtain the Wise Use, conservation, development, and protection of the *Village's* soil, water, wetland, woodland, and wildlife resources and attain a balance between land uses and the ability of the natural resource base to support and sustain such uses.

Prevent and Control Erosion and sedimentation.

Preserve Natural Growth and Cover and promote the natural beauty of the *Village*.

Implement those municipal, county, watershed, or regional comprehensive plans or their components adopted by the *Village*.

SECTION 1.6 Severability and Non-Liability (Addition)

The *Village* does not guarantee, warrant, or represent that those soils listed as being unsuited for specific uses are the only unsuitable soils within the *Village* and hereby asserts that there is no liability on the part of the *Village Board of Trustees*, its agencies, or employees for sanitation problems or structural damages that may occur as a result of reliance upon, and conformance with, this Ordinance.

SECTION 2.0 GENERAL PROVISIONS

SECTION 2.2 Compliance (Replacement)

No structure, land, or water shall hereafter be used and no structure or part thereof shall hereafter be located, erected, moved, reconstructed, extended, enlarged, converted, or structurally altered without a *Zoning Permit*, except minor structures, and without full compliance with the provisions of this Ordinance and all other applicable local, county, and state regulations.

SECTION 2.3 Zoning Permit (Addition)

Plat of Survey prepared by a land surveyor registered in Wisconsin, showing. . . and the type, slope, erosion factor, and boundaries of each soil mapping unit.

SECTION 2.4 Land Suitability (Addition)

No land shall be used or structure erected where the *Village Plan Commission* finds that the land has severe or very severe limitations for such use or structure by reason of flooding, concentrated runoff, inadequate drainage, adverse soil or rock formation, unfavorable topography, low percolation rate or bearing strength, erosion susceptibility, or any other feature likely to be harmful to the health, safety, prosperity, aesthetics, and general welfare of this community. The *Village Plan Commission*, in applying the provisions of this section, shall in writing recite the particular facts upon which it bases its conclusions that the land is not suitable for certain uses.

SECTION 2.5 Sanitary Regulation

Certain soil types lying in the *Village* of__________, as shown on the operational soil survey maps prepared by the U. S. Department of Agriculture, Soil Conservation Service, have severe or very severe limitations for soil absorption sewage disposal facilities because of one or more of the following reasons: high or fluctuating ground water table, flooding, ground water contamination, silting, slow permeability, steep slopes, or proximity to bedrock. Therefore, the *Village Plan Commission* finds the following:

Soils with Very Severe Limitations. All soil absorption sewage disposal facilities are prohibited on the following soil types:

4	*76*	*179*	*231*	*327*	*451*
11W	*87*	*203*	*233*	*328*	*452*
29	*124*	*212*	*278*	*364*	*454*

Soils with Severe Limitations. All soil absorption sewage disposal facilities are prohibited on the following soil types and on those soil types having slopes in excess of *twelve (12) percent*, unless their severe limitations are overcome by the elimination or avoidance of bedrock, provision of larger lot and soil absorption areas, or the terracing and reduction of steep slopes:

16	*24*	*39*	*82*	*170Z*	*325*
21	*31*	*40*	*99*	*172Z*	*336*
22	*32*	*44*	*100*	*295*	*397*

An Applicant desiring to use the above soils that have severe limitations for soil absorption sewage disposal facilities shall: have additional on-site soil investigations made, including percolation tests; obtain a certification from a soils scientist or soils engineer stating that specific areas lying within these soils are suitable for the proposed soil absorption sewage disposal facility; meet the State Division of Health regulations; and obtain the *Village Plan Commission's* finding that the proposed soil absorption sewage disposal facility has overcome the severe limitations.

SECTION 2.6 Steep Land Regulations (Addition)

In addition to any other applicable use, site, or sanitary regulations, the following restrictions and regulations shall apply to all lands having slopes of twelve (12) percent or greater, as shown on the operational soil survey maps prepared by the U. S. Department of Agriculture, Soil Conservation Service, and which are on file with the *Zoning Inspector*.

All Construction and Private Roads shall be of sound engineering design with footings and roadbeds designed by a registered professional engineer and shall be so treated so as to prevent erosion.

Tillage and Grazing are prohibited except as conducted in accordance with the County Conservation Standards.

Tree Cutting and Shrubbery Clearing for the purpose of changing land use from wildlife or woodlot management are conditional uses requiring review, public hearing, and approval by the *Village Plan Commission* and shall be so regulated so as to completely prevent erosion and sedimentation and promote preservation of its scenic qualities. The *Board of Zoning Appeals* shall request the review of the State District Forester, State Fish and Game Manager, and the County Soil and Water Conservation District Supervisors and await their recommendations before final action is taken, but not to exceed sixty (60) days.

SECTION 2.7 Erodible Land Regulations (Addition)

In addition to any other applicable use, site, or sanitary regulations, the following restrictions and regulations shall apply to the following lands as shown on the operational soil survey maps prepared by the U. S. Department of Agriculture, Soil Conservation Service, and which are on file with the *Zoning Inspector*.

Appendix E (continued)

Lands Having Slopes of Six (6) Percent or more shall be prohibited from intensive farming, such as cash grains, nurseries, orchards, horticulture, truck farming, viticulture, seed cropping, vegetables, tree fruits, nuts, and berries, except as conducted in accordance with the County Conservation Standards.

Land Subject to Soil Blowing (Wind Erosion), such as the following muck and peat soil types, shall have all tillage and grazing prohibited except as conducted in accordance with the County Conservation Standards:

452 453 458 459 460 461

Lands Having an Erosion Factor of 3 shall have all tillage and grazing prohibited except as conducted in accordance with the County Conservation Standards.

SECTION 2.8 Soil Capability Regulations

In addition to any other applicable use, site, or sanitary regulations, the following restrictions and regulations shall apply to the following soil types as shown on the operational soil survey maps prepared by the U. S. Department of Agriculture, Soil Conservation Service, and which are on file with the *Zoning Inspector*.

Tillage is prohibited on the following rough, broken, sandy, stoney, or escarpment soils because of their erodibility and very low agricultural capabilities:

1 75 303 416 431 462

Farm Drainage Systems shall not be installed on the following soils because of flooding hazard and generally unsuitable soil characteristics for an operative drainage system, unless installed in accordance with the County Conservation Standards:

4 10W 11W 11WY 462

Grazing is prohibited on the following soil types because of their very severe limitations for pasturing:

1 4 416 419 462

SECTION 3.0 ZONING DISTRICTS

SECTION 3.1 Establishment (Addition)

Boundaries of These Districts shall be construed to follow: . . . soil mapping unit boundaries.

SECTION 11.0 *BOARD OF ZONING APPEALS*

SECTION 11.4 Powers (Addition)

Errors. To hear and decide appeals where it is alleged that there is an error in the soil type, slope, erosion factor, or mapping unit boundaries shown on the operational soil survey maps or the analyses of such soils prepared by the U. S. Department of Agriculture, Soil Conservation Service The Board may request the County Soil and Water Conservation District to provide expert assistance from regional, state, or federal agencies which are assisting the District under a ''Memorandum of Understanding.''

SECTION 13.0 DEFINITIONS (Addition)

Conservation Standards

Guidelines and specifications for soil and water conservation practices and management enumerated in the Technical Guide prepared by the U. S. Department of Agriculture, Soil Conservation Service, for the County, adopted by the County Soil and Water Conservation District Supervisors, and containing suitable alternatives for the use and treatment of land based upon its capabilities from which the landowner selects that alternative which best meets his needs in developing his soil and water conservation plan.

Erosion Factor

An index of soil erosion or of the detachment and movement of the solid material of the land surface by wind, moving water, or ice, and by such processes as landslides and creep. The digits 1, 2, and 3 are used by the U. S. Department of Agriculture, Soil Conservation Service, to indicate the degree of such erosion as follows:

1 - None to one-fourth of the original surface soil has been removed by erosion.
2 - one-fourth to three-fourths of the original surface soil has been removed by erosion.
3 - three-fourths of the original surface soil to one-fourth of the subsoil has been removed by erosion.

Soil Mapping Units

The boundaries of soil types, slopes, and erosion factors shown on the operational soil survey maps prepared by the U S Department of Agriculture, Soil Conservation Service.

Appendix F
SPECIAL SOIL REGULATIONS TO BE INCORPORATED INTO LAND DIVISION ORDINANCES

The following sections and subsections have been designed to replace or be added to those regulations found in the Model Land Division Ordinance set forth in Appendix A of SEWRPC Planning Guide No. 1, Land Development Guide, 1963, or to other properly prepared subdivision control ordinances.

SECTION 1.0 INTRODUCTION

SECTION 1.3 Intent (Addition)

Prevent and Control Erosion, sedimentation, and other pollution of surface and subsurface waters.

Obtain the Wise Use, conservation, development, and protection of the *Village's* soil, water, wetland, woodland, and wildlife resources and attain an adjustment of land use and development to the supporting and sustaining natural resource base.

Preserve Growth and Cover and promote the natural beauty of the *Village* and its environs.

Prohibit the Creation of Building Sites in those areas poorly suited for development.

Implement those municipal, county, watershed, or regional comprehensive plans or components of such plans adopted by the *Village*.

SECTION 1.6 Severability and Non-Liability (Addition)

The *Village* does not guarantee, warrant, or represent that those soils listed as being unsuited for specific uses are the only unsuited soils within the *Village* and hereby asserts that there is no liability on the part of the *Village Board of Trustees*, its agencies, or employees for sanitation problems or structural damages that may occur as a result of reliance upon, and conformance with, this Ordinance.

SECTION 2.0 GENERAL PROVISIONS

SECTION 2.6 Land Suitability (Addition)

Lands Made, Altered, or Filled with non-earth materials within the last ten (10) years shall not be divided into building sites which are to be served by soil absorption waste disposal systems.

Lands Having a Slope of twelve (12) percent or more shall be maintained in permanent open space use. No lot shall have more than fifty (50) percent of its minimum required area in slopes of ten (10) percent or greater.

Lands Having Bedrock within eight (8) feet of the natural undisturbed surface shall not be divided into building sites to be served by soil absorption sewage disposal systems.

Lands Having Ground Water within eight (8) feet of the natural undisturbed surface shall not be divided into building sites to be served by soil absorption sewage disposal systems.

Soils Having a Percolation Rate slower than sixty (60) minutes per inch or faster than ten (10) minutes per inch in shoreland areas shall not be divided into building sites to be served by soil absorption sewage disposal systems.

The Following Soil Types, which have very severe limitations, shall not be divided into building sites:

2
3
4
5
7
9
10
11
13
217
218
302
451
452
453
455
456
457
458
459
460

Lands Drained by farm drainage tile or farm ditch systems shall not be divided into building sites to be served by on-site soil absorption sewage disposal systems.

SECTION 4.0 PRELIMINARY PLAT

SECTION 4.2 Plat Data (Addition)

Soil Type, Slope, and Boundaries as shown on the detailed operational soil survey maps prepared by the U. S. Soil Conservation Service.

Location and Results of Soil Boring Tests made to a depth of eight (8) feet, or five (5) feet below the bottom of a proposed deep absorption system, whichever is greater. The number of such tests shall be adequate to portray the character of the soil and the depths of bedrock and ground water from the natural undisturbed surface but no less than two (2) tests per acre shall be made.

Location, Depth, Area, and Type of all soil absorption waste disposal facilities.

Location and Results of Percolation Tests conducted in accordance with Section H 65.06 of the Wisconsin Administrative Code, taken at the location and depth in which the soil absorption waste disposal system is to be installed. The number of such tests shall not be less than three (3) tests per disposal system area.

SECTION 4.7 Soil and Water Conservation (Addition)

The *Village Engineer*, upon determining from a review of the preliminary plat that the soil, slope, vegetation, and drainage characteristics of the site are such as to require substantial cutting, clearing, grading, and other earthmoving operations in the development of the subdivision or otherwise entail a severe erosion hazard, may require the subdivider to provide soil erosion and sedimentation control plans and specifications.

Tree Cutting and Shrubbery Clearing shall not exceed thirty (30) percent of the lot or tract and shall be so conducted as to prevent erosion and sedimentation; preserve and improve scenic qualities; and, during foliation, substantially screen any development from stream or lake users.

Paths and Trails shall not exceed ten (10) feet in width and shall be so designed and constructed as to result in the least removal and disruption of trees and shrubs and the minimum impairment of natural beauty.

Earth Movements, such as grading, topsoil removal, mineral extraction, stream course changing, road cutting, waterway construction or enlargement, removal of stream or lake bed materials, excavation, channel clearing, ditching, drain tile laying, dredging, and lagooning, shall be so conducted as to prevent erosion and sedimentation and to least disturb the natural fauna, flora, watercourse, water regimen, and topography.

Review of Such Cutting, Clearing, and Movement may be requested of the County Soil and Water Conservation District Supervisors, the State District Fish and Game Managers, and the State District Forester by the *Village Engineer* or *Village Plan Commission* as they deem appropriate.

SECTION 7.0 DESIGN STANDARDS

SECTION 7.1 Street Arrangement (Addition)

Street, Block, and Lot Layouts shall be adjusted to the capability of the soil and water resources and shall be designed so as to least disturb the existing terrain, flora, fauna, and water regimen and to meet all the use, site, sanitary, floodland, and shoreland regulations contained in the *Village* Zoning, Sanitary, and Building Ordinances.

SECTION 8.0 REQUIRED IMPROVEMENTS

SECTION 8.2 Grading (Addition)

Cut and Filled Lands shall be graded to a maximum slope of *one on four* or the soils angle of repose, whichever is the lesser, and covered with permanent vegetation.

SECTION 8.8 Storm Water Drainage Facilities (Replacement)

The subdivider shall construct storm water drainage facilities, which may include curbs and gutters, catch basins and inlets, storm sewers, road ditches, and open channels, as required by the *Village Engineer*. All such facilities shall be of adequate size and grade to hydraulically accommodate the maximum potential volumes of flow. The type of facility required, the design criteria, and the sizes and grades shall be determined by the *Village Engineer*.

Storm Drainage Facilities shall be so designed as to prevent and control soil erosion and sedimentation and to present no hazard to life or property; and the size, type, and installation of all storm water drains and sewers proposed to be constructed shall be in accordance with the plans and standard specifications approved by the *Village Engineer*. Such facilities may at the request of the *Village Engineer* include water retention structures and settling basins so as to prevent erosion and sedimentation.

Unpaved Road Ditches and street gutters shall be shaped and seeded or sodded as grassed waterways. Where the velocity of flow is in excess of four (4) feet per second on soils having a severe or very severe erosion hazard and in excess of six (6) feet per second on soils having moderate, slight, or very slight erosion hazard, the subdivider shall install a paved invert or check dams, flumes, or other energy dissipating devices in accordance with plans and specifications approved by the *Village Engineer*.

SECTION 8.14 Sediment Control (Addition)

The subdivider shall plant those grasses, trees, and vines, a species and size specified by the *Village Engineer* or the *Village Plan Commission*, necessary to prevent soil erosion and sedimentation.

In Addition, the *Village Plan Commission* may require the subdivider to provide or install certain protection and rehabilitation measures, such as fencing, sloping, seeding, riprap, revetments, jetties, clearing, dredging, snagging, drop structures, brush mats, willow poles, and grade stabilization structures.

SECTION 9.0 CONSTRUCTION

SECTION 9.1 Commencement (Replacement)

No construction or installation of improvements shall commence in a proposed subdivision until the preliminary plat or map has been approved and the *Village Engineer* has given written authorization.

SECTION 9.2 Permits (Replacement)

No building, zoning, or sanitary permits shall be issued for erection of a structure on any lot not of record until all the requirements of this Ordinance have been met.

SECTION 9.3 Plans (Addition)

The following plans and accompanying construction specifications may be required by the *Village Engineer* before construction or installation of improvements is authorized.

Erosion and Sedimentation Control Plans showing those structures required to retard the rate of runoff water and those grading and excavating practices that will prevent erosion and sedimentation.

Planting Plans showing the locations, age, caliper, and species of any required grasses, vines, shrubs, and trees.

SECTION 9.5 Erosion Control (Addition)

The subdivider shall cause all grading, excavations, open cuts, side slopes, and other land surface disturbances to be so mulched, seeded, sodded, or otherwise protected that erosion, siltation, sedimentation, and washing are prevented, in accordance with the plans and specifications approved by the *Village Engineer*.

Sod Shall be Laid in strips at those intervals necessary to prevent erosion and at right angles to the direction of drainage.

Temporary Vegetation and mulching shall be used to protect critical areas, and permanent vegetation shall be installed as soon as practical.

Construction at any given time shall be confined to the smallest practical area and for the shortest practical period of time.

Sediment Basins shall be installed and maintained at all drainageways to trap, remove, and prevent sediment and debris from being washed outside the area being developed.

SECTION 9.6 Existing Flora (Addition)

The subdivider shall make every effort to protect and retain all existing trees, shrubbery, vines, and grasses not actually lying in public roadways, drainageways, building foundation sites, private driveways, soil absorption waste disposal areas, paths, and trails.

Such Trees are to be protected and preserved during construction in accordance with sound conservation practices, including the preservation of trees by well islands or retaining walls whenever abutting grades are altered.

SECTION 11.0 DEFINITIONS (Addition)

Deep Absorption System

A soil absorption sewage system for disposal of effluent through the bottom and sides of a hole or trench at a depth of more than three (3) feet below the natural undisturbed surface.

Soil Mapping Unit

Soil types, slopes, and erosion [illegible] detailed operational soil survey maps prepared by [illegible] U. S. Soil Conservation Service.

Wisconsin Administrative Code

The rules of administrative agencies having rule-making authority in Wisconsin, published in a loose-leaf, continual revision system as directed by Section 35.93 and Chapter 227 of the Wisconsin Statutes, including subsequent amendments to those rules.

Appendix G
SPECIAL SOIL REGULATIONS TO BE INCORPORATED INTO BUILDING ORDINANCES

The following sections and subsections have been designed to replace or be added to those regulations found in properly prepared local building ordinances so as to assist in effectively and efficiently preventing and controlling erosion and sedimentation.

SECTION 1.0 INTRODUCTION

SECTION 1.3 Intent (Addition)

Prevent and Control Erosion, sedimentation, and other pollution of surface and subsurface waters.

Preserve Growth and Cover and promote the natural beauty of the *Village*.

Provide for the Least Disturbance of existing terrain, flora, fauna, and water regimen.

SECTION 1.8 Non-Liability (Addition)

The *Village* does not guarantee, warrant, or represent that those soils listed as being unsuited for specific uses are the only unsuitable soils within the *Village* and hereby asserts that there is no liability on the part of the *Village Board of Trustees*, its agencies, or employees for sanitation problems or structural damages that may occur as a result of reliance upon, and conformance with, this Ordinance.

SECTION 2.0 GENERAL PROVISIONS

SECTION 2.2 Compliance (Replacement)

No structure shall be erected, constructed, altered, repaired, relocated, reconstructed, extended, converted, enlarged, demolished, occupied, or maintained without a *Building Permit* and without full compliance with the provisions of this Ordinance; the Wisconsin Statutes; the National Board of Fire Underwriters standards; and all other applicable local, county, and state regulations.

SECTION 2.3 *Building Permit* (Addition)

Plat of Survey prepared by a land surveyor registered in Wisconsin, showing the type, slope, erosion factor, and boundaries of these soils as shown on the detailed operational soil survey maps prepared by the U. S. Soil Conservation Service.

SECTION 2.6 Land Suitability (Addition)

No structure shall be erected where the *Village Building Board* finds that the land has severe or very severe limitations for such structure by reason of flooding, concentrated runoff, inadequate drainage, adverse soil or rock formation, unfavorable topography, low percolation rate or bearing strength, erosion susceptibility, or any other feature likely to be harmful to the health, safety, prosperity, aesthetics, and general welfare of this community. The *Village Building Board*, in applying the provisions of this section, shall in writing recite the particular facts upon which it bases its conclusions that the land is not suitable for certain uses.

SECTION 2.7 Unbuildable Soils (Addition)

Certain soil types lying in the *Village* of____________, as shown on the operational soil survey maps prepared by the U. S. Soil Conservation Service, have very severe limitations for residential development because of low-bearing capacity, high shrink-swell potential, high water table, frequent overflow, steepness, or erosiveness. Therefore, the erection or construction of residential structures is prohibited on the following soil types:

2	*5w*	*11w*	*327*	*451*	*461*
4	*11*	*54*	*416*	*458*	*462*

An Applicant shall have an opportunity to present evidence to the *Village Building Board* contesting the soil classifications, slope, boundaries, and analyses if he so desires.

The Village Building Board may request the County Soil and Water Conservation District to provide expert assistance from regional, state, or federal agencies which are assisting such District under a Memorandum of Understanding.

SECTION 2.8 Steep Lands (Addition)

Certain soil types lying in the *Village* of____________, as shown on the operational soil survey maps prepared by the U. S. Soil Conservation Service, have severe limitations for development because they occur on slopes of twelve (12) percent or greater; and the following restrictions shall be complied with:

All Construction and Private Roads shall be of sound engineering design with earthworks and roadbeds designed by a registered professional engineer and shall be so treated so as to prevent erosion.

SECTION 3.0 SITE IMPROVEMENT

SECTION 3.1 General (Addition)

Building Sites shall be so designed, developed, and improved as to result in the minimum disruption of the natural terrain, flora, fauna, and water regimen; excavation, grading, cutting, and filling shall be directly related to the construction of public rights-of-way, private driveways, and building foundations; and natural drainage patterns shall not be altered so as to divert water onto adjoining properties.

SECTION 3.2 Erosion Control (Addition)

All grading, excavations, open cuts, and other land surface and subsurface disturbances shall be so mulched, seeded, sodded, or otherwise protected that erosion, siltation, sedimentation, and washing are prevented during and after site development.

SECTION 3.3 Existing Flora (Addition)

Every effort shall be made to protect all existing trees, shrubbery, and grasses not actually lying in public roadways, drainageways, building foundation sites, private driveways, soil absorption waste disposal areas, pathways, and trails.

Such Trees are to be protected and preserved during construction in accordance with sound conservation practices, including the preservation of trees by well islands or retaining walls whenever abutting grades are altered.

SECTION 3.4 Drainage (Addition)

All Excavations or changes in the natural terrain shall be provided with adequate drainage so as to prevent ponding.

SECTION 4.0 FOUNDATIONS

SECTION 4.2 Disturbed Soils (Addition)

Lands filled with non-earth materials over five (5) feet in depth within the last ten (10) years shall not have structures erected thereon unless designed, constructed, and supervised in accordance with plans and specifications approved by a professional engineer registered in Wisconsin who is experienced in foundation engineering; and such engineer shall certify that such structures are designed and were constructed in accordance with such plans and specifications.

SECTION 10.0 DEFINITIONS

Words used in the present tense include the future; the singular number, the plural; the plural number, the singular; and the word ''shall'' is mandatory and not directory.

Building

Any structure having a roof supported by columns or walls designed, used, or intended to be used for human occupancy or for the permanent, year-round sheltering, enclosure, or storage of animals, equipment, machinery, or other materials.

Building Inspector

A person recommended by the *Village Building Board* and appointed by the *Village Board of Trustees* to administer and enforce this Ordinance. References to the *Building Inspector* shall be construed to include duly appointed *deputy inspectors.*

Foundation

A substructure, including masonry walls, piers, footings, piles, grillage, and similar construction, which is designed to transmit the load of any superimposed structure to natural soil or bedrock.

Soil Mapping Unit

Soil types, slopes, and erosion factors delineated on operational soil survey maps prepared by the U. S. Soil Conservation Service.

Structure

Any erection or construction, such as boons, bridges, buildings, bulkheads, carports, cribs, decorations, machinery, masts, piers, poles, posts, signs, towers, and walls.

Appendix H

SPECIAL SOIL REGULATIONS TO BE INCORPORATED INTO SANITARY, HEALTH, OR PLUMBING ORDINANCES

The following sections and subsections have been excerpted from the Model Sanitary Ordinance set forth in full in Appendix K to SEWRPC Planning Guide No 5, Floodland and Shoreland Development Guide, 1968, and may be incorporated into any properly prepared health, sanitary, or plumbing ordinance.

SECTION 1.0 INTRODUCTION

SECTION 1.3 Intent

The general intent of this Ordinance is to regulate the location, construction, installation, alteration, design, and use of all private water supply and waste disposal systems so as to protect the health of residents and transients and to:

Secure Safety from disease, pestilence, and other health hazards.

Further the Maintenance of safe and healthful conditions for the enjoyment of aquatic recreation.

Prevent and Control further pollution of surface and subsurface waters.

Further the Appropriate Use and conservation of the land and water resources of the *County*.

Implement those municipal, county, watershed, and regional comprehensive plans and their components adopted by the county.

SECTION 1.6 Severability and Non-Liability

If any section, provision, or portion of this Ordinance is adjudged unconstitutional or invalid by a court of competent jurisdiction, the remainder of this Ordinance shall not be affected thereby. The *County* does not guarantee, warrant, or represent the safe and proper operation of water supply and waste disposal systems located, constructed, and maintained in accordance with this Ordinance and hereby asserts that there is no liability on the part of the *Board of Supervisors*, its agencies, or employees for any health hazards or damages that may occur as a result of reliance upon, and compliance with, this Ordinance.

SECTION 2.0 GENERAL PROVISIONS

SECTION 2.2 Compliance

No private water supply or waste disposal systems or parts thereof shall hereafter be located, installed, or moved without a *Sanitary* Permit and without full compliance with the provisions of this Ordinance and all other applicable local, county, and state regulations.

SECTION 2.3 *Sanitary* Permit

Applications for a *Sanitary* Permit shall be made by the property owner in duplicate to the *Sanitary Inspector* on forms furnished by him prior to issuance of a building or zoning permit and prior to purchase or installation of any septic tank and shall include the following, where pertinent and necessary, for proper review by the *Sanitary Inspector*.

Names and Addresses of the applicant; owner of the site; either the surveyor, architect, licensed master plumber, or professional engineer; and the installer and any state license held by him.

Description of the Subject Site by lot, block, and recorded subdivision or by metes and bounds referenced to the U.S. Public Land Survey System; address of the subject site; type of proposed installation; septic tank specifications; existing and proposed operation or use of the structure or site; maximum number of users of proposed installation, including employees, customers, or pupils; and any special or unusual wastes anticipated.

Plat of Survey prepared by a land surveyor registered in Wisconsin, showing the location, property boundaries, dimensions, type, elevations, and size of the following: subject site, soil mapping unit, soil boring and percolation test holes, shallow or deep absorption system sites, high-water elevation, floodlands, and shorelands. In addition, the plat of survey shall show the location and elevation of all existing or proposed buildings, cisterns, springs, wells, other sources of domestic water supply, watercourses, drainage ditches, farm drainage tile systems, slopes exceeding twelve (12) percent, and bodies of water within the subject site and within one hundred (100) feet of the disposal system site.

Results of Soil Boring Tests made to a depth of *eight (8)* feet. The number of such tests shall be adequate to portray the character of the soil and the depths of bedrock and ground water from the natural undisturbed surface but shall not be less than *two (2)* tests per disposal system site.

Results of Percolation Tests conducted in accordance with Section H 65.06 (4) of the Wisconsin Administrative Code, taken at the location and depth at which the soil absorption waste disposal system is to be installed. The number of such tests shall not be less than *six (6)* per disposal site.

SECTION 2.6 Sewage Disposal

Width and Area of all lots hereafter created, not served by a public sanitary sewer system or other approved system, shall be sufficient to permit the use of an on-site soil absorption sewage disposal system designed in accordance with this Ordinance but in no case shall be less than *one hundred and fifty (150)* feet in width and *forty thousand (40,000)* square feet in area.

SECTION 2.7 Land Suitability

The *County Health Agency* may prohibit the installation or operation of any waste disposal facilities where such facilities would harm, impair, or reduce surface or subsurface water quality.

Floodlands shall not be used for any type of waste disposal or well water supply systems.

Shorelands shall not be used for any type of waste disposal except domestic waste burial sites and shallow soil absorption sewage disposal systems serving individual single-family dwellings. Deep absorption systems shall not be used unless the applicant can show the natural or induced hydraulic gradient is away from the stream, pond, flowage, or lake.

Lands Having a Slope of twelve (12) percent or more shall not be used for soil absorption disposal systems.

Lands Having Bedrock within eight (8) feet of the natural undisturbed surface shall not be used for soil absorption disposal systems.

Lands Having Ground Water within eight (8) feet of the natural undisturbed surface during any season of the year shall not be used for soil absorption disposal systems.

Lands Drained by farm drainage tile or farm ditch systems shall not be used for soil absorption disposal systems.

SECTION 5.0 SEWAGE EFFLUENT DISPOSAL

SECTION 5.1 General

The effluent from septic tanks shall be disposed of by shallow systems or by some other system approved by the State Division of Health, provided such alternate system does not create a nuisance or health hazard.

Deep Absorption Systems shall not be used where shallow systems can be provided, where porous subsurface materials do not exist in their natural undisturbed condition, and where any well is less than fifty (50) feet deep within five hundred (500) feet of the system.

Such Systems shall be located, sized, constructed, used, and maintained so as to assure that effluent from the septic tank will not reach surface or subsurface waters in a condition which will contribute to health hazards, taste, odor, turbidity, fertility, or impair the aesthetic character of any navigable water.

SECTION 5.2 Soil Survey

Certain soil types lying in the *County*, as shown on the operational soil survey maps prepared by the U.S. Department of Agriculture, Soil Conservation Service, for the Southeastern Wisconsin Regional Planning Commission, which are on file with the *Sanitary Inspector* and are to be published as Soil Survey, __________ County, U.S. Department of Agriculture, Soil Conservation Service, U.S. Government Printing Office, Washington D.C., 1969, and on Table 8, Soils of Southeastern Wisconsin, SEWRPC Planning Report No. 8, 1966, have severe or very severe limitations for soil absorption sewage disposal systems because of one or more of the following reasons: high or fluctuating water table, flooding, ground water contamination, silting, slow permeability, steep slopes, or proximity to bedrock.

SECTION 5.3 Soils with Very Severe Limitations

Soil types described in the aforementioned publications and designated by the following numbers shall not be used for soil absorption sewage disposal facilities:

4
5
5W
27
28
28Z
37Z
38
38Z
51
52
53
66
73
76
80Z
81
87
126Y
172R
174
181Z
182
188

SECTION 5.4 Soils with Severe Limitations

Soil types described in the aforementioned publications and designated by the following numbers and any soils whose slopes exceed twelve (12) percent shall not be used for soil absorption sewage effluent disposal facilities unless the *County Health Agency* finds that such severe limitations have been overcome by elimination or avoidance of bedrock, provision of larger absorption areas, protection from runoff, terracing and reduction of steep slopes, or other corrective measures in accordance with Section 9.5 of this Ordinance.

16
21
21Y
22
24
31
32
33Z
39
40
44
70Y
70Z
72V
72Z
82
84Z
110Y
170Z
172Z
295
297
297S
324Z
325
331
336

SECTION 5.5 Percolation Test

The type and size of soil absorption waste disposal systems to be used for effluent disposal on soils not having severe and very severe limitations, enumerated in Sections 5.3 and 5.4 of this Ordinance, shall be determined through percolation tests conducted by a person approved in writing by the *Sanitary Inspector*. The percolation tests shall be conducted in accordance with Section H 65.06(4) of the Wisconsin Administrative Code, except

Tests shall be taken at the location and depth in which the absorption disposal system is to be installed and shall not be less than *six (6)* uniformally spaced separate test holes per disposal site.

SECTION 5.6 Vertical Location

Soil absorption sewage effluent disposal systems shall be placed within undisturbed soils that have not been made, altered, or filled with non-earth material within the last ten (10) years.

Bedrock, Creviced, or Fractured Rock shall be no closer than four (4) feet to the bottom or sides of any such system.

Ground Water shall be no closer than four (4) feet to the bottom of any such system.

Surface Elevation of all lands used for such systems shall be at an elevation of at least two (2) feet above the elevation of the one hundred (100)-year recurrence interval flood level or, where such data is not available, five (5) feet above the maximum flood of record.

SECTION 5.7 Horizontal Location

Soil absorption sewage effluent disposal systems shall be located at a point lower than the grade of any well or spring lying within one hundred (100) feet; shall not be located closer than twenty-five (25) feet to any dwelling or cistern; shall not be closer than one hundred (100) feet to any well or spring; shall not be closer than twenty (20) feet to any property line; shall not be closer than one hundred (100) feet to any stream, lake, pond, flowage, or wetland; shall not be closer than ten (10) feet to any tree; and shall not be closer than fifty (50) feet to the edge of steep slopes falling away toward ponds, streams, lakes, flowages, or wetlands.

SECTION 5.8 Size

The minimum soil absorption area required to dispose of the sewage effluent shall be computed as specified in Section H 62.20(2)(c)1 of the Wisconsin Administrative Code by use of percolation test rates; however:

Deep Absorption Systems shall not be installed in areas having percolation rates slower than thirty (30) minutes per inch of fall nor where shallow wells are in use.

Shallow Absorption Systems shall not be installed in areas having percolation rates slower than sixty (60) minutes per inch of fall.

Deep Absorption Systems shall not be installed in areas having percolation rates faster than ten (10) minutes per inch of fall.

No Liquids other than sewage effluent shall be permitted to drain, wash, or discharge onto or into a soil absorption area.

SECTION 5.9 Construction

Soil absorption disposal systems shall be constructed in accordance with Section H 62.20(2)(b) and (c) of the Wisconsin Administrative Code.

Soils above the absorption area shall not be surfaced with impervious materials; shall not be planted with deep-rooted plants, which will disrupt the system; and shall not be planted with root vegetables which may be used for human consumption.

SECTION 9.0 ADMINISTRATION

SECTION 9.5 Appeals

Any person, firm, or corporation or any office, department, or board of the *County* aggrieved by an order, requirement, interpretation, or determination made by the *Sanitary Inspector* may appeal such decision to the *County Health Agency*.

An Applicant desiring to install soil absorption sewage disposal facilities on the soils having very severe limitations, listed in Section 5.3 of this Ordinance, shall have an opportunity to present evidence contesting such classification and analyses if he so desires.

The *County Health Agency* shall fix a reasonable time and place for a public hearing, give a Class 1 notice thereof at least ten (10) days prior thereto, and give notice by mail to the parties-in-interest.

Upon a Finding-of-Fact after the hearing, the *County Health Agency* may affirm, modify, or reverse the decision appealed from.

The Distances Required in Sections 3.1, 4.2, and 5.7 of this Ordinance may be modified by the *County Health Agency* on any legal lot or parcel of record in the County Register of Deeds office existing before the adopted date of this Ordinance, providing such modification is not below the minimum distance required by the Wisconsin Administrative Code.

An Applicant desiring to install soil absorption sewage disposal facilities on the soils having severe limitations, listed in Section 5.4 of this Ordinance, shall have additional on-site investigations made, including soil boring and percolation tests; shall obtain the certification of a soils scientist that specific areas lying within these soils are suitable for the proposed soil absorption sewage disposal system; and shall meet the State Division of Health and the State Department of Natural Resources regulations. Thereafter, the *County Health Agency* must find that the proposed corrective measures have overcome the severe soil limitations and may attach any conditions it deems necessary to fulfill the purpose and intent of this Ordinance.

The *County Health Agency* may request the County Soil and Water Conservation District to provide expert assistance from regional, state, or federal agencies which are assisting such District under a ''Memorandum of Understanding.''

SECTION 10.0 DEFINITIONS

Words used in the present tense include the future; the singular number includes the plural; the plural number includes the singular number; and the word ''shall'' is mandatory and not directory. Definitions provided in Sections RD 12.03, H 62.02, H 65.02, and RD 13.02 of the Wisconsin Administrative Code are hereby adopted by reference. In addition, the following definitions shall also be used:

Deep Absorption System
A soil absorption sewage effluent disposal system for disposal of effluent through the bottom and sides of a hole or trench at a depth of more than three (3) feet *below the natural undisturbed surface.*

Floodlands
Those lands, including the floodplains, floodways, and channels, subject to inundation by the one hundred (100)-year recurrence interval flood or, where such data is not available, the maximum flood of record.

High-Water Elevation
The average annual high-water level of a pond, stream, lake, flowage, or wetland referred to an established datum plane or, where such elevation is not available, the elevation of the line up to which the presence of the water is so frequent as to leave a distinct mark by erosion, change in, or destruction of vegetation or other easily recognized topographic, geologic, or vegetative characteristic.

Parties-In-Interest
All abutting property owners and all property owners within *two hundred (200)* feet of the subject site.

Sanitary Inspector
A person recommended by the *County Health Agency* and appointed by the *County Board of Supervisors* to administer and enforce this Ordinance. References to the *Sanitary Inspector* shall be construed to include duly appointed deputy inspectors.

Septic Tank
A watertight, covered receptacle, which receives crude untreated sewage, and by bacterial action and sedimentation *effects* a process of clarification and decomposition of the solid sewage and discharges an effluent.

Shallow Absorption System
A soil absorption sewage effluent disposal system for disposal of effluent through open-jointed or perforated pipe at a depth not to exceed three (3) feet below the natural undisturbed surface.

Shorelands
Those lands lying within the following distances: one thousand (1,000) feet from the high-water elevation of navigable lakes, ponds, and flowages and three hundred (300) feet from the high-water elevation of navigable streams or to the landward side of the floodplain, whichever is greater.

Soil Mapping Unit
Soil types, slopes, and erosion factors delineated on operational soil survey maps prepared for the County by the U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the Southeastern Wisconsin Regional Planning Commission.

Wisconsin Administrative Code
The rules of administrative agencies having rule-making authority in Wisconsin, published in a loose-leaf, continual-revision system as directed by Section 35.93 and Chapter 227 of the Wisconsin Statutes, including subsequent amendments to those rules.

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Appendix I
GUIDES FOR EROSION CONTROL

The following technical guides deal with several practices designed to control erosion and sedimentation and to preserve existing vegetation in the urban development process. These guides were prepared by the Milwaukee and Waukesha Soil and Water Conservation Districts, cooperating with the U. S. Department of Agriculture, Soil Conservation Service and are reproduced verbatim herein.

Appendix I - 1

STANDARDS AND SPECIFICATIONS FOR TOPSOILING (URBAN AREAS)

Definition: Stripping the upper five to seven inches of surface soil from areas to be disturbed by construction, stockpiling for later use, and top dressing the exposed surface of completed outs and fills after land grading.

Purpose: To provide for a better quality of fill material and to ensure that exposed surfaces of graded areas will provide a favorable environment for plant growth.

Conditions Where Practice Applies: This practice is applicable to areas that are to be disturbed by land grading.

Specifications

The topsoils shall be stripped from areas to be disturbed and stockpiled (uncompacted). Upon completion of grading, the exposed soil material surface shall be top dressed with a minimum of four inches of topsoil. All roots larger than three inches in diameter shall be removed from the topsoil layer in order to leave it in suitable condition for the establishment of vegetation.

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STANDARDS AND SPECIFICATIONS GUIDE FOR PROTECTION OF EXISTING TREES DURING URBAN DEVELOPMENT

Definition: Protection of desirable trees from physical and mechanical injury while land is being converted from rural to urban use.

Purpose: To employ the necessary protective measures and to ensure the survival of desirable trees for shade, beautification, and erosion control.

Conditions Where Practice Applies: On areas now containing single specimen trees or groups of trees.

Specifications

1. Criteria for protecting trees:

    a. Where existing ground levels are raised, drainage tile will be placed at the old ground level and open into a well built around the base of the tree. The well will be left open or can be filled with coarse stones or gravel. Tile may be installed in a radiating pattern or laid in parallel lines.

    b. Trees within 25 feet of a building site will be ''boxed in'' to prevent mechanical injury.

    c. Nailing of boards to trees during building operations will not be tolerated.

    d. Heavy equipment operators will be warned to avoid damages to existing tree trunks and roots during land leveling operations. Major feeder roots shall not be cut.

    e. Tree trunks and exposed roots damaged during above operations will be painted immediately with a good grade of tree paint.

    f. All tree limbs damaged during building or land leveling will be sawed flush at tree trunks or large branches and painted with tree paint.

    g. The use of heavy equipment near desirable trees should be avoided as much as possible to minimize soil compaction.

    h. Waste concrete should be removed from the area and not dumped around the base of trees. This practice will kill trees and new landscape materials.

    i. All limbs removed from trees should be cut flush at trunks and painted with a good grade of tree paint.

2. Trees to be left:

    a. Trees that are relatively free from disease, that have relatively long life, and that have aesthetic beauty shall be preserved. Experienced builders and developers consider that having desirable shade trees on a residential home site frequently enhances the market value by $500 or more. By careful planning and development, desirable trees can often be saved at little or no cost to the developer.

Appendix I - 3

STANDARDS AND SPECIFICATIONS GUIDE FOR ESTABLISHING TEMPORARY VEGETATIVE COVER ON CRITICAL AREAS

Definition: Establishing temporary vegetative cover on high silt-producing areas created during urban construction activities. This includes the seeding of annual grasses, legumes, small grain, or the use of anchored straw mulch.

Purpose: To afford rapid cover for the control of accelerated runoff and erosion during periods of construction on disturbed areas and until permanent vegetation or other stabilization material can be established. (This practice is expected to give protection for a period of 6 to 12 months.)

Conditions Where Practice Applies: On areas of land that are being converted from agricultural or related uses to urban development and when the period of exposure will be at least 60 days but generally less than 12 months.

Technical Specifications for Establishment of Temporary Vegetative Cover

1. Apply 500 lbs. per acre of 20-10-10 or equivalent fertilizer.

2. Incorporate fertilizer into the top four inches of surface soil by disking or other suitable means.

3. Seed one of the following mixtures at the rate shown per acre:

    a. July 1 to September 15
    2 bu. of Rye (small grain)

    b. April 1 to July 1
    3 bu. of oats

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STANDARDS AND SPECIFICATIONS FOR ESTABLISHING PERMANENT VEGETATION ON CRITICAL AREAS

Definition: Stabilizing silt-producing and highly erodible areas resulting from construction activities by the establishment of permanent vegetative cover. This includes grass and legumes established by seeding or sodding to provide long-term ground cover.

Purpose: To stabilize the area so as to protect it from accelerated erosion and/or minimize damages from sediment and runoff to downstream areas.

Conditions Where Practice Applies: On critical erodible areas disturbed by construction activities where vegetation is difficult to establish with normal seeding methods and where appearance and heavy use are considerations.

Technical Specifications for Establishment of Grasses and Legumes Other Than Lawns

1. Site preparation:

   Where practical and economical, cover exposed subsoil areas with topsoil. A four-inch covering is usually adequate.

2. Supporting practices:

   Where possible and practical, use diversions to carry runoff water away from the areas until cover is established.

3. Fertilization:

   Apply 400 to 800 lbs. of 20-10-10 or 16-8-8 fertilizer (or equivalent) per acre, and work into top three or four inches of soil.

4. Seed to one of the following mixtures:

   a. All soils except drouthy sands.

      15 lbs. Southern Type Smooth Brome Grass)
      10 lbs. Tall Fescue) per acre
      5 lbs. Birdsfoot Trefoil)
      or
      15 lbs. Southern Type Smooth Brome Grass
      15 lbs. Tall Fescue

   b. Drouth sands and gravel.

      20 lbs. Southern Type Brome Grass)
      8 lbs. Vernal Alfalfa) per acre

5. Time of seeding:

   April 1 to September 15 where mulch is used. Seeding is normally not recommended without mulching. Seedings should not be made during late September and October.

6. Mulching:

   a. Straw or meadowgrass 1 to 1 1/2 tons per acre spread evenly. Straw or meadowgrass mulch should be anchored either by 1) asphalt at a minimum of 200 gallons per acre, 2) a straight disc, or 3) fiber netting secured with wire staples.

   b. Wood fiber materials - 1000 lbs. per acre.

   c. Jute netting - 43,560 sq. ft. per acre.

   d. Other protective materials as developed by industry.

7. Stabilizing crop:

   a. If mulching is not practicable, use stabilizing crop instead of mulch.

   b. Seeding rate - 1 1/2 bushels of rye or 3 lbs. of ryegrass not to exceed 10 percent of mixture.

   c. Mow stabilizing crop when it has started to head out. If stabilizing crop will not be mowed, use oats in fall and rye in spring.

   d. Plant stabilizing crops April 1 to July 1 or August 1 to September 1 and make grass seeding at one time. (Use mulch during July.)

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STANDARDS AND SPECIFICATIONS GUIDE FOR ESTABLISHING COVER BY SODDING IN URBAN DEVELOPMENT

Definition: The placement of suitable grasses removed from another site under growing conditions, containing a sufficient thickness of soil to hold in place and to temporarily support the existing plant growth.

Where Applicable: This practice is applicable where it is desirable to get quick permanent cover for protection against hazardous erosion conditions and/or where steepness of slope or other conditions makes establishment of vegetation by other methods questionable or impossible.

Site Preparation: The area where sod is to be placed should be prepared as for seeding. Soil preparation should be 3 inches deep. All nonarable areas should be resoiled with topsoil. Apply 500 lbs. of 20-10-10 fertilizer or equivalent per acre. This should be applied on site during soil preparation and mixed thoroughly with the top 3 inches of soil prior to placement of sod.

Sod Requirements: Grass sod shall be freshly cut and of good quality, having a clean growth of acceptable grasses free from weeds and harmful insects. It shall be cut 2 inches thick in strips with straight side and square ends. Sod selected should contain a minimum of 1 inch of soil material that adheres to the root system.

Sod Placement: Sod shall be placed uniformly on a well-prepared site; the strips will be tightly compacted together and smoothed down with a roller where possible. When placement on slopes greater than 2 1/2:1, sufficient staking should be done to ensure stabilization. On extremely sloping land (1:1) fine mesh wire or other suitable material will be employed to prevent slippage. On sloping areas, the sod strips should be placed so that the cracks will lie perpendicular to the slope. Sod strips should also be staggered so that the cracks between the strips are not continuous from the top to the bottom of the slope.

Supplemental Irrigation: Irrigation is often desirable and sometimes necessary for use when unfavorable weather or other conditions prevail. Employment of this practice both on areas where the sod is being produced and on the areas where sod has been placed, will ensure successful growth and establishment during most of the growing season. Application rates should be such as to minimize runoff.

Maintenance: Top dress with 500 lbs. of 20-10-10 fertilizer or equivalent per acre each year. Remove undesirable growth by clipping or the use of a recommended chemical weed killer.

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JUTE THATCHING USE IN WATERWAYS

Definition: Jute thatching is a coarse, open mesh, web-like material woven of heavy jute twine. It comes in rolls 225 feet long and about 4 feet wide.

Purpose: Jute thatching is used as a mechanical aid to protect the soil from erosion during the critical period of vegetative establishment. It serves better all the purposes of mulch. It is easier to lay and hold in place against wind. It has the tensile strength and weight to resist water flow and erosion.

How Used: Used in place of mulch or sod.

1. Preparing the channel:

   To prevent meandering, grade center to a slight V-shaped channel to confine low flows to the channel where thatching will be laid.

2. Fertilization:

   Lime and fertilize to standard recommendations.

   Disk as needed but do not cultipack.

3. Vegetative spriggings:

   Plant grass sprigs or similar material before the thatching is put down. Spacings for planting may vary. Suggested maximum: 18 x 36 inches.

4. Seedings:

   Split the application. Sow half the seed before placing the thatching. Plant the remaining half after the thatching is laid.

5. Laying the thatching:
   (If instructions have been followed, the thatching will be laid in loose soil.)

   Start laying the thatching from the top of the channel and unroll downgrade so that one edge of the strip coincides with the channel center. Lay a second strip parallel to the first on the other side of the channel and allow a two-inch overlap. If one roll of thatching does not extend the length of the channel, continue downhill with additional rolls.

6. Securing the thatching:

   Bury the top end of the jute strip in a trench four inches or more deep. Tamp the trench full of soil. Reinforce with a row of staples driven through the jute about four inches downhill from the trench. These staples should be about ten inches apart. Then staple the overlap in the channel center. These staples should be four to ten feet apart. The outside edges may be stapled similarly at any time after the center has been stapled. Closer stapling along the sides is required where concentrated water may flow into the channel.

   Succeeding strips of thatching farther down the channel are secured in a similar manner.

   Where one roll of thatching ends and another roll begins, the end of the top strip overlaps the trench where the upper end of the lower strip is buried. Make the overlap at least four inches and staple securely. If the ends and edges of the strips of thatching are securely stapled, stapling in the strip middles may be ten feet apart or omitted entirely.

7. Erosion stops:

   At any point the thatching may be folded for burying in slit trenches and secured as were the upper ends. This checks water flow and erosion that may begin under the matting. It also gives improved tie-down. The procedure is recommended on the steeper slopes of sandy soil and gentler slopes subject to seepage. Spacing may vary from 25 to 100 feet.

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STANDARDS AND SPECIFICATIONS FOR OPEN AND CLOSED STORM DRAINS

(URBAN AREAS)

Definition: Installing open or closed conduits with fixed linings of materials, such as concrete, metal, or other durable material.

Purpose: To provide for the disposal of excess water without damage by erosion.

Conditions Where the Practice Applies: This practice is applicable at sites where there is a constant flow of water that prohibits growth of vegetative protection or at other locations which prohibit use of grassed waterways or outlets.

Specifications

Capacity: The minimum capacity shall be that required to confine the peak runoff expected from a storm of 25-year frequency, based on recognized procedures for the particular type of installation planned.

Design and Installation: Design and installation will be in accordance with a plan approved by a qualified engineer.

Appendix I - 8

STANDARDS AND SPECIFICATIONS GUIDE FOR TEMPORARY DEBRIS BASIN

(URBAN DEVELOPMENT)

Definition: Constructing a barrier or dam across a waterway or at other suitable locations to form a silt or sediment basin.

Scope: This guide is applicable to impoundment heights of 15 feet or less.

Purpose: To provide for trapping and storing sediment from the drainage area above during the development period and until the area can be stabilized to a point where erosion and sedimentation are reduced to a safe level.

Conditions Where the Practice Applies: This practice is applicable where sites for small impoundments can be located below high sediment source areas, and the trapping of sediment at key points will protect areas and installations below. This is a temporary measure since the goal will be to permanently stabilize sediment source areas when development of the area is completed.

Specifications

Capacity: Adequate sediment storage capacity, where possible, shall be provided for the estimated volume of sediment that will be moved from the drainage area during the development period.

Spillways: All debris basins created by the construction of a dam shall be provided with a spillway or a combination of spillways and temporary storage capacity to handle safely the peak runoff expected from a storm of 25-year frequency.

1. Pipe Spillways:

   Each structure will be provided with a pipe drawdown or trickle tube to handle normal flow and to drain flood runoff from the sediment pool. The drawdown structure will consist of a horizontal pipe under the dam with a vertical riser at the upstream end. The crest elevation of the riser shall be set at the top of the sediment pool, and the riser shall be perforated to prohibit permanent storage of water.

   a. Size of horizontal pipe and riser--The drawdown pipe shall have a capacity adequate to discharge the flow from seeps and springs plus sufficient capacity to empty the sediment pool within a period of five days following storm flow. The minimum diameter of pipe that will be used shall be eight inches. The cross-sectional area of the riser pipe shall be at least 1.5 times the cross-sectional area of the horizontal pipe.

   b. At least one anti-seep collar at the centerline of the dam will be required on smooth pipe exceeding eight inches in diameter and on corrugated pipe exceeding twelve inches in diameter.

   c. Where a drawdown pipe is not provided, the accumulated storm water may be drawn out by pumping.

2. Vegetated Spillway:

   The elevation of the control section of the vegetated spillway shall be a minimum of one foot above the elevation of the crest of the riser pipe. Additional temporary storage obtained by increasing the minimum is desirable to reduce frequency of emergency spillway flow.

a. The length of the control section shall be not less than the crest width of the dam or more than twenty feet in length.

b. The entrance to the vegetated spillway shall be at least 25 percent wider than the control section. The grade of the vegetated spillway from the control section to the entrance shall be not less than 3 percent.

Earth Embankment:

1. Side slopes:

   The side slopes for settled embankments shall be not steeper than 2 1/2: 1 on both sides.

2. Top Width:

   The width of the embankment shall be not less than 8.0 feet for fill heights of ten feet or less, and not less than ten feet for fill heights of ten feet to fifteen feet.

3. Freeboard:

   The settled top elevation of the embankment shall be a minimum of one foot higher than the maximum flood water level in the pool.

4. Site Preparation:

   The embankment site and borrow area shall be cleared of trees, stumps, sod, and other undesirable material.

   a. The area below sediment pool level shall be cleared of all trees, brush, and fallen timber.

   b. A core cutoff trench, where required by soil conditions, shall be excavated to a layer of slowly permeable material.

   c. The core cutoff trench and all steep or overhanging banks in or on which fill material will be placed shall be sloped to a 1:1 or flatter slope.

5. Embankment Construction:

   The fill material shall be obtained from designated areas. It shall be free of roots, limbs, sod, or other objectionable material. Frozen material shall not be placed in the fill nor shall fill material be placed on a frozen foundation.

   a. Fill material shall be placed in the embankment in layers not exceeding six inches in thickness and with suitable moisture content for obtaining desired compaction. Each layer shall be kept as near level as practicable and be completed over the entire fill area before the next layer is started.

   b. Fill around pipe shall be placed in approximate four inch layers and compacted with hand operated equipment. The hand tamped material will be brought at least two feet above the top of the pipe before heavy equipment is operated over it.

Vegetative Protection: All exposed areas of the embankment and spillway shall be protected by establishment of suitable vegetation.

Safety: Adequate safety signs will be displayed to warn the public of the hazards from soft silt and flooding.

Final Disposal: After the structure has served the desired purpose and the drainage area is stabilized against erosion, the embankment and resulting silt deposits will be leveled or otherwise disposed of.

References:

1. ''Engineering Handbook for Soil Conservationist,'' U. S. Department of Agriculture, Soil Conservation Service.

Appendix J
SOILS EDUCATIONAL PROGRAM IN THE SOUTHEASTERN WISCONSIN REGION

INTRODUCTION

As a result of the Interagency Soils Agreement executed for the Southeastern Wisconsin Region (see Appendix A of this Guide), an educational program has been prepared and sponsored by the U. S. Department of Agriculture, Soil Conservation Service; the University of Wisconsin; the Waukesha County Extension Service, Institutions, and Park and Planning Commission; and the Southeastern Wisconsin Regional Planning Commission. The purpose of this educational program is to explain to potential users of the soil survey data and analyses how the survey was made and to demonstrate how the survey and analyses could be used for various land use planning and development purposes as applied to an actual tract of land.

SITE LOCATION

The demonstration site is located in the southeast one quarter of Section 28, Town 7 North, Range 19 East, just north of the City of Waukesha and southwest of the Waukesha County Airport on the Waukesha County Institutions grounds. This 160-acre tract of land contains about eight acres of sparse woodland, about two acres of orchard, about 15 acres of Class IV e agricultural lands, and over 100 acres of Class III e and II w agricultural lands. The slope of the land ranges from 1 percent to 13 percent, with the land elevations ranging from a low of 898 to a high of 963 feet above mean sea level datum. The tract contains two low-lying areas, with elevations of 898 and 929. Land use adjacent to the tract includes medium-density single-family development to the south and west and agricultural uses to the north and east.

SITE SOIL MAP

While the 1'' = 2000' (1:24000) scale at which the regional soil survey was performed met regional planning needs, local land use planning and development work requires topographic and cadastral maps at a scale of 1'' = 100' (1:1200) or 1'' = 200' (1:2400). Therefore, the available topographic maps at a scale of 1'' = 200' and the soil maps of this 160-acre demonstration site were enlarged to a scale of 1'' = 100'; and additional soil borings were made to delineate more precisely the soil mapping unit boundaries at the larger scale. In addition, demonstration pits were dug solely for educational purposes. These pit locations were selected for well-, moderately well-, and poorly-drained soils. The majority of the soil types on the site are Hochheim (360) and Lamartine (364) silt loams, and over 25 acres are Ehler (212) silt loams. The type, slope, erosion factor, and boundaries are shown on the soil map for each soil type on the demonstration site. Based on the enlarged soil and base map, two series of graphic displays were prepared for educational and demonstration purposes; namely, a suitability series and a plan series.

SUITABILITY SERIES

Suitability maps based on the analyses of the soils for selected urban, recreational, and agricultural uses were prepared at the same scale as the enlarged soil map. This suitability series included the following uses:

1. Residential uses served by on-site soil absorption (septic tank) sewage disposal systems.
2. Residential uses served by public sanitary sewer.
3. Industrial uses.
4. Recreational uses.
5. Agricultural uses.

PLAN SERIES

Development plans based upon the analyses of the soils and closely related to the above suitability maps were prepared at the same scale as the suitability maps. This plan series included the following map and development plans:

1. Zoning district map.
2. Residential development plan (on-site soil absorption sewage disposal systems).
3. Residential development plan (public sanitary sewer systems).
4. Industrial development plan.
5. Park development plan.
6. Conservation farm plan.

MATERIALS AVAILABLE

Colored slides have been made of the original base map, soil map, suitability series, and development plan series prepared for this educational program. These 13 slides with a narrative text are available at a cost of $3 directly from the Department of Agricultural Journalism, 14 Agricultural Hall, University of Wisconsin, Madison, Wisconsin 53706. Large colored displays mounted on poster boards at a scale of 1'' = 100' have been prepared for use at the demonstration site. These 13 boards are in the custody of the Regional Planning Commission, and arrangements may be made for their use through the Commission, the U. S. Soil Conservation Service, or the Waukesha County Extension Service.

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