SOILS OF THE TWIN CITIES METROPOLITAN AREA

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and their relation to urban development

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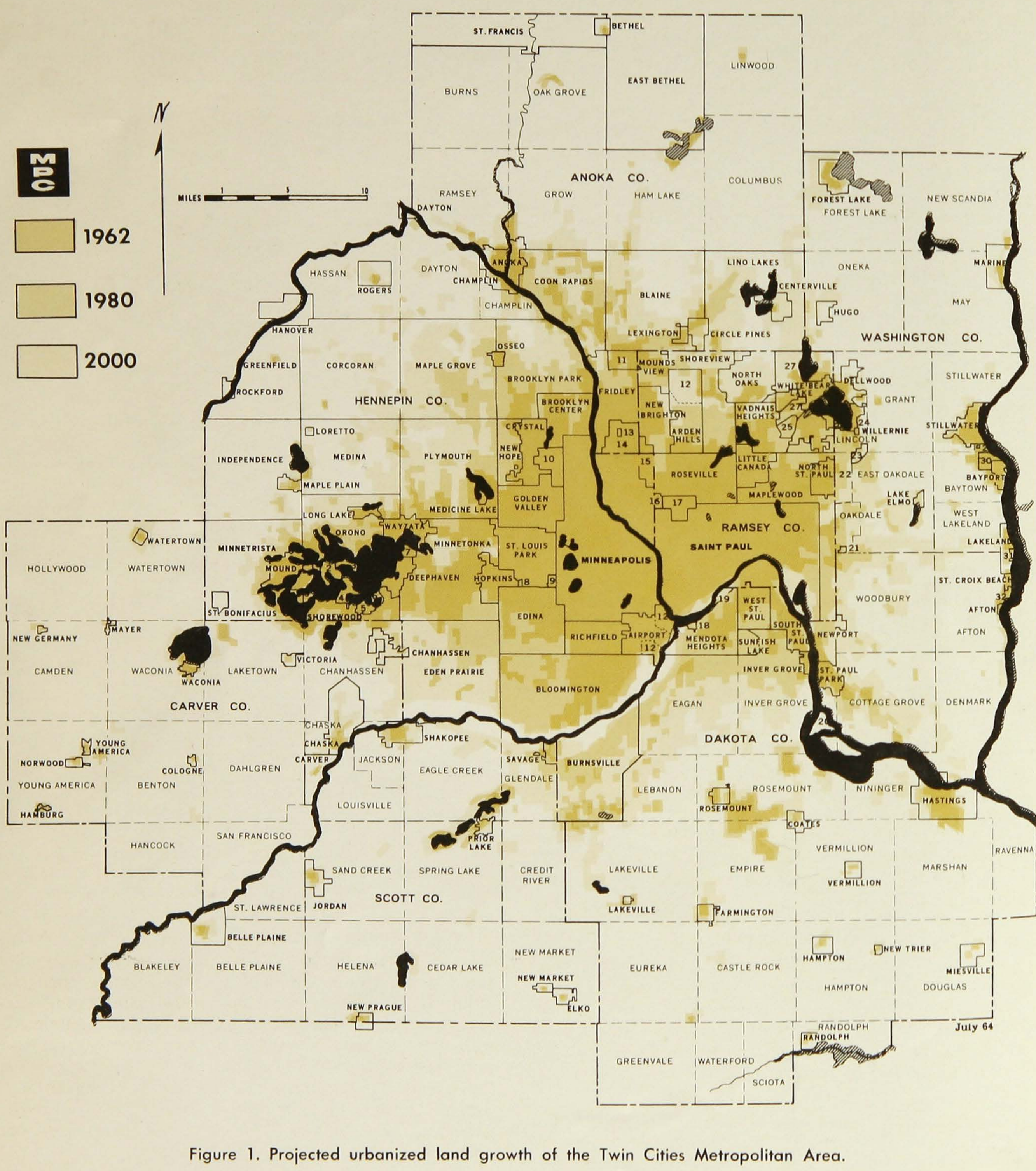


Figure 1. Projected urbanized land growth of the Twin Cities Metropolitan Area.

INTRODUCTION

Soil is one of the most common parts of our environment. Its very familiarity often leads to lack of appreciation of its significance. But the composition and topography of a soil are powerful determinants of the way we use land. Whether soils are sand or clay, level or steep, organic or inorganic, wet or dry, makes a significant difference in constructing roads and buildings, in landscaping and plant growth, and in sewage removal.

This bulletin provides information on soils of a general nature as well as soils technology, particularly as it concerns urban problems related to engineering. It includes the establishment and description of eight interpretive soil groups, suggests various applications of soils information to urban development, and points out the advantages as well as the shortcomings of soils for various uses. A generalized soil map of the Twin Cities Metropolitan Area is inside the back cover.

A principal objective of this bulletin is to show how local soils differ in properties of particular interest to those engaged in urban planning, land zoning, real estate development, highway construction, recreation projects, and public utility service. The emphasis is on broad soil groups of a divergent nature that are useful for large-scale, general interpretations. It is not intended to provide specific information for individual small sites; such information can be obtained from professional testing and engineering companies and from soil survey reports.

Soil survey reports are available for the Twin Cities Metropolitan Area, except Carver County. These reports include descriptions of the soils, suggested uses, and a detailed soil map of each county. The maps show the location of individual kinds of soils rather than groups of soils, and provide more specific information than the generalized soil map. Additional information about these reports and their availability is given on pages 34 to 36.

The seven-county Twin Cities Metropolitan Area population of 1.7 million is expected to increase an additional 2.5 million by the year 2000.[1] While the Twin Cities Metropolitan Area population is growing, its physical size is also increasing at a faster rate because the amount of space used per person has been increasing. Thus, the land requirements of the area for the year 2000 are tremendously expanded (see figures 1 and 2). If present land use trends continue, the built-up portion of the area will increase from 360 square miles to over 900 square miles.

Since a wide range of population densities, land values, and levels of accessibility are found in and around the Twin Cities, it is important to evaluate the impact of soils in various parts of the urban area. On the urban fringe, low-density urban development has been quite sensitive to soil differences because levels of accessibility and land values are relatively low. Development is often influenced by construction costs associated with soil and topographic differences, so low, wet areas or steep sites that require earthmoving generally are avoided.

The quantity of land on the urbanizing fringe available for development expanded rapidly as automobile transportation provided freedom of residential location. With new highways and freeways being built to respond to these needs, there seems little doubt that the opportunity to choose suitable land and bypass high-priced or lower quality land will be strengthened.

At the other end of the scale, where accessibility is high, land values are high. In these locations it is more economical to correct deficiencies of the site through drainage, filling, or leveling than would be the case under low intensity uses. With the passing of time, development of a difficult and expensive area may become economically feasible.

In the case of location decisions for commercial or industrial developments, accessibility to people and markets and other locational factors will generally override the differences commonly found in soils. However, site development and construction costs will vary with the nature of soils of the area selected.

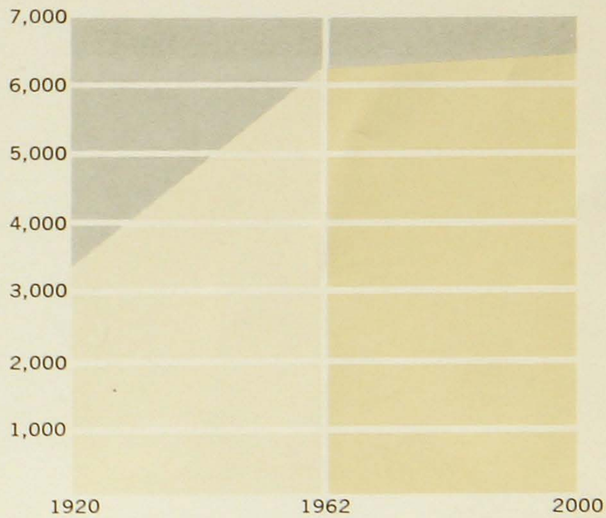


Figure 2. Square feet of urbanized land per person in the Twin Cities Metropolitan Area. Chart courtesy of the Joint Program for Land Use-Transportation Planning.

This bulletin describes the major kinds of soils in the Twin Cities Metropolitan Area and interprets the significance of the differences of these soil areas for nonagricultural uses, with emphasis on urban and residential use. Most of the analysis, particularly the generalized soils map, is based on detailed soil surveys previously published by the U. S. Department of Agriculture and the University of Minnesota. The nature of subsurface formations is not provided in this bulletin, but the useful general relationships between soils and the nature of deeper subsurface materials are included.

[1] *New Population Projections for 1980 and 2000*. The Joint Program Info. Bull. No. 1, St. Paul, Twin Cities Metropolitan Planning Commission, August 1963.

SOILS AND THEIR CLASSIFICATION

Forces Shaping the Landscape

Recent geologic history of the Twin Cities Metropolitan Area landscape is that of an extensive sorting of previous deposits by glacial action. Although the popular concept of a glacial activity is one of a massive sheet of ice scouring over bedrock and periodically depositing a mixture of material, many glacial deposits are a result of the water and wind actions of the period. Only when all three transportation agents of deposition are considered can one explain the complex pattern of uniform coarse sands in some areas, fine-textured silts in others, and an intimate mixture of huge boulders in a matrix of sand and clay in still others. Our soils have developed from these diverse glacial materials.

The pattern of glacial deposits and, therefore, soils is complex. But it is not difficult to understand when the processes involved are considered. Although not included in this report, the preglacial geologic story provides a useful background.

The reader is referred to the selected reference list at the end of the bulletin. An excellent popular discussion is found in *Minnesota's Rocks and Waters.*[2]

The confluence of the Minnesota and Mississippi Rivers accounts for much of the variety of the parent material deposits of soils in the Twin Cities Metropolitan Area. Glacial melt water channeled through these then much larger rivers, laying down large quantities of outwash sands and gravels. Sandy soil areas frequently are the result of such melt water deposits.

Moraines, rolling hills marking the margins of the glacial ice, are prominent features to the south and east. In contrast to the well-sorted materials laid down by flowing or standing water, a morainic area is typically a variety of mixed materials from coarse cobbles and boulders to fine silts and clays. The topography is rolling, with sharp changes in relief and short slopes.

Relatively level areas deposited directly from glacial ice are called *till plains.* Much of the landscape of Hennepin, Carver, and Scott Counties, and some in Washington County is formed from this material. Here water had less effect in modifying and sorting particle sizes, and hundreds of square miles have a uniform texture.

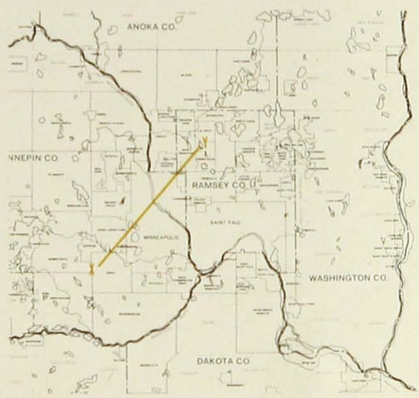
Soil parent materials deposited by wind and lake water are less extensive. Wind apparently has modified many of the surfaces of the Twin Cities Metropolitan Area, but there are no large areas of significant wind deposits. Wind deposits, called *loess,* cover large sections of southeast and southwest Minnesota. Loess occurs in the Rosemount area of Dakota County, and it is quite probable that the so-called silt caps, shallow surface layers of silty soil, common in Washington and Ramsey Counties were deposited by wind.

Lacustrine deposits result from deposition in nonflowing lake water. Fine clays and silts are characteristic textures and are found in scattered areas of northern Washington County and in Vadnais Heights, north of St. Paul. Parts of the Anoka Sand Plain also are reported to consist of lake-laid silts and fine sand.[3]

Since the soil areas mapped for this bulletin have been selected primarily on the basis of texture, drainage, and topography, the distribution of the soils groups is closely related to the original glacial deposits of outwash, till, loess, and lacustrine materials.

[2] George M. Schwartz and G. A. Thiel, *Minnesota's Rocks and Waters, a Geological Story,* M.G.S. Bull. No. 37, Minneapolis, Univ. of Minn. Press, 1963.

[3] J. E. Stone, *Surficial Geology of the New Brighton Quadrangle, Minnesota,* Geol. Map Series G.M.2, Minn. Geol. Survey, Minneapolis, Univ. of Minn. Press, 1965.



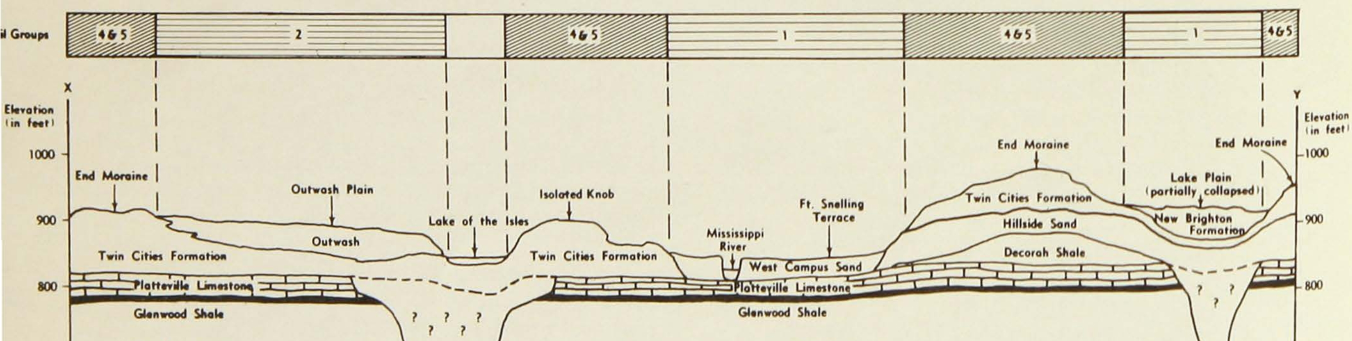


Figure 3. Geologic cross section through Minneapolis-St. Paul indicates relationship of soil groups to geological profile along the line indicated on inset map at right. The upper bar diagram indicates the usual association of soil groups and glacial deposits. Geologic section by J. E. Stone, Minnesota Geologic Survey.

Given the geological parent materials or, in a sense, raw materials, different types of soils develop according to other factors of soil formation. In addition to parent material, four other factors of soil formation are recognized: topography, climate, vegetation, and time. None of these operates independently; they have a combined effect, as each affects the slowly changing characteristics of a particular soil.

Soil Formation

A brief review of the effect of the five soil-forming factors is given here to assist the reader in evaluating the nature and range of variations of soils to be expected in a particular area.

Parent material—The texture and chemical composition of the parent material deposits are the starting point for soil formation. In the Twin Cities Metropolitan Area textures show little change because the glacial period is recent and the cool climate has restricted chemical alteration. Chemical changes have taken place, however, particularly a loss of soluble materials and an accumulation of organic matter at the surface. In general, sandy parent materials have changed less than fine-textured materials.

Climate—In terms of regional or world patterns of soils, climatic variations account for most of the soil differences. In a relatively small area like that represented by this report, climate effect is less obvious. However, microclimatic effects such as the cool, moist conditions of peat bogs and the hot, arid-like microclimate of south-facing hills modify the kind of soil that develops. Vegetation is sensitive to climate, and cool, wet sites generally develop more vegetation and deeper, more friable soils than do dry, warm sites.

Vegetation—Whenever the microclimate and soil water-holding factors combine to form a moist soil, tree vegetation usually develops. On dry sites, such as sands and gravels in the Twin Cities Metropolitan Area, prairie grass was the native vegetation.

Forests tend to develop light-colored, shallow, low-organic-matter, acid soils in contrast to dark, high-organic-matter,

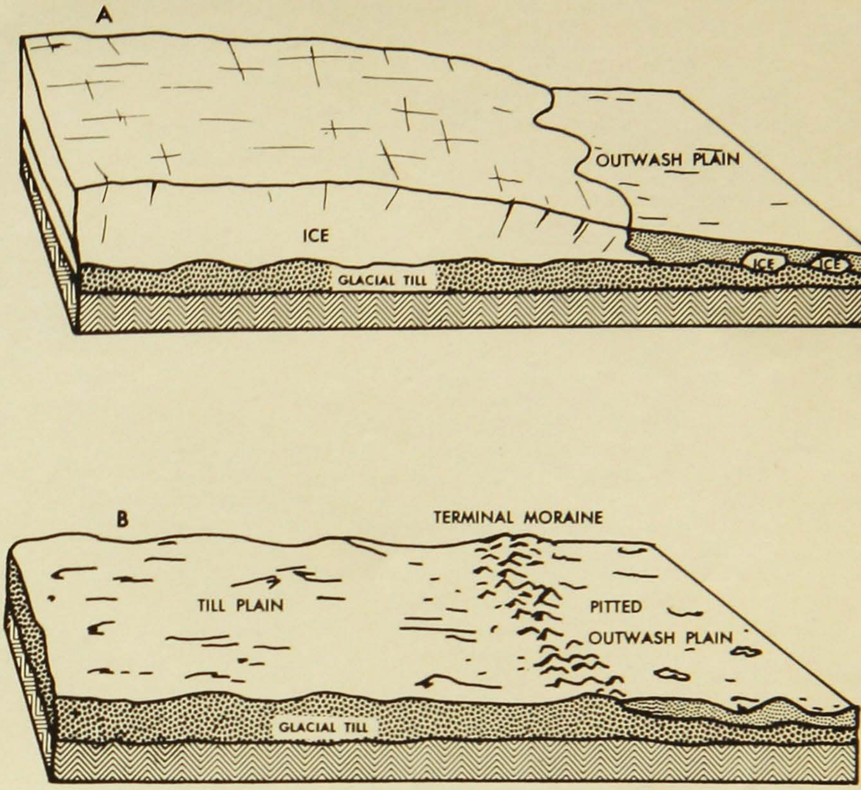


Figure 4. Formation of an outwash plain and a terminal moraine; (A) represents the melting stage of glacial ice and (B) the landscape after the ice has melted. The glacial till, deposited directly from the ice, is a mixture of fine clay and coarser particles. Sands and gravels make up the water-sorted outwash plains. Illustration by permission from "Minnesota Rocks and Waters: A Geological Story," by George M. Schwartz and George A. Thiel. Minnesota Geological Survey Bulletin 37, University of Minnesota Press. Copyright 1954, 1963 by the University of Minnesota.

less acid prairie soils. An exception is the poorly drained wet site where trees do not grow because of the high water table. Here sedges and other water-tolerant plants thrive and their residues accumulate to form organic surface layers.

Time—This factor represents how long the various soil-forming factors have affected the parent materials. Geologists estimate that the most recent glacial activity in this area occurred about 10,000 to 14,000 years ago.[1] Compared to areas to the south and east that have more rainfall, warmer temperatures, and longer warm seasons as well as older parent materials, Minnesota soils are youthful.

Topography—Several side effects result from different types of topography, or the "lay of the land." Steep soils have lower rates of water intake and more erosion than level or depressional sites. Erosion and the usually drier conditions of hilly land cause shallow soils, sometimes little different from the parent material, to develop.

In areas where soil textures are medium to fine, both internal and surface drainage are directly related to slope and landscape position. The more sloping soils are better drained.

[1] H. E. Wright, Jr. and R. V. Ruhe, "Glaciation of Minnesota and Iowa," in *The Quaternary of U.S.*, H. E. Wright, Jr. and D. G. Frey, Editors, Princeton, N.J., Princeton Univ. Press, 1965, pp. 29-41.

Soil Properties

Texture is the most basic property of soils. Texture refers to the fineness or coarseness of soils, essentially the size of the individual soil particles. Knowledge of soil texture, both surface and underground, is of vital importance for proper planning of land uses because it influences so many soil characteristics.

Landscape architects and gardeners are interested in the textural classification of surface soils because texture affects soil's natural fertility, its ability to drain properly, and its capacity for holding water. Engineers and building contractors are concerned with the texture of subsurface soils because it indicates their drainability, water-holding capacity, stability, ease of excavation, and erodibility.

A general indication of the effect of texture on some of the more common soil characteristics is shown in table 1.

Descriptive terms such as sand, silt, and clay were mentioned in the previous section. Since soils and soillike materials usually consist of a mixture of various proportions of the three main size categories of particles, coarse (sand), medium (silt), and fine (clay), a system to describe the common types of size mixtures is necessary.

Although several systems of textural classification are in use, three are most common: the USDA, official for the U. S. Department of Agriculture; the Unified, a system used by civil engineers; and the AASHO, a system of the American Association of State Highway Officials. There is some variation in the size definition of the particles, but the differences are not great. Figure 6 shows the particle size categories of the three systems.

Since the USDA system is utilized in the soil maps on which the generalized map inside the back cover is based, descriptions of soils in this bulletin will also use this system.

There are 12 main classes of texture in the USDA system. Textural class describes soils through use of combinations of terms such as sandy, silty, and loam. The last term reflects the most important size category. For example, a sandy clay means a fine-textured soil, mainly clay but containing some sand. Loam refers

Table 1—The effect of texture on soil characteristics

Soil characteristics	Soil texture	
	Coarse	Fine
Water conductivity (or drainability)	High	Low
Water-holding capacity	Low	High
Total pore space	Small	Large
Size of pores	Large	Small
Tendency to shrink and swell	Low	High
Bearing strength, dry	High	High
Bearing strength, wet	High	Low
Soil fertility—nitrogen and potassium	Low	High
Stability against sliding on slopes	High	Low
Erodibility (water)	Low	High

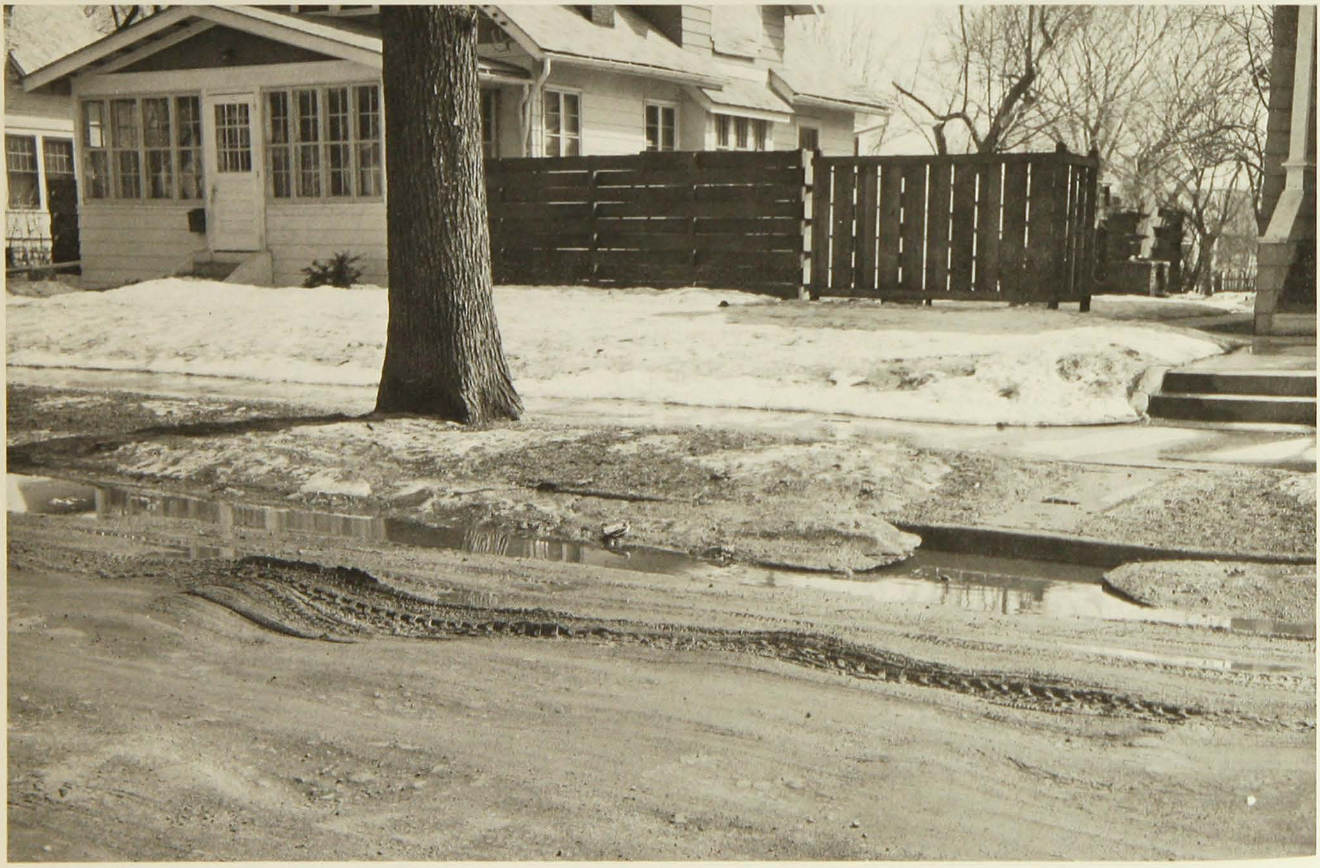


Figure 5. Organic and plastic soils provide insufficient bearing support for today's traffic loads.

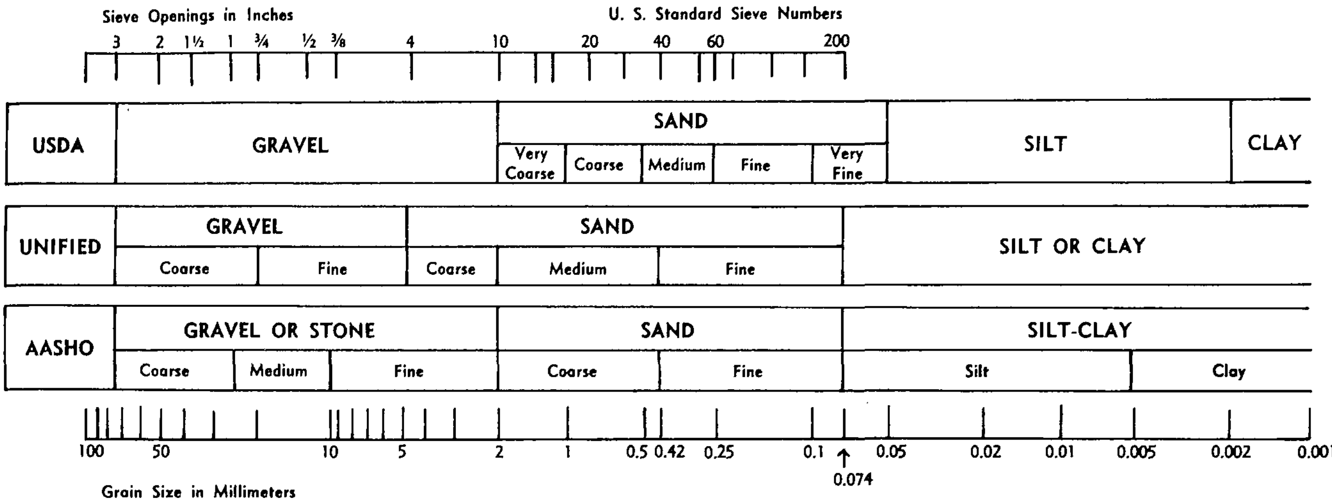


Figure 6. Comparison of soil particle size for three commonly used texture systems. Because of the wide range in sizes, the actual size of sand, silt, and clay particles is not in direct proportion to distance on the scale. Particles range from about 1/25,000 inch for clay to 3/8 inch for gravel. Diagram developed by Soil Conservation Service, USDA.

to an almost equal mixture of sand, silt, and clay and therefore is an intermediate textural class.

When a soil consists of a wide range of particle sizes, clay has a tendency to dominate and to set the behavioral pattern. So clay must be given first consideration. If the clay fraction of a soil exceeds 30 percent, its engineering behavior should be considered strictly as a clay, even though as much as 70 percent of the total sample consists of coarser materials.

Figure 8 shows the proportions of sand, silt, and clay that make up the various textural classes of the USDA system.

Color of the surface soil is an important property when soils are considered for agricultural use. Dark colors indicate relatively high amounts of organic matter, which contributes to favorable tilth and nitrogen release. But surface color is less important for urban applications.

Subsoil colors are important in that light brown, yellow, and red colors indicate rapid drainage; dull gray and mottled colors usually mean slow internal drainage. These colors are more reliable in indicating natural soil drainage than the particular moisture condition when a site is examined.

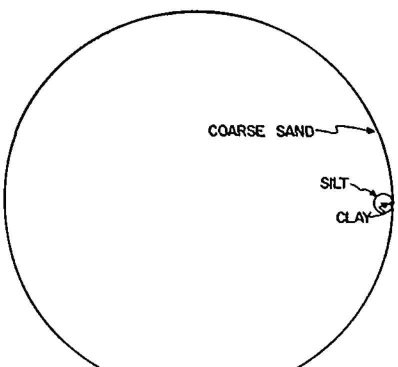


Figure 7. Relative sizes of three kinds of soil particles. Although they have been enlarged about 56 times, the clay particle can barely be seen.

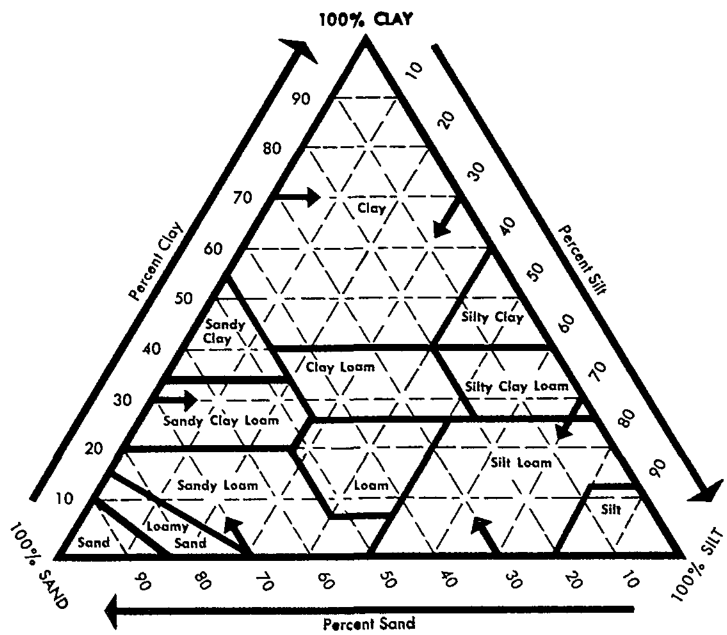


Figure 8. The texture class of a soil—such as loam, sandy loam, or clay loam—is determined by the percentage of sand, silt, and clay. Follow the appropriate percentage lines for sand, silt, and clay to their intersection. For example, a soil with 35 percent clay, 30 percent silt, and 35 percent sand is classified as clay loam.

Structure of a soil refers to the way the primary particles of sand, silt, and clay are arranged into aggregates. Structure is of some significance in that undisturbed soils, especially fine textures, have a much more compact structure and higher density than disturbed soils. So with these textures a filled area can be expected to settle for a year or more, even when the material is initially packed.

Organic matter content refers to the percent by weight of plant and microorganism residues in various stages of decomposition in the soil. Soils that contain more than 30 percent organic matter are called organic soils, either peat or muck. Organic matter darkens the soil color, reduces the volume weight, and increases the water-holding capacity.

Soils containing considerable organic matter tend to compress when loaded. So when the role of soil is that of support for structures or a base for roads, organic matter reduces the value of the material and normally is removed.

Percolation information indicates the relative rate at which water movement occurs in the soil (see table 2).

Permeability is a qualitative term often used interchangeably with percolation to indicate rate of water movement in the soil.

Strictly speaking, rate of water movement in the soil under defined, saturated conditions should be referred to as *hydraulic conductivity*. Coarse textures and peat soils usually have relatively high rates of water movement or percolation. Estimates of this important property are often made by use of the auger hole percolation test. Figure 9 illustrates such a test.

Table 2—Percolation rates of soils in drained condition*

Soil characteristics	Percolation rates (minutes/inch)
Sand and gravel soil with none to slightly developed B horizons	Less than 10
Silty clay loam to sandy clay loam B horizons underlain by sand or gravel	11-30
Silty clay loam to clay loam B horizons underlain by loam to sandy loam C horizons	31-60
Strongly structured silty clay loam to silty clay B horizons underlain by silty clay loam C horizons	61-90
Weakly structured silty clay and clay B horizons underlain by silty clay to clay C horizons	More than 90

* Source: Lindo J. Bartelli, "Use of Soils Information in Urban Fringe Areas," in *Journal of Soil and Water Conservation* 17:3, May-June 1962, pp. 99-103.

Note: The terms *A, B,* and *C horizons* refer to soil layers visible in a vertical cross section (profile). The A horizon is at the surface and the upper part is dark in color from organic matter. The B horizon is often enriched in clay and soluble chemicals from the A horizon. A few soils lack a B horizon. The lowest horizon is the C, the parent material.

Percolation tests determine the rate of water movement through the soil mass. So percolation is an important soil characteristic for land use planning. The feasibility and location of on-site sewage disposal facilities and need for basement drainage are frequently determined by data from percolation tests.

Since the absorbing ability of soils is extremely variable, several percolation tests should be made at each particular building site. Percolation rates obtained from these tests are usually expressed as the minutes required for the water level in a test hole to drop 1 inch. The following procedure for making percolation tests is similar, in general, to that recommended by the Minnesota Department of Health:

(1) Bore several test holes with a 4- to 8-inch auger, spacing such holes uniformly over the proposed site. Their depth should extend to the depths of the soil being studied.

(2) Carefully scratch sides and bottom of each hole with knife or other sharp-pointed instrument to provide natural interface between water and soil.

(3) Remove loosened soil from bottom of hole and add 2 inches of coarse sand or fine gravel to protect bottom of hole from scouring.

(4) Gently fill hole with clear water to a depth of at least 12 inches above top of gravel. If possible, maintain water at approximately this depth (by refilling) for at least 4 hours and preferably overnight.

Make percolation rate measurements 24 hours after water is first added to the hole. If water remains in hole after overnight saturation, adjust depth of water to approximately 6 inches over gravel. From a fixed reference point, measure drop in water level over a 30-minute period and use this drop to calculate percolation rate (see figure 9).

If no water remains in test hole after the overnight saturation period, add clear water to approximately 6 inches over gravel. From a fixed reference point, measure the drop in water level at

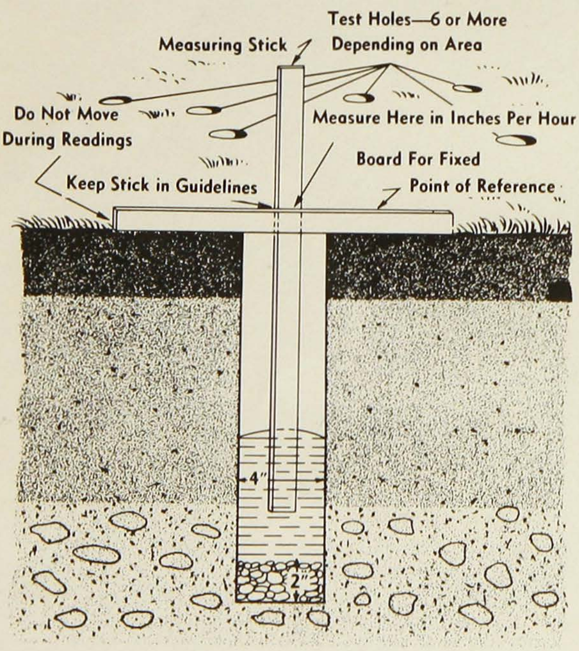


Figure 9. Guide for making a percolation test.

approximate 30-minute intervals for 4 hours, refilling the hole to a depth of 6 inches as necessary. The drop that occurs during the final 30-minute period is used to calculate the percolation rate.

In sandy soils, or those soils in which the first 6 inches of water seep out of the test hole in less than 30 minutes, measurements in water level should be taken at 10-minute intervals over a 1-hour period. As before, the hole is refilled to the 6-inch depth as necessary for each measurement, and the drop in the final 10-minute period is used to calculate the percolation rate.

Typical percolation rates for various soils are shown in table 2. Because of their porosity, sandy soils do not require overnight saturation as described above. The percolation tests in such soils can usually be made after the water from one or two fillings has seeped away.

One of the problems of evaluating the relative suitability of a soil for absorbing septic effluents is that the rate of absorption of clear water is usually more rapid than that of septic tank liquids.

Reaction is one of the chemical properties of soil and refers to the pH or degree of acidity; pH values below 7.0 are acid and those above 7.0 are alkaline. The normal pH range of soils in the area is from 4.5 to 7.5. Lime is commonly applied if it is desired to raise the pH,

Table 3—Bearing strength of undisturbed northern Illinois soils as related to soil texture*

Soil texture	Bearing strength: Dry site	Bearing strength: Wet site
	(1,000 lb./sq. ft.)	
Sandy loam	6-8†	6-8†
Loam and silt loam	6-9	4-6
Silty clay loam	4-8†	3-6†
Silty clay	10-12	1-3

* Source: Lindo J. Bartelli, "Use of Soils Information in Urban Fringe Areas," in *Journal of Soil and Water Conservation* 17-3: May-June 1962, pp. 99-103.

† Test values.

and elemental sulfur can be used to acidify a soil. Soils with pH values less than 7.0 tend to corrode underground conduits and pipes. Tests for pH and electrical conductivity, therefore, provide useful data for prediction of the corrosive tendencies of soils. Other chemical properties, such as availability of nutrients, can be determined in the laboratory.

Bearing strength refers to the weight-holding capacity of soils, usually in an undisturbed condition. Although fine textures may have a higher bearing strength in a dry condition than sandy textures, the opposite is true under wet conditions. Texture is one of the main variables determining bearing strength, as illustrated in table 3.

Soil Classification

Soils of the Twin Cities Metropolitan Area are classified in accordance with a nationwide system of soil classification. The *soil series* is the basic unit of classification. A series comprises soil profiles (vertical cross sections) with similar properties of texture, horizon development, and drainage. Most of the soil series found in this area are listed in the appendix, page 34. Detailed descriptions of these soils are available in individual county soil survey reports.

The soil series of the area are grouped into eight categories. This interpretive grouping allows generalizations about relative suitability and problems relating to urban types of land use.

Of the many characteristics of soil that affect suitability of land for urban development, three major characteristics—texture, slope, and internal and surface drainage—have been used for grouping the soils in this bulletin.

Many of the other soil characteristics of interest to urban land users are closely related to these three variables. A detailed discussion of characteristics and their implications for urban use is given in the next section.

DESCRIPTION OF SOIL GROUPS

Group 1—Level to Gently Sloping Sandy Soils with Sandy or Gravelly Substratum[5]

General description and location—Sands sorted by the meltwaters of glacial ice and rivers are the parent materials of the extensive area in the Group 1 category. They are (1) the *Anoka Sand Plain* soils with a complex inner mixture of peat, wet, and well-drained soils, and (2) the *Hubbard and other soils of the Mississippi alluvial valley train*, which are more uniform in texture and landform.

The part of the Anoka Sand Plain extending into the Twin Cities Metropolitan Area forms a large wedge extending from Osseo and Brooklyn Center near the Mississippi River on the west to a line roughly parallel to Highway 8 on the east.

The rest of the Group 1 area, mainly Hubbard soil, is located in the southern part of Minneapolis and reaches through Richfield, the eastern two-thirds of Bloomington, and along the top of the river bluffs into Eden Prairie Village. A third and smaller area is found in the southeastern part of Cottage Grove Township and parts of Grey Cloud Township in Washington County. And there are numerous small areas of this soil group in northern Ramsey and Washington Counties.

Parent materials, texture, and topography—The primary basis for defining Group 1 soils is the common property of sandy texture from near the surface to depths ranging from 15 to several hundred feet. The sorting action of the glacial meltwaters which carried away most of the fine silt and clay particles left this generally uniform coarse-textured material.

There is some range in texture (see figures 13 and 14), but compared to the glacial till and morainic areas the texture

[5] A slope of 8 to 10 percent is believed to be the critical point at which land is less desirable for commercial and industrial development in this metropolitan area. However, 12 percent was the closest breaking point common to the existing soil surveys. Although there is a slight tendency to overstate the amount of land that is most desirable in today's market, at some future date the 12-percent slope may be more acceptable due to increased pressures for urban land.

Figure 10. An aerial photograph about 2 miles northwest of the city of Anoka. Note the pattern of numerous poorly drained areas (Group 6) in the Anoka Sand Plain in contrast to the uniform, well-drained soils in the Mississippi Valley Train. Both are Group 1 soils. Zimmerman loamy sand is the predominant soil type in the sand plain, while Hubbard loamy sand is common in the valley train. The three main categories of wet soils are indicated by circled numbers on photograph that correspond to these descriptions: (1) Peat and wet sand bogs in the sand plain, (2) river bottom soils wet or subject to flood, and (3) pothole depressions of wet mineral soils that occur within areas of Groups 4 and 5. Photo: Aerial Photography Division, USDA.

is uniform. Loamy sand is the dominant texture, which means that more than 70 percent of the soil is composed of sand.

The topography of the Anoka Sand Plain area ranges from a region of well-defined low hills of well-drained sands interspersed with peat bogs, to flat areas where there is only a few feet of difference in elevation between the sands and poorly drained peat. The low hills and bogs are in the northern part of the metropolitan area; Columbus, Ham Lake, and Grow Townships are typical of this landscape. The area around Coon Rapids, Mounds View, and Blaine is an example of the level topography. High water tables are a frequent problem.

Investigations show that the water tables of lakes, bogs, and streams in this area are closely related, so any attempted change in the water level through drainage in a small area is likely to affect a much larger area. Conflicts of interest between agricultural and urban land use regarding drainage are not surprising.

In the area of Group 1 soils where Hubbard type soil is dominant rather than Zimmerman and Anoka, the landscape has an entirely different appearance. Here much of the local relief is 5 feet or less per mile and most areas have adequate drainage. The land around the Minneapolis-St. Paul International Airport is typical of this part of Group 1.

Soil profile pattern and native vegetation—The typical profile (vertical cross section of soil) is also different in the Hubbard and Zimmerman areas. Most of the Anoka Sand Plain area had a native vegetation of forest, causing a

Figure 11. Uniform sand texture of Group 1 soils makes them easy to excavate and grade but subject to wind erosion when vegetation is disturbed.

Figure 12. Level, sandy soil near the Minneapolis-St. Paul International Airport is typical of Group 1 soils in the Richfield-Bloomington area.

low organic matter, light-colored surface soil to develop. In contrast to the rather uniform light brown Zimmerman profile, the Hubbard soil formed under prairie vegetation has a dark-colored surface horizon that grades into a bright brown-colored subsoil. Larger medium sands are typical in the Hubbard profile while fine sands are associated with the Anoka Sand Plain soils.

The present vegetation is much modified from native vegetation, but the original pattern is still evident. Species of oak, primarily northern red and bur, predominate on the well-drained soils of the Anoka Sand Plain. Aspen and hazel brush are common on the wet sands.

Most of the Hubbard areas are devoid of native tree vegetation, which is an expression of the more arid, low water table conditions of this part of Group 1. Here sands may occupy a depth of 50 to 200 feet, allowing deep percolation of surface water. Relatively impermeable deposits 20 to 40 feet deep underlay the Anoka Sand Plain.

Most of the Group 1 soils have a percolation rate of less than 10 minutes per inch. The exceptions are locations where bands of fine-textured material occur in the subsoil or where the water table is high. In general, all of the Group 1 soils south of Anoka County are well drained with deep water tables. Standing water or wet basements are rare problems. On the other hand, low water-holding capacity and rapid drainage leads to droughty conditions in the summer and occasional wind erosion.

High water table, poor drainage problems are restricted to the margins of the Group 1 soils in the areas previously noted. But surface water may accummulate in spite of permeable soils when soils are frozen.

The rapid internal drainage of these soils has caused leaching of lime and potassium. Acid soils that require lime and potash fertilizer for good plant growth are the rule. Nitrogen is also usually in short supply, as organic matter levels are low. Nitrogen fertilizers are especially important for lawns.

Suitability for urban use—Soils in this group are well suited to most urban development. Sands conduct water rapidly, are readily compacted, consist of particles of relatively uniform size, and have a low shrinkage-expansion index.

One of the disadvantages of these soils is that when vegetation is disturbed, blowing sand collects in yards and causes abrasion on buildings.

Much of the early growth of Minneapolis suburbs following World War II

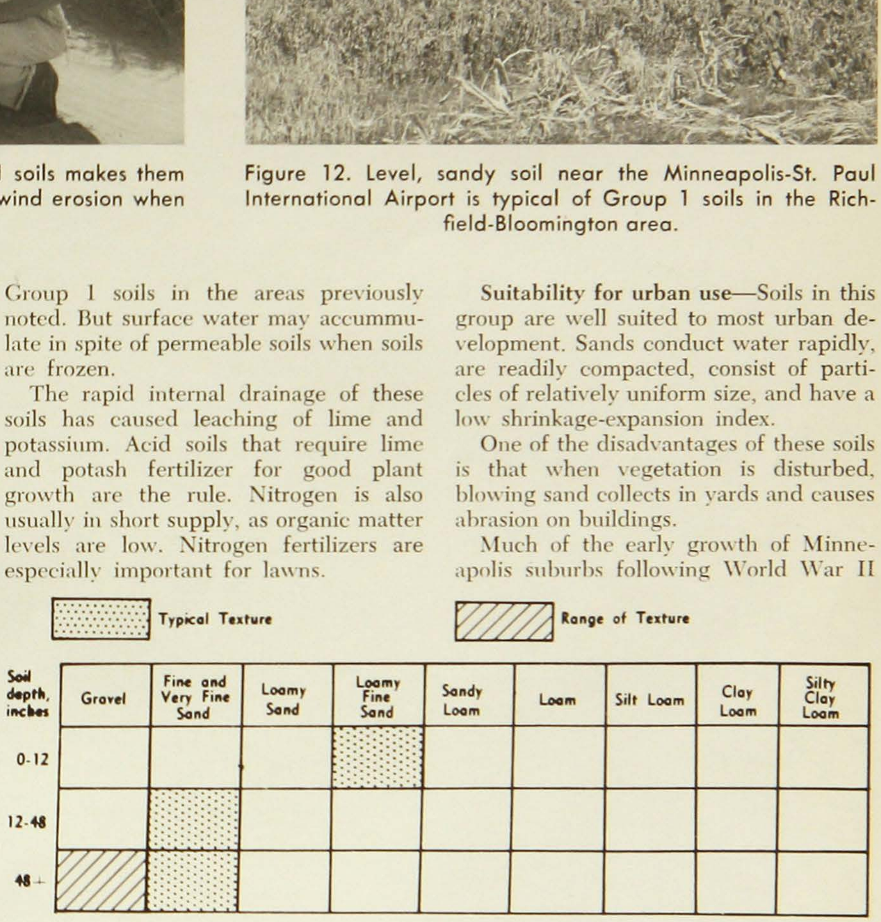


Figure 13. Texture profile of Group 1 Zimmerman soils.

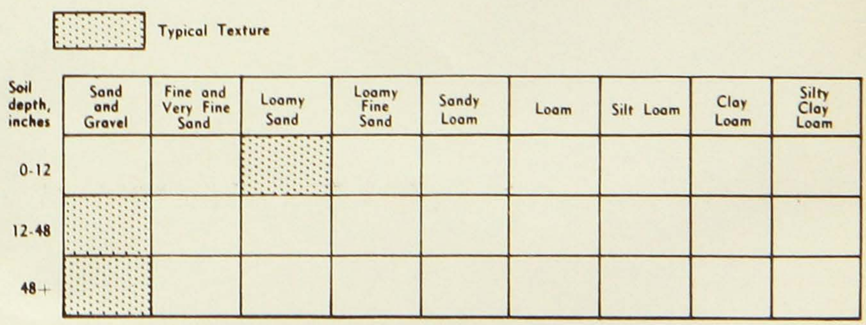


Figure 14. Texture profile of Group 1 Hubbard soils.

took place on soils of this group. The ease of development, especially the ability to provide water for individual wells at low cost and to absorb septic tank drainage, permitted the extension of urban growth beyond the limits of public water and sewer systems. Growth in Bloomington during the 1950's closely followed the area of Group 1 soils and bypassed less desirable soils in the process.

During the past 10 years a significantly large proportion of the major tract developers have sought soils in this group because of the ease of development. These soils have been especially important to builders of low-cost homes. But the supply of land in this group with good access is rapidly being depleted. The largest undeveloped areas are in Brooklyn Park and in Champlin, Ramsey, Grow, and Cottage Grove Townships.

Itemized development characteristics:

1. Sewage effluent is rapidly dispersed.[8]

2. Ease of water movement in soils necessitates the use of deep-cased sanitary wells to avoid pollution by on-site sewage disposal systems.

3. Excavation costs are low except for deep trenches where caving of walls often becomes a problem. Lower excavation costs result from:

- ability to work soil in winter because it is porous and does not retain moisture nor freeze as solidly as other soils.
- rapid drainage which permits earth-moving equipment to work soon after a rain and results in less waste time for equipment.
- lack of boulders.

4. Level land results in lower grading costs for site development requiring flat areas for large industrial and commercial buildings. Tract housing developments also benefit from the lower grading requirements.

5. Road and parking lot construction costs are lower because coarse-textured soils need less subbase materials and preparation.

6. Drainage is rapid enough to minimize basement seepage and costs for waterproofing.

7. Cost savings are possible through smaller storm drainage requirements because of less runoff.

8. Wind erosion is often a problem when vegetation is lacking.

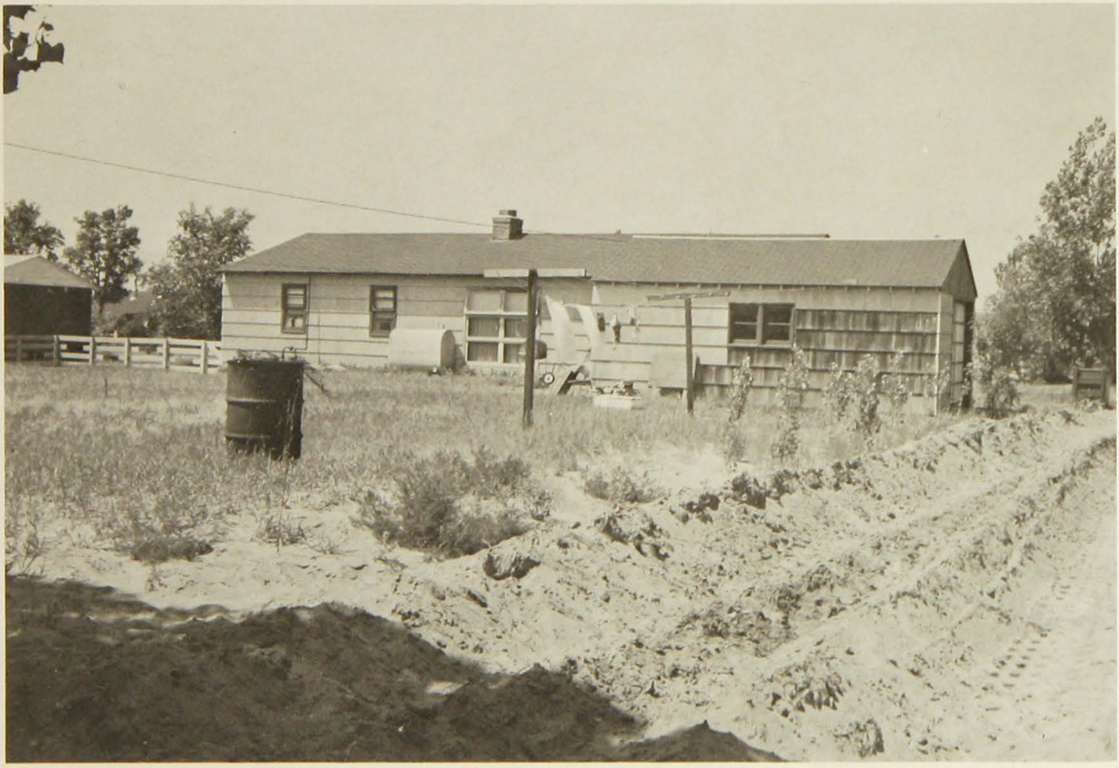
9. It is not good agricultural land and, therefore, cannot as easily be held off the urban market.

10. Rapid drainage of water contributes to drought conditions for lawns and ornamental plantings. About 35 days of moisture shortage per year is normal. Lawns and other plantings must be watered frequently or finer textured soil material used as topdressing to increase the water-holding capacity.

SUMMARY—*The soils included in this group are sandy. This coarse character facilitates many urban uses because of such factors as ease of excavation, suitability for foundations and roads, and rapid removal of drainage water. The topography is level to gently rolling, and adaptable to many uses. However, the flatness also makes the area somewhat lacking in variety. Home sites on Group 1 soils are less interesting than those on rolling sites.*

[8] Due to the low relief and impermeable substratum in extensive areas of this soil group, such as Brooklyn Park, Blaine, and Coon Rapids, poor external drainage has resulted in a high water table level. A high water table precludes proper operation of on-site disposal systems.

Figure 15. Sand blowing in a Group 1 soil area where vegetation had been removed caused this problem.



Group 2—Level to Gently Sloping Soils With Silty or Loamy Surfaces and With Sandy or Gravelly Substratum; Slopes Are Less Than 12 Percent

General description and location—In terms of general landscape and use, these soils appear similar to those of Group 1. They are well drained, but differ in that the 18- to 30-inch surface horizons are medium to moderately coarse rather than sandy textured as in Group 1.

If one of the eight soil groups identified in this bulletin could be classed as superior for most urban types of land use, this category would be so designated. These soils have the advantages of rapid drainage and firm foundation material without the disadvantages of a coarse, droughty, sandy surface subject to wind erosion.

Group 2 ranks second in amount of land within the study area. It strongly predominates over all of northern Dakota County and is extensive in the southern three-fourths of Washington County. A small belt extends westward from Minneapolis through Hopkins and Minnetonka, and another area follows along the Minnesota River in northern Scott County.

Parent materials, texture, and topography—Outwash sands and gravels account for most of the underlying parent materials, but the surface, to a depth of 1 to 3 feet, has a finer texture. In some cases this silty material has been deposited by wind after the coarser material had been laid down by water. In other cases the finer textured surface material may have been deposited by slow-moving or slack water.

A wider range of original and developed soil materials is represented in Group 2 than in Group 1. Nevertheless, these soils are relatively uniform over much of the southeastern Twin Cities Metropolitan Area south of the Minnesota and Mississippi Rivers. Lebanon, Rosemount, and Nininger Townships in Dakota County represent typical examples of these uniform Group 2 soils.

Waukegan and Dakota soil types are common. They are loams or silt loams and are underlain at 14 to 36 inches with well-sorted sands and gravels. This underlying sand and gravel extends to several hundred feet in the Rosemount area(see figure 17).

The large areas of Group 2 soils in Washington County are similar to those of central Dakota County. Nearly level topography is characteristic of these "Waukegan flats."

The Group 2 soils located within the morainic hills immediately south of the rivers in Dakota County and those of south Minneapolis and western Hennepin County consist of more diversified soils.

These soils may change abruptly in a hundred yards and textures are variable. This is particularly true in the hills of northern Dakota and northeastern Scott Counties, where the landforms often look similar but each hill varies in texture. For accurate information on soil texture for a *small parcel* of land in this area, refer to the detailed soil survey map of Dakota or Scott County.

The pattern described for the variation in soil texture also applies to the landscape pattern of Group 2. Two distinct subregions exist within the group—that of the level-lying uniform soils in central Dakota and parts of Washington Counties, and the more rolling sandy and gravelly soils located in the end and ground moraine areas of Hennepin and Ramsey Counties and in northern Dakota County.

Figure 16. A Group 2 landscape in Dakota County. Waukegan soil is in the foreground and the more variable, hilly, Burnsville and Lakeville soils are in the background.

Figure 16 illustrates the two soil types, with the flat outwash area in the foreground and the hilly area in the background representing material of more variable topography and texture.

The distinction between Group 2 and Group 3 soils is largely one of steepness of slope. Sandy soils with slopes exceeding 12 percent (12-foot change in elevation within 100 feet) are included in Group 3. Therefore, a number of Group 2 soils grade into the Group 3 category in the rolling areas.

Poorly drained soils are rare in most Group 2 regions, particularly where the topography is quite level. This lack of potholes and wet soils is a result of the 100- to 200-foot-deep coarse sediments. The log of a well near Rosemount shows 200 feet of porous sand and gravel above the bedrock.[7] Even where rather

[7] George A. Thiel, *Geology and Underground Waters of Southern Minnesota*. Minn. Geol. Survey Bull. No. 31, 1944.

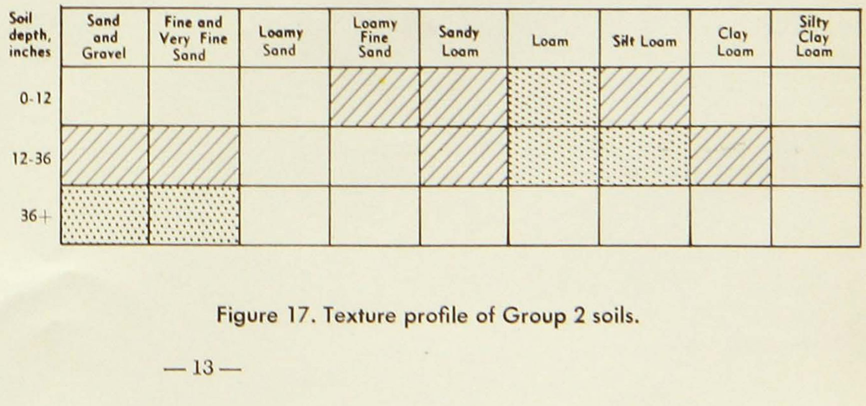


Figure 17. Texture profile of Group 2 soils.

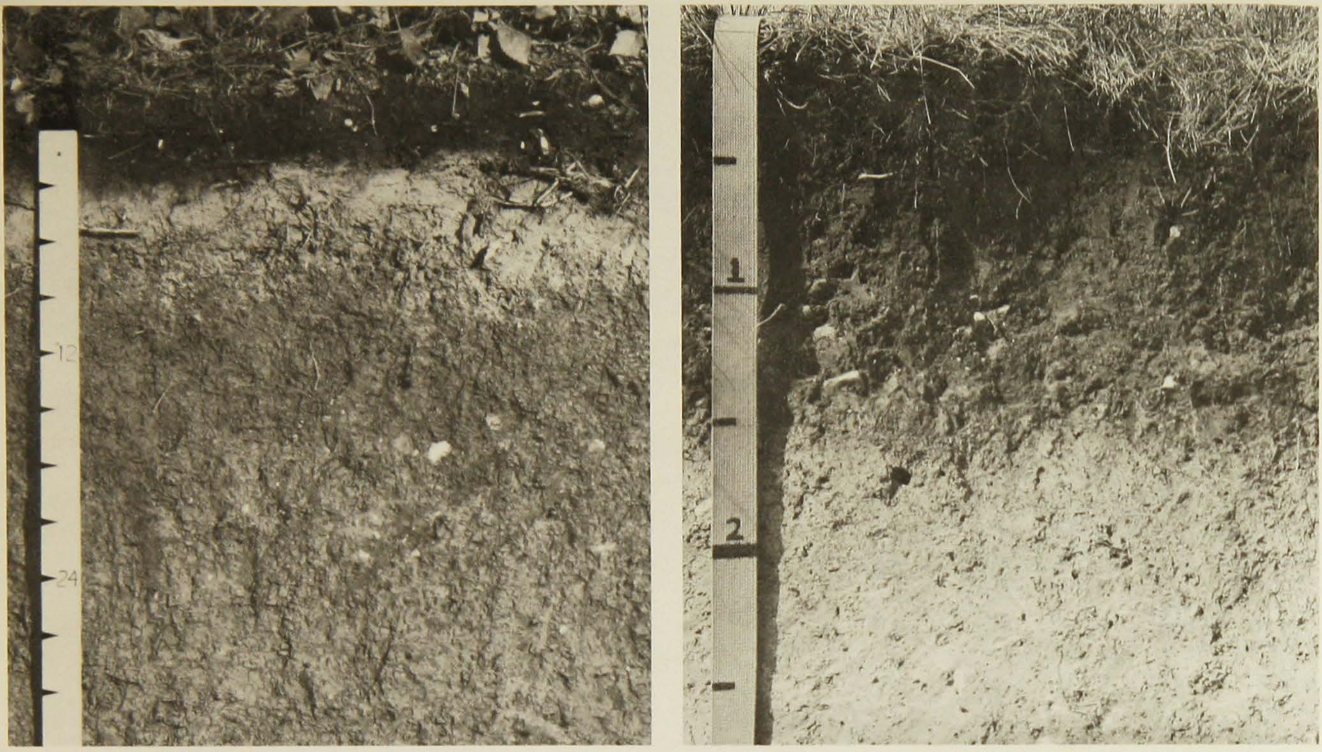


Figure 18. These profile views show how vegetation causes soils to differ. Forest soil is on the left and prairie soil on the right. The layers in the profile are called *horizons*. They are easiest to see in the forest soil.

deep depressions occur in this area, the soils are seldom wet.

Small potholes and some wet areas of an extent large enough to be mapped as Group 6 soils occur in the gently rolling areas of Dakota, Ramsey, and Hennepin Counties. This indicates that the less permeable deposits are near the surface.

Part of southern Minneapolis mapped as Group 2 is often referred to as pitted outwash area. The surface is level or gently undulating, but several depressions—such as Powderhorn Park Lake—occur. These are explained as the result of large blocks of residual glacial ice that melted after the sands and gravels were deposited.

Figure 19. Profile typical of Group 2 soils shows medium-textured material above and sandy and gravelly material below. Depth of the horizons varies within the group. Depth in feet is indicated.

Soil profile pattern and native vegetation—A total of 26 individual soil series are included in Group 2. These soils represent various combinations of color and texture and combinations of horizons. As in the case of the pattern of landscapes and textures, the individual soil profiles and native vegetation are not randomly distributed.

Native prairie grass vegetation generally covers the extensive areas of level, well-drained, Group 2 soils in Dakota and Washington Counties. Deep, dark soils high in organic matter developed in these regions as a result of the grass vegetation. Figure 18 shows the typical forest and prairie type profile which develops as a result of differences in vegetation. Depending on native vegetation, this same pattern of relatively light- or dark-colored surface horizons is repeated throughout most of the soil groups shown on the generalized map.

The original vegetation in the more rolling areas of Group 2 apparently was a mixture of trees and grass. The higher water table levels in these regions no doubt accounts for the greater proportion of trees, which are less tolerant of drought than grass.

Whether a particular soil has developed a "prairie" or "forest" type profile is usually not a significant factor in urban use. But the soil profile does serve as an indicator of normal soil water content of the site.

Large stones and boulders do not generally occur on the level portions of Group 2 soils, but do occur on the rolling moraines and nearby glacial till soils (Groups 4 and 5).

Drainage, permeability, and chemical properties—Since the substrata of all Group 2 soils are coarse textured, percolation rates of less than 10 minutes per inch indicated in table 2 normally hold for depths below 4 feet. But the surface infiltration rate of the loam and silt loam textures is slower than the rate on the loamy sands of Group 1.

Internal drainage and possibly lateral water movement can be a problem on the Group 2 soils which occur near areas of Groups 4 and 5 soils. In this case, fine-textured impermeable layers may restrict downward movement, and the sandy lenses serve as aquifers of soil water.

The chemical properties vary considerably, both because of natural soil variation and recent soil amendments. Compared to the finer textured soils, however, Group 2 soils are leached, resulting in moderate acidity and a need for nitrogen, phosphorus, and potassium for truck and agricultural crops. Lawns and golf course fairways normally will not require as intensive management as those on Group 1 soils. Drought probability is 5 to 10 days per growing season.

Suitability for urban use—Soils in this group, as noted earlier, are well suited to urban development. For most urban uses this soil group has all the advantages of Group 1 soils without the disadvantages related to wind erosion and droughty conditions. Another feature of Group 2 soils is that they occupy large areas and tend to be uniform.

Compared to Group 1, little new suburban growth has taken place on this soil group because it is not as accessible to employment centers as Group 1. An exception was the early growth westward from Minneapolis on a belt of Group 2 soils through St. Louis Park, Hopkins, and Minnetonka. Some development occurred in Richfield and in Plymouth where it followed a narrow belt along State Highway 55 and Hennepin County Road 6. Other areas of recent development of this group of soils are in southwestern Roseville, Mendota Heights, West St. Paul, South St. Paul, Inver Grove Township, Eagan Township, and Lebanon Township.

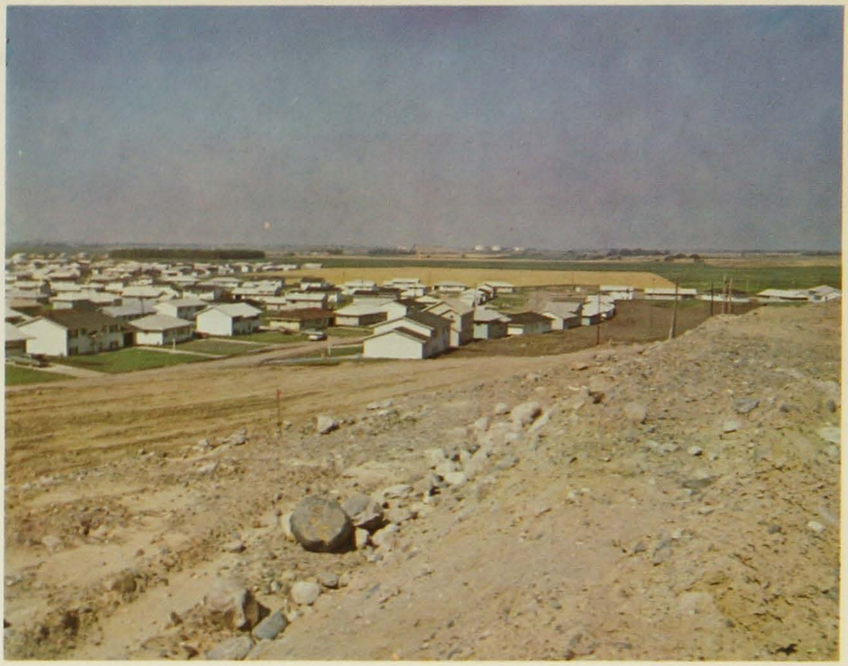


Figure 20. A new residential development on level Group 2 soil with gravelly, stony material typical of rolling soils of Groups 2 and 3 in the foreground. Underlying material of the level area consists of boulder-free sands and gravels.

Group 2 soils provide the area's largest and most favorable reserve of land for urban purposes, particularly for higher density residential developments. More new development is expected to be shifted to these locales in the near future as accessibility is improved by highway construction.

The major areas of these soils are located in directions which have grown slowly—south and east of St. Paul. This area will be better served from both Minneapolis and St. Paul as new highways are completed.

Itemized development characteristics:

1. Characteristics listed under Group 1 from 1 through 6 are applicable here.

2. Soils have a good potential for agricultural purposes, so the shift of land use to urban may be slower than in the case of Group 1 soils. In the metropolitan margin, better agricultural land enables the agricultural user to resist development if he so desires.

3. On slopes, particularly over 6 percent, water runoff requires special attention. There is an erosion hazard, particularly if any grading is done.

4. Qualities of soil are uniform throughout large areas.

5. Lawns, trees, and shrubs are relatively easy to establish and maintain.

6. The subsoils are usually good sources of sand and gravel.

SUMMARY—*The desirable combination of rapid internal drainage and medium-textured surface makes Group 2 soils easily adaptable to almost all urban or agricultural uses. Most of the land is level, and what is not level is only moderately undulating. Terrain characteristics for general residential use are more interesting than the normal landscape of Group 1.*

Group 3—Rolling to Hilly Soils With Sandy to Loamy Surfaces and With Coarse Substratum; Slopes are 12 Percent or Greater

General description and location—Although many of the soil series in Group 3 are the same as those of Group 2, the character of the landscape is markedly different because of the hilly topography. This rolling land with sharp changes in soils and drainage is typical end moraine terrain. Figure 21, taken at the intersection of Highways 52 and 55 in Dakota County, is a good example of this group.

There are few extensive areas of Group 3 soils. The largest area is in northern Dakota County where they are mixed with Group 2 soils. One concentrated area is in the western part of Minnetonka Village and another winds through St. Paul, north and east of the State Capitol. There are also limited areas in Minneapolis between lakes Harriet and Calhoun and east and north of Lake of the Isles.

Parent materials, texture, and topography—A combination of water and ice is perhaps the best way to describe the agents of deposition for these soils. In contrast to the Group 2 uniform sand and silt laid down by wind and water, the moraines of Group 3 contain a mixture of textures. The materials are sandy or gravelly, as compared to Groups 4 and 5, but areas of several acres of sandy loam or clay loam soils often occur within the area designated as Group 3. Some of the areas of Group 3 as well as nonlevel areas of Group 2 are considered glacial till rather than outwash, but the textures are coarser than those of Groups 4 and 5 (see figure 23).

As in the case of the gently rolling areas of group 2, accurate information on a specific site should come from the appropriate detailed soil survey map or from an on-site inspection.

Stones and boulders are common and are a hazard in excavation.

Two types of landscape patterns occur: One is characterized by extensive areas of rolling hills and valleys; the other by narrow ridges or escarpments separating sandy terraces from the upland along rivers and streams. Some of the latter occur in the field in dimensions too narrow to show on the generalized soil map.

Numerous potholes and poorly drained sloughs occur throughout the area, although most of them are too small to be noted on the map. Local relief in extreme cases may reach 200 feet, which severely limits the type of land use.

Water erosion is a constant hazard whenever native grass and tree vegetation is disturbed. Gullies can develop rapidly and are difficult to control. Soil Conservation Service technicians located

Figure 21. Group 3 landscape in the urban fringe south of St. Paul. Recreation uses such as golf courses and ski slopes are appropriate for this kind of land.

Figure 22. Residential land use on Group 3 soils.

at local county offices can provide erosion control and other soil information.

Soil profile pattern and native vegetation—Because the nature of a soil depends on climate, topography, vegetation, and parent material, variations in these factors cause soil differences. Group 3 soils are marked by wide differences as a result of changes with position in the topography and associated localized climatic and vegetational differences. Organic matter, depth of leaching, acidity, and sequence of horizons can be quite different within several hundred feet. Most properties are those of coarse-textured soils and are similar to those described in the Group 2 section.

Mixed deciduous forest was the native vegetation, except for grasses on arid south-facing slopes and where soils were particularly sandy. Oak, elm, basswood, birch, and aspen are common species.

Drainage, permeability, and chemical properties—Surface and internal drainage is largely a matter of slope position. Most of the material is quite permeable, but water rapidly accummulates in depressions and valleys and wet soils result.

It is difficult to generalize about the chemical properties because of variation in the physical characteristics of the soils.

Suitability for urban use—Soils in this group have most of the advantages of Groups 1 and 2 for urban development. But the steep slopes present problems of development that preclude certain land uses. On the other hand, this varied topography provides some of the most attractive sites for homes and other uses such as parks and open space.

Except in Minneapolis and St. Paul, little of the Group 3 soils area is developed. A partial explanation is that, in most cases, these soils have not been in the main path of growth. In Dakota County development has been mainly individual building sites as opposed to subdivision development. More development can be expected on these soils as growth reaches farther into northern Dakota County.

There is little doubt that development of land with the relief found in this group is much more expensive than in Groups 1 or 2. The engineer for one builder estimates grading costs at an additional $350 or more per lot for this type of land as compared to grading costs for Groups 1 and 2. Sewer costs could increase 20 percent, and other costs, such as surveying, would also increase. In areas of moderate roughness the increase in development costs would easily exceed $500 per lot.[8]

SUMMARY—*While land in Group 3 has higher development costs that may cause some developers to bypass it, certain amenity values make the land desirable for higher value homes. Rolling areas with proper subdivision design offer lots with vistas and an environment that encourages variety among housing styles.*[9] *In addition, under most circumstances, one could expect to find larger lot sizes because a selection of natural siting for the home reduces the amount of grading that is required.*

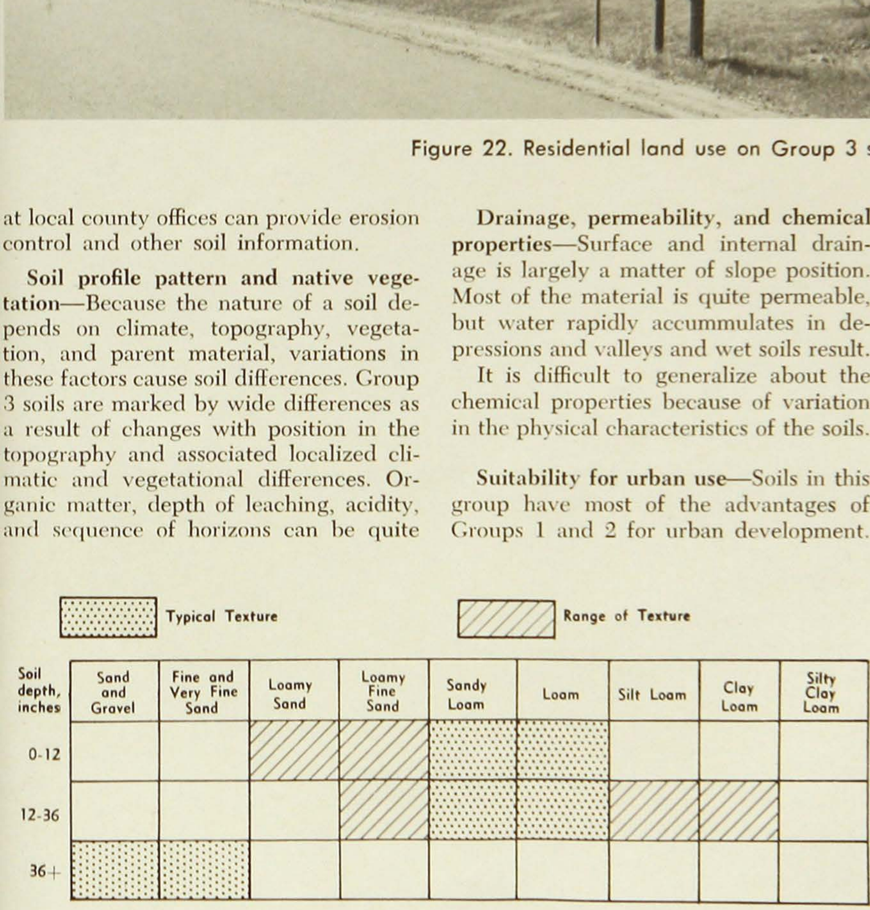


Figure 23. Texture profile of Group 3 rolling to hilly soils.

[8] *Selected Determinants of Residential Development.* Background Document No. 1, St. Paul, Twin Cities Metropolitan Planning Commission, March 1962, p. 28.

[9] Ibid.

Figure 24. Profile of Grantsburg Sublobe, Wisconsin Age buff till in Ramsey County. Although commonly referred to as "clay" soil, this Group 4 soil is not as fine textured as Group 7 soils.

Group 4—Level to Gently Rolling Medium- to Fine-Textured Soils With Slopes of Less Than 12 Percent

These gently rolling medium- to moderately fine-textured soils are the most extensive of the eight groups in the seven-county Twin Cities Metropolitan Area.

Formed from compact sandy loam to clay loam till, their physical characteristics are in sharp contrast to the coarse materials of Groups 1, 2, and 3. Extensive urban development has taken place on these soils, but several adjustments from practices appropriate on sandy soils have been required in the engineering of foundations, drainage, and road construction.

Group 4 soils account for about 75 percent of the land in Hennepin, 90 percent in Carver, and 70 percent in Scott Counties. Extensive areas also occur in suburban Ramsey and both the south and north one-third of Washington County. Dakota (within the study area) and Anoka Counties have insignificant amounts.

Parent materials, texture, and topography—The soils of Groups 4 and 5 are formed from till plain or ground moraine material directly deposited from glacial ice. In contrast to the well-sorted materials of Groups 1 and 2, the soil particle sizes of till range from the very fine clays to coarse sands, pebbles, and boulders. But this is not to say that most of the material is variable in texture. The proportions of sand, silt, and clay that make up the matrix of the soils are usually remarkably uniform over thousands of acres. For example, subsoil of Hayden soil found near the Control Data plant in northern Ramsey County (figure 24) has the same texture as the Hayden soils of western Hennepin and Carver Counties. In fact, there is small variation between this buff till parent material in the Twin Cities Metropolitan Area and the same deposit found 250 miles away near Des Moines, Iowa.

As with most of the groups, there are two subtypes of materials within the group. Figures 24 and 25 illustrate these two types of glacial till, representing two different directions of glacial movement and different source material.

The buff till which occupies all of the Group 4 and 5 areas in Carver, Hennepin, and parts of Ramsey Counties, was moved in by the Grantsburg sublobe of the Des Moines lobe glacier from southwest to northeast about 10,000

Figure 25. Profile of red till near Highway 36 in Ramsey County. The soil developed here is Group 4, Milaca sandy loam.

Figure 26. Lake Vadnais, in northern Ramsey County, is typical of lakes in the Group 4 and 5 soil areas. Shorelines often are steep, with numerous bays and islands. These lakes are usually deeper than those in sandy outwash soil areas, and are slow to warm in the spring.

Figure 27. Laddie Lake in Anoka County is typical of lakes in sandy soil areas. Extensive sandy beaches suitable for swimming, low-profile shorelines, and few islands or bays are common. These lakes warm faster in spring than do deep lakes of till areas.

years ago. It is of "heavy" loam to clay loam texture and is high in lime.

The Superior lobe, a glacier moving from north to south, deposited the red, sandy till parent materials. The time of this glaciation was perhaps 12,000 to 14,000 years ago. (References regarding glacial history are given at the end of the bulletin.)

This material is slightly coarser in texture, averaging 15 to 20 percent clay rather than the 25 to 35 percent of the buff till. This difference is not considered large enough to establish a separate urban use soil group for this generalized map, but the areas would be separated in a detailed study. Deficient in lime, the red till is normally more acid than the buff. The red till is more stony and cobbly than the buff, and becomes very hard when dry.

Surface and B horizon textures immediately below the surface are more variable than the C horizon or parent material textures (figure 28). The range is from sandy loam to silty clay loam, depending on the soil type and slope position. The soils in the western part of the Group 4 area, Carver, Scott, and western Hennepin Counties, are of finer texture than those in Ramsey and Washington Counties.

Percolation rates are usually in the range of 25 to 70 minutes per inch, or 5 to 15 times slower than in sandy areas. Another characteristic of these medium to fine textures, brought about primarily by the clay content, is swelling on wetting and shrinking on drying.

Frost disturbance is also more severe on these soils than on Groups 1, 2, and 3. These factors have important engineering implications for foundations and earthen structures. The high water-holding capacity of these textures, 30 to 60 percent, also causes engineering problems. Consistency of the material can vary from very hard to plastic, depending on moisture. Bearing capacity is high when dry, 8,000 to 11,000 pounds per square foot, but is markedly reduced when wet.

The regular pattern of numerous potholes and sloughs interspersed among gently rolling hills is the main feature distinguishing these landscapes from those of the sandy outwash areas. This direct relationship between topography and drainage is due to water moving mainly on the surface rather than internally in these rather impermeable soils.

Slopes range from level to 12 percent, but the majority are less than 5 percent. The slope pattern is usually irregular as the "youthful age" of these deposits, in terms of geologic time, has not allowed sufficient natural erosion to develop drainage channels and even out the hills.

One interesting contrast between the landscape of outwash and till areas is the difference in appearance of lakes. Figures 26 and 27 illustrate a typical lake for each of the regions.

Lake Minnetonka is another typical lake in the Groups 4 and 5 area. Because the lake is formed in a large depression of irregular topography, the shoreline is irregular with many steep shores and islands. The lake bottom profile is also irregular as contrasted with

Typical Texture — Range of Texture

Soil depth, inches	Gravel	Fine and Very Fine Sand	Loamy Sand	Loamy Fine Sand	Sandy Loam	Loam	Silt Loam	Clay Loam	Silty Clay Loam
0-12					Range	Typical	Typical	Range	
12-48						Range	Range	Typical	
48+					Range	Typical	Range	Range	

Figure 28. Texture profile of Group 4 medum-textured soils.

Figure 29. Undisturbed soil is preferred for building sites. Note difference in appearance between undisturbed natural soil profile at right and filled area at left. Both are in the same excavation.

the usual saucer-shaped profile of a lake in a sandy area. Natural sand beaches suitable for swimming are more common in areas of sandy soil.

Soil profile pattern and native vegetation—Deep, dark soils high in organic matter are almost universal in the western parts of Group 4 in Carver, Scott, and Hennepin Counties while the soils appear light-colored, shallow, and low in organic matter in Ramsey and Washington Counties. Although these differences between individual soils within the group appear distinctive, they are not particularly significant for most urban purposes. These color and organic matter differences result from original vegetation, predominantly prairie in the west and forest in the east.

Drainage, permeability, and chemical characteristics—Natural drainage is largely a function of the landscape position in this group.

Natural internal drainage of a site is indicated by the color of the substrata. Dull, gray colors, often with small specks of bright yellow and orange, indicate restricted drainage and waterlogged condition. Bright browns and reddish colors, on the other hand, indicate a well-drained site. Soil profile colors, properly interpreted, can be very useful in predicting water problems associated with subsurface construction.

Permeability of the material is least in the compact, fine-textured gray till and somewhat higher on the slightly coarser textured red till.

Percolation rates may vary with material of the same permeability because of slope position and water table level. So on-site tests are usually recommended in this area. Adjustments can be made to assure workable septic tank and drainfield systems by backfilling gravel around the tile line.

Chemical and fertility characteristics of these soils are more favorable for plant growth than is the case with sandy soils. Finer textures mean higher nutrient supplying and holding capacity as well as higher moisture-holding capacity. The prairie soils are well supplied with reserve nitrogen, are limey, and usually are medium to high in potassium. The lighter forested soils in this group normally are more acid and are lower in available nitrogen and potassium. Appropriate fertilization following soil tests allows good growth of most vegetable crops, agricultural crops, and ornamentals. Drought probability for deep-rooted plants averages only a few days a year on these soils. Golf courses and lawns require much less frequent watering than on sandy soils.

Suitability for urban use—Soils in Group 4 have some disadvantages for urban uses compared to soils of Groups 1 and 2. Nevertheless, they are generally suitable for most urban development. Development costs usually will be higher because of greater expense encountered due to characteristics of the soil, especially the slower drainage.

The finer texture of the soils creates some earthmoving problems because they retain water longer and are difficult to work while wet. One home builder reported an incident in which workmen were called off the job of digging footings for a home. When they returned to the project several days later they were forced to use jackhammers to continue their excavation where the soil had dried out in their absence. Poor internal drainage of the soil also requires greater expenditures in waterproofing basements. And boulders occurring in the glacial till interfere with excavations.

If development continues in the same direction that it has, Group 4 soils will be an important source of land. Almost all development that occurs on the Minneapolis side from the southwest sector to the northwest sector will be on these soils. A major portion of the remaining open land in Ramsey County is also in this group. It therefore appears that Group 4 soils will be used to accommodate an important segment of the new developments.

Intensive development on these soils is often accompanied by the provision of central sewerage disposal systems. In New Hope and Edina sewerage systems accompanied development. In contrast, areas of these soils, such as Plymouth, with relatively good access to downtown or other employment centers have been slower to develop a central sewer system. Consequently, they have not grown as fast as sewered areas with more unfavorable locations.

Some of the same conclusions are drawn by observing St. Paul's growth toward White Bear Lake. Development jumped several miles of open land in soil Group 4 to areas sewered through the White Bear system.

Figure 31. A gently rolling landscape of the Group 4 soils in Roseville.

Itemized development characteristics:

1. Local topographic variation in soils demands greater precautions in the development and more frequent soil percolation tests.

2. On-site sewerage disposal systems are not as likely to give reasonable service compared to systems on more porous soils. Larger trenches and more lengthy drainfields are required. Drainfield requirements may mean larger minimum lot sizes. The total costs of on-site disposal systems will likely be higher than with central sewerage disposal systems.

3. Excavation costs are higher than on sandy soils because of finer textures and boulders.

4. Higher clay content of soils means greater expansion and contraction with variations in moisture content. Bearing strength of these materials is markedly lower when wet than when dry. These factors are mainly applicable to the buff-colored Group 4 soils.

5. Artificial fill requires a longer period to settle on this soil group than on sandy material (see figure 29).

6. Road construction requires a thicker subbase and thicker paving mat than on more porous soils.

7. Soils are medium to high in fertility and water-holding capacity so that lawns and other plantings do well.

8. Wet basements are a common problem unless water is diverted and basement walls are sealed at the time of construction. Water runoff creates storm drainage and erosion hazards.

SUMMARY—*Finer textured materials and an irregular topography give this group of soils entirely different characteristics than those of groups 1, 2, and 3. Mainly because of slower water movement, higher water content, scarcity of level land, and sharp changes in soils within a short distance, site development costs are higher on these soils than on sands. However, there are advantages of scenic views, topographic variety, and ease of establishing and maintaining lawns, shrubs, and gardens that are not provided by other soils.*

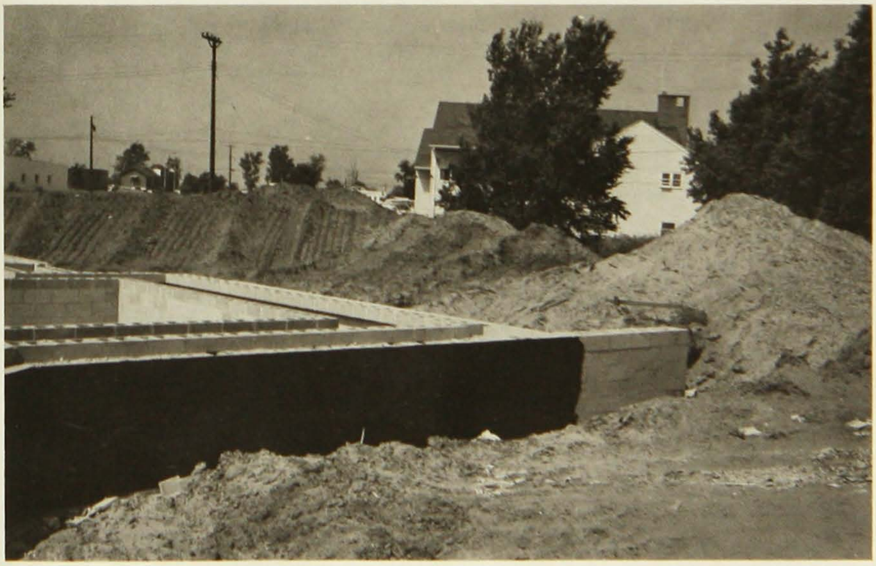


Figure 30. Asphalt coatings are applied during construction to protect against basement seepage. On wetter soils outside walls often are plastered with cement before asphalt is applied. Polyethelene plastic also is used as a moisture barrier. Basement seepage problems are closely related to soil type and surface drainage.

Group 5—Rolling to Hilly Soils, Medium to Fine Textured, With Slopes Over 12 Percent

General description and location—This group consists of the same soils as Group 4, differing only in having steeper topography. This difference is considered to be critical enough to establish a separate category.

Group 5 soils occupy only 1 or 2 percent of the study area. They occur within the Group 4 area as concentrations of hills and ridges along streams and lakes.

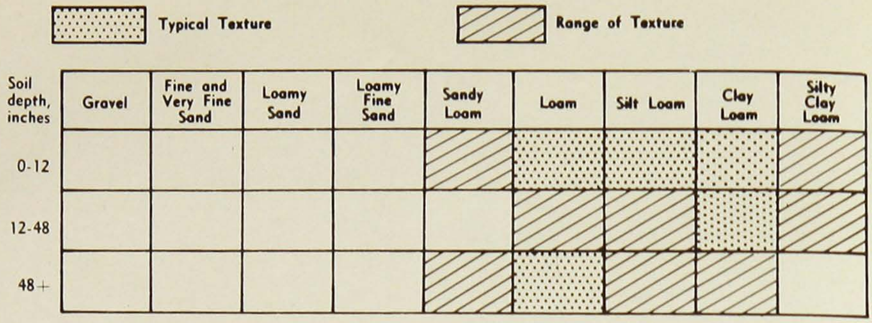


Figure 33. Texture profile of Group 5 medium-textured tills.

Parent materials, texture, and topography—Most of this rolling land is found in Hennepin and Scott Counties, so most of the parent material is a buff loam to clay loam till. Some areas of red till are represented in Ramsey and Washington Counties.

The descriptions of these materials can be referred to in the previous section.

Although subsurface texture, as indicated by figure 33, is usually in the narrow range of loam to clay loam, surface textures are likely to be more variable than the subsurface or than the surface textures of Group 4. Natural or accelerated erosion has modified surface textures. Local depressions are being filled by deposition, which gives these soils a finer surface texture than the steep slopes.

The landscape is similar to that of Group 3, as both are defined by recessional moraines and slopes in excess of 12 percent.

There are contrasts in the landscapes of Groups 5 and 3, however, as fewer lakes and sloughs occur in the sandy Group 3. Fine-textured, relatively impervious till of these groups holds water in depressions.

Profile pattern and native vegetation—With a relatively high rainfall and a composition of high water-holding materials, moisture has been and is adequate for forest vegetation. Farther west these steep soils are often developed under grass vegetation, but here the typical "shallow" forest soil profile usually has developed.

Since these soils are too steep for cultivation, most of the land in undeveloped urban areas is still wooded. Native species include white and red oak, sugar maple, elm, ash, and basswood.

Individual soil profiles are somewhat variable in organic matter and depth because of sharp changes in slope and microclimate.

Drainage, permeability, and chemical characteristics—As in the case of Group 4 soils, drainage is primarily surface rather than internal. The percolation rates are relatively slow, but perhaps somewhat more rapid than Group 4 because coarse-textured lenses often occur in steep topography. Lateral water movement occassionally results in springs and seepage areas. Careful selection of building sites should be made to avoid these spots.

Fertility characteristics are similar to those described under Group 4.

Suitability for urban use—Because of the topography and soil texture, Group 5 combines the disadvantages of Groups 3 and 4. Little urban growth has occurred on these soils, and, due to their small extent, they will not be significant in the future. The rough topography requires greater effort for road building and most types of construction. The characteristics of the areas make them especially well suited for recreational uses.

Itemized development characteristics—All the generalizations about Group 4 are appropriate for Group 5 with these additions:

1. Soils are favorable for heavy wooded growth, which results in higher development costs but more pleasant sites.

2. Rolling and varied nature of the topography affords pleasant sites and views.

3. Water runoff creates storm drainage and erosion hazard problems.

SUMMARY—*These rolling wooded hills are some of the most scenic areas of the Twin Cities Metropolitan Area, but make stringent demands on the individual who attempts to develop this land. Siting is made difficult by steep slopes, boulders, and trees. The cost of development appears to be a force that will restrict development to fairly low intensity uses such as recreation, large residential lots, or certain types of institutions.*

Figure 32. River bottom soils in the wide flood plain along the Minnesota River near the Mendota Bridge. These soils are included in Group 6.

Group 6—Depressional and Level Wet Soils, and Adequately Drained Soils Subject to Flooding

General description and location—The common characteristic of these soils is poor drainage all or part of a normal year. This wetness is usually caused by a combination of depressional position and slow permeability. Also included in Group 6 are soils subject to overflow from rivers and streams, and situations of high water table caused by an impermeable underlying strata.

The largest concentration of wet soils is the peats and associated poorly drained wet sands within the Anoka Sand Plain north of the metropolitan area. Depressional areas within the till of Groups 4 and 5 account for considerable acreage of these soils. River bottoms subject to overflow along the Minnesota River and parts of the Mississippi below Fort Snelling also contain considerable acreage. Scattered smaller acreage occurs as occassional swales and numerous very small potholes in the rolling areas of Groups 2 and 3. Many of these small spots are not shown on the generalized map.

Parent materials, textures, and topography—Parent materials of the wet soils are usually the same as those of the surrounding soils with better drainage, therefore the textures are also similar. These texture generalizations are discussed under the other groups.

The only important exception to this relationship is the organic soil. In this case, the parent materials are partially decomposed accummulated plant residues. These organics, peat and muck, differ radically from the mineral soils in that their low volume weight and higher water-holding capacity result in low bearing strength.

The pattern of wet soils is rather different and specific for each of the three subtypes of soils within this group.

Wet Sand-Peat Subtype

The most extensive and concentrated subtypes are the wet sand-peat complex, shown on the map as Group 6 soils within the Group 1 area. In most of this area there is a sharp distinction between the sandy, well-drained Group 1 soils and the wet peat soils. This is especially true in the northern sections of the Twin Cities Metropolitan Area. Farther south, near Anoka County Airport and west toward Coon Rapids, these is less local relief and consequently a more gradual change from wet to better drained soils. Some peat occurs in this area, but here sands account for a higher proportion of the wet soils.

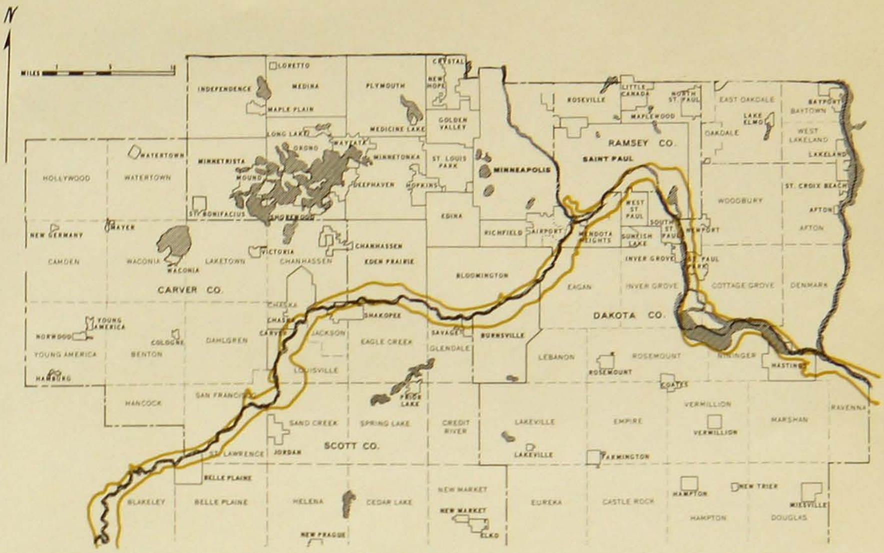


Figure 35. General extent of 1952 and 1965 floods in the Minnesota and Mississippi River Valleys.

Depressional Subtype

Wet soils of the depressional subtype occur primarily within the Group 4 and 5 areas and to a more limited extent in Groups 2 and 3. The cause of the poorly drained condition here is low permeability of the soil texture either at the surface or at a relatively shallow depth (10 to 25 feet). In the extensive area of Group 4 the heavy loam to clay loam texture restricts internal drainage, causing any topographic depression to be wet. The size of wet areas varies from a few hundred square feet to thousands of acres of irregular areas or a continuous chain of slough and marsh land.

It is difficult to generalize about the occurrence of Group 6 soils within the rolling portions of Groups 2 and 3 due to the extreme variability of the materials. A typical area of rolling Group 2 and wet Group 6 soils is between Rosemount and the Mendota bridge. Here, wet potholes occur in the lowlying depressions, but a number of depressions at slightly higher elevation are quite well drained. This is a marked landscape difference between Groups 2 and 3 and Groups 4 and 5.

Flood Plain Subtype

The third subtype of these wet soils is the flood plain, subject to stream overflow. Here the topography varies from the narrow areas along minor streams up to several miles wide along the broad Minnesota and parts of the Mississippi River Valleys. Since river water levels vary widely depending on the time of the year, appearance of a valley in the summer months gives no indication of flooding levels in the spring.

Figure 34 gives the location of land covered in April 1965, a time of severe flooding, by flood-level water in the Minnesota and Mississippi River Valleys.

Native vegetation and profile pattern—Native vegetation differs from that of surrounding land because of the high water table conditions at least part of the year. Sedges, coarse tall-growing grasses, or, in some cases, water-tolerant woody plants like willow and aspen are the common species. The soil profile consistently has a high organic matter surface horizon underlain by dull gray or bluish-colored substrata. The only exception to this pattern is some of the bottom land along rivers where deposition may have caused a deep thickness of rather

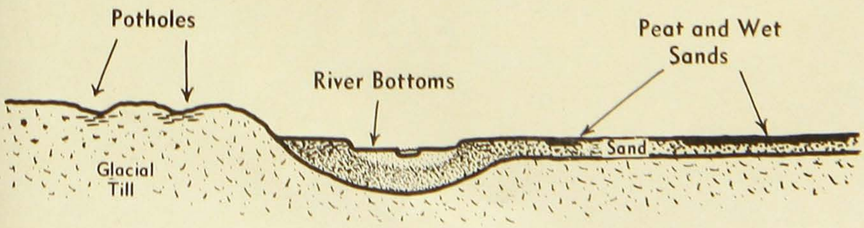


Figure 34. Landscape position of the three kinds of Group 6 soils.

Figure 36. This property is not near a river but in a low-lying area that was not protected with adequate storm sewers.

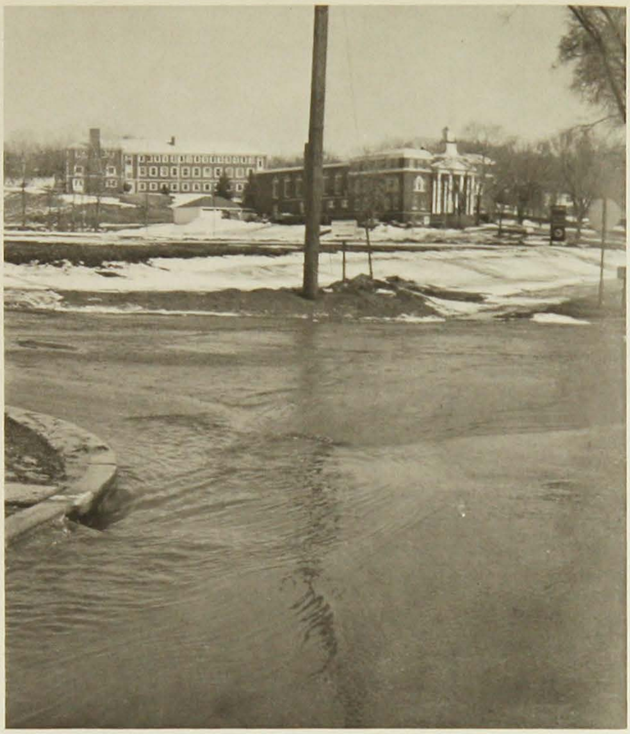


Figure 38. Storm sewers in this area carried heavy 1965 spring runoff and prevented property damage.

Figure 37. Poor surface drainage often results in frequent flooding of basements and can lead to rapid deterioration of buildings.

Figure 39. Pilings driven to support an apartment building development on Group 6 soils near Lake Phalen, St. Paul. Development costs are high for building sites on these soils.

Figure 40. An excavation of peat soil for development in Edina. Good accessibility often justifies costly site development.

uniform but stratified material. Rocks and boulders do not occur in river bottom lands, but often occur in the wet till areas of Groups 4 and 5.

The individual soils range in wetness from intermittent, shallow water surfaces to soils used for annual crop production. The best drained soils of the group, Webster and Floyd, for example, need artificial drainage for efficient crop production, but are drained well enough for some types of buildings.

Drainage, permeability, and chemical characteristics—By definition, these soils are poorly drained. But this is not to say that all of them have low permeability. Air and water movement is quite rapid when drainage is provided for organic soils or wet sands. Peat soils become very loose when drained and stabilization from blowing or mechanical disturbance is a problem.

Percolation rates at individual sites vary from 0 under saturated conditions to values of up to 5 inches per hour when soils are dry or artificially drained. Permeability characteristics usually are similar to those of surrounding soils. Water table levels vary widely, depending on the time of the year, so the drainage condition of the soil must be interpreted in terms of the date of examination. As previously indicated, the color of the substrata is a better indication of natural drainage than is the moisture content of the soil. Dull colors indicate poor drainage.

The chemical and fertility characteristics of these soils vary widely. Acidity varies widely from acid sands and peats to alkaline wet mineral soils within the Group 4 area.

Suitability for urban use—In spite of the drawbacks, there have been a few major industrial developments on these soils. Most development, however, is located in the Minnesota or Mississippi flood plains and is not on the peat soils.

With flood protection more river bottom lands might be expected to develop, especially for uses that can justify higher foundation costs. Accessibility to water transportation has been a factor in encouraging development. The 1965 flood dramatically pointed out the hazards of construction on river bottom lands.

Information regarding past flood levels at specific locations and current flood control projects is available from the Army Corps of Engineers. With minor exceptions, the flood hazard land is the same as the Group 6 soils along the rivers, but this map does not provide sufficient detail for many needs.

Throughout the closer-in areas there has been a slow increase in development of this lower value land. As the locational aspects of a parcel of land increases its value, higher investment in development cost is warranted. The use of pilings or the removal of unstable soils are two ways of improving foundation conditions. Technology and special machines have made the replacement of poor soils with compacted fill more practical than has been true in the past. With greater familiarity, applications of this practice will undoubtedly increase in future years.

Developments on problem soils have not been of a large enough scale to have much impact on the amount of land available. Some of the Group 6 soils have been utilized for park and open space purposes. Although in most cases they are not particularly suited for intensive recreational use, a short par-three golf course was recently built on peat land without serious problems. Other golf

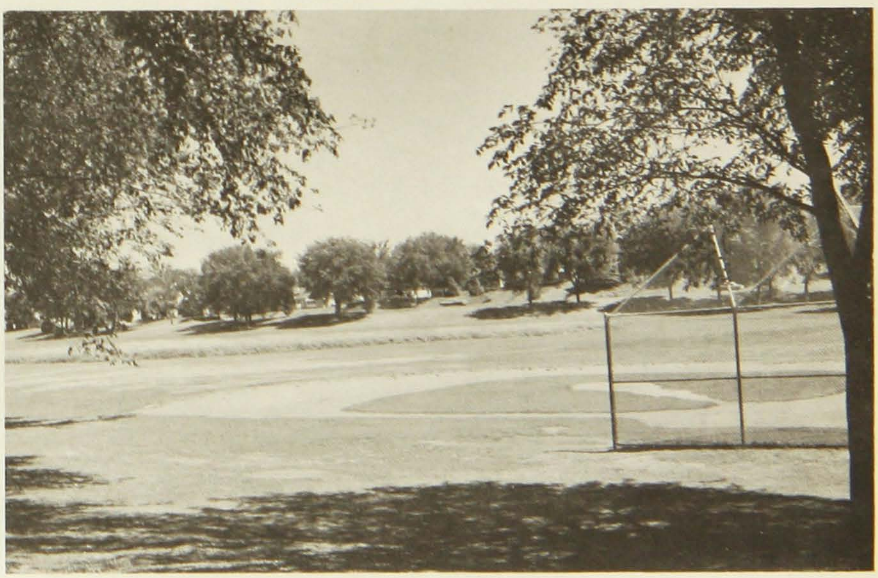


Figure 41. This ballfield in Pearl Park in south Minneapolis utilizes Group 6 soil types. Considerable fill and drainage were required for site development.

courses, such as Brookview, Westwood Hills, and Braemar contain areas of poorly drained soils. Some residential developers have put these problem areas to use by dredging, firming the shoreline, and creating small ponds that lend interest to the adjoining developments.

Itemized development characteristics:

1. Development costs are very high because of poor foundation conditions or needed protection against flood hazards.

2. On-site sewage disposal systems are not satisfactory.

3. Road construction costs are higher in areas that have peat deposits and wet sands.

4. Poor drainage conditions do not permit below-grade construction such as basements.

It appears that soils in Group 6 will continue to account for a modest amount of development in the future. In terms of the amount of land that may be effectively used, park and open spaces have the greatest promise.

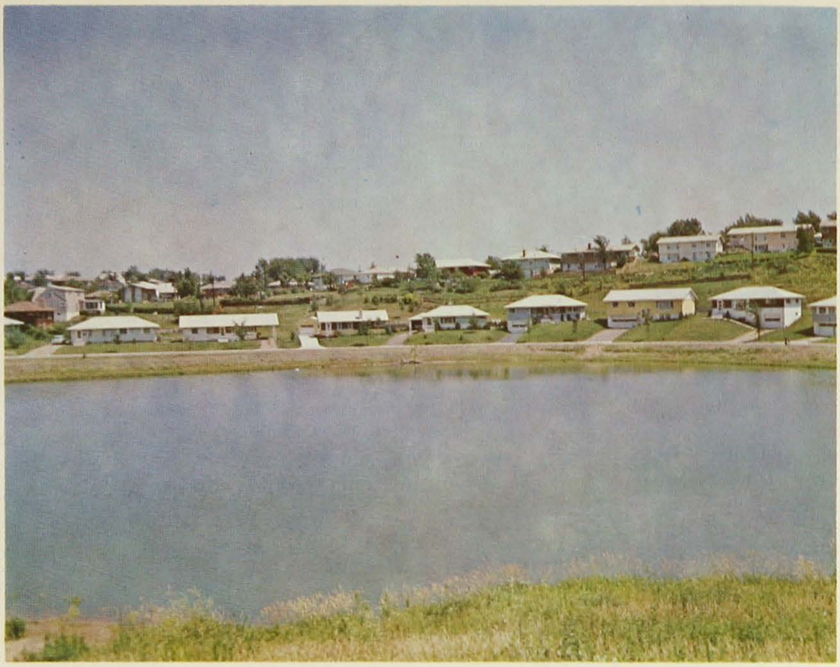


Figure 43. Shallow lagoon created in a poorly drained peat area handles surface water runoff and contributes to the residential setting.

SUMMARY—*Since poor drainage is a hazard in a very large portion of the Twin Cities Metropolitan Area, the location of Group 6 soils should be noted in planning any type of construction. Mechanical properties of soil materials change drastically on the addition of moisture. This is particularly true of fine textures where very firm, hard, and brittle material changes quickly to plastic consistence, causing soil to flow under slight pressure. In addition to the implications for construction, high water tables cause basement seepage and prevent the absorption of septic tank effluents.*

On the positive side, there are several ways in which the wet soils can be utilized in an urbanized area. Due to their initial bypass in a period of residential development, these undeveloped areas are often available for use as playgrounds and athletic fields. However, drainage and fill are usually required to make the area satisfactory. Also, as land becomes scarce in a developing area, major site development costs may be justified to permit construction of shopping centers and parking lots.

In the urban fringe area and sometimes well within built-up areas, peat and other poorly drained soils are often used for truck crops and sod production. A very fast-growing cultured sod industry has developed near the Twin Cities Metropolitan Area in the last 7 years, almost exclusively on peat areas of the north side. About 100 commercial sod producers now utilize 4,000 to 5,000 acres. There are some quality advantages to sod produced in medium-textured soils, so the acreage grown on these soils will perhaps increase in the future.

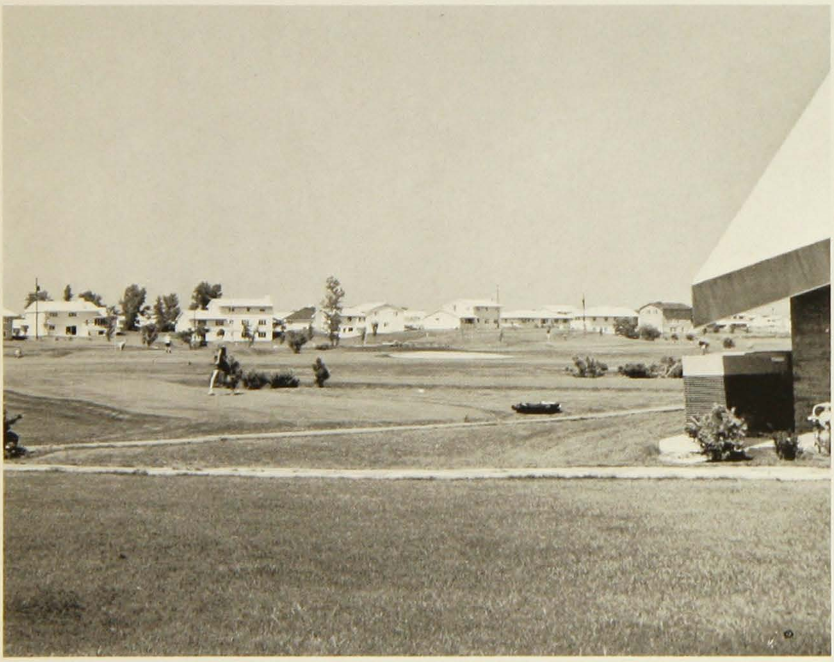


Figure 42. A potential, though unusual, use for peat land is in golf courses such as this short course in a Twin Cities suburb.

Figure 44. An unimproved site similar to that of the lagoon in figure 43.

Group 7—Nearly Level, Fine-Textured Soils

General description and location—These are the finest textured soils of the eight groups in the Twin Cities Metropolitan Area. (Finest refers to soil particle size, not to soil quality.) The acreage accounted for by this group is not large, but the soils are distinctive, with specific problems when used for urban purposes. The largest area is about 700 acres in the Vadnais Heights-Little Canada vicinity north of St. Paul. Smaller parcels of these clay soils occur in the northern half of Washington County.

Parent materials, textures, and topography—Quiet, standing water was the agent of deposition for the parent materials of these clay soils. *Lacustrine deposits* is the term used to describe these lake-laid materials. In cases where moving soil or wind was the agent of deposition the fine clay particles were sorted away from the coarser sand and gravel. Here, under impounded glacial melt water, the clay was allowed to settle slowly to form a level plain of fine particles covering the coarser materials deposited earlier (see figure 46).

In the vicinity of Vadnais Heights the soils are silty clay to clay in texture and are gray in color below the darkened surface horizon. Red colors are common for these soils in Washington County. Percentage of clay varies from 50 to 80. Percolation rates usually are very slow within these soils—in the range of 60 minutes or more per inch.

A level, uniform plain would best describe the topography of the Vadnais Heights part of the Group 7 soils. The elevation of this area is 910 feet, which is above some of the rolling land immediately surrounding this area.

Group 7 soils in Washington County are more variable in topography than those in Ramsey County. In this case, the lacustrine materials may have been disturbed by later glacial action, which would account for the patchy occurrence and variable topography.

Native vegetation and profile pattern—As with the topography, the native vegetation was different in the two areas of these soils. Prairie grasses grew in the Vadnais Heights area and developed a dark-colored, high-organic-matter soil. Underlying material is grayish brown and of clay texture. The soils of this group which occur in Washington County were originally forested with hardwoods, and consequently developed a light-colored, low-organic-matter surface horizon. There is also a marked difference in the silt loam texture of the surface 10 inches, and that of the underlying clay. Subsoil colors are reddish brown, and since these materials were deposited by water there are virtually no stones or boulders.

Drainage, permeability, and chemical characteristics—Percolation rates are very slow in this material, in the range

Figure 45. Cultured sod production utilizes about 5,000 acres of Group 6 peat soil, mostly in Anoka County.

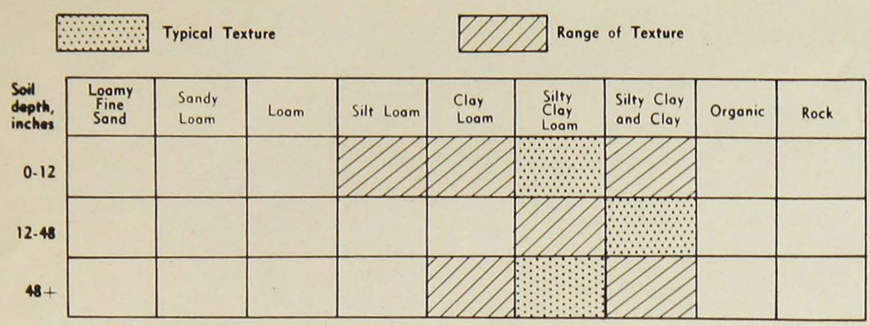


Figure 46. Texture profile of Group 7 fine-textured soils.

of 60 to 100 minutes per inch. These soils would be unsuitable for on-site septic tank filter fields.

The chemical and fertility characteristics are similar to the medium- and fine-textured Group 4 and 5 soils. Gardens, lawns, and vegetable crops are grown without problem if some surface drainage is provided. The clay texture accounts for a high water- and nutrient-holding capacity. However, more physical problems are encountered in tillage and seedbed preparation of clay-textured soils than of medium- and coarse-textured soils.

The low-organic-matter clay material underlying these soils may have specific uses in an urban area. Occassionally clay is desired for surfacing tennis courts, and the red clay of Washington County might be suitable for this use. It could also be used for mixing with coarser textured materials if a specified "manufactured" soil were to be constructed.

These materials usually are quite high in the montmorillonite and illite clay minerals, but both are unsuitable for high-quality pottery and china. Kaolnite type clays are desired for this type of use. Deposits of clays of this type are found in older geologic material south of Red Wing and in western Minnesota.

Clay deposits are not restricted to this group of soils. Clay pits once used for brick manufacture are scattered throughout the area—at Chaska, Anoka, and Stillwater. Only one firm now manufactures brick in the Twin Cities area.

Suitability for urban use—In general, these soils are not well suited to urban development. Nevertheless, some single-family homes have been constructed on these soils along county roads in Ramsey County prior to 1952. Many of the homes do not have basements, while grades around others are raised 5 or 6 feet. The frequency of drainage ditches around the homes suggests that this is a problem area and that development may not have occurred had better knowledge or controls been used. Because of the high clay content the tendency to shrink and swell with moisture changes is marked. Proper development of these areas would be expensive.

SUMMARY—***These soils were developed from very fine-textured lake-laid deposits. They occupy a relatively small total area, about 2,000 acres, but are placed in a separate group because they are so distinctively different. Because of the texture, water percolation rates are very slow and foundations of large buildings present special engineering problems.***

Figure 47. This area of Group 7 soil in Ramsey County used for agriculture is surrounded by urban land. Lack of construction on this site indicates the shortcomings of clay soil for building purposes.

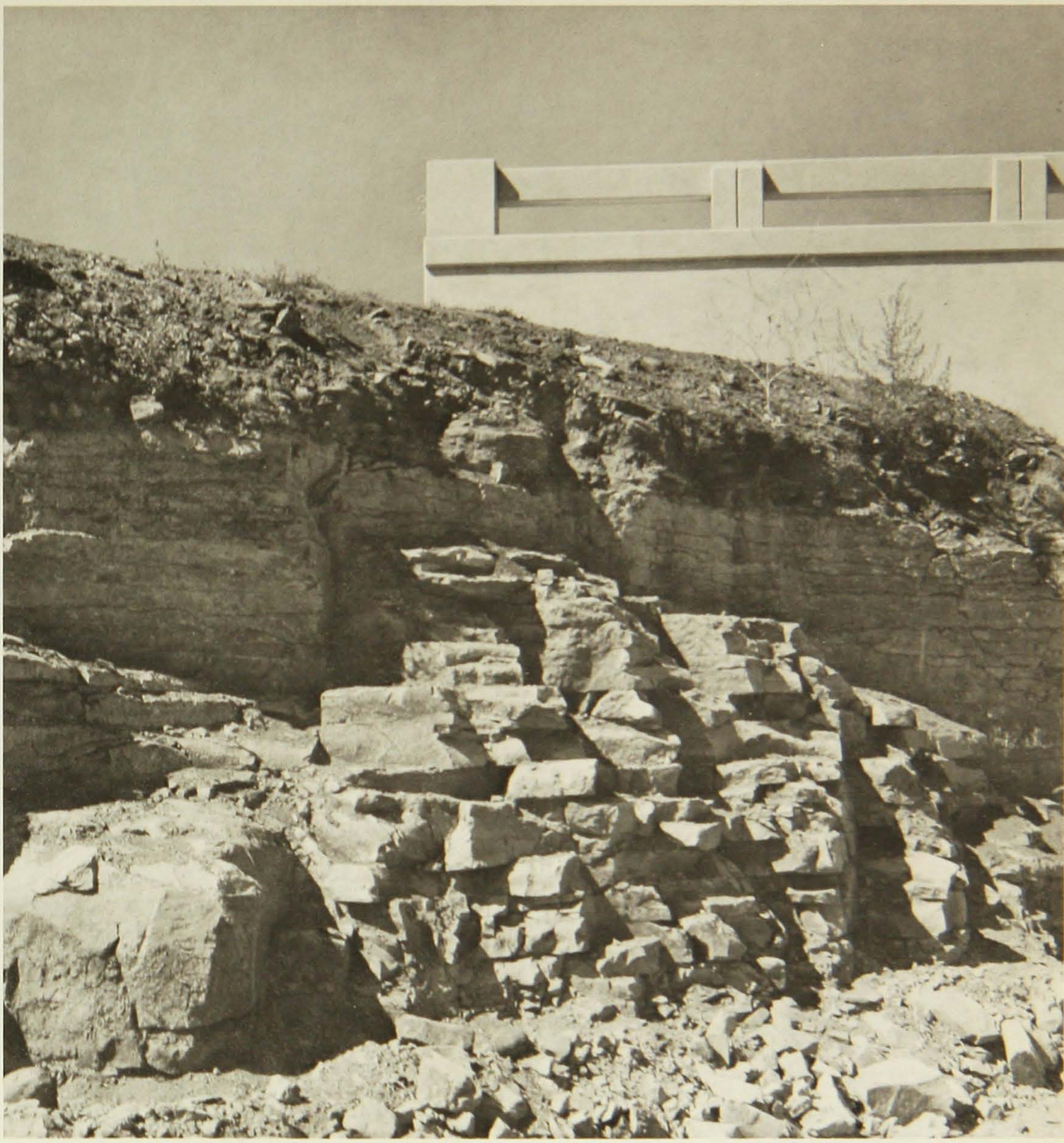


Figure 48. Excavation costs are increased when underlying rock of Group 8 soils is unweathered limestone.

Group 8—Soils Shallow to Rock or Rock Outcrops

General description and location—As in the case of the Group 7 soils, the total area of Group 8 soils is not large, but the characteristics of the soils are distinctive. Here the soil material is shallow (40 inches or less to various types of bedrock) or the bedrock is exposed at the surface.

The largest areas of these shallow soils are along the east side of the Minnesota River Valley between Shakopee and Jordan, south of the river near Savage, and near Fort Snelling and along West 7th Street in St. Paul. Another sizable area is in the Newport vicinity on the east side of the Mississippi River. Scattered smaller areas occur in southeastern Washington County.

Parent materials, texture, and topography—These areas of shallow soils which occur on the Minnesota River terraces are formed from coarse- to moderately fine-textured materials; some are water-worked glacial till and some are stratified sands. The parent materials and textures of these soils are more uniform in Washington County. In this part of Group 8 the soils generally are formed from silty windblown deposits which overlie limestones, although sandstone and shale outcrops occur occasionally.

The sandstone and limestone underlying these soils between Jordan and Shakopee is hard and resistant compared to the rather soft and loosely consolidated light gray St. Peter sandstone.

Figure 48 shows a cut of this shallow soil in a highway roadcut where limestone is the bedrock.

Two main subtypes exist in this group; the river valley or structural bench position along the rivers, and the upland divide area away from the major rivers. The bench positions along the rivers are above the bottom land overflow positions but below the elevation of the upland. Surface boulders were moved in by glacial action; they are not related to the underlying bedrock. These soils may appear very similar to soils deeper to bedrock and occupy similar landscape positions. Most of this land is quite level, but drainage is variable. Slopes up to 12 percent occur in the group but are of minor extent.

The upland shallow soils also appear to be similar to surrounding deeper soils. Most of these soils occur on side slopes in rolling terrain, and the bedrock often shapes the landscape. A few level areas containing soils shallow to limestone occur on relatively flat upland divides in southeastern Washington County. Also, the bedrock in this area has a thin layer of glacial deposits on the surface, and rock outcroppings occur around the edges of the resistant upland rock strata. A few acres of shallow soils over shale occur (see figure 49).

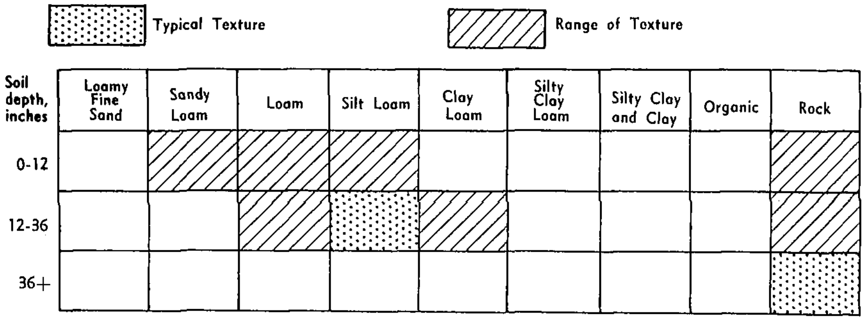


Figure 49. Texture profile of Group 8 shallow to rock or rock outcrop soils.

Profile pattern and native vegetation—Both depth and material over the bedrock vary. Depth ranges from 0 to 40 inches. Both light and dark and fine- and coarse-textured horizons overlie the rock. Dark colored shallow soils high in organic matter are general along the rivers, while the upland soils of this group are usually developed under forest and are light colored.

Drainage, permeability, and chemical characteristics—The drainage and permeability characteristics of these soils vary quite widely despite the uniform characteristic of shallow bedrock. This is true because of the nature of the bedrock and topographic position. In areas along river valleys the combination of low relative position and dense, impermeable sandstones results in wet, poorly drained soils. Nevertheless, some of the soils in the same relative position are often well drained and even droughty for crops, due to shallow sandy material and more permeable underlying limestone bedrock.

There is less variability of the characteristics of the upland Group 8 soils. Limestone is the most common bedrock and has usually developed sufficient solution cavities and cracks to allow internal drainage. Where shale is the bedrock, soils have a low permeability.

One advantage of these soils and the underlying material is the stability of the bedrock for foundations. For certain types of large structures these soils have an obvious advantage.

Chemical and fertility characteristics of these soils are variable. Detailed county soil maps show this information.

Suitability for urban use—Although soils in this group may present difficult problems, there has been development in the past. This is particularly true along the north bank of the Mississippi River in St. Paul where location overcomes construction problems. Small amounts of this land have been developed for industrial use best able to support the higher costs. In some cases the rock foundation may be an advantage to industrial uses that need solid foundation conditions. River bottom land development may have been encouraged by the proximity of the river for transportation or as a water source. More development might have taken place if these areas were not subject to flood.

Some commercial and residential development in St. Paul has occurred on areas of bedrock. A time comes when the value of the location outweighs the disadvantages of higher development costs. Central sewerage systems are essential in these areas because of the inability to use septic tanks or filter fields.

SUMMARY—***Although these soils are uniform in being shallow to bedrock, the topography, drainage, and organic matter content are quite variable. The underlying sedimentary rock strata is mainly limestone (dolomite), sandstone, and shale. The hard igneous rocks are hundreds of feet below the surface in the Twin Cities Metropolitan Area.***

Although the shallow bedrock appears to be a serious barrier to excavation and construction, most of the Group 8 area suitable in location for construction is underlain by limestone which is quite readily excavated with heavy equipment. The contact zone of the rock with the soil has been subject to weathering and is relatively easy to break up.

IMPLICATIONS FOR FUTURE DEVELOPMENT

This study and the soils map are useful in understanding the occurrence of past development and probable location of future development. A significant finding is that the land suited for development without central sewers in the direction of past growth to the west of Minneapolis has all but disappeared. Land of desirable location has soils generally not well suited for on-site disposal systems and is far from the existing metropolitan sewage disposal plant.

On the other hand, the largest reserve of choice land from the developmental cost aspect is located in Dakota County, historically a slow-growing portion of the metropolitan area. The implication is that if residential developers' past reactions to soils and their associated problems continue, a shift in direction of growth of a major magnitude will occur.

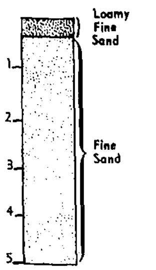
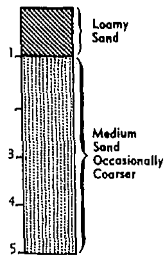
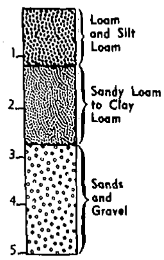
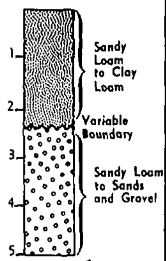
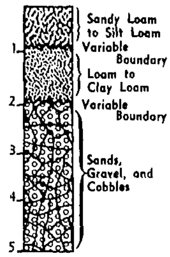
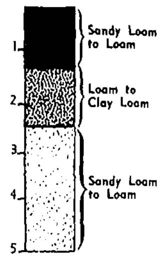
APPENDIX

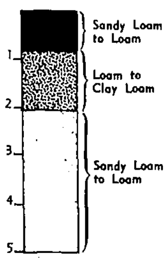
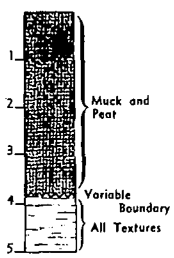
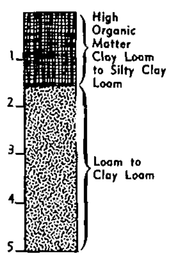
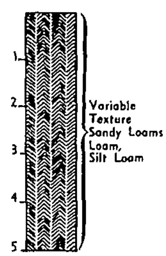
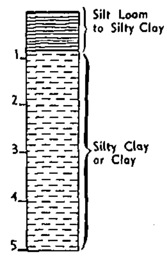
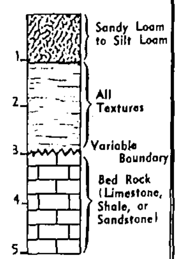
General Features of the Soil Groups

Order of Texture Classes

Sands and Gravel	Loamy Sand	Sandy Loam	Loam	Silt Loam	Clay Loams	Silty Clay	Clay

Coarse → Fine

	GROUP 1		GROUP 2		GROUP 3	GROUP 4
TYPICAL PROFILE FEATURES (numbers indicate depth in feet)	 Anoka Sand Plain	 Mississippi Valley Train	 Level Areas	 Gently Rolling Areas		
Slope and nature of topography	Mostly gently rolling, interspersed with peat bogs, all slopes less than 12%.	Nearly level, uniform soils, few poorly drained areas.	Nearly level, few poorly drained areas, most slopes less than 2%.	Most slopes between 3% and 6%, range up to 12%, many small poorly drained depressional areas.	Slopes greater than 12%, topography strongly rolling.	Slopes mostly 3 to 8% range from 0 to 12%, many poorly drained areas.
Drainage and permeability	Surface drainage and internal drainage are rapid, permeability is rapid.		Surface infiltration is moderate, internal drainage and permeability are rapid.	Both surface and internal drainage are rapid, permeability is relatively rapid below 3 feet.	Surface drainage is rapid, internal drainage and permeability are moderate to rapid.	Surface drainage is moderate, internal drainage and permeability are moderate to slow.
Special features	Boulders infrequent, water table is relatively high in the Anoka Sand Plain.		Boulders are rare, water table is low.	Cobbles and boulders are common, water table is variable.	Cobbles and boulders are common, water table is variable.	Boulders are common, especially in red till.

	GROUP 5	GROUP 6			GROUP 7	GROUP 8
TYPICAL PROFILE FEATURES (numbers indicate depth in feet)		 Organic Soils	 Mineral Soils	 River Bottom Soils		
Slope and nature of topography	Slopes are over 12%, topography is strongly rolling.	Level and depressional areas, mostly in Anoka Sand Plain.	Depressional and level areas occur as potholes and swales within Groups 4 and 5.	Level areas slightly above river channel.	Level areas in Ramsey Co., short slopes less than 12% in Washington Co.	Slopes less than 12%, occurs both in upland and river terrace positions.
Drainage and permeability	Surface drainage is moderate, internal drainage and permeability are moderate to slow.	Surface drainage is slow due to position, but these soils drain well when water table is lowered.	Surface and internal drainage are slow due to both texture and position.	Level of river determines wetness, subject to flood.	Surface and internal drainage very slow, permeability very slow.	Drainage and permeability depends on nature of underlying rock.
Special features	Boulders occur occasionally, cleared slopes erode readily.	Peats raw to decomposed, continuously water saturated unless drained; no boulders.	Thin peat layer often at surface, some boulders.	Oxbow lakes and old channels are common.	Boulders are rare.	Surface boulders are few, upper rock layer often loose due to weathering.

Generalized Suitability Relationships of Land Use and Soil Groups

LAND USE	*Group 1—Sandy, level soils*	*Group 2—Medium-textured surface, sandy subsoils, level to 12% slope*	*Group 3—Medium and sandy textured soils, over 12% slope*	*Group 4—Medium- to fine-textured soils, level to 12% slope*
Subdivision type residences	These mostly level, well-drained soils are well adapted to this type of land use as site development costs are low. Sandy materials reduce construction costs of roads and foundations compared to other soils. Group 2 is more desirable for lawns and plantings.		Materials are coarse textured, but topography is rolling, increasing site development costs. Fewer suitable residential sites per acre can be uitlized than in Groups 1, 2, or 4.	These medium-textured soils are readily adapted to this use, but usually require somewhat higher site development costs than Groups 1 and 2. Excavation is more difficult because of boulders and compact subsoil material. Slow water percolation rates are the rule, so sanitary sewerage systems are highly desirable. Plan construction to prevent wet basements.
Residences on large lots	No restrictions for engineering aspects of this use. Sandy surface soil will blow occassionally and soil is too droughty for ideal lawns and ornamental plantings.	Preferable to Group 1 because medium-textured surface soil is more resistant to wind erosion, allows ready establishment of bluegrass lawns and ornamentals.	Well suited for residences on large lots. Interesting topography and views are combined with readily worked soil materials for construction and roadbeds.	
Multiple dwelling, commercial, industrial, and transportation	Desirable for foundations and roadbeds because of their low shrinkage and expansion index, good drainability, and minimum expansion due to frost. Relatively level topography is also an advantage for large buildings, parking lots, airports, and highways.		The advantages noted under 1 and 2 apply, but rolling topography may restrict uses for some categories.	With appropriate attention to drainage and foundations, these soils are readily utilized for these uses. Easily adapted to a variety of landscaping plans. Central sewerage systems necessary.
Recreation, agriculture, parks, playgrounds, golf courses, truck farming	Competition from residential, commercial, and industrial use will often outbid these very suitable but less intensive investment applications. Where an extensive area of level land is required, as for an athletic field, these soils will compete. Group 2 is more desirable than Group 1 for agriculture, golf courses, and recreation areas that need good turf development.		To the extent large lot residences do not use this land, these uses will likely predominate. However, land is usually too steep for cropland. Recreational uses such as golf courses and ski slopes are appropriate.	As in the case of Groups 1 and 2, more intensive kinds of land use will usually prevail on the desirable land. However, the uses listed are appropriate unless flat land is required.

LAND USE	*Group 5—Medium- to fine-textured soils, over 12% slope*	*Group 6—Poorly drained, wet soils*	*Group 7—Clay soils, level to 12% slope*	*Group 8—Shallow soils to bedrock*
Subdivision type residence	These are the same soils included in Group 4, but with an average slope of over 12%. They are not well suited to tract development because of higher site development costs.	These high - water - table, poorly drained soils are not desirable for residential use unless substantial investments are made in drainage, piling, and filling. Good subdivision planning could utilize small amounts of this group in providing local parks and shallow lagoons for amenity.	These soils are fine-textured clay in which water moves very slowly. Houses should be elevated by filling or placed on high foundations, and central sewerage systems must be provided.	Shallow depth to bedrock creates problems in excavating for foundations and utilities. Central sewerage systems are necessary.
Residence on large lots	A pleasant view and a timbered landscape are usually associated with the estate type residential use. Appropriate lot sizes are 1 acre and larger.		Unsuitable for residential use unless serviced by central sewerage systems.	Geographic location of these soils makes them unsuitable for this type of use except in southeastern Washington County. Excavation costs are higher.
Multiple dwelling, commercial, industrial, and transportation	These high-intensity land uses may justify development costs, except where level land is required. Road construction requires thicker subbase and paving material than on coarse-textured soils.	Wet soils provide poor foundation conditions for structures but these uses are possible with appropriate site modification, which could take place when the locational value of the site increases.	Sizable structures are not appropriate because clayey nature of the lake-laid deposits causes poor foundation conditions.	The solid foundation base of bedrock may be of particular advantage for these land uses.
Recreation, agriculture, parks, playgrounds, golf courses, truck farming	Soils in this group are very suitable for recreational uses, parks, and golf courses. Agriculture would not compete for this land.	Some of these areas could be utilized for parks and playgrounds, but will usually require substantial site development in terms of drainage and grading.	Recreational and agricultural uses are most suitable for these soils. Drainage will be required.	These soils offer few restrictions for recreational use.

Soil Series by Groups

Listed below are the names of the various soil series from each of the individual county surveys and the group in which they were placed. Because the various soil surveys were done over a long period of time, similar soils in different counties may not have the same name.

GROUP 1—Level to gently sloping outwash terrace soils with sandy surfaces and a sandy or gravelly substratum:

Anoka	Hinckley	Nymore
Beach Material	Hubbard	Omega
Beach Sand	Kinghurst	Sparta
Berrien	Kroschel	Zimmerman
Duelm	Lino	
Dune Land	Merrimac	

GROUP 2—Level to gently sloping outwash with silty or loamy surfaces and sandy loam to clay loam subsurfaces with a sandy or gravelly substratum; slopes are less than 12 percent:

Bayport	Greenbush	O'Neill
Burkhardt	Hixton	Rosemount
Burnsville	Judson	Scandia
Chaseburg	Kasota	Thurston
Chetek	La Crosse	Wadena
Dakota	Lakeville	Waukegan
Dickinson	Langdon	Waukesha
Estherville	Nininger	Withrow
Gale	Onamia	

GROUP 3—Rolling to hilly soils with sandy to loamy surfaces and with coarse substrata and 12 to 18 percent (or greater) slopes:

Edith	Oneka-Milaca Complex
Kingsley-Burnsville Complex	Rough Broken Lands
Lakeville-Burnsville Complex	Steep Lands
	Terrace Escarpment

Also includes Group 2 soils of over 12 percent slope.

GROUP 4—Level to gently rolling, medium- to fine-textured surface and subsurface soils with slopes of less than 12 percent:

Carrington	Lester	Ostrander
Clarion	Le Sueur	Port Byron
Freer	Le Sueur-Lester	Santiago
Hampton	Milaca	Tallula
Hayden	Milaca Complex	Timula
Hines	Oneka	

GROUP 5—Rolling to hilly soils with medium- to fine-textured surface and subsurfaces with slopes over 12 percent:

Soil series are the same as in Group 4

GROUP 6—Depressional to level, wet soils of variable textures and soils subject to flooding:

Adolph	Glencoe	Rauville
Blue Earth	Isanti	Peat
Bluffton	Lawson	River Wash
Clyde	Marsh	Sawmill
Colo	Marshan	Warman
Comfrey	Maumee	Webster
Dorchester	Muck	
Floyd	Oshawa	

GROUP 7—Fine-textured soils that are nearly level:

Brickton	Fargo	Knife Lake

GROUP 8—Soils in silty to loamy materials and shallow to rock or rock outcrops:

Copas	Langdon (over rock)	Stony Land
Faxon	Rockton	Whalan

Description of Soil Surveys

The U. S. Department of Agriculture, in cooperation with the state agricultural experiment stations and other federal and state agencies, has been making and publishing soil surveys since 1899. These surveys are designed to furnish soil maps and interpretations needed in planning research and disseminating the results of the research, to be used in educational programs and for technical assistance to farmers and ranchers, and in guiding other decisions about soil selection, use, and management. Sound scientific and technical standards are used in a nationwide system of soil classification, nomenclature, interpretation, and publication.

Soil classification has improved as our knowledge about soils and their potential uses has increased. As agriculture has become more technical, a proper fit between the kind of soil and the combination of practices used has become more critical. Because of this, soils bearing the same names are more narrowly defined in recent surveys than in the older ones.

Little was known about the soils of the United States when soil survey work began in 1899. Since then, a great deal has been learned, methods have been improved, and the results of the surveys are more accurate and detailed. For planning farms, engineering structures, parks, urban developments, and other uses of land, the recently published soil surveys are more useful. The older surveys can be of considerable assistance for many users, but their maps are more general than those in recent surveys, soil definitions are broader, and some of the interpretations need updating.

Published soil surveys contain, in addition to soil maps, general information about the agriculture and climate of the area and descriptions of each kind of soil. They include a discussion of the formation and classification of the soils in the area and also soil laboratory data when available.

Soil surveys published since 1957 contain many different kinds of interpretations for each of the different soils mapped in the area. The kinds of interpretations included in these recent surveys vary with the needs of the area, but the following interpretations may be found in most of them: Estimated yields of the common agricultural crops under defined levels of management, land capability interpretations, soil-woodland interpretations, rangeland interpretations, engineering uses of soils, interpretations for community planning and urban development, suitability of the soil for drainage and irrigation, and suitability of the soil for recreation and wildlife.

A soil survey published by the U. S. Department of Agriculture that is still in print may be obtained in one of the following ways:

> Land owners or operators in the area surveyed and professional workers who have use for the survey can obtain a free copy from the local office of the Soil Conservation Service, from their county agent, or from their congressman. Those outside the area surveyed who have a use for the survey can obtain a free copy from the Information Division, Soil Conservation Service, Washington, D.C. 20250. The Minnesota Agricultural Experiment Station does not generally supply them, but a limited number of copies are on hand and are available as long as the supply lasts. Requests should be made to Department of Soil Science, University of Minnesota, St. Paul, Minnesota 55101.
>
> For a time after publication, copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.
>
> Many libraries keep published soil surveys on file for reference. Also, soil conservation district offices and county agricultural extension offices have copies of the local soil surveys that may be used for reference.

Soil survey maps are available for all counties in the Twin Cities area. Some were made years ago, and some are quite recent. A discussion of the soil survey situation in each county follows:

Anoka County—A soil survey report and map published in 1918 are out of print. Reference copies are available in the Anoka County Soil and Water Conservation District Office, the University of Minnesota St. Paul Campus Library, and in the Anoka County Agricultural Extension Office. The map is on a scale of 1 inch to 1 mile. It lacks much of the information needed by urban users. Since the formation of the Anoka County Soil and Water Conservation District in 1946, approximately 80 percent of the county has been resurveyed. This survey provides much more information about the soils than the original one. However, interpretative information needed by urban users has not been prepared. When this survey is completed it will likely be published on a photomosaic background and on a scale of 4 inches to 1 mile. It will contain information on the engineering properties of the soils and information on the suitability of the soils for various kinds of urban and industrial developments. Definite plans have not been made as yet for completing the field work or for publishing the map and report. The individual field sheets of the mapped areas are available for reference in the Anoka County Soil and Water Conservation District Office, Anoka.

Carver County—A soil survey of this county was completed in 1964. The map and report are now being processed for publication and should be available in 1968. The map will be on a photomosaic background and on a scale of 4 inches to 1 mile. The report will have a chapter on the engineering properties of the soils and also a section relating soil conditions to urban use and development. Until the map is published, copies of the soil survey field sheets will be available for reference in the Carver County Soil and Water Conservation District Office, Waconia.

Dakota County—The soil survey was completed in 1955 and a map and report published in 1960. Copies are available. The map scale is approximately 3.2 inches to 1 mile. The report does not have a section on the engineering properties of the soils or any interpretative material on the suitability of the land for various kinds of urban uses. It would be possible to prepare a supplement to the report covering these items, but no plans have been made to do this.

Hennepin County—A soil survey report and map were published in 1929. The map scale is 1 inch to 1 mile. The map and report are out of print, but reference copies are available in the Hennepin County Soil and Water Conservation District Office in Golden Valley, the Hennepin County Agricultural Extension Service Office, and in the library and the soil science building on the University of Minnesota St. Paul Campus. Since organization of the Hennepin Soil and Water Conservation District in 1949, approximately 22 percent of the county has been resurveyed. The new maps provide much more information about the soils than the original survey. However, information showing the relationship of the soils to various kinds of urban uses has not been prepared as yet. When the survey is completed, it will likely be published on a 4 inches to 1 mile scale on a photomosaic background. It will contain information on the engineering properties of the soils and information on the suitability of the soils for various kinds of urban and industrial developments. There are no definite plans at present for completing the survey or for publishing a map and report. The individual field sheets (aerial photographs) of the mapped areas are available for reference in the Hennepin County Soil and Water Conservation District Office in Golden Valley.

Ramsey County—A soil survey report and map published in 1916 are out of print. This report and map lack the detailed information needed about the soils for urban users, but furnish information useful in general land use planning.

Scott County—The soil survey was completed in 1955 and a map and report published in 1959; they are currently available. The map is published on a photomosaic background on a scale of approximately 3.2 inches to 1 mile. The report has a chapter on the engineering properties of the soils, but lacks the interpretative material needed by urban users. This type of information could be prepared and published as a supplement to the report.

Washington County—A soil survey was published as a physical land conditions survey report with map in 1944. Copies of the report are available. The map is on a scale of 4 inches to 1 mile and is in color. The colors represent the eight land capability classes designated by the U. S. Department of Agriculture to indicate the capability of the land for various agricultural users.

Wright County—A soil survey was completed in 1963. The map and report are being processed for publication and should be available in 1966. The map will be on a photomosaic background and on a scale of 4 inches to 1 mile. The report will have a chapter on the engineering properties of the soils and also a section relating soil conditions to urban use and development. Until the map is published, copies of the soil survey field sheets will be available for reference in the Wright County Soil Conservation District Office, Buffalo. Although not included in the Twin Cities Metropolitan Area soil map, part of Wright County lies within the Twin Cities urban complex.

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