# GEOLOGY FOR PLANNING IN THE SPRINGFIELD-DECATUR REGION, ILLINOIS

Robert E. Bergstrom, Kemal Piskin, and Leon R. Follmer

ILLINOIS STATE GEOLOGICAL SURVEY

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This report is a contribution to the celebration of the American Bicentennial. The picture of Springfield on the front cover touches the history of Illinois as it shows the Old State Capitol (foreground) and the present Capitol (background). During the past 200 years the political status of Illinois has changed several times. In 1776 Illinois was part of a county of Virginia. It became part of the Northwest Territory in 1787, was designated part of the Indiana Territory in 1800, and became the Illinois Territory in 1809. Illinois was admitted as the 21st state in 1818, with Kaskaskia as the capital. Vandalia was the capital from 1820 until 1838, when Springfield became the capital and the State Legislature began meeting in the Old Capitol. Construction of the present Capitol was begun in 1868 and completed in 1888.

The picture on the back cover shows Decatur, with Lake Decatur in the foreground. Both cover pictures were provided by the Illinois Department of Transportation.

AMERICAN REVOLUTION BICENTENNIAL
1776-1976

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## ABSTRACT

Ninety percent of the land area of the Springfield-Decatur Region of Central Illinois is farmland; however, the economy of the region is dominantly urban-industrial. The geology and the mineral resources of the region were mapped to provide a physical basis for land-use planning.

Unconsolidated, mainly glacial deposits as much as 300 feet thick underlie the land surface, the thicker deposits occurring in Macon County within the Wisconsinan drift border and the thinner deposits in Sangamon County beneath the Illinoian drift plain. The unconsolidated deposits consist of windblown silt and glacial till in the uplands, and river sediments and glacial outwash beneath the valleys. Sand and gravel within the unconsolidated deposits is the main source of ground water in the region; it is a particularly favorable source in the Mahomet Bedrock Valley in northeastern Macon County. Sand and gravel is also mined as a building material along the Sangamon River. The Sangamon and its tributaries are the prime surface-water resources of the region.

Additional resources occur in the bedrock beneath the unconsolidated deposits. The Herrin (No. 6) and the Springfield (No. 5) Coals have been extensively mined near Springfield, and there are still large reserves, although only one mine is operating at present. Oil is produced from a number of fields in Devonian and Silurian rocks at depths of less than 2,000 feet. Deposits of clay, shale, and limestone have been worked in the region.

The major soils are highly productive. The greatest soil limitations are poor natural drainage and erosion.

The region presents few serious problems to construction. The most common problem is the difficulty of draining relatively flat, dense glacial deposits. Some subsidence of land surface has occurred in areas that have been undermined for coal. The region is one of low risk from earthquakes.

Geologic conditions are relatively favorable for solid-waste disposal by landfill throughout much of the upland and relatively unfavorable in many of the sloping and bottomland areas.

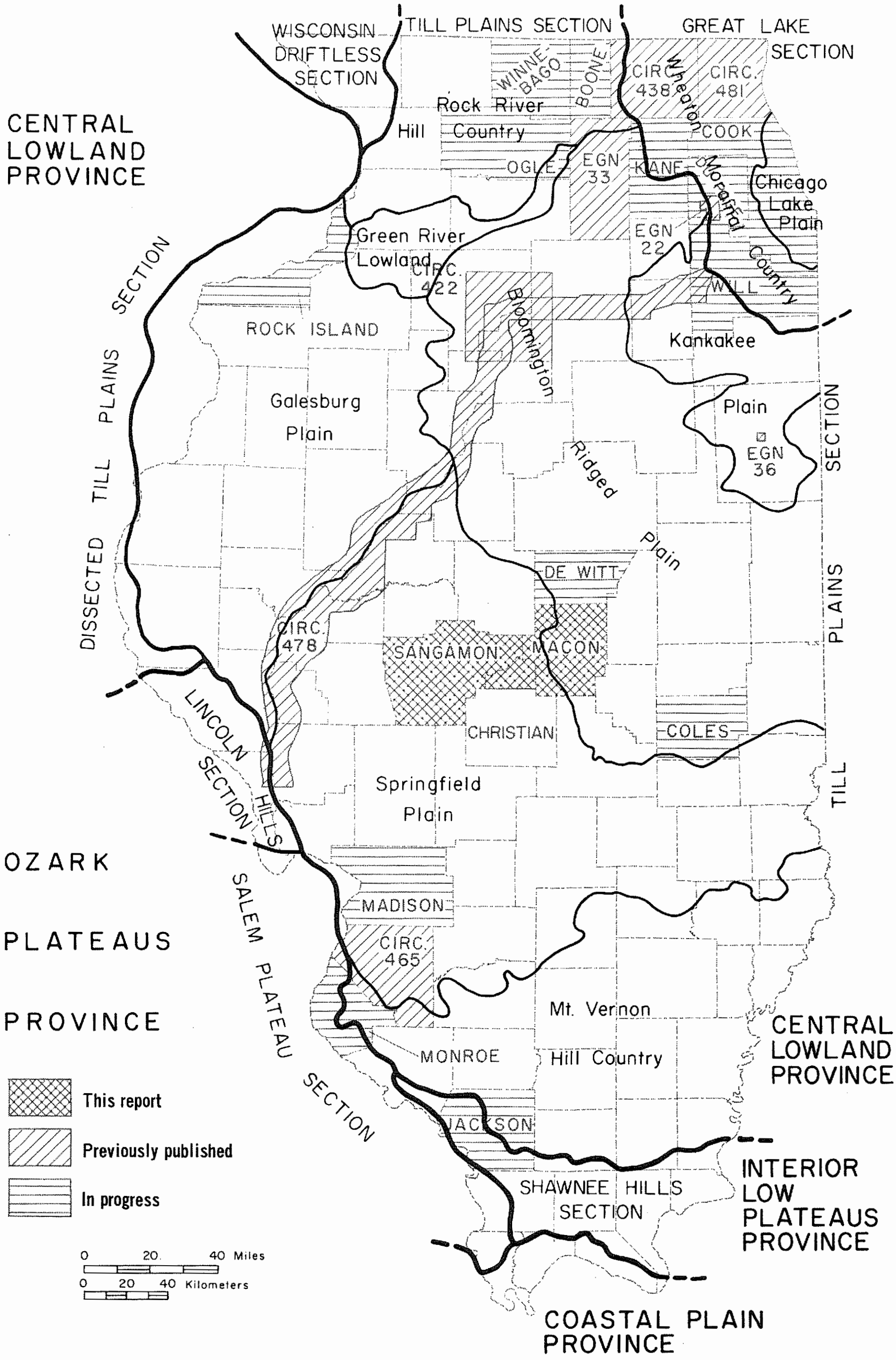

Fig. 1 - Physiographic provinces of Illinois, highlighting areas where Illinois State Geological Survey environmental geology studies have been made or are in progress. Physiographic provinces are from Leighton, Horberg, and Ekblaw (1948).

# INTRODUCTION

The Springfield-Decatur Region includes Sangamon and Macon Counties and Christian County north of township 14 north (figs. 1 and 2). It is a region extending about 65 miles from east to west and 15 to 30 miles from north to south; it covers about 1,550 square miles.

Ninety percent of the area is in farms; however, on the basis of dominant types of employment, sources of income, and value of products produced in the area, the economy of the region is primarily urban-industrial rather than rural-agricultural. The cities of Springfield and Decatur, as centers of manufacturing, trade, and services, affect the activities and development of the surrounding rural areas. These cities, and the social and physical problems that they encounter from concentrations of people and facilities, provide the dominant impetus to land development in the region.

The physical problems include: 1) procurement of adequate water supplies and certain other mineral resources; 2) conflict in uses of land and water; 3) disposal of solid and liquid wastes; and 4) local natural conditions that create some difficulties in construction, habitation, and development.

County and city planning agencies are at present concerned with identifying these and other environmental problems, with studying the expanding needs of the populace, and with formulating policies and plans for using the land most efficiently. However, information on the geology, hydrology, and natural resources of the region and their relation to man's uses of the land has not been systematically collected, nor have all the implications of the physical environment been appreciated by planners and users of the land.

## Purpose and Scope

This report summarizes currently available information on the geology, hydrology, and mineral resources of the Springfield-Decatur Region as it relates to regional planning. The objective of the report is to provide comprehensive information on the physical environment and the relation of that environment to specific land uses in the region, including the development of water and other mineral resources, construction, and waste disposal. Within this report the geologic framework of the region is presented, the distribution of the geologic formations at the land surface is delineated, and ground-water and surface-water sources and mineral deposits are described. Interpretations of the geologic and hydrologic information in relation to possible land uses in the region are made to the extent feasible from data that are not uniformly distributed.

This investigation in Sangamon, Macon, and Christian Counties is part of a program of environmental geology studies that was begun in the Chicago Metropolitan Region by Hackett in 1962 and defined and described by him in 1964 (Hackett, 1967). Other published reports on environmental geology in Illinois include those by McComas (1968), Hackett (1968), Hackett and McComas (1969), Gross (1970), Bergstrom (1970), Jacobs (1971), Willman (1973), and Larsen (1973) (fig. 1); the Illinois State Geological Survey Environmental Geology Notes series, begun in 1965, covers a variety of topics related to environmental problems in Illinois. The application of geologic information to man's use of his environment is by no means new, but the systematic collection, synthesis, and application of geologic, hydrologic, and mineral-resource data to land-use planning and environmental problems are tasks of increasing urgency in today's urbanizing civilization.

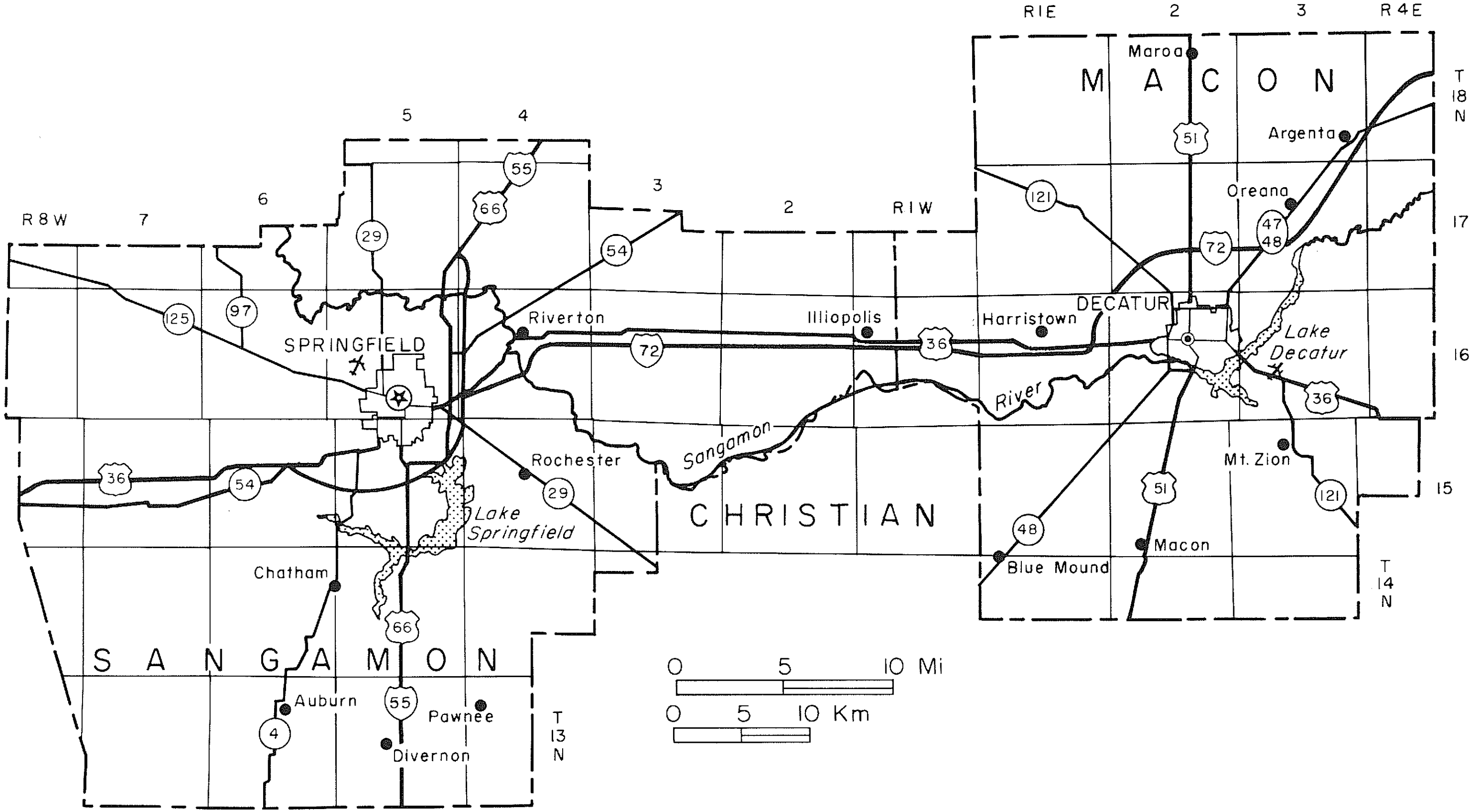

Fig. 2 - Principal geographic features of the Springfield-Decatur Region.

## Additional References

The earliest reports on the rocks and the mineral resources of the Springfield-Decatur Region are contained in the volumes of the first Geological Survey of Illinois under the direction of Worthen (1873, 1882; Broadhead, 1875, 1882). Leverett (1899) discussed the distribution, character, and thickness of glacial drift and the ground-water conditions of the area. (Savage (1907, 1915) reported on the geology and on the occurrence of ground water and mineral resources of the Springfield Quadrangle. Crook (1912) reported on the geology of Sangamon County. Shaw and Savage (1913) prepared geologic maps of the Tallula and Springfield Quadrangles and discussed the drainage, the stratigraphy of formations, and the mineral and water resources of the two quadrangles.

Stratigraphy, structure, and possible oil and gas horizons and prospecting localities in the eastern part of the region were studied by Collingwood (1924). Payne and Easton (1942) reported on stratigraphy, mining and structural features of the Herrin (No. 6) Coal Member, and oil and gas development in the southwestern part of Sangamon County. Payne and Cady (1944) reported on a similar study of southeastern Sangamon and southwestern Macon Counties. Whiting (1956) reported on the geology and on the history of oil production of the Lake Decatur-Mt. Auburn-Springfield area. Clegg (1961) investigated the surface geology and the coal resources of the Pennsylvanian System of the region. Johnson (1964) and Miller (1973) studied the glacial deposits of the area. Whiting and Stevenson (1965) reported on the geologic structure of the area in relation to oil reservoirs. Hester and Anderson (1969) reported on the sand and gravel resources of Macon County, and Hester (1970) on those of Sangamon County.

In addition to these geologic studies, there have been a number of studies bearing on physical conditions and natural resources by planning agencies and their consultants and by the U.S. Army Corps of Engineers. A number of these studies were made for the proposed Lake Springer on the Sangamon River in Macon County.

Quadrangle topographic maps, some on a scale of 1:62,500 (approximately 1 inch to the mile) and some on a scale of 1:24,000 (approximately $2\frac{1}{2}$ inches to the mile), have been made for the region by the U.S. Geological Survey in cooperation with the Illinois State Geological Survey (fig. 3). The U.S. Geological Survey has also issued maps showing flood-prone areas for some of these quadrangles. A 1:250,000 (approximately 4 miles to the inch) scale topographic map of the Decatur Quadrangle, which includes all of Macon County but the northern part, has also been issued; and mapping of the surficial geology of that area is in progress at the State Geological Survey.

## Acknowledgments

This report was prepared with the assistance of many of the staff members of the Geological Survey. Robert E. Bergstrom initiated and coordinated the study and prepared the introductory material and the sections on geographic features, geology, and water resources. Kemal Piskin assisted Bergstrom in assembling this material and prepared most of the figures and some of the plates dealing with these topics. Leon R. Follmer mapped the surficial deposits of Sangamon County, coordinated the description and map of surficial deposits, and prepared the material on soils. Robert M. Mason mapped the surficial deposits of Macon County.

Paul B. DuMontelle and Stephen R. Hunt prepared the material dealing with engineering geology and construction conditions. Roger B. Nance prepared the

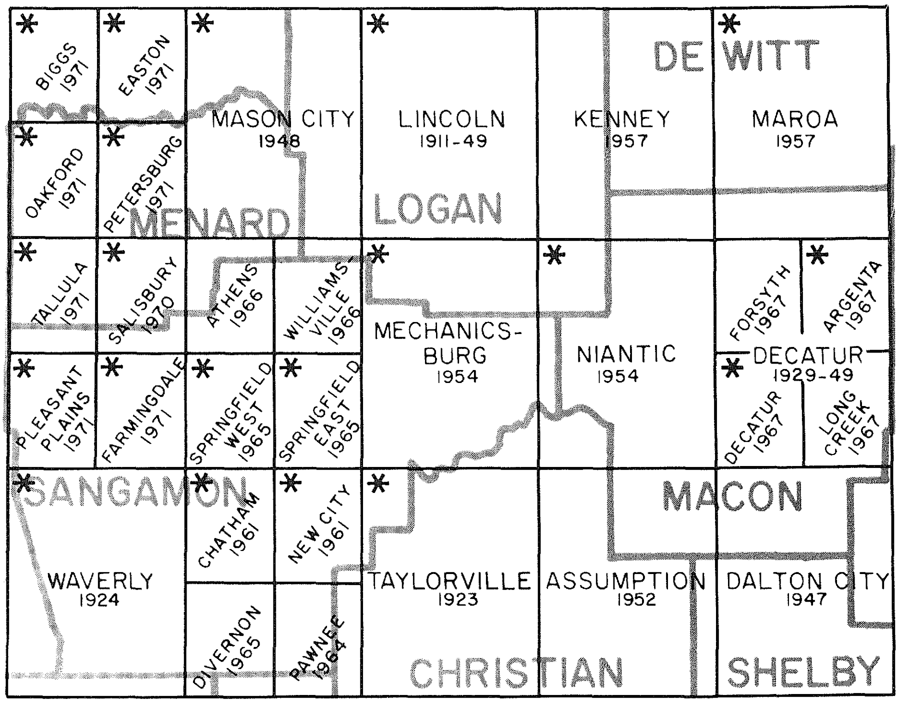

Fig. 3 - Index of available 15-minute and $7\frac{1}{2}$-minute quadrangle topographic maps of the Springfield-Decatur Region. Maps showing flood-prone areas are available for quadrangles marked by an asterisk.

material on coal resources; Norman C. Hester and James C. Cobb, the material on sand and gravel resources; Frank B. Sherman, the material on waste disposal; Richard H. Howard, the material on oil and gas resources; Paul C. Heigold, the section on seismicity; Richard D. Harvey, the material on limestone resources; W. Arthur White, the material on clay and shale resources; and Robert L. Major, the section on the economy of the region.

## GEOGRAPHY

### General Features and History

The Springfield-Decatur Region is part of the cash-grain farming area of east-central Illinois. The region includes 1,549 square miles (991,360 acres), of which 879 square miles (562,560 acres) are in Sangamon County, 578 square miles (369,920 acres) are in Macon County, and 92 square miles (58,880 acres) are in Christian County (fig. 2).

Settlement of the region began more than 150 years ago. Springfield was first occupied in 1818-19, by settlers from South Carolina, Kentucky, and Virginia. It became the county seat in 1823, when Sangamon County was established; and in 1831 it was incorporated as a town. Partly through the efforts of Abraham Lincoln, it was made the state capital in 1837.

Settlers, most of them from Kentucky, began moving into the Decatur area in 1822-24. Macon County was established in 1829, with Decatur as the county seat. Decatur was incorporated as a town in 1836.

Lake Decatur was constructed on the Sangamon River in 1922, and Lake Springfield was constructed on Sugar Creek, a tributary of the Sangamon, in 1935.

The Baltimore and Ohio, Chicago and Illinois Midland, Chicago and Northwestern, Illinois Central Gulf, Illinois Terminal, and Norfolk and Western Railroads provide freight transportation for the region. The main highways are Interstates 55 and 72 and U.S. 36, 51, 54, and 66 (fig. 2). Ozark Air Lines and commuter lines provide air transportation.

## Climate

The average annual precipitation of the Springfield-Decatur Region is 35 to 38 inches, increasing from west to east (Illinois State Division of Industrial Planning and Development, 1958). The lowest average monthly precipitation occurs in February and is about 1½ inches, according to records at Springfield. May and June, with slightly more than 4 inches, and September, with slightly less than 4 inches, have the highest average monthly precipitation. Once in 5 years the annual precipitation reaches a low of 30 inches, and once in 50 years it reaches a low of 24 inches. The highest annual precipitation once in 50 years is about 56 inches.

The January mean temperature is 30° F, and the July mean temperature is 76° F. The average length of the growing season is about 180 days.

## Population

In 1970 the population of the region was 287,504 people—161,335 in Sangamon County, 125,010 in Macon County, and 1,159 in Mosquito and Mt. Auburn Townships of Christian County (U.S. Bureau of the Census, 1973). More than 75 percent of the population was classified as urban.

The population trends for Sangamon and Macon Counties and the two large cities for the past 40 years are shown in figure 4. They show that Decatur has nearly overtaken Springfield in population (90,397 and 91,753, respectively) and that Sangamon County is maintaining its population lead over Macon County.

## Economy

Manufacturing and trade dominate the economy of Sangamon and Macon Counties (table 1). In 1967 the "value added by manufacture" totaled $532 million; wholesale and retail trade sales totaled $1,175 million in the same year. Part of the large wholesale trade in Sangamon County can be accounted for by substantial business with agencies of the state government in Springfield.

Most of the region's manufacturing is located in the Decatur area of Macon County. The principal category of manufacturing in Macon County is foodstuffs, mainly grain products. The fabrication of metal products ranks second in manufacturing. Manufacturing and retail trade provide jobs for about half of the persons employed in the county. Fig-

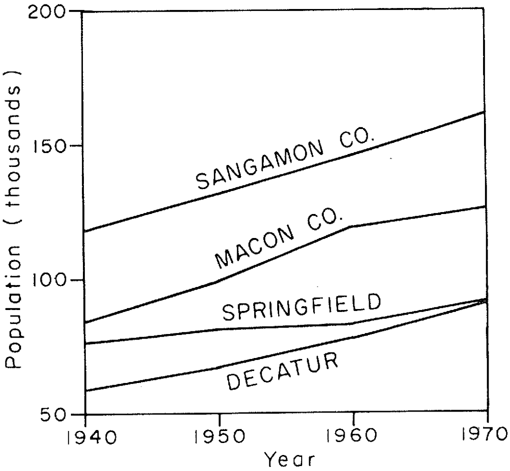

Fig. 4 - Population of Sangamon and Macon Counties and of Springfield and Decatur since 1940.

TABLE 1 - SUMMARY OF ECONOMY—SPRINGFIELD-DECATUR REGION

| | Sangamon County | Macon County |
|---|---|---|
| AGRICULTURE (1969)[1] | | |
| Value of farm products ($1,000) | 48,699 | 28,731 |
| Number of farms | 1,739 | 1,264 |
| MANUFACTURING (1967)[2] | | |
| Value added ($1,000) | 159,600 | 372,400 |
| Payroll ($1,000) | 76,000 | 139,900 |
| Number of employees | 11,100 | 18,500 |
| Number of establishments | 150 | 136 |
| MINERAL INDUSTRIES (1974)[3] | | |
| Value of mineral products ($1,000)* | 25,914 | 1,118 |
| SELECTED SERVICES (1967)[4] | | |
| Receipts ($1,000) | 42,870 | 27,980 |
| Payroll ($1,000) | 12,582 | 9,024 |
| Number of employees | 3,394 | 2,288 |
| Number of establishments | 1,300 | 809 |
| WHOLESALE TRADE (1967)[5] | | |
| Sales ($1,000) | 380,314 | 267,220 |
| Payroll ($1,000) | 22,235 | 12,617 |
| Number of employees | 3,249 | 1,872 |
| Number of establishments | 301 | 202 |
| RETAIL TRADE (1967)[6] | | |
| Sales ($1,000) | 302,530 | 225,133 |
| Payroll ($1,000) | 35,820 | 27,361 |
| Number of employees | 9,297 | 7,193 |
| Number of establishments | 1,488 | 968 |

*No coal was mined in 1967.

[1] U.S. Bureau of the Census, Census of Agriculture, 1969, Volume I, Area Reports, Part 12 - Illinois. Washington, D.C.: U.S. Government Printing Office, 1972.

[2] U.S. Bureau of the Census, Census of Manufactures, 1967, Volume III, Area Statistics, Part 1 - Alabama-Montana. Washington, D.C.: U.S. Government Printing Office, 1971, p. 14-1 - 14-49.

[3] Records of Illinois State Geological Survey, Urbana, Illinois.

[4] U.S. Bureau of the Census, Census of Business, 1967, Volume V, Selected Services—Area Statistics; Part 1, U.S. Summary and Alabama to Indiana. Washington, D.C.: U.S. Government Printing Office, 1970.

[5] U.S. Bureau of the Census, Census of Business, 1967, Volume IV, Wholesale Trade—Area Statistics. Washington, D.C.: U.S. Government Printing Office, 1970.

[6] U.S. Bureau of the Census, Census of Business, 1967, Volume II, Retail Trade—Area Statistics, Part 1, U.S. Summary and Alabama to Indiana. Washington, D.C.: U.S. Government Printing Office, 1970.

ure 5 shows grain storage facilities of the A. E. Staley Manufacturing Co. at Decatur, one of the principal manufacturing concerns of the region.

Manufacturing in Sangamon County is concentrated in the Springfield area, where, like Decatur, foodstuffs are the major industry. Printing and publishing, in terms of value added, are a distant second behind foodstuffs in manufacturing. Manufacturing, retail trade, public administration (government service), and health services account for more than half of Sangamon County's employment.

In 1969 the value of farm products grown on the region's 3,000 farms was $77.4 million.

Mining and the mineral industries occupy a minor role in the economy of this region. Production of mineral resources is currently limited to coal, clays, crude oil, and sand and gravel. Although abundant coal resources exist in the region, only one commercial coal mine is operating at present. Local clays are used in the production of structural clay products, such as face brick and lightweight aggregates, at plants in Sangamon County.

Figure 6 shows the coal-fired power plant of Springfield Water, Light, and Power Co. from across Lake Springfield.

## GEOLOGY

### Physiography and Drainage

The Springfield-Decatur Region is part of the Springfield Plain and the Bloomington Ridged Plain of Illinois (figs. 1 and 7).

The Springfield Plain, which includes the part of the study area west of Decatur, has a relatively flat upland that is well dissected by numerous shallow valleys. Moderately thick glacial deposits of Illinoian and older ages underlie the land surface except along some of the drainages where erosion has reached bedrock. The Buffalo Hart Moraine, a broad, discontinuous, glacially built ridge (end moraine), rises above the general level of the plain in the vicinity of Buffalo Hart (fig. 7).

The border of the Bloomington Ridged Plain, a province more recently glaciated than the Springfield Plain, is marked by a fairly prominent end morainic system, the Shelbyville Morainic System, which underlies Decatur and stands some 75 feet above the Springfield Plain to the west. Figures 8 and 9 illustrate the rolling topography of the Shelbyville System. Another end moraine, the Cerro Gordo, forms the high ground along the east side of Macon County. The glacial deposits beneath the Bloomington Ridged Plain are relatively thick and conceal the bedrock.

The highest land in the region, which is on the Shelbyville and Cerro Gordo Moraines, ranges in elevation from about 700 to about 750 feet above sea level. Most of the Springfield Plain is from about 575 to about 625 feet above sea level, with points on the Buffalo Hart Moraine attaining a maximum elevation of about 700 feet above sea level.

The Sangamon River, the principal stream in the region, enters eastern Macon County through a narrow high-walled valley at an elevation of about 620 feet above sea level, passes into a mile-wide, terrace-bordered valley on the Springfield Plain, and leaves northwestern Sangamon County at an elevation of about 490 feet, dropping 130 feet in 70 miles. Figure 10 shows the narrow Sangamon River Valley upstream from Lake Decatur, and figure 11 shows the Sangamon Valley where the river crosses the Buffalo Hart Moraine north of Roby. All of the region but the northeastern corner of Sangamon County and the northwestern corner

(Text continued on page 14)

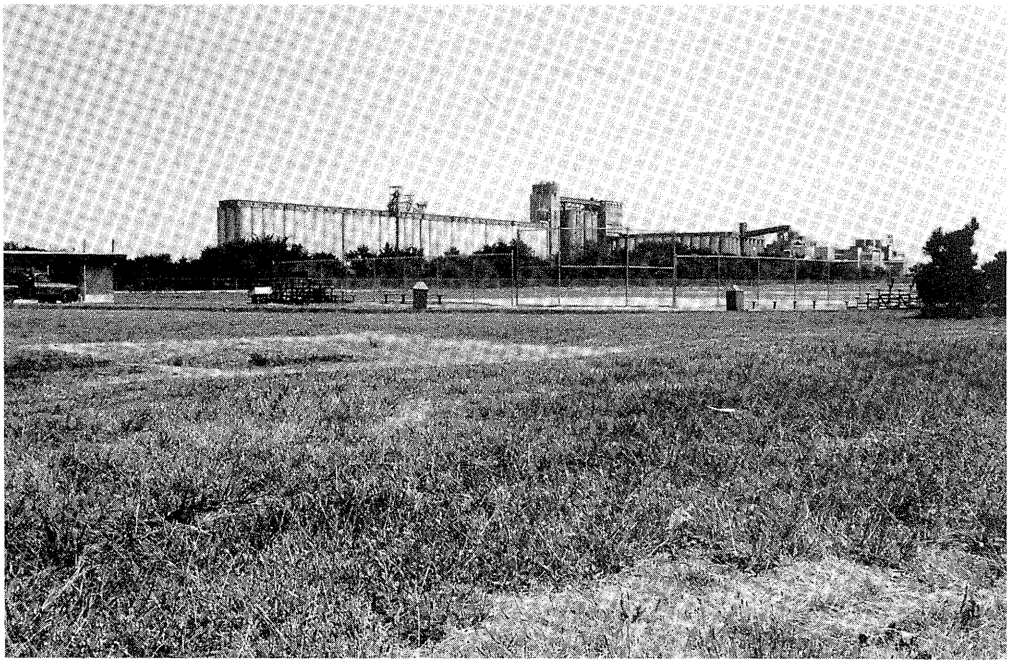

Fig. 5 - Grain storage facilities at A. E. Staley Manufacturing Co., Decatur.

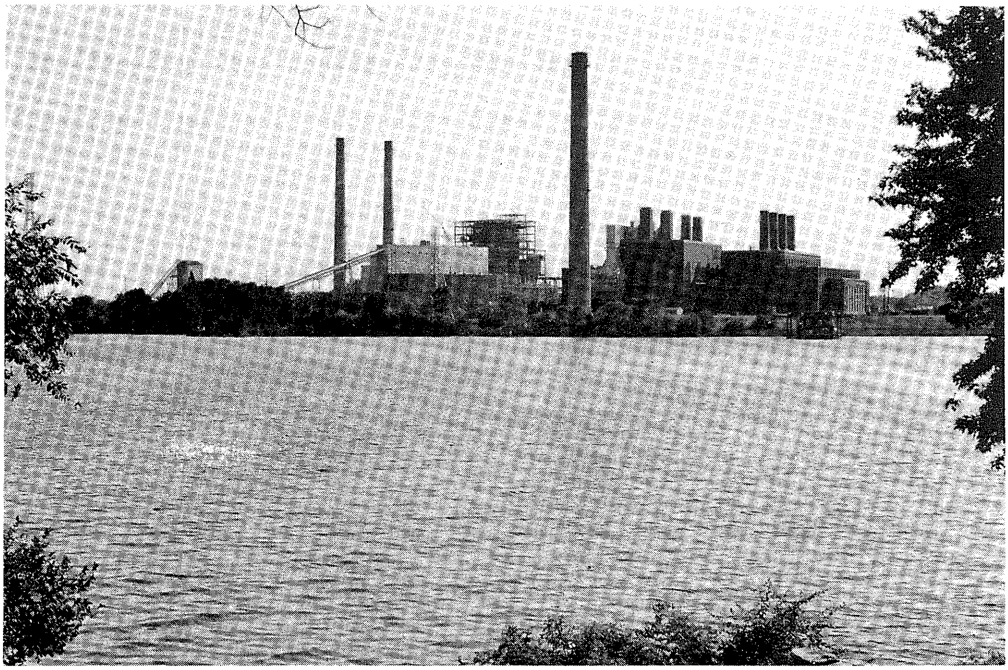

Fig. 6 - Springfield Water, Light, and Power plant, on Lake Springfield.

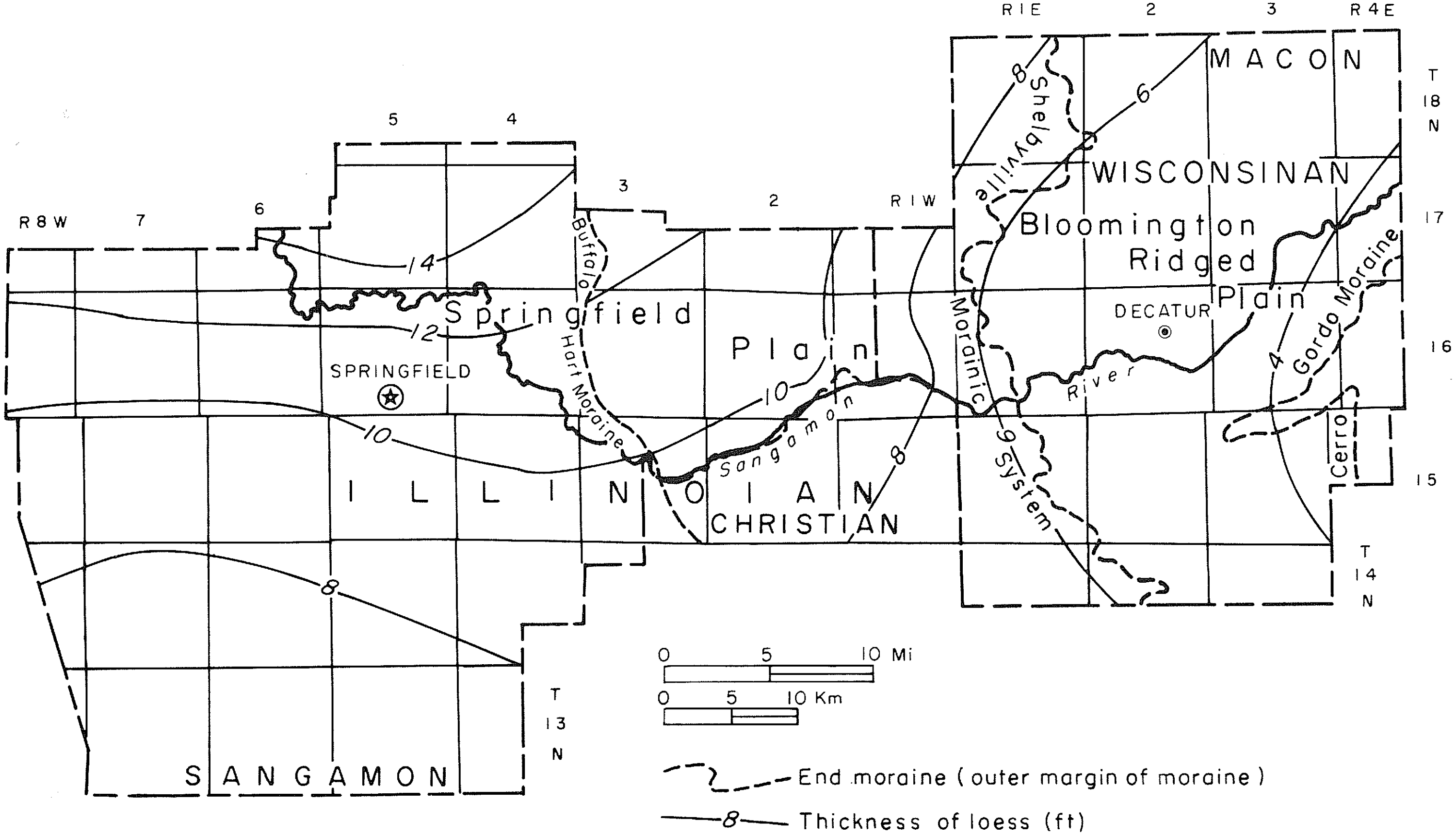

Fig. 7 - End moraines and thickness of loess in the Springfield-Decatur Region.

Fig. 8 - Farm on slightly rolling moraine of Shelbyville System, Macon County.

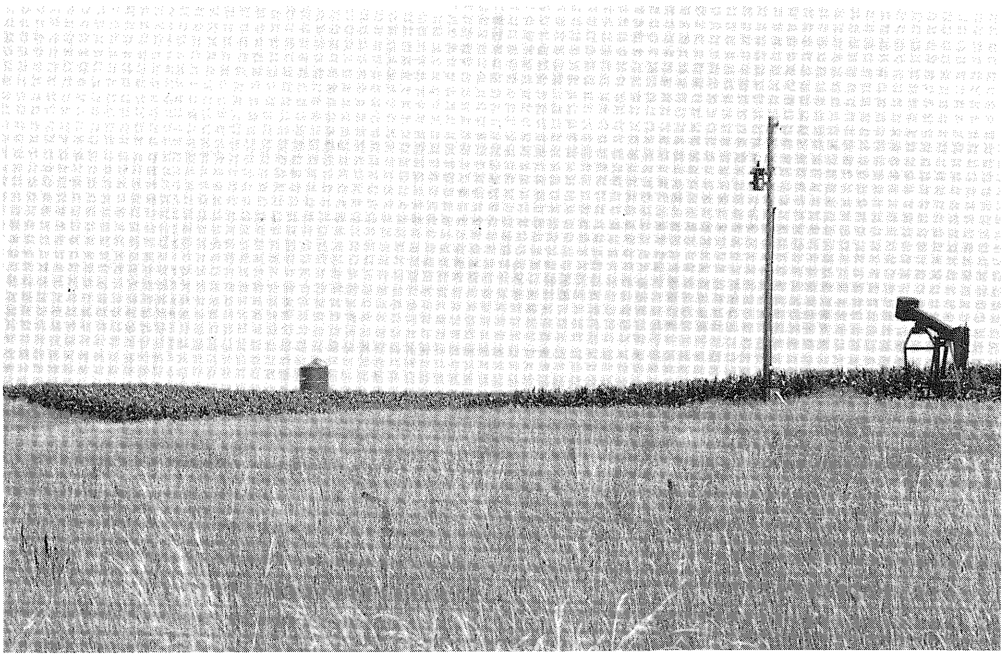

Fig. 9 - Oil pump at Harristown oil field, on slightly rolling moraine of Shelbyville System, Macon County.

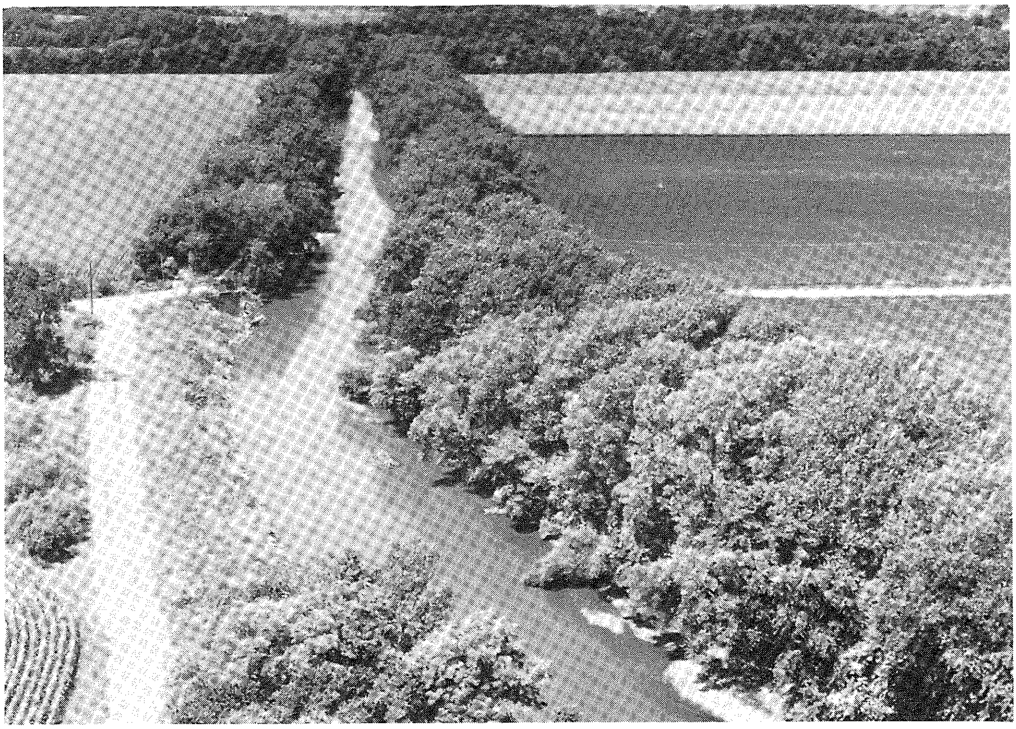

Fig. 10 - Narrow Sangamon River Valley upstream from Lake Decatur, Macon County. Photo from Illinois Department of Transportation.

Fig. 11 - Sangamon River Valley on Springfield Plain, north of Roby.

of Macon County is drained by the Sangamon River or its tributaries. The tributary network is much more extensively developed on the Springfield Plain than on the younger Bloomington Ridged Plain. In contrast, some of the broad uplands between drainage lines on the Bloomington Plain contain small pits and undrained depressions, less than 10 feet deep and a few hundred feet across, and knolls and ridges of similar scale, that have been little altered since the glacial ice melted in the region some 20,000 years ago.

## The Rocks and Their Structure and Uses

The sequence of earth materials in the Springfield-Decatur Region (fig. 12) consists of unconsolidated* glacial, windblown, and alluvial (river) deposits up to about 300 feet thick; bedded sedimentary rocks—mainly limestone, dolomite, sandstone, and shale—extending to a depth of 5,000 to 6,500 feet; and ancient (Precambrian) crystalline rocks—probably granite—below. The unconsolidated deposits underlie the land surface and are the parent materials of the soils throughout the region. Along some of the streams in the western part of the region, the uppermost sedimentary rocks—those of the Pennsylvanian System—crop out.

The Pennsylvanian System of rocks is the uppermost bedrock throughout the region. The sedimentary rocks thicken and dip to the southeast, and the underlying surface of the crystalline rocks slopes gently to the southeast toward the center of a saucer-shaped structure in the earth called the Illinois Basin. At the center of the basin, in Hamilton and White Counties in southeastern Illinois, the crystalline rocks occur at depths of 13,000 to 14,000 feet.

The character, thickness, and structure of the rocks are known from studies of the numerous wells and borings that have been made in search of ground water and mineral deposits. For example, many borings have been made in the Pennsylvanian rocks to determine the depth and thickness of minable coal beds. Deeper drilling, penetrating the Silurian rocks, has taken place in search of oil and gas. In nearby areas of Illinois, oil exploration holes have gone entirely through the section of sedimentary rocks and reached the top of the Precambrian crystalline rocks. Figure 13, a cross section prepared from information obtained from wells in and adjacent to the Springfield-Decatur Region, illustrates the sequence of the major geologic units, the eastward dipping and thickening of formations, and the quality of ground water present at various depths.

The geologic units illustrated in the cross section and in figure 12 are of chief significance to man because of their position, their physical properties, and the resources that they provide. For example, the glacial and alluvial deposits, which form a veneer over the bedrock, are the earth materials on which man lives, works, and builds. In addition, they are the only potential sources of large groundwater supplies in the region and are the sources of sand and gravel needed for construction.

The Pennsylvanian rocks are sources of coal. Coal formerly was produced by extensive underground mining in the region, chiefly in Sangamon County, but at present only one mine is operating. However, there are substantial reserves of coal. The Pennsylvanian rocks are also sources of shale and clay for brick-making. In adjacent counties, there is some oil and gas production from Pennsylvanian strata.

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* The term unconsolidated deposits is used in this report in a general sense for all the overburden materials above the firm, layered bedrock.

The Mississippian, Devonian, and Silurian rocks consist largely of formations of limestone and dolomite and contain a few relatively tight shale formations. Oil and gas are produced from all of these rocks in other regions of Illinois, but essentially all of the oil production in the Springfield-Decatur Region is from the Devonian and Silurian rocks.

The Ordovician and Cambrian rocks are dolomites and sandstones, with prominent and persistent shale units in the Maquoketa and Eau Claire that retard the vertical movement of fluids, including water and gas. Oil is produced from the Galena-Platteville (Ordovician) rocks in other regions of Illinois, but to date there is no production in Illinois below this zone. Thus the lower half of the sedimentary rock section shown in figure 12 is not known at this time to contain oil or gas resources.

All ground water below the lower part of the Pennsylvanian rocks is highly mineralized. In the thick Mt. Simon Sandstone, the basal sedimentary rock formation in most of Illinois, the water is brine, probably containing more than 100,000 parts per million (ppm) total dissolved minerals.

Because the Mt. Simon Sandstone contains relatively porous zones, it is used or has been tested at several places in Illinois (Ancona, Crescent City, Herscher, Mahomet, Pontiac, Troy Grove, Tuscola, and McLean County) for the storage of natural gas. Gas is injected into sandstone reservoirs from pipelines from the gas fields during periods of the year when not all of the gas is immediately needed by homes and industry, and is withdrawn in the winter when gas demands exceed pipeline capacities. Besides requiring a porous rock for the reservoir, a gas storage project requires a caprock, such as a shale formation arched over the sandstone reservoir, to confine the gas vertically and laterally.

Another use that has been made of the Mt. Simon Sandstone and other deep formations where they contain highly mineralized water in Illinois is as a reservoir for disposal of industrial liquid wastes. The wastes are injected into the deep reservoirs through specially constructed wells (Bergstrom, 1968). This technique offers a solution for certain industrial disposal problems, provided that the proper geologic and hydrologic conditions are present.

## Unconsolidated Deposits

The surficial materials mapped on plate 1 constitute about the upper 20 feet of the unconsolidated deposits overlying bedrock in the region. The unconsolidated deposits, whose sequence and field relationships are shown in figure 14, range in thickness from less than a foot to about 300 feet. Within the various mapped tracts on plate 1, the sequence of materials from the surface down to a depth of about 20 feet is indicated by columns of abbreviations that stand for the various geologic units. Delineation of these units to a depth of about 20 feet was undertaken because most of the activities of man are concentrated within this depth. On plate 1 the various earth materials or formations are described from youngest to oldest and their thicknesses are listed. The earth materials are also listed by texture (grain size) on plate 1 to aid in locating kinds of materials.

As shown on plate 1, alluvial deposits form branch-like patterns along the Sangamon River and its tributaries. These deposits underlie the river floodplains and the terraces that stand as low benches above the floodplains. The uplands are underlain mainly by windblown silt (loess) over glacial deposits (fig. 14). The various glacial deposits are sometimes collectively called drift.

| SYSTEM | SERIES | GROUP OR FORMATION | THICKNESS (ft) | DESCRIPTION | RESOURCES |
|---|---|---|---|---|---|
| QUATERNARY | PLEISTOCENE | | 0-300 | Alluvium, loess, and glacial drift | Sand, gravel, and clay; major ground-water supplies from thicker sand and gravel aquifers in bedrock valleys and Sangamon River bottom. |
| PENNSYLVANIAN | | McLeansboro<br>Kewanee<br>McCormick | 375-1100 | Shale, sandstone, limestone, clay, and coal | Clay; large coal reserves; small ground-water supplies from fractured shale, creviced limestone, and permeable sandstone. |
| MISSISSIPPIAN | CHESTERIAN | | 0-275 | Shale, limestone, and sandstone | Petroleum |
| | VALMEYERAN | Aux Vases | 0-50 | Limestone, partly dolomitic; shale; and sandstone | |
| | | Ste. Genevieve | 0-100 | | |
| | | St. Louis | 70-225 | | |
| | | Warsaw | 100-350 | | |
| | | Keokuk-Burlington | 20-275 | | |
| | | Fern Glen | 0-100 | | |
| | KINDERHOOKIAN | | 25-100 | Shale and thin limestone | |
| DEVONIAN | | | 0-175 | Limestone and shale | |
| SILURIAN | NIAGARAN | | 125-400 | Dolomite, some limestone | |
| | ALEXANDRIAN | | 25-50 | | |
| ORDOVICIAN | CINCINNATIAN | Maquoketa | 170-225 | Principally shale | |
| | CHAMPLAINIAN | Galena | 125-175 | Limestone and dolomitic limestone | |
| | | Platteville | 175-325 | | |
| | | Joachim | 25-75 | Dolomite | |
| | | St. Peter | 75-225 | Sandstone | |

| | | | | | |
|---|---|---|---|---|---|
| ORDOVICIAN | CANADIAN | Prairie du Chien | 675-775 | Dolomite and sandstone | Fractured limestones and dolomites and porous, permeable sandstones are possible reservoirs for waste disposal and gas storage. |
| CAMBRIAN | CROIXAN | Eminence | 140-175 | Dolomite | |
| | | Potosi | 240-300 | | |
| | | Franconia | 225-300 | Principally dolomite | |
| | | Ironton-Galesville | 50-150 | Sandstone; thin dolomite at top | |
| | | Eau Claire | 425-550 | Siltstone, limestone, dolomite, and shale | |
| | | Mt. Simon | 750-1800 | Sandstone | |
| PRECAMBRIAN | | | | Granite and other igneous rocks | |

Fig. 12 - Unconsolidated deposits and bedrock in the Springfield-Decatur Region.

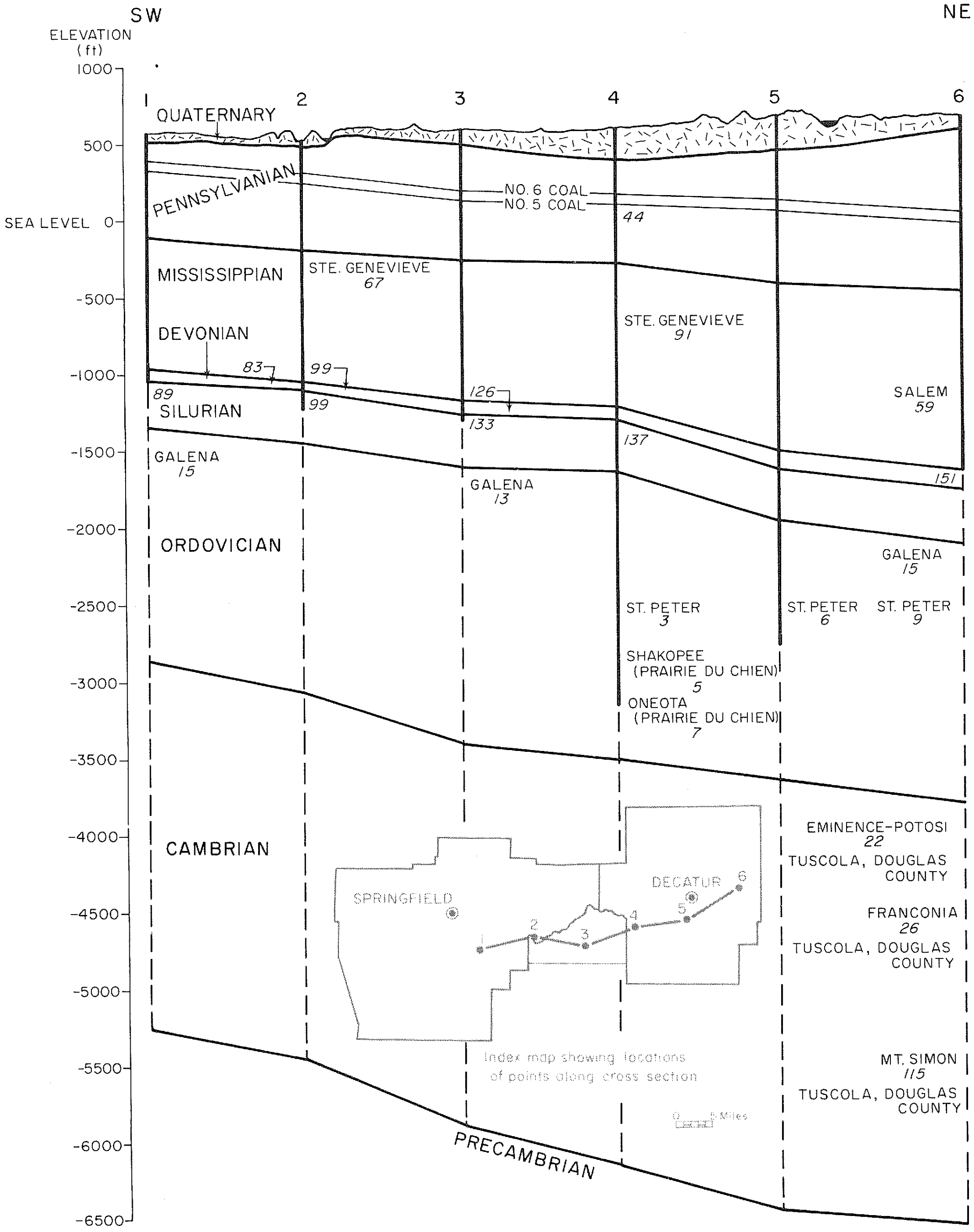


Fig. 13 - Cross section showing main bedrock units and quality of ground water as determined in water wells and oil tests. Italic numbers in cross section indicate mineral content as total dissolved minerals in thousands of parts per million for designated rock units (examples: Devonian, St. Peter) approximately at depths shown. Locations of sampling points for analytical data are shown by town and county where data are not available from the Springfield-Decatur Region. A detailed columnar section is given in figure 12.

## Valley Deposits—Cahokia Alluvium, Equality Formation, and Henry Formation

The widest valley—and the one with the most extensive alluvial deposits—is that of the Sangamon River, including the South Fork, on the Springfield Plain in Sangamon County and extreme western Macon County (plate 1). This part of the Sangamon Valley attains a width of 2 miles and in much of the area is more than a mile wide. The valley of the Sangamon on the Bloomington Ridged Plain, in the eastern third of the region, is much narrower, rarely exceeding half a mile in width. The tributary streams of the region, with the exception of the lower part of Sugar Creek in Sangamon County, all have narrow valleys, generally less than a few hundred yards wide.

The Sangamon River Valley is underlain mainly by the Cahokia Alluvium (c) and the underlying Henry Formation (h). The Cahokia Alluvium is dominantly silt, clayey silt, and sandy silt, yellowish brown to gray to almost black, and as much as 30 feet but typically 8 to 12 feet thick. It is fine-grained sediment deposited in the floodplain in recent time by running water, standing water, and organisms such as water-dwelling plants and snails. Much of the sediment has been deposited by floodwaters.

The Henry Formation underlies the Cahokia Alluvium along most of the Sangamon River, but it is not restricted to the river valley (fig. 14). The Henry Formation is dominantly sand and gravel that was sorted by meltwater released by a glacier that stood east of the border of the Shelbyville Moraines. Such meltwater-transported sediment is called outwash. Some of the meltwater deposited sand and gravel outwash in front of the Shelbyville Moraines, thereby forming an outwash plain, but much of the sand and gravel was carried farther and deposited along streams such as the Sangamon River, forming a valley-train deposit. The Henry Formation consists of well-sorted to poorly sorted medium- to coarse-grained sand, with some lenses of gravelly sand. It ranges in thickness from about 10 to about 60 feet. The sand and gravel of the Henry Formation constitutes the basal part of the fill in the Sangamon Valley in the western half of the region and rests on Pennsylvanian bedrock. Depth to bedrock along the Sangamon River averages 60 feet and locally reaches a maximum of slightly more than 100 feet.

The alluvial deposits of the tributary valleys are narrower, thinner, and generally finer than those of the Sangamon River Valley. The South Fork Sangamon, Sugar Creek, Spring Creek, and Richland Creek contain deposits that consist of Cahokia Alluvium at the surface and the Equality Formation (e) underlying the Cahokia. The Equality Formation is dominantly silt that was deposited in lakes formed in the lower reaches of tributary valleys when meltwater was filling the Sangamon River Valley with the sand and gravel of the Henry Formation.

Upstream from the deposits shown as Cahokia Alluvium overlying the Equality Formation in the tributary valleys, the valleys are essentially cut into, and floored with, the deposits of the uplands, as described later.

The valleys whose deposits have been described above are significant to the region for several reasons. They funnel the flow of surface water through and out of the region, and they contain significant ground-water reservoirs at shallow depths. They thereby afford the only sites in the region for the impoundment of water and some of the most favorable sites for the development of wells. They commonly contain much flat land with fertile soils, and locally contain commercial deposits of sand and gravel. However, they are also subject to flooding and poor drainage, and in some places are underlain by deposits that provide poor founda-

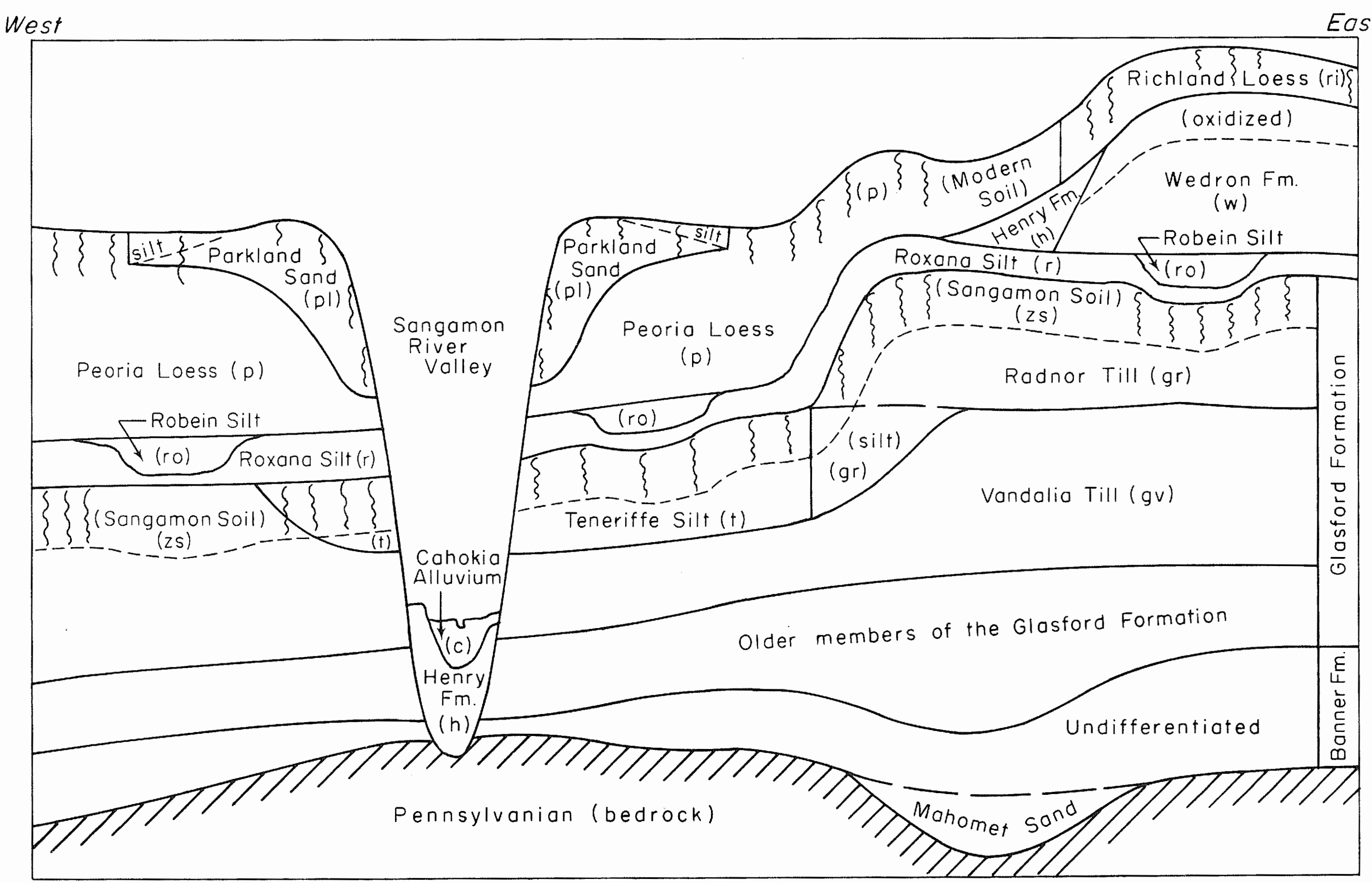


Fig. 14 - Geological classification and field relations of the unconsolidated deposits in the Springfield-Decatur Region.

tion conditions. Thus the valleys have both advantages and disadvantages for various land uses, such as the development of water and mineral resources, farming, construction, and urban and industrial settlement.

### Loess, Silt, and Windblown Sand—Peoria Loess, Richland Loess, Roxana Silt, and Parkland Sand

Loess mantles all of the region except for the floodplains of the Sangamon River and the alluvium-filled lower portions of the large tributary valleys. The silt that forms the loess was derived mainly from the broad Illinois River Valley near Havana to the north and northwest during Wisconsinan glacial time, when glaciers were contributing great volumes of meltwater to streams. The silt was blown from the sediment-laden floodplain by prevailing northwesterly winds and deposited on the bluffs and upland, forming thick deposits of loess adjacent to the Illinois River and thinner ones farther from the river. The lines showing the thickness of the loess in figure 7 reflect this thinning away from the source area.

In Sangamon County the loess ranges in thickness from about 15 feet in the north to about 6 feet in the south. In Macon County the loess thins from west to east, with considerable thinning occurring along the Shelbyville Morainic System (fig. 7). The loess overlying the Shelbyville and Cerro Gordo Moraines is generally thinner (less than 4 feet thick) than that of northwestern Sangamon County (about 15 feet thick).

The thickness lines in figure 7 depict the generalized maximum thickness of loess on flat, uneroded upland. The loess varies in thickness with the topography. Much loess has been washed into bottomland, where it lies at the foot of the slopes or is mixed with other sediments of the streams.

Besides thinning rapidly away from the bluffs of the Illinois River, the loess also becomes finer grained. In Sangamon and Macon Counties, which are 20 miles or more from the Illinois River bluffs, the loess generally consists of a few percent sand, about 80 to 90 percent silt (.002 to .062 mm in diameter), and 10 to 20 percent clay (less than .002 mm in diameter). Along the bluffs of the Sangamon River, the loess locally contains a larger percent of sand. Near the land surface, where the loess has been weathered, it contains a larger percent of clay.

On plate 1 the loess is differentiated by formation and thickness. The Peoria Loess (p) is the uppermost formation on the uplands in Sangamon County and western Macon County, west of the Shelbyville Moraines. The Richland Loess (ri), thinner than the Peoria Loess, is the uppermost formation along and east of the Shelbyville Moraines. The Peoria Loess overlies older silt formations, the Robein (ro) and Roxana (r) Silts. The Robein Silt, a silt rich in organic matter, is locally peaty and contains wood fragments. It ranges from 1 to 6 feet in thickness and represents the accumulation of slope wash and alluvium during an exposure to soil-forming processes that were dominated by the growth and accumulation of organic material. The Roxana Silt is sandy silt as much as 6 feet thick, on which the Robein organic deposits developed. The Roxana Silt, principally a loess deposit, was weathered during the soil-forming period prior to the deposition of the Peoria Loess. The Richland Loess occurs in Macon County, where it is underlain by Wisconsinan glacial deposits, principally glacial till of the Wedron Formation (w).

The loess in the region is yellow, tan, brown, or gray, depending upon the mineral and organic-matter content, moisture content, and degree of weathering.

Fig. 15 - Loesses and Sangamon Soil exposed along Spring Creek 9 miles west of Springfield. From top down are: 1. Peoria Loess, light-colored, 8 feet; 2. Roxana Silt, dark, 4 feet; 3. Sangamon Soil, light-colored "A" horizon (at head of pick), 1 foot; and 4. Sangamon Soil, dark "B" horizon, 2 feet exposed.

The upper 4 to 6 feet of the loess is altered by the development of the Modern Soil. Loess is usually massive rather than bedded; it is compact and stands well in vertical faces along stream banks and road cuts. Where it is graded back into gentle slopes, it is subject to erosion and slumping, particularly when saturated. Where thick, such as in northern Sangamon County, it is well drained in sloping areas and poorly drained in level areas, relatively permeable, and calcareous; in some places it contains fossil snails. Where it is less than about 6 feet thick, as in eastern Macon County, it is leached of carbonates, unfossiliferous, less permeable, and relatively enriched in clay. Loess deposits overlying the Sangamon Soil are illustrated in figure 15.

Another windblown deposit in the region is the Parkland Sand (pl), which occurs in dunes (fig. 16) on the upland bordering the Sangamon River Valley in Sangamon and Christian Counties (plate 1). Maximum extent of the Parkland Sand is attained on the eastern and southern borders of the valley (fig. 14). In places near the valley the Parkland Sand is the surficial material. Measurements away from the valley indicate that the Parkland Sand thins and forms a wedge of sand that is underlain by loess and overlain by silt. The sand was blown from the

Fig. 16 - Sand dunes (Parkland Sand) behind bean field, south side of Sangamon River, northern Christian County.

Sangamon floodplain during Wisconsinan glacial time, when the river was carrying a larger and coarser load of sediment (Henry Formation). The dunes, consisting mainly of medium- to fine-grained sand, are now stabilized by vegetation. Sand thicknesses of 25 to 50 feet are logged in a few borings on some of the larger dunes; these figures probably represent the thickest sand. Figure 16 shows two sand dunes in northern Christian County adjacent to the Sangamon Valley.

## Glacial Deposits of the Uplands—Wedron Formation, Henry Formation, Pearl Formation, and Glasford Formation

Beneath the loess, the glacial deposits that form both the end moraines and the flat to undulating plains between the moraines constitute the bulk of the unconsolidated overburden above bedrock. These deposits are mainly glacial till, an unsorted mixture of rock fragments of diverse sizes—from clay to boulders—deposited directly by the ice. At most places the till is firm and tight because it is a compacted mixture of clay, silt, and sand in which larger rocks are embedded. Within the till there commonly are lenses of silt, sand, and gravel deposited by meltwater from the ice.

The glacial till underlying the Richland Loess from the Shelbyville Moraines eastward is part of the Wedron Formation. This till is typically gray to blue-gray below the weathered zone, which is generally yellowish brown in well-drained positions. It is generally uniform in appearance and composition, but contains isolated lenses of silt, sand, or gravel. The texture of the till is commonly 40 to 50 percent silt, 25 to 45 percent sand, and 15 to 25 percent clay. The gravel content is usually less than 10 percent. There are a few boulders, most of which are randomly distributed.

Generally the till of the Wedron Formation is underlain by discontinuous bodies of sand and gravel that were deposited in front of the advancing glacier and are included as part of the Wedron Formation. However, within the mapped area of the Wedron Formation there are relatively few deposits of sand and gravel associated with the till compared with the number of such deposits on the outwash plain just west of the Shelbyville Moraines or in the hilly areas of the Buffalo Hart Moraine in eastern Sangamon County.

The thickness of the Wedron Formation in Macon County ranges from about 30 feet behind the moraines to about 100 feet in the Shelbyville Moraines, with an average of about 45 feet. Illinoian and older glacial deposits have been identified below the Wedron Formation in some exposures and in well logs and samples.

Bordering the Shelbyville Moraines on the west side is a tract of loess-covered outwash sand of the Henry Formation. In many places till or till-like material of the Wedron Formation actually extends for 1 to 2 miles west of the hilly area of the Shelbyville Moraines and eventually wedges out in the sandy outwash of the Henry Formation (Hester and DuMontelle, 1971). The sand, which contains little gravel, forms a pitted plain a mile or two wide at the front of the moraine, west of Warrensburg, Harristown, and Macon (plate 1).

In the Springfield Plain, west of the Shelbyville Moraines, Illinoian deposits, mainly till, underlie the loess. The Springfield Plain comprises a partly dissected till plain and a discontinuous, irregular end moraine called the Buffalo Hart Moraine (fig. 7).

A notable feature of the Illinoian deposits is that they commonly bear parts or all of a soil or weathering profile at the top, even where they are overlain by considerable thicknesses of younger glacial deposits or loess. The soil or weathering profile was formed during a long, mild interglacial period between the time the Illinoian glacier melted and Wisconsinan glaciation began. The interglacial interval is called the Sangamonian Stage and is represented by the Sangamon Soil (zs) on top of the Illinoian deposits. The main geological significance of the weathering and soil products to environmental considerations is that the characteristic earth materials—clay and organic materials—affect foundation strength, slope stability, and drainage, which will be discussed later.

The Sangamon Soil (weathered zone), at the top of the Illinoian deposits, has a range of characteristics that is very much like the range of characteristics of the Modern Soil, but the characteristics of the Sangamon Soil are more strongly developed. One important difference between the present-day soil and the old, usually buried soil is that the Modern Soil is developed primarily in loess and the Sangamon Soil is developed in pebbly, sandy, or silty glacial drift.

The Sangamon Soil is separated into two general types: the poorly drained, unoxidized, gleyed type (mapped as zs-g on plate 1) and the better-drained type (mapped as zs-ox). The poorly drained type contains a subsoil horizon that is gray, contains high amounts of silt and clay, and has a high water content. The better-drained type is generally grayish brown, but is yellowish or reddish brown in well-drained positions. The better-drained type contains a greater amount of coarse material and is generally less clayey than the poorly drained type.

Immediately overlying the Sangamon Soil is the Roxana Silt, which has been weathered. The drainage characteristics of the soil in the Roxana are similar to those of the Sangamon Soil. Gleyed, unoxidized Roxana (r-g) overlies zs-g, and the better-drained, oxidized Roxana (r-ox) overlies the zs-ox.

The Illinoian tills of the Springfield Plain are grouped into the Glasford Formation and are differentiated into various members (plate 1). The till west of the Buffalo Hart Moraine is called the Vandalia Till Member (gv). It is gray where unweathered. It is a medium-grained, relatively silty till, on the average containing 35 percent sand, 45 percent silt, and 20 percent clay. The Vandalia Till has many characteristics similar to those of the till in the Wedron Formation, such as color and grain-size distribution. A significant difference is that the Vandalia Till is more compact and dense; thus its permeability is lower and water becomes perched above it for longer periods of time. Thin sandy zones and pebble bands are common in the Vandalia.

The Buffalo Hart Moraine, which consists of a tract of ridges and knobs that stand as much as 75 feet above the general level, marks the outer (western) edge of the Radnor Till Member (gr, plate 1). The Radnor Till is gray where unweathered and is a relatively silty till. In the area of the Buffalo Hart Moraine the clay content may be higher than in the Vandalia or the Wedron Tills. The sand content in the Radnor Till is relatively low in the Buffalo Hart Moraine and increases to the east. The significant difference between the Radnor Till and the other tills of the area is that it is less compact and has more non-till material associated with it. For example, in the Buffalo Hart Moraine area, gravel, sand, or silt may overlie the till or be contained within it. In other areas of the Radnor Till, stratified silt and clay commonly overlie, or are contained within, the till.

The topography east of the Buffalo Hart Moraine is somewhat like that of the Bloomington Ridged Plain. Some of the prominences in the Buffalo Hart Moraine are composed of complex sorted gravel, sand, and silt deposits (Pearl Formation, pe, plate 1) that were formed by meltwater in contact with a glacier. Somewhat similar deposits (Hagarstown Member, gha) underlie the loess in Macon County southwest of Macon.

North and east of Springfield the uppermost Illinoian deposit is not till but layered silt and clay (Teneriffe Silt, t), deposited apparently by meltwater flowing into the still water of a lake that was formed by the advance of the Illinoian glacier that created the Buffalo Hart Moraine. This material ranges from 5 to 25 feet in thickness.

The Illinoian deposits in Macon County are overlain mainly by till of Wisconsinan age. Where Wisconsinan and Illinoian tills can be compared in one exposure, the Illinoian till is much more compact and jointed. More detailed information on the glacial deposits in the subsurface is given in the section on groundwater conditions.

## WATER RESOURCES

Analysis of the water resources and hydrology of the Springfield-Decatur Region is beyond the scope of this report, except for geological aspects such as the occurrence of water-yielding deposits (aquifers) and the effects of water on earth materials and structure. Study of water resources is mainly the responsibility of the Illinois State Water Survey, with related responsibilities discharged by the Illinois State Geological Survey, the U.S. Geological Survey, the Division of Water Resources of the Illinois Department of Transportation, the State Environmental Protection Agency, and other agencies.

Some of the findings of these agencies are summarized here inasmuch as water constitutes a major element of the physical environment to be considered in regional planning.

TABLE 2 - EXISTING AND POTENTIAL WATER DEMANDS AND SUPPLIES FOR MACON AND SANGAMON COUNTIES
(in millions of gallons per day, mgd)

| County | Municipal, industrial, and urban demand | | | Existing water-supply reservoirs (net yield) | Potential water supplies | | |
|---|---|---|---|---|---|---|---|
| | 1967 | 1980 | 2020 | | Ground water | Stream flow | Reser-voirs |
| Macon | 27.400 | 32.607 | 48.663 | 6.20 | 44.5 | 6 | 9.1 |
| Sangamon | 19.786 | 22.904 | 34.753 | 11.83 | 27.5 | 25 | 10.9 |

Explanation of terms:

The net yield of existing water-supply reservoirs and potential reservoirs is that water available in a drought of a frequency of once in 40 years, using half the storage of the reservoir. The potential ground-water yield is the calculated potential reduced by one half. The stream flow is that water available 95 percent of the time.

Source: Illinois Department of Business and Economic Development (1970).

## Use and Sources of Water

A summary of water demand and potential supply for Macon and Sangamon Counties, compiled by the Illinois Department of Business and Economic Development (1970, p. 14, 15), is given on table 2.

As shown on table 2, for future water demands Macon County has a relatively large ground-water potential, little potential from stream flow, and a reservoir potential 150 percent greater than the capacity that is now developed. Sangamon County has only a moderate ground-water potential, a significant potential from stream flow, and an additional reservoir potential approximately equal to the capacity now developed.

## Stream Flow

The main drainage features of the region, as well as other features that relate to water resources, are shown on plate 2. The principal tributaries of the Sangamon River in Macon County—Friends Creek, Stevens Creek, Long Point Creek, Big Creek, Finley Creek, Sand Creek, and Spring Creek—are short streams with relatively small drainage areas. Mosquito Creek and Buckhart Creek are the main tributaries of the Sangamon in the northern part of Christian County. In Sangamon County several of the south-side tributaries of the Sangamon are substantial streams of considerable significance to the water resources of the Springfield area. They include the South Fork Sangamon River with Horse Creek and Brush Creek branches, and Sugar Creek, site of Lake Springfield. Other tributaries in Sangamon County include Clear Creek, Wolf Creek, Fancy Creek, and Cantrall Creek on the north side, and Prairie Creek, Richland Creek, and Spring Creek on the south side.

Measurements of stream flow in Illinois are made cooperatively by the U.S. Geological Survey, the Illinois Division of Water Resources, and the State Water Survey. Some of the characteristics of stream flow at the various gaging stations in the region (locations shown on plate 2) are given in table 3. Perhaps the most notable aspect of these figures is the wide range between maximum and minimum discharges of the streams. For example, at the gaging station with the longest record—the Sangamon River at Riverton—the maximum instantaneous discharge, which occurred during the severe flood of May 1943, was 68,700 cubic feet per second (cfs), a rate of more than 44 billion gallons per day (1 cfs equals 646,000 gallons per day), whereas the minimum discharge was 3 cfs, or less than 2 million gallons

TABLE 3 - STREAM FLOW AT GAGING STATIONS
(Locations of stations shown on plate 2.
Flow reported in cubic feet per second, cfs.)*

| Location of gaging station | Sangamon River near Oakley, Macon Co. | South Fork Sangamon River, near Rochester, Sangamon Co. | Sangamon River at Riverton, Sangamon Co. | Spring Creek near Springfield, Sangamon Co. |
|---|---|---|---|---|
| Drainage | 750 $mi^2$ | 872 $mi^2$ | 2,560 $mi^2$ | 107 $mi^2$ |
| Duration of record | 1951-65 | 1949-65 | 1908-12;<br>1915-27;<br>1929-31;<br>1933-56;<br>1957-65 | 1948-65 |
| Average discharge, years of record | 331 cfs<br>5 yr<br>(1951-58) | 442 cfs<br>16 yr | 1,695 cfs<br>46 yr<br>(1908-12; 1914-56) | 54.6 cfs<br>16 yr |
| Maximum discharge, date | 15,300 cfs<br>May 9, 1961 | 18,100 cfs<br>July 1, 1957 | 68,700 cfs<br>May 19, 1943 | 6,750 cfs<br>March 30, 1960 |
| Maximum flood crest elevation, year | 624.85 ft<br>1943 | 539.66 ft<br>1957 | 539.4 ft<br>1943 | 537.35 ft<br>1960 |
| Minimum discharge, date | 0.2 cfs<br>Oct. 8-9, 1954 | 0.4 cfs<br>July 19-20, 1954<br>Sept. 8-9, 1954 | 3.0 cfs<br>Oct. 3-15, 1914 | No flow for many days in most years |
| Flow equaled or exceeded 95 percent of days† | | 0.0034 $cfs/mi^2$ = 2.96 cfs total flow | | 0.0000 $cfs/mi^2$ |

* Sources of all data except that from the Illinois Technical Advisory Committee on Water Resources (1967) are U.S. Geological Survey Water Supply Papers 1727 (1964) or 1915 (1971).

† Illinois Technical Advisory Committee on Water Resources (1967, p. 55).

per day (mgd), in October 1914. An even greater range is recorded at the gaging station on the South Fork Sangamon River near Rochester, where the maximum measured discharge was 18,100 cfs and the minimum was 0.4 cfs. The average discharge during 16 years of recording at this station was 442 cfs (267 mgd). However, this figure for average discharge is misleading inasmuch as the flow 50 percent of the days did not exceed 118 cfs (76.4 mgd) (Illinois Technical Advisory Committee on Water Resources, 1967, p. 55). The flow equaled or exceeded 95 percent of the days is only 2.96 cfs (1.9 mgd); in other words, during some 18 days of the year it is possible that the flow is less than 2.96 cfs. In contrast, the flow of the Mississippi River at East St. Louis equaled or exceeded 95 percent of the days is more than 17 billion gallons per day (Illinois Technical Advisory Committee on Water Resources, 1967, p. 105).

Such considerations show why it is necessary to provide for impoundments of water for municipal water supplies along the streams in the Springfield-Decatur Region rather than utilize stream flow itself. During many days of the year some streams have either no flow or flows too low to meet daily municipal demands. Usually the periods of lowest flow of the streams are in the summer, when water demands are highest.

The periods of low flow in the late summer are also generally times when the quality of water in the streams is the poorest, inasmuch as sewage effluent and industrial wastes constitute a larger ratio of the flow at those times. The deterioration in quality of water takes the form of an increase in coliform bacteria, chlorides, and organic constituents and depletion of oxygen by organisms.

## Floods

An additional aspect of stream flow in relation to the environment is the occurrence of floods. The maximum discharges listed in table 3 occurred when the streams were in flood. The elevation of the flood crests at the gaging stations, when compared with the elevations of the adjacent land shown on topographic maps, suggests the magnitude of inundation possible on the floodplain if flood control structures do not keep the water within a river channel. For example, during the flood of May 1943 on the lower Illinois River Basin, which caused damage of more than $31 million, the flood crest had an elevation of 539.4 feet at the gaging station at Riverton. The floodplain in the vicinity ranges in elevation from about 520 feet, just above normal river level, to 530 feet at the base of the steep river bluff. Thus, in some places the floodplain may have been covered with 20 feet of water.

Floods of various magnitude occur at various frequencies, with very large floods likely to occur less frequently than smaller floods. The large floods have the most dramatic impact. However, most flooding in Illinois takes place along smaller streams and drainageways and produces only local damage. The cumulative losses from these local but more frequent floods cause an average annual damage of $30 million in Illinois, which is approximately the same amount as the damage caused by the great 1943 flood on the lower Illinois River Basin (Illinois Technical Advisory Committee on Water Resources, 1967, p. 240, 262).

The identification of lands subject to flooding by streams is an important step in planning land uses that are compatible with the physical environment. The U.S. Geological Survey has outlined flood-prone areas on some topographic maps as part of a nationwide federal program for managing flood losses. Maps containing these outlines are available for parts of the Springfield-Decatur Region (see fig. 3). Information about these maps is available from the District Chief, Water Resources Division, U.S. Geological Survey, P.O. Box 1026, Champaign, Illinois 61820. Information on flood hazards to lands is also available from the Illinois State Water Survey, Urbana, Illinois 61801.

Reports on flood conditions in certain parts of Sangamon County and Macon County have been prepared by private consulting engineering companies.

Urban encroachment on floodplains has greatly increased flood damage and has aggravated flooding conditions both upstream and downstream; however, some damage and considerable nuisance also result from minor flooding that takes place in depressions and blocked natural drainageways on the uplands, particularly in urban areas, where paving hastens the concentration of runoff. The filling of land for subdivisions is sometimes done without regard for the various subtle drainageways that exist or without providing adequate channels or storm drains for the discharge of runoff. The design of urban drainage systems is a matter of greatly increasing importance and complexity today.

### Reservoirs

The locations of existing, proposed, and potential surface-water reservoirs are shown on plate 2. Data on these reservoirs, including watershed area, pool area, depth of water at dam, storage capacity, and yield, are given by Dawes and Terstriep (1966).

Lake Springfield, completed in 1935, has a storage capacity of more than 19 billion gallons and is the largest reservoir in the region. About 18 mgd is pumped from Lake Springfield at present. The net yield of the reservoir during a once-in-40-year drought, using half the storage of the reservoir, is estimated to be 11.83 mgd (Illinois Technical Advisory Committee on Water Resources, 1967, p. 104-5).

After considerable loss in original storage capacity as a result of siltation, Lake Decatur has a storage capacity of slightly more than 4.5 billion gallons and is being pumped by the city of Decatur and by self-supplying industries at a rate of more than 26 mgd. The net yield under the conditions described above is 6.2 mgd (Illinois Technical Advisory Committee on Water Resources, 1967, p. 104-5). The other reservoirs in use in the region are small.

Another large reservoir in the planning stage will be located east of Lake Springfield on Horse Creek and Brush Creek. The reservoir will be constructed for water supply for the city of Springfield, and will have a capacity of 14,800 million gallons, a surface area of 2,980 acres, an average depth of 15.3 feet, and a net yield (once-in-40-year drought) of 19 mgd.

Potential surface-water reservoirs for this region also are shown on plate 2. These sites were selected by the State Water Survey (Dawes and Terstriep, 1966).

Of these potential reservoir sites, 10 are in Macon County, 17 in Sangamon County, and 1 in the included part of Christian County. They range in size from 64 to 1,856 acres, and in storage capacity from 200 million gallons to 7.6 billion gallons. The total net yield from all of these reservoirs, with variations resulting from the capacity to which the reservoirs are drawn down and from the severity of drought conditions during a particular year, should be several tens of million gallons per day.

### Quality of Surface Water

The quality of water in the streams and reservoirs of the Springfield-Decatur Region results from many physical, chemical, and biological properties that reflect both natural and man-made factors. These properties are monitored by Illinois agencies at sampling points shown on plate 2. The Illinois State Water Survey, in cooperation with the Champaign District Office of the U.S. Geological Survey, has maintained a program of sampling and analysis of surface-water sources since 1945 (Larson and Larson, 1957; Harmeson and Larson, 1969; Harmeson et al., 1973). Since 1958 the Illinois Environmental Protection Agency (and formerly the Illinois Sanitary Water Board), in cooperation with the Illinois Department of Public Health, has carried on a program of sampling and analysis of the water quality of Illinois streams. The summary of water quality in this section is based upon data collected by these agencies.

Temperatures of surface waters range from freezing to nearly 90° F during the year, but more moderate temperatures prevail most of the days.

Turbidity is an expression of the amount of suspended material such as clay, silt, and/or finely divided organic matter in the water. It is influenced by characteristics of stream flow, types and topography of soil, vegetative cover, land-use and farming practices, and discharges of effluent. At most sampling stations, turbidity shows a marked increase during periods of high stream flow, such as those that commonly occur during late spring rains. Although turbidity of the Sangamon River is generally lower than that of the larger rivers of Illinois, such as the Mississippi and the Wabash, the turbidity is sufficiently high to require filtration of the water before it is used for domestic supply (Harmeson and Larson, 1969, p. 8).

The dissolved minerals in the waters consist mainly of the carbonates, chlorides, nitrates, and sulfates of calcium, magnesium, sodium, and ammonium. They are present as a result of solution of minerals during the movement of water through the ground, of runoff and drainage from fertilized fields and feedlots, and of discharges from sewers and sewage treatment plants.

The Illinois Environmental Protection Agency has adopted a limit of 500 milligrams per liter (mg/l, which is approximately equal to parts per million, ppm) monthly average value for total dissolved minerals in the raw water sources of a public water supply. The surface waters in the region generally meet this standard, although at some stations downstream from municipalities during some times of low flow in the winter or late summer, total mineralization in excess of 500 mg/l is reported. Total mineralization is in the range of 350 to 550 mg/l for the various sampling stations.

Much of the mineralization consists of dissolved calcium and magnesium carbonates and some sulfates, which make the waters hard. The waters of the streams contain 300 to 400 mg/l hardness. The waters of Lake Springfield and Lake Decatur contain slightly less dissolved calcium carbonate and slightly fewer related hardness minerals (less than 300 mg/l) and are classified as moderately hard.

Nitrates and phosphates, whose main sources are wastes, detergents, and fertilizers, are present in the waters in concentrations that may promote undesirable algal growths in artificial lakes and reservoirs developed in the region (Harmeson and Larson, 1969, p. 10). Chlorides are present in quantities well below the limit recommended by the U.S. Public Health Service for drinking water. At some stations downstream from municipal sewage treatment outfalls, however, the chloride content of the water is several times the level in natural waters.

In addition to some of the mineral constituents of water mentioned above, there are certain biologic constituents and characteristics that are related largely to man's activities and serve as indicators of the level of water pollution. With respect to these characteristics, the Illinois Technical Advisory Committee on Water Resources (1967, p. 147, 153) reports that a particular reach of the Sangamon may appear to be severely degraded at one time and to indicate recovery at a later date; or pollution may be indicated in one reach while downstream reaches show no evidence of it. The Sangamon River exhibits the best quality during the late spring period of precipitation and the poorest quality during times of low rainfall in late summer and midwinter.

## Ground Water

The conditions governing the occurrence of ground water in the region permit only minimal supplies from the shallow bedrock and range from poor to favorable for large water supplies in the unconsolidated deposits overlying bedrock. The availability of ground water from sand and gravel in the unconsolidated deposits is related partly to the thickness of the drift, which is shown by thickness contours on plate 3. Chances of encountering water-yielding deposits of sand and gravel are greater where the unconsolidated deposits are thick rather than thin. The glacial drift is more than 100 feet thick in most of Macon County, and in the Mahomet Bedrock Valley north of Argenta and Maroa it is as much as 300 feet thick. In Sangamon County, however, these deposits are less than 50 feet thick in most places, with bedrock cropping out in the bluffs and in the channels of many of the streams. Accordingly, the conditions for obtaining adequate supplies of ground water are considerably more favorable in Macon County than in Sangamon County. A classification of areas on the basis of geologic conditions relating to ground-water potential is given in figure 17, and cross sections showing the occurrence of water-yielding sand and gravel deposits are given in figure 18. Some sand and gravel aquifers are shown on plate 2. Data on wells and borings shown on plate 2 and on water-yielding zones penetrated are tabulated in appendix 1.

The thickest, most extensive, and most permeable sand and gravel deposits occur in the Mahomet Bedrock Valley, whose axis lies a few miles north of Argenta and Maroa. Deposits overlying this valley attain a thickness of more than 300 feet in Macon County. Sand and gravel deposits are commonly encountered at depths below 100 feet, and are abundant below a depth of about 200 feet, as shown in figure 18. The municipal well at Maroa is about 280 feet deep, and the one at Argenta is about 230 feet deep. In 1954 the City of Decatur drilled test holes and constructed two wells in the Mahomet Valley to augment Lake Decatur during a period of low flow of the Sangamon River. This drilling, in the northeastern township of Macon County, revealed glacial deposits from 250 to slightly more than 300 feet thick, and nearly continuous sand and gravel below a depth of about 175 feet. The two wells for Decatur were constructed in Piatt County about 10 miles upstream from Lake Decatur, where the Mahomet Valley is near the Sangamon River. They were 244 and 252 feet deep and were tested at 1,400 and 2,500 gallons per minute (gpm), respectively.

The next most favorable area for ground water is the valley of the Sangamon River (fig. 17). The valley contains extensive deposits of sand and gravel (Henry Formation) below a surficial cover of 10 to 20 feet of silt and clay (Cahokia Alluvium). However, suitable water-yielding sand and gravel are not present at all locations; thus test drilling is necessary in water-supply investigations. The sand and gravel deposits are from 15 to 40 feet thick and in some places in the valley are more than a mile wide.

These deposits, sometimes supplemented by pumpage directly from the river, provided the municipal water supply for Springfield for about 50 years until Lake Springfield became the source of supply in 1936. The wells and infiltration galleries were in the Sangamon River flat just north of the city. In 1923 the capacity of the city ground-water facilities was more than 8 million gallons per day.

Other municipal water supplies have been developed in the Sangamon River deposits near Springfield by Williamsville, Riverton, Dawson, and Mechanicsburg-Buffalo. Drilling for these communities showed that the river deposits extend to a depth of 50 to 65 feet; the wells are completed at depths from 30 to 65 feet. The water-yielding deposits are sand with some gravel.

The most extensive study of the Sangamon River floodplain was made for the construction of the Sangamon and Oak ordnance plants near Illiopolis during World War II. A water supply of 300 to 400 thousand gallons per day (gpd) was required for construction and 1.6 to 1.8 mgd for operation; test drilling conducted after an electrical.earth resistivity survey by the State Geological Survey showed that the best

(Text continued on page 36)

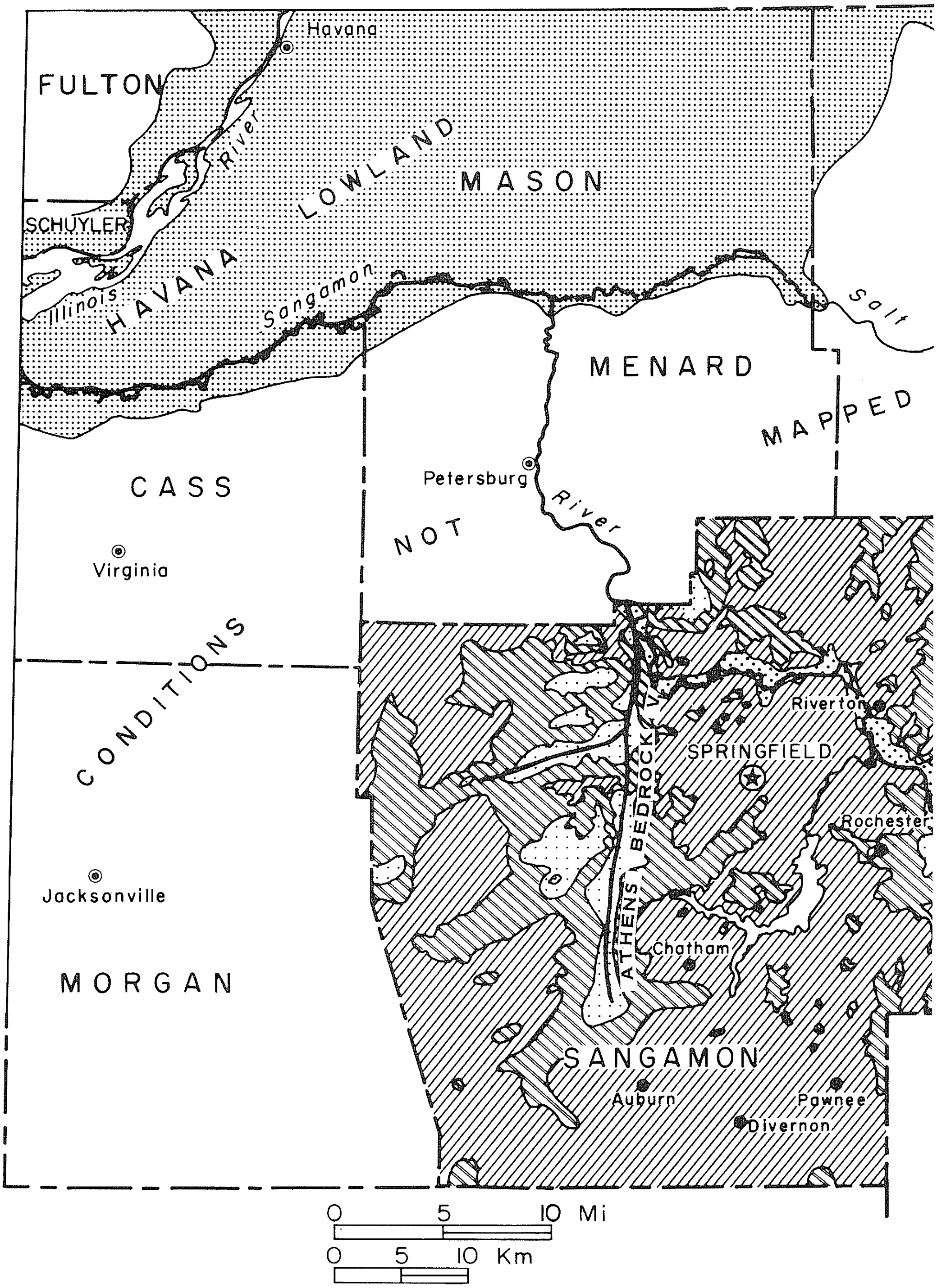
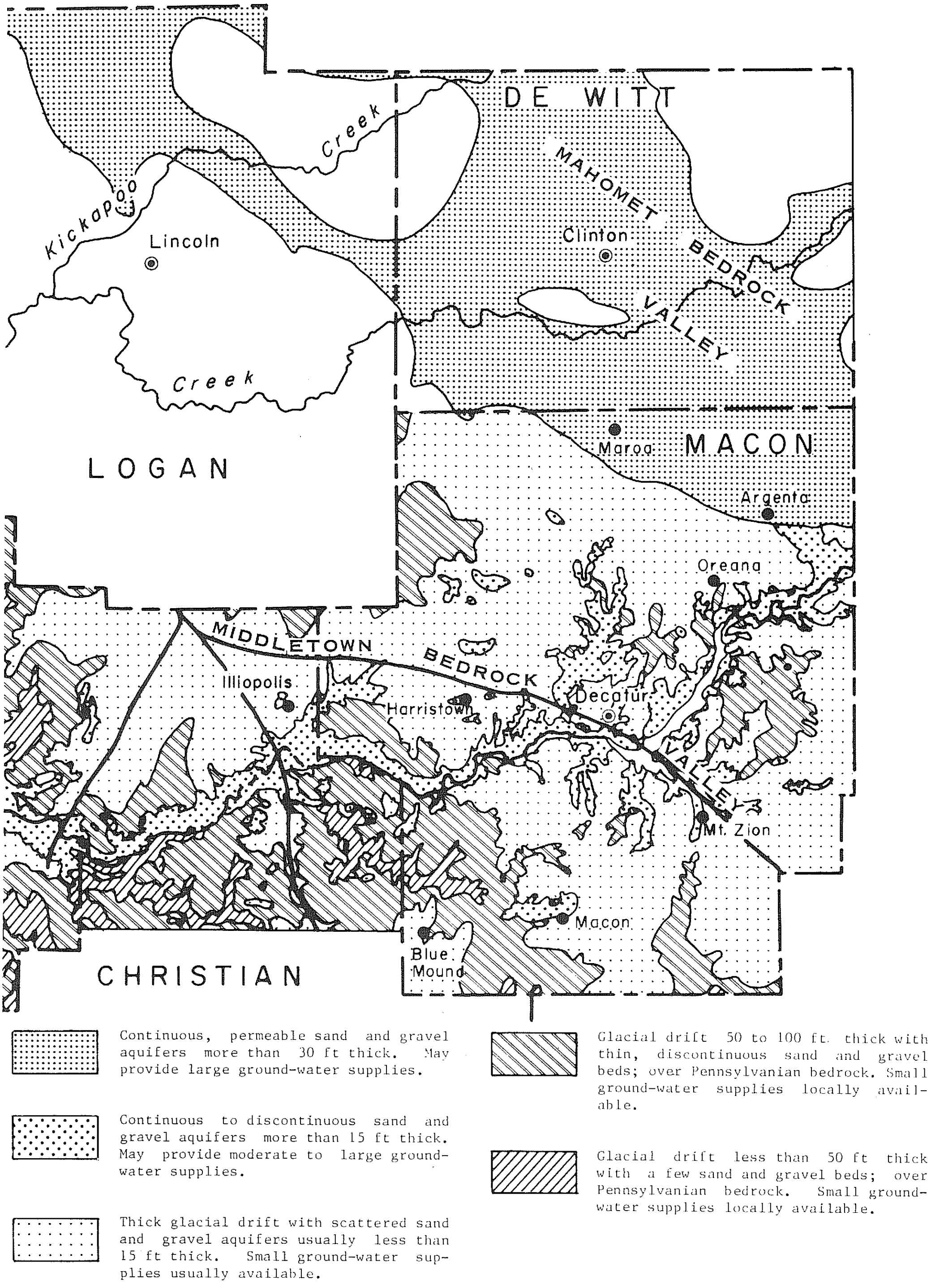


Fig. 17 - Ground-water conditions in and



adjacent to the Springfield-Decatur Region.

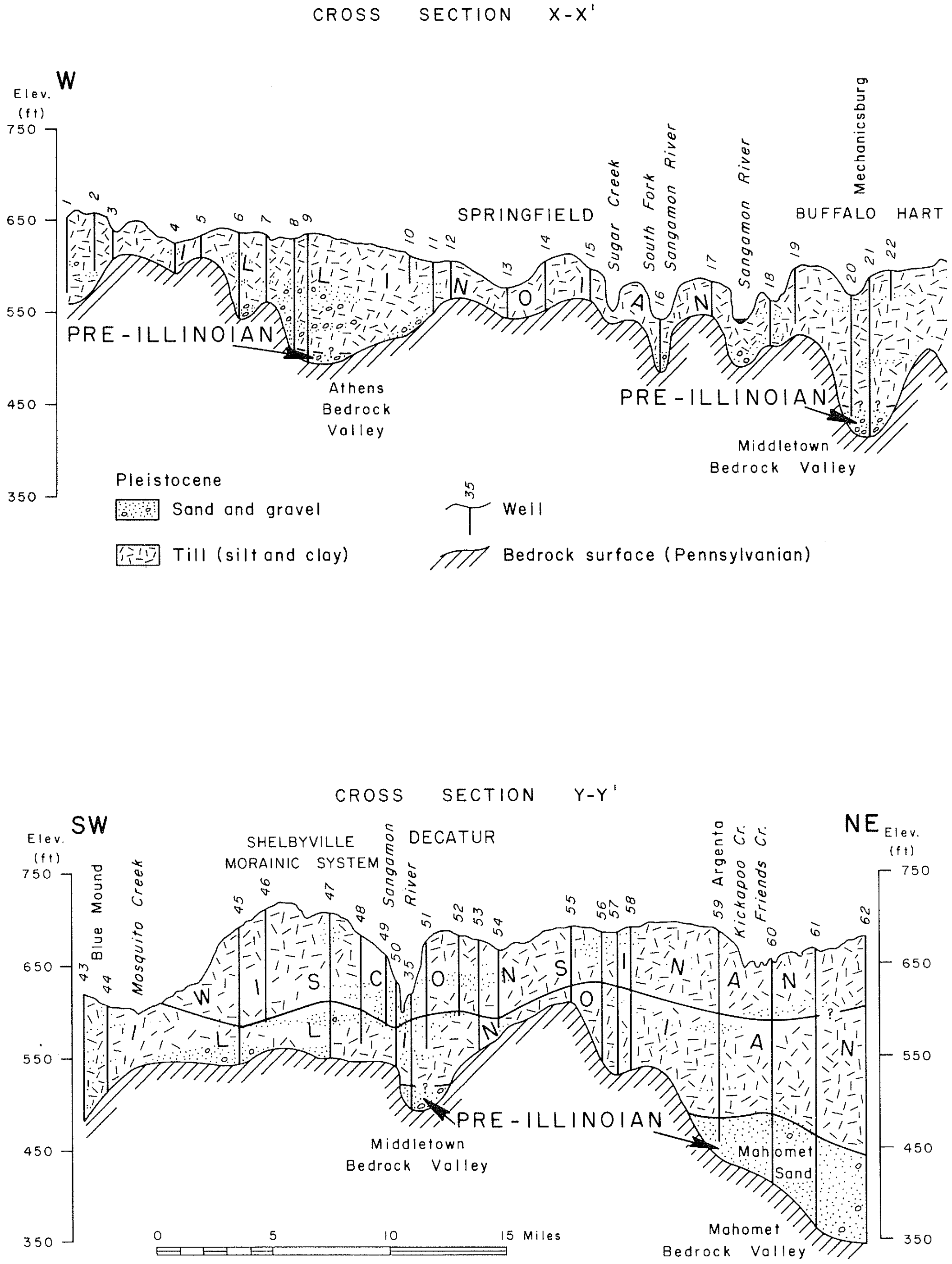
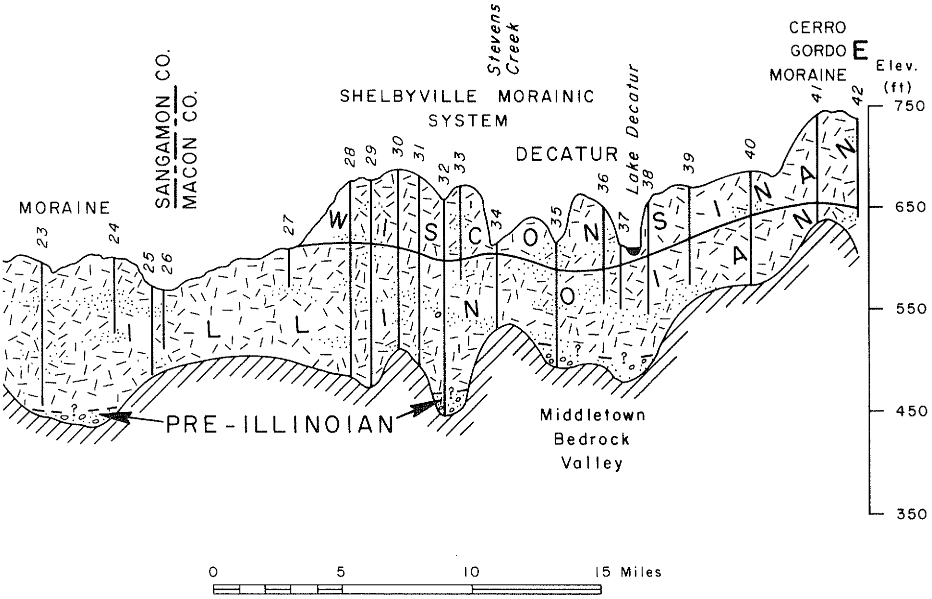
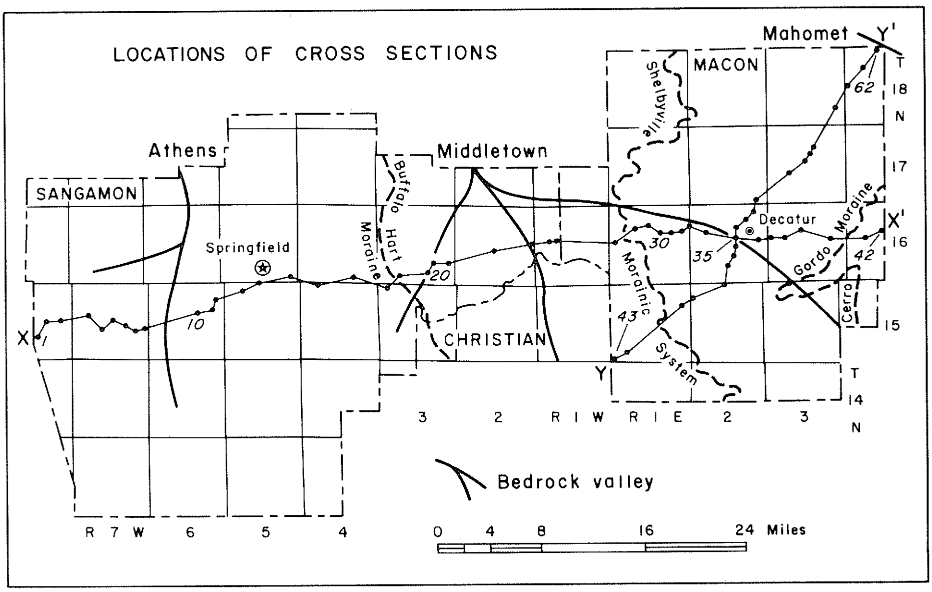


Fig. 18 - Cross sections showing nature of the unconsolidated deposits and



CROSS SECTION X-X'



LOCATIONS OF CROSS SECTIONS

the surficial and bedrock topography of the Springfield-Decatur Region.

available water-bearing sand and gravel deposits occur at a depth of 40 to 43 feet and are 15 to 40 feet thick. The formations have an average width of 2,000 feet and range from 1,000 to 4,000 feet in the valley in eastern Sangamon County and western Macon County.

Water-bearing sand and gravel deposits also undoubtedly underlie the Sangamon River floodplain in the remainder of Macon County and downstream from Springfield in northwest Sangamon County; however, there has been no extensive test drilling or ground-water development in these parts of the floodplain.

After the Mahomet Bedrock Valley and the Sangamon River floodplain, the next most favorable area for ground water is an area of moderately thick glacial drift in Macon County. In this area, the towns of Warrensburg, Forsyth, Oreana, and Macon obtain municipal ground-water supplies from wells about 125 feet deep that penetrate sand and gravel deposits. A number of wells penetrating significant deposits of sand and gravel have also been drilled adjacent to the Sangamon River in the eastern part of Decatur.

Two buried bedrock valleys somewhat like the Mahomet Bedrock Valley, but filled largely with relatively impermeable glacial deposits rather than water-bearing sand and gravel, are present in the region. They are the Middletown Bedrock Valley and the Athens Bedrock Valley (Horberg, 1950). Locally, thick beds of sand and gravel may be present in the Middletown Bedrock Valley, but favorable beds are probably not present in the Athens Bedrock Valley. In ground-water potential, these valleys do not compare with the other, favorable areas shown in figure 17, namely, the Mahomet Valley and its lower termination, the Havana Lowland; the Illinois River Valley; and the Sangamon River Valley.

In addition to the sand and gravel deposits which occur in sections of thick to moderately thick glacial drift and in the river flat of the Sangamon, thin beds of sand and gravel occur locally in areas of thin glacial drift or beneath small valley flats (note logged thicknesses of sand and gravel in appendix 1). Pleasant Plains and Williamsville, for example, obtain municipal ground-water supplies from shallow wells that penetrate local sand and gravel beds. Domestic water supplies also are obtained, in areas of thin glacial drift, from shallow deposits.

Because sand and gravel deposits suitable for wells are less extensive in Sangamon County than in Macon County, about one-sixth of the wells in Sangamon County are completed in the Pennsylvanian bedrock. Only a very small percentage of the wells in Macon County go into the bedrock for water.

The Pennsylvanian bedrock wells range in depth from about 30 to about 300 feet and obtain water from beds of sandstone a few feet thick or from fractured shale or limestone. Yields of no more than a few gallons per minute are the rule. Below a depth of about 200 feet, ground water in the bedrock is too highly mineralized for most purposes.

## Quality of Ground Water

Ground water obtained from sand and gravel deposits in the region is constant in temperature year-round, being close to 55° F. It is relatively constant in mineral quality at a given place and depth, and usually is free of pollution. However, not all ground water can automatically be assumed safe to drink; wells and underground aquifers themselves are sometimes polluted and thus the water from them should be analyzed periodically for determination of its hygienic quality.

| Time-stratigraphic units | | Rock-stratigraphic units | | | Average thickness of formation (ft) | Description |
|---|---|---|---|---|---|---|
| System | Series | Group | Formation | Selected members | | |
| Pennsylvanian | Missourian | McLeansboro | Mattoon | | 100+ | Shales, siltstones, sandstones, and thin limestones, claystones, and coals. |
| | | | Bond | Millersville Limestone | 200 | |
| | | | | Shoal Creek Limestone | | |
| | Desmoinesian | | Modesto | Chapel (No. 8) Coal | 250 | |
| | | | | Trivoli Sandstone | | |
| | | | | Lonsdale Limestone | | |
| | | Kewanee | Carbondale | Danville (No. 7) Coal | 225 | |
| | | | | Brereton Limestone | | |
| | | | | Herrin (No. 6) Coal | | |
| | | | | St. David Limestone | | |
| | | | | Springfield (No. 5) Coal | | |
| | | | | Summum (No. 4) Coal | | |
| | | | | Colchester (No. 2) Coal | | |
| | | | Spoon | Litchfield Coal | 150 | |
| | Atokan | McCormick | Abbott | | 150 | |

Fig. 19 - Rocks of the Pennsylvanian System. The Pennsylvanian rocks directly underlie the unconsolidated deposits in the Springfield-Decatur Region.

In mineral quality, ground water from sand and gravel aquifers in the region is similar to the surface water, though somewhat harder and somewhat higher in total dissolved minerals. The total dissolved minerals from public water supplies in the region range from about 350 to about 700 ppm, and hardness ranges from about 325 to about 500 ppm (Hanson, 1950, 1958, 1961).

Ground water from the shallow Pennsylvanian bedrock below the glacial deposits is usually more highly mineralized than the water from the glacial deposits. It contains more sulfate and chloride, but is not quite as hard (Illinois Technical Advisory Committee on Water Resources, 1967, p. 87).

As shown in figure 13, the ground water in the lower part of the Pennsylvanian and in the Mississippian, Devonian, Silurian, Ordovician, and Cambrian rocks is highly mineralized. In 1972 a test well for a mobile-home subdivision south of Decatur (Sec. 34, T. 16 N., R. 2 E.) was drilled to the St. Peter Sandstone at a depth of 3,440 feet. Water in the St. Peter was found to contain 6,682 ppm total dissolved minerals, with 3,450 ppm chlorides.

## MINERAL RESOURCES

### Coal

The most important coals of commercial value in the Springfield-Decatur Region are the Herrin (No. 6) and the Springfield (No. 5) Coal Members of the Carbondale Formation (fig. 19). Plate 4 shows mined-out areas, thicknesses, and

TABLE 4 - ESTIMATED REMAINING COAL RESOURCES IN THE GROUND, JANUARY 1975
(thousands of tons)

| County | Herrin Coal | Springfield Coal | Colchester Coal | Litchfield Coal | Total |
|---|---|---|---|---|---|
| Christian* | 177,396 | 336,172 | | | 513,568 |
| Macon | 162,928 | 1,689,960 | | | 1,852,888 |
| Sangamon | 2,139,717 | 3,324,204† | 280,804‡ | 4,086 | 5,748,811 |
| Total | 2,480,041 | 5,350,336 | 280,804 | 4,086 | 8,115,267 |

* Includes resources for only that part of Christian County included in the area of this report.
† Includes 418,365,619 tons of strippable resources.
‡ Consists mostly of weakly indicated resources.

Source: Smith (1975).

depths for both of these coals. Although few reliable data exist for other coals in the region, the Chapel (No. 8), Colchester (No. 2), and Litchfield Coal Members may have some potential economic importance. The Danville (No. 7) and Summum (No. 4) Coal Members are not known to attain a minable thickness in the region.

Considerable acreages have been mined out by underground operations in Sangamon County, but only minor production, in the vicinity of Decatur, has occurred in Macon County. The total amount of coal produced to date from the region is 268,718,534 tons, of which approximately 11 million tons has been produced in Macon County. The remaining coal resources in the region, indicated in table 4, represent the total amount of coal still in the ground. No exclusions are made for mining conditions, populated areas, highways, lakes, or man-made structures, although areas of concentrated drilling for petroleum have been excluded. The figures for total coal in the ground do not indicate the amount of coal that may be recovered. This is dependent on many factors, such as thickness, minability, mining methods, availability for mining, and a variety of economic factors. In an underground mine, normally about 50 percent of the coal is recovered.

## Chapel (No. 8) Coal Member

The Chapel (No. 8) Coal Member is rather widespread throughout Illinois, but generally is too thin for mining. However, before the discovery of the deeper and thicker Springfield (No. 5) Coal, the Chapel Coal was the only coal worked around Springfield. The mines were small drifts along the outcrop in the banks of ravines and steep hillsides. Numerous traces of many of these old workings are still visible along the south bank of the Sangamon River in Secs. 5 and 6, T. 16 N., R. 4 W., and others are in Tps. 15 and 16 N., R. 5 W. The Chapel Coal lies from about 175 feet to more than 200 feet above the Herrin (No. 6) Coal.

The Chapel Coal is absent from much of the western part of Sangamon County because it was removed by preglacial and glacial erosion. The Chapel Coal ranges in thickness from about 1 foot to as much as 30 inches in the areas where it has been mined.

## Herrin (No. 6) Coal Member

The Herrin (No. 6) Coal Member is the most important commercial coal of Illinois and is present in almost all of the region. The Herrin Coal is one of the two important commercial coals in the region and is the only one being mined at present (T. 13 N., R. 4 W., Sangamon County).

TABLE 5 - TYPICAL RANGES IN CHEMICAL ANALYSES OF THE SPRINGFIELD (NO. 5) COAL MEMBER, SANGAMON AND MACON COUNTIES, AND THE HERRIN (NO. 6) COAL MEMBER, SANGAMON COUNTY, ILLINOIS*
(as received basis)

| | Springfield Coal Member | Herrin Coal Member |
|---|---|---|
| Moisture | 12% to 16% | 13% to 15% |
| Volatile matter - those products in coal (other than moisture) released as a gas or vapor rather readily during heating. | 34% to 39% | 34% to 39% |
| Fixed carbon - that part of the carbon content of coal which is not readily liberated on heating, but which supplies the coal with longer lasting burning characteristics. | 36% to 43% | 37% to 41% |
| Ash - inorganic residue from coal combustion. | 8% to 13% | 8% to 12% |
| Sulfur - includes both inorganic and organic sulfur content. | 2.5% to 5% | 3.5% to 5% |
| Calorific value - in relation to fuels, a measurement of the heat produced by combustion in a calorimeter under specified conditions. | 10,300 to 11,100 Btu/lb | 10,200 to 10,900 Btu/lb |

* Prepared from Cady (1935, 1948).

Where the coal has been mined underground in Sangamon County (Tps. 13 and 14 N.), it lies at depths of 300 to 450 feet and is from 6 to 8 feet thick. Northward, the Herrin Coal gradually becomes thinner and generally is thin or absent in central and northern Sangamon and Macon Counties.

The Herrin Coal—and the Springfield Coal as well—is classified as high-volatile C bituminous coal in rank; at present most of the Herrin Coal being mined is used in the generation of electric power. Typical ranges in analytical coal-quality data are presented in table 5 for both of these coals.

## Springfield (No. 5) Coal Member

The Springfield (No. 5) Coal Member is one of the most important coals of Illinois and has been mined extensively around the city of Springfield, where it is about 200 to 250 feet deep and has an average thickness of 5 to 6 feet. The coal becomes gradually more shallow to the west and northwest, where in some areas it lies between 50 and 150 feet in depth and has been included as strippable resources (table 4). The Springfield Coal thins south of Springfield, where the Herrin Coal becomes thicker (plate 4).

A conspicuous feature associated with the Springfield Coal in Sangamon County is the presence of claystone dikes, called "horsebacks" by miners. These are irregular, nearly vertical, claystone-filled fissures that range from less than an inch to as much as several feet across and extend downward into and sometimes through the coal. Horsebacks contribute to the instability of mine roofs and add to the waste material that must be removed from the coal.

### Colchester (No. 2) and Litchfield Coal Members

The Colchester Coal Member is the lowest member of the Carbondale Formation and is remarkably persistent throughout the Illinois Basin. Colchester Coal crops out in counties to the west and northwest of the area discussed here and has been mined in those counties for many years. The Colchester Coal thins southward and generally is not of minable thickness along its southern and southeastern limits in the state.

In the vicinity of Divernon (T. 13 N., R. 5 E.), the Colchester Coal is about 100 feet below the Herrin (No. 6) Coal. This interval increases northward and eastward to as much as 200 feet in southern Macon County. The Colchester Coal varies in thickness from less than 1 foot to about 2.5 feet within the region. The mapped resources of this coal, indicated in table 4, lie mainly in the northern half of Sangamon County and were figured on an average coal thickness of 28 inches.

The Litchfield Coal Member is a lenticular seam that occurs in several places throughout the state. Only a few coal test holes in the region have penetrated deep enough to encounter this coal. The Litchfield Coal is of minable thickness in only one of these holes (Sec. 21, T. 13 N., R. 5 W., Sangamon County), where it lies approximately 150 feet below the Colchester Coal and is 54 inches thick.

## Oil and Gas

### Crude Oil

In the past 30 years 22 oil fields have been discovered in the report area (table 6, plate 4). The oil-producing strata are Devonian and Silurian rocks (table 6) and are mostly limestone or dolomitic limestone, usually less than 2,000 feet deep (figs. 12 and 13). Although most of the oil above 2,000 feet in the report area has probably been discovered, nearly every year brings at least one new field in the area. This discovery rate is expected to continue.

When crude oil is produced, brine (water containing a considerable proportion of dissolved salts) also is generally produced (Meents et al., 1952). If the volume of brine is appreciable, it is usually pumped back into a disposal well that returns the brine to the oil-producing strata or other strata well below those containing potential drinking water supplies. When brine disposal is carried out according to accepted practices, no damage is done to the land surface or to ground-water supplies.

### Natural Gas and Gas Storage

A small amount of gas has been produced along with crude oil in the report area. No commercial gas deposits have been found.

No underground gas storage projects are located in the report area.

TABLE 6 - OIL FIELDS IN THE SPRINGFIELD-DECATUR REGION

| Field | Location: county; township-range | Depth to Devonian-Silurian | Number of wells | Discovery date | Oil production (bbl)* | |
|---|---|---|---|---|---|---|
| | | | | | During 1974 | To end of 1974 |
| 1. Berry | Sangamon; 15N-3W | 1,740 | 40 | 1961 | 9,100 | 539,600 |
| 2. Blackland | Christian, Macon; 15N-1E,1W | 1,935 | 41 | 1953 | 200 | 490,400 |
| 3. Blackland N. | Macon; 16N-1E | 1,950 | 21 | 1960 | 2,000 | 242,300 |
| 4. Black Branch | Sangamon; 15N-4W | 1,600 | 24 | 1967 | 29,000 | 535,900 |
| 5. Black Branch E. | Sangamon; 15N-4W | 1,720 | 1 | 1969 | --- | 2,800 |
| 6. Clear Lake E. | Sangamon; 16N-4W | 1,600 | 2 | 1970 | 1,700 | 13,000 |
| 7. Dawson | Sangamon; 16N-3W | 1,640 | 1 | 1971 | --- | --- |
| 8. Decatur | Macon; 16N,17N-2E | 2,000 | 6 | 1953 | Abd. 1959 | 15,000 |
| 9. Decatur N. | Macon; 17N-3E | 2,200 | 1 | 1954 | Abd. 1955 | 100 |
| 10. Edinburg W. | Christian, Sangamon; 14N-3W,4W | 1,680 | 126 | 1954 | 42,300 | 2,852,200 |
| 11. Forsyth | Macon; 17N-2E | 2,120 | 6 | 1963 | 1,900 | 24,600 |
| 12. Glenarm | Sangamon; 14N-5W | 1,680 | 9 | 1955 | 600 | 57,200 |
| 13. Harristown | Macon; 16N-1E | 2,050 | 12 | 1954 | 1,500 | 179,800 |
| 14. Mechanicsburg | Sangamon; 16N-3W | 1,720 | 5 | 1972 | 33,900 | 77,700 |
| 15. Mt. Auburn Cons. | Christian; 15N-1W,2W | 1,890 | 9 | 1943 | 71,500 | 6,477,700 |
| 16. New City | Sangamon; 14N-4W | 1,730 | 37 | 1954 | 5,700 | 203,100 |
| 17. Oakley | Macon; 16N-3E | 2,285 | 9 | 1954 | Abd. 1965 | 22,900 |
| 18. Riverton S. | Sangamon; 15N-4W | 1,590 | 3 | 1965 | 1,600 | 86,500 |
| 19. Roby | Sangamon; 15N-3W | 1,775 | 25 | 1949 | 10,200 | 355,700 |
| 20. Roby N. | Sangamon; 16N-3W | 1,700 | 4 | 1962 | 0 | 19,000 |
| 21. Roby E. | Christian, Sangamon; 15N-2W,3W | 1,800 | 69 | 1970 | 107,400 | 713,000 |
| 22. Springfield E. | Sangamon; 15N-4W | 1,600 | 22 | 1960 | 4,900 | 319,100 |

* Production figures taken from Illinois Petroleum 107 (Van Den Berg and Lawry, 1975).

## Sand and Gravel

Most of the sand and gravel occurring in the Springfield-Decatur Region was deposited by glacial meltwaters. The most extensive deposits (Henry Formation) are located in the low terraces and in the floodplain of the Sangamon River, but an abundant supply of sand and fine gravel is available in terraces on many of the streams tributary to the Sangamon River, in reentrants of the Shelbyville Morainic System, and, to a lesser extent, in the outwash apron of the morainic system (plates 1 and 5).

Terrace remnants along the Sangamon River east of Springfield are prominent topographic features; however, those along the Sangamon west of Springfield are not easily recognized because the terrace has been partially buried by floodplain deposits (Cahokia Alluvium) of the Sangamon River.

Hills (kames) and elongate ridges (eskers) containing small amounts of sand and gravel of Illinoian age are prominent features in southwestern Macon County. Similar features are located in northeastern Sangamon County.

Windblown sand deposits (Parkland Sand) composed of medium- to fine-grained sand occur on the uplands bordering the Sangamon River in western Macon County and in a few places along the Sangamon River through Sangamon County.

On plate 5, the areas labeled as "generally devoid of sand and gravel" contain glacial till overlain by a veneer of loess that ranges in thickness from 1 to 12 feet. Water-well borings and deep foundation tests have encountered sand and

Fig. 20 - Sand and gravel pit, west side of Decatur.

gravel in many localities underlying, or interbedded with, glacial till, but the limited thickness of the gravel or the depth of it makes recovery economically impractical at present.

Production of sand and gravel in the region is carried out almost exclusively in the low-level terraces and the floodplain of the Sangamon River. East of Springfield into Macon County, sand and gravel production is from recognizable Wisconsinan Sangamon River terrace remnants, terrace remnants in valleys tributary to the Sangamon River, and other deposits beneath the floodplain sediments of the Sangamon River. Production at present occurs in Sangamon County east of Springfield; however, deposits in other parts of the county are of resource quality. West of Springfield, the sand and gravel deposits of the partially buried terrace are much like those being exploited east of Springfield. In the northeastern part of Sangamon County, and the southwestern part of Macon County, the large hills and ridges of sand and fine gravel may be a source of fine aggregate, but the erratic distribution and extreme textural variation of the deposits will require thorough testing before development. Gravel-sizing equipment at a sand and gravel pit west of Decatur is shown in figure 20.

The sand dunes scattered along the uplands bordering the Sangamon River have possibilities of development as a "blend sand" resource (Hester and Labotka, 1970).

A more detailed treatment of the sand and gravel resources of Macon and Sangamon Counties has been given by Hester (1970) and Hester and Anderson (1969).

## Limestone

Outcrops of limestone more than 3 feet thick occur south and southeast of Springfield and extend into the adjacent part of Christian County. This limestone is the Shoal Creek Limestone Member of the Bond Formation (fig. 19). Small quantities of Shoal Creek Limestone are exposed at a number of isolated outcrops along creeks and gullies in this area. Generally the thickness exposed is less than 6 feet. Overburden is generally more than 15 feet thick, and it consists of Pleistocene sediments, relatively easily removed, and in many places of several feet of hard Pennsylvanian shales and sandstones. The thickness of limestone in the area, as determined from well records, varies greatly, and in all cases examined it was less than 12 feet. Frequently, 2 to 3 feet of shale separates two units of limestone 3 to 7 feet thick each.

The limestone contains coarse fragments of a variety of fossils (mainly crinoids and other echinoderms, brachiopods, foraminifera, and algae) and has beds and laminations with very fine-grained quartz, clay, and iron oxides. Quartz, feldspar, and hematite sand grains are scattered in the limestone; these are rather abundant in some outcrops of the Shoal Creek. For the most part, a minor amount of the mineral dolomite occurs with calcite in the limestone; however, at one outcrop in southern Sangamon County, thin beds of nearly pure dolomite are interbedded with limestone.

Essentially no stone has been produced from quarries in Sangamon County since about 1930. From 1837 to 1853 sandy limestone beds 1 to 2 feet thick from the county were cut and used for the construction of the Old State Capitol Building. The restoration of this historic building between 1966 and 1968 required the replacement of a few stone blocks, especially in the columns, but a dolomite from a quarry in Minnesota was used.

Crushed stone for roads and for agricultural limestone was produced by the Old Mill Stone Company during the late 1940s from a quarry, now abandoned, on the south side of the Sangamon River in Christian County near Roby (west-central part of Sec. 13, T. 15 N., R. 3 W.). Calcium carbonate equivalent test results (CCE, or aglime, test) of samples from this quarry site averaged 81 percent CCE.

Exposures of the fine-grained and gray limestone of the Shoal Creek Limestone in northern Christian and southern Sangamon Counties weather into thin slabs because of the clayey nature of this limestone; therefore the Shoal Creek does not make a sound aggregate. Because of this characteristic and the persistence of shale beds within the limestone strata, little potential exists for modern quarrying operations within this area. No limestones more than 3 feet thick are known to crop out in Macon County.

### Clay and Shale

There is no record of Pennsylvanian or older clay and shale outcrops in Macon County. The map of drift thickness (plate 3) indicates that most bedrock clay and shale deposits may lie beneath 50 or more feet of glacial drift, which would make the red-burning clays and shales impractical to mine under present economic conditions.

In some areas the Pleistocene surface clays could be used for common brick, drain tile, and backup or structural tile or blocks. Before a plant is constructed, these materials should be thoroughly tested for their suitability for the intended use.

In Sangamon County, shale from above the Trivoli Sandstone Member of the Modesto Formation (fig. 19) has been mined near Springfield for the manufacture of red brick, building block and tile, drain tile, and lightweight expanded shale aggregate. This shale crops out in the vicinity of Springfield, and the overburden thickens to the south and east. To the south there are other shales above this shale, but they are thin and are sandwiched between sandstones and limestones; these shales tend to be calcareous and are of little economic importance.

In the area shown as shale on plate 5, the shale of the Trivoli Member can probably be found with 50 feet or less of overburden. However, drilling should be done to determine the thickness of overburden and the quality and quantity of the shale. The shale of the Trivoli Member may reach thicknesses of 50 feet or more in Sangamon County. The shale is silty to sandy, giving the product a medium shrinkage during drying and firing. The workability is good, and the burning color is red. It can be used in the manufacture of structural clay products, drain tile, sewer pipe, pottery, stoneware, and expanded lightweight aggregate.

## SOILS

The distribution of soils in the Springfield-Decatur area reflects the nature of the surficial deposits, or parent materials, which collectively form one of the primary factors in the formation and differentiation of agricultural soils. A generalized soil map of the Springfield-Decatur area is shown in figure 21; it can be compared with the surficial materials map (plate 1) to see the relationship between soils and materials. This map (fig. 21) has been compiled and slightly modified from the following sources: Fehrenbacher, Smith, and Odell (1950); Fehrenbacher, Walker, and Wascher (1967); Odell (1958); and Wascher and Odell (1954). Commonly associated soils of the Springfield-Decatur Region are grouped into eight map units. Two units have a sequence of soils that are developed in one type of parent material: soils in unit A have developed in loess, and soils of unit Z are in alluvium. Five other soil groupings contain soils that have developed in loess over another parent material. Another unit, N, is a complex composed of five different materials.

Within each soil map unit (soil association), a sequence of soil types, arrayed by topographic position, is present. The topographically high areas and the sloping areas tend to be moderately well to well drained and generally display yellow, brown, or red colors in the subsoil. The level and depressional areas tend to be poorly drained and generally display gray, green, or blue colors in the subsoil. Topographically high, level areas may be well drained when overlying coarse permeable materials. Conversely, a soil developed in coarse permeable materials may be poorly drained when present in a low-lying level area with a high water table. Most of the land area in the Springfield-Decatur Region is intermediate between the extremes mentioned.

In each soil area shown on figure 21, the dominant soils, indicated by names, cover a large proportion of the area. Other, similar soils are included in each area and individually make up only a small percentage of the total.

The dominant soils in areas labeled A are Tama, Ipava, and Sable; they are among the most productive soils in Illinois. Drainage is poor over much of the A area because the land surface is nearly flat and the water table is shallow. Corn and soybeans are the major crops.

Areas labeled Ba are dominated by the Flanagan and Drummer soils, which are as productive as the soils labeled A. Drummer is found in depressions and in low areas of drainageways and in many places contains several feet of water-deposited material above the till. Much of the Ba area is poorly drained. Corn and soybeans are the major crops.

Catlin, Flanagan, La Rose, and Drummer are the dominant soils in areas labeled Bb, which are in the hilly area of the Shelbyville Morainic System. Catlin and La Rose are on the stronger slopes and may suffer from erosion. Natural drainage is adequate in sloping parts, whereas tile drains the low parts. Grains and soybeans are the major crops.

The dominant soils of areas labeled D—Harrison, Herrick, and Virden—occur on a nearly level upland that is continuous with A areas. The soils are gradational from those of the A areas to the more mature soils in D areas. The soil surface in D areas tends to be not as dark colored as that of A areas, and it is more silty. The subsoil horizons contain more clay than those of A, and, as a consequence, the soils when wet do not drain with tile as successfully as similar soils of A areas. These soils are not as fertile as those in A areas. Corn and soybeans are the major crops.

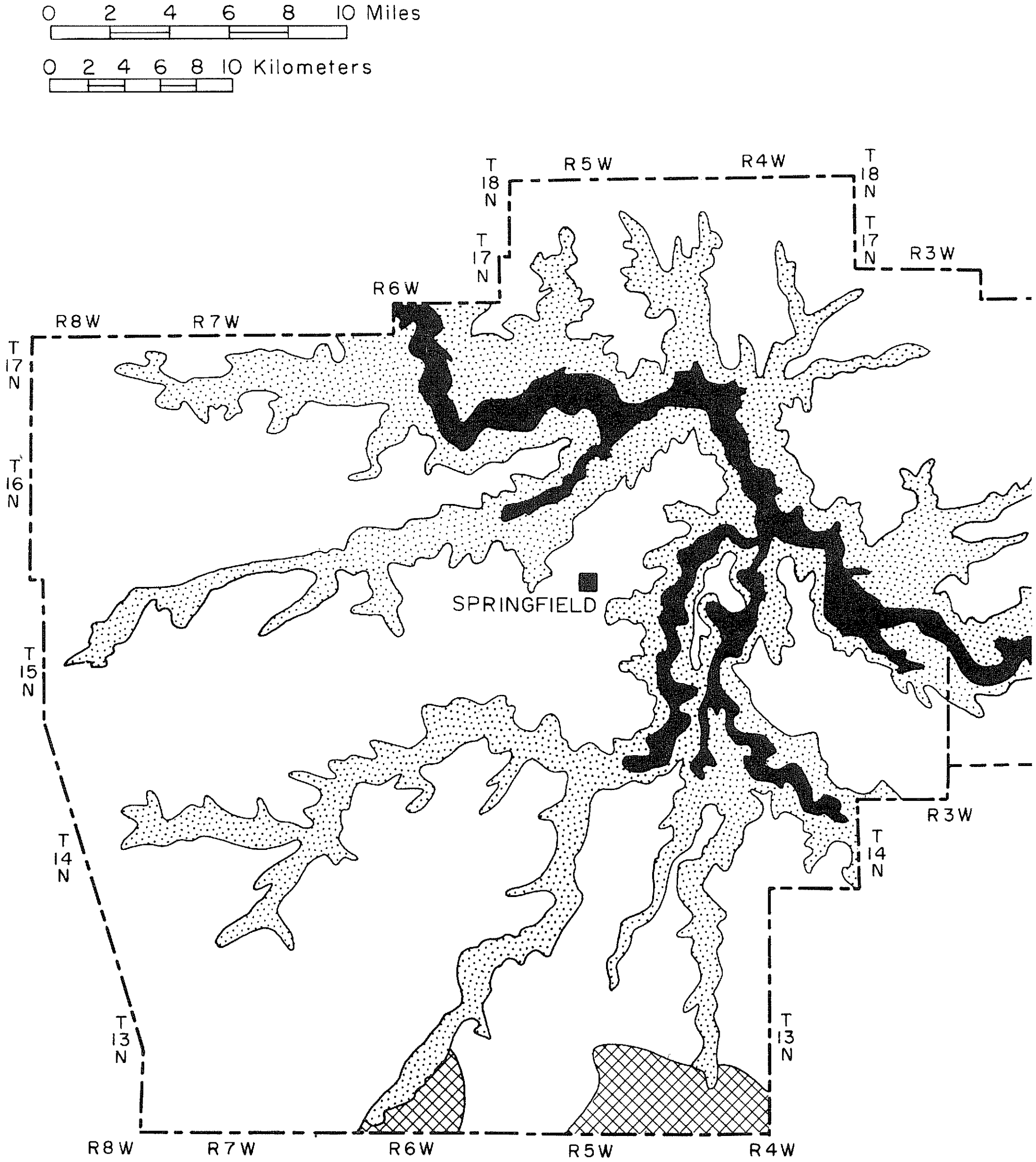
Areas designated M are dominated by Birkbeck, Strawn, and Hennepin soils. These light-colored soils are less productive than the dark soils. Erosion is a severe hazard. Grain and pasture crops are important, and there is a small amount of timber production.

The areas labeled N constitute the most varied unit in the region; they contain a wide range of greatly contrasting soils and materials. These areas are confined to the stream valleys west of the Shelbyville Morainic System and are characterized by hills created by stream erosion and, to a minor extent, by dunes constructed by windblown Parkland Sand. Clinton and Keomah are light-colored silty soils developed in Peoria Loess. Camden and Alvin are light-colored sandy soils developed in Parkland or Henry Sand. Hickory and Elco are light-colored silty soils developed in thin Peoria Loess over weathered Illinoian drift. Erosion is a severe hazard to sloping sandy soils. The need for fertilization and conservation is greater for these areas than for any of the other areas. Grain and pasture crops are important in these areas, and a small amount of timber is produced.

The dominant soils in areas labeled W are Plano, Proctor, Brenton, and Drummer. These nearly level areas are confined to the outwash plain that lies west of the Shelbyville Morainic System. The soils are productive and have relatively small fertilization and conservation needs. Corn and soybeans are the major crops.

Huntsville, Lawson, Tice, Camden, and Sawmill are the dominant soils in areas labeled Z. The fine-textured Sawmill and Tice are subject to overflow from the streams during annual flooding. Lack of adequate drainage is the major problem in the area. These soils are highly productive if adequate drainage is provided. Corn and soybeans are the major crops in the larger bottomlands; the smaller, narrower bottomlands are pasture lands.

(Text continued on page 48)

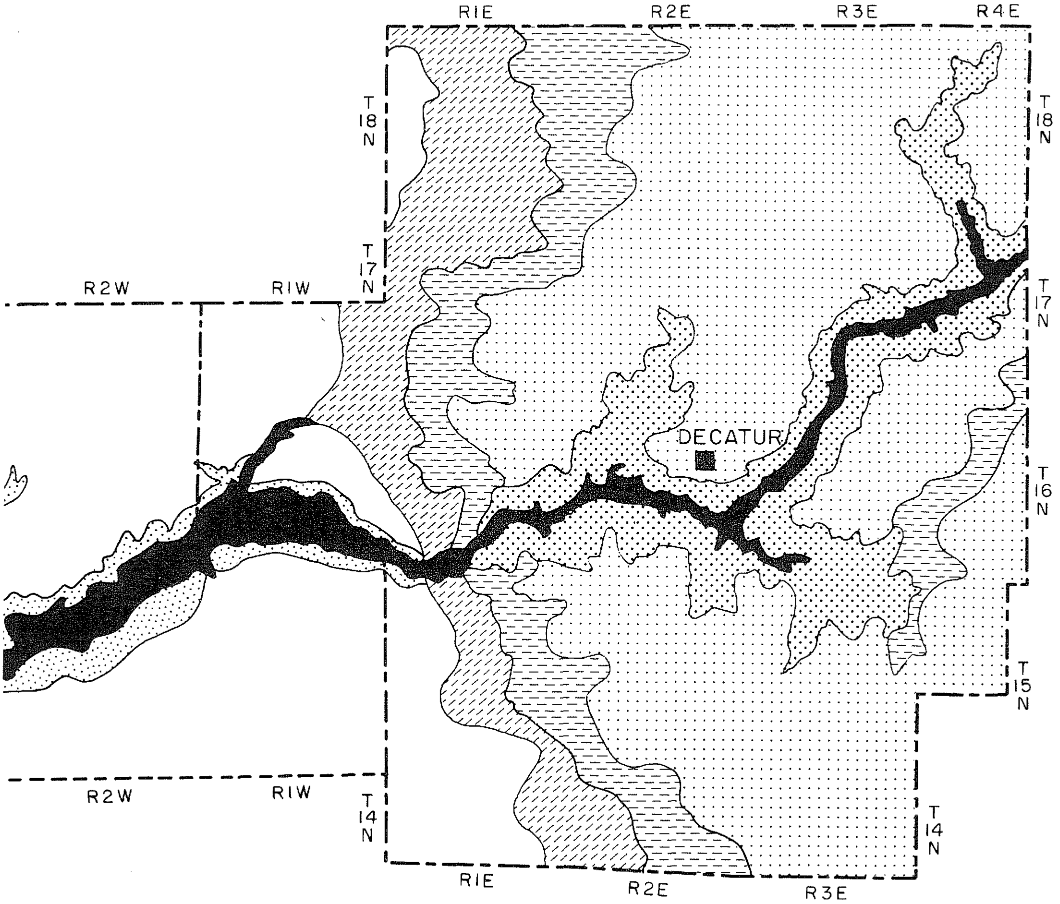


A ☐ Level to gently sloping dark prairie soils developed in 6 to 15 ft of Peoria Loess. Dominant soils: Tama, Ipava, and Sable.

Ba ⬚ Nearly level dark upland prairie soils developed in 3 to 7 ft of Richland Loess overlying silty till of the Wedron Formation. Dominant soils: Flanagan and Drummer.

Bb ▤ Rolling upland prairie soils developed in 1 to 4 ft of Richland Loess overlying silty till of the Wedron Formation. Dominant soils: Catlin, Flanagan, La Rose, and Drummer.

Fig. 21 - Soils of the Springfield-Decatur Region. Compiled and modified from Odell (1958); and



D ▩ Level to gently sloping upland prairie soil developed in 4 to 7 ft of Peoria Loess overlying weathered Roxana Silt. Dominant soils: Harrison, Herrick, and Virden.

M ░ Nearly level to strongly sloping light-colored upland timber soils developed in 0 to 4 ft of Richland Loess overlying silty till of the Wedron Formation. Dark alluvial soils in drainageways. Dominant soils: Birkbeck, Strawn, and Hennepin.

N ░ Level to strongly sloping light-colored terrace or upland timber soils developed in loess, dune sand, outwash, or till. Dark alluvial soils in drainageways. Dominant soils: Clinton, Keomah, Camden, Alvin, Hickory, and Elco.

W ▨ Nearly level dark upland prairie soils developed in 2 to 6 ft of Peoria Loess overlying sandy outwash of the Henry Formation. Dominant soils: Plano, Proctor, Brenton, and Drummer.

Z ■ Bottomland soils developed in silty Cahokia Alluvium.· Dominant soils: Huntsville, Lawson, Tice, Camden, and Sawmill.

Fehrenbacher, Smith, and Odell (1950); Fehrenbacher, Walker, and Wascher (1967); Wascher and Odell (1954).

## GEOLOGIC CONDITIONS RELATED TO USES OF THE LAND

### Construction

The Springfield-Decatur Region generally presents few serious problems to construction. The most common problem in the region is inadequate drainage.

The map showing geologic conditions related to construction (plate 6) was developed from the map of surficial geology (plate 1). In order to denote areas having similar engineering characteristics, some geologic units have been combined and given symbols familiar to the engineering geologist (Galster, 1975).

Each area is keyed with a set of abbreviations denoting the surface material to a depth of about 20 feet. A number subscript is used to indicate the average thickness of the unit. For example, an area having an average of 10 feet of loess over silt beds is keyed as $Wm_{10}/m$. The abbreviation for each type of material is provided in the map key.

Schematic cross sections showing the relative position of the materials underlying each mapped area are given with the map on plate 6. Definitions of the qualitative terms used in the following descriptions are given in appendix 2.

The valleys are divided into two kinds of areas. The lower areas are designated as alluvium (Asm) on plate 6. Parts of these areas are subject to annual flooding. In these areas a high water table may cause basements to flood, sewer excavations to cave, and septic effluents to rise to the ground surface. The sequence of materials ranges from organic silts and fine sands to some gravels. Locally, these materials encompass a wide range of types and make prediction of construction conditions difficult.

The second kind of area of the valleys is formed by the slopes. The slope areas are designated as colluvium (Csm) on the map. Colluvium is unsorted earth material carried downslope by gravity. Included in this group of materials in plate 6 are loess sloughed into the valleys, slumped earth material, and some of the upper terrace deposits. These diversely formed materials are grouped together because they tend to have similar engineering characteristics. Lower parts of the areas may be flooded occasionally and may be subject to the conditions of a high water table. The valley slopes accentuate changes of moisture content, which cause shrinking and swelling of fine-grained materials. Both surface and subsurface drainage must be engineered to prevent erosion and creep.

The uplands are subdivided into five kinds of areas on the basis of the sequence of materials. Parts of the uplands bordering the valleys are underlain by windblown sand. Thin loess may overlie as well as underlie the sand. These areas are designated as sand (Ws) on plate 6. The high permeability of the sand is responsible for good drainage, a low water table, and low susceptibility to frost heave. The sand offers medium bearing capacity and low shrinkage or swelling. Erosion is likely to occur when these materials are exposed in road cuts or other excavations. The slopes are gentle and in places resemble typical dunes.

The uplands outside the sand areas may be subject to water problems during periods of heavy precipitation. The thick blanket of loess (Wm), having low permeability, tends to support high saturation levels, which may lead to stability problems and damp basements.

In some areas in northeastern Sangamon County organic silts (Gp) occur beneath the loess blanket. The organic silts are compressible and may allow settlement under loading. The nonorganic silts (Gm) that usually underlie the loess in the upland regions have low bearing strengths and include a wide range of silt-size materials, but they are not compressible. At lower depths these silts commonly have high densities and bearing strengths.

Till (Gsmc(t)) or weathered till units provide the highest bearing strengths and the best foundation conditions. Local interbedded deposits of silt or sand in the till may cause the sides of trenches to collapse during excavations. Because of the low volume of water involved, these deposits are usually relatively easy to drain. Wet basements often result from excavating too large a hole and then backfilling around the basement wall with granular materials. Water from downspouts or from eaves without gutters collects in the granular material around the walls and then seeps through the walls.

Areas of shallow bedrock, shown on plate 6 by a dot pattern, provide high bearing strengths for heavy-construction purposes. Such strengths are not necessary for home construction; in fact, the presence of shallow bedrock increases excavation costs for sewer lines, storm drainage lines, and basements. The Pennsylvanian rocks (LS-SH) exposed during construction do not need to be sealed against pollution unless they are suitable for use as aquifers.

Continuous sands occur at relatively shallow depths in some areas shown on the map. These units provide high bearing capacities when drained. In places these sands may be saturated with water under pressure, causing collapse of excavations and walls and seepage into basements. Sump pumps used in these situations may be required to overrun their design capacity. Failure of basement walls and floors may occur from uplift pressure if the water is pumped out of a partly filled basement.

Areas where coal has been mined out are shown on plate 4. All of those areas are potential areas for subsidence, unless they are properly backfilled or are totally collapsed. Pillars, roofs, or floors of mines can fail within a few weeks to months of mining, or they may remain a hazard for 30 years or longer. Failure after many years may be attributed to recent pumping or flooding of the mined-out area. Unless the mine works are relatively shallow, surface loading from the building of homes is not likely to trigger subsidence. In any case, the maximum amount of potential subsidence can be estimated in order that a reasonable plan for land use can be developed.

The range in properties in an earth material is a significant characteristic in itself. Some units are consistent within narrowly defined limits, while others present a wide range of values. To facilitate the evaluation of an earth material, the degree of expected variance is included for each material in table 7. The variance may occur in any category; for instance, there may be a great variance in grain size whereas the thickness of the unit may be nearly constant.

Specific conditions related to the engineering properties of the units summarized in table 7 may be used to plan areas suited for septic tank installations, homes with basements, or other construction projects.

(Text continued on page 53)

## TABLE 7 - ENGINEERING PROPERTIES OF

| | General conditions | | | | Geologic units and index properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Key to map area (pl. 6) | Slope | Depth to bedrock | Flooding | Ground-water level | Unit | Thickness (ft) | Drainage | Variability of unit | Bearing capacity | Swelling | Frost heave | Compression | Erosion |
| Asm | Nearly level to depressional | Local exposures | Seasonal | High to surface | Cahokia Alluvium | 10-30 | Low | Very high | Very low to very high | Non-critical to marginal | High (F3) | Low to medium | High |
| | | | | | Equality and Henry Fms. | 5-20 | Low | Very high | Very low to very high | Non-critical to marginal | High (F3) | Low to medium | High |
| Csm | Strongly sloping to very steep (near Sangamon R.) | Locally shallow | Occasional | Wide range—high to low | Mixture of surface units | 0-10 | Low | High | Low | Marginal to critical | High (F3) | Low to medium | Low to medium |
| Ws | Gently sloping to sloping | Deep, >20 ft | Seldom to never | Low | Parkland Sand | | High | Low | Medium | Non-critical | Low to medium (F2) | Low | High |
| Wm<br>Gm | Nearly level to gently sloping | Very deep, >20 ft | Not likely | High | Peoria Loess | 8-12 | Poor to fair | Low | Medium to low | Marginal | Very high (F4) | Low | Very high |
| | | | | | Roxana Silt | 2-4 | Poor to fair | Medium | Medium | Non-critical | High (F3) | Low | Medium to low |
| | | | | | Sangamon Soil | 4-10 | Poor to fair | High | Medium | Non-critical | High (F3) | Low | Low |
| | | | | | Teneriffe Silt | 5-30 | Poor to fair | Medium | Medium to high | Non-critical | Very high (F4) | Low | Very high |
| Wp<br>Gpm<br>Gm | Nearly level to gently sloping | Very deep, >20 ft | Not likely | High | Peoria Loess | 8-10 | Poor to fair | Low | Low to medium | Marginal | Very high (F4) | Low | Very high |
| | | | | | Robein Silt | 1-7 | Poor to fair | High | Low to medium | Non-critical | Very high (F4) | Low to high | Very high |
| | | | | | Sangamon Soil | 4-10 | Poor to fair | High | Medium | Non-critical | High (F3) | Low | Low |
| Wm<br>Gm<br>Gsmc(t) | Nearly level to gently sloping | Locally shallow, < 20 ft; dense shale with very high bearing capacity | Not likely | High | Peoria Loess | 8-12 | Poor to fair | Low | Medium to low | Marginal | Very high (F4) | Low | Very high |
| | | | | | Roxana Silt | 2-4 | Poor to fair | Medium | Medium | Non-critical | High (F3) | Low | Medium to low |
| | | | | | Sangamon Soil | 4-10 | Poor to fair | High | Medium | Non-critical | High (F3) | Low | Low |
| | | | | | Till | 10-50 | Very poor | Low | High | Non-critical | High (F3) | Low | Low |
| Wm<br>Gsmc(t) | Nearly level to gently sloping | Very deep, >20 ft | Locally ponding may occur | Locally very high | Richland Loess | 6-9 | Poor to fair | Low | Low to medium | Marginal | Very high (F4) | Low | Very high |
| | | | | | Wordfordian till (weath.) | 2-8 | Poor | Low | Medium to high | Non-critical | High (F3) | Low | Low |
| | | | | | Woodfordian till (unweath.) | 20-60 | Very poor | Very low | High | Non-critical | High (F3) | Low | Low |

* See appendix 2 (p. 69-76) for explanations of terms used in this table.

## UNCONSOLIDATED DEPOSITS IN THE SPRINGFIELD-DECATUR REGION*

Geologic units and index properties

| Classification | | Grain size (%) | | | Density | | Atterburg limits | | Compressive strength | | Natural moisture content (% water, dry wt.) | Optimum moisture content | | Perme- ability (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AASHO† | Uni- fied‡ | >.063 mm | .063- .002 mm | <.002 mm | Wet wt. (lb/ft³) | Dry wt. (lb/ft³) | Liquid limit (% water, dry wt.) | Plastic Index (% water, dry wt.) | (Qu) (tons/ft²) | N (blows/ ft pen.) | | (%) | Density (lb/ft³, dry wt.) | |
| — | SC, SM | 10-50 | 35-75 | 0-25 | — | — | — | — | — | — | — | — | — | — |
| — | SM, SC | 0-80 | 35-75 | 0-25 | — | — | — | — | — | — | — | — | — | — |
| — | ML, CL | Ave. 30 | Ave. 55 | Ave. 15 | — | — | — | — | — | — | — | — | — | — |
| — | SP | 40-70 | 20-40 | 5-15 | — | — | — | — | — | — | — | — | — | — |
| A-4-6 | ML | 0-2 | 67-79 | 20-32 | 115-132 | 95-105 | 32 | 6 | 0.5-1.0 | 4-9 | 20-30 | 14-18 | 106-110 | $10^{-3}$-$10^{-6}$ |
| A-6 | CL | 4-18 | 55-62 | 18-32 | 110-140 | 100-120 | 40-80 | 20-60 | 0.5-1.3 | 3-8 | 19-31 | 13-16 | 112-116 | $10^{-3}$-$10^{-6}$ |
| A-6 | CL | 2-23 | 37-70 | 18-50 | 110-140 | 100-120 | 40-80 | 20-60 | 0.5-1.3 | 3-8 | 19-31 | 12-18 | 110-118 | $10^{-3}$-$10^{-6}$ |
| A-4-6 | ML | 10-40 | 50-70 | 20-30 | 125-130 | 100-130 | 40 | 10 | 1.3-2.5 | 13-20 | 22-26 | — | — | $10^{-3}$-$10^{-6}$ |
| A-4-6 | ML | 0-2 | 67-79 | 20-32 | 115-132 | 95-105 | 32 | 6 | 0.5-1.0 | 4-9 | 20-30 | 14-18 | 106-110 | $10^{-3}$-$10^{-6}$ |
| A-8 | OH, M | 0-5 | 65-85 | 10-20 | — | — | — | — | 0.1-1.4 | 2-10 | 20-100 | — | — | $10^{-3}$-$10^{-6}$ |
| A-6 | CL | 2-23 | 37-70 | 18-50 | 110-140 | 100-120 | 40-80 | 20-60 | 0.5-1.3 | 3-8 | 19-31 | 14-18 | 110-114 | $10^{-3}$-$10^{-6}$ |
| A-4-6 | ML | 0-2 | 67-79 | 20-32 | 115-132 | 95-105 | 32 | 6 | 0.5-1.0 | 4-9 | 20-30 | 14-18 | 106-110 | $10^{-3}$-$10^{-6}$ |
| A-6 | ML to MH, CL | 4-18 | 55-62 | 18-32 | 110-140 | 100-120 | 40-80 | 20-60 | 0.5-1.3 | 3-8 | 19-31 | 13-16 | 112-116 | $10^{-3}$-$10^{-6}$ |
| A-6 | ML to MH, CL | 2-23 | 37-70 | 18-50 | 110-140 | 100-120 | 40-80 | 20-60 | 0.5-1.3 | 3-8 | 19-31 | 14-18 | 110-114 | $10^{-3}$- 10-6 |
| A-6 | CL | 21-39 | 37-52 | 18-33 | 120-155 | 110-140 | 36 | 15 | 4-8 | 50-80; many >100 | 10-13 | 11-15 | 116-124 | $<10^{-5}$ |
| A-4-6 | ML | 3-10 | 60-80 | 10-35 | 115-132 | 95-105 | 32 | 5 | 0.4-0.8 | 3-7 | 20-28 | 14-18 | 106-110 | $10^{-3}$-$10^{-6}$ |
| A-6 | CL | 20-40 | 40-60 | 15-40 | 110-140 | 100-120 | — | — | 0.8-3.0 | 5-20 | 14-30 | 12-18 | 110-118 | $<10^{-5}$ |
| A-6 | CL | 30-40 | 30-40 | 30-40 | 120-155 | 110-140 | 36 | 15 | 2.5-4.5 | 15-30 | 12-14 | 10-14 | 116-122 | $<10^{-5}$ |

† Highway Research Board (1945). ‡ American Society for Testing Materials (1975), p. 309-313 (ASTM D 2487).

### TABLE 8 - MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES WITH APPROXIMATELY CORRESPONDING RICHTER MAGNITUDES

(After Arthur Holmes, Principles of Physical Geology, Second Edition, The Ronald Press Company, New York. Copyright © 1965.)

| Intensity | Description of characteristic effects | | Richter scale magnitude approximately corresponding to highest intensity reached |
|---|---|---|---|
| I | Instrumental: | detected only by seismography | |
| II | Feeble: | noticed only by sensitive people | 3.5 to 4.2 |
| III | Slight: | like the vibrations due to a passing heavy truck; felt by people at rest, especially on upper floors | |
| IV | Moderate: | felt by people while walking; rocking of loose objects, including standing vehicles | 4.3 to 4.8 |
| V | Rather strong: | felt generally; most sleepers are wakened and bells ring | |
| VI | Strong: | trees sway and all suspended objects swing; damage by overturning and falling of loose objects | 4.9 to 5.4 |
| VII | Very strong: | general alarm; walls crack; plaster falls | 5.5 to 6.1 |
| VIII | Destructive: | car drivers seriously disturbed; masonry fissured; chimneys fall; poorly constructed buildings damaged | 6.2 to 6.9 |
| IX | Ruinous: | some houses collapse where ground begins to crack; pipes break open | |
| X | Disastrous: | ground cracks badly; many buildings destroyed and railway lines bent; landslides on steep slopes | 7.0 to 7.3 |
| XI | Very disastrous: | few buildings remain standing; bridges destroyed; all services (railway, pipes, and cables) out of action; great landslides and floods | 7.4 to 8.1 |
| XII | Catastrophic: | total destruction; objects thrown into air; ground rises and falls in waves | 8.1+ |

Table adapted by permission of The Ronald Press Company, New York, and Thomas Nelson & Sons, Ltd., London.

## Seismicity

Seismicity, which refers to the characteristics of a region with regard to earthquakes, is an important consideration in the planning of large structures, for example, nuclear power stations.

A seismic risk map of conterminous United States (Algermissen, 1969) places the Springfield-Decatur Region in Zone 1. Zone 1 is characterized by the risk of minor damage corresponding to earthquake intensities V and VI on the Modified Mercalli Scale (table 8).

Central Illinois has been relatively free of earthquakes. The earthquake history of the United States (Eppley, 1958) shows that the largest earthquake in the area occurred on July 18, 1909, and had a maximum intensity of VII on the Modified Mercalli Scale. This earthquake was centered in Mason County between Havana and Petersburg. Other quakes of lesser intensity have been observed. A quake of maximum intensity V took place in southwest Menard County. One of maximum intensity IV occurred in southeastern Fulton County. Another quake, of maximum intensity III, was centered near Bloomington. Still another, of unknown intensity, was observed near the De Witt-McLean County border.

Other, more distantly centered earthquakes also have disturbed the Springfield-Decatur Region. The quake of May 26, 1909, thought to be centered on the Illinois-Wisconsin border, had an intensity of about V in the Springfield-Decatur Region. The earthquake of November 9, 1968 (centered near Broughton in Hamilton County, southern Illinois), was the largest instrumentally recorded Illinois earthquake (magnitude 5.5 and maximum intensity VII, table 8). In the Springfield-Decatur Region the intensity from this quake was as high as V.

Perhaps the greatest seismic hazard to the Springfield-Decatur Region, and to most of Illinois, would come from a reoccurrence of the 1811-1812 type earthquakes that occurred in the active New Madrid seismic zone, located roughly between Memphis, Tennessee, and Cairo, Illinois. According to Nuttli (1973), such a reoccurrence would result in intensities between VI and VII on the Modified Mercalli Scale in the Springfield-Decatur Region.

The seismic risk map of Algermissen (1969) does not take the local nature and thickness of unconsolidated sediments into account. Structures resting on deposits of unconsolidated sediments experience greater shaking from earthquakes than those on or near bedrock. This phenomenon has been observed many times during past earthquakes, when greater shaking occurred on the floodplains of rivers and over bedrock valleys filled with unconsolidated glacial sediments than on adjacent land where the bedrock was closer to the land surface. In the Springfield-Decatur Region, the floodplains of the Sangamon River and its major tributaries and the region of thick glacial drift in northeastern Macon County are the areas that would probably experience the greatest ground motion from an earthquake.

## Solid-Waste Disposal

Solid wastes can be managed in many ways; but without total recycling, some portion is ultimately disposed of on or in the earth. The Illinois Environmental Protection Agency (EPA) has the responsibility of ensuring that such disposal produces the least amount of environmental degradation.

The usual objective in disposing of solid wastes or residues (food waste, nonsalvageable metal and paper, incinerator ash, lawn clippings, etc.) is to contain them within the earth by a process called sanitary landfilling. The solid refuse is placed in layers on the land or in trenches, compacted, and covered with earth materials at regular intervals (at least daily). In the presence of water, most types of solid waste will produce a concentrated mineralized liquid called leachate. The water may be either ground water or infiltrating precipitation. The physical conditions at proposed landfill sites in Illinois are evaluated to determine whether pollution of ground water or surface water is likely to occur through contamination by leachate. If contamination of a water resource appears likely, either the facility will not be approved by the EPA or modification of the site by installation of liners, drains, or other engineering works may be considered.

In general, fine-grained earth materials limit both the amount of leachate that will travel from a landfill site and the rate at which it moves. Sites in areas of silts, clays, or glacial tills are therefore considered to be more favorable locations for waste-disposal operations than sites where sand, gravel, or creviced bedrock is found.

Regional geologic data are useful in the early stages of selecting a landfill site. Areas where physical conditions are probably unsuitable for a landfill can be avoided; or, where possible, site modifications that would overcome the operational and environmental problems likely to be encountered can be considered.

Plate 7 is based on the geologic conditions that affect the movement of ground water in the vicinity of a solid-waste disposal site. The areas designated by map symbol 7 are predominantly stream bottomlands, where the surficial earth materials are alluvial deposits of silt or sand. There are usually thick sand deposits underlying these surficial materials. The natural conditions in this environment are unsuitable for most solid-waste disposal operations. The sands have considerable potential for water supply, and several small towns along the Sangamon River obtain water supplies from them. The water table is generally high, and some areas may be flooded during periods of high stream flow. Any disposal site located in these areas would be close to surface streams or lakes, resulting in short travel distances between a disposal operation and the surface water.

The areas designated by symbol 6 have deposits of windblown sand at or near the land surface. These deposits are found bordering the valley of the Sangamon River. The sand is a poor cover material for most landfill operations. The materials may be suitable for the development of wells of low yield, which might be the only sources of ground water in the area. Any leachate developed at the site could migrate through the sand fairly rapidly (tens to hundreds of feet per year). Major site modifications might enable a site in this environment to meet current requirements of the EPA.

Areas labeled by symbol 5 are characterized by surficial deposits of alluvial silts in stream bottomlands. In general, the natural conditions are unsuitable for landfill operations. The water table is usually within a few feet of the land surface. The proximity of surface streams to any potential site would mean short travel distances from the site to surface waters for any leachate developed.

The areas indicated by pattern 4 have sand or sand and gravel at depths ranging from 10 to 20 feet below the land surface. These sands are glacial outwash deposits and are usually near small modern streams. Some parts of these areas may be suitable for landfill operations, depending primarily on the nature and thickness of both the sand and the overlying material. Where the sand has potential for development as a water resource, it should be protected because of the general scarcity of suitable water-yielding materials outside the river bottoms.

The areas designated by symbol 3 are characterized by thin glacial deposits, mostly loess and till, over bedrock. The bedrock surface consists mainly of

Pennsylvanian age shale or sandstone. This geologic environment is generally suitable for landfill operations; however, difficulties may be encountered in trenching or in obtaining sufficient cover material. Rapid movement of landfill leachate might occur along the bedrock surface. Large-diameter dug or augered wells are the most likely sources of ground water, although drilled wells may be present where sandstone beds are found at relatively shallow depths.

The areas designated by symbol 2 consist of surficial till deposits in or near surface drainageways. No appreciable thicknesses of sand or sand and gravel are believed to occur under these deposits. If a site is located several hundred feet away from any surface stream, there should be no significant problems in developing a landfill.

The areas not patterned (1 on plate 7) are characterized by thick loess deposits underlain by glacial till; these are primarily upland areas. Here conditions are regarded as most favorable for landfill operations, and most sites within these areas should prove suitable for waste disposal.

A test drilling program is required to obtain subsurface data for landfill sites in the state of Illinois. The early use of the generalized data contained in this report may shorten the process of site selection and could eliminate costly and time-consuming data collection in areas where the probability of locating a suitable landfill is low.

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# APPENDIX 1 - DATA ON GROUND-WATER WELLS, TEST HOLES, AND AQUIFERS SHOWN ON PLATE 2.

Read left side of table to bottom of facing page; then return to this page (right-hand side).

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|
| SANGAMON COUNTY | | | | |
| 9-13N-5W, 1 | D | 24 | 9 | 33 |
| 9-13N-5W, 2 | B | 37 | 1 | 41 |
| 9-13N-5W, 3 | B | 34 | 1 | 36 |
| 16-13N-5W, 1 | B | 31 | 1 | 35 |
| 16-13N-5W, 2 | B | 27 | 1 | 35 |
| 17-13N-5W | B | 31 | 1 | 35 |
| 31-13N-5W, 1 | B | 38 | 2 | 40 |
| 31-13N-5W, 2 | B | 53 | 3 | 61 |
| 34-13N-5W | D | 12 | 2 | 20 |
| 6-13N-6W | B | 32 | 28 | 157 |
| 8-13N-6W | D | 24 | 2 | 28 |
| 12-13N-6W, 1 | D | 22 | 2 | 34 |
| 12-13N-6W, 2 | D | 20 | 4 | 35 |
| 36-13N-6W | B | 37 | 9 | 46 |
| 3-13N-7W | D | 68 | 17 | 85 |
| 20-13N-7W | B | -- | -- | 299 |
| 1-14N-4W | D | 15 | 20 | 35 |
| 3-14N-4W | D | 30 | 6 | 36 |
| 5-14N-4W, 1 | D | 20 | 4 | 44 |
| 5-14N-4W, 2 | D | 28 | 20 | 50 |
| 6-14N-4W, 1 | D | 25 | 11 | 36 |
| 6-14N-4W, 2 | D | 32 | 4 | 36 |
| 6-14N-4W, 3 | D | 32 | 7 | 39 |
| 13-14N-4W | D | 27 | 5 | 35 |
| 18-14N-4W | D<br>B | 25<br>30 | 5<br>9 | 39 |
| 6-14N-5W, 1 | D | 18 | 12 | 30 |
| 6-14N-5W, 2 | B | 30 | 17 | 47 |
| 19-14N-5W, 1 | D | 15 | 3 | 30 |
| 19-14N-5W, 2 | D | 18 | 2 | 30 |
| 21-14N-5W, 1 | D | 18 | 1 | 30 |
| 21-14N-5W, 2 | B | 16 | 7 | 23 |
| 21-14N-5W, 3 | B | 20 | 7 | 27 |
| 13-15N-4W | D | 20 | 2 | 23 |
| 20-15N-4W, 1 | D | 18 | 2 | 29 |
| 20-15N-4W, 2 | D | 18 | 2 | 30 |
| 21-15N-4W | D | 14 | 2 | 30 |
| 28-15N-4W | D | 30 | 3 | 33 |
| 31-15N-4W | D | 30 | 12 | 67 |
| 1-15N-5W, 1 | B | 23 | 3 | 26 |
| 1-15N-5W, 2 | D | 19 | 5 | 24 |
| 2-15N-5W, 1 | B | 25 | 5 | 30 |
| 2-15N-5W, 2 | D | 20 | 2 | 34 |
| 2-15N-5W, 3 | D | 29 | 1 | 39 |
| 2-15N-5W, 4 | B | 25 | 5 | 30 |
| 3-15N-5W | B | 55 | 26 | 81 |
| 10-15N-5W | D | 14 | 2 | 20 |
| 11-15N-5W | B | 65 | 22 | 105 |
| 13-15N-5W | D | 14 | 2 | 20 |
| 16-15N-5W, 1 | D | 14 | 7 | 21 |
| 16-15N-5W, 2 | D | 13 | 8 | 21 |
| 21-15N-5W, 1 | D | 16 | 2 | 21 |
| 21-15N-5W, 2 | D | 21 | 1 | 35 |
| 21-15N-5W, 3 | D | 16 | 2 | 24 |
| 28-15N-5W, 1 | D | 14 | 10 | 24 |
| 28-15N-5W, 2 | D | 12 | 2 | 21 |
| 29-15N-5W, 1 | D | 21 | 1 | 30 |
| 29-15N-5W, 2 | D | 18 | 2 | 32 |
| 29-15N-5W, 3 | D | 18 | 3 | 21 |
| 29-15N-5W, 4 | B | 56 | 34 | 109 |
| 29-15N-5W, 5 | D<br>B | 74<br>95 | 21<br>3 | 98 |
| 32-15N-5W, 1 | D | 30 | 1 | 49 |
| 32-15N-5W, 2 | B | 83 | 17 | 100 |
| 33-15N-5W, 1 | D | 20 | 2 | 39 |
| 33-15N-5W, 2 | D | 18 | 3 | 33 |
| 35-15N-5W, 1 | D | 15 | 15 | [illegible] |

|  |  |  |  |  |
|---|---|---|---|---|
| 27-14N-5W, 1 | B | -- | -- | 111 |
| 27-14N-5W, 2 | B | -- | -- | 100 |
| 27-14N-5W, 3 | B | -- | -- | 760 |
| 27-14N-5W, 4 | B | 30 | 40 | 160 |
| 20-14N-6W | D | 106 | 24 | 130 |
| 28-14N-6W | D | 132 | 7 | 139 |
| 4-14N-7W | D | 72 | 7 | 79 |
| 7-14N-7W | D | -- | -- | 45 |
| 8-14N-7W | D | 27 | 9 | 36 |
| 12-14N-7W | D | 127 | 1 | 130 |
| 13-14N-7W | D | 60 | 7 | 67 |
| 14-14N-7W | B | -- | -- | 63 |
| 1-14N-8W | D | -- | -- | 61 |
| 3-15N-2W, 1 | D | 6 | 55 | 61 |
| 3-15N-2W, 2 | D | 5 | 30 | 88 |
| 4-15N-2W, 1 | D | 7 | 34 | 41 |
| 4-15N-2W, 2 | D | 12 | 25 | 37 |
| 4-15N-2W, 3 | D | 5 | 57 | 101 |
| 4-15N-2W, 4 | D | 8 | 37 | 65 |
| 4-15N-2W, 5 | D | 8 | 36 | 55 |
| 4-15N-2W, 6 | D | 8 | 27 | 44 |
| 5-15N-2W, 1 | D | 5 | 48 | 53 |
| 5-15N-2W, 2 | D | 9 | 21 | 34 |
| 5-15N-2W, 3 | D | 8 | 29 | 37 |
| 8-15N-2W, 1 | D | 7 | 23 | 36 |
| 8-15N-2W, 2 | D | 4 | 37 | 41 |
| 8-15N-2W, 3 | D | 10 | 25 | 35 |
| 11-15N-3W, 1 | D | 15 | 29 | 44 |
| 11-15N-3W, 2 | D | 18 | 30 | 48 |
| 20-15N-3W | D | 28 | 2 | 44 |
| 32-15N-3W | D | 14 | 9 | 23 |
| 1-15N-4W | D | 24 | 3 | 30 |
| 4-15N-4W, 1 | D | 40 | 3 | 59 |
| 4-15N-4W, 2 | D | 20 | 9 | 29 |
| 4-15N-4W, 3 | D | 18 | 2 | 30 |
| 4-15N-4W, 4 | D | 18 | 2 | 36 |
| 6-15N-4W, 1 | D | 24 | 4 | 41 |
| 6-15N-4W, 2 | D | 18 | 1 | 30 |
| 6-15N-4W, 3 | D | 18 | 2 | 30 |
| 7-15N-4W, 1 | D | 18 | 6 | 30 |
| 7-15N-4W, 2 | D | 15 | 3 | 29 |
| 35-15N-5W, 2 | D | 18 | 4 | 30 |
| 35-15N-5W, 3 | D | 23 | 4 | 30 |
| 1-15N-6W, 1 | D | 14 | 7 | 21 |
| 1-15N-6W, 2 | D | 12 | 2 | 24 |
| 1-15N-6W, 3 | D | 58 | 2 | 70 |
| 1-15N-6W, 4 | D | 12 | 3 | 23 |
| 1-15N-6W, 5 | D | 18 | 2 | 29 |
| 2-15N-6W, 1 | D | 18 | 2 | 30 |
| 2-15N-6W, 2 | D | 20 | 4 | 24 |
| 2-15N-6W, 3 | D | 21 | 3 | 24 |
| 2-15N-6W, 4 | D | 14 | 2 | 24 |
| 2-15N-6W, 5 | D | 12 | 12 | 24 |
| 4-15N-6W | D | -- | -- | 29 |
| 5-15N-6W | D | -- | -- | 45 |
| 13-15N-6W, 1 | D | 24 | 6 | 30 |
| 13-15N-6W, 2 | D | 18 | 8 | 41 |
| 16-15N-6W | D | 14 | 2 | 27 |
| 21-15N-6W | D | 12 | 2 | 18 |
| 22-15N-6W | D | 28 | 2 | 50 |
| 23-15N-6W | D | 24 | 3 | 40 |
| 25-15N-6W, 1 | D | 32 | 3 | 60 |
| 25-15N-6W, 2 | D | 35 | 2 | 57 |
| 25-15N-6W, 3 | D | 47 | 3 | 50 |
| 26-15N-6W, 1 | D | 44 | 5 | 60 |
| 26-15N-6W, 2 | D | 18 | 17 | 35 |
| 26-15N-6W, 3 | B | 30 | 13 | 43 |
| 26-15N-6W, 4 | D | 21 | 2 | 45 |
| 27-15N-6W | D | 14 | 10 | 24 |
| 31-15N-6W, 1 | D | 62 | 7 | 69 |
| 31-15N-6W, 2 | D | -- | -- | 40 |
| 33-15N-6W | D | -- | -- | 151 |
| 35-15N-6W | D | 18 | 4 | 36 |
| 4-15N-7W | B | -- | -- | 150 |
| 5-15N-7W, 1 | D | 16 | 4 | 30 |
| 5-15N-7W, 2 | B | 43 | 2 | 45 |
| 8-15N-7W, 1 | D | 18 | 2 | 30 |
| 8-15N-7W, 2 | D | 21 | 3 | 24 |
| 15-15N-7W | D | -- | -- | 43 |
| 16-15N-7W, 1 | D | -- | -- | 81 |
| 16-15N-7W, 2 | D | -- | -- | 25 |
| 16-15N-7W, 3 | D | -- | -- | 35 |

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*Where two or more wells are shown in a section, wells are numbered on plate 2.

(Continued on next page.)

# Appendix 1 - Continued

Read left side of table to bottom of facing page; then return to this page (right-hand side).

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|
| 16-15N-7W, 4 | D | 12 | 4 | 17 |
| 17-15N-7W, 1 | D | -- | -- | 35 |
| 17-15N-7W, 2 | B | 35 | 2 | 45 |
| 19-15N-7W, 1 | D | -- | -- | 23 |
| 19-15N-7W, 2 | B | 34 | 2 | 60 |
| 20-15N-7W, 1 | D | -- | -- | 37 |
| 20-15N-7W, 2 | D | -- | -- | 33 |
| 22-15N-7W | D | -- | -- | 48 |
| 23-15N-7W | B | -- | -- | 274 |
| 26-15N-7W | B | -- | -- | 432 |
| 29-15N-7W | D | 25 | 5 | 30 |
| 30-15N-7W, 1 | D | -- | -- | 27 |
| 30-15N-7W, 2 | B | 35 | 2 | 60 |
| 31-15N-7W | D | -- | -- | 49 |
| 12-15N-8W | D | 17 | 3 | 25 |
| 13-15N-8W | B | -- | -- | 146 |
| 22-15N-8W | D | -- | -- | 85 |
| 23-15N-8W | D | -- | -- | 65 |
| 24-15N-8W | B | 19 | 2 | 24 |
| 6-16N-1W | D | 53 | 4 | 59 |
| 7-16N-1W, 1 | D | 46 | 24 | 190 |
| 7-16N-1W, 2 | D | 39 | 13 | 96 |
| 8-16N-1W, 1 | D | 9 | 21 | 58 |
| 8-16N-1W, 2 | D | 10 | 29 | 55 |
| 17-16N-1W, 1 | D | 20 | 10 | 95 |
| 17-16N-1W, 2 | D | 9 | 16 | 58 |
| 17-16N-1W, 3 | D | 12 | 33 | 50 |
| 19-16N-1W, 1 | D | 36 | 30 | 104 |
| 19-16N-1W, 2 | D | 5 | 50 | 68 |
| 20-16N-1W, 1 | D | 16 | 42 | 70 |
| 20-16N-1W, 2 | D | 8 | 22 | 45 |
| 20-16N-1W, 3 | D | 10 | 55 | 65 |
| 20-16N-1W, 4 | D | 19 | 18 | 56 |
| 20-16N-1W, 5 | D | 10 | 37 | 55 |
| 3-16N-2W | D | -- | -- | 85 |

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|
| 17-16N-4W, 2 | B | 21 | 6 | 27 |
| 17-16N-4W, 3 | D | 8 | 13 | 21 |
| 17-16N-4W, 4 | D | 14 | 2 | 26 |
| 17-16N-4W, 5 | D | 14 | 6 | 30 |
| 17-16N-4W, 6 | B | 49 | 24 | 116 |
| 19-16N-4W, 1 | B | 25 | 2 | 27 |
| 19-16N-4W, 2 | B | 26 | 14 | 82 |
| 20-16N-4W | B | 20 | 33 | 87 |
| 21-16N-4W, 1 | B | 27 | 23 | 50 |
| 21-16N-4W, 2 | D | 17 | 20 | 43 |
| 22-16N-4W, 1 | D | 6 | 40 | 64 |
| 22-16N-4W, 2 | D | 5 | 55 | 60 |
| 25-16N-4W, 1 | D | 20 | 34 | 54 |
| 25-16N-4W, 2 | D | 17 | 23 | 40 |
| 28-16N-4W | B | 48 | 16 | 64 |
| 32-16N-4W, 1 | D | 18 | 12 | 45 |
| 32-16N-4W, 2 | D | 18 | 6 | 30 |
| 33-16N-4W | B | 61 | 1 | 100 |
| 35-16N-4W, 1 | D | 15 | 10 | 25 |
| 35-16N-4W, 2 | D | 22 | 2 | 30 |
| 35-16N-4W, 3 | D | 20 | 2 | 42 |
| 36-16N-4W, 1 | D | 14 | 10 | 24 |
| 36-16N-4W, 2 | D | 21 | 9 | 30 |
| 36-16N-4W, 3 | D | 18 | 4 | 29 |
| 1-16N-5W, 1 | D | 18 | 6 | 29 |
| 1-16N-5W, 2 | D | 12 | 8 | 30 |
| 1-16N-5W, 3 | D | 22 | 47 | 71 |
| 2-16N-5W, 1 | D | 19 | 25 | 63 |
| 2-16N-5W, 2 | B | 27 | 3 | 30 |
| 4-16N-5W, 1 | D | 18 | 6 | 24 |
| 4-16N-5W, 2 | D | 52 | 2 | 62 |
| 7-16N-5W, 1 | D | 18 | 3 | 29 |
| 7-16N-5W, 2 | D | 15 | 3 | 30 |
| 8-16N-5W, 1 | D | 22 | 10 | 32 |
| 8-16N-5W, 2 | B | 30 | 2 | 32 |

| | | | | |
|---|---|---|---|---|
| 12-16N-2W | D | -- | -- | 25 |
| 22-16N-2W | D | -- | -- | 140 |
| 24-16N-2W | D | 23 | 29 | 76 |
| 25-16N-2W, 1 | D | 15 | 51 | 66 |
| 25-16N-2W, 2 | D | 24 | 33 | 60 |
| 25-16N-2W, 3 | D | 95 | 10 | 105 |
| 25-16N-2W, 4 | D | 5 | 30 | 106 |
| 26-16N-2W, 1 | D | 18 | 4 | 39 |
| 26-16N-2W, 2 | D | 18 | 3 | 30 |
| 26-16N-2W, 3 | D | 10 | 20 | 58 |
| 26-16N-2W, 4 | D | 5 | 55 | 70 |
| 34-16N-2W, 1 | D | 10 | 36 | 61 |
| 34-16N-2W, 2 | D | 10 | 25 | 50 |
| 34-16N-2W, 3 | D | 6 | 31 | 66 |
| 34-16N-2W, 4 | D | 8 | 32 | 66 |
| 35-16N-2W, 1 | D | 55 | 25 | 86 |
| 35-16N-2W, 2 | D | 8 | 46 | 54 |
| 35-16N-2W, 3 | D | 8 | 46 | 58 |
| 10-16N-3W, 1 | D | 14 | 33 | 108 |
| 10-16N-3W, 2 | D | 18 | 16 | 84 |
| 10-16N-3W, 3 | D | 36 | 20 | 68 |
| 11-16N-3W | D | 45 | 5 | 50 |
| 12-16N-3W | D | 68 | 11 | 122 |
| 15-16N-3W, 1 | D | 116 | 16 | 142 |
| 15-16N-3W, 2 | D | 16 | 16 | 50 |
| 22-16N-3W | D | 13 | 4 | 44 |
| 28-16N-3W | D | 120 | 3 | 126 |
| 31-16N-3W | D | 17 | 13 | 30 |
| 32-16N-3W, 1 | D | 30 | 6 | 36 |
| 32-16N-3W, 2 | D | 30 | 6 | 36 |
| 3-16N-4W | D | 20 | 2 | 30 |
| 4-16N-4W | D | 15 | 10 | 25 |
| 8-16N-4W, 1 | D | 18 | 2 | 30 |
| 8-16N-4W, 2 | D | 21 | 3 | 24 |
| 9-16N-4W, 1 | D | 5 | 25 | 30 |
| 9-16N-4W, 2 | D | 10 | 10 | 43 |
| 15-16N-4W, 1 | D | 12 | 3 | 29 |
| 15-16N-4W, 2 | D | 12 | 28 | 56 |
| 15-16N-4W, 3 | D | 16 | 6 | 24 |
| 17-16N-4W, 1 | D | 10 | 14 | 24 |
| 9-16N-5W, 1 | D | 12 | 4 | 29 |
| 9-16N-5W, 2 | B | 26 | 4 | 30 |
| 9-16N-5W, 3 | D | 18 | 2 | 36 |
| 10-16N-5W, 1 | B | 25 | 2 | 27 |
| 10-16N-5W, 2 | D | 11 | 19 | 30 |
| 10-16N-5W, 3 | D | 18 | 6 | 24 |
| 10-16N-5W, 4 | D | 20 | 6 | 40 |
| 10-16N-5W, 5 | D | 8 | 48 | 57 |
| 11-16N-5W | D | 21 | 2 | 30 |
| 12-16N-5W, 1 | B | 27 | 53 | 80 |
| 12-16N-5W, 2 | D | 20 | 3 | 39 |
| 12-16N-5W, 3 | D | 40 | 4 | 54 |
| 12-16N-5W, 4 | D | 18 | 3 | 36 |
| 12-16N-5W, 5 | D | 20 | 10 | 30 |
| 12-16N-5W, 6 | D | 22 | 3 | 30 |
| 12-16N-5W, 7 | D | 16 | 6 | 30 |
| 12-16N-5W, 8 | B | -- | -- | 155 |
| 12-16N-5W, 9 | D | 15 | 9 | 30 |
| 13-16N-5W | D | 20 | 7 | 27 |
| 16-16N-5W, 1 | B | 20 | 46 | 66 |
| 16-16N-5W, 2 | B | 21 | 3 | 24 |
| 16-16N-5W, 3 | D | 18 | 8 | 30 |
| 18-16N-5W | D | 15 | 3 | 30 |
| 20-16N-5W | D | 25 | 3 | 45 |
| 24-16N-5W, 1 | D | 21 | 2 | 39 |
| 24-16N-5W, 2 | D | 16 | 2 | 30 |
| 24-16N-5W, 3 | B | 31 | 11 | 42 |
| 30-16N-5W | D | 18 | 1 | 30 |
| 36-16N-5W, 1 | B | 106 | 15 | 126 |
| 36-16N-5W, 2 | B | 26 | 24 | 50 |
| 36-16N-5W, 3 | D | 18 | 1 | 29 |
| 11-16N-6W | D | 14 | 10 | 24 |
| 12-16N-6W, 1 | D | 10 | 41 | 52 |
| 12-16N-6W, 2 | D | 43 | 12 | 56 |
| 12-16N-6W, 3 | D | 18 | 3 | 21 |
| 13-16N-6W | B | 56 | 4 | 94 |
| 24-16N-6W | B | 24 | 6 | 30 |
| 25-16N-6W | D | 18 | 2 | 21 |
| 30-16N-6W | D | 13 | 5 | 24 |
| 34-16N-6W | D | 38 | 5 | 69 |

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*Where two or more wells are shown in a section, wells are numbered on plate 2.

(Continued on next page)

## Appendix 1 - Continued

Read left side of table to bottom of facing page; then return to this page (right-hand side).

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|
| 35-16N-6W, 1 | D | 18 | 2 | 30 |
| 35-16N-6W, 2 | D | 18 | 6 | 24 |
| 35-16N-6W, 3 | D | 18 | 2 | 20 |
| 35-16N-6W, 4 | D | 16 | 1 | 25 |
| 35-16N-6W, 5 | D | 14 | 9 | 23 |
| 36-16N-6W | B | 47 | 33 | 80 |
| 1-16N-7W | D | 20 | 4 | 59 |
| 24-16N-7W | D | 31 | 8 | 39 |
| 19-17N-2W, 1 | D | 59 | 4 | 63 |
| 19-17N-2W, 2 | D | 18 | 1 | 29 |
| 24-17N-2W | D | 56 | 28 | 98 |
| 18-17N-3W | D | 24 | 2 | 44 |
| 2-17N-4W, 1 | D | 8 | 1 | 25 |
| 2-17N-4W, 2 | D | 15 | 7 | 28 |
| 3-17N-4W | D | 18 | 13 | 31 |
| 4-17N-4W | D | 23 | 3 | 26 |
| 5-17N-4W | D | -- | -- | 44 |
| 10-17N-4W | D | 5 | 6 | 20 |
| 29-17N-4W | D | 20 | 3 | 27 |
| 30-17N-4W, 1 | D | 18 | 7 | 33 |
| 30-17N-4W, 2 | D | 20 | 3 | 30 |
| 31-17N-4W, 1 | D | 48 | 8 | 56 |
| 31-17N-4W, 2 | D | 5 | 48 | 58 |
| 31-17N-4W, 3 | D | 25 | 28 | 60 |
| 32-17N-4W | D | 20 | 2 | 30 |
| 33-17N-4W | D | 20 | 10 | 30 |
| 34-17N-4W | D | 24 | 3 | 37 |
| 4-17N-5W | B | 63 | 20 | 83 |
| 8-17N-5W, 1 | B | 102 | 6 | 115 |
| 8-17N-5W, 2 | D<br>B | 28<br>96 | 5<br>22 | 200 |
| 20-17N-5W | D | -- | -- | 40 |
| 25-17N-5W | D<br>B | 27<br>65 | 15<br>25 | 127 |
| 29-17N-5W, 1 | D | 25 | 2 | 27 |
| 29-17N-5W, 2 | D | 22 | 7 | 29 |

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|
| 11-15N-1E | D | 38 | 4 | 42 |
| 12-15N-1E | D | 110 | 24 | 134 |
| 16-15N-1E | D | 28 | 2 | 30 |
| 25-15N-1E, 1 | D | 70 | 19 | 89 |
| 25-15N-1E, 2 | D | 55 | 20 | 75 |
| 35-15N-1E | D | 23 | 75 | 100 |
| 36-15N-1E, 1 | D | 20 | 44 | 75 |
| 36-15N-1E, 2 | D | 30 | 50 | 85 |
| 1-15N-2E, 1 | D | 45 | 8 | 60 |
| 1-15N-2E, 2 | D | 121 | 4 | 155 |
| 1-15N-2E, 3 | D | -- | -- | 51 |
| 1-15N-2E, 4 | D | 54 | 6 | 60 |
| 2-15N-2E | D | 47 | 11 | 62 |
| 3-15N-2E | D | 118 | 34 | 200 |
| 7-15N-2E | D | 120 | 3 | 123 |
| 9-15N-2E | D | 107 | 8 | 146 |
| 12-15N-2E | D | 86 | 5 | 91 |
| 14-15N-2E | D | 142 | 8 | 150 |
| 16-15N-2E | D | 71 | 5 | 76 |
| 17-15N-2E | D | 137 | 7 | 144 |
| 18-15N-2E | D | 109 | 6 | 115 |
| 28-15N-2E | D | 113 | 18 | 136 |
| 29-15N-2E | D | 110 | 23 | 134 |
| 32-15N-2E | D | 122 | 16 | 214 |
| 33-15N-2E | D | 112 | 9 | 130 |
| 36-15N-2E | D | 123 | 17 | 140 |
| 3-15N-3E, 1 | D | 65 | 19 | 101 |
| 3-15N-3E, 2 | D | 74 | 9 | 83 |
| 3-15N-3E, 3 | D | 67 | 18 | 100 |
| 3-15N-3E, 4 | D | -- | -- | 200 |
| 3-15N-3E, 5 | D | 72 | 5 | 87 |
| 4-15N-3E | D | 65 | 14 | 145 |
| 6-15N-3E, 1 | D | 80 | 3 | 83 |
| 6-15N-3E, 2 | D | 81 | 85 | 86 |
| 10-15N-3E, 1 | D | 79 | 4 | 83 |

|  |  |  |  |  |
|---|---|---|---|---|
| 29-17N-5W, 3 | D | 18 | 2 | 38 |
| 30-17N-5W | D | 21 | 3 | 36 |
| 31-17N-5W | D | 24 | 2 | 26 |
| 33-17N-5W | D | 16 | 20 | 36 |
| 25-17N-6W, 1 | D | 20 | 2 | 30 |
| 25-17N-6W, 2 | D | 30 | 5 | 45 |
| 32-17N-7W | B | -- | -- | 108 |
| 34-18N-4W | D | 18 | 10 | 41 |
| 35-18N-4W | D | 10 | 19 | 40 |
| CHRISTIAN COUNTY |  |  |  |  |
| 13-15N-1W | D | 32 | 2 | 41 |
| 14-15N-1W | D | 19 | 2 | 40 |
| 15-15N-1W | D | 25 | 7 | 55 |
| 31-15N-1W | D | 33 | 3 | 50 |
| 1-15N-2W, 1 | D | 40 | 29 | 69 |
| 1-15N-2W, 2 | D | 35 | 20 | 69 |
| 1-15N-2W, 3 | D | 45 | 20 | 138 |
| 11-15N-2W | D | 30 | 29 | 59 |
| 12-15N-2W, 1 | D | 54 | 11 | 68 |
| 12-15N-2W, 2 | D | 30 | 10 | 89 |
| 12-15N-2W, 3 | D | 50 | 9 | 79 |
| 12-15N-2W, 4 | D | -- | -- | 219 |
| 12-15N-2W, 5 | D | 53 | 21 | 197 |
| 27-15N-2W | D | 20 | 3 | 36 |
| 22-15N-3W, 1 | D | 26 | 1 | 40 |
| 22-15N-3W, 2 | D | 17 | 1 | 30 |
| 23-15N-3W, 1 | D | 14 | 3 | 41 |
| 23-15N-3W, 2 | D | 37 | 1 | 41 |
| 24-15N-3W | D | 17 | 4 | 35 |
| MACON COUNTY |  |  |  |  |
| 5-14N-1E, 1 | D | 41 | 13 | 55 |
| 5-14N-1E, 2 | D | 40 | 9 | 54 |
| 10-14N-1E | D | 21 | 6 | 27 |
| 13-14N-1E | D | 45 | 3 | 48 |
| 16-14N-1E | D | 35 | 53 | 88 |
| 18-14N-2E | D | 8 | 26 | 34 |
| 6-14N-3E | D | 50 | 5 | 55 |
| 14-14N-3E | D | 86 | 38 | 124 |
| 15-14N-3E | D | 109 | 2 | 113 |
| 10-15N-3E, 2 | D | 89 | 1 | 90 |
| 11-15N-3E | D | 75 | 6 | 81 |
| 36-15N-3E | D | 87 | 7 | 103 |
| 4-15N-4E | D | 149 | 10 | 159 |
| 2-16N-1W, 1 | D | 11 | 43 | 54 |
| 2-16N-1W, 2 | D | 22 | 23 | 72 |
| 2-16N-1W, 3 | D | 35 | 14 | 49 |
| 3-16N-1W, 1 | D | 5 | 44 | 53 |
| 3-16N-1W, 2 | D | 5 | 35 | 68 |
| 3-16N-1W, 3 | D | 10 | 45 | 78 |
| 4-16N-1W, 1 | D | 7 | 33 | 48 |
| 4-16N-1W, 2 | D | 10 | 13 | 63 |
| 11-16N-1W, 1 | D | 15 | 25 | 40 |
| 11-16N-1W, 2 | D | 20 | 20 | 49 |
| 11-16N-1W, 3 | D | 15 | 5 | 49 |
| 11-16N-1W, 4 | D | 35 | 5 | 45 |
| 1-16N-1E | D | 96 | 6 | 102 |
| 2-16N-1E | D | 67 | 5 | 72 |
| 8-16N-1E, 1 | D | 65 | 2 | 112 |
| 8-16N-1E, 2 | D | -- | -- | 190 |
| 8-16N-1E, 3 | D | 151 | 12 | 203 |
| 9-16N-1E, 1 | D | 129 | 3 | 132 |
| 9-16N-1E, 2 | D | 123 | 13 | 136 |
| 10-16N-1E | D | 103 | 1 | 145 |
| 13-16N-1E, 1 | D | 70 | 4 | 74 |
| 13-16N-1E, 2 | D | 39 | 1 | 41 |
| 13-16N-1E, 3 | D<br>B | 103<br>210 | 15<br>1 | 211 |
| 13-16N-1E, 4 | D | 83 | 7 | 90 |
| 13-16N-1E, 5 | D | 56 | 8 | 64 |
| 13-16N-1E, 6 | D | 84 | 5 | 97 |
| 14-16N-1E | D | 79 | 6 | 85 |
| 15-16N-1E, 1 | D | 135 | 5 | 140 |
| 15-16N-1E, 2 | D | 52 | 6 | 58 |
| 15-16N-1E, 3 | D | 70 | 3 | 73 |
| 15-16N-1E, 4 | D | 140 | 9 | 170 |
| 19-16N-1E | D | 32 | 3 | 35 |
| 24-16N-1E | D | 150 | 30 | 180 |
| 26-16N-1E, 1 | D | 65 | 6 | 73 |
| 26-16N-1E, 2 | D | 81 | 6 | 87 |
| 26-16N-1E, 3 | D | 90 | 3 | 93 |

*Where two or more wells are shown in a section, wells are numbered on plate 2.

(Continued on next page)

# Appendix 1 - Continued

Read left side of table to bottom of facing page; then return to this page (right-hand side).

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) | Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|---|---|---|---|---|
| 29-16N-1E | D | 84 | 5 | 89 | 29-16N-2E, 2 | D | 83 | 7 | 141 |
| 34-16N-1E | D | 65 | 8 | 73 | 29-16N-2E, 3 | D | 103 | 2 | 105 |
| 35-16N-1E | D | 100 | 10 | 110 | 29-16N-2E, 4 | D | 74 | 9 | 83 |
| 1-16N-2E, 1 | D | 45 | 2 | 75 | 31-16N-2E | D | 94 | 13 | 107 |
| 1-16N-2E, 2 | D | -- | -- | 115 | 33-16N-2E, 1 | D | 70 | 18 | 88 |
| 2-16N-2E, 1 | D | 87 | 42 | 130 | 33-16N-2E, 2 | D | 85 | 15 | 100 |
| 2-16N-2E, 2 | D | 55 | 12 | 67 | 33-16N-2E, 3 | D | -- | -- | 157 |
| 2-16N-2E, 3 | D | 75 | 27 | 102 | 33-16N-2E, 4 | D | 92 | 15 | 107 |
| 2-16N-2E, 4 | D | 67 | 4 | 71 | 34-16N-2E | D | -- | -- | 129 |
| 2-16N-2E, 5 | D | 38 | 10 | 48 | 35-16N-2E, 1 | D | -- | -- | 94 |
| 3-16N-2E, 1 | D | 61 | 3 | 64 | 35-16N-2E, 2 | D | 89 | 5 | 94 |
| 3-16N-2E, 2 | D | 78 | 5 | 83 | 35-16N-2E, 3 | D | 50 | 6 | 56 |
| 3-16N-2E, 3 | D | 55 | 15 | 70 | 35-16N-2E, 4 | D | -- | -- | 195 |
| 3-16N-2E, 4 | D | 37 | 20 | 57 | 36-16N-2E, 1 | D | 96 | 6 | 102 |
| 3-16N-2E, 5 | D | 42 | 13 | 55 | 36-16N-2E, 2 | D | 103 | 8 | 111 |
| 3-16N-2E, 6 | D | 43 | 33 | 76 | 36-16N-2E, 3 | D | 120 | 8 | 128 |
| 4-16N-2E, 1 | D | 100 | 2 | 102 | 3-16N-3E | D | 86 | 9 | 95 |
| 4-16N-2E, 2 | D | 90 | 8 | 130 | 5-16N-3E, 1 | D | 80 | 18 | 98 |
| 7-16N-2E, 1 | D | 62 | 2 | 69 | 5-16N-3E, 2 | D | 97 | 12 | 109 |
| 7-16N-2E, 2 | D | 78 | 2 | 105 | 7-16N-3E, 1 | D | 50 | 7 | 97 |
| 7-16N-2E, 3 | D | 75 | 4 | 79 | 7-16N-3E, 2 | D | 48 | 32 | 106 |
| 9-16N-2E, 1 | D | 110 | 4 | 114 | 7-16N-3E, 3 | D | 73 | 27 | 100 |
| 9-16N-2E, 2 | D | 111 | 3 | 123 | 7-16N-3E, 4 | D | 18 | 47 | 105 |
| 10-16N-2E | D | -- | -- | 95 | 7-16N-3E, 5 | D | 14 | 59 | 97 |
| 11-16N-2E, 1 | D | -- | -- | 85 | 7-16N-3E, 6 | D | 17 | 18 | 96 |
| 11-16N-2E, 2 | D | 40 | 24 | 84 | 7-16N-3E, 7 | D | 65 | 31 | 97 |
| 12-16N-2E, 1 | D | 32 | 54 | 86 | 8-16N-3E, 1 | D | 82 | 16 | 98 |
| 12-16N-2E, 2 | D | 30 | 53 | 83 | 8-16N-3E, 2 | D | 53 | 27 | 80 |
| 13-16N-2E | D | 56 | 37 | 93 | 8-16N-3E, 3 | D | 56 | 28 | 84 |
| 14-16N-2E, 1 | D | 80 | 34 | 114 | 8-16N-3E, 4 | D | 28 | 65 | 93 |
| 14-16N-2E, 2 | D | 93 | 7 | 106 | 8-16N-3E, 5 | D | 61 | 19 | 80 |
| 14-16N-2E, 3 | D | 82 | 27 | 109 | 8-16N-3E, 6 | D | 46 | 33 | 79 |
| 15-16N-2E, 1 | D | 20 | 7 | 34 | 8-16N-3E, 7 | D | 43 | 22 | 66 |
| 15-16N-2E, 2 | D | 20 | 15 | 40 | 9-16N-3E, 1 | D | 77 | 1 | 78 |
| 15-16N-2E, 3 | D | 45 | 9 | 54 | 9-16N-3E, 2 | D | 53 | 3 | 60 |

|  |  |  |  |  |
|---|---|---|---|---|
| 15-16N-2E, 4 | D | 54 | 10 | 64 |
| 17-16N-2E, 1 | D | 159 | 8 | 167 |
| 17-16N-2E, 2 | D | 5 | 33 | 47 |
| 18-16N-2E, 1 | D | 86 | 5 | 91 |
| 18-16N-2E, 2 | D | 60 | 4 | 64 |
| 20-16N-2E, 1 | D | -- | -- | 57 |
| 20-16N-2E, 2 | D | -- | -- | 47 |
| 20-16N-2E, 3 | D | -- | -- | 56 |
| 20-16N-2E, 4 | D | 106 | 10 | 116 |
| 21-16N-2E, 1 | D | 50 | 11 | 61 |
| 21-16N-2E, 2 | D | 61 | 5 | 66 |
| 22-16N-2E, 1 | D | 41 | 4 | 50 |
| 22-16N-2E, 2 | D | 37 | 15 | 53 |
| 22-16N-2E, 3 | D | 15 | 33 | 56 |
| 22-16N-2E, 4 | D | 40 | 22 | 62 |
| 22-16N-2E, 5 | D | 15 | 43 | 90 |
| 22-16N-2E, 6 | D | 23 | 4 | 61 |
| 22-16N-2E, 7 | D | 140 | 1 | 141 |
| 23-16N-2E, 1 | D | 59 | 14 | 73 |
| 23-16N-2E, 2 | D | 68 | 13 | 81 |
| 24-16N-2E, 1 | D | 58 | 50 | 108 |
| 24-16N-2E, 2 | D | 65 | 20 | 85 |
| 24-16N-2E, 3 | D | 34 | 3 | 135 |
| 25-16N-2E, 1 | D | 83 | 6 | 89 |
| 25-16N-2E, 2 | D | 58 | 3 | 61 |
| 25-16N-2E, 3 | D | 99 | 20 | 119 |
| 25-16N-2E, 4 | D | 63 | 1 | 64 |
| 25-16N-2E, 5 | D | 84 | 6 | 90 |
| 25-16N-2E, 6 | D | 77 | 9 | 86 |
| 25-16N-2E, 7 | D | 95 | 12 | 107 |
| 25-16N-2E, 8 | D | 63 | 8 | 71 |
| 25-16N-2E, 9 | D | 97 | 12 | 109 |
| 27-16N-2E, 1 | D | 55 | 25 | 80 |
| 27-16N-2E, 2 | D | 61 | 23 | 84 |
| 28-16N-2E, 1 | D | 75 | 17 | 93 |
| 28-16N-2E, 2 | D | 85 | 27 | 112 |
| 28-16N-2E, 3 | D | 46 | 6 | 52 |
| 28-16N-2E, 4 | D | 82 | 10 | 92 |
| 28-16N-2E, 5 | D | 28 | 14 | 107 |
| 29-16N-2E, 1 | D | 75 | 7 | 85 |
| 9-16N-3E, 3 | D | 88 | 8 | 96 |
| 14-16N-3E, 1 | D | 82 | 15 | 97 |
| 14-16N-3E, 2 | D | 64 | 5 | 175 |
| 14-16N-3E, 3 | D | -- | -- | 111 |
| 16-16N-3E, 1 | D | 77 | 13 | 114 |
| 16-16N-3E, 2 | D | 84 | 2 | 86 |
| 17-16N-3E, 1 | D | 56 | 7 | 73 |
| 17-16N-3E, 2 | D | 166 | 1 | 167 |
| 17-16N-3E, 3 | D | 63 | 7 | 143 |
| 18-16N-3E, 1 | D | 41 | 15 | 56 |
| 18-16N-3E, 2 | D | 37 | 14 | 51 |
| 18-16N-3E, 3 | D | 47 | 9 | 56 |
| 18-16N-3E, 4 | D | 73 | 4 | 83 |
| 18-16N-3E, 5 | D | 60 | 15 | 75 |
| 18-16N-3E, 6 | D | 60 | 12 | 72 |
| 19-16N-3E, 1 | D | 59 | 8 | 67 |
| 19-16N-3E, 2 | D | 69 | 3 | 72 |
| 19-16N-3E, 3 | D | -- | -- | 65 |
| 19-16N-3E, 4 | D | -- | -- | 117 |
| 20-16N-3E, 1 | D | 87 | 6 | 93 |
| 20-16N-3E, 2 | D | 74 | 15 | 117 |
| 20-16N-3E, 3 | D | 32 | 2 | 34 |
| 20-16N-3E, 4 | D | 35 | 5 | 40 |
| 25-16N-3E | D | 121 | 10 | 131 |
| 28-16N-3E | D | 72 | 6 | 97 |
| 29-16N-3E | D | 23 | 4 | 27 |
| 30-16N-3E, 1 | D | 71 | 6 | 88 |
| 30-16N-3E, 2 | D | 86 | 5 | 104 |
| 30-16N-3E, 3 | D | 122 | 4 | 126 |
| 31-16N-3E | D | 53 | 7 | 61 |
| 32-16N-3E | D | 71 | 3 | 74 |
| 33-16N-3E | D | 134 | 13 | 211 |
| 34-16N-3E, 1 | D | 93 | 1 | 94 |
| 34-16N-3E, 2 | D | 78 | 2 | 81 |
| 6-16N-4E | D | 94 | 4 | 98 |
| 8-16N-4E | D | 135 | 3 | 138 |
| 9-16N-4E | D | 106 | 1 | 107 |
| 16-16N-4E | D | 91 | 4 | 95 |
| 21-16N-4E | D | -- | -- | 109 |
| 28-16N-4E | D | 91 | 4 | 95 |

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*Where two or more wells are shown in a section, wells are numbered on plate 2.

(Concluded on next page)

## APPENDIX 1 - Concluded

Read left side of table to bottom of facing page; then return to this page (right-hand side).

| Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) | Well location Sec.-T.-R., Map no.* | Origin of water (D=drift; B=bedrock) | Depth to water-bearing zone (ft) | Total thickness of aquifer(s) penetrated (ft) | Total depth of well (ft) |
|---|---|---|---|---|---|---|---|---|---|
| 29-16N-4E | D | 102 | 6 | 108 | 9-17N-3E, 3 | D | 78 | 17 | 132 |
| 31-16N-4E, 1 | D | 90 | 6 | 96 | 14-17N-3E | D | 60 | 2 | 62 |
| 31-16N-4E, 2 | D | 107 | 2 | 109 | 16-17N-3E | D | 107 | 1 | 150 |
| 32-16N-4E | D | 71 | 9 | 80 | 21-17N-3E, 1 | D | 86 | 3 | 89 |
| 21-17N-1W | D | -- | -- | 41 | 21-17N-3E, 2 | D | 90 | 13 | 103 |
| 33-17N-1W | D | 49 | 11 | 60 | 22-17N-3E | D | 103 | 8 | 111 |
| 9-17N-1E | D | 101 | 33 | 137 | 23-17N-3E | D | 100 | 4 | 104 |
| 10-17N-1E, 1 | D | 89 | 41 | 130 | 25-17N-3E | D | 45 | 3 | 48 |
| 10-17N-1E, 2 | D | 105 | 13 | 140 | 26-17N-3E | D | 81 | 3 | 84 |
| 11-17N-1E | D | 110 | 3 | 115 | 27-17N-3E, 1 | D | 55 | 45 | 101 |
| 14-17N-1E, 1 | D | 108 | 23 | 138 | 27-17N-3E, 2 | D | 70 | 45 | 115 |
| 14-17N-1E, 2 | D | 153 | 1 | 154 | 27-17N-3E, 3 | D | 71 | 50 | 121 |
| 14-17N-1E, 3 | D | 142 | 11 | 160 | 28-17N-3E, 1 | D | 105 | 3 | 110 |
| 15-17N-1E, 1 | B | 150 | 6 | 156 | 28-17N-3E, 2 | D | 118 | 7 | 125 |
| 15-17N-1E, 2 | D | 105 | 16 | 121 | 28-17N-3E, 3 | D | 84 | 7 | 91 |
| 16-17N-1E | D | 69 | 3 | 72 | 28-17N-3E, 4 | D | 87 | 11 | 103 |
| 18-17N-1E | D | 39 | 2 | 135 | 30-17N-3E | D | 105 | 7 | 112 |
| 19-17N-1E | D | 30 | 4 | 180 | 34-17N-3E | D | 74 | 12 | 86 |
| 24-17N-1E | D | 128 | 5 | 165 | 4-17N-4E | D | 100 | 27 | 166 |
| 25-17N-1E | D | 121 | 3 | 124 | 6-17N-4E | D | 124 | 8 | 132 |
| 26-17N-1E, 1 | D | 78 | 2 | 80 | 9-17N-4E | D | 112 | 7 | 119 |
| 26-17N-1E, 2 | D | 98 | 6 | 128 | 21-17N-4E, 1 | D | 118 | 12 | 130 |
| 34-17N-1E, 1 | D | 63 | 4 | 67 | 21-17N-4E, 2 | D | 64 | 9 | 92 |
| 34-17N-1E, 2 | D | 107 | 2 | 110 | 21-17N-4E, 3 | D | 105 | 11 | 116 |
| 36-17N-1E | D | 128 | 2 | 130 | 21-17N-4E, 4 | D | -- | -- | 115 |
| 2-17N-2E | D | 105 | 4 | 109 | 21-17N-4E, 5 | D | 99 | 16 | 115 |
| 3-17N-2E | D | 109 | 4 | 113 | 33-17N-4E, 1 | D | 19 | 14 | 51 |
| 4-17N-2E, 1 | D | 109 | 3 | 112 | 33-17N-4E, 2 | D | 140 | 1 | 141 |
| 4-17N-2E, 2 | D | -- | -- | 126 | 1-18N-1E | D | 112 | 3 | 115 |
| 4-17N-2E, 3 | D | 108 | 10 | 118 | 3-18N-1E, 1 | D | 51 | 2 | 53 |
| 6-17N-2E | D | 89 | 8 | 97 | 3-18N-1E, 2 | D | 35 | 4 | 39 |
| 7-17N-2E, 1 | D | -- | -- | 170 | 24-18N-1E | D | -- | -- | 163 |
| 7-17N-2E, 2 | D | 150 | 16 | 166 | 35-18N-1E | D | 25 | 13 | 47 |
| 9-17N-2E, 1 | D | 144 | 4 | 148 | 10-17N-2E | D | 102 | 1 | 105 |
| 9-17N-2E, 2 | D | 126 | 2 | 150 | 11-17N-2E | D | 150 | 3 | 153 |

| | | | | |
|---|---|---|---|---|
| 14-17N-2E, 1 | D | 27 | 6 | 62 |
| 14-17N-2E, 2 | D | 54 | 6 | 60 |
| 14-17N-2E, 3 | D | 49 | 1 | 50 |
| 14-17N-2E, 4 | D | 59 | 6 | 65 |
| 15-17N-2E, 1 | D | 46 | 6 | 52 |
| 15-17N-2E, 2 | D | 34 | 27 | 61 |
| 17-17N-2E | D | 93 | 17 | 113 |
| 18-17N-2E | D | 32 | 12 | 44 |
| 21-17N-2E | D | 30 | 2 | 32 |
| 23-17N-2E | D | 57 | 4 | 61 |
| 26-17N-2E | D | 83 | 2 | 85 |
| 28-17N-2E, 1 | D | 69 | 2 | 131 |
| 28-17N-2E, 2 | D | 66 | 5 | 74 |
| 28-17N-2E, 3 | D | 61 | 3 | 74 |
| 28-17N-2E, 4 | D | 51 | 9 | 60 |
| 29-17N-2E, 1 | D | 27 | 3 | 30 |
| 29-17N-2E, 2 | D | 23 | 4 | 134 |
| 30-17N-2E, 1 | D | 103 | 3 | 106 |
| 30-17N-2E, 2 | D | 98 | 5 | 103 |
| 31-17N-2E | D | 90 | 3 | 93 |
| 33-17N-2E | D | 51 | 5 | 56 |
| 34-17N-2E, 1 | D | 53 | 39 | 92 |
| 34-17N-2E, 2 | D | 53 | 47 | 100 |
| 34-17N-2E, 3 | D | 55 | 43 | 98 |
| 34-17N-2E, 4 | D | 42 | 13 | 55 |
| 35-17N-2E, 1 | D | 65 | 20 | 85 |
| 35-17N-2E, 2 | D | 56 | 24 | 80 |
| 35-17N-2E, 3 | D | 67 | 4 | 71 |
| 35-17N-2E, 4 | D | -- | -- | 87 |
| 35-17N-2E, 5 | D | 92 | 9 | 101 |
| 7-17N-3E | D | 104 | 12 | 116 |
| 9-17N-3E, 1 | B | 186 | 29 | 264 |
| 9-17N-3E, 2 | D | 151 | 3 | 163 |
| 1-18N-2E | D | 78 | 6 | 84 |
| 2-18N-2E, 1 | D | 280 | 12 | 292 |
| 2-18N-2E, 2 | D | 219 | 69 | 288 |
| 2-18N-2E, 3 | D | 69 | 8 | 77 |
| 5-18N-2E | D | 213 | 23 | 236 |
| 6-18N-2E | D | 68 | 7 | 75 |
| 10-18N-2E | D | 78 | 2 | 81 |
| 11-18N-2E | D | 82 | 6 | 88 |
| 13-18N-2E | D | 55 | 5 | 60 |
| 26-18N-2E | D | 114 | 6 | 120 |
| 30-18N-2E | D | 72 | 9 | 82 |
| 32-18N-2E | D | 169 | 1 | 170 |
| 1-18N-3E | D | 208 | 26 | 234 |
| 4-18N-3E | D | 210 | 48 | 258 |
| 6-18N-3E, 1 | D | 50 | 9 | 59 |
| 6-18N-3E, 2 | D | 50 | 10 | 60 |
| 7-18N-3E | D | 210 | 25 | 235 |
| 10-18N-3E, 1 | D | 66 | 2 | 69 |
| 10-18N-3E, 2 | D | 93 | 2 | 95 |
| 21-18N-3E | D | 110 | 37 | 155 |
| 26-18N-3E, 1 | D | 201 | 51 | 254 |
| 26-18N-3E, 2 | D | 210 | 23 | 233 |
| 32-18N-3E | D | 170 | 7 | 177 |
| 4-18N-4E | D | 200 | 85 | 287 |
| 7-18N-4E | D | 102 | 1 | 104 |
| 8-18N-4E, 1 | D | 185 | 119 | 304 |
| 8-18N-4E, 2 | D | 184 | 109 | 300 |
| 9-18N-4E | D | -- | -- | 100 |
| 18-18N-4E | D | 79 | 1 | 80 |
| 19-18N-4E | D | 150 | 96 | 260 |
| 20-18N-4E | D | 90 | 4 | 94 |
| 29-18N-4E, 1 | D | 48 | 1 | 49 |
| 29-18N-4E, 2 | D | 180 | 74 | 255 |

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*Where two or more wells are shown in a section, wells are numbered on plate 2.

# APPENDIX 2

## DEFINITIONS OF ENGINEERING CHARACTERISTICS

Engineering terms used in the text, including table 7, are explained below in three categories: hydrologic conditions, classification of properties, and slope. The system of engineering geology map symbols used on plate 6 is also explained.

### A. Hydrologic Conditions

1. Flooding

Seldom to never - frequency less than once in 25 years

Occasional - frequency once in one to 25 years

Seasonal - frequency one or more times per year

2. Water table

| This report | General depth most of year, ft |
|---|---|
| High | Near surface down to basement level, 0-10 |
| Medium | Near basement or foundation level, 10-15 |
| Low | Lower than basement or foundation level, below 15 |

3. Natural moisture content

| This report | Moisture content (% dry wt.) | Materials |
|---|---|---|
| Very high | > 100 | Organic materials, including peat |
| High | 50-100 | |
| Medium | 30-50 | Materials rich in organic matter or alluvial silts and clays |
| Low | 10-30 | Loess, coarse alluvium, colluvium, or weathered till |
| Very low | < 10 | Unweathered till, desiccated materials, or bedrock |

4. Permeability is the relative ease with which a material is capable of transmitting water. The engineer and the hydrologist express permeability as a velocity or volume of flow as follows:

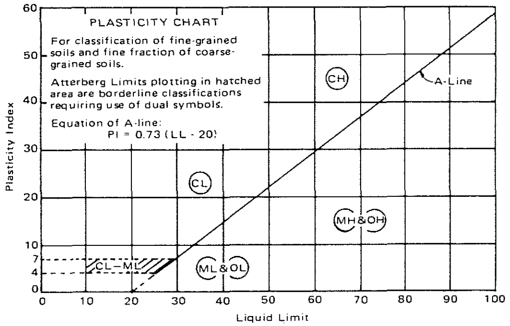
| This report | cm/sec | gal/day/ft$^2$ | Materials | Drainage for construction |
|---|---|---|---|---|
| Very high | $10^{-1}$<br>$10^{-1}$ to $10^{-2}$ | $> 10^3$<br>$10^3$ to $10^2$ | Clean gravels<br>Clean sands | Gravity<br>Gravity |
| High | $10^{-2}$ to $10^{-3}$ | $10^2$ to 10 | Sand and gravel mixtures | Gravity or well points |
| Low | $10^{-3}$ to $10^{-6}$ | 10 to $10^{-2}$ | Very fine sands; organic and inorganic silts; mixture of sand, silt, and clay; glacial till; or stratified clay deposits | Well points with or without vacuum |
| Practically impermeable | $10^{-6}$ to $10^{-8}$ | $10^{-2}$ to $10^{-4}$ | Homogeneous clays | Not feasible |
| Impermeable | $< 10^{-8}$ | $< 10^{-4}$ | Dense rock | |

## B. Engineering Properties and Classification of Surficial Deposits

### 1. Unified Soil Classification System

Classifications of the materials in the map units are determined in part from their classifications in the Unified Soil Classification System. This system is a soil-identification system based on a material's grain size, distribution, and plasticity characteristics. More information about this system is found in ASTM D 2487 (American Society for Testing Materials, 1975). See also table A on page 71.

## TABLE A - ASTM SOIL CLASSIFICATION SYSTEM (UNIFIED)†

| Major Divisions | | | Group Symbols | Typical Names | Classification Criteria | | |
|---|---|---|---|---|---|---|---|
| Coarse-Grained Soils<br>More than 50% retained on No. 200 sieve* | Gravels<br>50% or more of coarse fraction retained on No. 4 sieve | Clean Gravels | GW | Well-graded gravels and gravel-sand mixtures, little or no fines | Classification on basis of percentage of fines<br>Less than 5% pass No. 200 sieve GW, GP, SW, SP<br>More than 12% pass No. 200 sieve GM, GC, SM, SC<br>5% to 12% pass No. 200 sieve Borderline classification requiring use of dual symbols | $C_u = D_{60}/D_{10}$ Greater than 4<br>$C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 | |
| | | | GP | Poorly graded gravels and gravel-sand mixtures, little or no fines | | Not meeting both criteria for GW | |
| | | Gravels with Fines | GM | Silty gravels, gravel-sand-silt mixtures | | Atterberg limits plot below "A" line or plasticity index less than 4 | Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures | | Atterberg limits plot above "A" line and plasticity index greater than 7 | |
| | Sands<br>More than 50% of coarse fraction passes No. 4 sieve | Clean Sands | SW | Well-graded sands and gravelly sands, little or no fines | | $C_u = D_{60}/D_{10}$ Greater than 6<br>$C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 | |
| | | | SP | Poorly graded sands and gravelly sands, little or no fines | | Not meeting both criteria for SW | |
| | | Sands with Fines | SM | Silty sands, sand-silt mixtures | | Atterberg limits plot below "A" line or plasticity index less than 4 | Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols |
| | | | SC | Clayey sands, sand-clay mixtures | | Atterberg limits plot above "A" line and plasticity index greater than 7 | |
| Fine-Grained Soils<br>50% or more passes No. 200 sieve* | Silts and Clays<br>Liquid limit 50% or less | | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands |  | | |
| | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | | | |
| | | | OL | Organic silts and organic silty clays of low plasticity | | | |
| | Silts and Clays<br>Liquid limit greater than 50% | | MH | Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts | | | |
| | | | CH | Inorganic clays of high plasticity, fat clays | | | |
| | | | OH | Organic clays of medium to high plasticity | | | |
| Highly Organic Soils | | | PT | Peat, muck, and other highly organic soils | Visual-Manual Identification, see ASTM Designation D2488. | | |

*Based on the material passing the 3-in. (75-mm.) sieve.

† Table reprinted from PCA Soil Primer: Portland Cement Association, 1973, p. 19. Reprinted by permission of the Portland Cement Association, Skokie, Illinois.

2. The approximate bearing strengths (after Terzaghi and Peck, 1967) are grouped as follows:

| | Clayey soils | | | | Sandy soils | |
|---|---|---|---|---|---|---|
| This report | Relative strength | Field test | Unconfined compressive strength (tons/ft$^2$) | Standard penetration test, blow count* | Standard penetration test, blow count* | Relative density |
| Low | Very soft | Easily penetrated several inches by fist | 0.25 | 2 | | |
| | Soft | Easily penetrated several inches by thumb | 0.25-0.5 | 2-4 | 4 | Very loose |
| Medium | Medium | Can be penetrated several inches by thumb with moderate effort | 0.5 -1.0 | 4-8 | 4-10 | Loose |
| | Stiff | Readily indented by thumb, but penetrated only with great effort | 1.0 -2.0 | 8-15 | 10-30 | Medium |
| High | Very stiff | Readily indented by thumbnail | 2.0 -4.0 | 15-30 | 30-50 | Dense |
| | Hard | Indented with difficulty by thumbnail | > 4.0 | > 30 | > 50 | Very dense |

* Blow count for 12-in. penetration (140-lb hammer; drop of 30 in.).

3. Compressibility is the tendency of a material to consolidate, or decrease in volume, thus allowing a structure built on it to settle. The engineer is first interested in the amount of settlement. If the expected amount of settlement is greater at one part of a site than at another, remedial measures must be taken. The time required for consolidation to take place becomes an important factor because it may be necessary to allow additional time to load a site to produce consolidation before work on a structure begins. As consolidation progresses, the bearing strength of the material increases until a relatively stable condition is attained. The time necessary to consolidate is related to the compressibility of the material, the permeability of the material, and the drainage. The compressibility factor expressed in this report is as follows:

| This report | Reaction to loading | Compression index | Moisture content (%) | Earth materials and moisture conditions |
|---|---|---|---|---|
| Very high | | 1-3 | > 100 | Very clayey or organic materials having very high plasticity, very high moisture, and low density |
| High | Greatest expected settlement measured in inches | 0.4-1.0 | 50-100 | Clays having high plasticity, high moisture, and low density |
| Medium | | 0.2-0.4 | 30-50 | Silts and clays having medium plasticity, medium moisture, and medium density |
| Low | Greatest expected settlement measured in fractions of an inch | < 0.2 | < 30 | Sands; or silts and clays having low plasticity, low moisture, and high density |

4. Potential volume change

Tests may be conducted to determine the amount of change in volume or pressure associated with changes of moisture content in a material. These factors are important only when the natural moisture content changes periodically or will be changed significantly because of the construction project.

| This report | Potential volume change (Federal Housing Administration*) | Pressure due to swelling ($lb/ft^2$) |
|---|---|---|
| Very high | Very critical | 4,750 |
| High | Critical | 3,250-4,750 |
| Medium | Marginal | 1,750-3,250 |
| Low | Noncritical | < 1,750 |

* See Lambe (1960).

5. Frost susceptibility refers to the tendency of the materials under specific water and temperature conditions to heave or swell from the formation of ice. Materials that are highly susceptible may cause retaining walls to fail, pavements to crack, or other, similar construction problems to occur. The classification used in table 7 (p. 50-51) to describe frost susceptibility is as follows (T. H. Thornburn, personal communication, 1968):

| Frost group | Degree of frost suscepti-bility | Type of soil | Percent finer than 0.02 mm | Typical soil classifi-cation (Unified) |
|---|---|---|---|---|
| F1 | Negligible to low | Gravelly soils | 3-10 | GW, GP, GW-GM, GP-GM |
| F2 | Low to medium | Gravelly soils | 10-20 | GM, GW-GM, GP-GM |
| | | Sands | 3-15 | SW, SP, SM, SW-SM, SP-SM |
| F3 | High | Gravelly soils | > 20 | GM-GC |
| | | Sands, except very fine silty sands | > 15 | SM, SC |
| | | Clays having Plasticity Index > 12 | > 15 | CL, CH |
| F4 | Very high | All silts | > 15 | ML-MH |
| | | Very fine silty sands | > 15 | SM |
| | | Clays having Plasticity Index < 12 | > 15 | CL, CL-ML |
| | | Varved clays and other fine-grained, banded sediments | > 15 | CL, ML, SM, CH |

See also Linell, Hennion, and Lobacz (1963).

## 6. Dry density weight

| This report | Soil | | Rock | |
|---|---|---|---|---|
| | $lb/ft^3$ | g/cc | $lb/ft^3$ | g/cc |
| Very high | > 145 | > 2.3 | | |
| High | 120-145 | 1.9-2.3 | > 170 | > 2.7 |
| Medium | 100-120 | 1.6-1.9 | 145-170 | 2.3-2.7 |
| Low | 90-120 | 1.4-1.6 | 120-145 | 1.9-2.3 |
| Very low | < 90 | < 1.4 | 120 | < 1.9 |

7. Erosion is the removal of a material by wind or water. For this report, the erodability of materials is classified as follows:

| Erodability | Likely local conditions | | Typical materials |
|---|---|---|---|
| | Slope | Cohesive strength | |
| High | Steep | Low | Loess, fine sands |
| Medium | Moderate | Medium | Clayey silts |
| Low | Gentle | High | Silty clays, till |

C. Slope

Slope, as used in table 7, is a term denoting the vertical rise in feet per 100 feet of horizontal distance predominating within each unit. The terms for Illinois slope classes, as commonly used by the U.S. Department of Agriculture, are as follows*:

| This report | USDA | % Slope (ft/100 ft) | Approximate slope angle (degrees) |
|---|---|---|---|
| Nearly level | A | 0-2 | 0-1 |
| Gently sloping | B | 2-5 | 1-3 |
| Sloping | C | 5-10 | 3-6 |
| Strongly sloping | D | 10-15 | 6-9 |
| Moderately steep | E | 15-20 | 9-11 |
| Steep | F | 20-30 | 11-17 |
| Very steep | G | > 30 | > 17 |

* Personal communication, November 1973, from Kenneth Hinkley, Soil Conservation Service, U.S. Department of Agriculture, Champaign, IL 61820.

(Appendix 2 concluded on next page)

## ENGINEERING GEOLOGY MAP SYMBOLS

The following system of engineering geology map symbols was used in preparing plate 6. The system was introduced by Richard W. Galster (1975) of the U.S. Army Corps of Engineers at the 18th Annual Meeting of the Association of Engineering Geologists in November 1975. Some modifications, indicated by asterisks, have been made by Paul B. DuMontelle.

### Overburden Map Symbols

The basic symbol consists of a single capital letter representing the genetic symbol followed by a lower case letter or letters depicting materials with reference to grain size. These may be followed by qualifying descriptive symbols in parentheses and/or mappable units designated by Arabic numbers following a hyphen.

#### Genetic Symbols (Capital letters)

| | | | |
|---|---|---|---|
| A | Alluvial | R | Residual |
| C | Colluvial | W | Aeolian |
| L | Lacustrine | M | Marine |
| G | Glacial | V | Volcanic |
| | | H | Human activities* |

#### Material Symbols (Lower-case letters)

| | | | |
|---|---|---|---|
| c | clay | p | organic material/peat |
| m | silt | r | rock rubble |
| s | sand | b | boulders |
| g | gravel and cobbles | d | debris |

#### Qualifying Symbols (Always lower-case letters shown in parentheses)

| | | | | | |
|---|---|---|---|---|---|
| (t) | till | (u) | uncompacted spoil* | (mf) | mud flow |
| (ta) | talus | (c) | compacted fill* | (ls) | landslide |
| (o) | outwash* | (e) | excavation or cut | (ic) | ice contact* |

### Bedrock Symbols

Bedrock symbols are formed by two capital letters representing the first two letters of the rock name or by other commonly used two-letter abbreviations. Examples: BA-basalt, SS-sandstone, LS-limestone, GR-granite.

Illinois State Geological Survey Circular 497
76 p., 21 figs., 8 tables, 2 app., 7 plates, 5000 cop., 1976
Urbana, Illinois 61801

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