Subsurface Geology and Ground-Water Resources of the Jackson Purchase Region, Kentucky

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1987

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By R. W. DAVIS, T. WM. LAMBERT, *and* ARNOLD J. HANSEN, JR.

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1973

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 73-600249

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Stock Number 2401-02443

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By R. W. DAVIS, T. WM. LAMBERT, and ARNOLD J. HANSEN, JR.

ABSTRACT

The Jackson Purchase region of western Kentucky is underlain for the most part by aquifers that can yield ground water of suitable quality and quantity for many industrial, public supply, and irrigation uses in addition to furnishing domestic supplies throughout the area. Wells capable of yielding more than 1,000 gpm (gallons per minute) can be constructed in most of the area. The availability of ground water is controlled by the stratigraphy and structure of the aquifers that range in age from Paleozoic to Quaternary.

Sediments of Cretaceous through Eocene ages in the region were deposited in the northern part of the Mississippi embayment. These sediments lie unconformably on consolidated Paleozoic rocks that range in age from Mississippian in the eastern and northeastern periphery of the region to Ordovician in the southwest.

The formations that were deposited in the Mississippi embayment in ascending order, are Tuscaloosa Formation and McNairy Formation of Late Cretaceous age (includes beds of Clayton age at top), Porters Creek Clay of Paleocene age, Wilcox Formation and Claiborne Group of Eocene age (the Jackson Formation is included with the Claiborne Group, although it is not a member). The embayment sediments are unconformably overlain by deposits of Pliocene(?), Pleistocene, and Holocene ages.

The Paleozoic rocks underlying Cretaceous sediments have northward and eastward dips toward parts of the Illinois basin. Numerous faults displace the Paleozoic formations near their outcrop area and apparently also in the subsurface. The dip of the Cretaceous through Eocene age formations is toward the axis of the Mississippi embayment which, in general, is parallel with the Mississippi River. The dip of the formations changes from westward in the southeast to southward in the northwest. Several faults displace Cretaceous and Paleocene deposits at and near their outcrop areas, but data are insufficient to determine the extent of these faults. The Cretaceous through Eocene age formations are unconformably overlain by Pliocene(?) and Pleistocene gravel deposits that are flat lying in contrast with the regionally dipping sediments of the embayment. Alluvial deposits of Quaternary age are incised into Cretaceous through Eocene sediments. Part of the alluvial deposits near Paducah were deposited in a lake during the Pleistocene Epoch.

Most of the Paleozoic rocks are limestone, dolomite, and chert that were deposited in shallow seas. The Cretaceous through Holocene sands, clays, and gravels are mainly deltaic, continental, or lagoonal type sediments; only the Paleocene deposits are known to have been deposited in a marine environment.

Several aquifers in the Jackson Purchase region are capable of yielding large amounts of good-quality water. Water from most of the formations is commonly low in dissolved solids and is soft. The average temperature is about 15°C.

The gravellike rubble zone at the top of Paleozoic limestone or chert, or solutional openings in these rocks, may yield 1,000 gpm or more. The concentration of dissolved solids in the water is commonly less than 250 mg/l (milligrams per liter). Sands of the McNairy Formation can yield 500 to more than 1,000 gpm in the southeast quarter of the region; elsewhere, the formation contains substantial amounts of clay and yields are less. The dissolved solids in the water commonly are less than 100 mg/l.

Sands of the Wilcox Formation generally yield sufficient water for domestic use and yield as much as 600 gpm to individual wells. In most areas the formation contains too much clay to be an important aquifer for large supplies. The dissolved solids in the water commonly are less than 70 mg/l.

Sands of the Tallahatta Formation of the Claiborne Group can yield more than 1,000 gpm in about half of the region. Sand beds in the Sparta Sand of the Claiborne Group can yield more than 1,000 gpm in the eastern part of its area of occurrence; however, the formation grades westward into clay, and yields near the Mississippi River are much less. The dissolved solids in water from the two formations commonly are less than 70 mg/l.

Sands of the undivided Cockfield through Jackson Formation are known to yield 300 gpm; however, larger yields may be obtained. The dissolved solids in the water are commonly less than 100 mg/l; near the Mississippi River, however the water increases in hardness, which results in an increase in the dissolved solids.

Gravel deposits of Pliocene(?) and Pleistocene ages west of Paducah should yield more than 1,000 gpm. The dissolved solids in the water are commonly less than 250 mg/l. South of Paducah, gravel deposits generally yield only sufficient water for domestic use. The alluvial gravel and sand deposits along the Tennessee and Mississippi Rivers can yield more than 1,000 gpm at most places. The dissolved-solid concentration in water from the Tennessee River alluvium commonly is less than 200 mg/l; the dissolved solids in water from the Mississippi River alluvium are commonly less than 500 mg/l. The alluvium of the Ohio River can yield 1,000 gpm at places.

Coefficients of transmissibility and storage have been determined for four formations at five places in the Jackson Purchase. Transmissibility values range from 1,300,000 gpd per ft (gallons per day per foot) to 22,000 gpd per ft, both values being for the Tennessee River alluvium. Coefficients of storage of all aquifers tested indicate artesian conditions. There is no regional long-term trend of either rising or falling water levels in wells tapping the aquifers in the region. Water levels rise in wet years and decline in dry years. The amount of recharge by precipitation is estimated to be from 4.8 to 7.2 inches of precipitation yearly, or 10–15 percent of the annual average precipitation. Pumpage from wells is estimated to be 14.7 million gallons per day.

INTRODUCTION

DESCRIPTION OF THE AREA

The Jackson Purchase region comprises the eight westernmost counties of Kentucky. In 1818, General Andrew Jackson negotiated a treaty between the Chickasaw Indians and the U.S. Government to purchase the land between the Tennessee and Mississippi Rivers from the Indians. The Kentucky part of this area is commonly called the Jackson Purchase. The region is bounded by three major rivers, the Mississippi, Ohio, and Tennessee (Kentucky Lake), and is a distinct physiographic, geologic, and political part of Kentucky.

The Jackson Purchase differs from the rest of Kentucky geologically and physiographically. Located near the northern tip of the Mississippi embayment part of the Gulf Coastal Plain, the region is potentially one of the most productive ground-water areas in Kentucky. Large yields of water are obtained from wells tapping sediments that range in age from Paleozoic to Pleistocene and Holocene. The exposed sediments are generally unconsolidated sand, clay, gravel, and loess. Limestones, cherts, and shales of Paleozoic age underlie the sediments and are exposed only near and along the shore of Kentucky Lake.

The surface of the region generally is one of low relief, with gently rolling uplands and wide shallow valleys. Steep bluffs are found along Kentucky Lake and part of the Mississippi River valley.

The climate of the region is the humid-continental type. The average annual precipitation is about 45 inches. Monthly average temperatures range from about 37°F in January to about 80°F in July. The monthly average of precipitation and temperature at Murray, considered to be representative of the Jackson Purchase, are shown in figure 1.

The mineral resources are clay, sand, gravel, and limestone. Clay is produced from Claiborne and Wilcox age deposits. Deposits of Eocene and Cretaceous ages contain sand with a high-silica content throughout the Jackson Purchase. Sand and gravel for road metal is dug from the Pliocene(?) gravel deposits and is dredged from streams. Limestone is quarried from Paleozoic limestone near Kentucky Lake in the southeastern part of the region.

PURPOSE AND SCOPE OF INVESTIGATION

In order to determine the occurrence of ground water and the distribution of the aquifers in the Jackson Purchase, detailed

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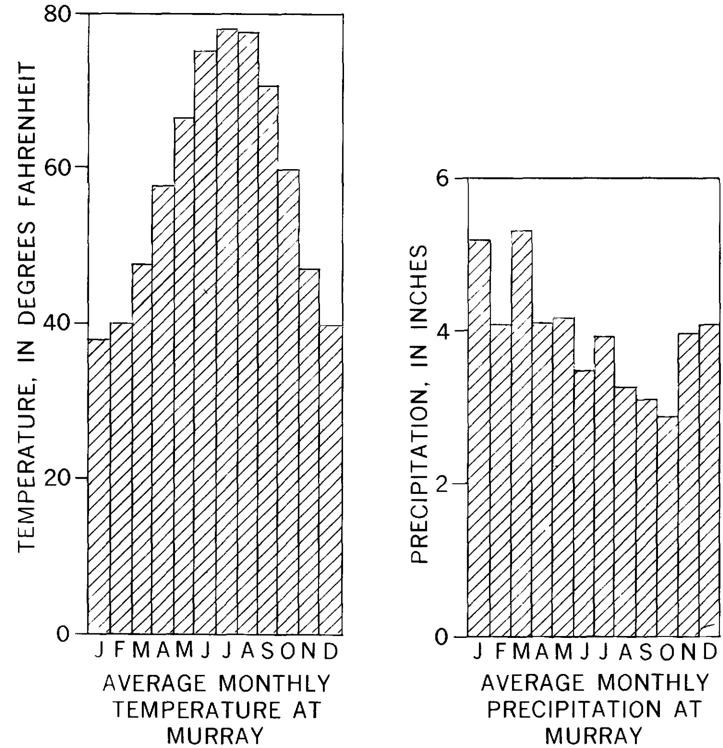

FIGURE 1.—Monthly average precipitation and temperature in the Jackson Purchase region as recorded at the meteorological station at Murray, Ky.

studies were started in 1960 by the U.S. Geological Survey in cooperation with the Kentucky Geological Survey to map the availability of ground water in the 53 7½-minute quadrangles that are in, or partly within, the Jackson Purchase region. The results of these studies have been published by the U.S. Geological Survey in 43 hydrologic investigations atlases (fig. 2).

The purpose of this report is to summarize on a regional basis the knowledge of the ground-water resource gained during the compilation of the hydrologic investigations atlases, to correlate aquifers and other formations between the various quadrangle maps, and to present new data collected since the publication of the atlases. A secondary, but important, purpose is to show that large amounts of ground water are available in almost all of the Jackson Purchase. This is important because the economic advancement of the region may depend in large part on the proper utilization of its ground-water resources.

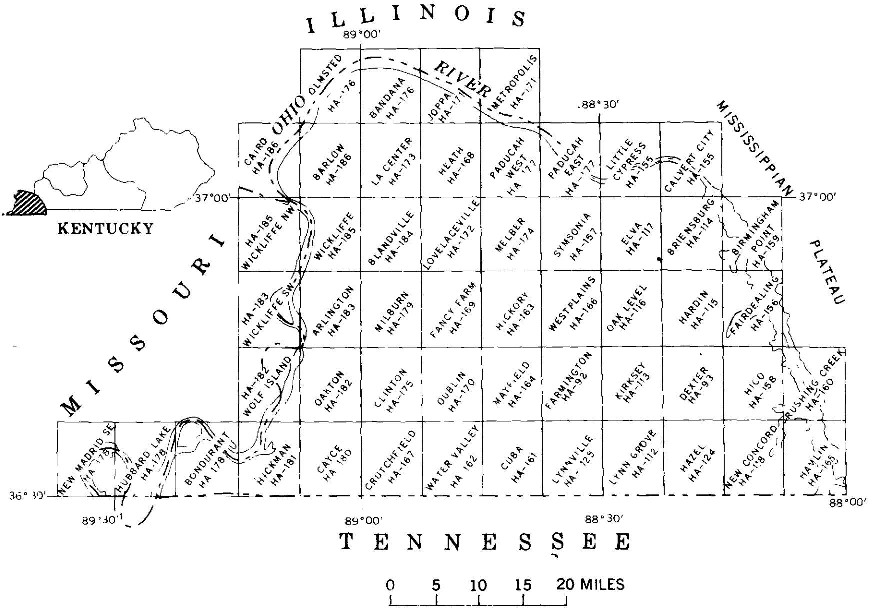

FIGURE 2.—Index map of Jackson Purchase region, showing locations and numbers of hydrologic investigations atlases and names of quadrangle maps.

The data collected on wells include, where possible, measurements of depth of well and depth to water, and, in large-yielding wells, measurements of discharge, drawdown, and specific capacity. Samples of water were collected for chemical analysis from wells of various depths and from different aquifers in all the area to obtain representative analyses of the available water.

Test holes were drilled by power augers, and drill cuttings were collected and studied from both auger holes and commercially drilled water wells, geologic-test holes, and oil-test wells. Drillers' logs and electric and gamma-radiation logs were made or collected in areas where deep holes were available. Samples of sand and clay were collected from several localities for particle-size and permeability analyses. Surface exposures were studied to aid in interpreting subsurface information.

PREVIOUS INVESTIGATIONS

The earliest report describing the geology of the Jackson Purchase is that of Loughridge (1888). Glenn (1906) described the water resources and the geology of western Kentucky, western Tennessee, and southern Illinois, with a discussion of the ground-water resources of each county. The geology, mineral resources, and Paleozoic geology of the Jackson Purchase region were described by Roberts, Gildersleeve, and Freeman (1945). Roberts described the geology of the Cretaceous and younger units, Gildersleeve described the clay resources of the Jackson Purchase, and Freeman described the Paleozoic rocks of western Kentucky. The most recent study of the Paleozoic formations in the Jackson Purchase is by Schwalb (1969).

The surface geology of the region is being mapped by the U.S. Geological Survey in cooperation with the Kentucky Geological Survey. The geology of Illinois adjacent to the Jackson Purchase part of Kentucky has been mapped by Pryor and Ross (1962) and Ross (1964). The structure of the southernmost part of Illinois was mapped by Ross (1963). Numerous faults are mapped in the Paleozoic rocks in Illinois. Some of the faults probably extend into the Jackson Purchase region of Kentucky.

The first detailed ground-water report on part of the Jackson Purchase region was by Pree and Walker (1952) who described the geology and ground-water resources of the Calvert City-Gilbertsville area. The geology and ground-water resources of the Paducah area were studied by Pree and others (1957). MacCary and Lambert (1962) made a study of the ground-water resources and subsurface geology of the entire region. Additional reports on the water resources and geology are listed in the references at the end of this report.

COOPERATION AND ACKNOWLEDGMENTS

The investigation was completed by the U.S. Geological Survey in cooperation with the Kentucky Geological Survey as a part of the cooperative program of continuing water resources studies of the State. Drilling contractors, well owners, local government and industry representatives, and water-system managers have contributed heavily to the knowledge on which this report is based, and their assistance is gratefully acknowledged. Personnel of U.S. Geological Survey districts in adjacent States and of the Mississippi embayment project also assisted in the geophysical and geologic study that materially aided the understanding of the hydrology of the region and the regional correlation of geologic formations.

SUBSURFACE GEOLOGY AND HYDROLOGY

The availability, quantity, and quality of ground water in the Jackson Purchase region are controlled by the geology; therefore, a knowledge of the geologic framework is necessary in order to describe and to understand the hydrology. Efforts made in the past at understanding the hydrology of the ground-water resources have been hampered by a lack of detailed knowledge of the subsurface geology. These data are now becoming available through the cooperative geologic-mapping program and through continued drilling and water-supply development.

The application of subsurface geologic data to hydrologic planning can be shown by using the change of facies in the Sparta Sand as an example. At Fulton the Sparta is an aquifer capable of supplying more than 1,000 gpm to wells. Westward, as traced on geophysical logs, the Sparta contains more clay than sand and is capable of supplying yields of probably less than 100 gpm. Water planners, using these data, know that the chances of obtaining large supplies of water from the Sparta Sand in the western part of the Jackson Purchase are poor, and large-yielding wells will have to be drilled deeper than the Sparta to the underlying Tallahatta Formation, an aquifer that is almost consistent in composition across the region.

The geologic data presented in the following sections and illustrations are intended to show the geologic framework of the Jackson Purchase in order to understand the occurrence and amount of water available at sites throughout the region. Lithologies and the distribution of the sedimentary units of the Jackson Purchase are shown and discussed on plate 11. Other important factors that contribute to the understanding of the hydrology, such as structure and geologic history, are discussed in subsequent sections.

SUBSURFACE CORRELATION

Subsurface correlations are based primarily on interpretation of electric and gamma logs of wells in the Jackson Purchase and in adjacent States. Distinctive patterns or curves on electric and gamma logs were found to mark formation contracts more reliably than drillers' logs, or even descriptions of drill cuttings examined by geologists. Criteria useful in subsurface correlation of formations is discussed and the lithologic descriptions are given on plate 11.

GENERAL GEOLOGIC FEATURES

The Jackson Purchase region of Kentucky is near the northern apex of the Mississippi embayment, a syncline which plunges to the south and whose axis generally parallels the Mississippi River

(Cushing and others, 1964, p. B1). In its northern part the embayment is filled with sediments ranging in age from Late Cretaceous at the base to Holocene at the surface. The Cretaceous sediments unconformably overlie Paleozoic rocks ranging in age from Ordovician to Mississippian.

In Kentucky the Cretaceous deposits are unconsolidated sand or clay overlying a noncontinuous basal gravel of limited extent near Kentucky Lake. Deposits of Paleocene age are clay; a few sand beds occur at the top and the base of the formation. Eocene deposits, as thick as 1,200 feet southwest of Hickman, are unconsolidated sand and lesser clay beds. Near the Mississippi River, thick clay beds are in the upper part of the Eocene Series.

Gravel deposits of Pliocene(?) and possibly partly of Pleistocene ages (here called Pliocene(?) gravel for ease of discussion) overlie Cretaceous through Eocene deposits with a regional angular unconformity. The gravel, along with loess and colluvial deposits, generally covers the Eocene and older sediments; continuous bedrock outcrops are scarce.

Alluvial deposits of Quaternary age, generally sandy gravel or gravelly sand overlain by silt and clay, are present along most stream valleys. In the larger valleys the upper silty part of the alluvium is of Pleistocene and Holocene ages, and the lower gravelly part is of Pleistocene age. A blanket deposit of Pleistocene loess overlies all older formations and may have been deposited contemporaneously with the upper part of the Quaternary alluvial deposists. Lake deposits of Pleistocene age have been mapped near Paducah by Finch and others (1964) and Olive (1966a).

GENERAL GROUND-WATER CONDITIONS

Large amounts of good-quality ground water can be obtained from aquifers of the Claiborne Group; McNairy Formation; alluvium along the Tennessee, Mississippi, and Ohio Rivers; Paleozoic limestone; parts of the Pliocene(?) gravel; and parts of the undivided Cockfield and Jackson Formations. These formations are given in order of decreasing capability of yielding large amounts of ground water; however, each formation does not have the same water-yielding capability at all places, and some vary more than others in their capabilities.

Plate 1 shows the expected maximum yields to individual wells in all the aquifers of the Jackson Purchase. Essentially, the map is a ground-water availability map of the Purchase. Maximum yield data were obtained from the hydrologic atlases that cover the

Jackson Purchase region. Expected yields are shown by patterns; known large yields and producing aquifers are shown by well symbols.

GENERAL OCCURRENCE AND CHEMICAL QUALITY OF GROUND WATER

A generalized concept of the occurrence of ground water in the Jackson Purchase is shown in plate 1. Water in the main zone of saturation is commonly under water-table conditions in the outcrops of the aquifers, but where clay beds intervene between the aquifer and the surface, generally downdip, the water is confined under artesian pressure. Many perched water zones are present; some large and areally extensive, and others small enough to be tapped by only one or two domestic wells.

The occurrence of ground water in each of the geologic units is described in the following pages in order of ascending stratigraphic position. For more specific information on the availability of ground-water at a particular place in the region, the reader is referred to the hydrologic investigations atlas for that area (fig. 2). The generalized columnar section (pl. 11) also contains descriptions of the various formations and their hydrologic characteristics.

PALEOZOIC ROCKS

GEOLOGY

Paleozoic rocks ranging in age from Ordovician to Mississippian underlie the Jackson Purchase. Rocks of Mississippian age are exposed along most shores of Kentucky Lake, and Devonian rocks are exposed in a small area along a fault in Marshall County. Elsewhere, in a southwestward direction, progressively older rocks are present below the embayment sediments but are not exposed. In the southwest corner of the region, oil-test wells have entered rocks of Early Ordovician age below Cretaceous sediments. The geologic map of the formations beneath the Cretaceous sediments, which can be considered an Early Cretaceous paleogeologic map (fig. 3), shows the distribution of the Paleozoic rocks, the bedrock of the Jackson Purchase. Their predominant lithologies are chert, limestone, and dolomite.

HYDROLOGIC PROPERTIES

A residual gravellike rubble zone at the top of the Paleozoic rocks, and fissures and fractures deeper in the rocks, can yield large amounts of ground water to wells. The largest yield from the Paleozoic rocks in the Jackson Purchase is 240 gpm from a

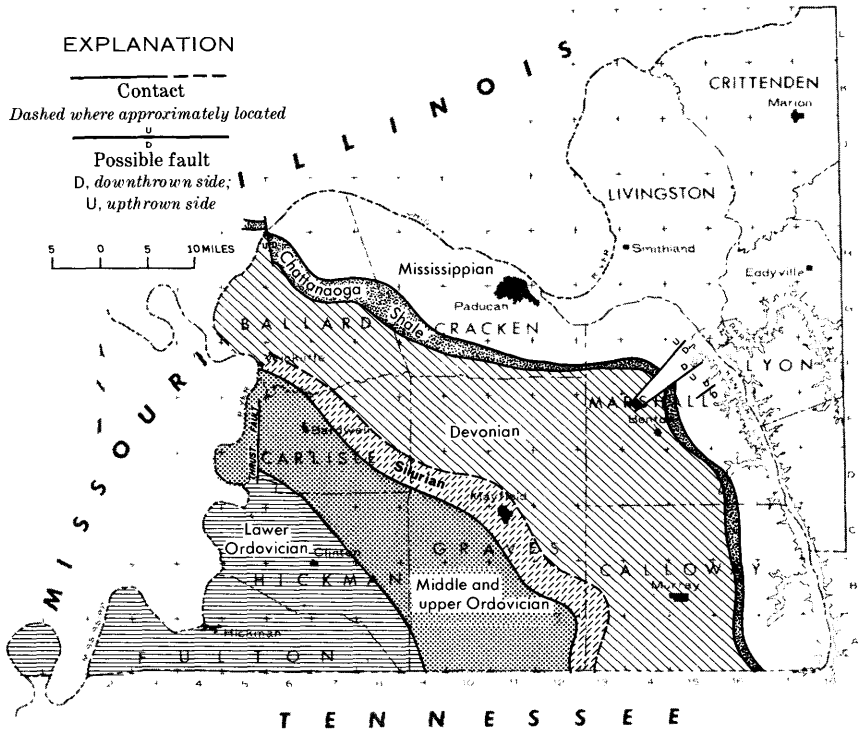

FIGURE 3.—Paleogeologic map of the pre-Cretaceous erosion surface in the Jackson Purchase region. From Schwalb (1969, p. 11); terminology modified.

well east of Paducah. Near Metropolis, Ill., a well tapping Paleozoic rocks similar to those in the region yields 1,500 gpm. The locations of wells that obtain large yields of water from the bedrock are shown on plate 1, and specific capacities of wells are shown on plate 2. Although the chances of obtaining an excellent yield are good, the possibility exists of drilling into solid non-water-bearing rock. This is a risk that cannot be completely eliminated in any limestone terrane.

Because shallower aquifers are present in much of the Jackson Purchase region, most wells drilled into Paleozoic rocks are in and near the area of outcrop of these rocks along Kentucky Lake, and in the Paducah area where the overlying formations are not capable of yielding sufficient water. Some of the deep domestic wells were drilled into bedrock in the Paducah area because shallower aquifer sands that could have supplied domestic needs were not tested or where overlooked in the drilling of the well. The configuration of the Paleozoic bedrock surface is shown on plate 3.

Ground water from the Paleozoic bedrock commonly contains less than 250 mg/l of dissolved solids (table 2). Water from the rubble zone at the top of the bedrock, as commonly encountered near Kentucky Lake, is soft to moderately hard [1] and is slightly acidic. Water from openings in the bedrock beneath the rubble zone is moderately hard to very hard and is slightly alkaline. Generally, the iron content of water from the bedrock is sufficiently high to require treatment for most uses. An iron content of more than 0.3 mg/l imparts a disagreeable taste to water and may cause staining of clothing and utensils. The temperature of the water is usually about 15°C (59°–60°F). A small amount of hydrogen sulfide has been observed in a few wells that tap the bedrock, but it is easily and economically removed in treatment.

Plate 4 shows the dissolved solids and hardness of water from wells tapping the Paleozoic bedrock. Typical analyses of water from selected wells are given in table 2. The locations of the wells from which the samples were collected are shown on plate 4.

The piezometric surface of water in the bedrock probably coincides with that of the McNairy Formation, discussed on page 13, because the two are connected hydraulically. Wells drilled to bedrock in low areas along the Mississippi and parts of the Ohio River valleys may flow at the land surface with low heads.

TUSCALOOSA FORMATION

GEOLOGY

The Tuscaloosa Formation is composed of chert gravel in a tripolitic matrix. It is exposed in the Jackson Purchase only near Kentucky Lake and is not known to have an identifiable characteristic on geophysical logs. Even where accurate well cuttings are available, it is generally difficult to distinguish the contact between the gravel in the Tuscaloosa and the deeply weathered, broken chert rubble at the top of the Paleozoic rocks. Well drillers generally report the rubble zone as "gravel"; therefore, the extent of the formation, based on drillers' logs, would be excessively large.

HYDROLOGIC PROPERTIES

The Tuscaloosa Formation is known to be present only near Kentucky Lake in the Jackson Purchase. Some wells west of Kentucky Lake have been drilled to a gravelly sand that has been called Tuscaloosa; but probably, at least as considered in this report, the gravelly sand is part of the base of the McNairy Formation.

Although the Tuscaloosa Formation is composed mainly of rounded chert gravel, the tripolitic matrix of the formation causes

[1] Hardness of water is classified by the U.S. Geological Survey as follows: 0–60 mg/l, soft; 60–120 mg/l, moderately hard; 121–180 mg/l, hard; and 181 mg/l or more, very hard.

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the permeability of the formation to be low and also tends to clog well screens; consequently, well yields are low.

McNAIRY FORMATION

GEOLOGY

In the southeastern part of the Jackson Purchase the McNairy Formation is mainly sand containing minor clay bodies. Near Benton and northwestward the sands appear to interfinger with clay and with sand interlaminated with clay. Farther north, near Paducah, the predominant lithology of the McNairy is clay, although sand, commonly very fine grained and micaceous, comprises a small part of the formation. The sand content seems to increase slightly west of Paducah.

Near Kentucky Lake a gravelly sand or sandy gravel at the base of the McNairy is considered as basal McNairy (Olive, 1965). Indications of a karst topography below the McNairy in parts of the area are revealed by drillers' reports of small caverns or crevices in the bedrock and by McNairy or Tuscaloosa sediments below Paleozoic limestone (Finch, 1966).

The upper part of the McNairy contact, as herein defined, is the top of a generally fine-grained, often very micaceous, in places slightly glauconitic sand that is commonly present below the richly glauconitic sand or clay at the base of the Porters Creek Clay. Clay beds below this sand have been identified as Clayton age by pollen assemblage (Olive, 1966b). The clays containing Clayton age pollen are not thick (Olive, 1965, 1966b), are not lithologically separable by normal methods from the McNairy clays, and have not been traced southward as a formation to Clayton sediments in southern Tennessee, or elsewhere. Therefore, the upper part of the McNairy Formation, as herein described, is recognized as being Clayton age (early Paleocene) but is combined with the main mass of McNairy sediments of Late Cretaceous age. The lithologic contact and the time contact are not the same. It is the opinion of the authors, based on lithologies and stratigraphic position, that the clays containing Clayton age pollen are part of the McNairy increment of sedimentation; the clays were deposited in early Paleocene time before the Midway sea transgressed northward to the northern tip of the embayment.

HYDROLOGIC PROPERTIES

The sand of the McNairy Formation is an excellent aquifer in the southeastern part of the Jackson Purchase. Present data are insufficient to show the areal extent of this excellent aquifer with accuracy, but the partial extent of the area and known large yields are shown on plate 1. In this area, wells tapping the McNairy can yield 500 to more than 1,000 gpm; similar yields probably can be obtained as far westward as Mayfield and Fulton. The largest withdrawals of ground water from the McNairy are near Murray where the city well field pumps about 600 million gallons per year. In much of the region the McNairy is either too deep to be economically considered as a source of supply, is overlain by younger formations containing excellent aquifers, or has insufficient permeability to supply domestic needs or industrial needs of more than 200 gpm.

An example of an area where the McNairy is not commonly a good aquifer is near Paducah. Here, the sand beds in the McNairy Formation are thin and generally fine to very fine grained. The thickest sands generally are at the base of the formation. At places, it is difficult to obtain an adequate yield from the sands, and wells are often drilled to the Paleozoic rocks, especially where large yields are needed. The change of facies toward Paducah is seen on the geologic sections on plate 8. Pump-test data from wells tapping the McNairy are given in table 1, and specific-capacity data are shown on plate 2. Laboratory determinations of hydrologic properties of McNairy sediments are given in table 3.

TABLE 1.—*Aquifer-performance tests in and near the Jackson Purchase region, Kentucky*

Aquifer	Owner of well	Quadrangle	Pumping rate (gpm)	Coefficient of transmissibility (gpd per ft)	Coefficient of storage	Method of analysis
Tennessee River alluvium.	B. F. Goodrich Chemical Co.	Calvert City	105	22,000	0.0002	Leaky artesian formula.
Do	General Analine & Film Corp.	do	1,100	1,300,000	.0009	Theis nonequilibrium formula.
Pliocene(?) gravel.	Missouri-Portland Cement Co.[1]	Joppa (Ill.)	328	50,000	.0002	Do.
Do	Bandana Water district.	Bandana	156	165,000	.075	Leaky artesian formula.
Tallahatta Formation.	General Tire & Rubber Co.	Hickory	96	280,000 275,000 310,000	.0004 .0001 .0003	Jacob method of nonequilibrium solution.
Do	Union City	Union City, (Tenn.)	1,750	62,000	.0003	Do.
McNairy Formation.	Benton Water & Sewer Co	Hardin	400	32,000	.0001	Do.

[1] Data from Illinois State Water Survey.

Plate 3 shows the altitude of the top of the McNairy Formation and the thickness of the formation. Water in the McNairy is under artesian pressure in all the area, except in its outcrop belt near Kentucky Lake. Water-level contours of the main zone of saturation of the McNairy are shown on plate 5. At places, perched zones of water in McNairy sand beds above McNairy clay beds (see well 33, pl. 1) contain sufficient water for domestic use. Most wells that tap these perched zones are large-diameter dug or bored wells.

The chemical quality of ground water from sand in the McNairy Formation is good to excellent. The dissolved solids are commonly less than 100 mg/l. The water is soft to moderately hard and generally slightly acidic; however, water from near the base of the formation, where the water is confined by overlying clays, is commonly slightly alkaline. Generally, the iron content is sufficiently high to require treatment for most uses. Water from the upper part of the formation generally has a higher iron content than that from the lower part. The temperature of the water from wells is usually about 15°C (59°–60°F).

Plate 6 shows the dissolved solids content of water from wells tapping the McNairy Formation. Chemical analyses of water from selected wells are given in table 2, and locations of these wells are shown on plate 4.

PORTERS CREEK CLAY

GEOLOGY

Light- to dark-gray or black clay that at the surface breaks with a conchoidal fracture, is the main component of the Porters Creek Clay. The basal 10–20 feet is a glauconitic clay and sand locally fossiliferous. Fine-grained micaceous commonly glauconitic sand beds are present in the upper part of the formation.

The glauconitic sand and clay between the uppermost sand of the McNairy Formation and the typically conchoidal-fracturing Porters Creek Clay is considered here as the basal part of the Porters Creek Clay. At outcroppings, traces of an unconformity within this interval (see Stenzel, 1952, p. 29, for criteria of marine trangressive disconformities in the Gulf Coastal Plain) are recorded by: an uneven erosional surface (Finch, 1964), a basal conglomerate of reworked clay, a basal glauconite-bearing stratum, a contrast in overall lithologic composition of the sedimentary sequence above and below the disconformity, and small burrow holes filled with material from the overlying sequence extending into the underlying one. One or more of these features can be found at outcrops of the glauconitic interval. This glauconitic interval is believed by the authors to be the lithologic equivalent and continuation of the Clayton and possibly the Owl Creek Formations. The contact of the Porters Creek Clay with the overlying Wilcox Formation, and possibly with the Claiborne Group at places, is unconformable.

HYDROLOGIC PROPERTIES

The Porters Creek Clay is not an aquifer, although a few bored or dug wells at places tap sands in the upper part of the formation.

The main hydrologic importance of the Porters Creek Clay is that it is the base of ground-water movement in the overlying Eocene sand beds and is a barrier to upward movement of water from the underlying McNairy Formation. Plate 3 is a map showing the thickness of the Porters Creek Clay and the configuration of its upper surface. Laboratory determinations of hydrologic properties of the Porters Creek Clay are given in table 3.

WILCOX FORMATION

GEOLOGY

The lithologies of the Wilcox Formation range from high-quality clay to granular sand and may change laterally in only hundreds of feet or less. The upper contact of the Wilcox with the Tallahatta Formation of the Claiborne Group is unconformable. At places, where the uppermost Wilcox lithology is sand, the contact is obscure and may be interpreted in two ways: (1) Either the Wilcox, a highly variable formation, is entirely sand and the Claiborne-Wilcox contact is a sand-to-sand contact, or (2) the Wilcox has been removed by post-Wilcox erosion and a thicker-than-normal Tallahatta Formation lies on the Porters Creek Clay. Lacking diagnostic lithologic criteria to separate coarse- to medium-grained Wilcox sand from similar sand in the Tallahatta, and also lacking sufficient accurately collected cuttings, the separation must be made by interpretation of geophysical logs and regional thicknesses.

Where the Wilcox appears to be all sand, small curves on geophysical logs have been selected for the position of the upper contact in order to represent a somewhat uniform thickness of Wilcox in that area, based on nearby logs where Wilcox contacts are more recognizable. The sand-to-sand contact of the Wilcox with the Claiborne is noted on logs of several wells near the Mississippi River valley and elsewhere. The Wilcox is shown as persistent and not removed by erosion in these areas; drill cuttings from some wells showing a sand-to-sand contact have a pronounced lithologic change at the contact chosen on the geophysical log.

HYDROLOGIC PROPERTIES

A generally persistent basal sand in the Wilcox Formation and other sand beds higher in the formation yield sufficient water for domestic wells, and at a few places can supply as much as 600 gpm for industrial or other needs. In parts of the Jackson Purchase, near where the Wilcox should be present beneath the Pliocene(?) gravel, such as at Kevil and La Center, the Wilcox is presently not separable from the overlying Claiborne sediments by lithologic criteria and the Wilcox sand may be the main Eocene aquifer. At such places where clay beds are absent, the Wilcox should be hydraulically connected with the Claiborne aquifers and have the general hydrologic characteristics of a thicker-than-normal Claiborne aquifer. In the Wilcox outcrop area, clay in the upper part of the Wilcox commonly perches water in sand of the overlying Claiborne Group.

Contours showing the top of the Wilcox Formation and thickness lines are on plate 3. In the Paducah area, where Wilcox clays perch water in the overlying Claiborne sands, the Claiborne at most places has a higher water level than water in the Wilcox (Davis, 1967); however, here the Wilcox is considered to be the main zone of saturation in the Eocene sediments. Farther downdip, near Columbus, limited data show that the water level in the Wilcox is about the same as in the overlying Claiborne deposits. The complex nature of the Wilcox sediments, including clay to sand facies changes, sand channels, and similar lateral changes, may have interconnected the Wilcox and Claiborne sediments so that hydraulically they act together as one unit. Laboratory determinations of hydrologic properties of Wilcox sediments are given in table 3.

Water from the Wilcox Formation is of good quality, but the formation is not known to be capable of supplying large yields in much of the area. The amount of dissolved solids is variable and is dependent on location. The water commonly contains less than 70 mg/l of dissolved solids. Table 2 gives typical chemical analyses of water from the Wilcox. The locations of the wells from which the samples were taken are shown on plate 4.

CLAIBORNE GROUP

GEOLOGY

The Claiborne Group in the Jackson Purchase is here subdivided into four formations: Cockfield Formation,[2] Cook Mountain Formation, Sparta Sand, and Tallahatta Formation. The subdivisions are based on subsurface criteria, and the units have not been recognized at the surface. They are virtually the same as in western Tennessee. The following table shows the nomenclature used in this report compared with current nomenclature in Tennessee.

The Tallahatta Formation and Sparta Sand are recognized instead of the Memphis Sand (as used by Moore and Brown, 1969), because the Sparta contains much clay and is not an important

[2] The Cockfield Formation is not separated in this report from sediments of the younger Jackson Formation, although occasionally it is referred to as a separate formation because it appears to be an important aquifer near the Mississippi River.

Geologic column for the Eocene of the Jackson Purchase region, Kentucky, and western Tennessee

<table>
<tr><th colspan="7">Western Tennessee</th><th colspan="2">Jackson Purchase region, Kentucky</th></tr>
<tr><td colspan="4">Water-Supply Paper 1809-F, Moore (1965, p. F8)</td><td colspan="3">Moore and Brown (1969, p. 18–19; a partial revision of WSP 1809–F)</td><td colspan="2">This report</td></tr>
<tr><td colspan="4"></td><td colspan="2">Cockfield through Jackson Formation undivided</td><td rowspan="7">Claiborne Group</td><td>Cockfield through Jackson Formation undivided</td><td rowspan="7">Claiborne Group</td></tr>
<tr><td colspan="4">Jackson(?) Formation</td><td colspan="2">Cook Mountain Formation</td><td>Cook Mountain Formation</td></tr>
<tr><td colspan="3">Unnamed sand unit</td><td rowspan="5">Claiborne Group</td><td>Sparta Sand (North of Memphis area)</td><td rowspan="5">Memphis Sand (Tallahatta, Zilpha, Winona, and Sparta equivalents)</td><td rowspan="2">Sparta Sand</td></tr>
<tr><td colspan="3">Unnamed clay unit</td><td>(Zilpha equivalent?)</td></tr>
<tr><td colspan="3">Sparta Sand</td><td rowspan="3"></td><td rowspan="3">Tallahatta Formation</td></tr>
<tr><td>Basic City Shale Member of Tallahatta Formation</td><td rowspan="2">Tallahatta Formation</td><td rowspan="2">"500-foot sand"</td></tr>
<tr><td>Meridian Sand Member of Tallahatta Formation</td></tr>
<tr><td colspan="4">Wilcox Group, undifferentiated</td><td colspan="2">Flour Island Formation
Fort Pillow Sand
Old Breastworks Formation</td><td>Wilcox Group</td><td colspan="2">Wilcox Formation</td></tr>
</table>

aquifer in the western part of the Jackson Purchase, and because it requires separation from the Tallahatta for hydrologic purposes. The subdivisions are based primarily on lithologies as interpreted from geophysical logs; however, palynologic determinations have confirmed the correlations of clay units in several test holes. The subdivisions and correlations of the Claiborne Group are more accurate where data are available from wells that have penetrated the entire Claiborne section. Common practice for correlating Claiborne units is to use the basal Claiborne contact as a starting point for correlation and then to identify and correlate units upward toward the surface. The Jackson Formation, also of Eocene age, is included with the Claiborne Group, although it is not a member, because of the uncertainty of the position of the Cockfield-Jackson contact.

As a guide to the interpretation of the subdivisions of the Claiborne Group, as shown on geophysical logs, figure 4 compares electric logs, gamma-ray logs, and lithologic logs of two test holes drilled for the Water Resources Division of the Geological Survey.

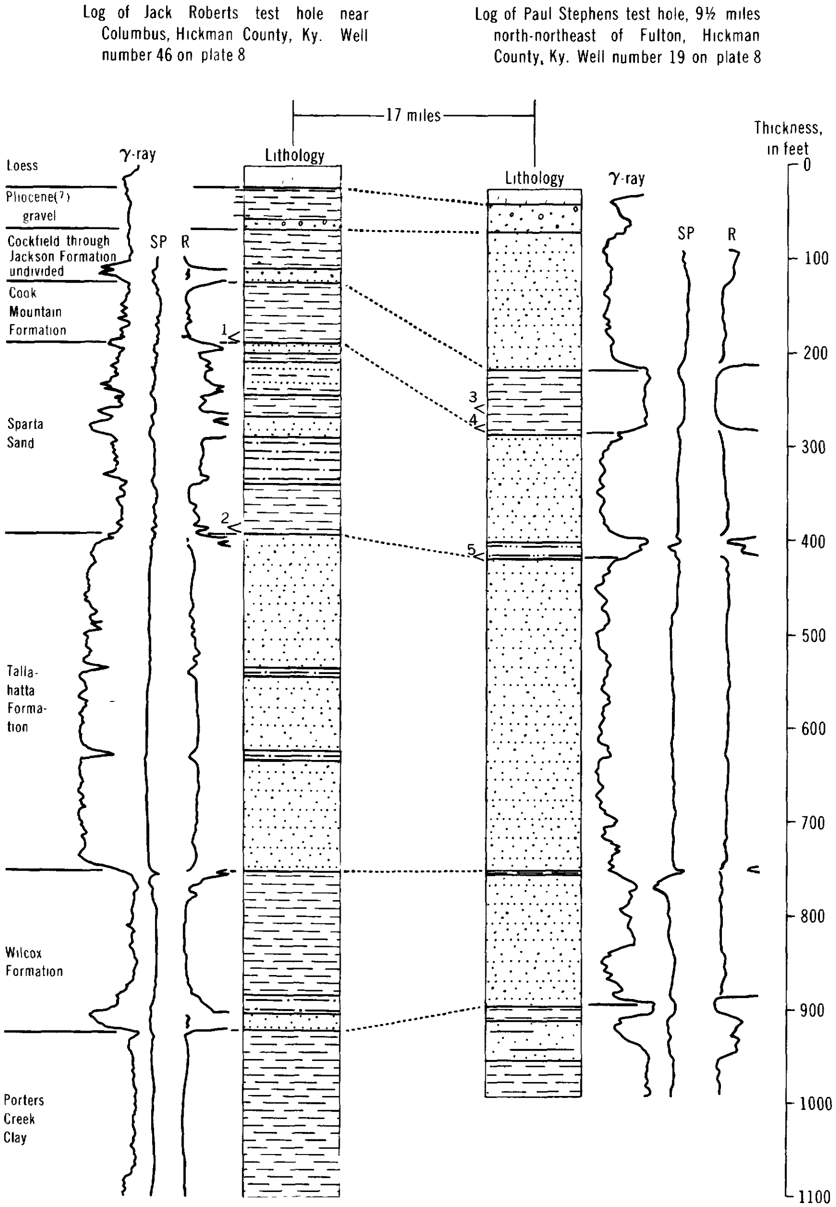


FIGURE 4.—Lithologic and geophysical logs of two test holes that penetrate the entire Claiborne Group.

EXPLANATION

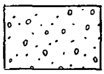
γ-ray

Radioactivity
increases →
Gamma-ray log

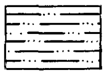
SP
Spontaneous-potential log

R
Resistivity log (short normal)

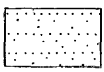
LITHOLOGIES



Gravel

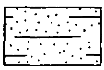


Silt and clay

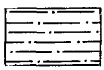


Sand

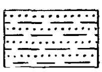
Clay



Clayey sand



Sandy clay



Interbedded sand and clay

Pollen and spore identification of samples from intervals indicated by footnotes by R. H. Tschudy, U.S. Geological Survey, indicate the following ages:

[1] Sample D 3962, depth 171 to 182 feet, yielded a good assemblage which compares well with assemblages from the Cockfield and Cook Mountain Formations. This sample is definitely from the upper Claiborne.

[2] Sample D 3963, depth 381 to 392 feet, resembles the Sparta in its palynomorph content.

[3] Sample D 3951, depth 229 to 240 feet.

[4] Sample D 3952, depth 251 to 261 feet. (Samples D 3951 and D 3952) yielded essentially identical assemblages. They are similar to assemblages from the Cockfield and Cook Mountain Formations. These samples represent the upper Claiborne.

[5] Sample D 3953, depth 392 to 403 feet, yielded an assemblage which most closely resembles an assemblage from the Sparta.

The division between the Cook Mountain and Cockfield Formations on the logs is based on lithologic criteria.

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Age determinations by R. H. Tschudy of the Geological Survey of pollen and spores contained in two clay sections are also included.

HYDROLOGIC PROPERTIES

Thick sand beds of the Claiborne Group are potentially the most productive and important aquifers in the Jackson Purchase. Laboratory determinations of hydrologic properties of sediments of the undivided Claiborne Group are given in table 3, and specific-capacity data, on plate 2.

To aid in understanding the hydrology of the Claiborne Group, isopach lines of thicknesses of the saturated sediments of the Claiborne Group are shown on plate 5. The thicknesses include the Jackson Formation near the valley of the Mississippi River and the Quaternary alluvium in the river valley. Clays and sands are included in the saturated thicknesses. A contour map of the water table of the Claiborne aquifer is also shown on plate 5. Isolated water levels higher than the regional levels near the Mississippi River appear to be caused by perching of water in the Cockfield Formation above the clays of the Cook Mountain and Sparta Formations. Little data are available on water levels in the deeper Claiborne aquifers in this area. It seems that the shallow water levels are generally about 10 feet higher than the deeper Claiborne water levels. Ground-water movement in both units is toward the incised valley of the Mississippi River, which controls the position of the water table along the west boundary of the Jackson Purchase.

Plate 6 shows the dissolved solids of water from the undivided Claiborne Group.

TALLAHATTA FORMATION

GEOLOGY

The Tallahatta Formation in the Jackson Purchase is mostly sand ranging in size from fine to very coarse grained. Clay beds are present, but they are not known to be continuous laterally. The contact of the Tallahatta Formation with the Wilcox Formation is unconformable, but, where the Wilcox Formation is a sand, the contact may be obscure.

HYDROLOGIC PROPERTIES

The Tallahatta Formation is the most extensive and most important aquifer of the Claiborne Group. It can yield more than 1,000 gpm to individual wells in about one-half of the Jackson Purchase. The sand lithology of the formation is more continuous across the region than the sands in the other formations of the Claiborne Group. The area of greatest pumpage from the Tallahatta is near Mayfield where wells pump one-half billion gallons of water per year (Davis, 1965). Pump-test data from wells tapping the Tallahatta are given in table 1.

The chemical quality of water from the Tallahatta Formation is good to excellent. The dissolved solids are low, commonly less than 70 mg/l. The water is soft and slightly acidic. Generally, the iron content is low, and treatment for removal of iron is not necessary. The temperature of the water from wells is usually about 15°C (59°–60°F). Water from the deeper parts of the formation is warmer than 15°C; the temperature of a well 640 feet deep at Hickman (bottom-hole altitude about 300 ft below sea level) is 18°C (64°F).

Selected chemical analyses of water from the Tallahatta Formation are given in table 2. The locations of the wells from which the samples were taken are shown on plate 4.

SPARTA SAND

GEOLOGY

The Sparta Sand ranges from almost entirely fine- to coarse-grained sand to dark clay and very fine sand with minor coarser sand beds. The clay and very fine grained sand content of the formation increases toward the Mississippi River.

An apparently persistent clay bed at the base of the Sparta is stratigraphically in the position of the Zilpha Clay of northern Mississippi and may be its lateral equivalent. This basal Sparta clay overlies sand of the Tallahatta Formation. No unconformity is known at the base of the clay, but from the tendency of the clay to thin and vary in thickness eastward, an intraformational unconformity may be present at the top of the clay. The unconformity may be restricted to only the eastern part of the Sparta Sand, however.

HYDROLOGIC PROPERTIES

The Sparta Sand is a good aquifer in the southeastern part of the area, where the sands of the Sparta are generally finer grained than the sands of the Tallahatta. West of a north-south line through Fulton, the Sparta grades laterally to finer grained sediments; however, at Fulton a municipal well yields 1,235 gpm from the Sparta Sand. Very fine grained sand, silt, and clay are common Sparta sediments near the Mississippi River, and sand beds are scarce and much thinner than those farther east. Examples of the facies changes are seen on the geologic sections, plate 8.

The chemical quality of water from the Sparta Sand is good to excellent. The dissolved solids are low, commonly less than 70 mg/l. The water is soft and slightly acidic. Generally, the iron content is low, and treatment for removal of iron is not necessary. The temperature of the water from wells is usually about 15°C (59°–60°F).

Selected chemical analyses of water from the Sparta Sand are given in table 2. The locations of wells from which the samples were taken are shown on plate 4.

COOK MOUNTAIN FORMATION

GEOLOGY AND HYDROLOGIC PROPERTIES

The Cook Mountain Formation is composed of light to dark clay. At places the clay tends to go into suspension in the drilling mud in rotary-drilled holes, and it is difficult or even impossible to obtain cuttings that are representative of the formation. The formation is not known to be an aquifer. Near the Mississippi River the clay of the Cook Mountain and Sparta Formations perch water locally in the overlying sand that probably is the Cockfield Formation.

COCKFIELD THROUGH JACKSON FORMATION UNDIVIDED

GEOLOGY

The undivided Cockfield and Jackson Formation consists of fine- to coarse-grained sand, grayish sandy clay, clay, and silt. Lateral lithologic changes are abundant but generally are not predictable from present data. The base of the unit unconformably overlies the Cook Mountain Formation and at places lies on units as old as the basal clay of the Sparta.

HYDROLOGIC PROPERTIES

The undivided Cockfield and Jackson Formation constitutes an aquifer in Fulton and Hickman Counties, the southwestern part of Carlisle County, and the extreme southwestern part of Graves County. The lower sand beds of the unit (the probable Cockfield Formation) are good aquifers, although not so prolific as those of the deeper Tallahatta Formation, nor so extensive, laterally. At Arlington a municipal well tapping the probable Cockfield Formation yields 300 gpm; however, larger yields probably may be obtained. At places, such as near the community of State Line, between Fulton and Hickman, the sand beds may be thin or too clayey to yield sufficient water. In such areas large production wells can be finished in the deeper lying Tallahatta Formation, and domestic wells, if necessary, may be finished in a sand in the shallower Sparta Sand.

The water is of good quality, generally low in dissolved solids, and is soft. Near the Mississippi River the hardness increases to very hard, perhaps because of infiltration of alluvial water into the Eocene aquifer during high river stages, or possibly by leaching of carbonate from the thick loess deposits along the river. Generally, the iron content is low, and treatment for removal of iron is not necessary. The temperature of the water from wells is usually about 15°C (59°–60°F).

PLIOCENE (?) GRAVEL

GEOLOGY

Deposits of Pliocene(?) gravel unconformably overlie Paleozoic through Eocene age formations in the Jackson Purchase. The gravel is generally composed of brown-stained chert. Quartz sand and clay or silt beds are present in some areas.

HYDROLOGIC PROPERTIES

The two main areas where the Pliocene(?) gravel is an aquifer are shown on plate 5. In the area west of Paducah the gravel is a good aquifer, and the contained water is in the main zone of saturation. Yields from the gravel should be sufficiently large for many industrial uses. Although few large-yielding wells are known in the area, yields of more than 1,000 gpm should be possible in much of the area.

In the southern area, the saturated thickness of gravel is commonly less than 10 feet, and the area is a large zone of perched water throughout most of its extent. The water is perched above the unsaturated Porters Creek Clay which is above the main zone of saturation of the underlying McNairy Formation. Although the gravel supplies adequate yields for domestic wells, it is not capable of large yields at most places. The southern gravel deposits are known to be sufficiently saturated to supply larger than domestic needs only near Symsonia and in part of a buried channel in the upper reaches of Middle Fork Creek in Marshall County. Pump-test data from wells tapping the Pliocene(?) gravel are given in table 1, and specific-capacity data are shown on plate 2. Contours showing the configuration of the water table in the gravel are shown on plate 5.

The chemical quality of ground water from the gravel is good. In the area west of Paducah the concentration of dissolved solids is variable, but it is commonly less than 250 mg/l. The water is moderately hard to hard and is slightly acidic. It generally contains sufficient iron to require treatment for most uses. The temperature of the water is about 14°–16°C (58°–60°F). South of Paducah the quality of the ground water from the gravel is somewhat different. The dissolved solids are generally less than 200 mg/l. The water is soft to moderately hard and is slightly acidic or neutral. Generally, the iron content is low, and treatment for removal of iron is not necessary. The temperature of the water is also about 14°–16°C (58° to 60°F).

Chemical analyses of water from selected wells are given in table 2. The locations of these wells and the dissolved solids and hardness of water from wells tapping Pliocene(?) gravel are shown on plate 4.

LOESS

GEOLOGY AND HYDROLOGIC PROPERTIES

Loess is composed of eolian deposited silt and clay with sandy and gravelly zones near the base in most of the Jackson Purchase region. It unconformably overlies the Pliocene(?) gravel in the upland areas and overlies older deposits on the hillsides. The loess is not considered an aquifer because it generally is above the zone of saturation and is composed of material that is too fine grained to transmit water readily. A few dug wells, mostly now abandoned, in the uplands southeast of Hickman obtain water from silt that is considered to be a fine-grained facies of the Pliocene(?) gravel deposits (Lambert, 1968); however, the aquifer may be loess.

ALLUVIUM

GEOLOGY

The alluvial deposits in the Jackson Purchase are composed of an upper silt and clay unit containing minor amounts of sand or gravel and a lower gravel and sand unit. In the small rivers and creeks the lower gravel and sand unit is thin, clayey, or absent.

HYDROLOGIC PROPERTIES

The alluvium along the major rivers that border the Jackson Purchase region contains large, nearly undeveloped, supplies of ground water. Plate 7 shows contours on the base of the alluvium in the valleys of the larger rivers and altitudes of the base of the alluvium in the smaller stream valleys. Most of the ground water from the alluvium is low in dissolved solids (the greatest dissolved solid content, generally less than 500 mg/l, is in the valley of the Mississippi River), is hard to very hard, and has a high iron content. The dissolved solids and hardness of water from wells tapping alluvial aquifers are shown on plate 4.

The major alluvial aquifers are the Tennessee River alluvium, the Ohio River alluvium, and the Mississippi River alluvium, and parts of the alluvial aquifers along small rivers and creeks. The area of most widespread alluvium along the Tennessee River is near the Calvert City chemical and industrial area. The alluvium along the flood plain in this area is 1–2 miles wide and 10 miles long. Much of this area is underlain by 80–100 feet of saturated sand and gravel. Large yields from wells are available in most of the area. A production well at a chemical plant yielded 1,100 gpm during an 8-hour pumping test. Pump-test data from wells tapping the Tennessee River alluvium are given in table 1, and specific-capacity data are shown on plate 2.

The chemical quality of water from the Tennessee River alluvium is low in dissolved solids, generally less than 200 mg/l; but the iron concentration ranges from 5 to as high as 36 mg/l, and the water must be treated for removal of iron for most uses. The water is soft or only moderately hard and is slightly acidic or neutral. The temperature of the water from wells is about 14°–16°C (58°–61°F). Selected chemical analyses of water from wells tapping the Tennessee River alluvium are given in table 2. The locations of the wells from which the samples were taken are shown on plate 4.

Yields of ground water from alluvium in the valley of the Ohio River are variable. North of Wickliffe, yields as great as 1,000 gpm are possible from the alluvial deposits of the Ohio River. Laboratory determinations of hydrologic properties of the alluvium in this area are given in table 3, and specific-capacity data for wells are shown on plate 2. North of Mound City the alluvium is finer grained. A few buried channel deposits of gravel apparently follow old river meanders, and yields of wells tapping these buried gravel channels may be several hundred gallons per minute. Yields of other wells in this area are generally low.

The alluvium of the Ohio River is narrow and thin at Paducah and for about 20 miles westward. In this reach of the Ohio the alluvium lies on Pliocene(?) gravel deposits that can yield large amounts of ground water. The alluvial deposits in this area can yield only small amounts of ground water. The chemical quality of ground water from the alluvium is good. The dissolved solids are generally less than 100 mg/l. The water is soft to moderately hard and is slightly acidic; generally, the iron content is sufficiently high to require treatment for most uses. The temperature of the water is about 14°–16°C (58°–60°F). Selected chemical analyses of water from wells tapping the Ohio River alluvium are given in table 2. The locations of the wells from which the samples were taken are shown on plate 4.

The alluvium of the Mississippi River is an excellent aquifer. It is about 200 feet thick near Hickman; thinner, in other areas. Wells tapping the alluvial deposits along the Mississippi River should be capable of large yields. No wells with large yields are known to exist in this area, but based on the saturated thickness of the gravel from test borings, the alluvial aquifer should yield more than 1,000 gpm to individual wells in a large part of the area.

The chemical quality of the ground water from the alluvium generally is good. The dissolved solids are generally less than 500 mg/l. The water is very hard, has an iron content that requires treatment for most nonagricultural uses, and is either neutral or slightly alkaline. The temperature of the water is about 14°–17°C (58°–62°F). Selected chemical analyses of water from wells tapping the Mississippi River alluvium are given in table 2. The locations of the wells from which the samples were taken are shown on plate 4.

The alluvium beneath the flood plains of the small rivers and creeks in the Jackson Purchase is generally too thin and fine grained to yield enough ground water for more than domestic use. Most of the alluvial material filling the valleys is silt and clay. Generally, the lower part is gravelly, but the gravel is thin in most areas.

Much of the alluvium along both forks of Clarks River is considered by Finch and others (1964, p. C130–C131) to be of lacustrine origin. Near Benton the basal gravel may be sufficiently thick and permeable to supply moderate yields to wells; elsewhere, the gravel appears to be thin or clayey and can supply only sufficient water for domestic needs. However, yields of several hundred gallons per minute of ground water might be obtained from the alluvium near the mouths of Clarks River, Mayfield and Obion Creeks, and Bayou du Chien at their junctions with the Tennessee or Mississippi Rivers. In these areas the lower gravel and sand deposits are sufficiently thick to yield enough ground water to supply small industrial and commercial needs, although few wells presently tap the alluvium in these areas.

The quality of the ground water from the alluvium of the smaller streams is similar to other alluvial ground water in the Jackson Purchase; good quality, but hard with excess iron. Selected chemical analyses of water from wells tapping the alluvium of the small streams in the region are given in table 2. The locations of the wells from which the samples were taken are shown on plate 4.

STRUCTURE

A knowledge of the structure and geologic history of the rocks of the area is important in the understanding of the occurrence and movement of ground water. According to Schwalb (1969, p. 9), the Paleozoic rocks in the Jackson Purchase area dip northward toward the Illinois Basin and eastward toward the western Kentucky extension of the Illinois Basin, except locally where apparent reversal of dips may be caused by faulting. The overlying sediments of the Mississippi embayment dip in an almost opposite direction toward the axis of the Mississippi embayment.

The distribution of Paleozoic rocks on the paleogeologic map (fig. 3) shows them to be a part of a domal structure. This feature, the Pascola arch, is shown more clearly on a paleogeologic map of a larger area of the Mississippi embayment (Marcher and Stearns, 1962, p. 1380). Although the term "Pascola arch" is well established in the geologic literature, in the Jackson Purchase region the same distribution of formations as shown in figure 3 could have been produced also by pre-Cretaceous erosion, the basal Cretaceous deposits, in a southwesterly direction, lying on progressively older, flat-lying or less steeply westward-tilted Paleozoic formations. Based on published well logs, the Paleozoic formations near the Kentucky-Tennessee State line appear to dip westward toward the Mississippi River. This westward dip is opposite to the presently recognized regional structure. Either some well logs are incorrect, or the present knowledge of the regional structure is in error.

In order to show structure in the Paleozoic rocks where data are available, plate 8 shows a geologic section (*A–A′*) near the outcrop of the Chattanooga Shale, using this formation as a marker bed. Numerous faults are shown to explain both subsurface and surface anomalies.

Additional structure of the Paleozoic rocks is shown in the northern part of section *F–F′* (pl. 8) which extends into southern Illinois. The previously unrecognized Chattanooge Shale in well 48 agrees with the structure to be expected in the American Graben shown by Ross (1963, p. 15).

The generalized structure of the Cretaceous through Eocene deposits is shown on a block diagram (pl. 9). The dip of the beds changes in direction across the Jackson Purchase region as the strike changes; however, the degree of dip does not change appreciably as the direction changes. Surface-geologic mapping has shown that faults (not shown on the block diagram) displace

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Paleocene and Cretaceous deposits along the eastern and northwestern periphery of the Paleocene outcrop belt. Displacement along the generally southwest-northeast trending faults does not appear to be more than about 100 feet; however, faults and fault zones with less displacement may be more common than have been recognized. The fault-strike direction radiates from the Reelfoot Lake, Tenn., area, and extends into the Illinois–Kentucky fluorspar district and the surrounding area.

Subsurface geologic data in the Jackson Purchase normally are too widely scattered to indicate the presence of faults. An exception is at Hickman, where both drillers' and geophysical logs are available on two deep water wells only 1.8 miles apart. The two logs do not correlate well, unless a fault is present between the two wells. Geologic section *C–C′* (pl. 8) shows a fault that has a small displacement downdropped in the east side between the wells. However, because of the uncertainty of the structure owing to channel deposits and random clay beds in the Claiborne, no faults are shown on the structural contour maps of the various formations. The stratigraphic position of the clay at the bottom of well 23 is not known. If it is interpreted to be the Porters Creek Clay, a fault between the two wells with a displacement of about 600 feet would correspond with the structure in the Paleozoic rocks (Howard Schwalb, Kentucky Geol. Survey, oral commun., 1968). Schwalb, on presently unpublished maps, in the Hickman area shows a fault downdropped on the west side with 500–700 feet displacement of the Paleozoic rocks. Another area of possible faulting is shown between wells 29 and 27 on section *D–D′*, plate 8.

GEOLOGIC HISTORY

The geologic history of an aquifer, interpreted in terms of the environment of its deposition, aids in estimating the continuity and distribution of the sands, clays, and gravels that regulate the hydrologic regimen. The Wilcox Formation, for example, was probably formed in a deltaic environment. Therefore, sand and clay beds can be expected to be discontinuous and the lithology to change abruptly in short distances.

The pre-Cretaceous geologic history of the Jackson Purchase region is similar to that of adjacent areas. From Ordovician through early Mississippian time the region was generally in a marine environment, probably a shallow sea. During Late Mississippian and Early Pennsylvanian time the area was in a shallow marine, deltaic, or continental environment.

Mississippian rocks of Meramec age are the youngest Paleozoic strata normally preserved in the Jackson Purchase region. The oldest Mesozoic strata are sediments of Late Cretaceous age. The history of the hiatus between the Mississippian and Cretaceous deposits is not known. Because rocks of Chester age are preserved in one known fault block, deposits of Chester age probably once extended across the region. Pennsylvanian deposits also may have covered the entire region to connect the Illinois and Western Kentucky coal fields with Pennsylvanian deposits in Arkansas, Mississippi, and Alabama; however, these deposits, if they existed, have been removed by erosion. Based on regional geographic distribution of Permian through Lower Cretaceous deposits, it appears unlikely that deposits of Permian through Early Cretaceous ages ever existed in the region.

A long period of nondeposition and weathering of the Paleozoic deposits, perhaps 180 million years long (Kulp, 1961, p. 1111), occurred in the region prior to deposition of the Tuscaloosa and McNairy Formations. During this time the Mississippi embayment, the northern part extending across the Jackson Purchase region of Kentucky, was formed. Whether it was formed by downfaulting, downwarping, erosion, or a combination of these forces is not known. Soil zones were formed at the top of the Paleozoic rocks, and deep leaching of the carbonate sediments occurred. Karst topography, with its associated underground drainage pattern, was probably formed in some of the limestone terranes.

The Tuscaloosa Formation occurs in the easternmost part of the Jackson Purchase and other adjacent areas. Marcher and Stearns (1962, p. 1384) concluded that

> During Tuscaloosa deposition the Pascola arch had the topographic form of a nose extending eastward from a highland nearly 1,000 feet above sea level in Missouri, where Cambrian and Ordovician rocks cropped out, to a coastal plain in the Western Highland Rim of Tennessee, where Tuscaloosa Formation was deposited as a veneer over a karst plain developed on Mississippian bedrock * * *
>
> The westernmost belt of typical stream-transported Tuscaloosa Formation was derived entirely from the Pascola arch and deposited on a coastal plain at elevations ranging from 100 feet or more above sea level to sea level.

The environment during deposition of the McNairy Formation differed from that of the Tuscaloosa. Pryor (1960, p. 1501–1502) concluded from his study of Cretaceous sedimentation in the upper Mississippi embayment that

> A deltaic system occupied the northeastern end of the Mississippi Embayment during late Cretaceous time. This system, the "McNairy Delta," dispersed sediments toward the south and west.
>
> * * * * * * *
>
> These sediments were transported to the embayment by a single large

stream system. Paleontological and petrographical evidences imply humid, temperate to subtropical climatic conditions for the source area and depositional area during the late Cretaceous.

In reconstructing the Late Cretaceous environment, Pryor relied strongly on cross-stratification measurements of sand beds. Apparently he ignored, or was not impressed by, the large amount of clay in the McNairy north of Benton; therefore, a modification of the depositional model seems necessary. The authors believe that the McNairy delta was in the southeastern part of the Jackson Purchase and in parts of Tennessee. Perhaps another distributary, north of this main delta, also delivered clastic sediments into the embayment. But between the two areas, clay, interlaminated sand and clay, and lignite were deposited, probably in a lagoonal or delta-platform environment.

The environment of the Jackson Purchase region was transitional from nonmarine to marine as the Porters Creek sea began to transgress across the underlying McNairy sediments. Pollen dating of clays (Olive, 1965) indicates that the lithologic boundary does not agree with the time boundary; the Paleocene-Cretaceous time boundary is lower within the McNairy clay beds.

The region was a marine area during the deposition of the main body of the Porters Creek Clay. The upper part of the clay contains sand beds, and at places the underlying clay beds have small burrows filled with sand of the overlying unit. These sand beds and local intraformational unconformities may have been the result of oscillations of the shorelines of the Porters Creek sea prior to its regression.

The Wilcox sediments may have been deposited in a delta that extended southward as the Porters Creek sea regressed. Part of the Porters Creek Clay was eroded and weathered prior to deposition of Wilcox deposits, leaving, at places, hills of Porters Creek Clay that were later buried beneath Wilcox sediments. In gross lithology the Wilcox is more like the McNairy deposits than any other formation in the region. The environments may have been similar, except that the sea was withdrawing from the region instead of encroaching upon it during Wilcox time.

A marked unconformity is present between the Tallahatta Formation of the Claiborne Group and the underlying Wilcox and, at places, between the Tallahatta and Porters Creek. Possibly, the thick sand beds of the Tallahatta were deposited by a vast system of anastomosing streams that carried clastic sediments across the Jackson Purchase toward a southerly delta in the Tallahatta sea.

Conditions changed later during Claiborne deposition, about the beginning of Sparta time, as clay and then sand beds again accumulated across much of the region. Possibly the entire Claiborne Group above the Tallahatta Formation is part of an extensive deltaic deposit, as evidenced by the facies changes in the Sparta Sand.

After deposition of the Sparta sands and clays, the Jackson Purchase was again an area of mostly fine-grained deposition as the clay of the Cook Mountain Formation was deposited. The stratigraphy of the post-Cook Mountain sediments is complex. Apparently, the Cockfield sands at places channeled deeply into the Cook Mountain and older sediments, removing the Cook Mountain in places, leaving the Cockfield deposits resting on the Sparta. Clays and silts that appear to be intermixed with the Cockfield deposits have been dated by pollen as Jackson age. Perhaps the channel sands are part of the Cockfield Formation, and the finer grained sediments are parts of the Jackson Formation. The Cockfield sediments may have filled the post-Cook Mountain channels, and the Jackson was part of a deltaic or even marine deposit that overlies and intertongues with deposits identical in appearance to the Cockfield sediments.

No Mississippi embayment-type deposits are known in the Jackson Purchase that are unequivocally younger than Eocene age. The chert gravel deposits that cover all formations in the region with an angular unconformity do not appear to be genetically related to the formations deposited earlier in the Mississippi embayment. Potter (1955b, p. 129) concluded that the gravel deposits were those of an alluvial fan, deposited by high-velocity braided streams that formed predominantly channel deposits. This conclusion may be an oversimplification, but it suffices to say that they are the gross product of sedimentation in the region from Eocene to Pleistocene time.

During Pleistocene time the region was covered by a blanketlike deposit of loess. The lower gravelly parts of the alluvium in the larger stream valleys may also be of Pleistocene age; the upper silty and clayey part may have been deposited contemporaneously with loess deposition, or they may be younger, the result of precipitation washing the easily eroded loessal sediments down valley slopes and redepositing them in the flood plains.

RECHARGE, MOVEMENT, AND DISCHARGE OF GROUND WATER

Precipitation is the source of all water in the Jackson Purchase. Part of the rainfall or snowmelt enters the ground as recharge and moves downward to the water table. Where clay beds or cemented sand or gravel beds are at shallow depths and above the main saturated zone, the ground water accumulates above them forming a perched water table. Ground-water movement is downward to the main zone of saturation, the upper surface of which is the water table, and then laterally toward streams draining the region. Downstream from the intersection of a stream with the water table, ground-water discharge maintains the perennial flow of the stream. Upon being freed from the ground-water phase of the hydrologic cycle, water flows toward the ocean and eventual evaporation.

The hydraulics of recharge through the blanketlike deposit of loess to the various aquifers in the Jackson Purchase region are poorly understood and deserve further study. Pree and others (1957, p. 69) assumed that recharge through the loess occurred in the Paducah area when its entire thickness was saturated, and they calculated the amount of water that could move through a 10-foot section of loess when entirely saturated. More recently, Robert C. Prill (oral commun., 1968) suggests that recharge through loess occurs as nonsaturated flow. During studies of the hydrology of loess in Kansas, Prill noted that the soil-moisture content of loess at depth below simulated irrigated land is less than the porosity of the loess, but more than the moisture content prior to wetting the surface.

Points of discharge are visible, but areas of recharge are less obvious. Winter through early spring is the main time of ground-water recharge when transpiration is slight or absent, evaporation is reduced, and the soil zone and the uppermost part of the loess become saturated. After the upper zone becomes saturated, water no longer subject to evapotranspiration losses moves downward through the lower part of the loess to the local water table. Hydrographs of water levels in water-table wells in the upland areas show a seasonal rise in the water table every winter, which is sustained through early Spring.

The amount of water that enters the ground-water reservoirs each year in the Jackson Purchase is not known accurately. A rough approximation of the amount of yearly recharge can be made using the hydrograph of the Holshouser well (fig. 5) that shows a rise in the water table of about 1–1½ feet each winter. The well is in an upland area, and recharge is only by precipitation. The aquifer in which this well is completed, based on borings in nearby areas, is coarse gravel underlying loess. Assuming that the porosity of the gravel is 40 percent, a rise of the water level of 1 foot would equal 4.8 inches of recharge by precipitation; a rise of 1½ feet would equal 7.2 inches of recharge by precipitation. This is equal to a recharge of about 84–125 million gallons per square mile, or about 10–15 percent of the annual average precipitation. These data probably are representative of the magnitude of recharge that occurs yearly in the region. They may be only minimum values.

Recharge to the various aquifers is discussed below.

Paleozoic rocks.—Recharge occurs in the area of outcrop of the Paleozoic rocks. They are locally recharged along Kentucky Lake; the regional recharge areas are probably the Nashville dome and the Ozark uplift.

McNairy Formation.—Recharge occurs in the area of outcrop. Some recharge of the lower sand beds is probably from the underlying Paleozoic rocks with which they are connected hydraulically.

Aquifers of Eocene age.—Recharge occurs in the area of outcrop. The small perched bodies of water in the western part of the Jackson Purchase illustrate that recharge occurs throughout the region, not only at areas where the water table is high.

Pliocene(?) gravel.—Recharge occurs through the loess in the area of the gravel. The formation is an aquifer only where underlain by clays that retard the downward movement of water.

Alluvium.—Recharge is received primarily as flow from adjacent aquifers that drain toward the streams. Probably a lesser amount of recharge is received from the streams at high stages or when flooding. A relatively small amount seems to be received by direct precipitation in the flood plain.

The largest part of ground-water movement is laterally through the aquifers down the hydraulic gradient toward the axis of the Mississippi embayment (see pl. 5), and thence as underflow southward along the dip of the embayment. As an example of the magnitude of this movement in the Mayfield area, about 6,000,000 gpd of ground water moves through a 6-mile-long strip of the Tallahatta Formation. This 6,000,000 gpd is water that is capable of being intercepted by pumping near Mayfield under the present hydraulic gradient. Wells near Mayfield pump about 5,000,000 gpd for all uses; therefore, the amount of water that naturally moves through the area is greater than the ground water withdrawn from the aquifer. Pumpage could be increased to 6,000,000 gpd or slightly more before water would be removed from storage; however, because of pumpage of about 3,000,000 gpd at an industrial plant north of Mayfield, water levels may be declining near this area of concentrated pumpage.

Ground-water discharge maintains perennial flows in streams downstream from the point where the streams intersect the water table. The perennial parts of streams and water-level contours showing the shape of the water table in the aquifers nearest the surface are shown on plate 10, a composite of parts of the water tables shown on the maps of the various aquifers. Part of the natural ground-water discharge to streams may be lost as evapotranspiration before reaching the stream.

Few springs, except those in the outcrop area of Paleozoic rocks, flow from the main zone of saturation. Natural discharge of the main zone of saturation is generally into the beds of streams or the adjacent basal gravelly alluvium. Several springs that possibly discharge from the main zone of saturation are present in the alluvial areas near the steep valley wall of Mayfield Creek south of Paducah (see Davis, 1967) ; however, clay beds underlie this area at shallow depth, and the water body from which the springs flow may be partly perched. These springs are in an area where the water table of a large body of perched water merges with that of the main zone of saturation.

Perched water bodies commonly discharge ground water as seeps or small springs along hillsides or in the upper reaches of small streams that drain the areas. The largest area of such seeps and small springs is around the flanks of the Pliocene(?) gravel deposits where they overlie the nearly impermeable Porters Creek Clay or clays of the McNairy Formation. This zone of seepage and plastic clays at the top of the clay beds forms a naturally poor base for highway construction.

The movement and discharge of ground water of the various aquifers is discussed below.

Paleozoic rocks and McNairy Formation.—In general, the Paleozoic rocks and the McNairy Formation act as a single, interconnected hydraulic unit, except locally near Kentucky Lake in areas of outcrop of Paleozoic rocks. Water levels in the McNairy Formation are shown on plate 5. Both units in the eastern part of the Jackson Purchase discharge ground water in an easterly direction toward Kentucky Lake. In fact, the impounding of the Tennessee River to form Kentucky Lake has caused a change in the slope of the water table near the lake, and the raised water level has caused water logging in some low-lying areas.

The McNairy discharges into alluvium along the East Fork Clarks River, into the Tennessee River below Kentucky Dam, and into the Ohio River valley west of the area near Kentucky Lake. The movement of ground water in the McNairy Formation where the McNairy is overlain by the Porters Creek Clay is northwestward. The same direction of movement is postulated for water in the Paleozoic aquifers in these latter areas.

The direction of ground-water movement in the McNairy, as shown on plate 5, is toward the west. Boswell and others (1965, p. C30) show a regional map of the piezometric surface of water in the McNairy Formation. According to their data, movement of water in the McNairy is westward from Kentucky to just east of Crowleys Ridge, where a southward component of ground-water movement is shown by the southward-trending 300-foot water-level contour. The area of discharge from the McNairy appears to be down the dip of the Mississippi embayment south of Kentucky. The shape of the piezometric surface of the water in the McNairy does not coincide with the subsurface structure of the formation. Westward movement of water low in dissolved-solid content to an area in Missouri west of the structural axis of the embayment may be partly responsible for the high dissolved solids in water from the McNairy in the Mississippi embayment part of of southeast Missouri.

Aquifers of Eocene age.—The main movement of ground water in the aquifers of Eocene age is westward towards the Mississippi River as shown on plate 5. Ground water moves eastward toward the East Fork Clarks River in a small area near Murray, but a larger part of the ground-water movement through the Eocene sediments is intercepted by the West Fork Clarks River. The water diverted to the two forks of Clarks River moves as surface water to the Ohio River.

The larger westward-flowing tributaries of the Mississippi River cause indentations of the water-level contours, and part of the ground water in the Eocene aquifers is drained into these streams and moves toward the Mississippi as surface water. Of the westward-flowing tributaries, North Fork Obion River in Tennessee intercepts the largest amount of ground water from Eocene deposits. Ground-water movement through Eocene sediments along the southern edge of the Jackson Purchase is southerly into North Fork Obion River.

Pliocene(?) gravel.—Ground-water movement in the Pliocene(?) gravel is not complex. Although isolated perched water occurs at places in the gravel, the main body of ground water is in two areas. One is approximately between both forks of Clarks River; the other is west of Paducah near the Ohio River.

Plate 5 shows the configuration of the water table in the gravel. Most east and northerly ground-water movement discharges into streams in the southern area. Westward-moving ground water recharges the Eocene aquifers. West of Murray, the shallow zone of saturation extends from the top of the Porters Creek Clay, through thin Eocene sediments, to the lower part of the Pliocene(?) gravel. Farther west, as the Porters Creek Clay dips deeper, the gravel is above the shallow zone of saturation and is not water bearing.

The movement of ground water in the Pliocene(?) gravel area west of Paducah is toward the Ohio River. Some ground water moves northward from Eocene sand into the lower lying gravel beds. Discharge of ground water from the gravel occurs in the alluvial deposits along the Ohio River, or into the river.

Alluvium.—Ground-water movement in the alluvium is normally downstream from the edges of the valley toward the stream where ground-water discharge occurs. This movement is generally a continuation of ground-water movement in the aquifers adjacent to the stream valley. The normal ground-water movement is reversed during high-river stages, and water from the stream moves into the alluvium as bank storage. At some places, as along the Mississippi River, the effect of this reversed movement may extend to ground-water movement in adjacent aquifers about a mile away from the edge of the valley. The higher-than-normal hardness of ground water from the shallow Eocene aquifers near the Mississippi River is attributed to this reversal of ground-water movement, but this fact has not been substantiated by observed changes in ground-water levels. Although high-river stages result in recharge to the alluvial aquifers, this recharge is temporal, as the main movement of ground-water discharge toward the river from adjacent aquifers is the long-term source of recharge to the alluvium.

METHODS OF OBTAINING GROUND WATER

Almost all ground water that is used in the Jackson Purchase is pumped from wells. Springs and seeps are present at places but are of minor importance. The types of wells, and the hydrologic conditions under which each type is commonly used, have been shown on plate 1.

All types of wells, both deep and shallow, drilled or bored, need protection against contamination, especially where the water table is shallow. Care should be taken in the disposal of sewage wastes to avoid contamination of ground water. A well should be securely sealed to prevent contamination by surface runoff. Possible sources of contamination, such as drainage from barnyards and leaching fields of domestic septic-tank systems, should be avoided when locating a well site. In the course of this study numerous bored or dug wells were noted which were located in or adjacent to barnyards and were not sealed at the surface to protect against contamination. These wells were generally located in barnyards to supply water for cattle, but the domestic supply was from the same potentially or actually contaminated source of water.

DOMESTIC WELLS

Large- and small-diameter bored wells are common sources of domestic supply in areas where ground water is shallow. Most modern bored wells are dug by an earth-boring machine, cased with 24-inch-diameter concrete tiles, and water is pumped by an electrically powered jet pump.

Drilled or jetted wells are common sources of domestic supply in the Jackson Purchase region where wells about 100 feet or more in depth are needed. Most of the modern wells of these types have 4-inch-diameter steel or PVC (Polyvinyl chloride) plastic casings. A few have 3-inch steel casings. The 4-inch wells are equipped with either a submergible pump or a deep-well jet pump; the 3-inch wells have sufficient space only for a jet or cylinder lift pump. Drilled wells are commonly drilled by rotary drilling machines, but a significant number are drilled by cable-tool drilling machines. Many of the older drilled or jetted wells have 2-inch galvanized-steel casings (generally ordinary water pipe) and are equipped with cylinder-lift pumps (locally called sucker-rod pumps). Such pumps use the inside of the well casing as a cylinder. After the galvanizing (zinc coating) has been removed by slightly acidic ground water, this type of well pumps water containing a high iron content, most of which is contributed by the reaction of the ground water with the 2-inch well casing. The 3- or 4-inch steel-cased wells, unless they are heavily used, add some iron to the pumped water, but not so much as from 2-inch wells with galvanized-steel casings. Plastic-cased wells do not contribute iron to the pumped water, and their use is rapidly increasing.

LARGE YIELDING WELLS

Many municipalities and industries depend on drilled wells for water for public supply or industrial use. Most of these wells are completed by placing an artificial gravel-pack around the well screen to increase the effective diameter of the well. Large-yielding wells obtaining water from the Paleozoic bedrock are open hole in the rock. The size of casing is dependent on the yield needed. Most public-supply and industrial wells with large yields are equipped with turbine pumps.

FLUCTUATIONS OF WATER LEVELS

The water-level fluctuations in the Jackson Purchase are caused by natural recharge to and discharge from the aquifer, barometric fluctuations, ground-water withdrawal, and river-stage management.

Barometric fluctuations affect the zone of saturation throughout the region because it is confined by loess and (or) other fine-grained sediments. The barometric efficiency of each aquifer is high; a change in atmospheric pressure has been observed to cause the water level in a well to vary about 1 foot in a 2- or 3-day interval.

Hydrographs of several wells representative of water-level fluctuations in the region are shown to illustrate most of these phenomena.

The Artell Holshouser well, a 38-foot dug well in the Pliocene(?) gravel (fig. 5), is typical of shallow wells in the Jackson Purchase. A bar graph of several climatic phenomena accompanies this hydrograph to show the seasonal cycle of recharge. The water level ranges between about 30 and 32 feet below land surface and varies about 1–1½ feet per year.

The J. Whittemore well at Viola, a 106–foot drilled well in the sand of the Tallahatta Formation (fig. 6), is typical of deep wells in the Jackson Purchase. This well shown no long-term trend in water level; the water level is lower in dry years (1954, 1956, 1964) than at other times. The level ranges between 14 and 19 feet below land surface and usually varies about 3–4 feet per year.

The Shawnee Steam Plant (TVA) well (fig. 7) illustrates water-level fluctuations in an 86–foot drilled well in the Pliocene(?) gravel that are caused by changes of river stage. The south bank of the Ohio River usually is about six-tenths of a mile from this well, but at high-river stages, the water's edge is only a quarter of a mile from the well. The water level ranges between about 40 and 55 feet below land surface and varies between about 5 and 10 feet per year. Figure 8 compares the water level in this well with stages of the Ohio River at Metropolis, Ill., for 1966, a typical year.

Water-level fluctuations in a former public-supply well at Murray (fig. 9) are representative of areas where ground-water withdrawal is concentrated. The well is a 345–foot drilled well in the sand of the McNairy Formation. The water level has ranged between 123 and 129 feet below land surface and usually fluctuates between 1.2 and 1.8 feet per year. The long-term record shows a downward trend in water level of about three-tenths of a foot per year in response to pumpage. The city well field with-

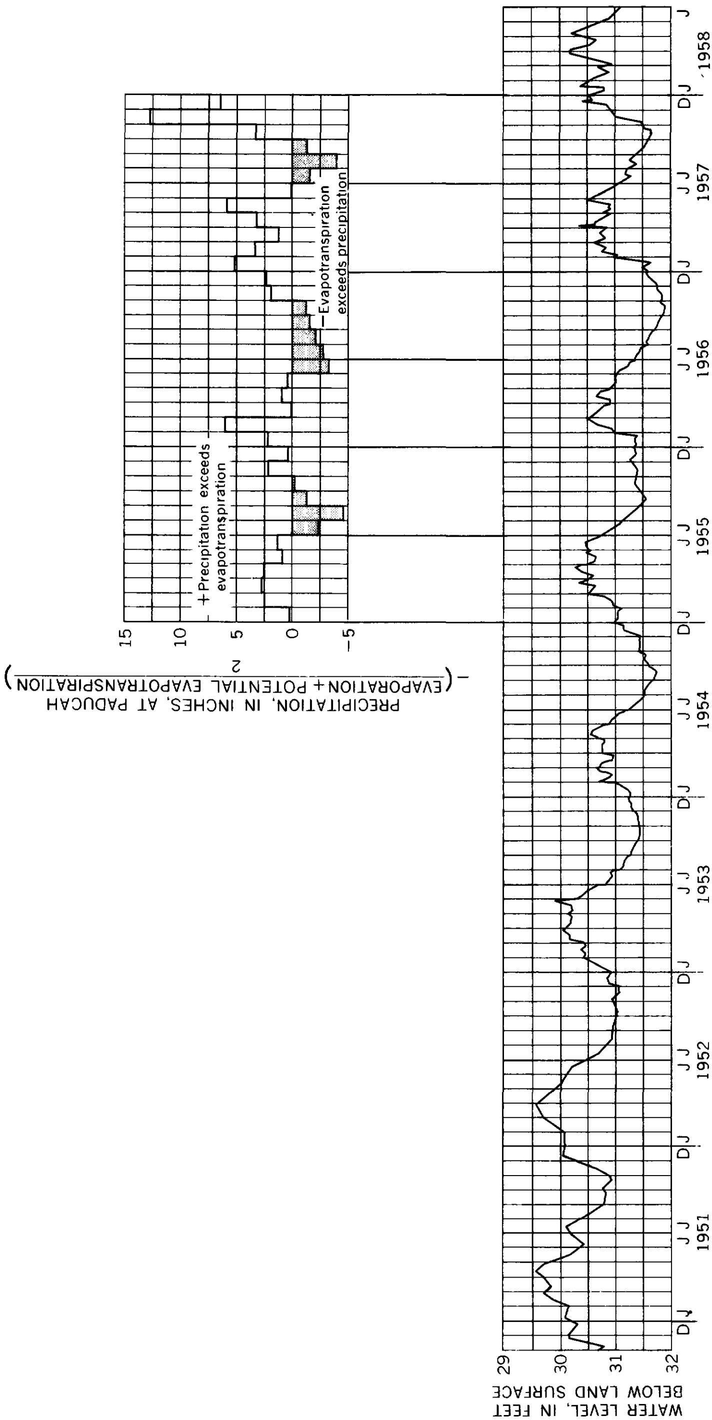

FIGURE 5.—Hydrograph of Artell Holshouser well, near Symsonia, Ky., 1950–58, and a comparison of water levels with potential recharge or runoff, 1955–57.

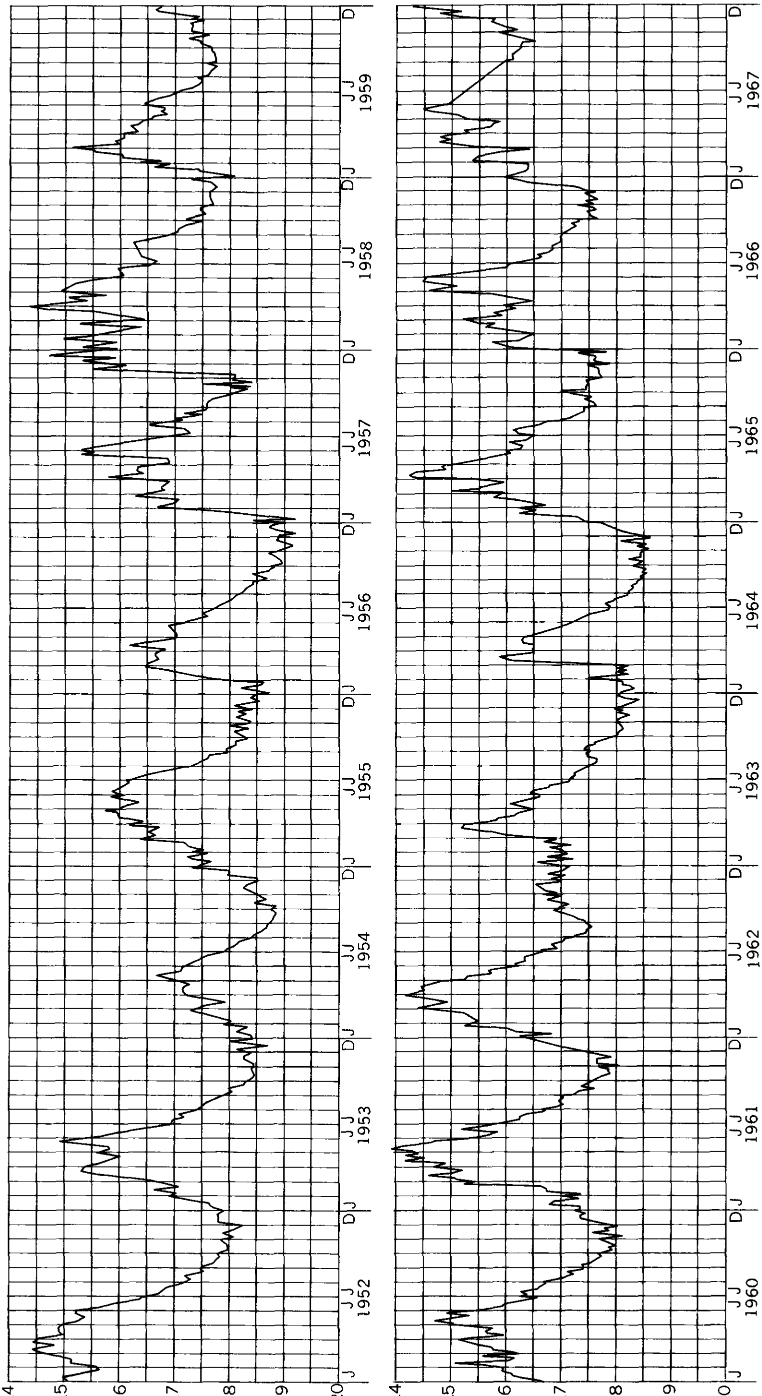

FIGURE 6.—Hydrograph of J. Whittemore well, at Viola, Ky., 1955–66.

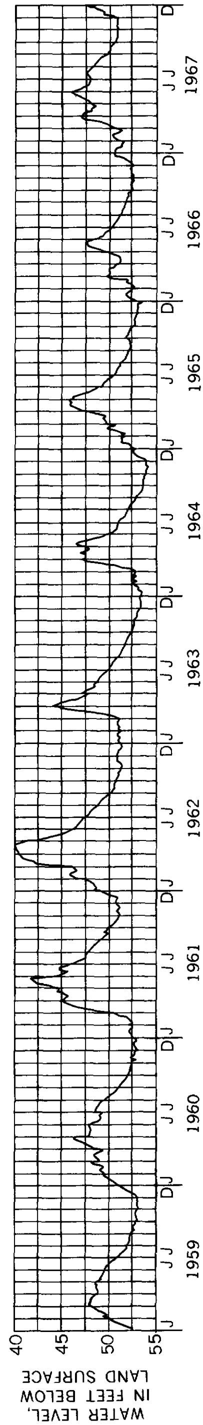

FIGURE 7.—Hydrograph of Shawnee Steam Plant (TVA) well, west of Paducah, Ky., 1959–66.

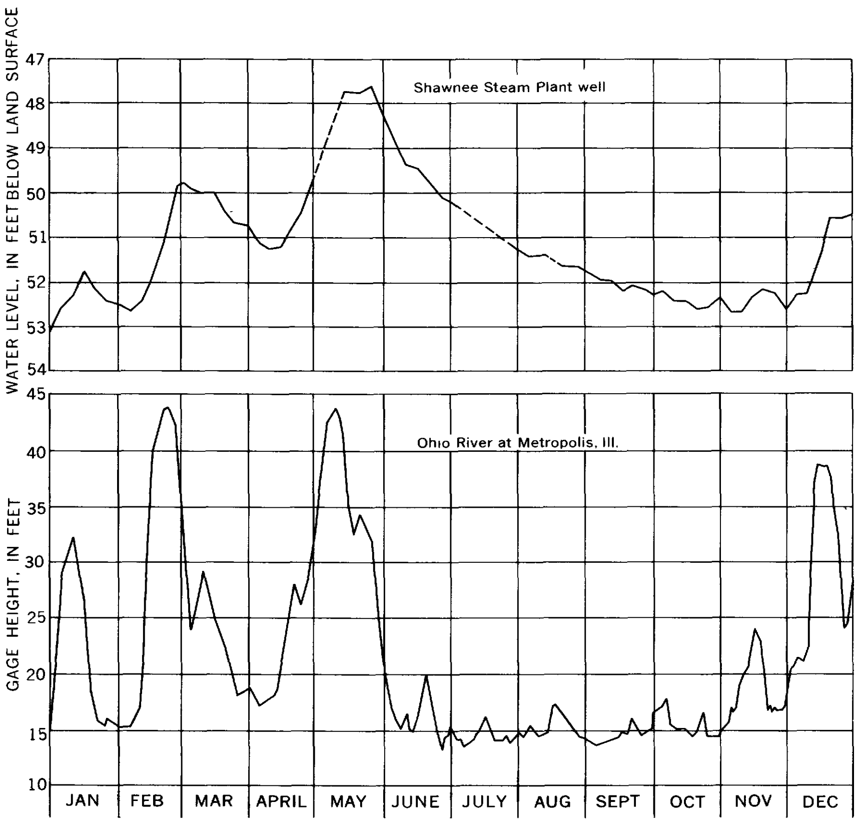

FIGURE 8.—Comparison of hydrograph of Shawnee Steam Plant (TVA) well with Ohio River stage at Metropolis, Ill., for 1966, a typical year.

draws about 600 million gallons per year; this pumpage recently has been increasing about 5 percent per year.

GROUND-WATER USE

Industries and municipal water systems that obtain water from wells constitute the largest users of ground water. Domestic use of water from individual home wells is a lesser withdrawal. Almost no water is withdrawn for irrigation in the Jackson Purchase. The table on p. 44 shows the estimated average daily amount of ground water withdrawn by wells in July 1967. The figures are modified from data obtained from the Kentucky Department of Natural Resources, Division of Water. The figure for discharge of individual domestic wells is based on the estimated population using such wells and an average use of 35 gpd per person.

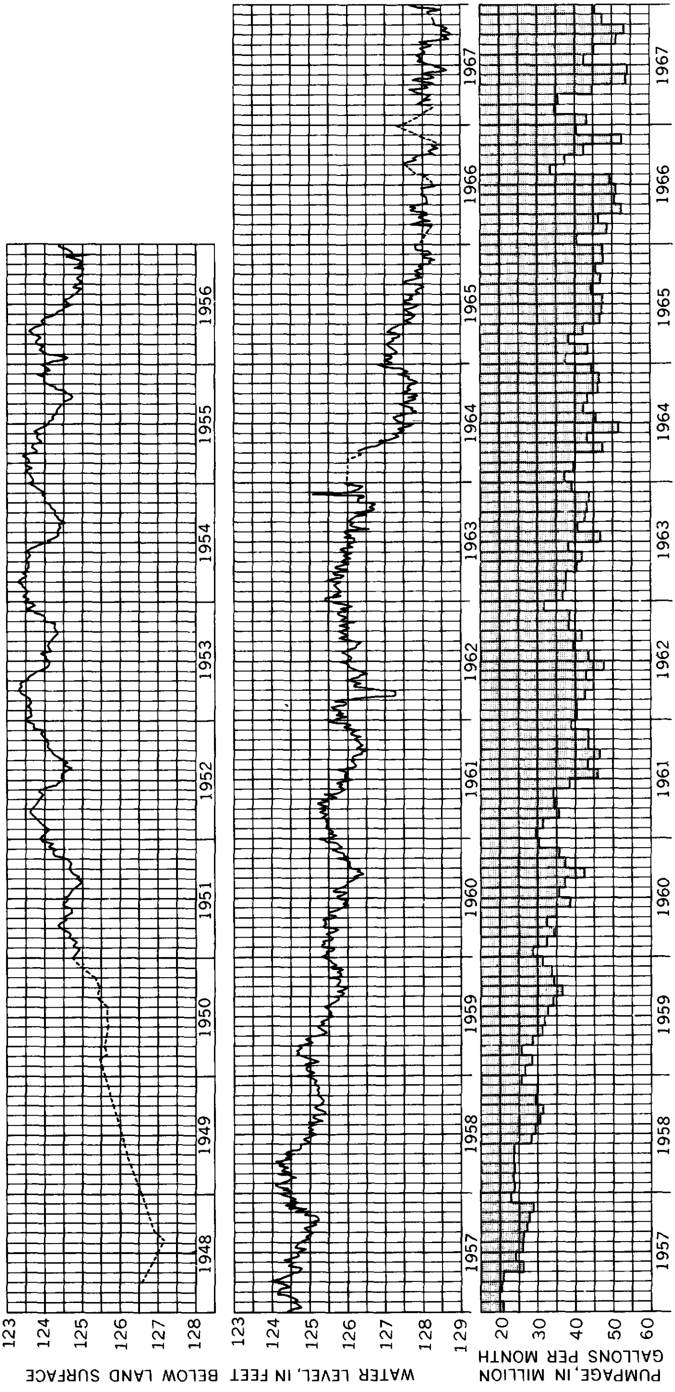

FIGURE 9.—Hydrograph of a former public-supply well at Murray, Ky., 1948–66, compared with municipal water pumpage, 1957–66. Well is about a mile west of present city well field.

Estimated average daily ground-water withdrawal, in million gallons per day, from wells in the Jackson Purchase in July 1967

Aquifer	*Withdrawal*
Industrial use (from private sources)	
Paleozoic rocks	0.06
McNairy Formation	.29
Eocene aquifers	4.47
Pliocene(?) gravel	None
Alluvium	1.30
Total	6.12
Municipal use [1]	
Paleozoic rocks	0.11
Paleozoic rocks and McNairy Formation	.15
McNairy Formation	1.94
Eocene aquifers	3.26
Pliocene(?) gravel	.03
Alluvium	.52
Total	6.07
Domestic use from individual wells	
All aquifers	2.50
Total estimated ground-water withdrawal	14.69

[1] Includes some industrial use from public supplies.

The amount of water presently being discharged is small compared with the amount of ground water in the various aquifers. In the area of the Mayfield quadrangle alone, the amount of ground water stored in the Eocene sands is estimated to be 1 trillion (1,000 billions) gallons (Davis, 1965). Although adequate quantitative data are not available for the entire Jackson Purchase region, the amount of ground water available greatly exceeds current needs and is capable of more than adequately supplying all foreseeable demands.

SUMMARY OF AVAILABILITY OF GROUND WATER

Ground water for domestic use is available in all of the Jackson Purchase. Ground water in amounts sufficient for industrial or public supply is available in most of the Jackson Purchase.

A ground-water availability map showing the shallowest formation capable of producing sufficient water for domestic use is shown on plate 10. The map is a composite availability area map made from the 43 hydrologic investigations atlases that cover the Jackson Purchase region. In each of the individual availability areas, except the bedrock of Paleozoic age, the shallow aquifer shown is underlain by deeper aquifers; many of the deeper aquifers are capable of producing larger yields than the aquifer shown for domestic use. Predicted maximum yields of wells are shown on plate 1.

Large yields of ground water are obtainable from the following aquifers: the Tallahatta Formation, the probable Cockfield Formation, and the eastern part of the Sparta Sand, all of Eocene age; the McNairy Formation of Cretaceous age in the southeastern part of the Purchase; the Pliocene(?) gravel west of Paducah; the Quaternary sand and gravel deposits in the valleys of the Tennessee, Mississippi and parts of the Ohio Rivers; and the bedrock of Paleozoic age in much of the northern and eastern parts of the Jackson Purchase.

The quantity of available ground water in the region is large, the quality is good, and the permanence will be sufficient for all foreseeable needs.

RECOMMENDATIONS FOR FURTHER STUDIES

Knowledge of the extent and capabilities of our natural resources is necessary in order to utilize them properly. This study has increased the subsurface geologic and hydrologic knowledge of the area to a level that is sufficient for the present ground-water development of the area; however, the present data are insufficient in many respects, if withdrawals of ground water increase greatly.

The following recommendations for further studies, not necessarily listed in order of importance, contain two types of suggested studies: One is for obtaining more data on conditions that presently cause, or may in the future cause, hydrologic problems. The other type of suggestion presently is more academic and cites some aspects of the hydrology or geology for which data are insufficient or are lacking. The two types of suggestions are not strictly separable. For example, data that presently are insufficient may be essential for understanding and solving a problem that may arise in the future if ground-water withdrawals are increased greatly beyond the present rate of withdrawal.

1. *Hydrology of loess*

All the upland areas of the Jackson Purchase are capped by deposits of loess ranging in thickness from a few feet to about 80 feet. Most of the recharge to the Cretaceous through Pliocene(?) aquifers occurs when water moves downward through the loess to the water table. Similarly, septic-tank effluent in the rural and suburban areas of the region is discharged into drain fields buried in the loess. The rate of water movement in the loess and the conditions requisite for water to move through the loess have not been studied in the region.

Quantitative data on loess hydrology would aid in determining the amount and rate of ground-water recharge transmitted through the loess. Such data also would aid in scientifically establishing regulations for disposal of septic-tank effluent to prevent the pollution of shallow aquifers by sewage, as is presently experienced in some densely populated suburban areas not presently served by sewer systems.

2. Stratigraphic correlation

Data are needed to outline more accurately the depths, thicknesses, facies changes, and continuity of the various aquifers, especially of those important aquifers of Eocene age. Present correlations have been determined from widely spaced wells or test holes that generally were drilled as oil-test wells or for public- or industrial-supply wells. A series of test holes that would be drilled solely for stratigraphic and hydrologic data are essential if these data are to be secured where needed.

Additional geophysical logs and uncontaminated clay samples from wells or test holes are needed along with better control material for palynological comparison from areas south of Kentucky where the formations are better exposed and have been studied in more detail. At present, palynological dating is in general agreement with correlations of geophysical logs of deep test holes, but samples from the same geologic horizon of outcrops and from shallow auger holes near the geophysically logged holes do not always agree with the determinations of age in the deep test holes. Most problems of correlation that can be aided by palynological techniques along with good geophysical logs are in the Sparta through Jackson sequence of sediments of Eocene age.

3. Quantitative hydrology

The utility of a water supply at a given location depends upon its quantity, quality, and cost of extraction. In addition to tracing the continuity of the various aquifers, much more quantitative data are needed on the hydrologic properties of the aquifers to guide future development in the Jackson Purchase region. Here too, test drilling may be necessary. The ability to store and transmit water measures the worth of an aquifer and is best determined by properly made pumping tests. At present, the coefficients of storage and transmissibility have been measured by pumping tests at five places and for three aquifers in the region. Greater areal distribution of aquifer performance values must be obtained as part of a quantative study of the aquifer systems of the region.

More quantitative data will be needed in the Calvert City industrial area to determine optimum yields and well locations if industries begin to use larger amounts of ground water than are presently pumped from the Tennessee River alluvial deposits. Additional data for hydrologic planning would be desirable in areas that may soon have new industries that require large quantities of ground water, such as Murray, Mayfield, or Fulton. As water resources approach total development, ground water may be used to augment the low flow of streams in areas where it is more feasible to do this than to create impoundments. Quantitative data are essential for planning for this conjunctive use of ground- and surface-water resources.

4. Determining the fresh-saline water interface

Saline water in the bedrock below fresh water is known to have been reached in only four oil-test wells in the Jackson Purchase; other wells, penetrating less deeply into the Paleozoic rocks, yield fresh water of good quality. A study of the fresh-saline water interface should be made prior to any industrial disposal of wastes into the deeper Paleozoic formations. Even though these formations may contain saline water that is not potable, a study should be made of the hydrology of the disposal formation and the relationship of the saline water to the overlying fresh water. As the requirements for water and air pollution become more restrictive, industries at the Calvert City industrial area may desire to dispose of wastes in the subsurface, and this may be the first area to require waste-disposal studies.

5. Conservation of ground water

At the present rate of withdrawal of ground water, there are no known areas that are considered to be overpumped. However, plans should be considered in the near future for preventing the problems that may develop should industrial and (or) municipal pumpage increase greatly. Presently, industrial cooling water is circulated through the factories one time and then discharged into a creek or ditch. Data should be obtained to determine the best way to dispose of the cooling water—by continuing to let the water flow to waste, by mandatory use of recirculating systems, by returning the used cooling water into the aquifer, or by municipal, rural water district, or other industrial use of the high quality water that only has been used only for cooling.

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TABLES 2 AND 3

TABLE 2.—*Selected chemical analyses of water from*

Type of casing: B, brick or clay tile; C. concrete tile; G, galvanized iron; I, black iron; P, are shown

[Dissolved constituents and hardness

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
Paleozoic bedrock								
Birmingham Point	159–6	Sam Reeder, Sr.	75	S	Mar. 27, 1963	15	--	2.7
Do	159–12	Moore's Camp	103	S	June 16, 1958	--	--	.27
Do	159–16	Camp Currie	77	S	Aug. 2, 1954	--	9.6	.06
Briensburg	114–1	Kentucky Dam Village.	184	S	July 3, 1957	20	8.0	12
Do	114–8	Mr. Soper	392	S	Oct. 24, 1957	--	--	.13
Do	114–14	Bob Husher	365	S	July 14, 1959	--	12	.82
Do	114–20	U-Totem Market	353	S	May 3, 1961	--	8.8	.43
Cairo	186 [1]	First Bank & Trust Co.	1,040	S	July 18, 1967	18	11	1.1
Calvert City	155–17	Duckett & Arnold.	375	S	Aug. 3, 1951	--	9.4	.35
Fairdealing	156–4	Fairdealing Grade School.	345	S	Mar. 27, 1963	16	7.1	2.6
Do	156–8	Boy Scout Camp	291	S	Oct. 25, 1957	--	--	7.6
Do	156–17	Kentucky Lake State Park.	175	S	22, 1951	15	8.0	.18
Hamlin	165–2	S. A. Caldwell	131	S	July 25, 1963	--	--	.28
Do	165–4	N. A. Young	114	P	15, 1959	--	--	.49
Do	165–8	Otis Bucey	220	S	Feb. 1, 1963	--	7.8	.73
Heath	168–8	Heath High School.	400	S	Apr. 6, 1965	18	8.6	1.4
Hico	158–4	Edward Lee	440	S	Dec. 8, 1959	12	8.8	2.7
Do	158–10	Jack Attkisson	83	(?)	Apr. 17, 1963	15	--	8.1
Do	158–22	Irvin Cobb Resort.	164	S	June 17, 1958	--	--	.65
Melber	174–2	Charles Pratt	650	S	Apr. 4, 1960	16	9.4	2.7
New Concord	118–6	Panorama Shores	128	S	Oct. 9, 1962	16	--	.70
Do	118–14	New Concord Grade School.	225	S	July 5, 1951	--	--	.39
Olmsted	176 [1]	Army Engineers	995	S	18, 1967	19	11	.41
Paducah East	177–58	WKYX (formerly WKYB).	333	S	Nov. 21, 1950	13	9.0	.05
Do	177–62	Reidland Water District.	535	S	Dec. 10, 1965	--	8.9	.08
Paducah West	177–5	Lynn Martin Fish Hatchery.	310	S	-------------	16	10	1.3
Do	177–8	West Paducah Grade School.	353	S	Jan. 5, 1954	16	6.3	.07
Do	177–34	R. F. Sullivan	540	S	June 24, 1958	--	--	2.2
Rushing Creek	160–8	Thomas Burnett	120	P	Feb. 4, 1963	--	--	.21
Do	160–13	Lynnhurst	130	S	June 1, 1954	15	8.1	.99
McNairy Formation								
Arlington	183–21	Jack Roberts	1,238	S	Aug. 6, 1965	21	16	1.5
Briensburg	114–10	North Marshall High School.	240	S	Sept. 23, 1954	--	9.0	.86
Do	114–17	Marco Restaurant.	205	S	May 3, 1961	--	7.9	.71
Do	114–25	Wanda Lane	120	S	May 4, 1961	--	--	1.9
Calvert City	155–20	T. Clyde Smith	145	S	Feb. 14, 1951	16	10	.50
Dexter	93–12	Cecil Cleaves	240	P	Aug. 30, 1962	16	10	.78
Do	93–20	Jack Frost	245	S	July 15, 1959	--	--	15
Do	93–25	S. E. Wheeler	288	S	May 8, 1958	15	9.6	.23
Elva	117–2	Brooks Freezor	78	C	Sept. 19, 1961	--	--	.14
Do	117–10	Tennessee Gas Transmission Corp.	[3]180	S	Oct. 19, 1951	15	9.8	.42
Do	117–19	C. V. Powell	467	S	Aug. 11, 1961	19	9.3	7.4
Hardin	115–2	City of Benton	192	S	May 9, 1958	15	13	.56
Do	115–11	Grover Lovett	117	C	Dec. 14, 1961	--	--	.14
Do	115–18	South Marshall High School.	360	S	8, 1959	14	9.9	7.1

See footnotes at end of table.

wells tapping various aquifers in the Jackson Purchase

plastic; R, rock; S, steel; (*), sum calculated from specific conductance. Locations of wells on plate 4.
given in milligrams per liter]

Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Sum	Dissolved solids: Residue at 180° C	Hardness as $CaCO_3$: Ca, Mg	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Paleozoic bedrock—Continued																	
---	----	----	----	---	170	0	20	4.0	0.1	0.2	*190	----	152	12	306	6.8	-
---	----	----	----	---	59	0	.4	5.0	.0	2.9	*70	----	39	0	112	6.2	-
0.03	78	10	5.1	0.2	284	0	3.3	9.0	.2	2.0	257	255	238	3	452	7.9	1
.08	14	4.2	11	.2	84	0	.4	5.5	.0	2.1	81	89	52	0	146	6.8	3
---	----	----	----	---	332	0	23	5.0	.6	.4	*350	----	288	16	546	7.8	-
.01	53	7.9	5.1	2.7	202	0	10	3.0	.1	.2	194	177	165	0	334	7.4	4
.11	58	9.3	5.7	1.4	214	0	15	6.0	.1	.3	210	246	183	7	361	7.7	-
.05	46	13	76	7.6	136	0	16	148	1.2	.9	387	424	169	57	727	8.0	-
.00	66	5.3	7.3	.6	226	0	9.9	6.0	.2	4.0	220	217	188	1	383	7.8	1
.07	3.6	1.3	2.3	.2	22	0	2.8	2.0	.0	.0	33	32	14	0	44	6.2	2
---	----	----	----	---	88	0	2.0	1.0	.1	.0	*88	----	72	0	150	6.6	-
---	5.0	2.1	3.7	.6	34	0	.7	1.5	.0	1.0	39	39	21	0	61.9	6.3	2
---	----	----	----	---	238	0	5.6	6.0	.4	.4	*215	----	195	0	382	7.4	-
---	----	----	----	---	34	0	15	10	.1	3.5	*75	----	34	6	124	6.1	-
.03	46	3.5	3.1	.5	160	0	3.6	2.0	.1	.1	146	146	130	0	254	7.4	12
.61	34	9.5	24	5.3	150	0	21	26	.4	.1	205	184	124	1	356	7.6	5
.08	2.8	9.4	2.0	.5	128	0	8.2	1.2	.1	.1	124	114	109	4	215	7.1	3
---	----	----	----	---	29	0	1.2	3.0	.1	.0	*40	----	14	0	57	6.8	-
---	----	----	----	---	116	0	9.0	6.0	.5	.1	----	----	82	0	174	6.6	-
.00	55	10	52	7.6	146	0	34	104	.3	1.4	348	336	178	58	644	6.8	3
---	----	----	----	---	10	0	16	.5	.1	1.1	*43	----	22	14	71	5.9	-
---	----	----	----	---	133	-	2	1	.1	.0	*130	----	112	----	226	--	-
.05	48	12	38	5.7	220	0	14	46	.4	.8	284	286	170	0	511	7.9	-
---	43	8.7	44		134	0	26	72	.1	.0	269	275	144	33	479	7.7	5
.00	49	9.3	18	5.4	164	0	22	36	.6	.2	230	230	160	26	415	7.7	0
.14	75	7.6	12	5.6	239	0	16	27	.1	.1	273	274	218	23	486	7.1	1
.00	42	11	25	5.6	168	0	15	41	.3	.0	232	234	150	12	421	7.4	1
---	----	----	----	---	160	0	13	42	.3	.3	*225	----	124	0	402	7.8	-
---	----	----	----	---	16	0	.8	1.5	.1	1.2	*25	----	9	0	35	5.8	-
.12	49	3.3	2.3	.5	166	0	1.8	2.0	.0	.7	151	149	135	0	265	6.5	1
McNairy Formation—Continued																	
0.01	17	3.5	79	7.1	190	0	11	48	0.4	0.9	277	285	57	0	489	6.7	25
.06	15	4.9	3.1	.4	63	0	9.2	2.8	.1	.0	76	74	57	6	127	6.8	3
.06	16	3.3	2.6	4.4	67	0	6.2	2.0	.1	.2	76	70	54	0	118	6.8	3
---	----	----	----	---	22	0	12	2.0	.1	.0	*30	----	1	0	51	6.1	-
---	6.8	1.0	15		58	0	2.2	2.5	.0	.6	67	62	21	0	99.3	6.2	3
.28	----	----	3.7	.8	32	0	4.4	4.0	.0	.1	*40	----	23	0	66	6.2	1
---	----	----	----	---	32	0	10	3.0	.1	.3	*60	----	25	0	81	6.1	-
.00	2.7	1.0	1.7	.5	11	0	6.0	.5	.0	.2	28	51	11	2	37	6.3	1
---	----	----	----	---	79	0	5.6	10	.1	6.2	*120	----	73	8	177	6.7	-
.00	57	9.5	6.1	2.2	208	0	14	10	.2	.2	212	213	182	11	372	7.6	2
.23	25	4.1	3.7	3.1	80	0	24	4.0	.1	.1	120	120	80	14	189	6.4	2
.00	5.3	2.5	2.6	.5	19	0	11	2.0	.0	.0	47	74	24	8	66	4.8	1
---	----	----	----	---	51	0	3.2	2.5	.0	2.8	*60	----	35	0	95	6.7	-
.18	4.8	2.9	2.2	.6	30	0	6.4	2.2	.1	.0	51	42	24	0	81	6.2	3

TABLE 2.—*Selected chemical analyses of water from wells*

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
McNairy Formation—Continued								
Hazel	124–6	City of Murray	255	S	May 7, 1958	--	17	2.3
Do	124–9	Murray Swimming Club.	440	S	Sept. 6, 1962	--	8.9	5.0
Do	124–16	Clifford Dodd	241	S	July 1959	--	--	.96
Do	124–27	Town of Hazel	305	S	July 5, 1951	17	34	6.0
Heath	168–7	Howard Seaton	210	S	28, 1964	--	15	1.2
Hico	158–5	Robert Parrish	74	C	Apr. 8, 1963	--	--	.28
Do	158–17	R. E. Hale	106	C	17, 1963	--	--	.04
Do	158–18	S. E. Wheeler	200	S	22, 1963	--	9.5	.29
Joppa	171–6	D. M. Pickett	177	S	6, 1964	--	12	16
Kirksey	113–12	D. L. Bazzell	452	S	May 20, 1954	--	32	8.0
La Center	173–5	H. Graves	244	S	June 30, 1964	--	--	1.1
Melber	174–3	William Just	530	S	Oct. 18, 1962	--	9.7	1.1
New Concord	118–9	J. D. Hendrick	226	S	9, 1962	17	--	5.8
Do	118–15	Odell Lamb	152	P	July 15, 1959	--	--	.18
Do	118–21	Hafford Adams	122	P	Oct. 9, 1962	--	8.7	.04
Lynn Grove	112[1]	B. M. Ford	488	P	Feb. 8. 1967	--	12	5.2
Oak Level	116–10	Let Lens	189	C	May 2, 1961	--	--	.96
Do	116–17	Brewers School	375	S	Feb. 14, 1951	--	31	2.6
Olmsted	176–10	Royce Alvey	[4]107	S	Sept. 2, 1954	17	19	15
Paducah East	177–61	Reidland Water District.	320	S	May 16, 1958	16	11	.94
Paducah West	177–1	Town of Brookport, Ill.	205	S	Oct. 24, 1962	16	5.9	.11
Do	177–44	Rolling Hills Country Club.	436	S	Jan. 4, 1954	--	4.5	.43
Symsonia	157–2	Dean Dodd	362	S	July 16, 1959	--	--	1.2
Do	157–6	H. C. Blair	250	S	Jan. 4, 1954	13	5.9	1.6
Wickliffe	185–5	State Highway Dept.	1,020	S	Mar. 9, 1966	14	15	1.3
Wilcox Formation								
Arlington	183–20	Jack Roberts	913	S	Aug. 6, 1965	20	27	4.7
Blandville	184–2	Artell Jones	275	S	June 23, 1966	14	16	1.7
Hazel	124–4	Murray State University.	183	S	13, 1958	15	9.3	.17
Heath	163–4	H. L. Tucker	68	C	July 28, 1964	--	--	.28
Do	168–10	Carl Thompson	43	C	Feb. 15, 1965	--	18	.11
Do	168–16	F. F. Miles	234	S	July 29, 1964	--	15	7.8
La Center	173–3	George Crice	87	S	Feb. 15, 1965	--	--	1.3
Do	173–6	Ballard Memorial High School.	143	S	Mar. 9, 1965	--	12	2.4
Do	173–10	Town of Kevil	180	S	Oct. 26, 1964	--	10	.23
Lynn Grove	112–21	Marvin Lassiter	292	S	Apr. 6, 1962	16	--	.11
Do	112–22	E. C. Morton	209	S	May 12, 1954	--	--	14
Melber	174–6	John Kaufman	119	C	Oct. 19, 1964	--	--	.06
Do	174–9	Woodlawn Memorial Gardens.	210	S	Apr. 15, 1964	15	10	1.4
Do	174–10	T. E. Emerson	126	P	16, 1964	15	15	.14
Oak Level	116–12	Roy Filbeck	86	C	May 2, 1961	13	--	.14
Paducah West	177–30	R. W. Davis	36	C	Nov. 21, 1962	16	--	.27
Do	177–35	Garland Blagg	127	P	June 25, 1965	--	--	.03
Do	177–48	R. L. Burnett	113	S	Nov. 19, 1952	15	12	.45
Symsonia	157–8	J. E. Wilkins	70	C	20, 1952	15	16	.15
Tallahatta Formation								
Barlow	186–7	Town of Barlow	150	S	Sept. 2, 1965	--	--	1.6
Do	186–14	Herbert Simmons.	206	S	Mar. 12, 1965	--	--	11

See footnotes at end of table.

tapping various aquifers in the Jackson Purchase—Continued

Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Sum	Dissolved solids: Residue at 180° C	Hardness as $CaCO_3$: Ca, Mg	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
McNairy Formation—Continued																	
0.13	5.6	2.2	2.8	0.5	11	0	16	2.0	0.0	0.0	54	----	23	14	68	5.5	2
.12	7.0	4.5	2.7	.9	41	0	11	3.0	.1	.1	64	62	36	2	170	6.6	2
---	----	----	----	---	16	0	22	2.0	.0	.1	*130	----	31	18	167	6.4	-
---	7.2	4.4	2.2	4.5	46	0	4.2	2.2	.2	.1	83	79	36	0	95.5	7.5	3
.03	39	9.8	20	4.1	185	0	14	14	.6	.2	209	185	138	0	351	7.6	5
---	----	----	----	---	6	0	9.6	2.5	.0	.7	*25	----	8	3	33	5.9	-
---	----	----	----	---	58	0	.8	.0	.1	.6	*60	----	42	0	100	7.4	-
.00	2.1	.8	4.4	.2	12	0	3.6	4.0	.0	1.6	32	32	8	0	44	5.7	3
.28	18	7.3	18	3.1	127	0	6.4	8.0	.2	.0	152	124	75	0	220	6.7	5
.22	17	5.7	3.7	5.9	86	0	11	1.4	.1	.2	128	117	66	0	165	6.5	1
---	----	----	----	---	205	0	10	12	.1	.1	*253	----	162	0	366	7.6	-
.09	36	8.3	29	6.3	132	0	19	48	.2	.2	223	221	124	16	412	7.5	5
---	----	----	----	---	26	0	1.8	2.0	.1	.1	*34	----	14	0	45	6.2	-
---	----	----	----	---	20	0	11	30	.1	8.0	*107	----	37	20	167	5.8	-
.02	1.4	.1	1.7	.2	9	0	1.6	2.0	.0	.6	22	20	4	0	20	5.7	2
.00	9.2	4.9	1.5	1.9	48	0	9.6	3.0	.2	.0	72	----	43	4	109	6.3	3
---	----	----	----	---	76	0	164	10	.3	18	*350	----	192	130	540	7.4	-
---	35	9.7	14		160	0	63	3.2	.0	.0	*209	215	128	40	308	6.4	4
.23	32	9.5	20	3.6	187	0	16	3.2	.0	.0	211	180	120	0	311	7.9	0
.07	51	8.2	18	4.6	166	0	21	35	.2	.1	232	250	161	24	395	7.8	2
.01	60	9.5	4.7	1.2	206	0	20	5.1	.4	.0	208	222	189	20	346	7.7	3
.03	42	10	30	5.8	148	0	21	52	.3	.3	239	245	148	25	445	7.1	1
---	----	----	----	---	136	0	20	46	.1	.2	*230	----	128	16	393	7.2	-
.27	16	4.5	9.7	2.6	66	0	8.7	16	.1	.1	98	114	59	4	183	6.2	1
.00	24	6.6	49	5.8	181	0	7.8	27	.8	.5	227	214	87	0	382	7.7	15
Wilcox Formation—Continued																	
0.87	15	3.6	30	5.7	127	0	21	3.0	0.0	0.4	173	167	52	0	232	6.5	20
.00	3.6	1.4	4.2	.1	24	0	2.6	3.0	.1	.2	45	49	15	0	51	5.8	2
.16	6.0	2.3	12	.5	12	0	.0	27	.0	3.2	66	88	24	14	125	5.5	4
---	----	----	----	---	101	0	6.4	62	.4	14	*370	----	78	0	408	6.7	-
.01	31	4.2	26	2.4	128	0	28	13	.0	2.8	189	209	94	0	314	7.0	2
.24	6.1	2.6	6.3	.6	38	0	5.2	4.5	.2	.1	67	48	26	0	83	6.3	5
---	----	----	----	---	136	0	19	66	.1	.1	*285	----	76	0	482	7.9	-
.12	7.6	3.4	11	.5	54	0	7.6	4.5	.1	.1	76	73	33	0	119	6.1	3
.04	12	3.7	32	.8	108	0	6.0	16	.1	2.2	136	134	45	0	238	6.8	2
---	----	----	----	---	14	0	1.4	2.0	.0	.1	*26	----	5	0	29	5.8	-
---	----	----	----	---	30	0	3.3	16	.0	.1	*64	----	20	----	103	--	-
---	----	----	10	---	78	0	2.0	10	.0	10	*116	----	66	2	185	6.1	-
.09	22	1.4	4.1	.3	29	0	.0	2.0	.0	.1	36	38	12	0	46	6.1	0
.08	1.4	.5	4.0	.6	15	0	.0	1.5	.0	.2	31	36	6	0	35	5.7	0
---	----	----	----	---	92	0	274	82	.4	.4	*580	----	350	274	938	6.3	-
---	----	----	----	---	122	0	256	74	.2	10	*550	----	336	236	925	6.9	-
.04	4.2	2.2	19	.6	29	0	2.8	14	.1	19	91	----	20	0	153	6.2	5
.00	3.6	1.2	6.4	1.6	32	0	1.0	3.2	.1	.1	46	----	14	----	58.4	5.9	1
.00	5.6	1.5	6.6	.6	29	0	1.2	4.5	.1	5.1	53	----	20	----	79.3	6.0	0
Tallahatta Formation—Continued																	
---	----	----	----	---	78	0	10	10	0.1	12	*120	----	57	0	196	6.5	-
---	----	----	----	---	52	0	2.4	5.0	.0	.4	*70	----	24	0	103	6.4	-

TABLE 2.—*Selected chemical analyses of water from wells*

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
Tallahatta Formation—Continued								
Blandville	184–1A	Rodney Leigh	180	P	Mar. 20, 1967	16	--	----
Do	184–1	E. F. Ohning	234	P	Sept. 24, 1965	--	--	7.0
Do	184–17	J. T. Morgan	265	P	23, 1965	--	--	.00
Crutchfield	167–20	Fulton Ice Co.	575	S	Nov. 3, 1958	--	14	.03
Cuba	161–5	V. L. Pickard	183	P	Sept. 23, 1963	16	--	.06
Do	161–9	Rhodes & Williams.	178	S	June 6, 1958	16	--	4.1
Fancy Farm	169–8	Brown Thompson.	259	S	May 12, 1958	15	17	2.1
Farmington	92–2	Paul Burton	95	C	Aug. 14, 1962	--	--	.12
Do	92–8	Glen H. Walker	165	P	----do ------	--	--	.06
Do	92–17	Harmon Jones	206	S	June 9, 1954	17	11	.17
Hazel	124–24	Clarence Stockdale.	95	S	Sept. 26, 1962	--	--	.21
Heath	168–12	J. R. Moss	150	S	July 28, 1964	--	13	.14
Do	168–17	L. H. Hodges	130	S	29, 1964	--	--	.20
Hickory	163–12	General Tire & Rubber Co.	244	S	Dec. 8, 1959	14	13	.48
Do	163–16	Pet Milk Co.	186	S	Oct. 22, 1951	14	16	.26
Kirksey	113–6	D. L. West	120	C	Apr. 16, 1962	--	--	.17
Do	113–15	Monroe Wilkinson.	104	C	----do ------	14	--	.13
La Center	173–9	T. J. Bowles	90	S	Sept. 2, 1954	16	13	.35
Do	173–11	Bondurant Bros.	212	S	Oct. 30, 1964	14	11	1.8
Lovelaceville	172–2	E. E. Bearden	156	S	Mar. 1, 1965	15	--	.04
Do	172–4	W. H. Ellis	193	S	Feb. 15, 1951	13	16	.52
Do	172–10	B. Edwards	136	S	Mar. 1, 1965	15	--	1.0
Do	172–12	John Lowe	162	S	Sept. 25, 1958	16	14	.03
Lynn Grove	112–5	Luck Burt	185	S	May 12, 1954	15	9.5	.16
Do	112–15	Leslie Dalton	143	S	---do ------	17	9.1	1.5
Do	112–20	Hugh Foster	190	P	Apr. 2, 1962	14	--	.09
Lynnville	125–1	Bennett Dycus	141	P	26, 1962	--	--	.12
Do	125–11	R. E. Motheral	232	S	June 7, 1954	16	11	.13
Do	125–19	Jeff Gills	110	P	July 24, 1962	17	15	.08
Mayfield	164–4	Town of Mayfield.	260	S	Feb. 4, 1958	15	15	.03
Melber	174–4	John Griffith, Jr.	124	S	Oct. 19, 1964	14	--	.88
Do	174–20	Caldwell Bros.	[5] 190	P	---do ------	15	11	.08
Do	174–24	Carter's Concrete Pipe Co.	136	S	Apr. 22, 1964	16	11	.29
Symsonia	157–14	Solon Smith	58	C	Nov. 20, 1952	17	--	.09
Water Valley	162–14	Town of Fulton	627	S	Aug. 6, 1951	16	12	.43
West Plains	166–8	Lola Summerville.	167	P	27, 1963	--	--	.07
Do	166–17	Thomas Carlisle	192	S	6, 1963	--	--	.19
Do	166–19	R. B. Cope	64	C	Sept. 11, 1963	--	--	.14
Wickliffe	185–3	E. Teeters	265	S	Mar. 12, 1965	--	--	.19
Do	185–13	John Turk	500	P	June 2, 1966	16	--	.30
Sparta Sand								
Arlington	183–4	Town of Bardwell.	107	I	Feb. 15, 1951	15	26	0.09
Do	183–19	Town of Columbus.	325	I	---do ------	14	16	.18
Blandville	184–12	Paul Coughlin	158	P	Sept. 9, 1966	16	17	.10
Do	184–18	J. T. Morgan	[6] 144	P	17, 1965	--	--	.07
Clinton	175–8	Town of Clinton	296	I	Feb. 14, 1951	17	19	.20
Cuba	161–1	O. C. Burton	210	G	Sept. 25, 1963	16	11	21
Do	161–16	J. D. Yates	175	I	June 12, 1958	15	15	.23
Dublin	170–2	E. P. Butler	195	P	Oct. 2, 1964	--	--	.32
Do	170–4	R. Wiman	206	P	Sept. 30, 1964	--	--	.24
Do	170–9	J. Skaggs	200	P	25, 1964	--	--	.18

See footnotes at end of table.

tapping various aquifers in the Jackson Purchase—Continued

Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Sum	Dissolved solids: Residue at 180° C	Hardness as $CaCO_3$: Ca, Mg	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Tallahatta Formation—Continued																	
---	----	----	----	---	68	0	4.0	6.0	--	2.1	----	88	31	0	129	6.3	-
---	----	----	----	---	46	0	.8	6.0	0.1	.2	*60	----	21	0	98	6.4	-
---	----	----	----	---	42	0	.8	4.0	.1	.1	*50	----	24	0	81	6.1	-
0.02	3.6	1.2	4.5	0.5	23	0	.6	3.5	.1	.1	39	34	14	0	48	5.7	1
---	----	----	----	---	48	0	2.0	5.0	.1	.7	*60	----	18	0	91	6.3	-
---	----	----	----	---	44	0	4.8	8.0	.1	.4	*65	----	26	0	98	6.5	-
.00	2.3	.4	6.0	.2	20	0	1.0	2.5	.0	.2	41	51	8	0	42	5.8	2
---	----	----	----	---	22	0	.0	7.0	.0	8.5	*50	----	18	0	73	6.3	-
---	----	----	----	---	12	0	1.6	.0	.0	.2	*25	----	6	0	26	5.9	-
.00	1.8	.7	3.2	.6	17	0	1.2	1.5	.1	.4	29	26	7	0	34.2	6.2	1
---	----	----	----	---	14	0	1.6	4.0	.1	4.7	*20	----	7	0	44	5.8	-
.00	4.3	1.7	9.1	.0	36	0	1.2	5.0	.3	.2	53	52	18	0	74	6.1	5
---	----	----	----	---	84	0	2.4	17	.3	2.7	*120	----	26	0	196	6.6	-
.01	3.1	1.0	3.9	.7	18	0	.0	2.2	.3	5.8	39	38	12	0	53	5.7	1
.00	3.4	.8	5.7	1.1	18	0	4.4	3.5	.1	3.2	*47	49	12	0	57.0	6.0	0
---	----	----	----	---	52	0	5.4	13	.0	8.1	*100	----	45	2	158	6.4	-
---	----	----	----	---	40	0	4.8	18	.0	16	*100	----	43	10	169	6.5	-
.02	7.4	2.8	21	.4	75	0	2.6	10	.1	.2	95	92	30	0	150	7.0	3
.08	7.1	3.8	10	.6	52	0	7.2	8.0	.2	.2	76	84	33	0	117	6.5	0
---	----	----	----	---	27	0	.4	8.5	.1	5.3	*40	----	14	0	89	6.1	-
---	6.4	1.0	16		62	0	1.3	1.8	.0	.1	74	66	20	0	97.3	6.2	5
---	----	----	----	---	27	0	.4	3.0	.0	.5	*41	----	14	0	56	5.8	-
.00	2.6	.8	4.6	.2	19	0	.0	4.0	.0	.5	36	34	10	0	44	6.1	3
.02	3.0	1.4	4.5	.6	14	0	5.0	4.6	.0	.5	36	37	13	2	50.5	6.4	2
---	3.3	1.1	6.1	.6	19	0	2.9	7.2	.0	1.0	43	41	13	0	62.8	5.9	2
---	----	----	----	---	16	0	2.8	4.5	.1	.1	*33	----	8	0	43	5.5	-
---	----	----	----	---	19	0	1.6	3.0	.0	.4	*35	----	10	0	49	6.0	-
.00	2.6	1.8	2.6	.7	21	0	1.1	1.0	.1	1.5	33	35	14	0	45.1	5.8	2
.01	.5	.6	6.0	.5	12	0	1.6	3.5	.0	3.8	38	36	4	0	39	7.1	0
.03	6.2	2.2	11	.4	24	0	16	9.0	.0	4.6	76	76	24	5	119	6.6	0
---	----	----	----	---	56	0	.4	2.5	.0	.6	*62	----	10	0	94	6.6	-
.02	2.2	.7	3.2	.6	14	0	.8	2.0	.0	2.8	30	30	8	0	35	5.9	2
.00	1.3	.7	3.1	.5	18	0	.2	2.0	.0	.0	28	30	6	0	36	6.0	0
---	----	----	----	---	109	-	11	20	.1	7.0	*160	----	87	----	272	--	-
---	3.2	1.5	4.7	.6	24	0	2.1	2.4	.0	.1	*39	38	14	0	47.7	7.1	0
---	----	----	----	---	16	0	1.6	.0	.1	.3	*28	----	7	0	33	5.9	-
---	----	----	----	---	20	0	4.8	5.0	.1	.4	----	----	9	0	56	6.4	-
---	----	----	----	---	50	0	1.2	2.0	.1	1.5	*62	----	34	0	94	6.5	-
---	----	----	----	---	52	0	2.0	6.5	.0	1.4	*69	----	26	0	106	6.2	-
.00	----	----	----	---	63	0	2.4	4.0	--	.1	----	68	42	0	109	6.3	-
Sparta Sand—Continued																	
---	8.8	4.4	13	0.5	61	0	4.6	7.5	0.0	8.8	104	94	40	0	152	6.5	5
---	60	15	40		354	0	2.7	2.5	.1	2.0	299	----	212	0	539	7.1	2
0.06	11	4.9	17	.3	84	0	1.2	11	.1	2.2	106	111	48	0	167	6.3	5
---	----	----	----	---	58	0	.8	4.0	.1	6.2	*75	----	30	0	122	6.3	-
---	9.6	3.6	9.6		64	0	1.7	3.5	.0	.6	79	78	39	0	125	6.3	2
.09	5.4	2.2	5.4	.5	30	0	.8	6.5	.3	.1	68	52	22	0	75	6.3	0
.00	1.5	.5	3.4	.2	15	0	.2	2.5	.0	.1	31	30	6	0	30	5.8	2
---	----	----	----	---	54	0	.4	1.5	.0	6.7	*65	----	10	0	106	6.3	-
---	----	----	----	---	18	0	.4	.0	.0	.3	*30	----	8	0	36	5.9	-
---	----	----	----	---	33	0	3.2	3.0	.0	1.2	*47	----	20	0	77	6.3	-

TABLE 2.—*Selected chemical analyses of water from wells*

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
Sparta Sand—Continued								
Fancy Farm	169–1	Gilliam Thompson.	128	G	Mar. 2, 1965	14	--	3.2
Do	169–3	J. J. Tyler	170	I	---do	15	--	.21
Do	169–6	R. W. Dodson	152	I	---do	--	15	.54
Hickman	181–8	Town of Hickman.	640	I	Feb. 14, 1951	18	11	1.8
Hickory	163–4	Alfred Westbrook.	163	I	Apr. 4, 1964	15	--	.47
Lovelaceville	172–11	R. C. Harper	94	C	Mar. 2, 1965	--	--	.12
Mayfield	164–1	Benthal Johnson	152	P	May 11, 1964	--	9.5	.04
Do	164–12	Earl Cartwright	166	P	Nov. 7, 1963	15	--	.09
Do	164–15	Town of Wingo	180	I	June 12, 1958	16	12	.06
Milburn	179–5	James Sullivan	290	P	1, 1966	--	20	1.5
Do	179–9	William Phelps	172	I	2, 1966	15	--	.67
Water Valley	162–3	J. W. Newhouse	410	G	Oct. 22, 1963	--	10	7.8
Do	162 [1]	Town of Fulton	296	I	June 8, 1966	15	21	.22
Do	162–9	Town of Water Valley.	182	I	Sept. 19, 1952	16	23	.24
Do	162–10	G. W. Cook	247	G	Nov. 4, 1963	--	--	2.7
Wickliffe	185–4	Town of Wickliffe.	137	I	Mar. 8, 1965	--	17	.91
Do	185–8	Lowell Carter	364	P	Nov. 18, 1966	15	--	.42
Do	185–16	Toy Fraser	327	P	June 16, 1966	--	--	.00
Cockfield and Jackson Formation undivided								
Arlington	183–7	G. H. Terry	220	S	Oct. 17, 1966	15	--	3.3
Do	183–16	Town of Arlington.	100	S	July 5, 1951	16	12	.24
Cayce	180–4	R. Plez Fields	106	P	May 2, 1966	--	--	.04
Do	180–13	Jesse McNeil	230	S	4, 1966	--	--	8.5
Do	180–19	Theo Brockwell	116	S	26, 1966	--	--	.18
Clinton	175–4	D. B. Brown	35	C	June 18, 1965	--	13	.00
Do	175–11	H. Poe Trucking Co.	185	P	July 6, 1965	--	--	.11
Crutchfield	167–1	E. J. Walton	60	P	8, 1964	--	--	.17
Do	167–7	W. Shelton	114	P	10, 1964	--	--	13
Do	167–13	B. F. Gilbert	110	P	7, 1964	--	--	.06
Dublin	170–15	J. F. Hopkins	160	P	Sept. 10, 1964	--	--	.26
Do	181–11	Richard White	238	S	June 21, 1966	17	16	.39
Hickman	181–17	Truman Benthal	262	S	Oct. 14, 1966	--	20	1.9
Do	181–20	Billy Helper	346	S	Sept. 30, 1966	--	13	4.3
Milburn	179–4	John Terry	118	P	June 1, 1966	16	13	.36
Do	179–14	Kermit Cromwell	86	S	---do	16	--	.12
Oakton	182–3	J. A. Schwartz	135	S	Sept. 2, 1966	--	--	.14
Do	182–8	B. W. Taylor	161	P	Oct. 21, 1966	14	23	.25
Do	182–15	E. M. Bolin	155	P	Aug. 17, 1965	--	--	.05
Water Valley	162–13	Pure Milk Co.	107	S	July 5, 1951	16	14	.54
Wickliffe	185–15	O. L. Galloway, Jr.	125	P	June 16, 1966	64	--	.24
Do	185–18	A. M. Hambrick	94	P	Sept. 13, 1966	--	--	.46
Pliocene(?) and Pleistocene gravel								
Bandana	176–6	WPSD–TV	70	S	May 14, 1964	--	--	0.21
Do	176–8	G. Throgmorton	46	B	---do	14	--	.14
Do	176–14	Bandana Grade School.	78	S	Oct. 30, 1957	--	--	.52
Do	176–16	C. L. Nichols	90	S	May 14, 1964	--	--	.96
Barlow	186–6	F. H. Webb	49	C	Mar. 12, 1965	--	--	.10
Dexter	93–5	James F. Parker	34	C	Aug. 30, 1962	15	11	.12
Do	93–16	Charles Starks	37	C	Aug. 31, 1962	--	8.7	.17
Do	93–22	Mrs. Elmo Boyd	45	C	---do	16	--	.08
Elva	117–18	E. H. Turner	43	C	Aug. 18, 1961	16	--	.14

See footnotes at end of table.

tapping various aquifers in the Jackson Purchase—Continued

Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Sum	Dissolved solids: Residue at 180° C	Hardness as $CaCO_3$: Ca, Mg	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Sparta Sand—Continued																	
---	----	----	----	---	40	0	5.6	9.0	0.1	1.3	*73	----	18	0	112	6.2	-
---	----	----	----	---	24	0	.4	5.0	.0	.7	*45	----	15	0	64	6.0	-
0.01	3.3	2.0	28	0.3	79	0	.8	3.5	.0	8.3	101	98	16	0	152	6.4	2
---	9.6	4.9	6.9		62	0	4.4	2.2	.0	.8	*72	66	44	0	113	6.1	2
---	----	----	----	---	43	0	3.2	4.5	.1	1.9	*55	----	28	0	85	6.1	-
---	----	----	----	---	74	0	2.8	20	.1	23	*146	----	52	0	236	6.5	-
.00	7.0	2.8	17	.7	50	0	5.6	16	.0	.8	84	78	29	0	144	6.1	2
---	----	----	----	---	26	0	1.2	6.0	.0	.6	*46	----	12	0	66	6.2	-
.00	2.0	.9	3.9	.2	17	0	.2	3.0	.0	.7	31	33	8	0	37	6.5	2
.30	9.5	3.5	5.4	2.0	55	0	.2	4.0	.1	4.0	78	65	38	0	102	6.2	5
---	----	----	----	---	42	0	.4	4.5	.0	.1	*55	----	17	0	79	6.2	-
.06	3.3	1.7	4.1	.5	37	0	2.4	3.0	.0	1.5	52	46	15	0	66	6.3	5
.22	4.6	1.6	9.6	.5	31	0	8.0	4.0	.1	.3	65	68	18	0	83	6.8	5
.41	12	5.1	23	1.1	19	0	26	33	.0	20	*153	153	51	35	246	6.9	3
---	----	----	----	---	86	0	2.0	3.0	.0	.2	*83	----	27	0	132	6.6	-
.32	30	12	9.8	.8	133	0	23	7.5	.1	.1	167	159	125	16	281	6.5	3
---	----	----	----	---	44	0	2.4	4.0	--	.5	----	47	28	0	82	6.0	-
.11	----	----	----	---	87	0	2.8	8.0	--	2.1	----	108	61	0	174	6.5	-
Cockfield and Jackson Formation undivided—Continued																	
0.17	----	----	----	---	60	0	1.2	5.0	0.2	0.2	----	56	34	0	108	6.4	-
---	26	14	16	1.1	118	0	36	12	.0	13	188	201	123	26	328	6.7	0
---	----	----	----	---	132	0	.8	4.0	.1	2.7	----	147	98	0	221	6.5	-
---	----	----	----	---	194	0	6.8	3.0	.1	.0	*174	----	127	0	311	6.8	-
---	----	----	----	---	148	0	1.6	5.0	.2	.1	*133	----	94	0	233	6.5	-
.03	11	5.1	22	.4	79	0	5.2	12	.1	8.8	116	115	48	0	200	6.3	5
---	----	----	----	---	76	0	.8	5.0	.1	.8	*85	----	51	0	139	6.5	-
---	----	----	----	---	37	0	.0	3.5	.1	6.9	*52	----	16	0	85	6.1	-
---	----	----	----	---	73	0	1.2	3.0	.3	.2	*78	----	39	0	127	6.3	-
---	----	----	----	---	37	0	1.2	8.0	.1	25	*85	----	40	10	140	6.0	-
---	----	----	----	---	27	0	.0	1.5	.0	1.6	*37	----	13	0	61	6.0	-
.34	49	18	9.8	5.2	260	0	7.2	6.0	.2	.2	240	243	196	0	415	6.4	5
.30	24	8.8	24	4.1	173	0	10	4.0	.1	.0	182	176	96	0	286	6.9	5
.12	39	17	9.4	3.0	224	0	6.4	3.0	.2	.0	205	193	168	0	339	7.9	5
.35	6.4	2.9	5.9	.8	41	0	2.0	4.0	.1	.4	56	61	28	0	84	6.1	5
---	----	----	----	---	76	0	.8	8.0	.0	12	*115	----	30	0	182	6.4	-
---	----	----	----	---	278	0	6.2	2.0	--	16	----	240	232	4	432	7.0	-
.00	16	9.6	8.7	.4	104	0	2.4	6.0	.1	4.8	122	122	80	0	200	6.4	1
---	----	----	----	---	41	0	4.0	4.0	.1	13	*66	----	30	0	109	6.1	-
---	17	6.3	24	3.0	40	0	42	29	.0	6.0	*162	178	68	36	282	5.9	0
.10	----	----	----	---	328	0	5.8	4.0	--	3.3	----	272	270	1	503	7.3	-
---	----	----	----	---	102	0	5.6	12	--	10	----	132	67	0	208	6.4	-
Pliocene(?) and Pleistocene gravel—Continued																	
---	----	----	----	---	118	0	10	32	0.0	37	*245	----	119	22	389	6.5	-
---	----	----	----	---	128	0	3.6	20	.1	26	*218	----	73	0	346	6.6	-
---	----	----	----	---	112	0	7.0	18	.2	4.3	*137	----	77	0	259	6.5	-
---	----	----	----	---	106	0	6.0	28	.2	26	*200	----	89	2	318	6.6	-
---	----	----	----	---	292	0	31	16	.2	20	*357	----	254	14	585	7.1	-
0.08	16	4.1	22	5.1	32	0	19	38	.1	17	148	162	57	31	263	6.3	4
.05	9.8	3.9	18	1.1	30	0	2.4	36	.0	6.8	102	121	40	16	190	6.2	2
---	----	----	----	---	25	0	2.0	49	.0	4.8	*130	----	40	20	218	5.9	-
---	----	----	----	---	32	0	2.4	26	.0	7.0	*100	----	48	22	157	6.0	-

TABLE 2.—*Selected chemical analyses of water from wells*

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
Pliocene(?) and Pleistocene gravel—Continued								
Hardin	115–8	Aubrey Washburn.	115	C	Jan. 17, 1962	--	--	0.04
Do	115–17	Unknown	36	C	Dec. 1, 1961	--	--	.16
Hazel	124–2	C. G. Paschell	65	C	June 30, 1954	--	11	.46
Do	124–12	C. O. Jenkins	23	C	May 27, 1954	--	--	.50
Do	124–30	J. M. Perry	62	C	do	18	7.7	.76
Heath	168–2	John Miller	86	S	July 28, 1964	--	18	.03
Do	168–11	James Lovett	50	C	29, 1964	--	--	.11
Joppa	171–1	H. Travelsteads	32	B	Apr. 6, 1964	14	--	.69
Do	171–9	State of Kentucky.	71	S	Mar. 1, 1965	--	--	.34
Kirksey	113–3	Mount Carmel Church.	43	C	Apr. 18, 1962	14	--	.38
Do	113–14	Raymond Palmer	40	C	17, 1962	--	--	.14
La Center	173–2	W. H. Meriwether.	60	S	Feb. 15, 1965	--	13	1.4
Oak Level	116–5	Charles McGregor.	47	C	Aug. 2, 1954	--	8.4	.68
Do	116–20	John Jones	42	B	May 3, 1961	14	--	.06
Paducah East	177–66	W. T. Peyton	40	C	Dec. 10, 1965	--	10	.27
Paducah West	177–9	Stanley Whitaker.	44	C	Nov. 18, 1952	16	--	.21
Do	177–12	Dexter Howell	45	C	do	16	--	.21
Symsonia	157–7	R. L. Bailey, Jr.	45	C	Nov. 20, 1952	14	11	.12
Do	157–17	R. J. McClure	48	C	do	14	12	.20
Alluvium of Quaternary age								
Arlington	183–9	Cye Mathis	35	S	Dec. 13, 1965	--	30	9.7
Bandana	176–1	Roy Sledd	27	S	Sept. 3, 1954	16	22	3.0
Barlow	186–1A	Renfrow Hunting Ranch.	37	S	June 8, 1967	16	--	.11
Do	186–13A	Unknown	11	S	do	14	17	.76
Bondurant	178–7	Ellis Smith	40	S	Apr. 20, 1965	16	21	12
Do	178–12	R. Hornsby	27	S	do	--	23	.40
Do	178–13	Singer(?)	50	S	do	16	--	14
Cairo	186–5A	Unknown	45	S	June 8, 1967	14	16	1.0
Calvert City	155–8	B. F. Goodrich Chemical Co.	100	S	May 9, 1957	16	18	15
Do	155–11	Town of Calvert City.	120	S	May 16, 1957	15	16	8.9
Do	155–24	Kentucky Dam Tree Nursery.	131	S	do	16	14	7.3
Cayce	180–1	Stowe Coffey	35	S	Aug. 10, 1966	--	28	1.1
Dexter	93–4	Lucie Ernestberger.	12	R	31, 1962	--	--	.28
Dublin	170–1	C. Burgess	30	B	Oct. 12, 1964	--	--	.14
Do	117–11	W. R. Vines	29	B	Aug. 2, 1954	17	12	2.3
Hardin	115–3	Mr. Stockdale	40	C	Dec. 1, 1961	--	--	.01
Do	115–22	Hardin Grade School.	44	C	Feb. 2, 1962	--	--	.33
Hazel	124–11	Bailey Barley	13	C	Sept. 27, 1962	--	--	.13
Hickman	181–3	Shelby Terminal	117	S	Nov. 15, 1966	14	23	3.1
Do	181–4	Armstrong Cork Co.	25	S	Dec. 13, 1965	--	20	5.9
Do	181–6	E. Weaks McKinney-Smith.	33	S	Oct. 12, 1966	15	49	.27
Hico	158–6	L. W. Wallace	18	C	Apr. 5, 1963	13	--	.28
Hubbard Lake	178–3	Joe Whitson	90	S	Jan. 13, 1966	--	--	17
Do	178–4	Johnny Cox	28	S	do	--	--	6.1
Kirksey	113–11	Claude Smith	14	S	Apr. 18, 1962	--	--	.97
Little Cypress	155–4	B. F. McFarland	31	B	Feb. 20, 1963	--	18	.02
Do	155–5	Altona Baptist Church.	37	C	do	14	--	.10

See footnotes at end of table.

tapping various aquifers in the Jackson Purchase—Continued

											Dissolved solids		Hardness as $CaCO_3$				
Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Sum	Residue at 180° C	Ca, Mg	Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Pliocene(?) and Pleistocene gravel—Continued																	
---	----	----	----	---	30	0	2.8	4.0	0.1	3.4	*50	----	33	8	87	6.2	-
---	----	----	----	---	95	0	19	6.0	.1	13	*140	----	78	0	262	7.0	-
0.11	15	3.1	24	1.0	68	0	8.6	18	.0	21	136	135	51	0	224	7.6	2
---	----	----	----	---	14	0	6.4	12	.0	19	*70	----	26	----	117	--	-
.05	11	1.5	3.9	1.2	33	0	3.5	5.6	.0	4.5	55	59	34	7	89.0	6.4	1
.00	18	7.1	37	.7	104	0	7.2	35	.3	14	188	167	74	0	325	6.5	5
---	----	----	----	---	58	0	4.8	46	.4	24	*185	----	66	18	306	7.5	-
---	----	----	----	---	102	0	8.4	26	.2	22	*182	----	61	0	298	6.4	-
.00	16	7.3	54	.6	186	0	9.2	18	.2	1.9	213	220	70	0	368	6.9	2
---	----	----	----	---	48	0	5.6	3.0	.1	.3	*60	----	33	0	91	6.3	-
---	----	----	----	---	54	0	11	11	.1	16	*120	----	62	18	186	6.4	-
.02	7.5	2.9	23	.4	75	0	.4	10	.1	6.2	102	105	30	0	168	6.9	5
.09	17	4.8	18	3.6	38	0	6.3	44	.1	11	133	147	62	31	246	6.8	-
---	----	----	71	18	88	0	50	55	.1	146	*450	----	170	98	716	6.5	-
.07	9.2	2.5	7.5	1.0	33	0	4.4	12	.2	5.2	68	73	34	6	120	6.1	6
.00	54	8.3	60	3.8	276	0	4.4	34	.2	5.0	348	----	168	----	580	7.0	2
---	----	----	----	---	161	-	8.2	74	.1	3.7	*300	----	116	----	503	--	-
.00	10	3.4	11	1.4	39	0	1.0	20	.1	5.5	88	----	40	----	140	6.1	0
.00	13	4.9	32	1.9	51	0	3.5	36	.1	26	160	----	53	----	274	6.1	0
Alluvium of Quaternary age—Continued																	
0.00	75	27	5.9	2.1	350	0	7.6	5.0	0.4	1.9	342	331	298	11	538	7.2	5
.03	4.9	1.7	6.2	1.0	18	0	6.7	3.2	.1	11	69	68	19	4	80.1	6.2	3
.00	----	----	----	---	--	-	15	2.0	--	24	----	83	40	25	114	5.9	-
.09	9.5	2.3	7.3	.2	58	0	1.2	4.0	.0	.0	70	70	33	0	106	6.1	3
6.3	67	29	6.0	1.0	348	0	12	2.1	.2	.1	328	305	286	0	530	6.9	5
2.7	114	42	21	2.2	418	0	98	22	.4	11	543	547	457	115	864	7.4	5
---	----	----	----	---	384	0	.8	3.0	.2	.2	*340	----	285	0	580	7.0	-
.16	46	11	4.7	2.8	149	0	35	9.0	.2	9.0	208	207	160	38	348	6.4	3
.13	44	7.3	9.5	.7	173	0	4.6	10	.3	9.9	197	182	140	0	299	6.9	5
.20	50	5.6	4.9	.4	179	0	3.6	4.0	.2	2.5	184	176	148	2	287	7.1	3
.00	50	8.2	7.8	.5	190	0	10	4.5	.1	2.5	198	198	159	3	316	7.1	2
2.4	120	30	8.6	2.0	462	0	48	6.5	.2	.5	474	461	423	44	760	7.7	5
---	----	----	----	---	5	0	64	53	.1	34	*250	----	77	73	404	5.2	-
---	----	----	----	---	27	0	7.2	16	.0	12	*90	----	22	0	148	5.9	-
.20	44	16	14	3.2	180	0	26	23	.1	.4	230	219	174	28	389	7.4	5
---	----	----	----	---	15	0	6.0	4.0	.0	7.0	*50	----	15	3	66	5.6	-
---	----	----	----	---	42	0	137	12	.1	24	*330	----	168	134	429	6.1	-
---	----	----	----	---	9	0	17	13	.0	8.2	*60	----	20	12	123	5.3	-
.75	140	36	9.5	3.7	608	0	21	2.8	.2	.0	536	543	498	0	898	7.4	5
.20	64	24	6.5	1.0	276	0	30	4.0	.2	.4	292	291	258	32	466	7.5	5
1.2	140	37	9.7	3.5	635	0	2.6	3.0	.2	.0	558	565	502	0	921	7.6	15
---	----	----	----	---	25	0	9.2	2.0	.0	1.2	*50	----	16	0	67	7.2	-
---	----	----	----	---	456	0	24	6.0	.2	.5	*450	----	398	24	698	7.1	-
---	----	----	----	---	605	0	7.8	5.0	.3	.5	*540	----	496	0	865	7.1	-
---	----	----	----	---	10	0	8.8	12	.0	18	----	----	26	18	110	5.5	-
.00	23	12	100	2.0	102	0	83	88	.3	39	416	422	107	24	720	6.3	7
---	----	----	----	---	56	0	6.0	14	.3	25	*140	----	51	5	197	6.3	-

TABLE 2.—*Selected chemical analyses of water from wells*

Quadrangle	No. of hydrologic atlas and well No. on atlas	Owner	Depth (feet)	Type of casing	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)
Alluvium of Quaternary age—Continued								
New Madrid	178–1	A. Stepp	68	C	Apr. 19, 1965	--	--	18
Oak Level	116–13	Cola Reed	17	C	May 3, 1961	14	--	.03
Olmsted	176–4	State of Kentucky.	58	S	June 17, 1958	17	12	6.4
Do	176–9	do	70	S	Nov. 20, 1965	--	--	19
Paducah East	177–26	Southland Motel	117	S	Oct. 29, 1957	--	--	2.3
Do	177–59	WKYX (formerly WKYB).	25	C	Apr. 10, 1965	--	31	1.1
Symsonia	157–3	J. T. Strong	32	B	Nov. 20, 1952	13	--	.08
Do	157–11	R. E. Simpson	27	C	Jan. 4, 1954	12	--	6.7
Wickliffe	185–11A	Ohio Valley Timber Co.	38	S	May 9, 1967	14	28	31
Wolf Island	182–1	James Ezzell	78	S	Oct. 21, 1965	16	--	14
Do	182–13	Roy Dillard	44	S	Dec. 13, 1965	--	24	14

[1] Sample collected after completion of atlas.
[2] Shown as Tuscaloosa Formation on HA–114.
[3] Depth on HA–117 is shown incorrectly as 204 ft.
[4] Well was later deepened to 416 ft.
[5] Shown as 199 ft on HA–174.
[6] Shown as 130 ft on HA–184.

tapping various aquifers in the Jackson Purchase—Continued

Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Sum	Dissolved solids: Residue at 180° C	Hardness as $CaCO_3$: Ca, Mg	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Alluvium of Quaternary age—Continued																	
---	----	----	----	---	484	0	22	9.0	0.2	0.0	*480	----	426	29	754	7.1	-
---	----	----	----	---	44	0	24	11	.1	9.9	*120	----	46	10	196	6.1	-
1.1	12	5.8	7.1	1.8	50	0	14	8.5	.1	3.1	96	103	54	13	154	6.7	3
---	----	----	----	---	76	0	3.2	5.0	.2	.2	*89	----	66	4	146	6.7	-
---	----	----	----	---	170	0	4.6	37	.1	1.7	*240	----	146	6	402	7.2	-
1.5	504	351	297	12	177	0	2,490	400	.1	.6	4,180	4,560	2,700	2,550	4,700	6.8	5
---	----	----	----	---	178	-	47	23	.4	25	*280	----	178	----	482	--	-
---	----	----	----	---	364	0	1.0	132	.1	7.8	560	----	462	----	973	--	-
.85	149	31	6.0	3.0	640	0	.8	5.0	.1	.1	547	542	500	0	923	6.9	5
---	----	----	----	---	475	0	45	8.0	.1	.2	*473	----	435	46	775	7.3	-
.30	43	88	7.2	2.2	518	0	47	6.0	.2	.2	487	502	469	44	794	7.9	5

TABLE 3.—*Hydrologic properties of geologic formations in the Jackson Purchase region, Kentucky*

[Particle-size distribution graphs are shown for several samples representative of each formation. Some data from the distribution curves are shown in the table. The 75-percent and 25-percent particle sizes were read from the curves; the sorting coefficient was calculated from the 25-percent particle sizes. The sorting coefficient is the square root of the ratio of the 75-percent particle size to the 25-percent size. Sedimentologists consider that a sorting coefficient of less than 2.5 indicates a well-sorted sediment; between 2.5 and 4.0, a normally sorted sediment; and larger than 4.0, a poorly sorted sediment. Location of samples are shown on pl. 10; an asterisk (*) before the sample number indicates a particle-size distribution curve of that sample is also shown on pl. 10]

County	Formation symbol and No. of sample	Depth of sample (feet below land surface)[1]	Moisture content (percent, by dry weight)	Coefficient of permeability (gpd per sq ft)	Average unit weight of constituents (g per cc)	Unit weight of dry sample (g per cc)	Porosity (percent, by volume)	Specific retention (percent, by volume)	Specific yield (percent, by volume)	75-percent particle size	25-percent particle size	Sorting coefficient
Alluvium of Quaternary age												
Ballard	*Qal-1	OV	10.7	480	2.62	1.28	51.1	5.7	45.4	0.205	0.165	1.11
Do	Qal-2	OH	10.3	460	2.68	1.30	51.5	5.7	45.8	.19	.15	1.13
Loess of Pleistocene age												
Ballard	Ql-1	OV	18.7	2	----	1.50	44.4	----	----	0.027	0.0085	1.78
Do	Ql-2	OH	23.9	--------	2.74	1.25	54.4	----	----	.029	.010	1.70
Do	*Ql-3	OV	24.4	1.6	2.76	1.48	46.4	16.9	29.5	.030	.011	1.65
Hickman	Ql-4	OV	23 8	6.1	2.74	1.39	49.3	16.2	33.1	.029	.011	1.63
Do	Ql-5	OH	20.7	4.1	2.74	1.35	50 7	16.0	34.7	.027	.0105	1.60
Cockfield through Jackson Formation undivided												
Graves	*Tj-1	OH	34.5	0.0003	----	1.37	48 5	44.9	3.6	0.0016	----	----
Do	*Tj-2	OV	8.1	170	----	1.52	42.6	1.4	41.2	.23	0.155	1.22
Do	Tj-3	OH	8.0	270	----	1.50	43.6	2.7	40.9	.25	.17	1.21
Claiborne Group of Eocene age												
McCracken	*Tc-1	OV	7.0	164	----	1.72	35.6	----	----	0.90	0.41	1.48
Do	Tc-2	OH	7.8	54	----	1.62	39.8	----	----	1.03	.61	1.30
Do	Tc-3	OV	4.7	575	----	1.39	47.7	----	----	.31	.21	1.22
Do	*Tc-4	OH	5.5	561	----	1.40	47.8	----	----	.32	.20	1.27
Calloway	*Tc-5	OV	8.1	230	----	1.52	43.5	1.0	42.5	.32	.225	1.19
Do	Tc-6	OH	8.1	400	----	1.48	44.6	1.0	43.6	.35	.25	1.18
McCracken	*Tc-7	53.5–54	----	420	----	1.59	40.4	.6	39.8	.31	.20	1.25
Do	Tc-8	54–54.5	----	410	----	1.53	42.5	1.4	41.1	.30	.20	1.23
Ballard	*Tc-9	OV	----	[2].0005	2.62	1.48	43.5	----	----	.0085	----	----
Graves	Tc-10 [3]	120–125	----	--------	----	----	----	----	----	.32	.21	1.23
Do	*Tc-11 [3]	145–150	----	--------	----	----	----	----	----	.42	.25	1.30
Do	Tc-12 [3]	155–160	----	--------	----	----	----	----	----	.31	.188	1.29
Do	Tc-13 [3]	170–175	----	--------	----	----	----	----	----	.27	.16	1.30

Do	Tc-14 [8]	185-188	----	--------	----	----	----	----	----	.33	.22	1.225
Wilcox Formation of Eocene age												
Graves	Tw-1	OV	----	[2]0.004	2.66	1.25	53.0	----	----	0.014	----	----
McCracken	*Tw-2 [4]	OV	----	--------	----	----	----	----	----	.27	0.01	5.2
Do	Tw-3 [4]	OV	----	--------	----	----	----	----	----	.14	----	----
Do	Tw-4 [4]	OV	----	--------	----	----	----	----	----	.54	.37	1.21
Porters Creek Clay of Paleocene age												
Graves	Tpc-1	42.5-44	----	300	----	1.56	42.6	25.7	16.9	----	----	----
Do	Tpc-2	60-61.5	----	15	----	1.49	45.2	23.9	21.3	----	----	----
Do	*Tpc-3	70.5-72	----	.002	----	1.31	51.3	29.7	21.6	0.12	0.045	1.64
Marshall	*Tpc-4	OV	----	[2].0005	2.55	1.05	58.8	----	----	.0062	----	----
Calloway	*Tpc-5	OV	----	[2].0005	2.51	.96	61.8	----	----	.30	.0045	8.2
McCracken	Tpc-6 [4]	OV	61.3	--------	----	1.59	----	----	----	.025	----	----
Do	*Tpc-7 [4]	OV	----	--------	----	----	----	----	----	.076	.002	6.2
Do	Tpc-8 [4]	OV	----	--------	----	----	----	----	----	.37	.0026	12.0
Do	Tpc-9 [4]	20	----	--------	----	----	----	----	----	.0016	----	----
Do	Tpc-10 [4]	OV	24.3	--------	----	1.54	----	----	----	.11	.014	2.82
Calloway	*Tpc-11	OV	[5]47.7	.0004	----	[5]1.18	[5]56.9	32.3	24.6	.020	.0011	4.3
McNairy Formation of Cretaceous age												
Calloway	Km-1	OV	4.7	318	----	1.51	43.4	----	----	0.285	0.21	1.17
Do	Km-2	OH	3.0	782	----	1.45	45.7	----	----	.31	.245	1.13
Marshall	Km-3	OV	3.6	380	----	1.53	42.5	----	----	.235	.195	1.10
Do	Km-4	OH	3.7	600	----	1.43	46.4	----	----	.23	.18	1.13
McCracken	Km-5 [4]	OV	26.8	--------	----	1.75	----	----	----	.047	.0051	3.04
Calloway	Km-6 [6]	OV	6.2	700	----	1 55	41.7	3.4	38.3	.43	.32	1.16
Do	Km-7 [6]	OH	3.9	1,000	----	1.59	40.2	2.6	37.6	.50	.35	1.20
Marshall	*Km-8 [7]	OV	30.0	.0003	----	1.49	43.6	12.6	31.0	.032	.0006	7.3
McCracken	Km-9	33.5-34	----	60	----	1.60	40.3	2.9	37.4	.265	.18	1.21
Do	*Km-10	34-34.5	----	8	----	1.63	39.0	3.9	35.1	.26	.145	1.34
Do	Km-11	34.5-35	----	4	----	1.71	36.0	6.2	29.8	.27	.16	1.30
Marshall	Km-12	34-34.5	----	220	----	1.56	41.6	5.2	36.4	.30	.22	1.17
Do	Km-13	34.5-35	----	1	----	1.60	40.1	9.0	31.1	.31	.18	1.31
Do	Km-14	35-35.5	----	35	----	1.53	43.1	5.7	37.4	.26	.21	1.12
Do	*Km-15	32.5-33	----	.02	2.68	1.83	31.7	4.9	26.8	.27	.16	1.30
Marshall	Km-16	32-32.5	----	0.4	2.66	1.79	32.7	4.2	28.5	.35	.22	1.26
Do	Km-17	31.5-32	----	100	2.67	1.70	36.3	.6	35.7	.50	.34	1.21
Do	Km-18	31.5-32	----	.8	2.66	1.64	38.3	3.0	35.3	.35	.24	1.21
Do	Km-19	31-31.5	----	30	2.66	1.63	38.7	5.5	33.2	.29	.25	1.08
Do	Km-20	17-17.5	----	.005	2 69	1.83	32.0	30.4	1.6	.22	.005	6.7
Do	*Km-21	16.5-17	----	.005	2.68	1.71	36.2	23.2	13.0	.22	.001	14.9
Do	*Km-22	17-17.5	----	.08	2.67	1.55	41.9	11.3	30.6	.23	.12	1.39
Do	Km-23	16.5-17	----	80	2.66	1.57	41.0	2.9	38.1	.19	.15	1.13
Calloway	Km-24	63-63.5	----	4	2 70	1.48	45.2	5.7	39.5	.11	.08	1.18
Do	*Km-25	62.5-63	----	4	2.69	1.33	50.6	12.7	37.9	.105	.072	1.21

See footnotes at end of table.

TABLE 3.—*Hydrologic properties of geologic formations in the Jackson Purchase region, Kentucky*—Continued

County	Formation symbol and No. of sample	Depth of sample (feet below land surface)[1]	Moisture content (percent, by dry weight)	Coefficient of permeability (gpd per sq ft)	Average unit weight of constituents (g per cc)	Unit weight of dry sample (g per cc)	Porosity (percent, by volume)	Specific retention (percent, by volume)	Specific yield (percent, by volume)	75-percent particle size	25-percent particle size	Sorting coefficient
McNairy Formation of Cretaceous age—Continued												
Do	*Km-26	14-14.5	----	0.03	2.69	1.52	43.5	20.6	22.9	0.17	0.076	1.50
Do	Km-27	13.5-14	----	10	2.67	1.35	49.4	4.7	44.7	.16	.125	1.13
Do	Km-28	34-34.5	----	.5	2.67	1.88	29.6	2.2	27.4	.26	.15	1.32
Do	Km-29	33.5-34	----	.7	2.67	1.85	30.7	3.4	27.3	.28	.18	1.25
Do	Km-30	20-20.5	----	3	2.66	1.77	33.5	4.8	28.7	.49	.25	1.40
Do	*Km-31	19 5-20	----	350	2.68	1.60	40.3	1.9	38.4	.53	.27	1.41
Do	Km-32	23.5-24	----	72	2.68	1.38	48.5	2.2	46.3	.15	.11	1.17
Do	Km-33	24-24.5	----	.3	2.67	1.59	40.4	5.3	35.1	.14	.103	1.17
Do	*Km-34	24.5-25	----	.2	2.67	1.76	34.1	14.0	20.1	.135	.09	1.23
McCracken	*Km-35 [4]	OV	28.1	--------	----	1.60	----	----	----	.028	.0029	3.12
Do	Km-36 [4]	120	25.8	--------	----	1.93	----	----	----	.039	.0043	3.02
Do	Km-37 [4]	118	24.2	--------	----	1.94	----	----	----	.022	----	----
Do	Km-38 [4]	108	23.1	--------	----	1.98	----	----	----	.030	----	----
Do	Km-39 [4]	47	26 0	--------	----	1.87	----	----	----	.158	.008	4.45
Do	Km-40 [4]	OV	36.6	--------	----	1.60	----	----	----	.058	.0054	3.29

[1] OV, exposure-vertical sample; OH, exposure-horizontal sample.

[2] Data on permeability may be only a maximum possible value, as the sample did not become saturated after 3 months of immersion in water. The coefficient of permeability was measured by coring the sample with a thin tube which was placed in a high-pressure permeameter. The permeability value may represent only the movement of water between the sample and the wall of the thin tube.

[3] Analyzed by Edward E. Johnson, Inc.

[4] T. C. Nichols, (written commun., 1968).

[5] I. A. Johnson, (written commun.. 1955), Hydrologic Laboratory: "Sample 54KY1 (Tpc-11) gave us considerable trouble in that we could not get it out of its cylinder. We had to cut it out, and in the process, part of the sample fell out. We believe we were able to pick up all of the sample but the remote possibility exists that the porosity, unit weight, and moisture content might be in error. However, we feel fairly confident that they are at least the right order of magnitude."

[6] These samples were reported as Eocene (sand) in MacCary and Lambert, 1962, p. 8, table 3.

[7] This sample was reported as Paleocene (Porters Creek Clay) in MacCary and Lambert, 1962, p. 8, table 3.

U. S. GOVERNMENT PRINTING OFFICE : 1974 O - 523-313