The values obtained indicate that water will move horizontally through the Eocene at 1½ to 3 times the vertical rate. The porosity of the samples ranged from 35.6 to 47.8 percent. The coefficient of permeability of a horizontal clay sample was determined to be 0.0003, and the porosity was 48.5 percent. The hydrologic properties and particle size of the Eocene sands and clays are shown in figures 27 and 28 and table 3.

Figures 29 and 30, the hydrographs of wells at Viola and Fulton, show a seasonal variation in water level, which is high in the spring and low in the fall. A long-term trend related to precipitation is shown by the well near West Viola. The rainfall at a weather station 15 miles away was 66.60 inches in 1950, 55.79 inches in 1951, 41.33 inches in 1952, 35.84 inches in 1953, and 39.76 inches in 1954. The water level in this well dropped nearly 3 feet in the 4 years, owing to a deficiency in recharge. Figure 11, the hydrograph of a well at Bardwell, shows the effect caused by the pumping of a well 52 feet away at a rate of 178 gpm.

Rocks of the Eocene series generally will yield sufficient water for modern domestic supplies. As in the Ripley formation, wells can be drilled as deep as necessary without danger of contamination by salt or sulfur water. Some evidence suggests that water in the lower part of the series locally is of better quality than that in the upper part. Except for water in deep aquifers and in thin aquifers in areas underlain largely by clay, the water in the Eocene is unconfined. Water in the artesian aquifers may rise to within a few feet of the surface.

Water samples from 76 wells in the Eocene series were analyzed. Of these, 48 were soft, 14 were moderately hard, 6 were hard, and 8 were very hard. Thirty-two samples had a hardness of less than 30 ppm. The range in hardness was from 7 ppm for water from a well at Sedalia to 404 ppm for water from a well 2 miles south of Hickman. The dissolved solids ranged from a minimum of 28 ppm in water from a well at Cuba to a maximum of 431 ppm, including 91 ppm of nitrate, in water from a well at Milburn. More than half the samples had a dissolved-solids content of less than 120 ppm. Most of the wells yielding hard water high in dissolved solids are along the Mississippi River bluffs in Fulton, Hickman, and Carlisle Counties. The high hardness and dissolved solids may be the result of percolation of water through calcareous loess, which attains a thickness of 40 feet in these counties. Ground water from the area of loess generally contains carbonate and is alkaline, having a pH of 8.0 or higher. The pH of ground water from the Eocene ranges from 5.4 to 8.4. Most water in the Eocene series has an iron content higher than the limit of 0.3 ppm recommended by the U. S. Public Health Service. The iron content reported in some samples was probably due in part to the effect of corrosive waters of low pH on the steel well casing. The silica content of ground water in the Eocene ranges from 6.6 to 59 ppm. The high content of iron and the low pH may present a problem in some industrial applications, but water in the Eocene is generally of good quality for domestic purposes. The water is of the sodium or calcium bicarbonate type. A nitrate content above the local average often indicates pollution of the water. With two exceptions, samples from all the drilled wells had nitrate contents less than 38 ppm. Samples from a few dug wells and tiled bored wells had nitrate contents greater than 100 ppm, and a sample from one bored well had a content of 439 ppm.

PLIOCENE(?)

Gravel of Pliocene(?) age covers most of the Eocene and older rocks in the Jackson Purchase. Although the gravel is not everywhere an aquifer, it supplies domestic wells in several areas. Dug wells 40 or 50 feet deep are most common. The gravel deposits are thickest in Marshall, McCracken, and Ballard Counties; they are thickest on the uplands and on the tops of hills and ridges. Water-bearing gravel occurs in Calloway, Marshall, McCracken, Ballard, and parts of Graves and Fulton Counties. The gravel is not generally capable of giving large yields because it is poorly sorted and is commonly cemented by iron oxide. Figure 31 shows the hydrograph of a well penetrating gravel of Pliocene(?) age on the upland near Symsonia, northeastern Graves County. Several drawdown tests were made to determine the specific capacity of wells in the gravel of Pliocene(?) age. In all except two wells the pumps broke suction in less than an hour. Those 2 wells had specific capacities of 5.1 and 12 gpm per foot of drawdown when tested. (See figs. 32 and 33.)

Springs are generally uncommon in the Jackson Purchase, although a few issue from the gravel of Pliocene(?) age. Most of these issue above cemented zones or above clay beds underlying the gravel. None yields more than 10 gpm except Hale Spring which flows approximately 50 gpm during wet weather. The measured discharge of a number of springs appears in table 4.

No samples of the sediments of Pliocene(?) age were collected for mechanical analysis. Detailed mechanical analyses of the sand and gravel are described by P. E. Potter in a thesis on file at the University of Chicago, entitled "The petrology and origin of the Lafayette gravel" (1952).

Areas in several counties in which the Pliocene(?) gravel is water bearing are shown on the availability map. The gravel is a good aquifer in the northern half of Ballard County and the northwestern third of McCracken County. Water occurs in the gravel beneath the uplands at Reidland and Symsonia. The ground water in the gravel of Pliocene(?) age is usually under water-table conditions, but artesian water may be found under layers cemented with iron oxide.

Water samples from 25 wells and springs in the gravel of Pliocene(?) age were analyzed. Of these, 12 were soft, 7 were moderately hard, 3 were hard, and 3 were very hard. The range in hardness was from 8 to 906 ppm, and in dissolved solids, 43 to 782 ppm. The pH ranged from 5.7 to 7.5. The iron content of ground water from the gravel generally is less than the limit of 0.3 ppm recommended by the U. S. Public Health Service. Only one sample had an iron content greater than 1 ppm. Four of the samples had a nitrate content greater than 44 ppm, the maximum value in water that might be safely used in infant feeding (Maxcy, 1950). The water in the gravel of Pliocene(?) age is of the calcium magnesium sulfate and calcium magnesium bicarbonate types.

QUATERNARY

The Pleistocene loess generally is not water bearing. The loess occurs as a blanket deposit over much of Fulton, Hickman, and Carlisle Counties. The thickness is greatest, about 40 feet, along the Mississippi River bluffs; it lessens to the east. One dug well in the loess was inventoried and was reported to furnish sufficient water for domestic use.

The coefficients of permeability of 2 vertical samples of loess were 2 and 6.1 meinzers; the porosities were 44.4 and 49.3 percent. (See fig. 34 and table 3.)

Alluvium of Pleistocene and Recent age in the Mississippi, Ohio, and Tennessee River valleys is an important source of water for irrigation and industry. As yet, there is little development of wells in the alluvium in the Jackson Purchase. The alluvium along the Clarks River and Obion and Mayfield Creeks probably will supply only domestic wells. The alluvium is 100 feet thick at Calvert City, 60 feet thick in northwestern Ballard County, and 120 feet thick in an oil test hole near Miller, Fulton County. Bridge borings indicate that the alluvium changes in lithology within short distances, both vertically and horizontally.

The potentially most productive areas of alluvium are in the Mississippi River bottoms, the Ohio River bottoms in Ballard County, and the Tennessee River valley below Kentucky Dam. The northwestern part of McCracken County also is potentially a good area for the development of wells in the alluvium of the Ohio valley. There is evidence that more than 50 feet of saturated sand and gravel can be found in both the Ohio and the Mississippi River flood plains. A 6-inch well in the bottoms in northwestern Ballard County penetrated nearly 50 feet of saturated sand and gravel. This well will produce more than 300 gpm. Many 1¼-and 1½-inch driven wells tap the alluvial aquifer at depths of 20 to 30 feet.

Water samples from 19 wells in the alluvium were analyzed. Of 16 tested for hardness, 6 were soft, 2 were moderately hard, 3 were hard, and 5 were very hard. The range in hardness was from 12 to 664 ppm. The range in dissolved solids in the 19 samples was from 53 to 1,220 ppm. The pH ranged from 5.5 to 7.4. Approximately two-thirds of the samples had an iron content higher than the limit recommended by the U. S. Public Health Service. The specific conductance decreased from 147 micromhos for a sample from Hazel to 114 micromhos for a sample from Almo and to a low of 66 micromhos for a sample from Hardin. Downstream from Benton the specific conductance of water from the alluvium increases to 389 micromhos in a sample from a well 1½ miles south of Sharpe and to 729 micromhos in a sample from a well at Paducah.

The alluvium was sampled at two localities for mechanical analysis. The coefficients of permeability were 480 and 300 meinzers for vertical samples and 460 and 240 meinzers for horizontal samples. The sieve analyses (fig. 35), which indicate that the alluvial sands are very well sorted, show that most of the particles fall in the range from 0.125 to 0.250 millimeter. (See also table 3.)

Two-hour specific-capacity tests were run on two wells in the alluvium. The results of these tests are shown graphically in figures 36 and 37.

The hydrograph of a well 3 miles southeast of Paducah (fig.38) shows the changes in water level in the alluvium along the Tennessee River. The fluctuations shown largely reflect changes in river stage.

One area shown on the availability map includes the alluvium along the Ohio, Tennessee, and Mississippi Rivers. Most wells in this area will furnish at least sufficient water for domestic purposes. Many of the shallow driven wells in Fulton County went dry in 1954 after a 3-year drought. Water-table conditions exist in most of the alluvial area, but where large amounts of clay are present, as at Paducah, the water in the lower part of the alluvium may be under artesian pressure. Several flowing wells have been found in the alluvial area in the bottoms of Obion Creek. One well was flowing 5 gpm at the time it was tested. It is possible, however, that these wells penetrate the Eocene series and obtain the flowing water from it.

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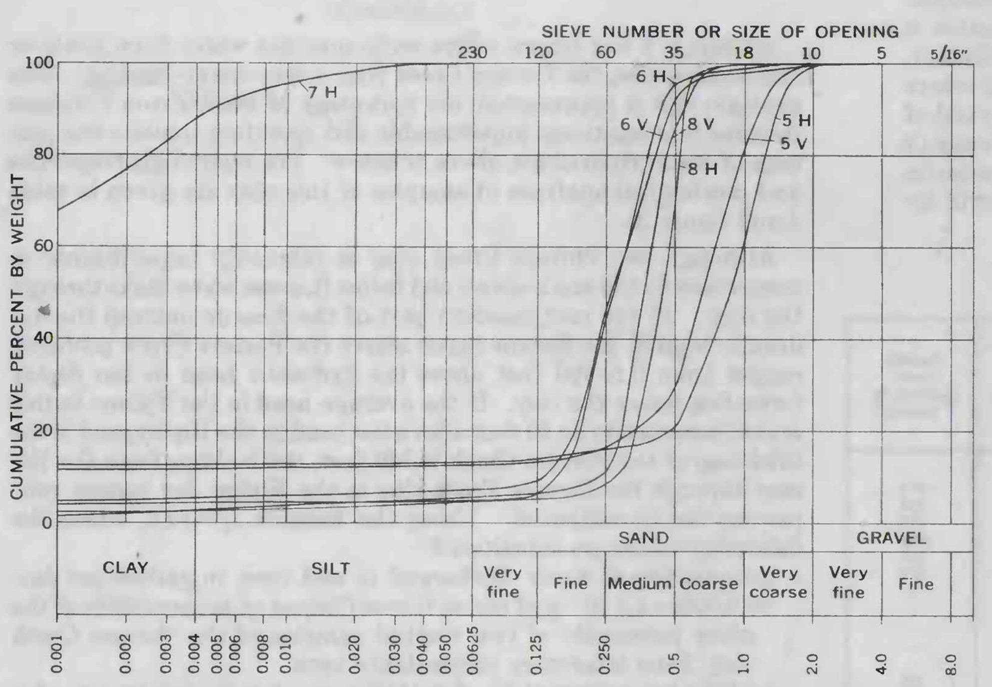

FIGURE 27—PARTICLE-SIZE DISTRIBUTION OF SAMPLES 5–8 OF THE EOCENE SERIES

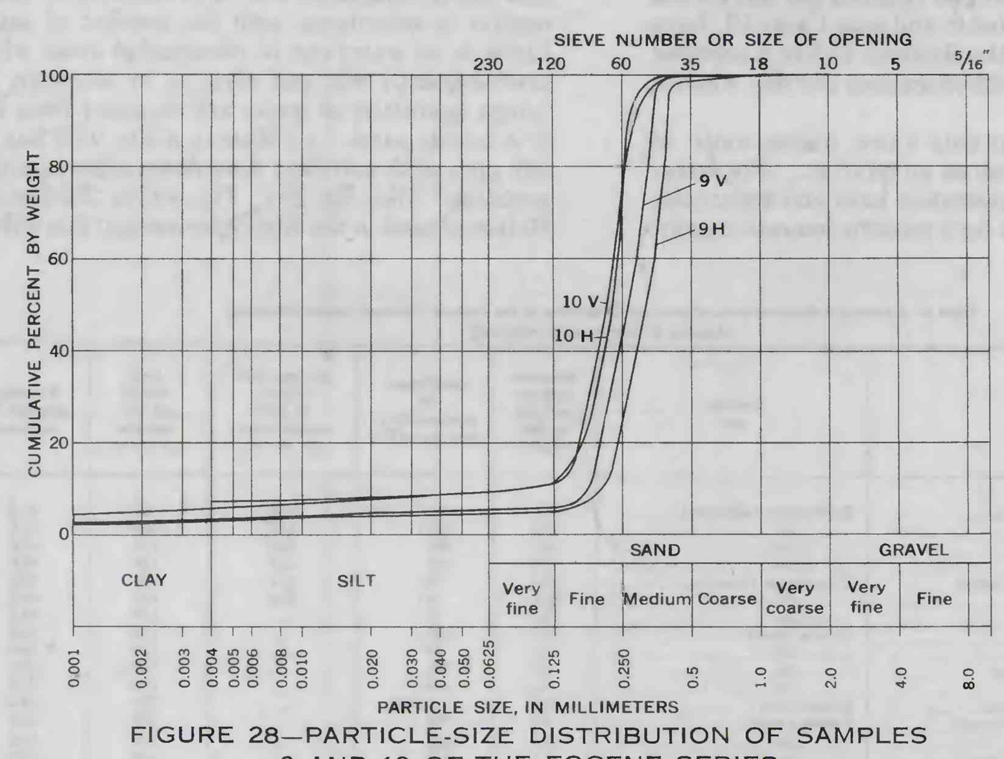

FIGURE 28—PARTICLE-SIZE DISTRIBUTION OF SAMPLES 9 AND 10 OF THE EOCENE SERIES

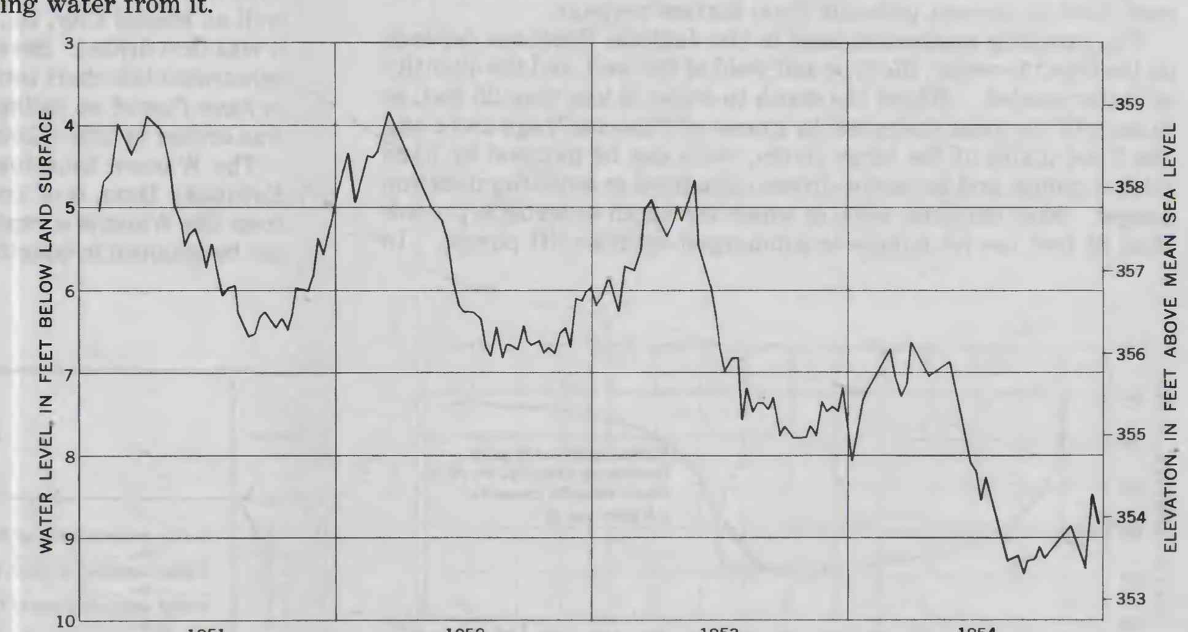

FIGURE 29—HYDROGRAPH OF A WELL 130 FEET DEEP IN THE EOCENE SERIES, FULTON, FULTON COUNTY, KENTUCKY

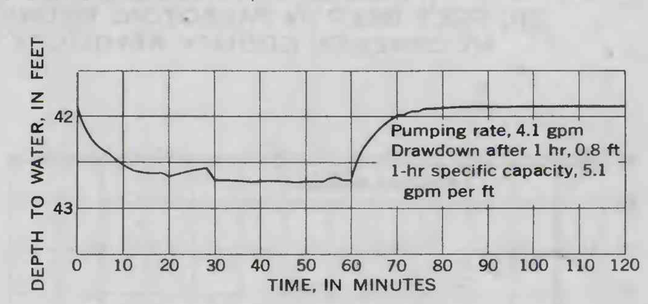

FIGURE 32—SPECIFIC-CAPACITY TEST OF A WELL 43 FEET DEEP IN GRAVEL OF PLIOCENE(?) AGE, FARMERS SUPPLY CO., SYMSONIA, GRAVES COUNTY, KENTUCKY

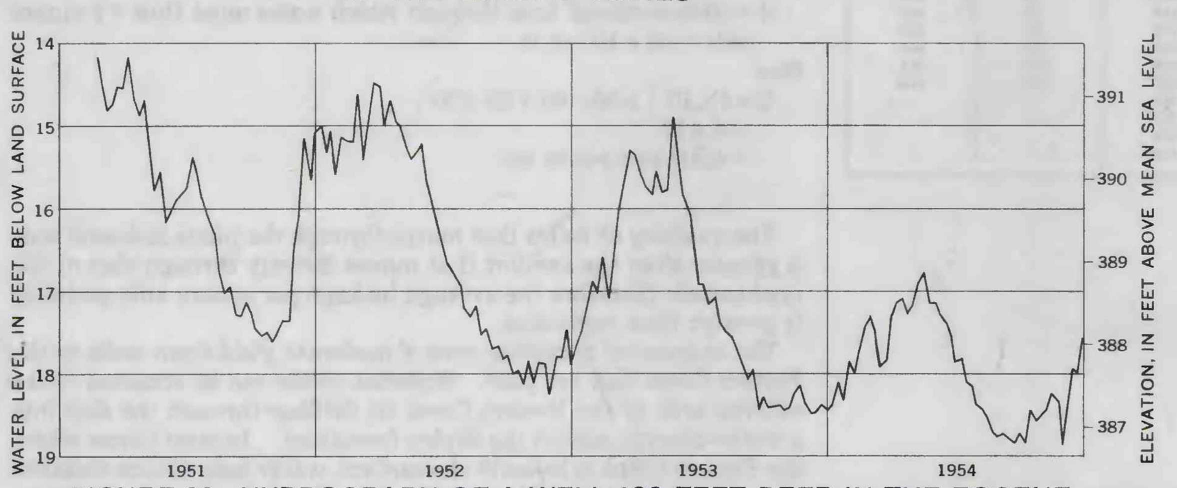

FIGURE 30—HYDROGRAPH OF A WELL 103 FEET DEEP IN THE EOCENE SERIES NEAR WEST VIOLA, GRAVES COUNTY, KENTUCKY

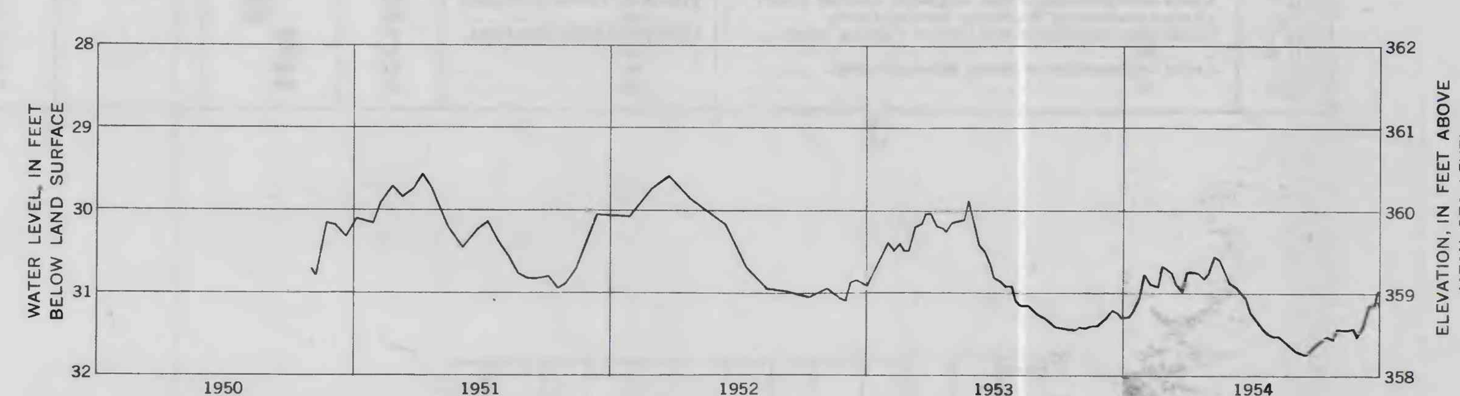

FIGURE 31—HYDROGRAPH OF A DUG WELL 36 FEET DEEP IN GRAVEL OF PLIOCENE(?) AGE, NEAR SYMSONIA, GRAVES COUNTY, KENTUCKY

Table 4.—Flow and temperature of springs discharging from gravel of Pliocene(?) age in the Jackson Purchase region, Kentucky

Date of measurement	Discharge (gpm)	Temperature (°F)
Wadesboro Spring, Calloway County		
June 17, 1954	12	59
July 19	8.1	60
Aug. 10	8.5	60
Sept. 8	8.2	60
Oct. 7	8.2	--
Nov. 5	7.7	59
Dec. 3	7.5	60
Jan. 2, 1955	7.7	59
Jan. 31	7.1	58
Mar. 1	6.0	59
Mar. 28	10.7	59
Apr. 26	10.7	59
May 23	10.7	60
Peggy Ann Spring, near Hardin, Marshall County		
Aug. 10, 1954	2.4	59
Sept. 8	2.9	59
Oct. 7	2.6	60
Nov. 5	2.1	59
Dec. 3	1.7	59
Jan. 2, 1955	1.2	59
Jan. 31	2.3	57
Mar. 1	5.2	57
Mar. 28	3.3	54
Apr. 26	6.5	54
May 23	3.8	55
Hale Spring, near Hardin, Marshall County		
Aug. 5, 1954	50	58
Oct. 25	36	—

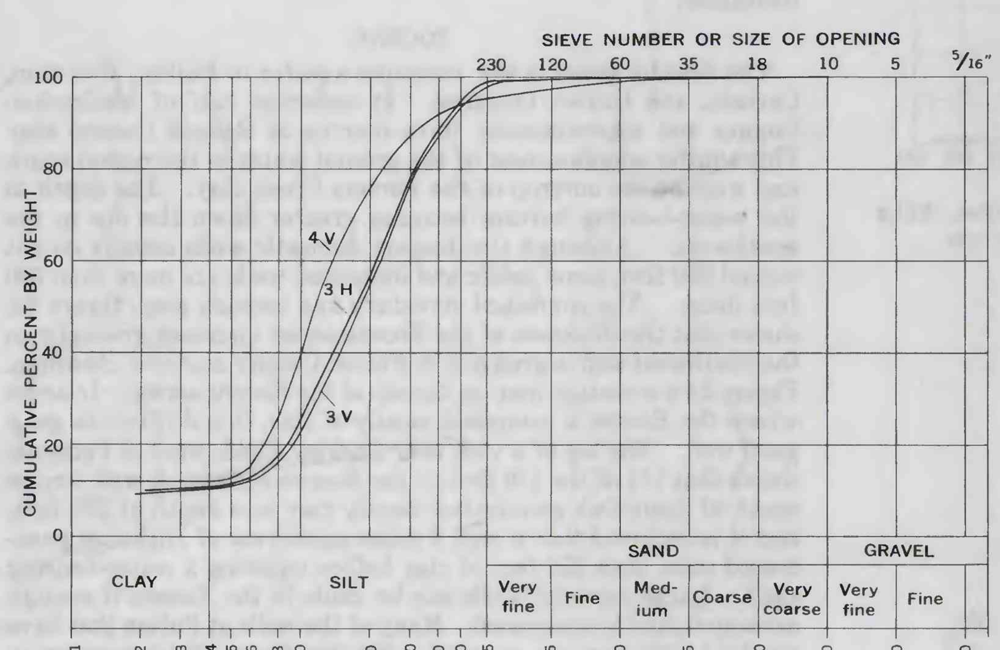

FIGURE 34—PARTICLE-SIZE DISTRIBUTION OF SAMPLES 3 AND 4 OF PLEISTOCENE LOESS

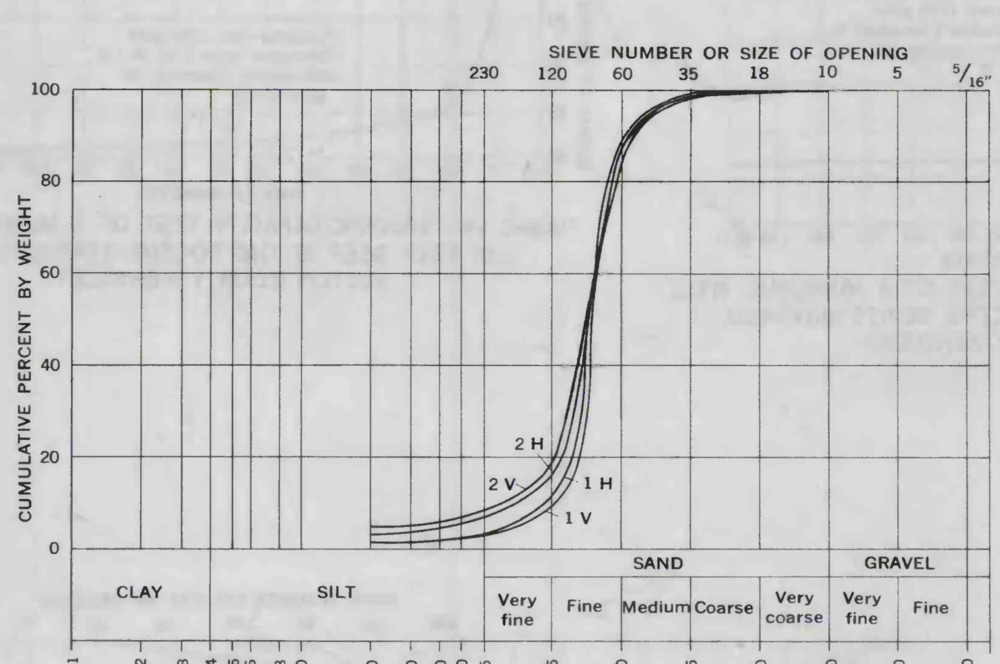

FIGURE 35—PARTICLE-SIZE DISTRIBUTION OF SAMPLES 1 AND 2 OF QUATERNARY ALLUVIUM

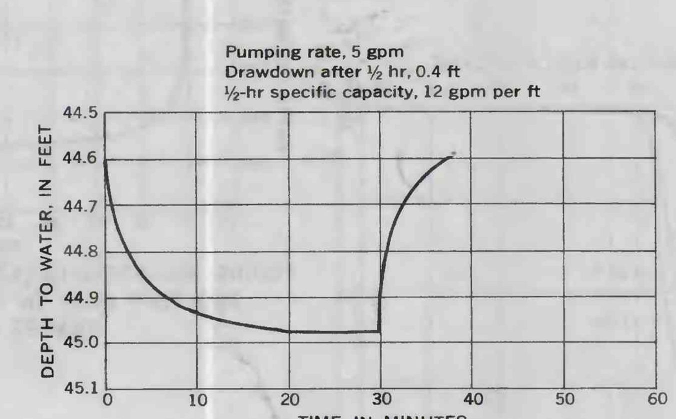

FIGURE 33—SPECIFIC-CAPACITY TEST OF A WELL 45 FEET DEEP IN GRAVEL OF PLIOCENE(?) AGE SOUTHEAST OF PADUCAH, MC CRACKEN COUNTY, KENTUCKY

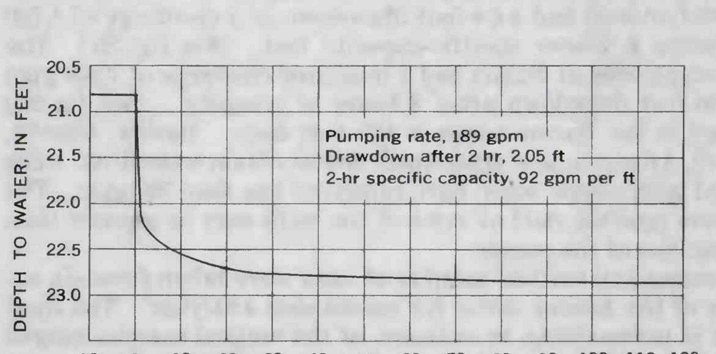

FIGURE 36—SPECIFIC-CAPACITY TEST OF A WELL IN QUATERNARY ALLUVIUM, KENTUCKY DAM VILLAGE, MARSHALL COUNTY, KENTUCKY

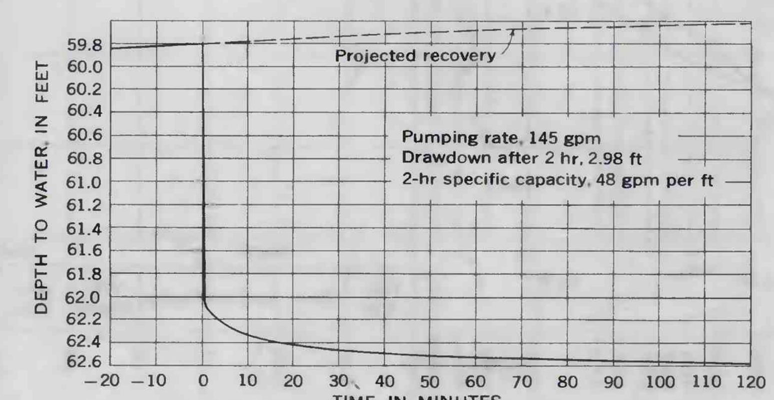

FIGURE 37—SPECIFIC-CAPACITY TEST OF A WELL 85 FEET DEEP IN QUATERNARY ALLUVIUM, SHAWNEE STEAM PLANT, KENTUCKY

FIGURE 38—HYDROGRAPH OF A WELL 39 FEET DEEP IN QUATERNARY ALLUVIUM NEAR PADUCAH, MC CRACKEN COUNTY, KENTUCKY