GROUND-WATER LEVELS IN THE ALLUVIAL AQUIFER

AT LOUISVILLE, KENTUCKY, 1982-87

By Robert J. Faust and Mark A. Lyverse

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CONVERSION FACTORS

For use of those readers who prefer to use metric (International System) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound units	By	To obtain metric units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon (gal)	3.785	liter (L)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Temperature in degrees Fahrenheit can be converted to degrees Celsius as follows:

$$\text{deg. C} = (\text{deg. F} - 32)/1.8$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level of 1929."

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ABSTRACT

Water-level data have been collected in the alluvial aquifer at Louisville, Kentucky by the U.S. Geological Survey since 1943. Interpretations of these data have been published in several reports by the Survey, but none have been published since 1983. Contour maps and hydrographs are presented in this report to document and to help interpret water-level changes for the period 1982-87.

Maps and hydrographs show that ground-water levels generally stabilized in the 1980's after rising for many years. Two areas of ground-water withdrawals are apparent in the maps and hydrographs. Withdrawals in an industrial area in west Louisville disrupt the typical pattern of the contour lines parallel to the river and cause some of the contours to curve landward around the area of withdrawal. Resumption of pumping of ground water for heating and cooling of some buildings in the downtown area in 1985 caused declines of about 3 to 4 feet in the downtown area.

INTRODUCTION

Water-level data for the alluvial aquifer at Louisville, Kentucky have been collected by the U.S. Geological Survey in cooperation with local and State cooperators since September 1943, and are presently being collected in cooperation with the Jefferson County Public Works and Transportation Department and the Kentucky Natural Resources and Environmental Protection Cabinet. Interpretations of water-level data have been published in numerous reports since the 1940's, the most recent by Kernodle and Whitesides (1977) and Whitesides and others (1983). These two reports focused on rising water levels in the alluvial aquifer. Maps and hydrographs for the period 1982-87 are presented in this report to document changes since the last report. Special attention is given to the downtown Louisville area where ground-water withdrawals resumed in 1985. This area is of special interest to the cooperators and water managers because of the renewed interest in ground water for heating and cooling and the expected competition for ground water as withdrawals increase.

HISTORICAL WATER-LEVEL DATA COLLECTION IN THE ALLUVIAL AQUIFER

Water-level data collection for the alluvial aquifer at Louisville started in 1943 because of a critical ground-water shortage that threatened to curtail production by the industries that were manufacturing war materials

(Rorabaugh, 1947, p. 202). Ground-water withdrawals reached a peak of about 61.5 million gallons per day (Mgal/d) in 1943. Water-level data were collected from 103 observation wells in 1943-44, and the number increased to 134 in the late 1940's. With the end of the war, introduction of conservation measures, and the imposition of a sewer tax on ground-water discharges in 1947, ground-water withdrawals decreased to about 30.5 Mgal/d in 1952 (Rorabaugh and Bell, 1955, p. 126) or about 50 percent of the peak withdrawal in 1943. This decline in ground-water withdrawals eased the ground-water shortage and the need for extensive water-level data. The number of observation wells declined and stayed between 40 and 50 for the period 1951-75. Additional observation wells were added to the network in the late 1970's as rising water levels, particularily in the downtown Louisville area, became a potential threat to man-made structures. The principal causes of the rising water levels were decreased withdrawals of ground water and above normal precipitation. The number of observation wells again reached 100 in 1981 and for the period 1981-87 has remained between 100 and 120. The present network (fig. 1) is maintained for long-term trend analysis and for water-management decisions in anticipation of increased ground-water use for the heating and cooling of buildings which resumed in the downtown area in 1985. Six new observation wells were drilled in the downtown area in 1986 and added to the network specifically to monitor water levels more closely in downtown Louisville. The wells are shown as 86-6 to 86-11 in figures with well numbers.

RECENT WATER-LEVEL DATA IN THE ALLUVIAL AQUIFER

Water Levels in West and Southwest Louisville

The altitude of the water table in the alluvial aquifer has remained relatively stable since 1980. Maps showing the altitude of the water table (figs. 2-4) are similar to each other and to that shown in Whitesides and others (1983, p. 12) for April 1982. Generally, water-level contours are parallel to the Ohio River with altitudes decreasing toward the river. This indicates that the movement of ground water is generally toward the river. Exceptions to this normal gradient are shown in the contour map for April 1987 (fig. 4). Water levels in observation wells close to the river during the April measurements were higher than those at some distance from the river. This gradient reversal occurs when a relatively high stage on the river, as occurred in April 1987, temporarily raises the water levels in wells adjacent to the river. The magnitude and extent of water-level rises in wells adjacent to the river produced by high river stages are discussed in Whitesides and others (1983, p. 15) for selected sites along the Ohio River. Hydrographs for an observation well in southwest Louisville (fig. 5) and for an observation well in west Louisville (fig. 6) show that water levels are fluctuating seasonally and with wet and dry years (table 1) but have no overall trend upward or downward in recent years.

Water-level contours deviate somewhat from the typical pattern parallel to the river in areas where ground-water withdrawals disrupt the natural water-table gradient (figs. 2-4). The industrial area in west Louisville is

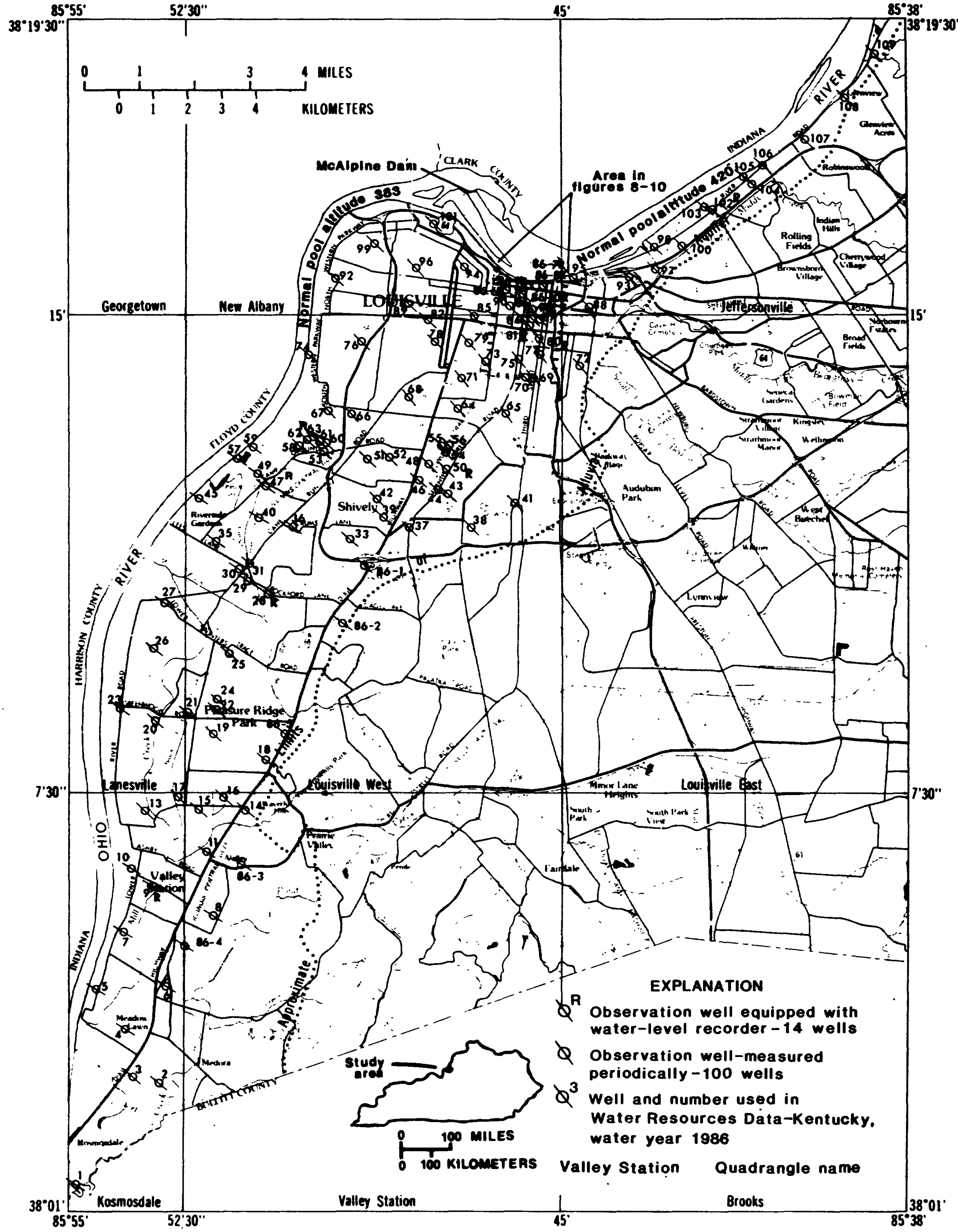

Figure 1.--Location of observation wells in the Louisville, Kentucky area.

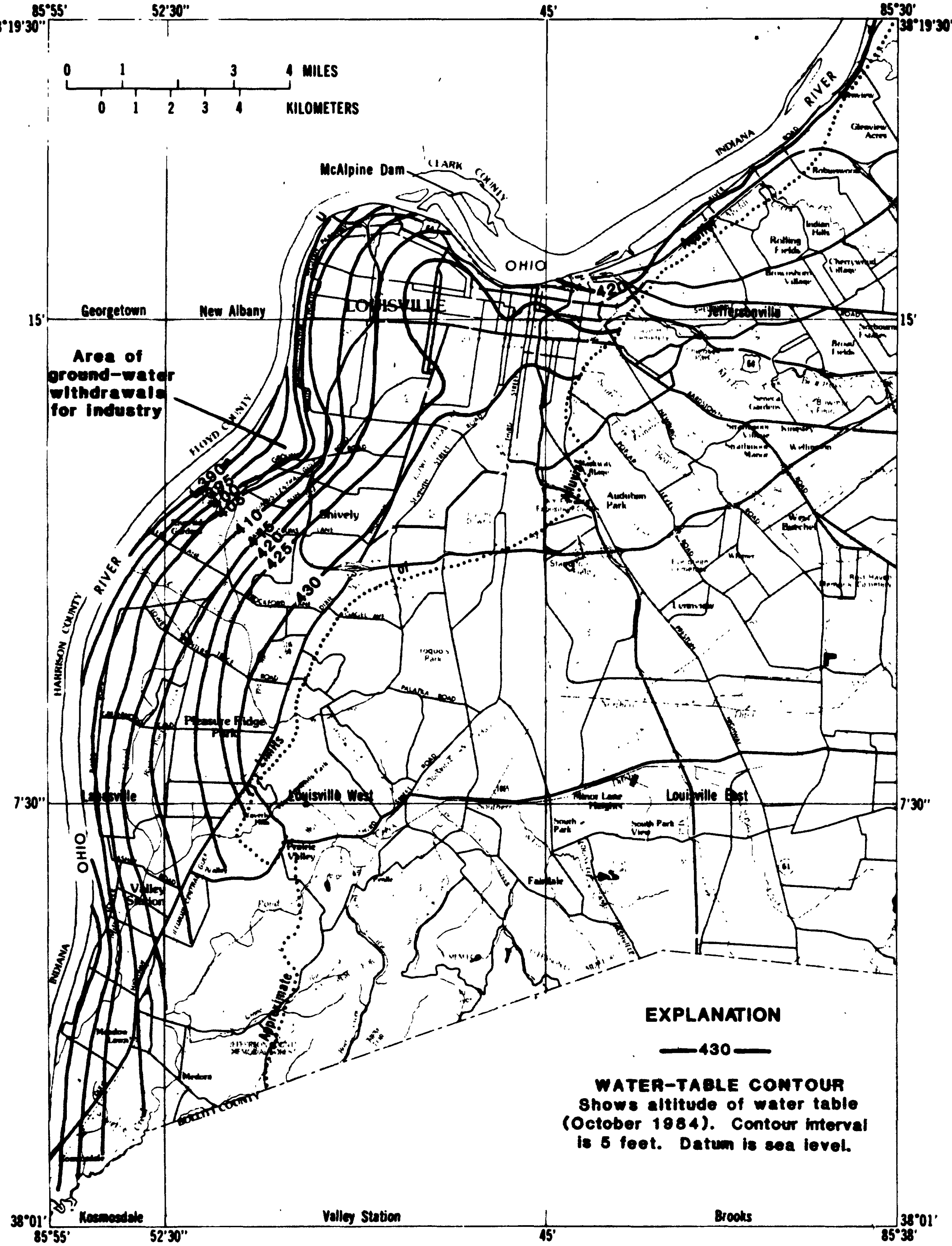

Figure 2.--Altitude of water table in Louisville area, October 1984.

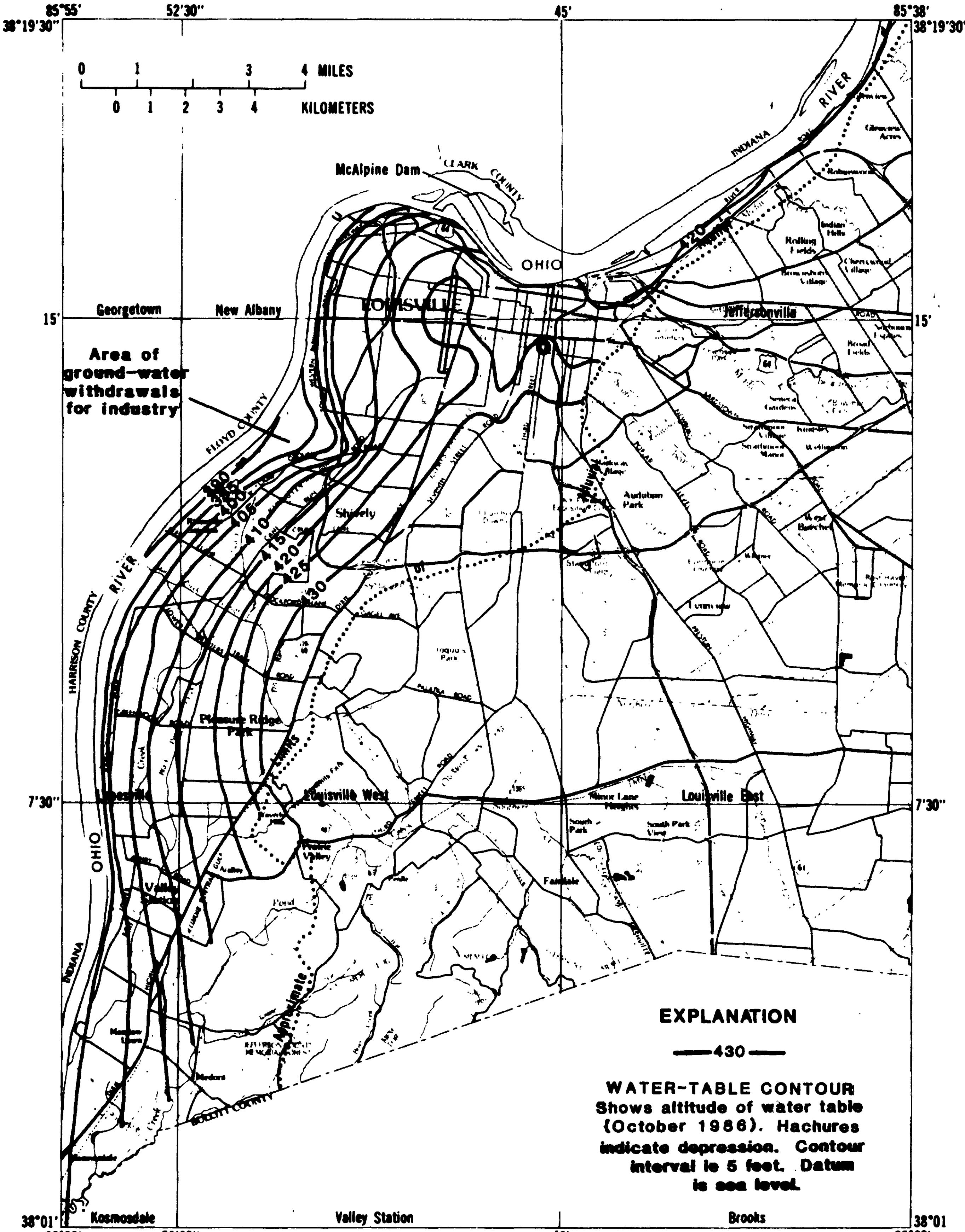

Figure 3.--Altitude of water table in Louisville area, October 1986.

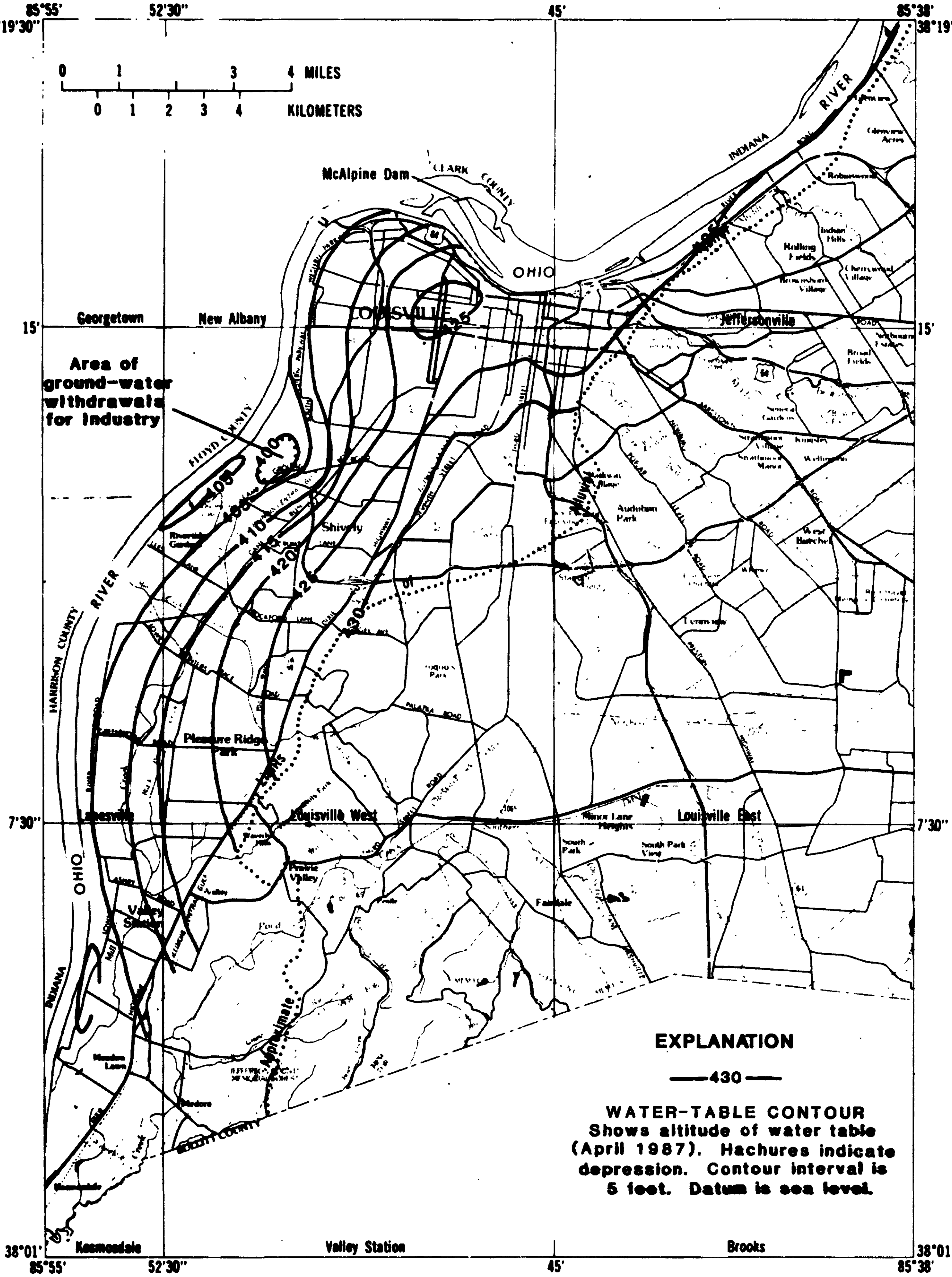

Figure 4.--Altitude of water table in Louisville area, April 1987.

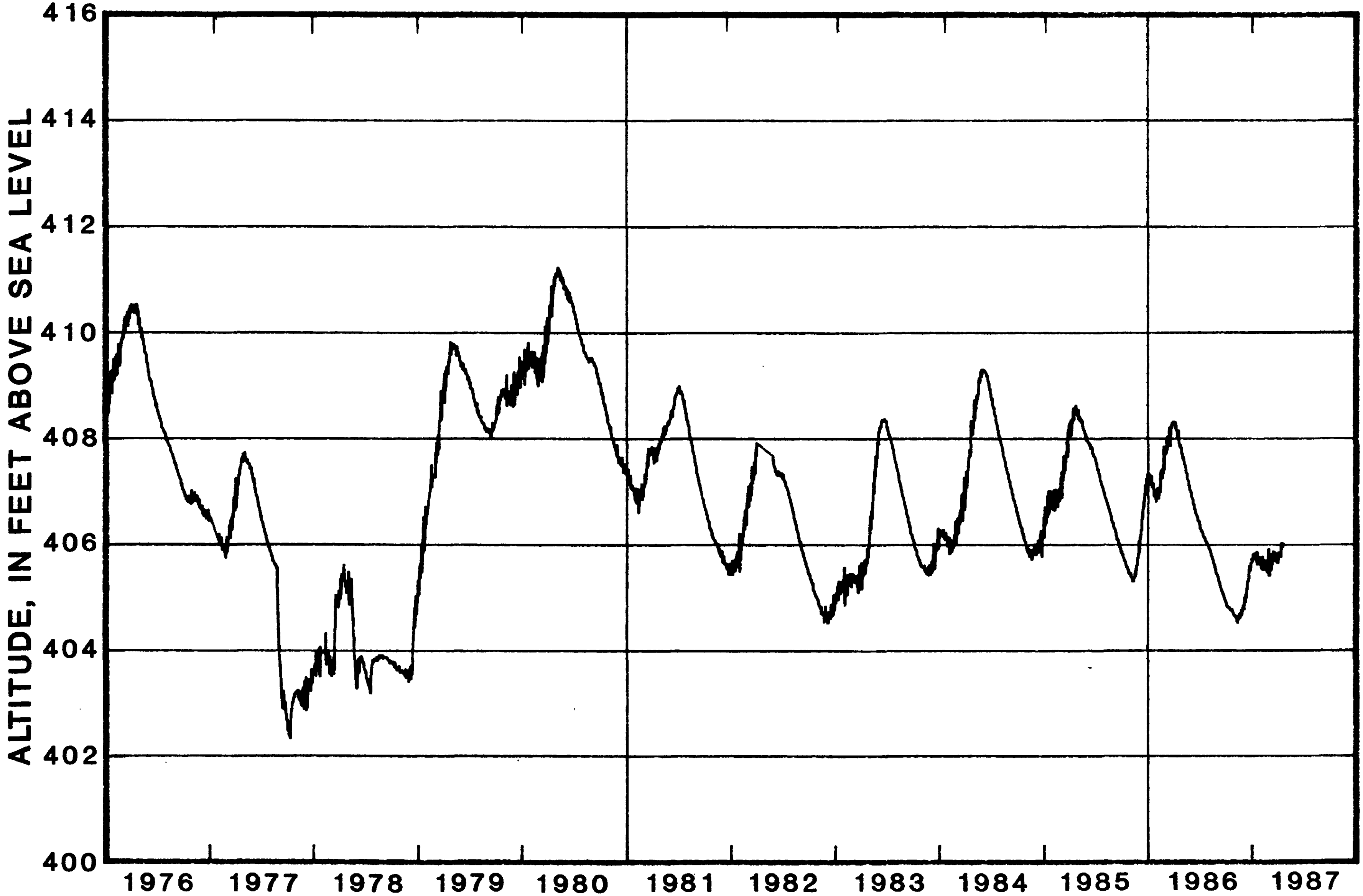

Figure 5.—Seasonal fluctuations of water level in well 9 in southwest Louisville.

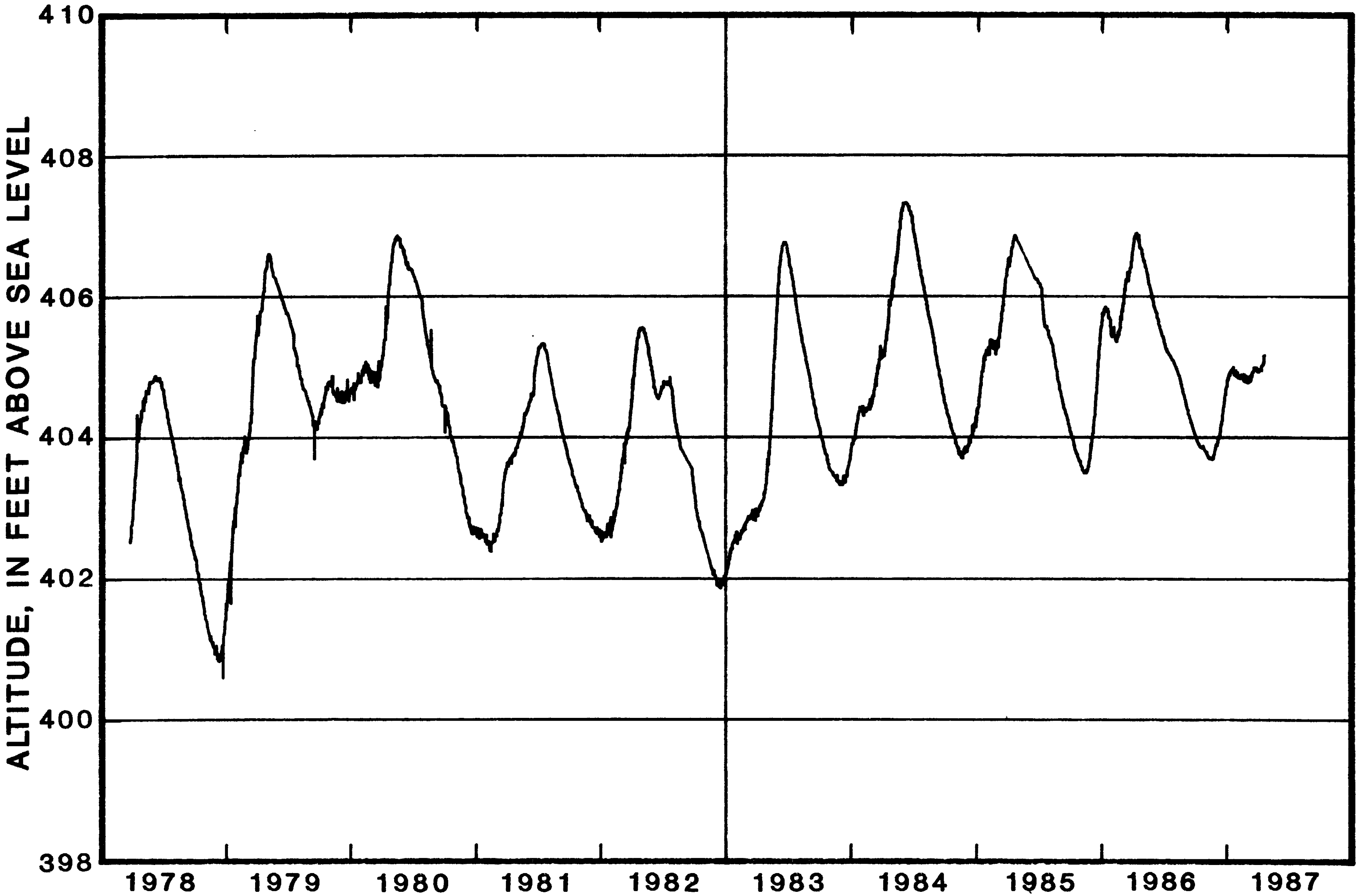

Figure 6.—Seasonal fluctuations of water level in well 47 in west Louisville.

Table 1.--Precipitation in inches at Louisville, 1976-87 (From U.S. Department of Commerce, National Oceanic and Atmospheric Administration)

	1976	1977	1978	1979	1980	1981
January	3.85	2.33	5.90	3.81	1.71	0.45
February	3.13	1.45	.76	4.49	1.09	3.23
March	2.87	4.69	3.76	2.71	4.80	1.54
April	.76	3.40	3.33	7.32	2.63	4.44
May	5.09	1.37	4.76	3.59	4.58	4.63
June	4.71	7.59	2.67	3.03	3.70	3.23
July	2.10	3.29	3.77	10.05	5.41	3.98
August	3.18	6.12	5.50	2.37	3.76	3.21
September	3.10	3.67	.96	10.49	3.17	3.22
October	3.99	4.76	2.26	2.27	3.37	1.60
November	.72	6.11	5.14	5.85	2.42	2.40
December	.65	4.32	7.64	3.82	1.25	2.02
Total	34.15	49.10	46.45	59.80	37.89	33.95

	1982	1983	1984	1985	1986	1987
January	5.28	1.63	0.92	2.20	0.91	0.81
February	1.55	1.52	1.68	2.08	3.90	4.42
March	5.89	2.16	4.41	4.43	2.69	3.05
April	3.05	7.10	5.53	1.69	1.04	
May	2.96	10.58	6.78	3.93	4.28	
June	3.86	4.42	.49	4.37	2.32	
July	3.72	.99	6.94	3.45	7.04	
August	3.74	2.39	5.08	4.49	2.19	
September	3.46	1.13	3.70	1.48	2.75	
October	1.26	6.47	2.12	4.24	3.08	
November	5.50	5.03	5.87	4.43	4.62	
December	5.11	3.96	5.86	.96	2.69	
Total	45.38	47.38	49.38	37.75	37.51	

Mean for period of record through 1984 = 43.07 inches.

one area where ground-water withdrawals have lowered the water table and caused the water-level contours to curve landward in the vicinity of the industrial area. The map for April 1987 (fig. 4) actually shows a slight cone of depression in this area. This is due mainly to the temporarily high ground-water levels adjacent to the river caused by the high river stage in April and not to increased withdrawals in the industrial area in 1987. An area slightly northeast of the industrial area noted in figures 2-4 is another area of ground-water withdrawals. These withdrawals have caused some flattening of the water table as indicated by the curvature of water-level contour 425 in figures 2 and 3.

Another area where ground-water withdrawals are disrupting the normal water-table gradient is in the downtown Louisville area. The effects of these withdrawals are discussed in the following section.

Water Levels in Downtown Louisville

Water levels declined 3 to 4 feet in the first 3 months of 1985 in the downtown Louisville area near the Humana Building as shown by the hydrograph for observation well 91 (fig. 7). This well is across the street from the front of the Jefferson County Courthouse. Pumpage for the Humana Building started in January 1985, but records of pumpage are not available until November 1985 (fig. 7). Pumping at the Humana Building and later at the Galt House East Building created a trough-shaped depression in the water table that trends slightly northeast-southwest. The development of this depression can be traced on the water-level contour maps for the alluvial aquifer (figs. 2-4) or on the more detailed water-table maps of the downtown area (figs. 8-10). Although the extent of the water-level decline has widened on the latest map for April 1987 (fig. 10), the magnitude of the decline has remained between 3 to 4 feet in observation well 91 near the Courthouse (fig. 7). Most of this decline can probably be attributed to the resumption of pumping in the downtown Louisville area. Precipitation at Louisville for 1985-86 (table 1) was below the normal yearly average of 43.07 inches. However, this below normal precipitation for the 2-year period caused declines of less than a foot in other observation wells in the alluvial aquifer away from areas of pumping.

Pumping at the Heyburn Building near the corner of Broadway and Fourth Street has created a slight cone of depression in the water table that is evident in the detailed maps in figures 8-10. This pumpage and probably some effect of pumping at the Humana Building and the Galt House East Building have caused a decline of about 2 feet in the water level in observation well 80 at the Louisville Free Public Library (fig. 11). The hydrograph for observation well 80 shows the rise in water levels in the 1970's, the stable period in the early 1980's, and small decline beginning in 1985 due to the resumption of pumping in the downtown Louisville area.

The saturated thickness of the alluvial aquifer can be calculated by subtracting the altitudes of the bedrock contours (fig. 12) from the altitudes of the water-level contours (figs. 8-10) at points of intersection if one set of contours is superimposed over the other set.

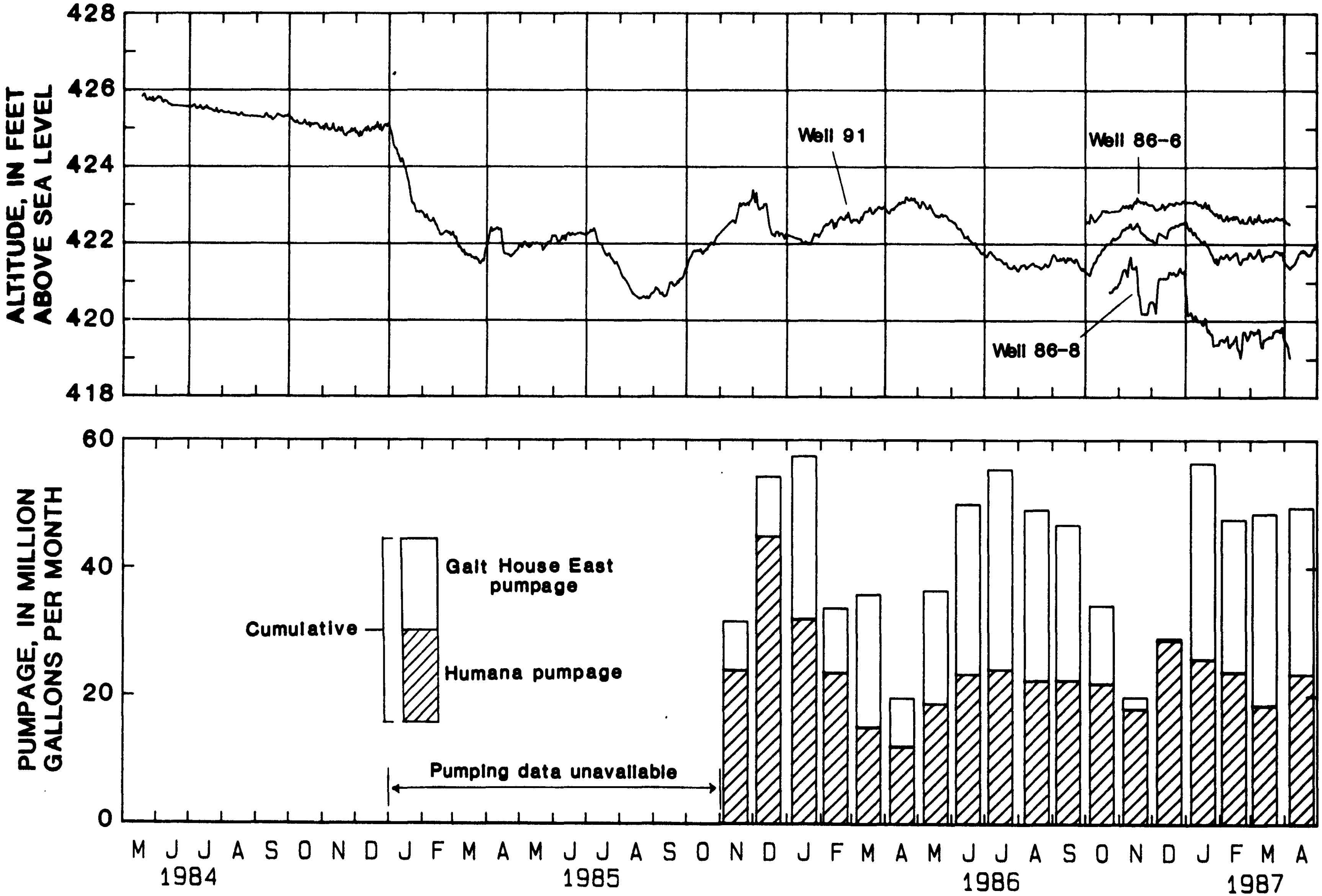

Figure 7.--Pumpage in downtown area and its effect on water levels in selected wells.

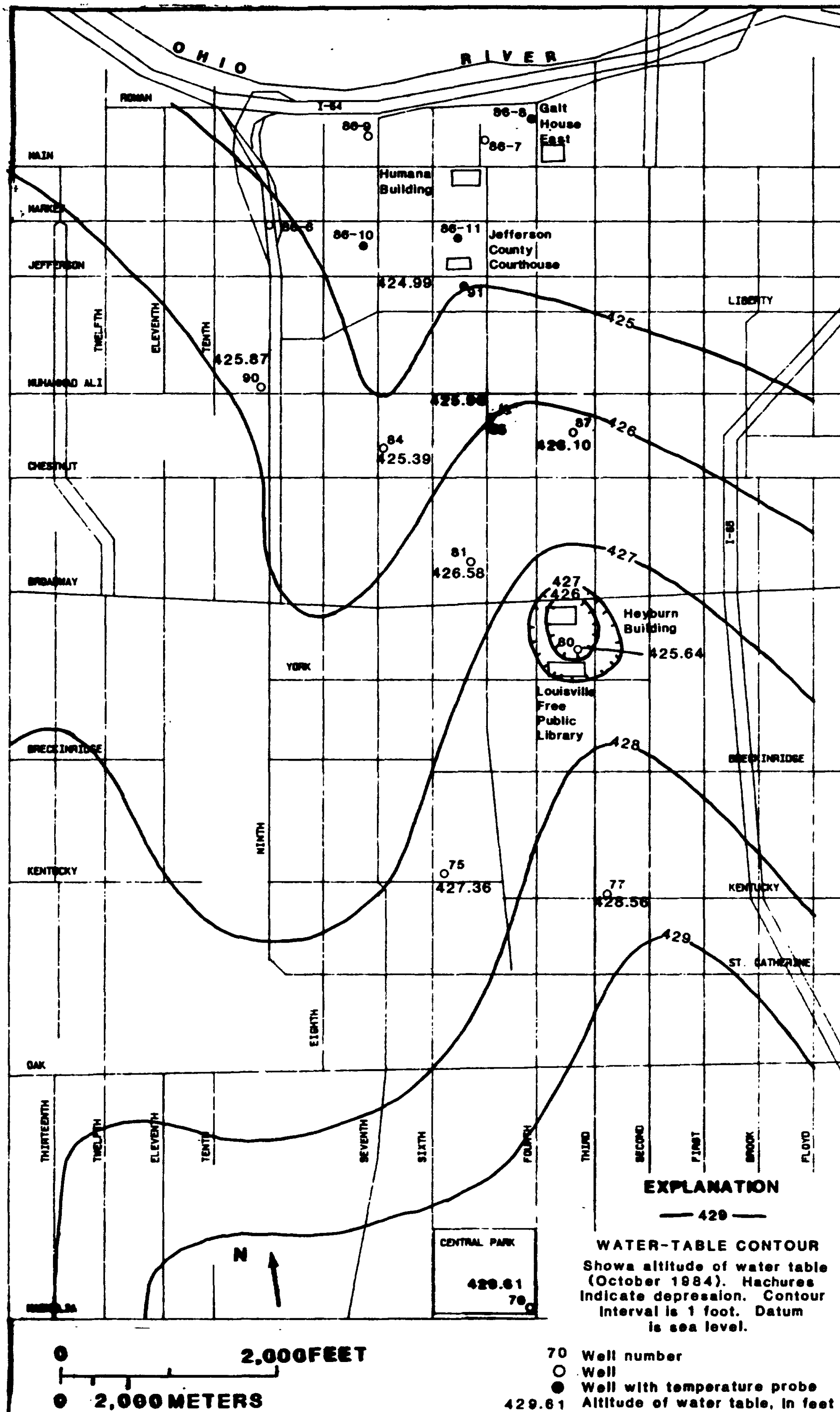

Figure 8.--Altitude of water table in downtown area, October 1984.

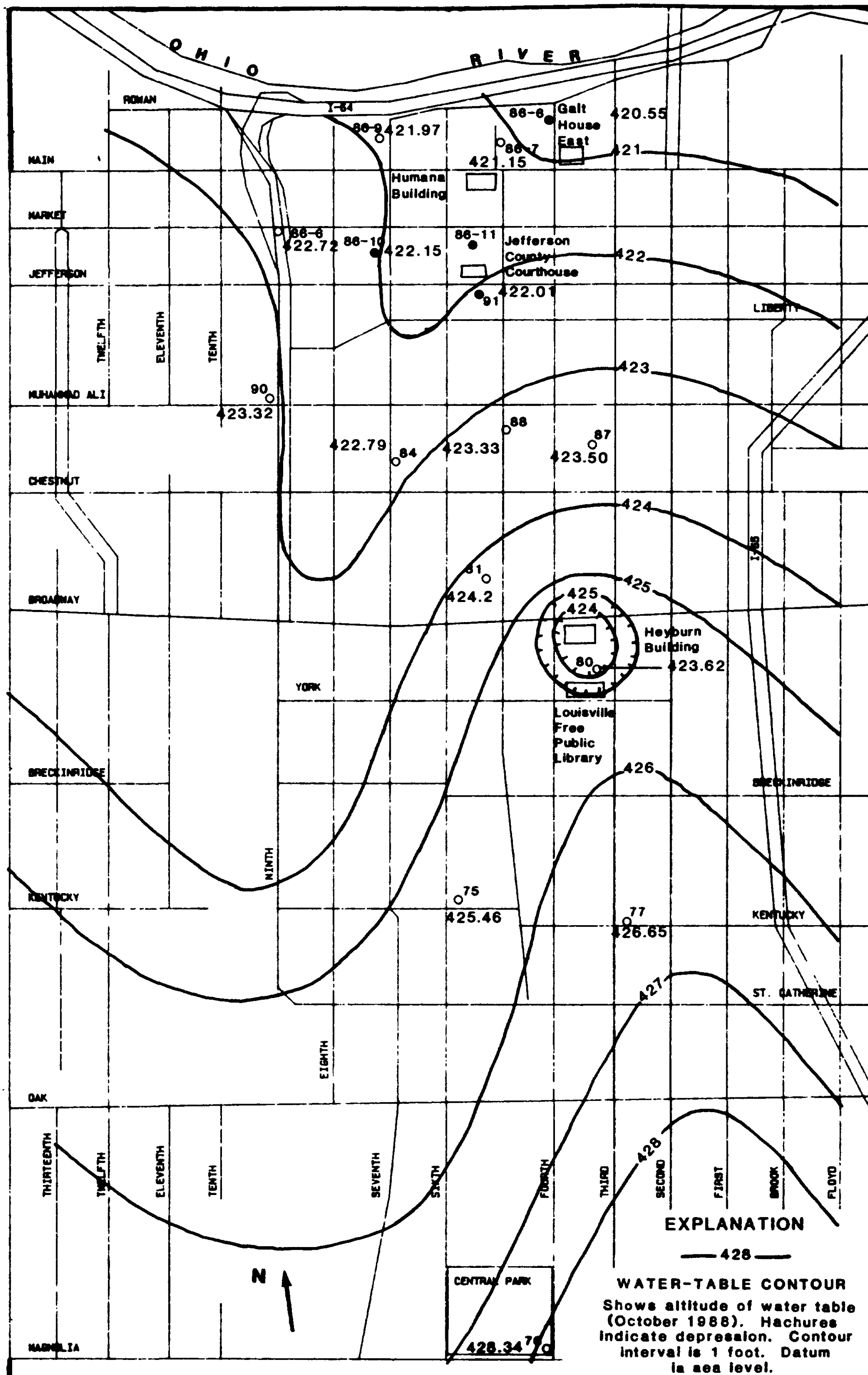

Figure 9.--Altitude of water table in downtown area, October 1986.

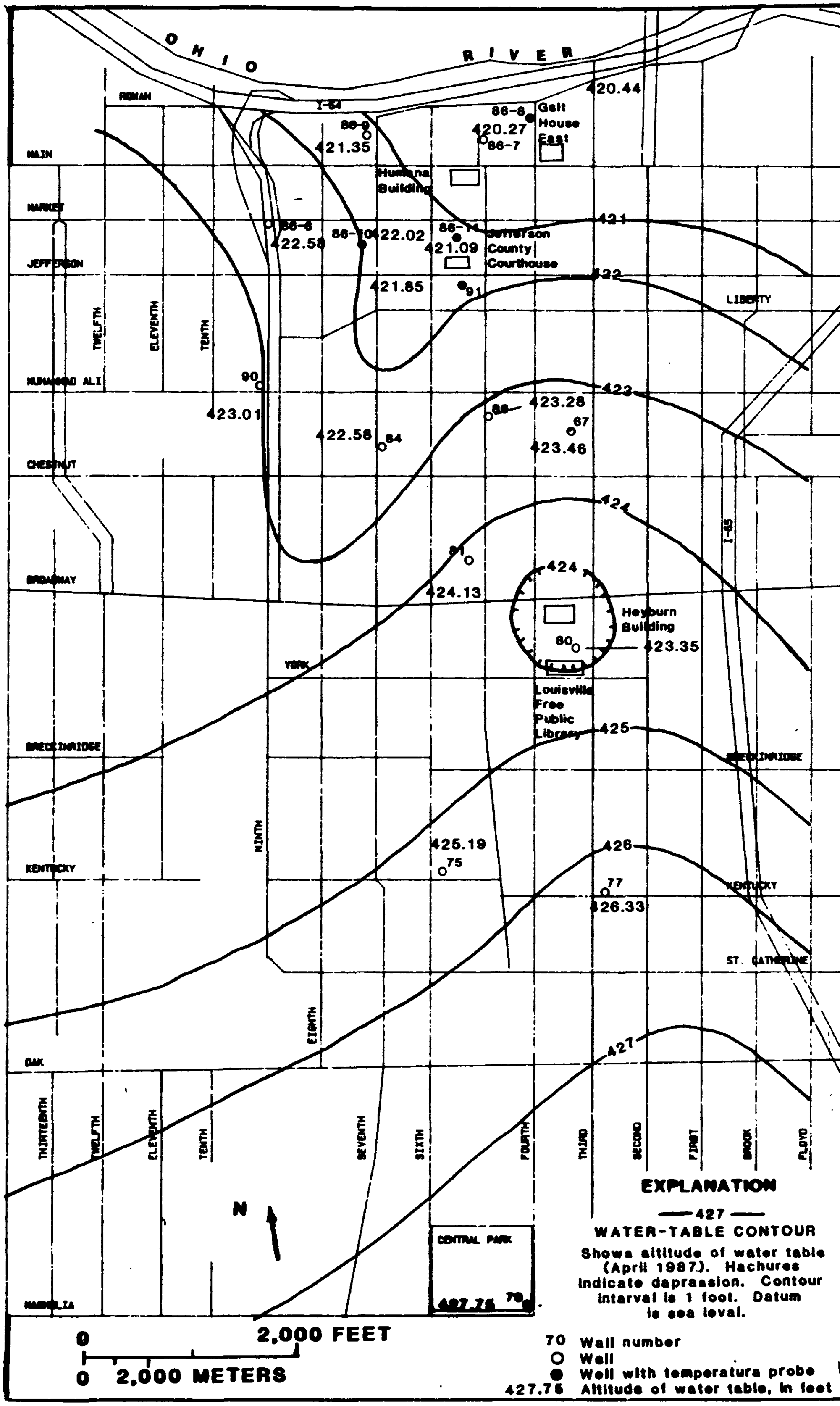

Figure 10.--Altitude of water table in downtown area, April 1987.

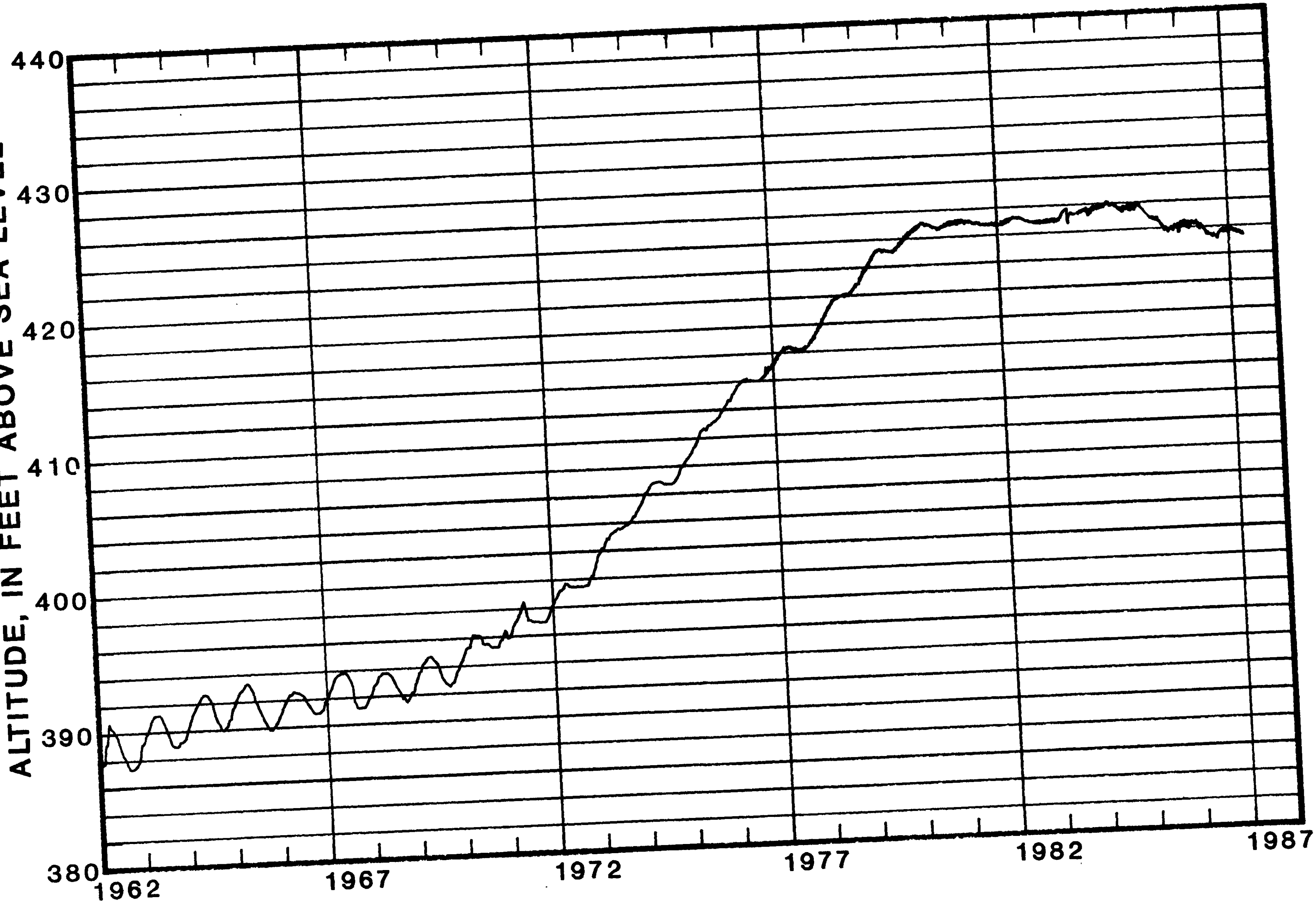

Figure 11.--Hydrograph for well 80 near the Louisville Free Public Library.

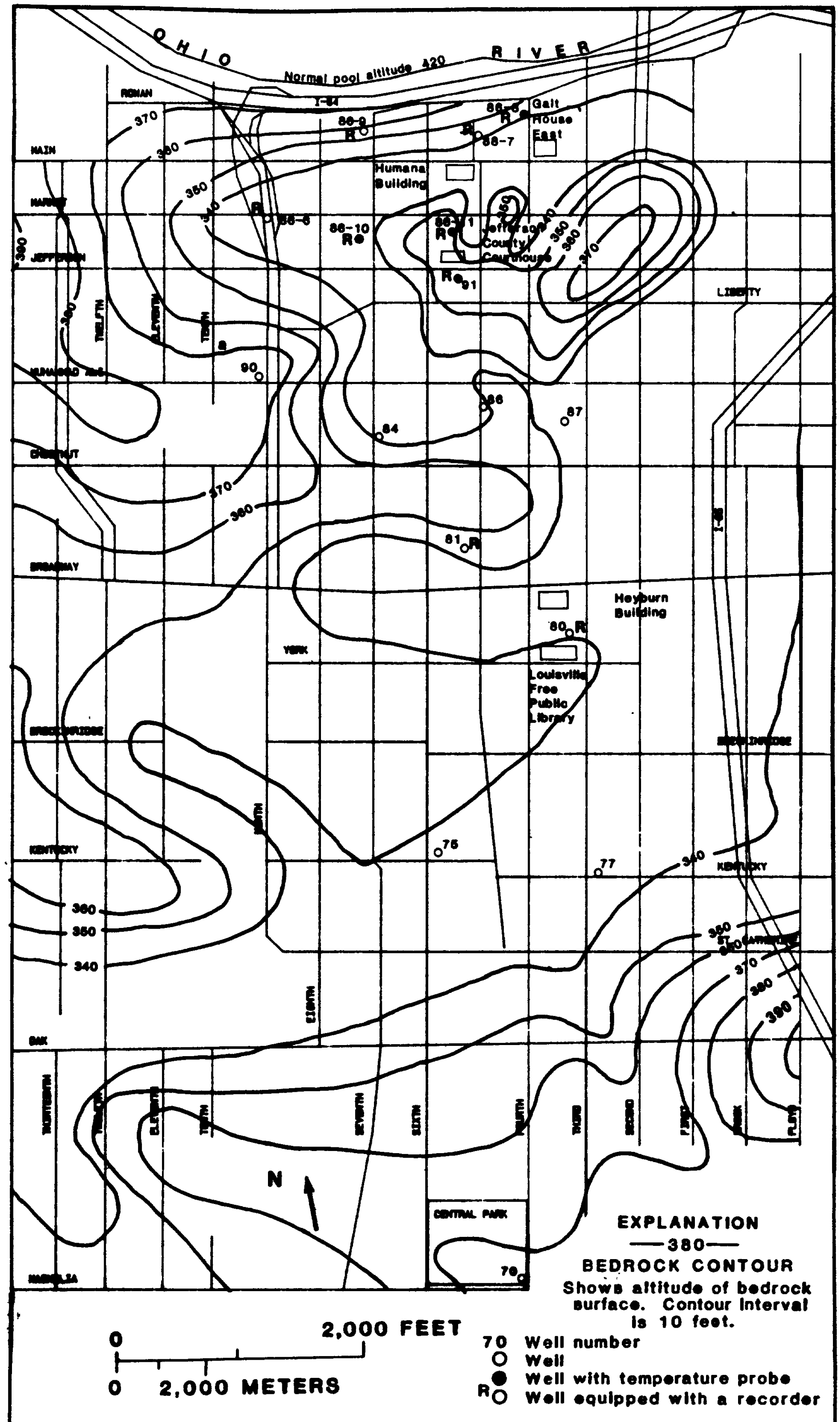

Figure 12.--Altitude of the bedrock surface beneath the alluvial aquifer (From Price, 1964).

Although pumping in the downtown area resumed in 1985 and caused an initial decline in water levels, the most recent measurements in April 1987 indicate that the water levels are approaching an equilibrium position relative to the present pumping rates. Of course, if additional withdrawals are made by new permittees, water levels will again decline and eventually establish a new equilibrium position at some lower level.

SUMMARY

Ground-water levels generally stabilized in the Louisville, Kentucky area in the 1980's after rising for many years. Water-level contours are generally parallel to the Ohio River and altitudes of the contours decrease toward the river. This indicates that the overall movement of ground water is toward the river. Pumping of ground water can disrupt the typical parallel pattern of the contours, and this is obvious in a couple areas in the Louisville area. One area is in west Louisville where pumping of ground water for industry causes the contours to curve landward around the area of pumping. Another area is in the downtown area where pumping resumed in 1985 for the heating and cooling of some buildings. This has created a trough-shaped depression in the water table that trends northeast-southwest. Water levels have declined 3 to 4 feet in this depression since 1985. In both areas of pumping the water levels seem to be in an equilibrium position relative to the present pumping rates. If pumping should increase, water levels will again decline and eventually establish a new equilibrium position at some lower level.

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