GROUND-WATER LEVELS IN THE ALLUVIAL AQUIFER AT LOUISVILLE, KENTUCKY, 1987-88

By Robert J. Faust and Bridgett E. Lyons

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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 (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8$$

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 "Sea Level Datum 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 are published periodically to update the record and help manage this ground-water supply. Maps and hydrographs are presented in this report to update the record for 1987-88 and to interpret recent trends.

Maps and hydrographs show that ground-water levels were stable for the period 1980-86 after rising rapidly in the 1970's. There has been a slight decline in the water levels during 1987-88 because of below normal precipitation for the period 1985-88. The decline has been about 1 to 3 feet in wells along the Ohio River and about 3 to 6 feet in wells away from the influence of the river. Ground-water withdrawals have also caused slight declines in the water table in three areas of Louisville. Declines in downtown Louisville due to pumpage seem to be stabilizing at or slightly below the normal pool stage of the Ohio River which indicates that water is probably being induced from the river into the aquifer.

INTRODUCTION

Water-level data for the alluvial aquifer at Louisville, Ky., have been collected by the U.S. Geological Survey in cooperation with local and State cooperators since September 1943. Data 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; some of the more recent are those by Faust and Lyverse (1987), Whitesides and others (1983), and Kernodle and Whitesides (1977). Maps and hydrographs are presented in this report to update the record for 1987-88 and to interpret recent trends in water levels in the Louisville area. Special attention is given to the downtown area where ground-water withdrawals resumed in 1985. This area is of special interest to cooperators and water managers because of the 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. 102). 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 World War II, 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, particularly 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 of 1981-88 has remained between 100 and 123. The current network (fig. 1 and table 1) is maintained for long-term trend analysis and to assist water-management decisions in anticipation of increased ground-water use for the heating and cooling of buildings. The use of ground water for heating and cooling, which is the primary use of ground water in downtown Louisville, resumed in 1985. Six new observation wells were drilled in the downtown area and added to the network in 1986 specifically to monitor water levels and ground-water temperature more closely. The wells are shown as 117 to 122 in figures with well numbers.

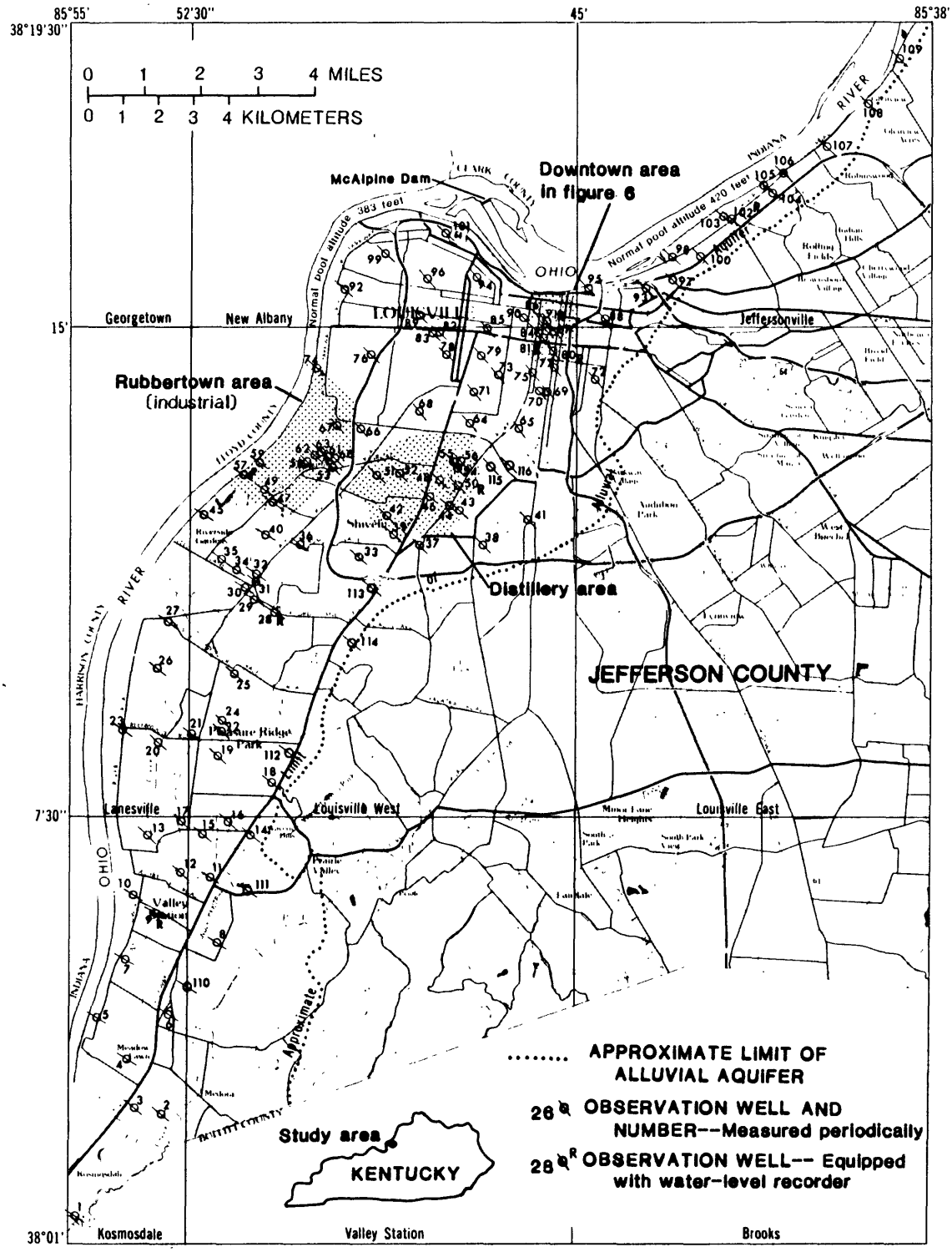
The hydrograph for well 80 (fig. 2) near York and Third Streets gives a historical perspective of water-level changes in Louisville. Water levels rose slowly during the period 1962-70 as the water table was slowly recovering from the very low levels that had existed since the 1940's. Levels rose rapidly in the 1970's when pumpage was decreasing and rainfall was above normal. Water levels stabilized during the period 1980-86, but resumption of pumpage in 1985 and below normal precipitation during the period 1985-88 caused declines of a few feet in 1985-88.

RECENT WATER-LEVEL DATA FOR THE ALLUVIAL AQUIFER

West and Southwest Louisville

The altitude of the water table in the alluvial aquifer in west and southwest Louisville was relatively stable during the period 1980-86, but it declined during 1987-88. The decline was generally 1 to 3 feet in wells along the river, and 3 to 6 feet toward the eastern edge (fig. 1) of the alluvial aquifer. This overall decline can be attributed to below normal precipitation for 4 consecutive years during 1985-88 (table 2). The combined deficit for the 4 years was about 28 inches. Below normal precipitation in 1985-86 had little effect on water levels, but a very dry year in 1987 initiated water declines and a moderately dry year in 1988 continued the declines (figs. 3 and 4).

The configuration of the water table in 1988 (fig. 5) was similar to that in 1986 (Faust and Lyverse, 1987, p. 5). The water-table contours generally paralleled the river, but the gradient toward the river was somewhat less in 1988 because of the progressively larger declines in water levels away from



Base from U.S.Geological Survey 1:24,000 quadrangles named in figure.

Figure 1.--Location of alluvial aquifer and observation-well network in the Louisville area, Jefferson County, Kentucky.

Table 1.--Observation wells in Jefferson County in 1988

Well number in figures 1 and 6	Well identification number	Local number or owner	Remarks
1	380122085545001	80-1	
2	380252085530601	79-3	
3	380308085533501	79-4	
4	380341085534501	83-1	
5	380423085541501	2	
6	380434085525101	E-1-d	
7	380517085535201	77-1	
8	380532085515301	51-5-2, (76-1)	
9	380606085531301	53-6-1, (RR-46)	Recorder
10	380616085532801	53-6-4, (TW-3)	
11	380637085521301	D-1-d	
13	380709085531101	C-5-d	
14	380715085512001	C-2-d	
15	380716085521801	52-7-2, (RR-47)	
16	380718085515802	C-3-s	
17	380718085524202	C-4-m	
18	380755085510701	78-4	
19	380816085520701	52-8-1	
20	380843085530701	B-3-d	
21	380843085522801	B-2-d	
22	380846085520101	B-1-d	
23	380850085534701	78-2	
24	380852085515901	51-8-1	
25	380940085514001	81-1	
26	380955085531801	83-2	
27	381032085525601	78-3	
28	381034085502601	50-10-2, (RR-30)	Recorder
29	381050085511001	51-10-1, (RR-29)	
30	381102085512102	51-11-2	
31	381108085511301	51-11-4, (RR-31)	
33	381123085491401	49-11-1, (RR-32)	
35	381130085515001	51-11-1	
36	381139085502301	81-2	
37	381142085475702	47-11-4, (RR-42)	
38	381143085465801	46-11-2, (RR-25)	
39	381155085483401	48-11-1	
40	381157085510201	51-11-6, (RR-39)	
41	381204085455301	CP-16	
42	381207085484601	48-12-15, (RR-41)	
43	381209085472101	47-12-3, (C-7)	
44	381212085473801	47-12-2, (C-6)	
45	381213085521701	52-12-2, (RR-22)	
46	381221085475001	47-12-1, (C-5)	
47	381222085505201	50-12-16, (RR-27)	Recorder
48	381224085474001	47-12-19, (Early Times #1)	
49	381229085510201	Triangle Refinery #1	
50	381246085470601	47-12-4, (Seagrams TW #2)	Recorder
51	381250085484901	48-12-1, (C-2)	
52	381251085483501	48-12-2, (C-3)	
53	381251085500501	50-12-18, (RR-35)	
54	381256085471501	47-12-14, (TW-2)	
55	381257085471801	47-12-15, (TW-4)	
56	381259085471502	47-12-16, (TW-1)	
57	381259085511002	51-13-1, (RR-21)	
58	381305085501302	Reynolds Metals #1	
59	381309085505302	50-13-56, (RR-24)	
60	381313085495501	49-13-25, (TW-2)	
61	381315085501401	50-13-65, (TW-11)	
62	381315085502602	50-13-79, (NC-TW-D)	Recorder
63	381316085502101	50-13-77, (TW-12)	
64	381320085464101	CP-15	

Table 1.--Observation wells in Jefferson County in 1988--Continued

Well number in figures 1 and 6	Well identification number	Local number or owner	Remarks
65	381324085460401	46-13-25, (Amer. Std.)	
66	381331085491601	49-13-40, (RR-26)	
67	381332085494001	49-13-5, (TW-10)	
68	381338085481601	CP-8	
69	381346085453801	45-13-2, (St. Patricks well)	
70	381346085454201	CP-1	
71	381355085465901	46-13-34, (Lou. Cooperage)	
72	381400085445001	CP-6	
73	381406085463001	78-1	
74	381417085500301	50-14-4, (RR-23)	
75	381424085454602	CP-12A	
76	381428085485701	78-6	
77	381430085452602	45-14-69, (Conna #3)	
78	381430085472501	CP-17	
79	381441085465301	46-14-13, (Bernheim #3)	
80	381441085452701	45-14-71, (A-2)	Recorder
81	381447085454001	45-14-66, (CJ&T #5)	Recorder
82	381453085474501	47-14-10, (Kroger)	
84	381500085454701	78-5	
85	381501085464601	CP-10	
86	381503085453301	45-15-36, (Ky. Towers)	
87	381503085452601	Stewart's #5	
88	381504085443202	CP-7A	
89	381505085475701	CP-5	
90	381508085455701	CP-4	
91	381514085453502	CP-11A	Recorder
92	381536085492801	CP-2	
93	381538085434401	78-7	
94	381539085465201	CP-9	
95	381540085443701	44-15-6, (M&M #1)	
96	381543085480101	CP-14	
97	381553085431602	M-2	
98	381604085430501	43-16-8, (WC-1)	
99	381607085483601	CP-3	
100	381613085421901	42-16-18, (WC-14)	
101	381628085473101	CP-13	
102	381638085415801	41-16-3, (WC-4)	Recorder
103	381648085421201	42-16-15, (WC-5)	
104	381653085413302	WC-9A	
105	381701085414002	WC-8A	
106	381722085405801	40-17-3, (WC-11)	
107	381742085402001	40-17-5, (WC-13)	
108	381827085392401	39-18-1, (WC-26)	
109	381904085384801	38-19-2, (WC-27)	
110	380458085523201	86-4	
111	380619085512301	86-3	
112	380827085503001	86-5	
113	381011085491601	86-1	
114	381102085485601	86-2	
115	381247085463301	CP-18	
116	381246085463201	CP-18A	
117	381517085455501	86-6	Recorder
118	381527085453001	86-7	Recorder
119	381524085452301	86-8	Recorder
120	381528085454201	86-9	Recorder
121	381518085454401	86-10	Recorder
122	381518085453402	86-11	Recorder
123	381518085451801	87-1	Recorder

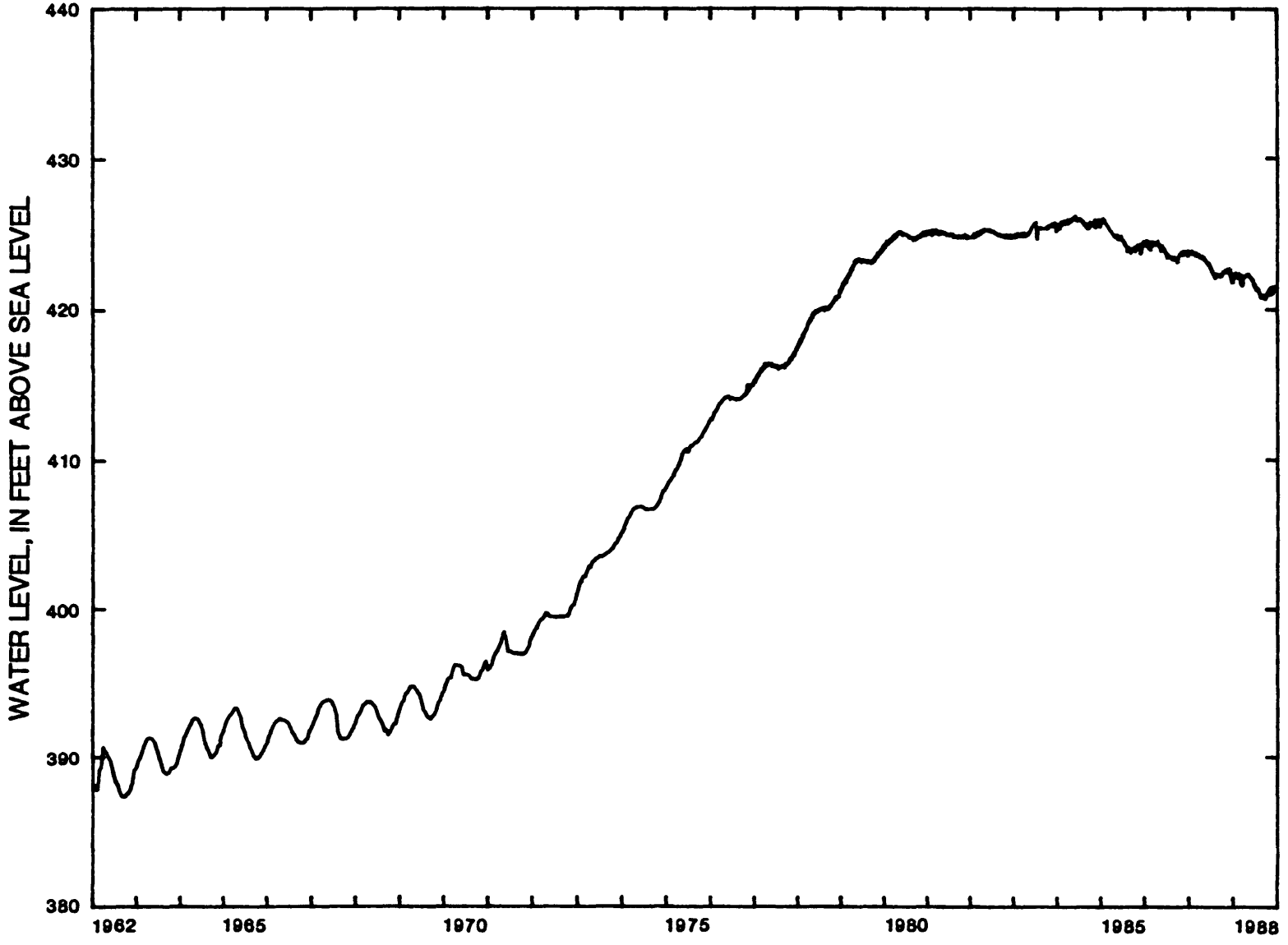


Figure 2.—Hydrograph for well 80 showing characteristic water-level changes during the period 1962–88.

Table 2.--Precipitation, in inches at Louisville, 1977-88

(From U.S. Department of Commerce, National Oceanic and Atmospheric Administration)

	1977	1978	1979	1980	1981	1982
January	2.33	5.90	3.81	1.71	0.45	5.28
February	1.45	.76	4.49	1.09	3.23	1.55
March	4.69	3.76	2.71	4.80	1.54	5.89
April	3.40	3.33	7.32	2.63	4.44	3.05
May	1.37	4.76	3.59	4.58	4.63	2.96
June	7.59	2.67	3.03	3.70	3.23	3.86
July	3.29	3.77	10.05	5.41	3.98	3.72
August	6.12	5.50	2.37	3.76	3.21	3.74
September	3.67	.96	10.49	3.17	3.22	3.46
October	4.76	2.26	2.27	3.37	1.60	1.26
November	6.11	5.14	5.85	2.42	2.40	5.50
December	4.32	7.64	3.82	1.25	2.02	5.11
Total	49.10	46.45	59.80	37.89	33.95	45.38

	1983	1984	1985	1986	1987	1988
January	1.63	0.92	2.20	0.91	0.81	4.00
February	1.52	1.68	2.08	3.90	4.42	3.58
March	2.16	4.41	4.43	2.69	3.05	2.97
April	7.10	5.53	1.69	1.04	2.35	3.52
May	10.58	6.78	3.93	4.28	1.61	2.68
June	4.42	.49	4.37	2.32	3.58	.87
July	.99	6.94	3.45	7.04	5.31	4.68
August	2.39	5.08	4.49	2.19	2.66	3.00
September	1.13	3.70	1.48	2.75	1.15	1.48
October	6.47	2.12	4.24	3.08	.39	1.54
November	5.03	5.87	4.43	4.62	2.62	5.76
December	3.96	5.86	.96	2.69	4.70	3.45
Total	47.38	49.38	37.75	37.51	32.65	37.53

Mean for period of record 1873-1988 = 42.84 inches.
Mean for 1977-88 = 42.90 inches.

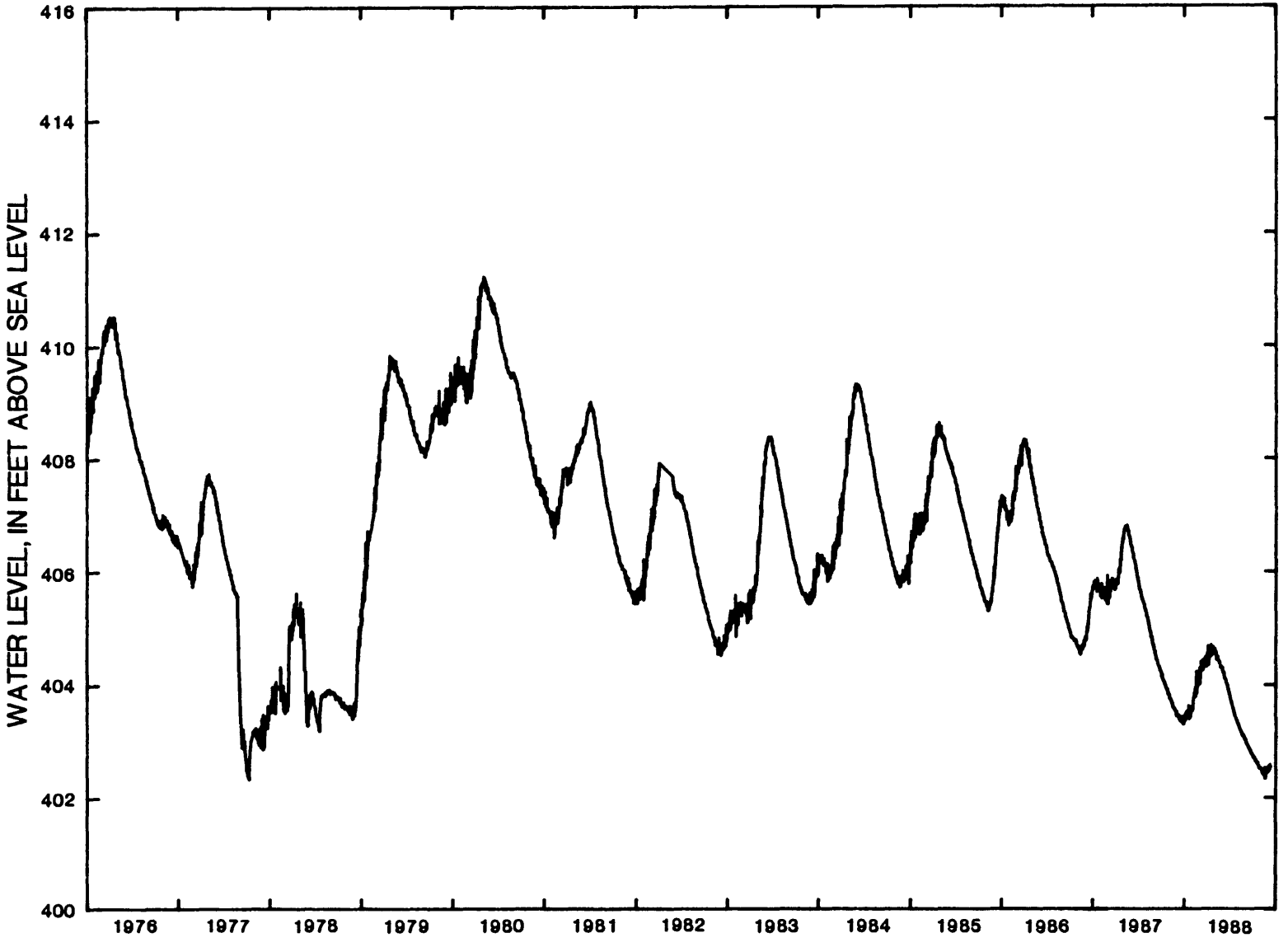


Figure 3.—Hydrograph for well 9 in southwest Louisville.

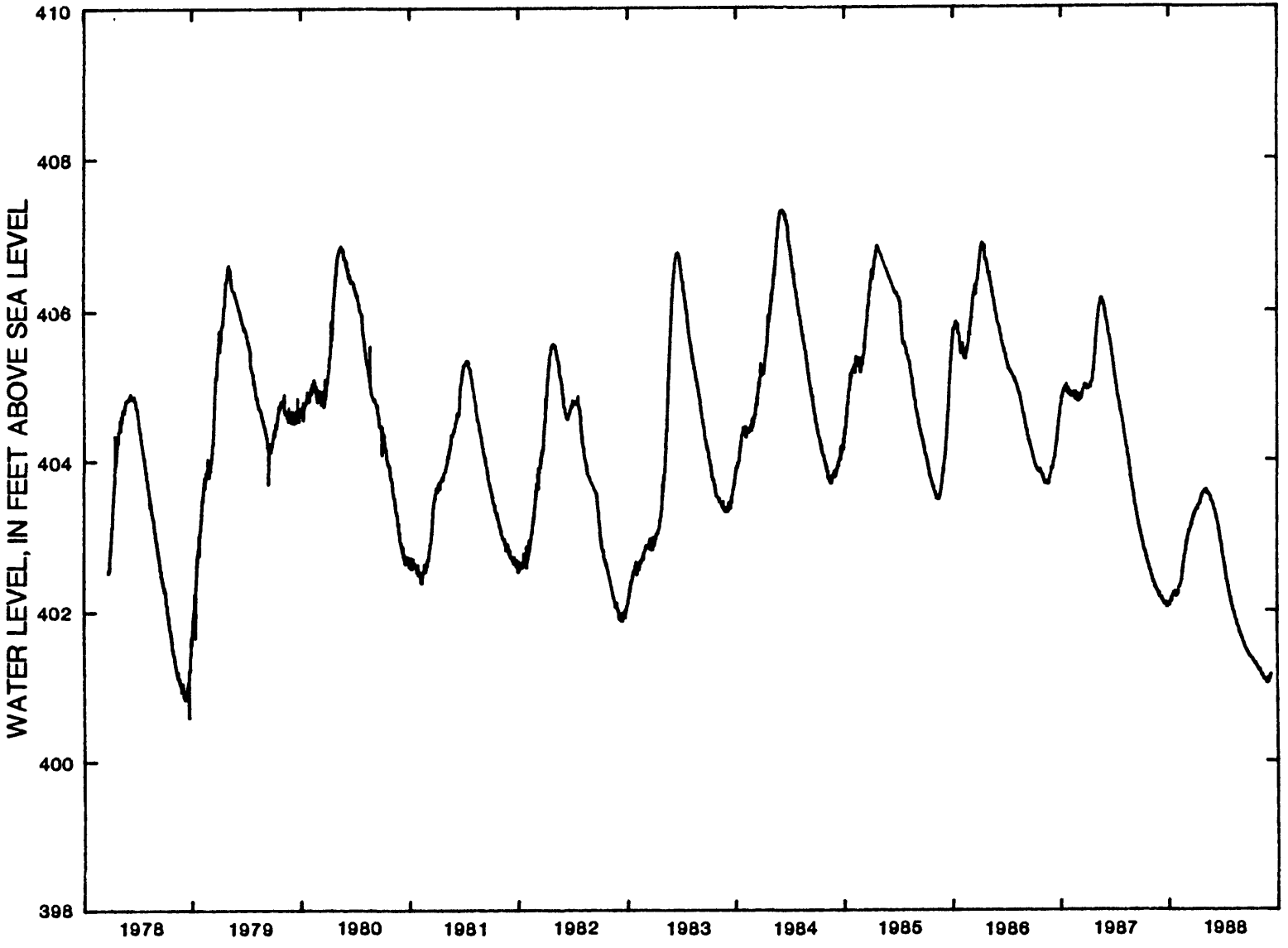
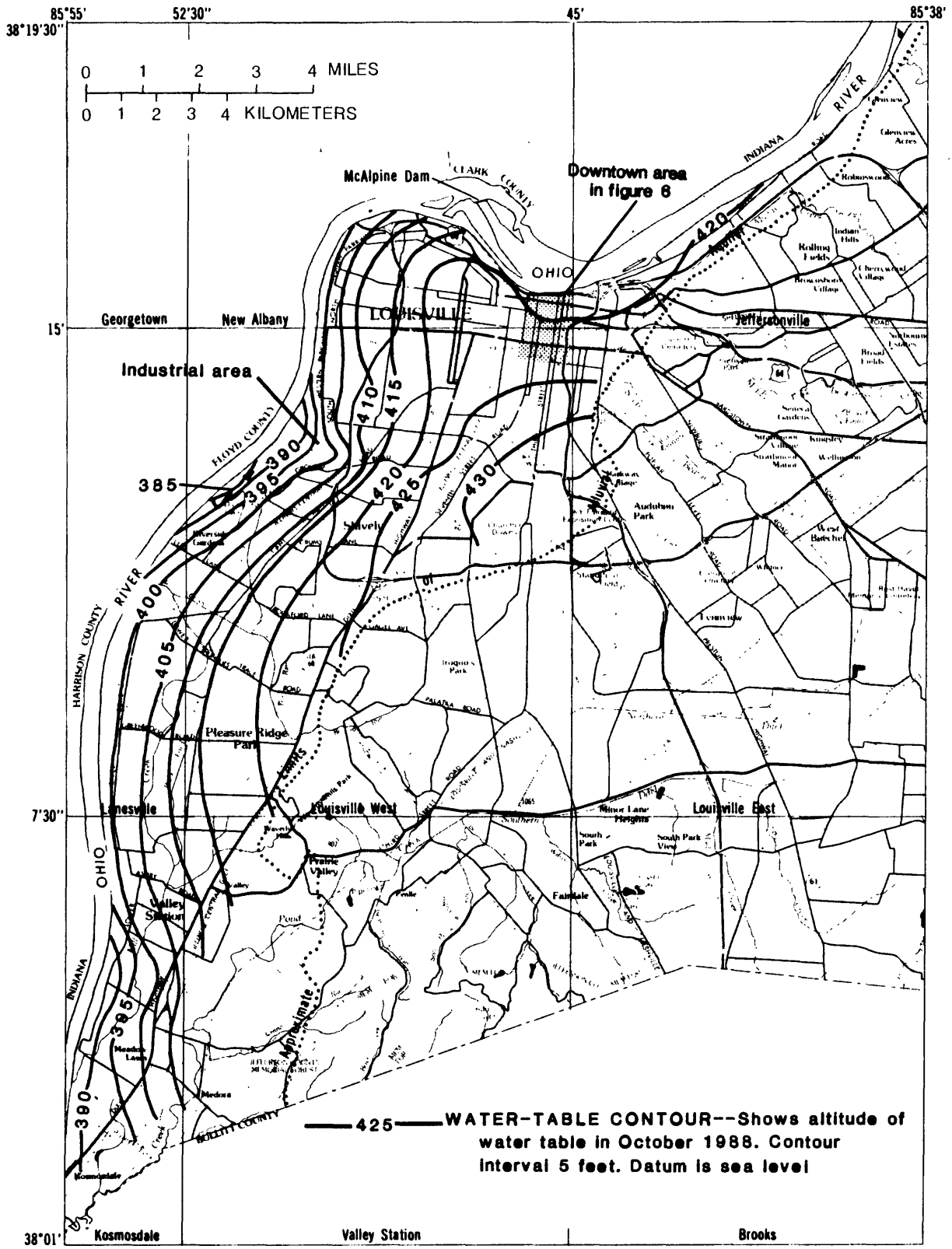


Figure 4.—Hydrograph for well 47 in west Louisville.



Base from U.S.Geological Survey 1:24,000 quadrangles named in figure

Figure 5.--Altitude of water table in Louisville area, October 1988.

the river. In 1988, the typical pattern of contours parralleling the river was disrupted in an area of industrial pumping in west Louisville (fig. 5). There the contours curved landward in the vicinity of the area of withdrawals.

Downtown Louisville

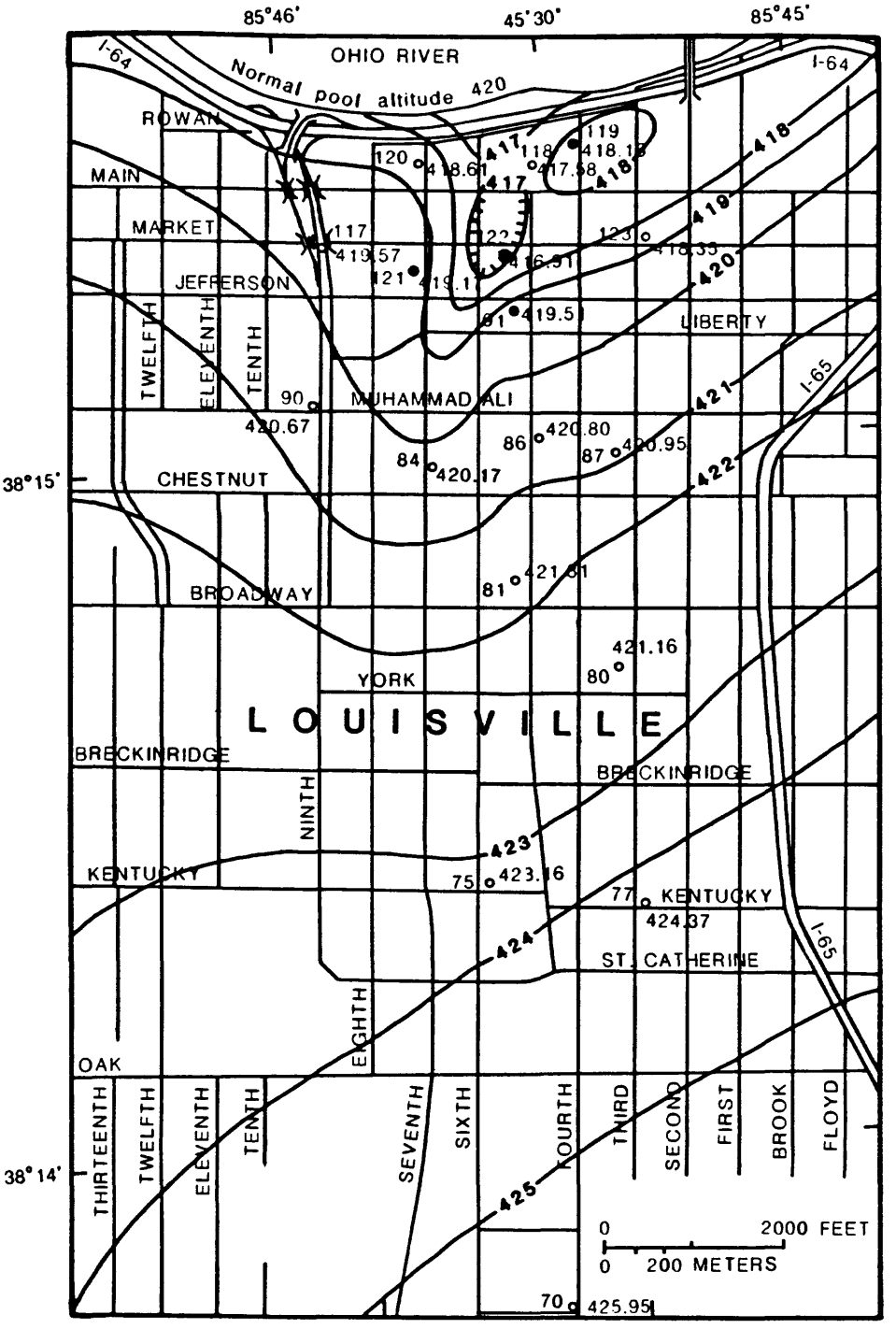
Water levels declined 3 to 5 feet in downtown Louisville because of pumpage and below normal precipitation in 1985-88. Pumpage effects are reflected in water levels of wells 80 and 122 (fig. 6), and represent withdrawals of ground water for heating and cooling which resumed in January 1985. Withdrawal wells for heating and cooling are along Main and Market Streets between Third and Sixth Streets, and on the south side of Broadway between Third and Fourth Streets.

Hydrographs for wells 91 and 119 in figure 7 show the combined effects of below normal precipitation in 1985-88 and the gradually increasing pumpage as shown in figure 8. Probably the initial decline in early 1985 for well 91 was caused mostly by pumpage near Main and Fifth Streets. This pumpage started in January 1985, but pumpage records are unavailable for the months of January through October 1985. The decline during the summer of 1988 was caused by very dry conditions and the relatively large ground-water withdrawals in the area (fig. 8). The water level for well 91 seems to have stabilized at about 420 feet above sea level which is the normal pool stage of the Ohio River. The water level for well 119 seems to have stabilized at about 418 feet or a couple feet lower than the normal pool stage of the river.

Even though pumpage has been increasing in downtown Louisville since 1985, the overall decline in the water table has not been much greater than that in areas of no pumpage. Most of the pumpage in downtown Louisville is concentrated along Main and Market Streets relatively close to the Ohio River. The lack of large or increasing drawdowns near these pumped wells indicates that water is probably being induced from the river as pumping levels fall below the normal pool stage of the river. Water levels in this area will probably remain near their present level until pumpage rates exceed the rate at which water can be induced from the river into the aquifer.

SUMMARY

Ground-water levels stabilized in the Louisville, Kentucky area during the period 1980-86 after rising rapidly in the 1970's. Below normal precipitation for the period 1985-88 resulted in a deficit of about 28 inches for the period. Water levels in the Louisville area showed little response to the dry years in 1985-86, but they declined in 1987-88. The magnitude of the decline at the end of 1988 was 1 to 3 feet in wells near the river and 3 to 6 feet in wells away from the influence of the river. Superimposed on this overall decline in water levels are declines due to pumpage in an industrial area of west Louisville and in two areas of downtown Louisville where ground water is being used for the heating and cooling of buildings. The declines due to pumpage in downtown Louisville seem to have stabilized at or slightly below the normal pool stage of the river which indicates that water is probably being induced from the river into the aquifer.



EXPLANATION

—425— **WATER TABLE CONTOUR--Shows altitude of water table in October 1988. Hachures indicate depression. Contour interval 1 foot. Datum is sea level**

70 o **OBSERVATION WELL AND NUMBER**

• **OBSERVATION WELL--Equipped with temperature probe**

425.95 o **ALTITUDE OF WATER TABLE, IN FEET ABOVE SEA LEVEL**

Figure 6.--Altitude of water table in downtown area, October, 1988.

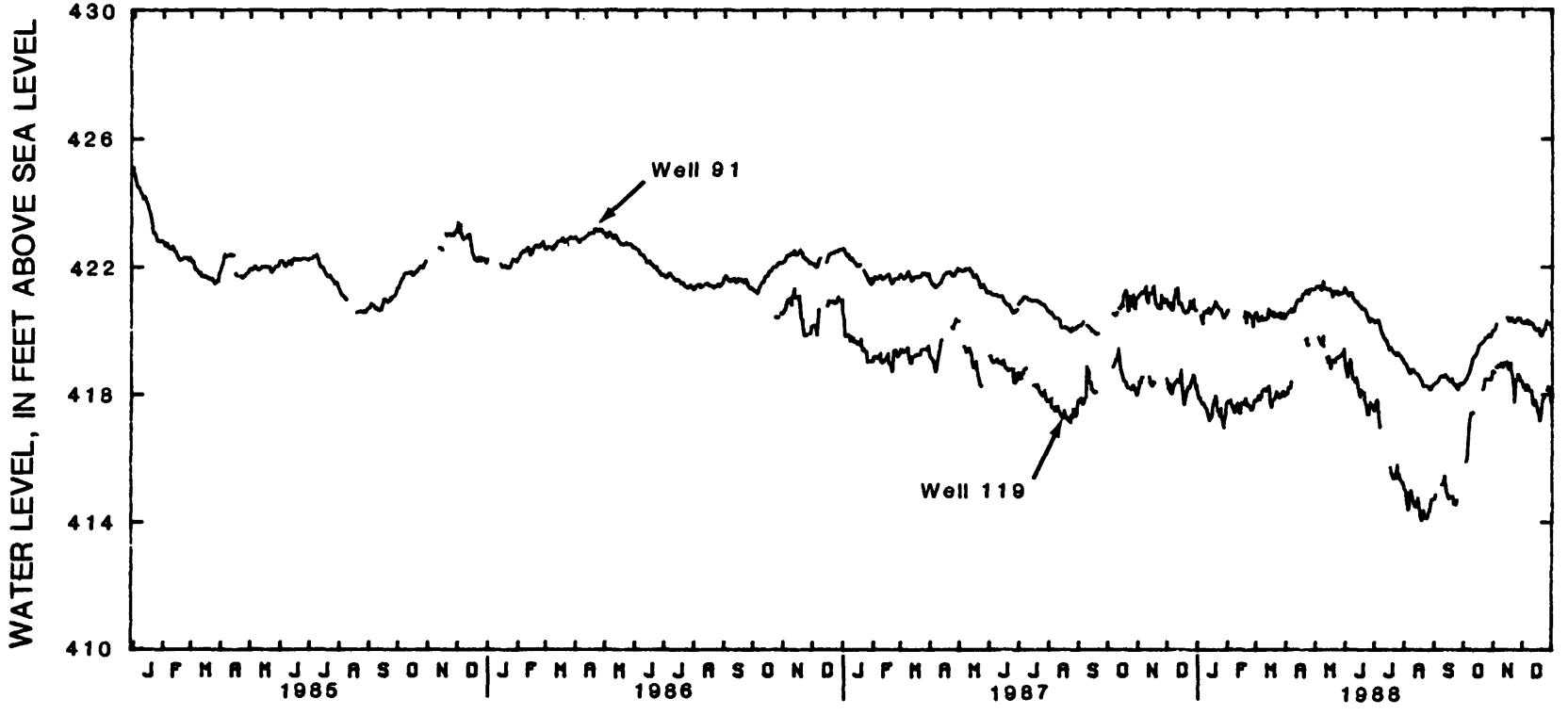


Figure 7.--Hydrographs for wells 91 and 119 in downtown Louisville.

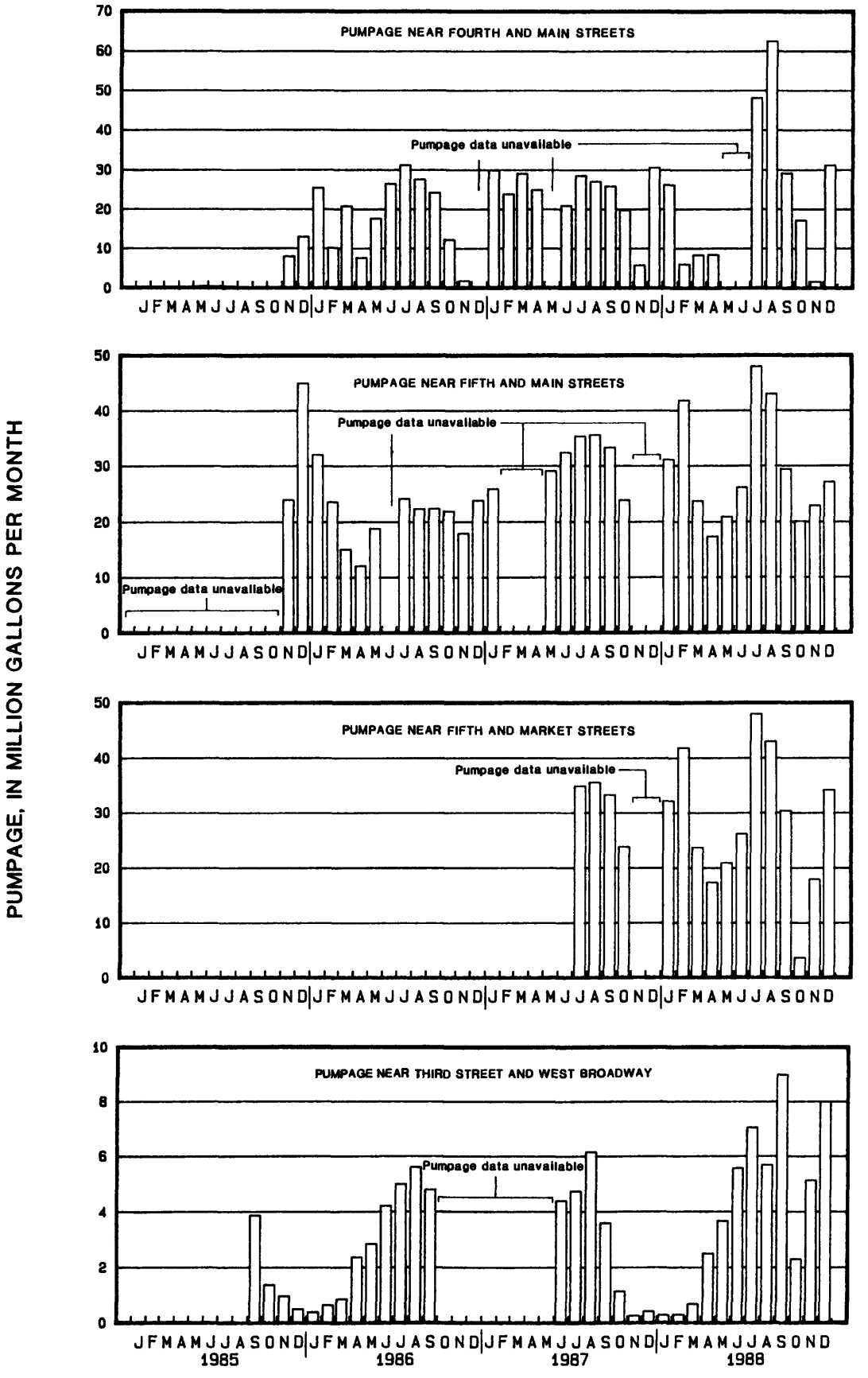


Figure 8.--Pumpage at selected sites in downtown Louisville. (Pumpage data from permit files of Kentucky Natural Resources and Environmental Protection Cabinet)

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