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Ground-Water Levels and Pumpage in the East St. Louis Area, Illinois, 1981-1985

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GROUND-WATER LEVELS AND PUMPAGE IN THE EAST ST. LOUIS AREA, ILLINOIS, 1981-1985

by Robert C. Kohlhase

ABSTRACT

Ground-water levels and pumpage in the East St. Louis area from 1981 through 1985 are considered in this report. Large quantities of ground water chiefly for industrial and municipal use are withdrawn from wells penetrating a sand and gravel aquifer along the valley lowlands of the Mississippi River.

Ground-water pumpage increased from 54.4 million gallons per day (mgd) in 1981 to 60.1 mgd in 1985. Of the total 1985 pumpage, 73.1 percent was industrial; 18.2 percent was for public water supplies; 6.7 percent was for domestic use; and 2.0 percent was for irrigation. Pumpage in the East St. Louis area is concentrated in. five major pumping centers: the Alton, Wood River, Roxana, Granite City, and National City areas. Pumpage in the Sauget (Monsanto) area, once considered a major pumping center, has decreased sufficiently that it is now a minor pumping center.

Ground-water levels throughout the entire area generally increased from levels measured in 1980. Above-normal precipitation and above-mean stream levels most likely were the major causes of the elevated ground-water levels. The only distinguishable decline in ground-water levels was seen in the Collinsville area, where increased pumpage continues to further diminish water levels.

INTRODUCTION

The East St. Louis area (figure 1) is one of the most heavily populated and industrialized areas in Illinois. The ground-water resources of a sand and gravel aquifer underlying the area have been developed extensively. It is estimated that during 1985 an average of 60.1 mgd was withdrawn, chiefly from industrial and municipal wells.

In 1965 the State Water Survey published Report of Investigation 51 (Schicht, 1965), which described in detail the ground-water resources of the East St. Louis area. The report was the culmination of a period of intensive data collection initiated in 1941 after alarming water-level recessions were observed by local industries. Previous reports which summarized water levels and pumpage and aided in the preparation of Report of Investigation 51 were published in 1953 (Bruin and Smith) and 1962 (Schicht and Jones). The ground-water geology of the area had previously been described by the State Geological Survey (Bergstrom and Walker, 1956).

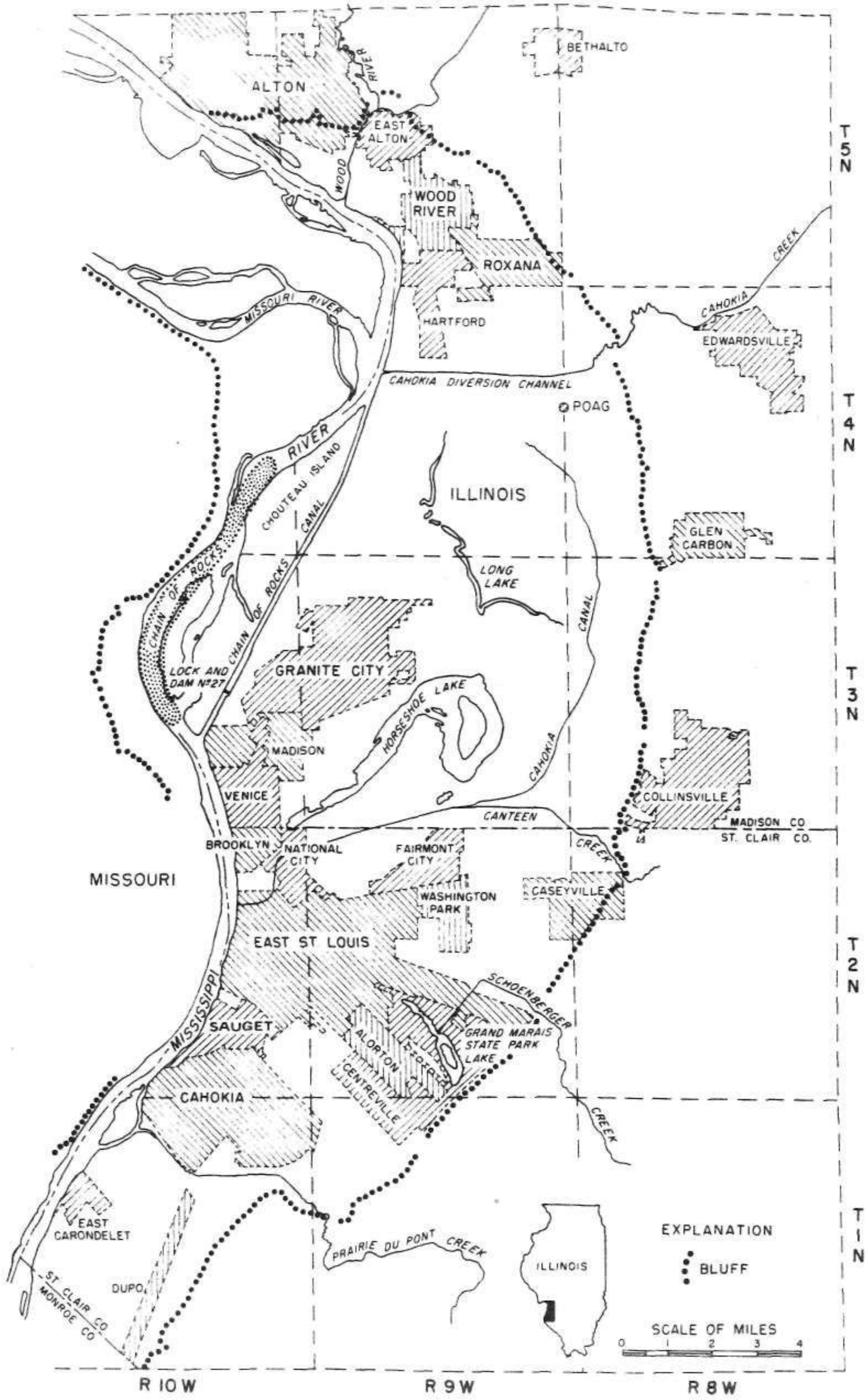

Figure 1. Location of the East St. Louis area

Studies described in Report of Investigation 51 indicated that the practical sustained yield of the sand and gravel aquifer exceeded withdrawals in 1962. However, extrapolation of past ground-water use indicated that pumpage would exceed the practical sustained yield in the Sauget area within a few years. The practical sustained yield of the other major pumping centers probably would not be reached until after 1980. It was estimated that with the development of additional pumping centers the potential yield of the sand and gravel would exceed 188 million gallons per day (mgd). However, peak withdrawals of 111.0 mgd had been reached in 1956 and the projected ground-water use was' never approached because of the general economic decline in the area and the shifts in pumpage to the Mississippi River.

Data collection originally was continued to validate the predictions of Report of Investigation 51 and to delineate problem areas. Now, data collection continues in order to monitor rising ground-water levels and shifts in pumpage. Previous summaries of pumpage and water levels were published in 1968 (Reitz), 1972 (Baker), 1979 (Emmons), and 1986 (Collins and Richards). This report summarizes water-level and pumpage data collected from 1981 through 1985.

Acknowledgements

This report was prepared under the direction of Ellis W. Sanderson, Head of the Ground-Water Section of the Illinois State Water Survey. The author gratefully acknowledges the assistance of Mark Collins during preparation of technical portions of this report. James R. Kirk supplied water use data and information regarding data collection methods, and assisted with the section of the report on pumpage from wells. Linda Riggin prepared the illustrations; Pamela Lovett did the typing; and Gail Taylor did the final editing. Special thanks to Stuart Cravens, Ken Hlinka, John Nealon, and Jeffrey Stollhans, who participated in the water-level data collection efforts.

GEOLOGY AND HYDROLOGY

Large supplies of ground water, chiefly for industrial development, are withdrawn from permeable sand and gravel in unconsolidated valley fill in the East St. Louis area. According to Bergstrom and Walker (1956), the valley fill is composed of recent alluvium and glacial valley-train material and is underlain by Mississippian and Pennsylvanian rocks consisting of limestone and dolomite with subordinate amounts of sandstone and shale. Because of the low permeability of the bedrock formations and poor water quality with depth, the bedrock does not constitute an important aquifer in the area. The valley fill ranges in thickness from a featheredge near the bluff boundaries and along the Chain of Rocks reach of the Mississippi River to more than 170 feet near the city of Wood River, averaging 120 feet across the entire area. The thickness of the valley fill is generally greatest and exceeds the average in places near the center of a buried bedrock valley that bisects the area, as shown in figure 2. The valley fill becomes progressively coarser with depth. The coarsest deposits most favorable for development are commonly encountered near bedrock and often average between 30 and 40 feet in thickness.

Ground water in the valley fill occurs under leaky artesian and water-table conditions. Because ground water occurs most commonly under these conditions, the surface to which water rises in wells is hereafter called the potentiometric surface.

Recharge within the area is from precipitation, induced infiltration of surface water from the Mississippi River and lesser water bodies in the area, and subsurface flow from the bluffs bordering the area. A fraction of the annual precipitation seeps downward through surface materials and into the valley fill material. Recharge by induced infiltration occurs at places where pumpage from wells has lowered the elevation of the potentiometric surface below the water-level elevation of a surface water body.

PUMPAGE FROM WELLS

The first significant withdrawal of ground water in the East St. Louis area started in the late 1890s. Prior to 1900 ground water was primarily used for domestic and farm supplies; since 1900 pumpage has been mostly for industrial use. Estimated pumpage from wells increased from 2.1 mgd in 1900 to 111.0 mgd in 1956, as shown in figure 3. Pumpage then declined sharply to 92.0 mgd in 1958. By 1964 pumpage had again increased to 110.0 mgd. After 1966 pumpage steadily declined to 54.4 mgd in 1981, and slowly increased to 60.1 mgd in 1985. This recent increase in pumpage appears to have been caused by increased dewatering activities and increases in industrial pumpage. The Illinois Department of Transportation (IDOT) operates dewatering wells along roadways in the area to prevent water levels from rising above the road surfaces. These continuing dewatering efforts have created a dominant pumping center in the East St. Louis area.

Pumpage data are classified in this report according to four categories: 1) public, including municipal and institutional; 2) industrial, including dewatering; 3) domestic, including rural farm non-irrigation and rural non-farm; and 4) irrigation, including farms, golf courses, and cemeteries. Most water-supply systems furnish water for several types of uses. A public supply commonly includes water used for drinking and other domestic uses, manufacturing processes, and lawn sprinkling. Industrial supplies may also be used in part for drinking and other domestic uses. No attempt has been made to determine the final use of water within the public and domestic categories; for example, any water pumped by a municipality is called a public supply, regardless of the use of the water. However, the final use of water within the industrial category has been determined in part, and

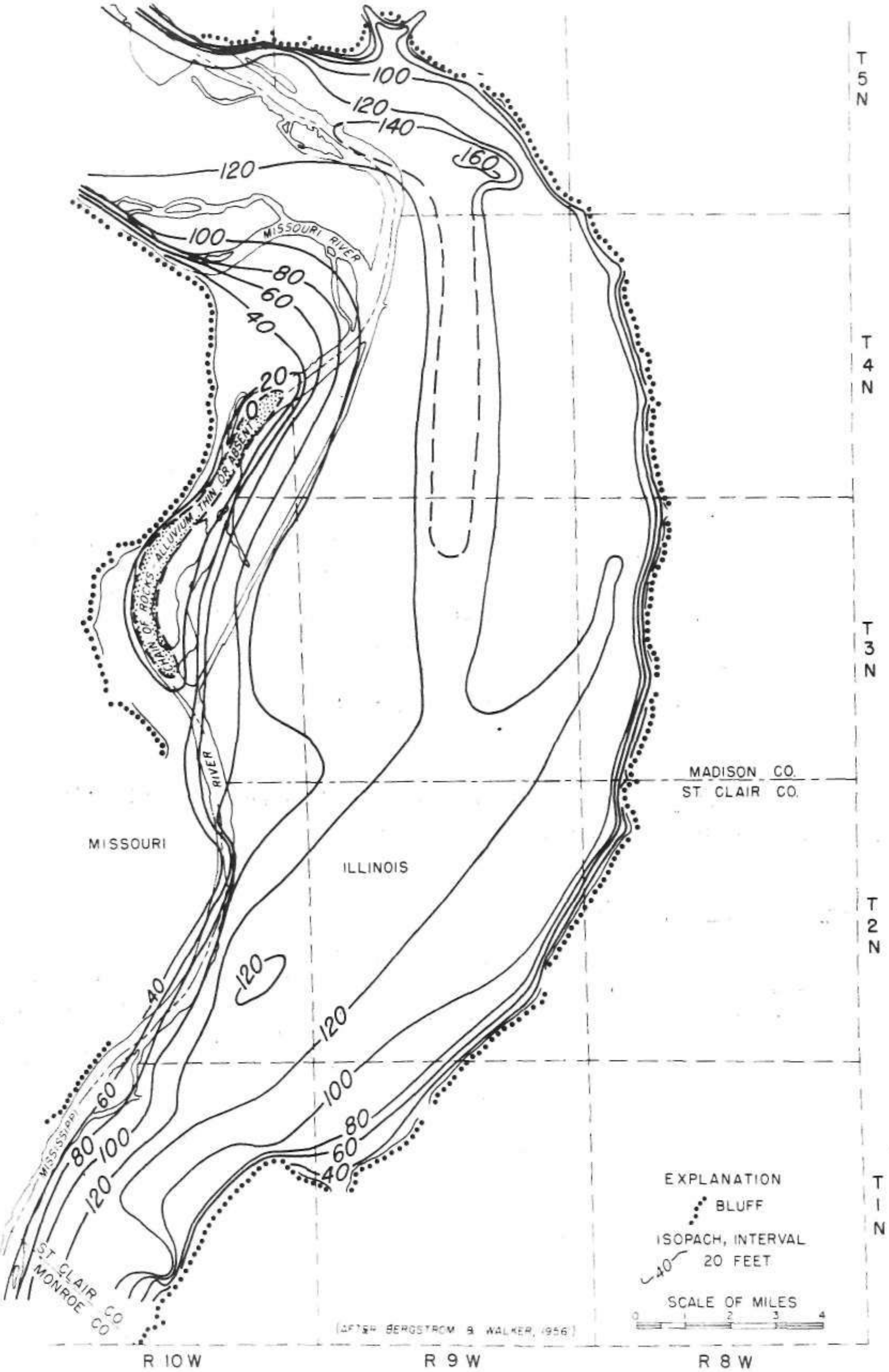

Figure 2. Thickness of valley fill deposits

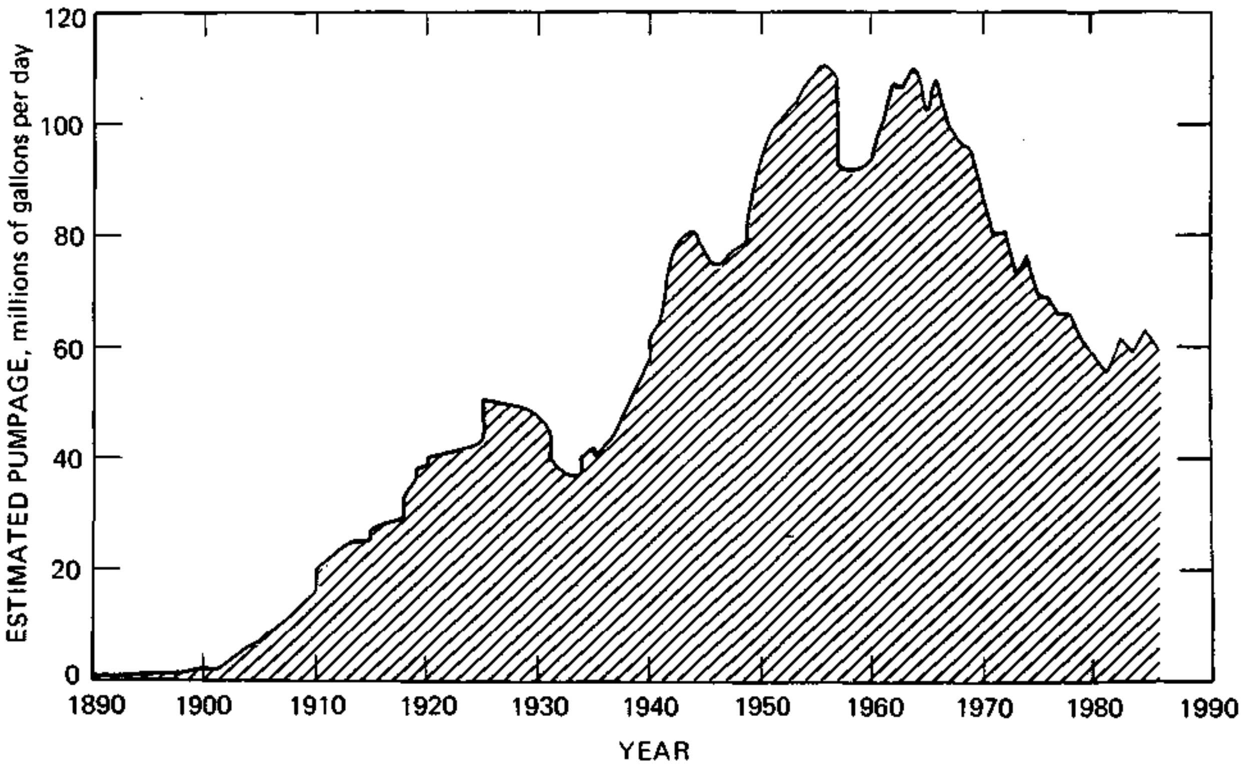

Figure 3. Estimated pumpage, 1890-1985

any water pumped by an industry and furnished to a municipality is included in the public supply category.

Pumpage. 1981 through 1985

Pumpage increased from 54.4 mgd in 1981 to 60.1 mgd in 1985. Estimated pumpage for the period 1976 to 1985 is shown in figure 4. Distribution of 1985 pumpage was as follows: public supply systems accounted for 18.2 percent or 11.0 mgd, industrial pumpage was 73.1 percent or 43.9 mgd, domestic pumpage was 6.7 percent or 4.0 mgd, and irrigation pumpage was 2.0 percent or 1.2 mgd.

Public Supplies. Municipal and institutional uses are included in public supplies. The estimated pumpage for public water supply systems showed a slight increase from 1981 to 1985. Public supply withdrawals totaled 9.6 mgd in 1981, 9.8 mgd in 1982, 10.5 mgd in 1983, 11.5 mgd in 1984, and 11.0 mgd in 1985.

Pumpage of public water supplies reflects seasonal variations to some extent. Municipal pumpage is generally 25 to 30 percent higher during the summer months than during the winter months. Institutional pumpage is primarily for air conditioning, and therefore is also affected by seasonal changes in temperature.

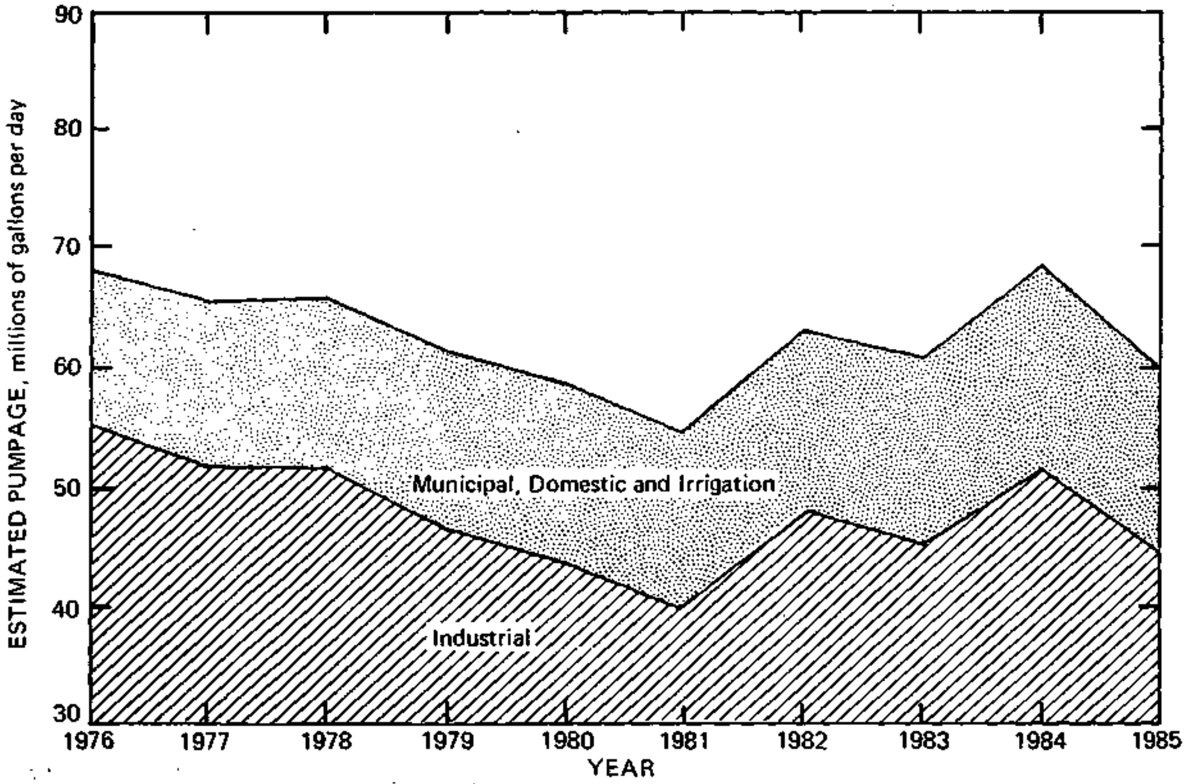

Figure 4. *Estimated pumpage, 1976-1985, subdivided by use*

Industrial Supplies. The major industrial users of ground water in the East St. Louis area include oil refineries, chemical plants, ore refining plants, meat packing plants, and steel plants. Most of the industrial plants do not meter their pumpage, and pumpage estimates are typically based on the number of hours the pump operated, on pump capacity, and in some cases on production data. Industrial pumpage generally is more uniform throughout the year than public pumpage unless large air conditioning installations are used, the industry is seasonal, or a change in operation occurs as a result of strikes or vacation shutdowns. Industrial pumpage (figure 4) increased from 39.7 mgd in 1981 to 43.9 mgd in 1985. This increase was due to increases by four primary users, most likely caused by stronger economic markets for these companies.

Domestic Supplies. Emmons (1979) estimated domestic pumpage, including rural farm non-irrigation and rural non-farm use. This estimate was made by considering rural population as reported by the U.S. Bureau of the Census and per capita use of 50 gallons per day (gpd). Average domestic pumpage for the period 1971 to 1978 was estimated to be 2.4 mgd. More recent data (provided by James Kirk from the Water Survey's Water Inventory Program files) indicate per capita use for the East St. Louis area to be approximately 84 gpd. On the basis of this figure, average domestic use in 1985 is estimated to be 4.0 mgd.

Irrigation Supplies. Irrigation pumpage is seasonal and can vary considerably from year to year. The amount of irrigation pumpage should generally reflect precipitation patterns and the number of acres irrigated. Irrigation pumpage estimates in the East St. Louis area were based on the estimated number of acres irrigated, and precipitation patterns from May to September each year. Irrigation pumpage is averaged over the entire year although the actual pumpage occurs on a seasonal basis.

In 1981, irrigation pumpage was estimated to be 0.96 mgd (figure 5). In 1982 irrigation pumpage rose to 1.98 mgd and in 1983 it increased to 2.68 mgd. In each of these three years approximately 3500 acres of land were irrigated. This increase in irrigation use resulted from above-average temperatures and below-average precipitation during the 1982 and 1983 growing seasons.

The number of acres irrigated during 1984 and 1985 declined to approximately 2400. Therefore irrigation pumpage declined during those years to 2.2 and 1.2 mgd, respectively.

Distribution of Pumpage

Pumpage in the East St. Louis area is now concentrated in five major pumping centers and four minor pumping centers. The major pumping centers are at Alton, Wood River, Roxana, National City, and Granite City. Minor pumping centers are at Poag, Glen Carbon, Collinsville, and Sauget.

Distribution of the 1985 pumpage and locations of the pumping centers are shown in figure 6. Prior to 1953 pumpage from wells was

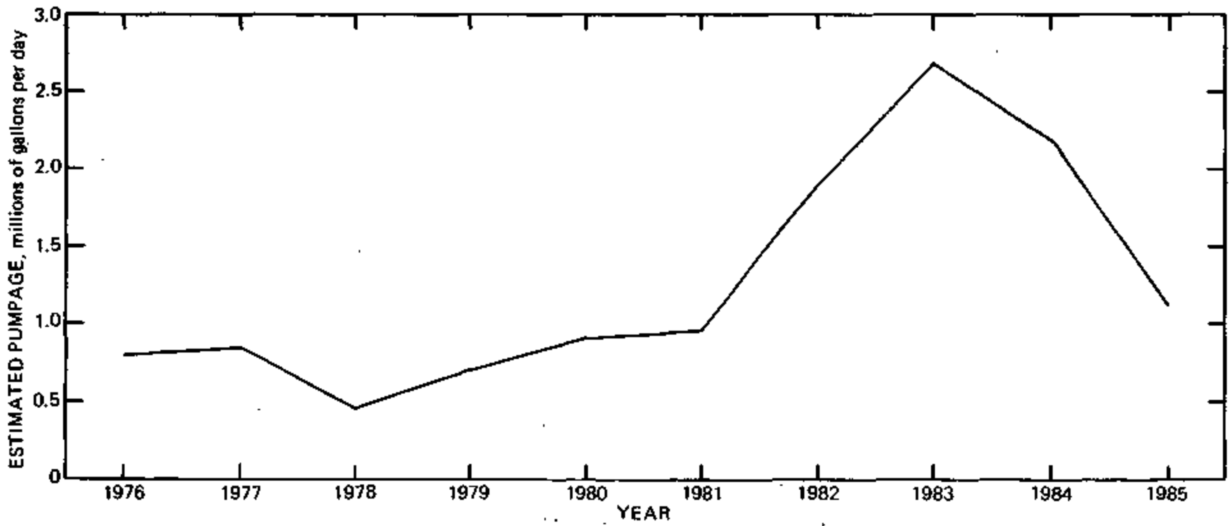

Figure 5. Estimated irrigation pumpage, 1976-1985

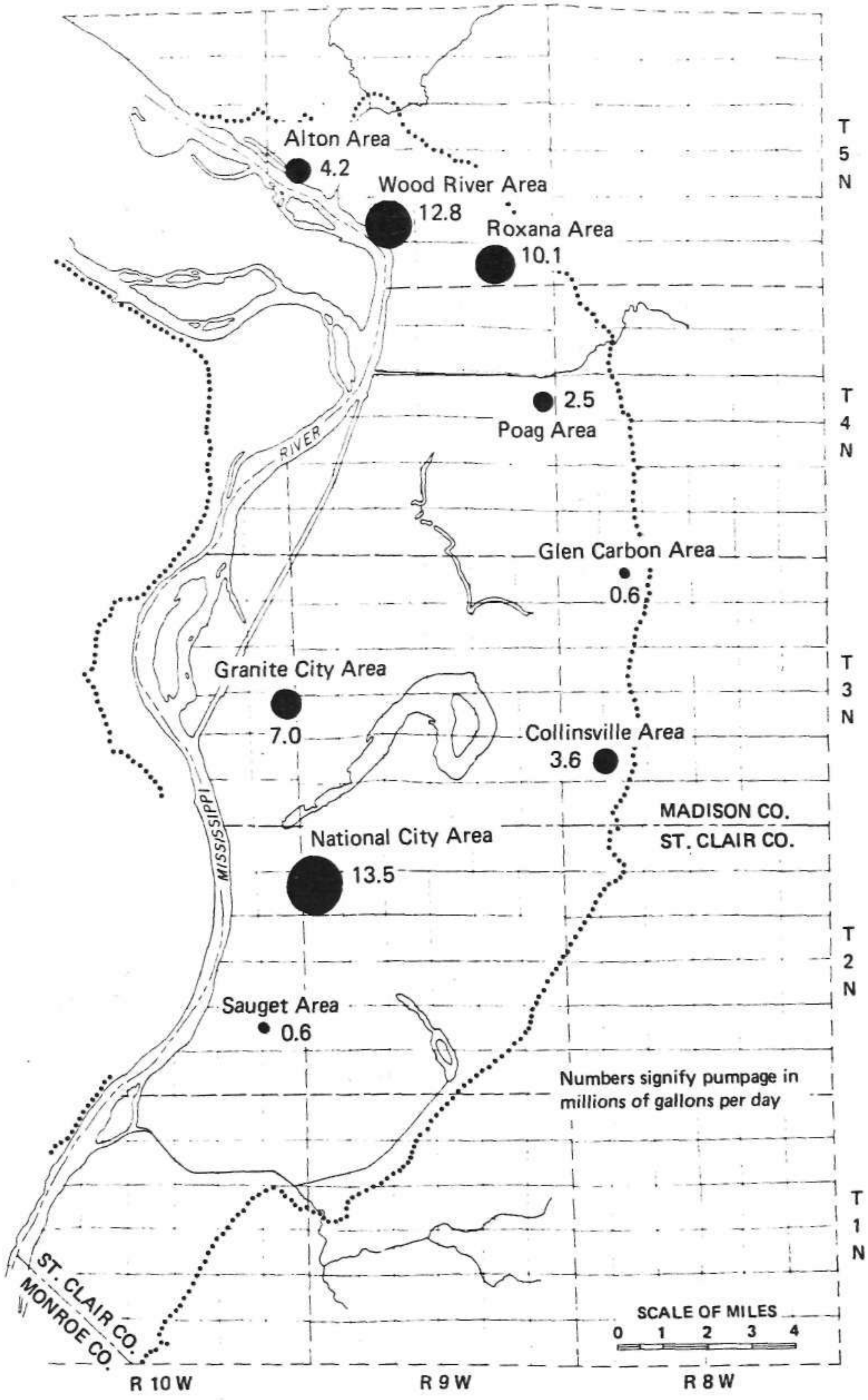

Figure 6. Distribution of estimated pumpage, 1985

concentrated for the most part in areas 1 or more miles from the Mississippi River. During and after 1953, pumpage from wells located a few hundred feet or less from the Mississippi River increased greatly. During 1985, the amount of pumpage from wells near the river (less than a mile) was slightly less than 1980 pumpage. At Alton, the total pumpage during 1985 (4.2 mgd) was pumped from wells near the river; 6.0 mgd was pumped there during 1980. The only other pumpage near the river is at Wood River, where 12.8 mgd was pumped from wells near the river during 1985; in 1980, 12.8 mgd was also pumped in this area from wells near the Mississippi.

Estimated pumpage in the major pumping centers is shown in figure 7.

Ground-water withdrawals in the Alton area are primarily from wells owned by two industries. The greatest use of water is for boxboard manufacturing. During the 1980s, water use by the boxboard industry has remained rather steady, while other uses have declined. Thus total estimated pumpage during 1981-1985 declined from a peak of 5.7 mgd in 1981 to 4.2 mgd in 1985.

The Wood River/Roxana area is the largest pumping center in the American Bottoms. Pumpage in 1985 totaled 22.9 mgd. Pumpage in the Wood River/Roxana area supplies oil refineries and municipalities.

Pumpage in the Granite City area fluctuated erratically throughout the 1970s. After 1978, estimated pumpage decreased from 9.3 mgd to 7.7 mgd in 1979 and 4.6 mgd in 1980. Between 1981 and 1985 pumpage increased to as much as 11.7 mgd (in 1984) and declined to 7.0 mgd during 1985. These changes reflect ground-water use demands by steel production industries, the primary users in this area.

Ground-water withdrawals in the National City area are used for meat packing plants and dewatering sites near interstate highways. Pumpage decreased from a peak of 10.5 mgd in 1972 to 8.1 mgd in 1976. After 1976, pumpage increased to 13.5 mgd in 1985. This rise is attributed to the increased pumpage at the interstate highway dewatering sites necessary to offset reductions in pumpage in the Sauget and Granite City areas. The area-wide rise in water levels also contributed to the need for increased pumpage at dewatering sites.

Combined ground-water pumpage from the minor pumping centers, including Sauget, is shown in figure 8. Pumpage in these pumping areas primarily supplies municipalities. Total pumpage from these minor pumping centers has increased slightly in the 1980s.

WATER LEVELS IN WELLS

Water levels in wells in the East St. Louis area have been measured periodically for more than 45 years by the State Water Survey

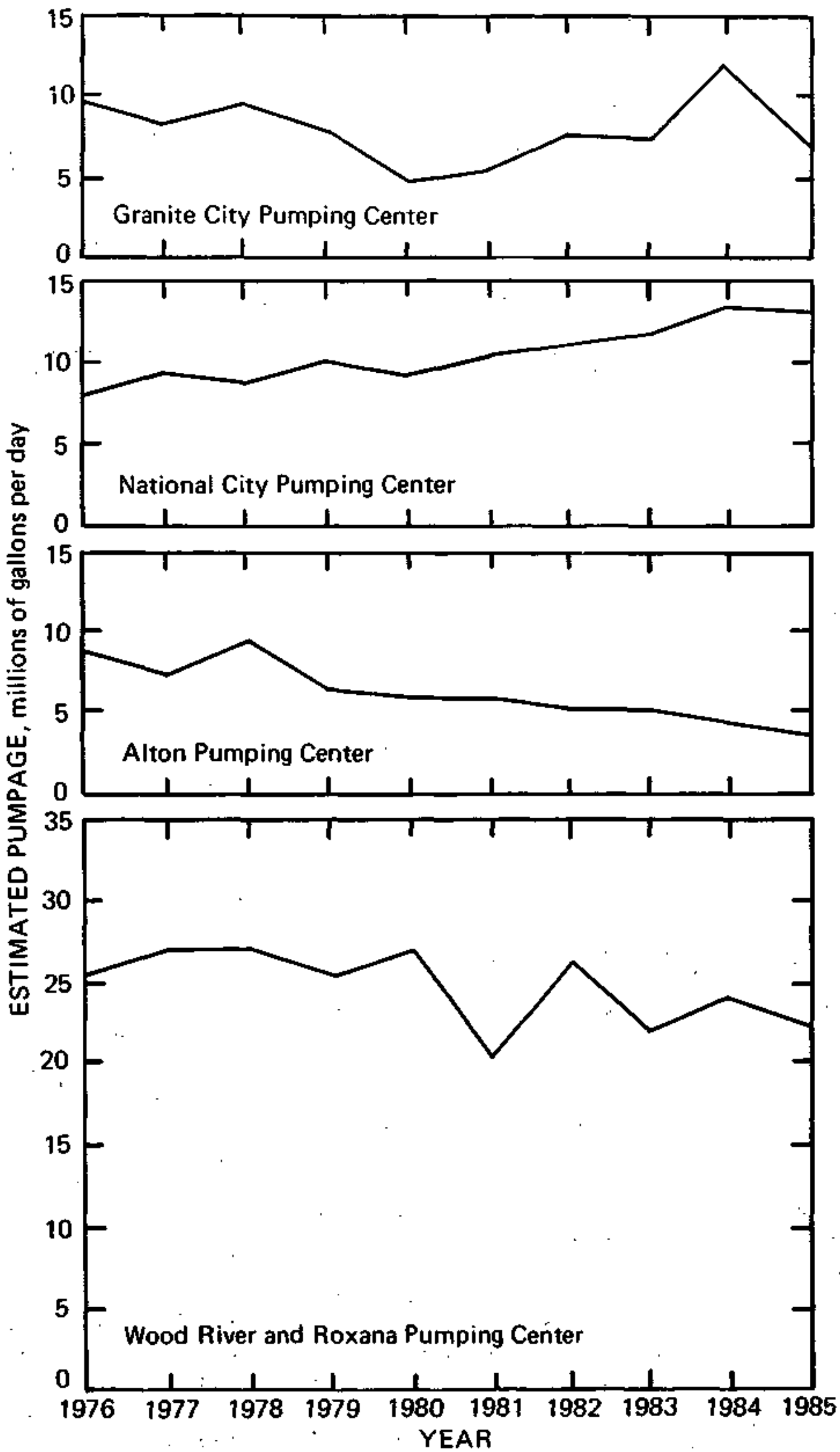

Figure 7. Estimated pumpage, major pumping centers

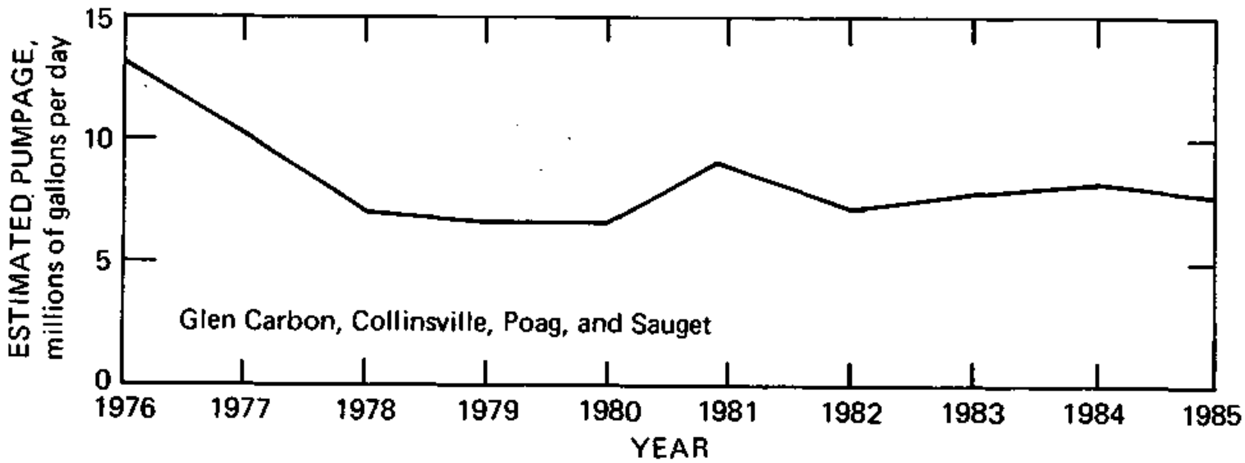

Figure *8. Estimated pumpage, minor pumping centers*

and other concerned public and private parties. The locations of SWS observation wells active (serviced monthly) from 1981 to 1985 are shown in figure 9.

Water levels in wells generally recede in late spring, summer, and early fall when discharge from the ground-water reservoir by evapotranspiration, ground-water discharge to streams, and pumpage combine to exceed recharge from precipitation and infiltration induced from surface water bodies. Ground-water levels generally begin to recover in early winter when conditions are favorable for recharge from precipitation. The recovery of ground-water levels is especially pronounced during the early spring months when precipitation recharge exceeds evapotranspiration and discharge to streams, resulting in most of the annual recharge to the aquifer.

The water level measured in a well at a particular time will reflect not only seasonal variation, but also factors such as recent climatic conditions, nearby pumpage, and the water levels of nearby surface water bodies. Figure 10 shows the average monthly high and low water levels and the record high and low water levels observed during the period of record for four wells located in the East St. Louis area. From these graphs, it can be seen that ground-water levels are usually highest during April to June, and are lowest in September, October and November. The influence of nearby hydrologic features can also be seen.

Well MAD3N9W-16.8a (fig. 10a) is located approximately 1/3 mile from Horseshoe Lake. Horseshoe Lake can be considered to have a nearly constant water surface elevation, which limits fluctuations of the surrounding ground-water levels. In addition to the influence of the lake, a nearby drainageway acts to limit extremely high ground-water levels at this site. As a result of these factors, the annual fluctuation at Well MAD3N9W-16.8a is only about 1 foot.

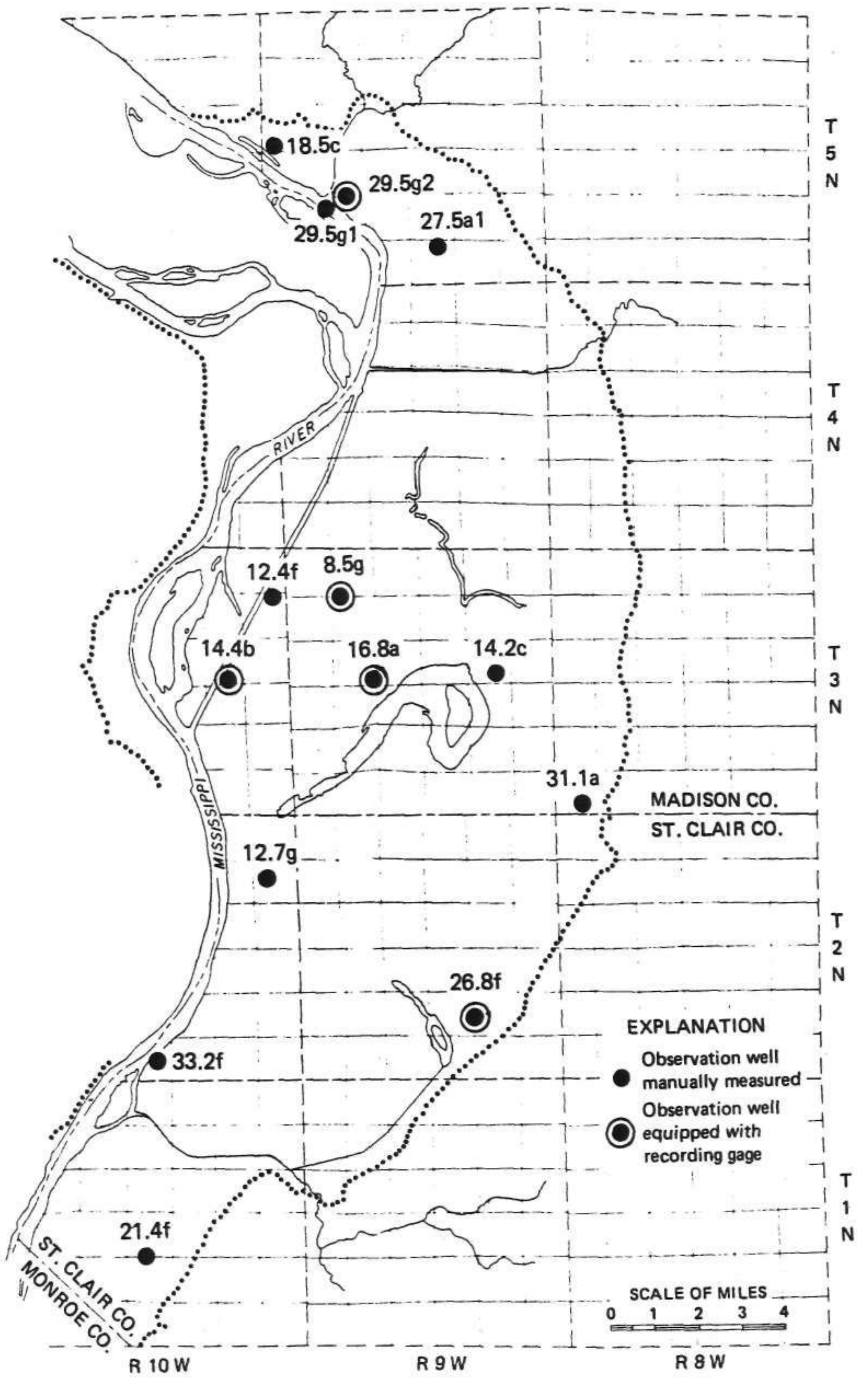

Figure 9. Locations of State Water Survey observation wells

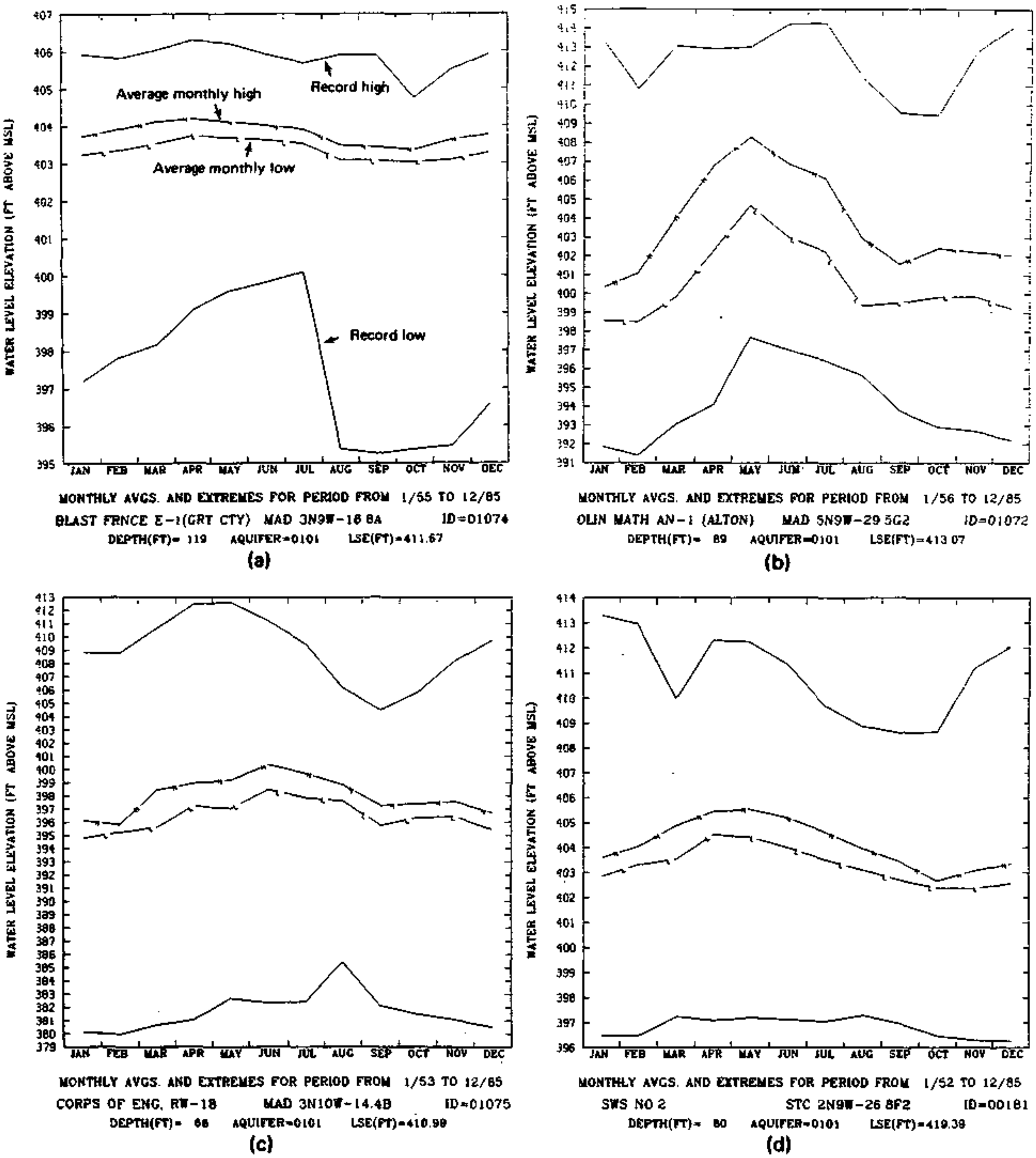

Figure 10. Average and record monthly high and low water levels

Well MAD5N9W-29.5g2 (fig. 10b), located near the Mississippi River at Alton, is influenced by river stage fluctuations and pumpage. It is not unusual for ground-water levels at this well to be at land surface or for ponded water to occur during high river stages. Well MAD3N10W-14.4b (fig. 10c) is located in the west-central part of the area near Chain of Rocks Canal. Water levels in Well MAD3N10W-14.4b fluctuate about 4 to 5 feet annually. This is less than at Well MAD5N9W-29.5g2, probably because of less pumpage influence and because more geologic modification (levee construction) has occurred near Well MAD3N10W-14.4b. In contrast, Well STC2N9W-26.8f2 (fig. 10d) is located near the bluff in the southern part of the area and is not greatly affected by pumpage or surface water influence. The annual fluctuation at Well STC2N9W-26.8f2 is about 2 feet.

Since 1900, ground-water levels have changed appreciably in the major pumping centers. According to Schicht and Jones (1962), the greatest water-level declines for the period from 1900 to November 1961 occurred in major pumping centers: 50 feet in the Sauget area (formerly a major pumping center), 40 feet in the Wood River area, 20 feet in the Alton area, 15 feet in the National City area, and 10 feet in the Granite City area. Part of the declines, 2 to 12 feet, were attributed to the construction of levees and drainage ditches.

Reitz (1968) and Baker (1972) described the changes in ground-water levels for the period from 1962 through 1971. Ground-water levels generally continued to decline through 1964, but began to rise about 1965 as the effects of decreased pumpage and above-average precipitation and river stages became noticeable.

Ground-water levels generally continued to rise for the period from 1972 to 1977 (Emmons, 1979). Decreases in pumpage caused ground-water levels to rise 2 feet in the Sauget and Wood River areas and 5 feet in National City. Little change was observed in the Alton and Granite City pumping centers. In Alton, a change of observation wells to a site nearer the center of pumpage obscured the rise in ground-water levels resulting from a decrease in pumpage. Erratic pumpage in the Granite City area produced small observed changes in ground-water levels.

During the period 1978 to 1980 ground-water level changes outside pumping centers showed little change (Collins and Richards, 1986). Near pumping centers, trends established between 1971 and 1977 continued. Decreases in water-levels in areas near the Mississippi River were generally due to low river stages. In the Wood River area, however, decreases in water-level elevations of more than 5 feet were attributed to a change in the spatial distribution of pumpage. In the Granite City area, ground-water levels generally rose in proportion to decreased pumpage. Increased pumpage in the National City area expanded the area of declining ground-water levels near the river. Ground-water levels continued to recover in the Sauget area with reduced pumpage.

Figure 11 shows the mean monthly Mississippi River stages for the period from 1976 through 1985, and figure 12 shows the observed annual precipitation for the same period at Edwardsville (which lies near the crest of the bluff slightly north of the center of the area). Hydrographs of selected wells for this period are shown in figure 13. Single-line hydrographs represent water levels for wells where the water level is measured monthly. Hydrographs with two lines represent water levels for wells equipped with continuous recorders; the lines represent the observed monthly high and low ground-water levels.

The hydrographs in figure 13 show that these wells all share a similar fluctuation pattern for the period 1981 through 1985, differing only in magnitude of fluctuation. The trend during this period was for increasing water levels during 1981 and 1982, with apparent stabilization within an elevated range from 1983 to 1985. Factors contributing to this pattern are above-normal precipitation, river stages, and the response of water levels to annual pumpage changes. Annual precipitation was slightly below normal during 1979, approximately 25 percent below normal in 1980, and near normal through 1981. From 1982 through 1985, precipitation was significantly above normal. Fluctuations seen in the hydrograph for mean monthly river stages correlate closely to the well hydrograph fluctuations for the same time period. In relation to the 120-year mean river elevation, river stages during this time period had a below- and above-average pattern similar to the precipitation pattern.

From 1981 through 1985, ground-water levels in Well MAD5N9W-29.5g2 (fig. 13a) and Well MAD3N10W-14.4b (fig. 13b) can be seen as generally reflecting Mississippi River stages. Flood events are reflected by corresponding peaks in both ground-water hydrographs. Daily water-

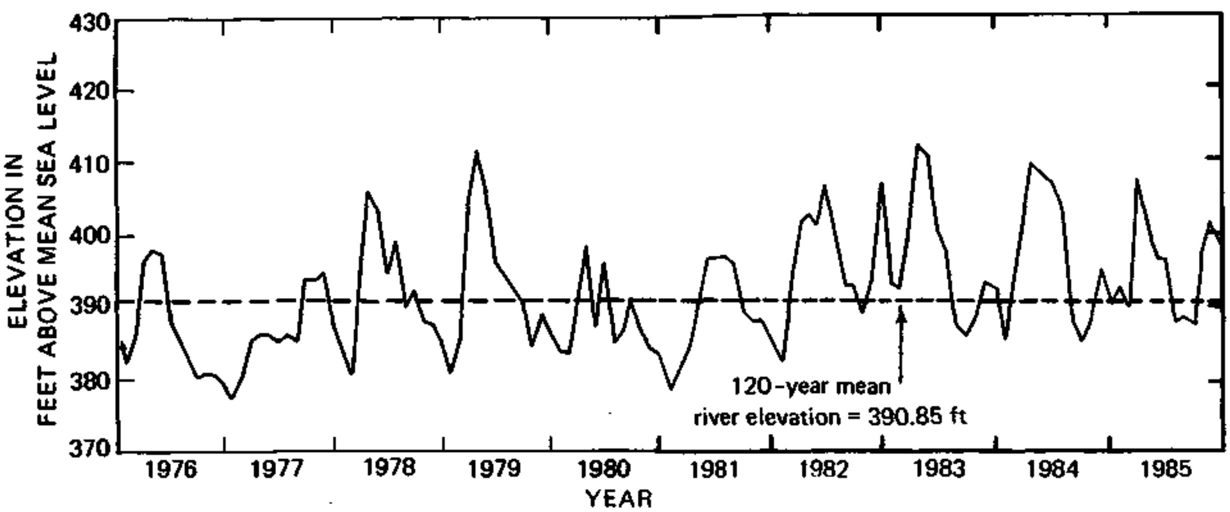

Figure *11. Mean monthly Mississippi River stages, St. Louis gaging station, 1976-1985*

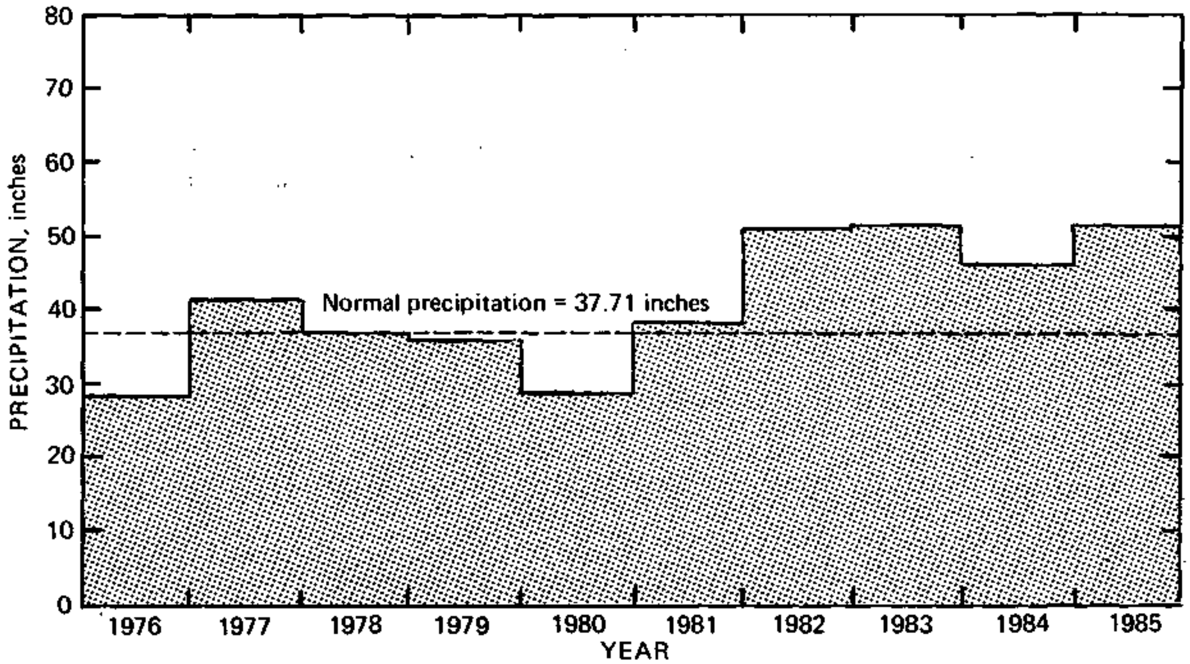

Figure 12. Annual precipitation at Edwardsvi1le, 1976-1985

level fluctuations due to activities at Lock 27 can be seen in figure 14, which shows a single-month hydrograph from the monthly recorder at Well MAD3N10W-14.4b.

The magnitude of water-level change during 1981 to 1985 was controlled by each well's proximity to pumping centers and to the Mississippi River and other surface water bodies. Well MAD3N9W-14.2c (fig. 13c), which lies near the northeast end of Horseshoe Lake, is a good example of a well that is not strongly affected by a pumping center and that has the stabilizing influence of Horseshoe Lake nearby and no drainageway in the immediate area. These conditions result in an annual fluctuation of water levels in this well of about 3 feet. This is more variation than in Well MAD3N9W-16.8a (figure 10a), discussed previously. The lesser fluctuation at Well MAD3N9W-16.8a is explained by the presence of the drainageway adjacent to that well.

Ground-water levels in Well STC2N9W-26.8f2 (fig. 13d) and Well MAD3N9W-8.5gl (fig. 13e) vary in an almost identical manner, probably because both wells are in urban areas. The presence of high-density buildings and large paved surface areas limits the area through which vertical recharge can occur. Also, as a result of the network of storm drainage in urban areas, potential recharge from precipitation is carried away quickly, resulting in moderated water-level changes. In contrast, water levels in Well STC2N10W-12.7g (fig. 13f) are impacted heavily by pumpage and by river-stage levels. The resulting impact of these influences is an annual water-level change of 5 feet. At Well

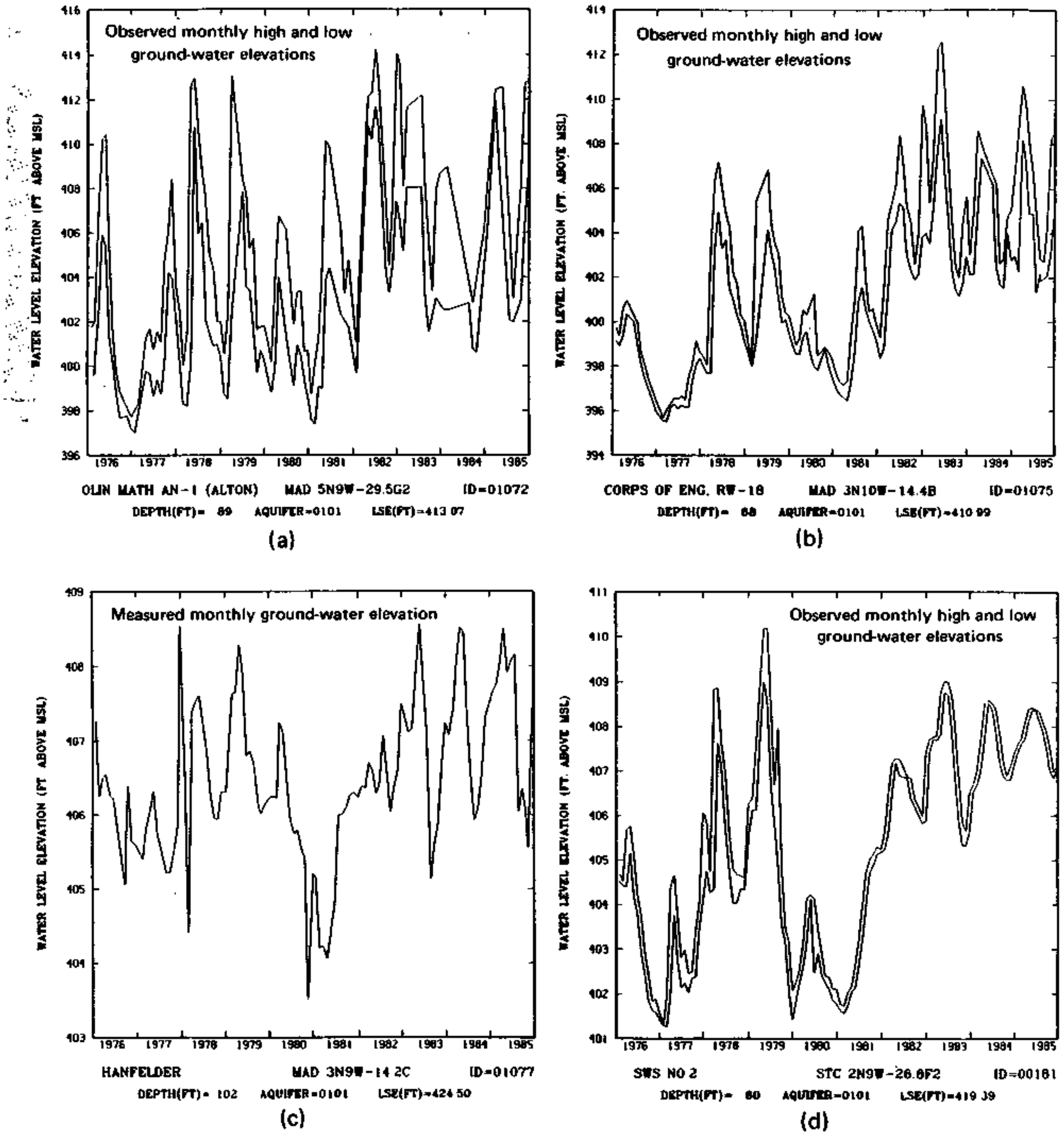

Figure 13. Hydrographs of selected wells, 1976-1985

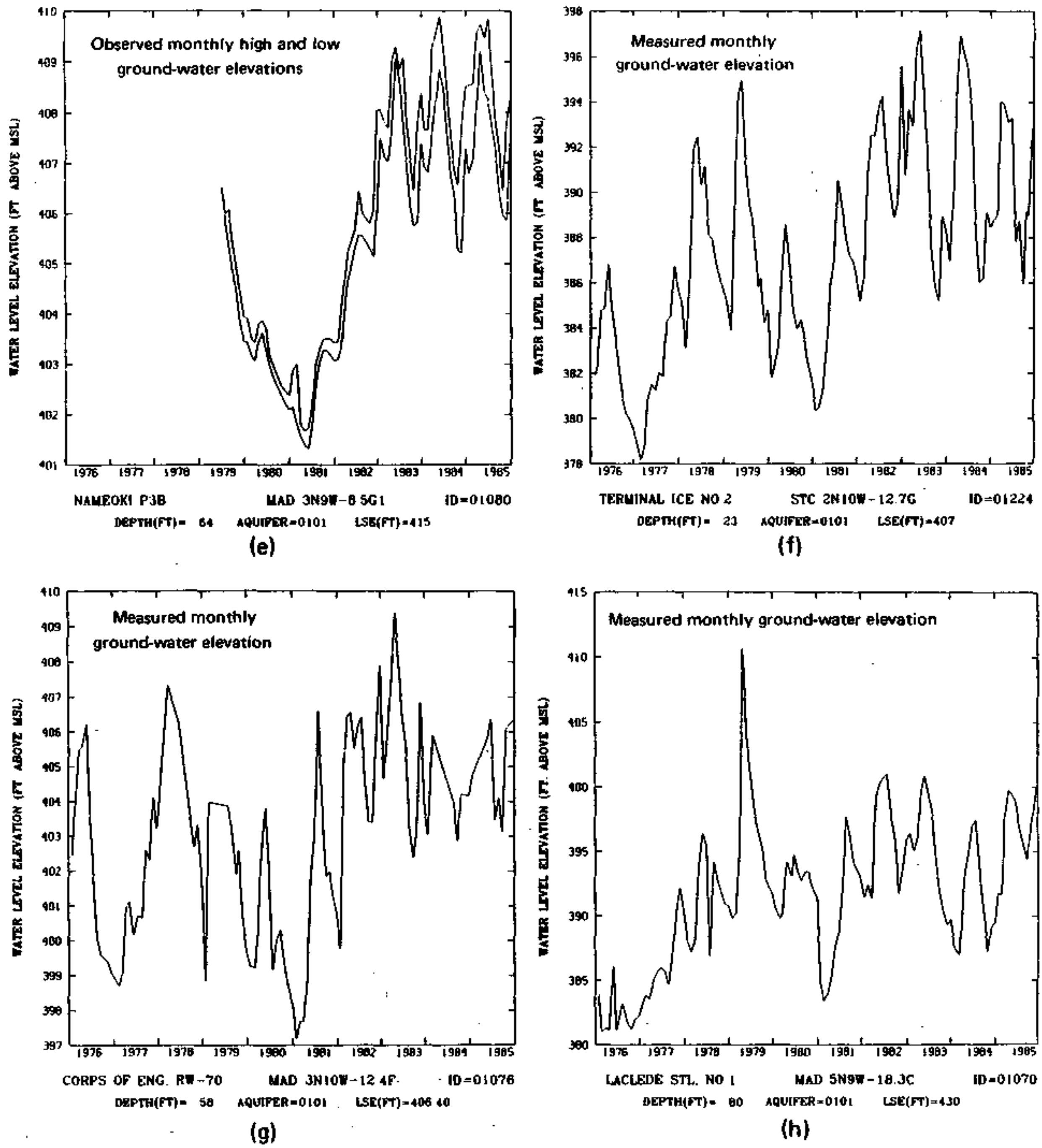

Figure 13. Concluded

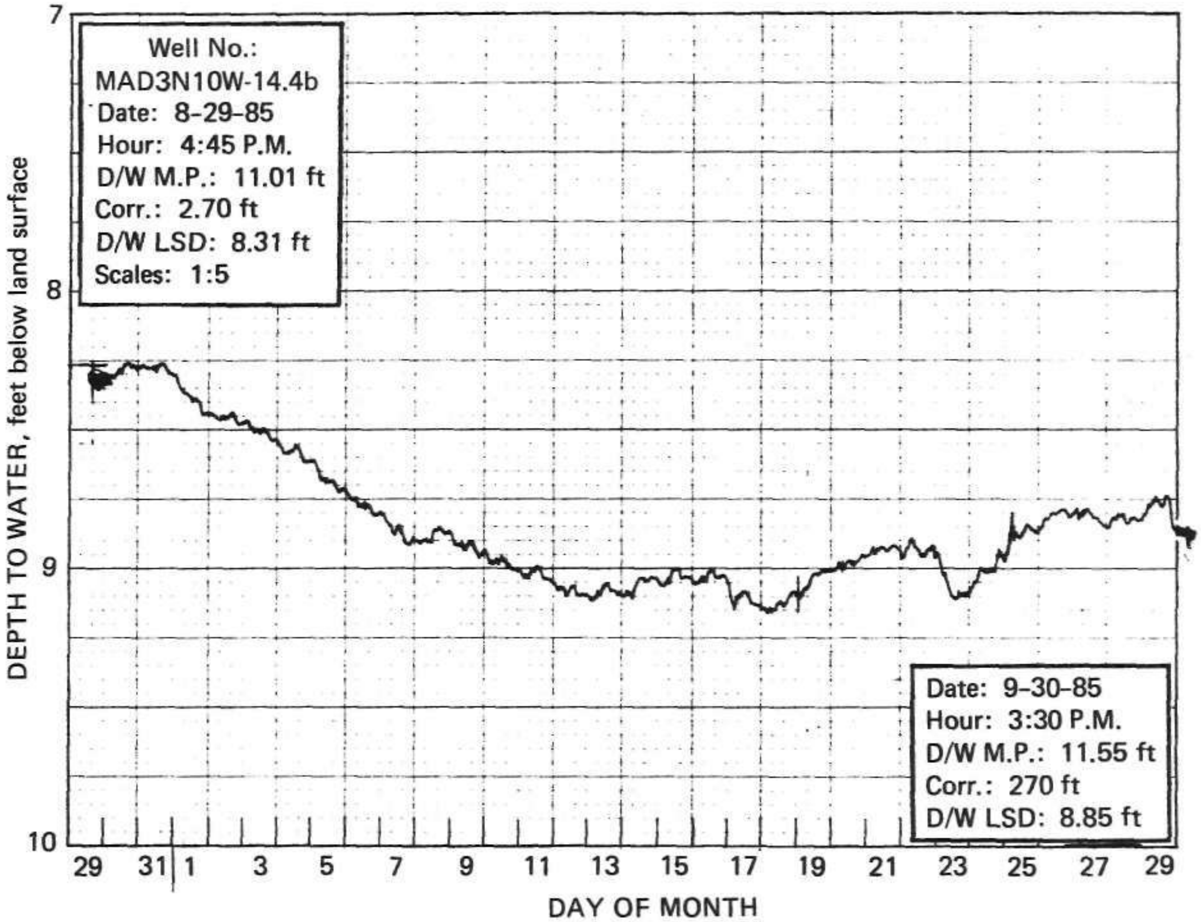

Figure 24. *Daily water fluctuations near Lock & Dam 27*

MAD3N10W-12.4f (fig. 13g), rapid and dramatic water-level changes occur because of the effect of fluctuations in the Mississippi River. Water-level trends at Well MAD5N9W-18.3c (fig. 13h) may show the effects of reduced pumpage in the Alton area.

Figure 15 shows hydrographs of selected wells for the entire period of record. Well MAD3N8W-31.1a (fig. 15a) reflects the slight downward trend of water levels in the Collinsville area as a result of the growing pumping cone. Wells MAD3N9W-16.8a (fig. 15b), MAD3N10W-12.4f (fig. 15c), and MAD5N9W-27.5al (fig. 15d) indicate the continuing rise of water levels experienced in the area since 1965 because of the overall decrease in ground-water use and shifts in the distribution of pumpage. (However, water-level trends between 1981 and 1985 appear to have been controlled by precipitation and stream levels.) After June 1957 a major ground-water user began using the Mississippi River as a water-supply source, and water levels in nearby wells recovered at a fast rate, averaging 12 feet per year through 1961. This dramatic trend is shown in the hydrograph for Well MAD3N9W-16.8a (fig. 15b).

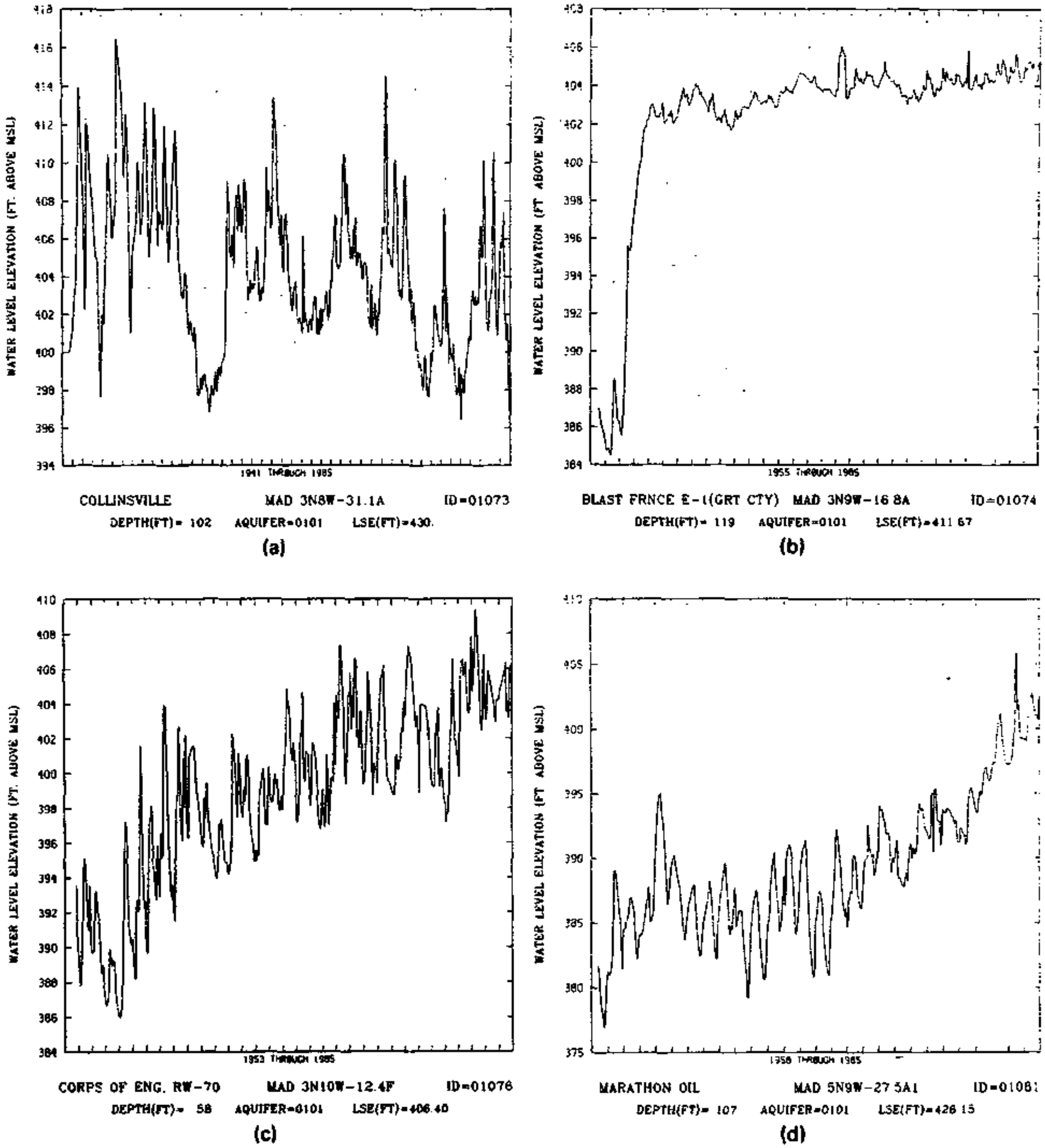

Figure 15. Hydrographs of selected wells for entire period of record

POTENTIOMETRIC SURFACE

Ground-water level measurements were made in 247 wells (figure 16) in November 1985 when ground-water levels were near minimum annual stages. Water-level data for surface water bodies in the area are given in tables 1 and 2, and water-level data for the measured wells are provided in the appendix. A potentiometric surface map for November 1985 (figure 17) was prepared from the water-level data.

Emmons (1979) compared the features of potentiometric surface maps made in November 1977 and November 1971, and found that changes could be noted in all the major pumping centers. In the Alton area, a large decrease in pumpage by one industry caused the cone of depression to move slightly to the southwest. In 1971 the Wood River area had a well-defined center of pumpage. An expansion of the pumpage center occurred by 1977 because a major industry changed the location of its ground-water source. In the Granite City area a decrease in ground-water withdrawal by one industry caused the center of pumpage to decrease in size. In the National City area the cone of depression enlarged because of increased pumpage. In the Sauget area, a conversion in water supply from ground water to surface water caused one of the two cones of depression evident in 1971 to disappear.

Between 1977 and 1980, these trends continued. At Alton, the cone of depression remained near the Mississippi River and ground-water levels seemed to be recovering near the bluff. At Wood River, the center of pumpage also shifted toward the Mississippi, and spread along the river in response to changes in the distribution of pumpage. The cones of depression at Granite City and Sauget were no longer evident because of continued reduced levels of pumping. At National City, the increase in pumpage at the highway dewatering sites was causing a decline of ground-water levels and expansion of the cone of depression in the area.

Changes in the cones of depression appeared to be more subtle between 1980 to 1985 than the changes observed in previous studies. At Alton, the cone of depression remained nearly the same. The Roxana pumping cone became more prominent, distinguishing the Roxana center from the Wood River pumping center. Previously, the Roxana center was considered part of the Wood River center; but this cannot be considered the case in the current study. The Sauget and Granite City cones of depression continue to be relatively obscure compared with past observations. In the Collinsville and National City areas, the cones of depression continue to expand in response to increased pumpage.

The general pattern of ground-water flow throughout the 1970s was slow movement toward the cones of depression or the Mississippi River and other streams. Historically, pumpage established hydraulic gradients from the Mississippi River toward all major pumping centers; this was not true in 1980. The combination of reduced pumpage at Sauget and low river stage in November 1980 created an apparent ground-water divide between the National City and Sauget pumping

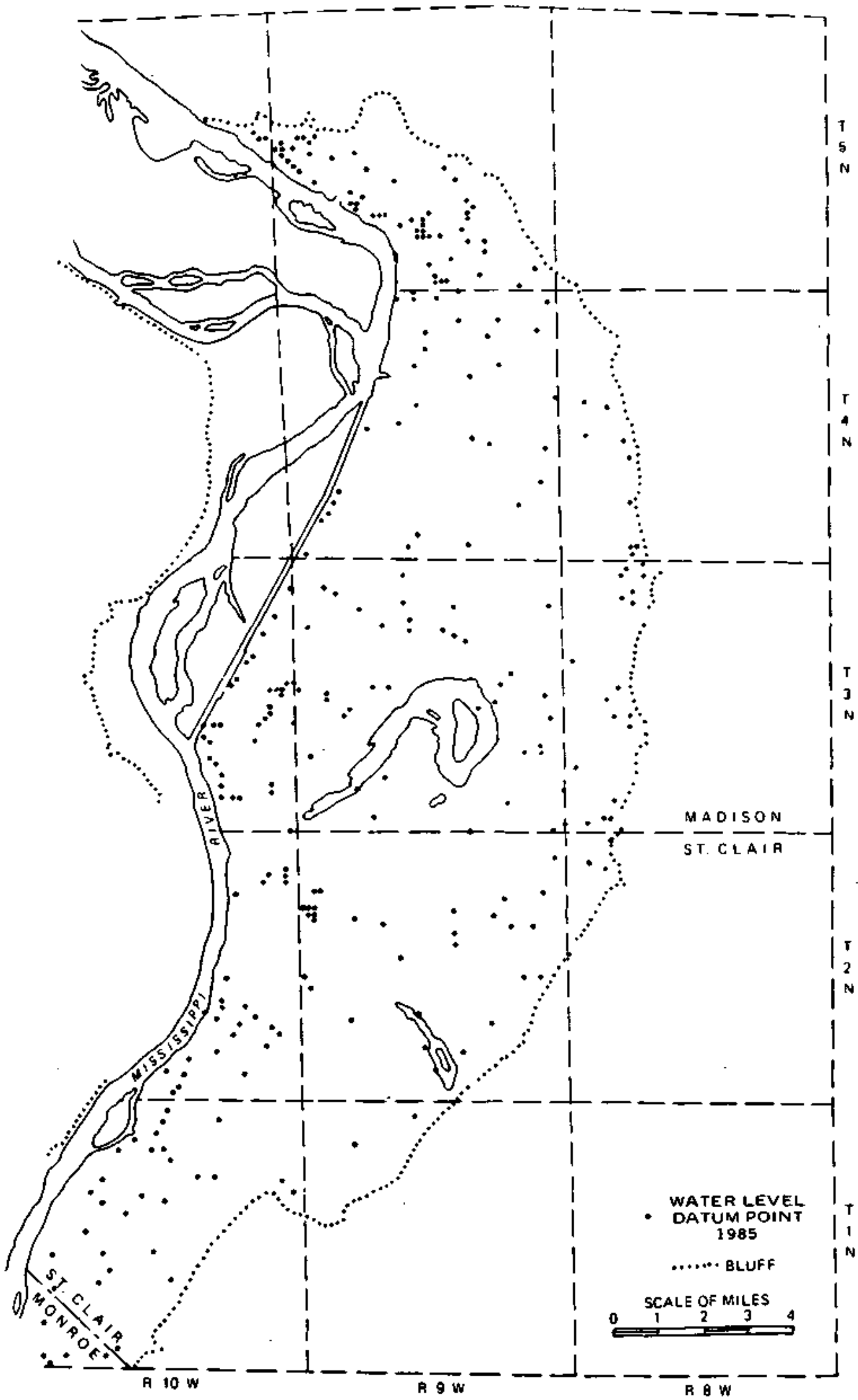

Figure 16. Location of datum points used for 1985 mass measurement

Table 1. Stream Elevations

Location of gage	Elevation of measuring point (feet above msl)	Water-surface elevation (feet above msl) Nov 1977	Nov 1985
Ill. Route 203 Bridge, NW cor,sec 5,T2N,R9W	415.30	403.01	400.27
Black Lane Bridge, Canteen Creek,near center sec 36,T3N,R9W	420.80	401.46	401.55
Sand Prairie Road Bridge, Canteen Creek,near center sec 35,T3N,R9W	418.04	400.31	401.11
Sand Prairie Road Bridge, NW cor,sec 35,T3N,R9W	418.55	399.31	400.45
Highway Bridge,1,NE cor, sec 16,T4N,R9W	444.36	414.02	414.39
Highway Bridge,2,NW cor, sec 14,T4N,R9W	440.42	413.99	414.23
Highway Bridge,3,NW cor, sec 13,T4N,R9W	441.38	414.05	414.26

Table 2. Mississippi River Stages

Gage description	Mississippi River mile number	Water-surface elevation (feet above msl) 11/15/77	11/12/80	11/11/85
Lock and Dam No. 26 Alton, IL (lower)	202.7	408.3	418.9	408.48
Hartford, IL	196.8	407.6	399.3	406.83
Chain of Rocks, MO	190.4	399.9	398.6	400.71
St. Louis, MO	179.6	396.3	383.4	394.34
Engineer Depot, MO	176.8	394.9	382.7	393.58

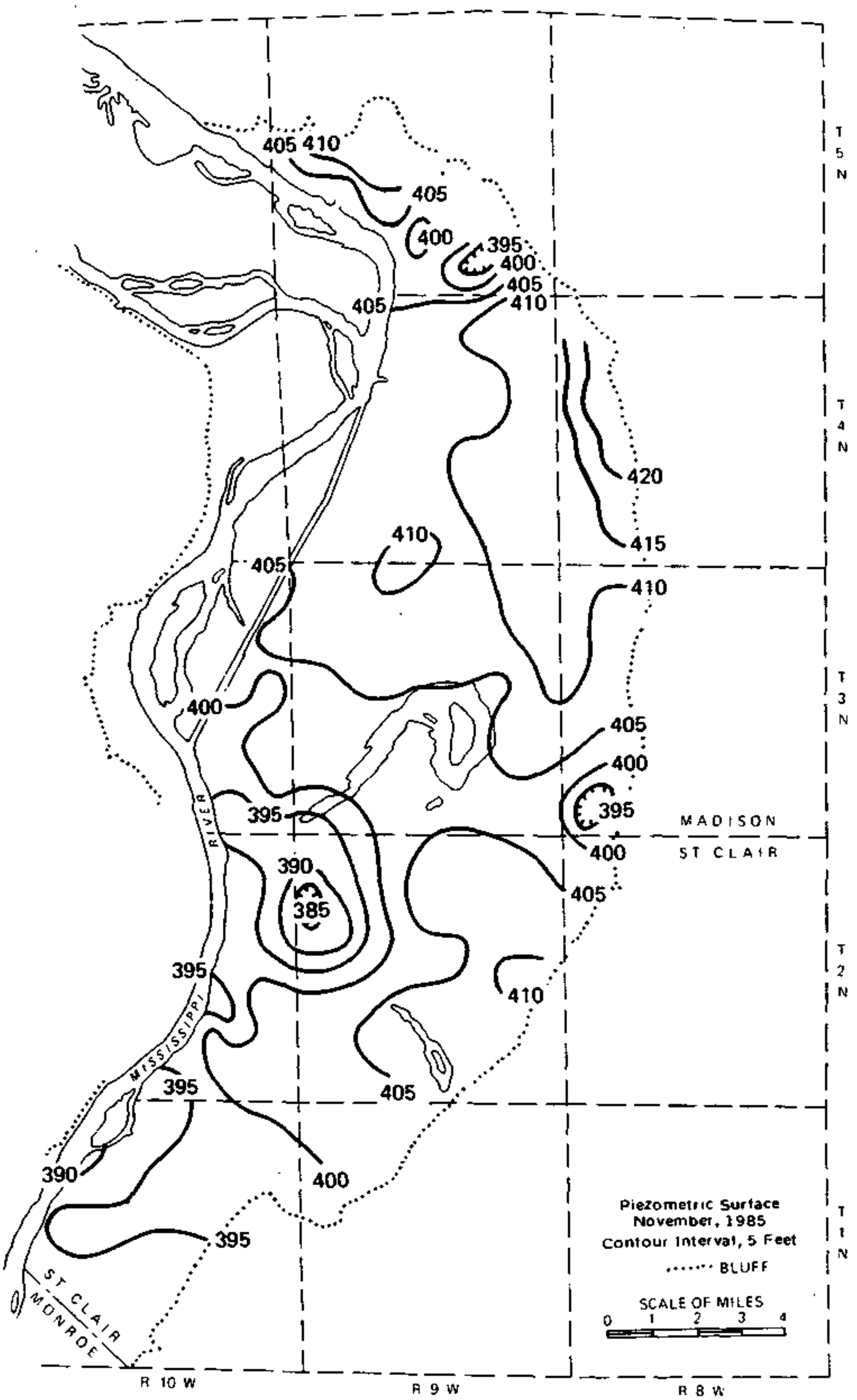

Figure 17. Approximate elevation of potentiometric surface, November 1985

centers and the Mississippi River. In 1985, the high river stages and increased pumpage eliminated that ground-water divide. Therefore all major pumping centers are inducing infiltration of river water into the ground-water system.

The average slope of the potentiometric surface away from the cones of depression was 5 feet per mile in 1971, 4 feet per mile in 1977, 3 feet per mile in 1980, and 3.5 feet per mile in 1985. In the Wood River/Roxana cone of depression, the gradient averaged. 15 feet per mile in 1971 and 1977, reduced to 10 feet per mile in 1980, and again returned to 15 feet per mile in 1985. In the Alton area, the average slope of the potentiometric surface was 15 feet per mile in 1971, 10 feet per mile in 1977, 20 feet per mile in 1980, and 10 feet per mile in 1985. The gradient averaged 10 feet per mile in National City in 1971, 1977, 1980, and 1985.. In the Granite City area, the gradient of the cone of depression averaged 10 feet per mile in 1971 and 1977, but decreased to 5 feet per mile in 1980 and 1985.

Changes in Ground-Water Levels

Ground-water-level changes were computed from a comparison of potentiometric surface maps for November 1980 and November 1985, and a map was then prepared to illustrate estimated changes in water levels (figure 18). Dramatic changes in water levels occurred in the Sauget, Wood River, and Alton pumping centers during the period from 1971 to 1977. Emmons (1979) attributed these changes to shifts in pumpage distribution or to reduction of pumpage. From 1977-1980, ground-water levels outside pumping centers showed little change. Near pumping centers, trends established between 1971 and 1977 continued.

Definite changes in water levels occurred between 1980 and 1985. The major change was an increase in ground-water levels throughout the area. These water-level changes could not be attributed to pumpage changes, except in localized areas. Above-normal precipitation and stream levels most likely were the major causes of the elevated ground-water levels. A consistent increase in water levels in areas near the Mississippi River can be seen in figure 18. This increase is caused by the elevated river levels. In the northern portion, in the Alton, Wood River, and Roxana areas, increases in water levels may have been augmented by the continuing decreases in pumpage in those areas. In the Granite City area, ground-water levels generally rose even with increased pumpage. Increased pumpage in the National City area has attenuated the area-wide increase of ground-water levels near the river. The only distinguishable decline in ground-water levels was seen in the Collinsville area, where increased pumpage continues to further diminish water levels. Because the Collinsville pumping center is not near the Mississippi River's immediate influence, water levels are more responsive to changes in pumping than at pumping centers closer to the river.

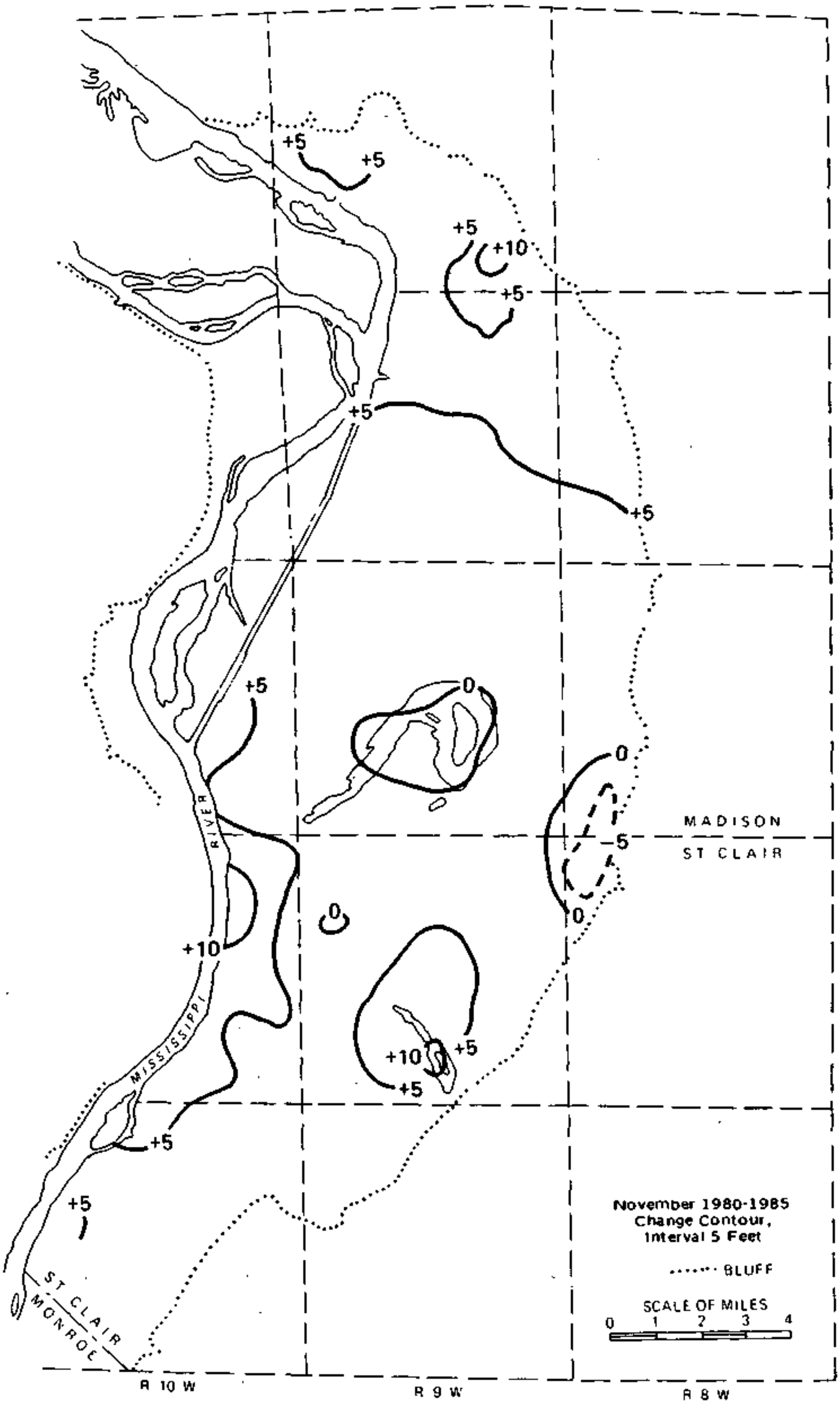

Figure 18. Changes in potentiometric surface from November 1980 to November 1985

Areas of Diversion

Pumping-center areas of diversion in November 1980 and November 1985 are listed in table 3 and shown in figure 19. The boundaries of areas of diversion represent approximate locations of ground-water divides. The intersection of two or more ground-water divides represents a stagnation point, or a point of zero velocity. In figure 19, however, this interpretation should not be applied. In this figure, intersections are drawn merely for convenience; they represent, at best, regions of low velocity and extreme complexity in flow patterns.

Within the boundaries of an area of diversion of a pumping center, ground water will flow toward that pumping center. Change in the size of an area of diversion reflects a change in pumpage or geohydrologic boundaries. Table 3 indicates the changes in diversion areas of major and minor pumping centers from 1980 to 1985. The Alton pumping center appears to have increased slightly, which does not follow the decrease in pumping seen in that area. It appears that a major decrease in the Wood River pumping center exists. However, the distinction of another diversion area, Roxana (which was previously included in the Wood River center) was discernible in this study. Both the Granite City and National City centers decreased significantly in area. Although pumpage has increased in these areas, increasing water leve.ls may have had the effect of reducing the areas of diversion. Minimal change occurred at Sauget. The Poag center doubled in area because of the continued increase in pumpage. During the last investigation the Collinsville, Troy, and Glen Carbon pumping centers created three separate diversion areas. The current study indicates the Troy and Collinsville centers merging as one diversion area while the Glen Carbon center still has a separate diversion area. The Collinsville center continues to expand in response to increased pumpage.

Table 3. Areas of Diversion

Pumping center	Diversion area (square miles) 1980	1985
Alton	2.9	3.9
Wood River	15.7	8.6
Roxana	-	5.7
Granite City	20.9	6.5
National City	51.5	37.3
Sauget	1.5	2.7
Poag	4.6	11.1
Collinsville	7.4	11.8
Troy	3.8	
Glen Carbon	2.9	6.0

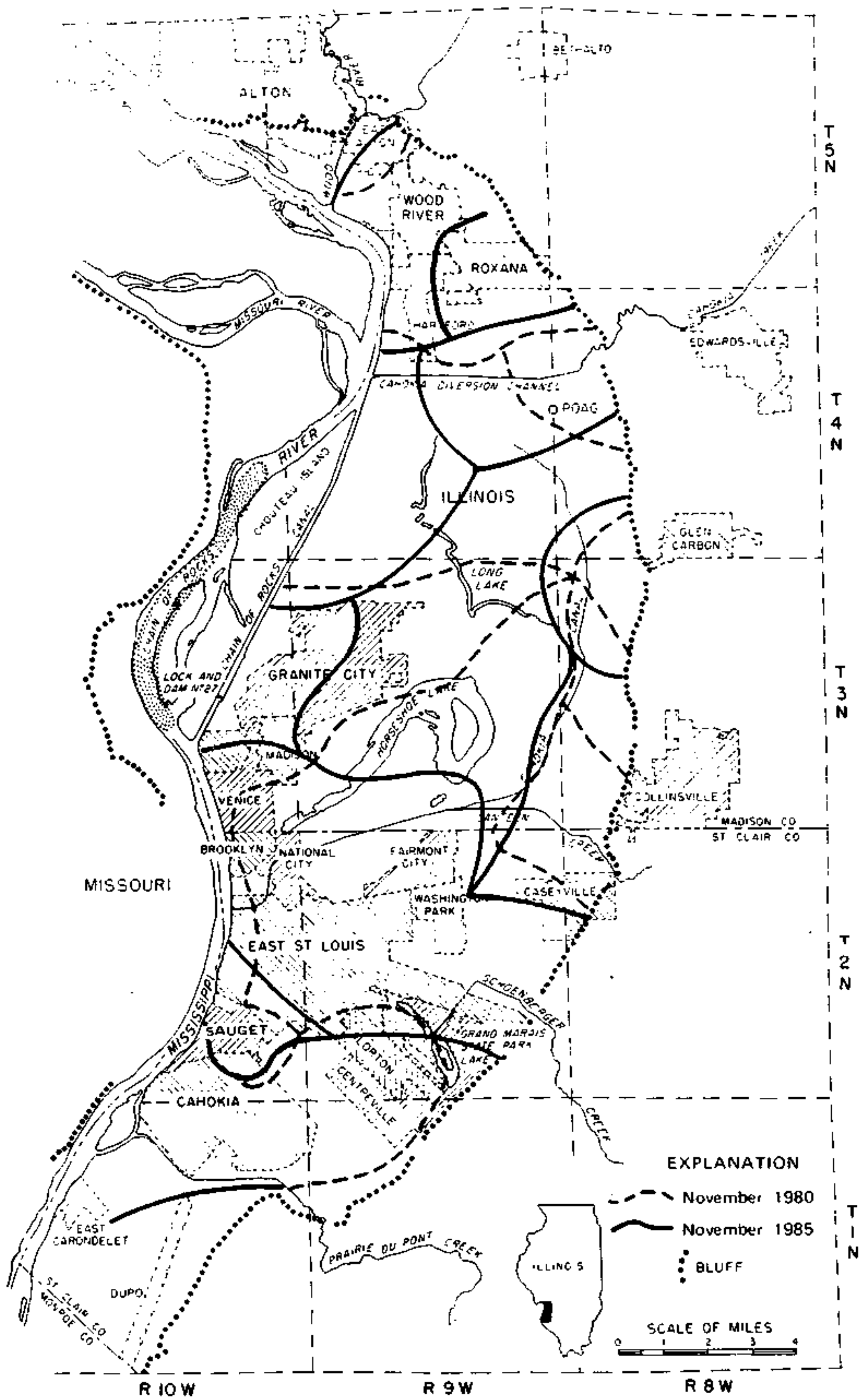

Figure 19. Approximate areas of diversion in November 1980 and November 1985

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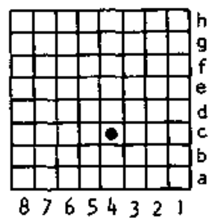
APPENDIX

The well-numbering system used in this report is based on the location of the well, and uses the township, range, and section for identification. The well number consists of five parts: county abbreviation, township, range, section, and coordinate within the section. Sections are divided into rows of 1/8-mile squares. Each 1/8-mile square contains 10 acres and corresponds to a quarter of a quarter of a quarter section. A normal section of 1 square mile contains 8 rows of 1/8-mile squares; an odd-sized section contains more or fewer rows. Rows are numbered from east to west and lettered from south to north as shown in the diagram.

St. Clair County
T2N, R10W
sec. 23



The number of the well shown above is STC 2N10W-23.4c. Where there is more than one well in a 10-acre square they are identified by arabic numbers after the lower-case letter in the well number. Any number assigned to the well by the owner is shown in parentheses after the location well number. The abbreviations for counties discussed in this report are:

Madison	MAD	Monroe	MON	St. Clair	STC

There are parts of the East St. Louis area where section lines have not been surveyed. For convenience in locating observation wells, normal section lines were assumed to exist in areas not surveyed.

Water Level Data for Wells

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 5N10W-				
13.1a	402.58	399.89	407.10	+7.21
13.1b		397.72	401.25	+ 3.53
13.2a		399.06	407.09	+ 8.03
13.4cl				
13.4c3	393.63	392.03	402.03	+10.00
13.4c7		390.78	401.18	+10.40
13.5c	405.84	400.06	408.84	+8.78
13.6d		400.81	410.50	+ 9.69
24.1h	408.29	399.00	407.50	+8.50
MAD 5N9W-				
18.3c	388.68	393.51	391.88	- 1.63
18.4b				
18.5cl		393.30	406.16	+12.86
18.5c2		394.02	390.50	- 3.52
18.5c		397.30		
18.6c	387.38	390.30	394.17	+ 3.87
18.7a			385.35	
19.3c	406.89	401.02	409.50	+8.48
19.4h	395.19	396.33	399.61	+ 3.28
19.6e	405.32	402.86	407.59	+4.73
19.7f	405.06	400.12	407.95	+ 7.83
19.8g	405.05	399.59	408.10	+8.51
20.2e	398.60			
20.4hl		402.0	404.31	+ 2.31
20.4h2		404.0	403.98	- 0.02
20.4h3	398.16	399.0	404.41	+ 5.41
20.5a				
20.8g2				
21.5c	404.11	404.88	411.30	+6.42
22.2c2	388.86			
22.2c3	389.80			
22.2c6	381.22	391.46	400.34	+ 8.88
22.2c7	391.87	392.13	404.78	+12.65
22.2c8		392.38	404.78	+12.40
22.2c9		391.52	404.80	+13.28
22.2cl0		392.60	399.20	+6.60
22.4e	401.66			
26.7f		396.12	405.89	+9.77
26.8d	387.31	393.84		
26.8d		396.21	404.38	+ 8.17
26.8e	388.39			

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 5N9W-(Cont.)				
26.8gl	394.03	398.61	408.18	+ 9.57
26.8g2		397.25	405.94	+8.69
27.1bl				
27.1b4	388.80			
27.5al	389.44	390.42	400.85	+10.43
27.5a2	389.88	391.23	400.68	+ 9.45
27.7a		387.43	395.35	+ 7.92
27.7e	386.03	388.95	395.64	+ 6.69
27.7e2	391.70	395.14	402.68	+7.54
27.7e3	391.86	393.11	402.91	+ 9.80
27.8al	387.77	387.91	396.38	+ 8.47
27.8a2	387.77		396.53	
27.8bl	387.14	390.06	397.38	+ 7.32
27.8b2		399.08	411.62	+12.54
27.8b3	388.60	383.58		
27.8c		384.46	398.64	+14.18
27.8dl				
27.8d2	390.96			
28.1al		390.27	398.96	+ 8.69
28.1a2			398.37	
28.1bl	389.20	386.94		
28.1b2		394.06	399.50	+ 5.44
28.2d	387.86			
28.4c		396.96	407.75	+10.79
28.7el	394.60	398.75	409.97	+11.22
28.8e		394.84	404.66	+ 9.82
28.8el		393.45	402.46	+ 9.01
28.8e2		395.14		
28.8e5	400.64			
29.1e		397.68	405.15	+ 7.47
29.3hl				
29.3h2		398.91		
29.3h3		399.44	403.87	+ 4.43
29.4f		399.58		
29.4g	407.27	404.22	405.66	+ 1.44
29.5g		403.57	409.53	+ 5.96
29.5g		399.14		
33.5el	400.44	393.0	400.76	+ 7.76
33.5e2	400.89			
33.5f	409.50	394.0		
34.3el	392.38			
34.3e2		393.71		
34.4a	394.71			

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 5N9W-(Cont.)				
34.5al	393.62			
34.6al	407.76	395.37		
34.6a2	393.59	395.50		
34.6b				
34.7dl	394.54	394.79	402.86	+ 8.07
34.7d2	393.74		401.35	
35.5f	384.94		390.40	
35.5h	388.38	390.0	390.36	+ 0.36
35.6b	396.0	396.0		
35.8hl	390.17	392.84	402.65	+ 9.81
35.8h3		393.08		
36.4c	408.73	409.77		
MAD 4N9W-				
1.2e		410.26	417.87	+ 7.61
1.7h	404.09	404.50		
2.3b	407.0	409.31	413.09	+3.78
3.2b		402.00	410.03	+8.03
3.2g			402.11	
3.6f	397.79	398.21		
4.2g3	405.80	396.07		
4.2g4		396.31	403.04	+6.73,
4.2g5	407.05	403.14		
4.2f	400.05	397.99	404.58	+6.59
4.5f	406.42	396.19		
9.2b	405.30	400.87		
10.8e	402.70	402.30		
10.8h	405.18	402.82	408.06	+5.24
11.3bl		404.83		
11.3b2		405.30	410.36	+5.06
11.3b3		405.13		
11.5g		406.40		
12.4h2		410.45		
12.4hl		408.21	413.90	+ 5.69
13.1d5	409.50	407.49	413.17	+ 5.68
13.1d7	409.15	407.17	415.37	+8.20
13.1d8			414.96	
14.8h		401.76	405.90	+4.14
16.2cl	407.03		408.23	
16.2c2	404.13	400.16	407.11	+6.95
20.3g	406.82	401.90	406.61	+4.71
21.5h	411.59	410.73		
23.5d	407.87	406.07	411.01	+ 4.94

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 4N9W-(Cont.)				
23.5f	402.85			
23.8e	404.22			
24.3c	404.37			
25.4e	409.06	406.76	412.48	+ 5.72
25.8a	409.90	408.16		
29.8d	404.93	400.99	405.52	+4.53
30.1b	404.75	400.93	405.53	+ 4.60
31.2h	404.61	400.91	405.40	+4.49
31.3g	403.56	399.08	405.43	+ 6.35
31.6a	403.97	400.78	405.33	+ 4.55
33.2d		406.93	410.38	+ 3.45
33.4b		407.80	410.79	+ 2.99
34.1b	407.87	406.60		
MAD 4N8W-				
17.8bl			425.57	
17.8b2	420.54	412.60	421.13	+8.53
18.4c	412.10	411.20	416.36	+ 5.16
19.4e	407.87			
20.4a	417.90	413.70	424.99	+11.29
20.5d	412.95		419.41	
29.4a	414.39	412.35	416.32	+ 3.97
32.3a	412.64	412.83	421.21	+ 8.38
32.4a	411.76	413.03		
MAD 3N10W-				
1.1c	403.39	400.92	404.90	+3.98
12.4f	403.05	400.77	404.56	+ 3.79
12.6c	402.05	400.62	404.43	+ 3.81
13.1b3			402.13	
13.1b4		395.88		
13.2b	395.41			
13.3a	395.37	398.42		
13.4a		393.94	396.61	+ 2.67
13.5a	394.52			
13.8g		399.63	407.98	+ 8.35
13.8gl	409.43	409.55	414.21	+ 4.66
14.1f	399.09	399.53	403.33	+ 3.80
14.3c	403.25	398.84	402.61	+ 3.77
14.4b	399.85	398.34	401.35	+ 3.01
22.1a	398.85	392.02	398.19	+ 6.17
22.1c	398.17		402.57	
23.6c	396.62	395.80	399.87	+ 4.07

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 3N10W-(Cont.)				
23.7c	398.34	392.90	398.05	+ 5.15
24.1cl	399.37	391.60		
24.3h2	389.11	397.40	401.07	+ 3.67
24.5e			396.47	
24.5f	385.16	393.50	397.01	+ 3.51
24.6d	391.60	397.44	401.41	+ 3.97
24.7c	390.02	395.05	399.05	+4.00
25.8h	391.89	390.27	401.10	+10.83
26.6b	396.34	393.88	397.14	+ 3.26
26.7d				
26.8e	397.02	393.53	398.75	+ 5.22
26.8h	398.92	392.72	397.72	+ 5.00
35.3f			394.46	
35.4f			394.03	
35.6f	396.63	390.47	394.48	+ 4.01
35.6h	396.31	392.50	396.87	+4.37
36.5g2	398.17	397.49	401.10	+ 3.61
36.5h			400.39	
MAD 3N9W-				
3.1a	407.76	405.29	408.40	+3.11
4.5e	406.44	406.66		
6.1b	403.84	405.22	409.06	+3.84
6.3c	403.47	401.77	405.93	+4.16
7.6d	402.23	398.55	407.07	+ 8.52
8.1d	405.80	405.47	408.52	+3.05
8.5g		408.45	409.92	+ 1.47
9.4c		400.38		
9.4e				
9.5h	404.10			
10.2a		405.82	407.62	+ 1.80
10.4b	406.17	405.25	406.01	+ 0.76
10.4gl	410.60			
10.4g2	406.40	406.47	408.72	+ 2.25
10.6c	409.60			
12.3g	414.60	409.72	413.42	+ 3.70
14.2c	404.18	402.01	406.05	+ 4.04
14.4a	404.33	404.55	405.04	+0.49
16.8a		403.48	405.19	+ 1.71
17.3a	404.95	404.90	406.48	+ 1.58
18.8al	394.10	DRY	402.60	
18.8a2		399.00	402.59	+3.59
19.3gl	399.37	400.30	400.18	- 0.12

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
MAD 3N9W-(Cont.)				
19.3h	398.92	400.46	403.84	+ 3.38
20.7e2			404.17	
20.8d2			402.88	
20.8d3			402.45	
20.8d4			400.54	
23.5f	402.85	402.48	403.04	+0.56
23.8e	404.43	406.43	404.54	- 1.89
24.3c	404.37			
24.4g	409.65	409.32	410.44	+ 1.12
25.5e		402.44		
25.5f	403.36	403.45	403.86	+ 0.41
25.8e	404.50		406.30	
29.1a	398.82		400.23	
30.6e	402.47	398.19		
32.3b				
32.6g	397.45	398.11	400.40	+ 2.29
35.3d	401.95	403.50	403.54	+0.04
36.1f	402.57			
MAD 3N8W-				
5.2d	409.04	409.41		
5.2f2				
5.2f3		409.97		
5.4al	406.07			
5.4a3		406.26		
5.4h			413.23	
5.5e	410.25	409.63	409.99	+0.36
5.6dl			410.43	
5.6d2			411.06	
8.4g	405:35	404.90		
8.6h	410.78	410.88	408.00	- 2.88
18.7e	408.13	407.99		
19.1f	407.54		408.65	
20.5al	398.66	401.02	403.04	+ 2.02
20.5a2		399.98	401.94	+1.96
20.5a3		402.23	403.88	+1.65
20.5c	402.00	403.50		
20.7h	403.12	404.02		
20.8c	405.24	405.54	406.64	+1.10
30.7b	402.64	402.57	403.83	+1.26
31.1a		394.21	390.25	- 3.96
31.2a	396.40	395.86	390.44	- 5.42
32.8d	400.36	400.22		

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
STC 2N10W-				
1.2h	386.44	385.64	389.94	+4.30
1.3al	385.79	383.36	392.19	+8.83
11.4e		382.70		
12.3g	390.29	387.45		
12.3hl		384.20	392.87	+8.67
12.3h2			390.88	
12.7g2	394.19	390.64	396.96	+6.32
12.6hl	395.81		395.69	
12.6h2		387.00	396.02	+ 9.02
23.3a3	402.40	399.32	401,46	+ 2.14
23.6f	394.19	386.80	396.32	+ 9.52
23.7a	392.07	388.70	392.72	+ 4.02
23.7b	394.24		393.30	
25.5d	395.83	396.24	400.57	+ 4.33
25.6e		392.64		
25.7b	394.66	395.79		
26.1gl	392.28			
26.4f	386.56			
26.5d2	392.46			
26.5d3	392.55	397.68	394.92	- 2.76
26.8a3	390.54	397.88	403.68	+ 5.80
26.8g		388.73		
27.2hl	395.49			
33.1f	388.64	388.58	395.17	+ 6.59
34.5h	392.16	388.45	394.30	+ 5.85
34.6e			393.62	
34.7c	391.92	389.34	394.09	+ 4.75
34.8b	391.20	390.02	394.74	+ 4.72
35.3e		396.40		
STC 2N9W-				
1.1h			401.56	
1.3b	400.96	403.43	403.80	+ 0.37
1.3g	404.78	401.86	402.36	+ 0.50
3.2g	402.78	403.93		
7.5el	383.26	383.85	388.56	+ 4.71
7.5e2		384.10	389.02	+ 4.92
7.6a2			382.90	
7.6a3			385.50	
7.6a4			385.40	
7.6b2			380.43	
7.6el	383.77			

Water Level Data for Wells (Continued)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
STC 2N9W-(Cont.)				
7.6e3		386.52	388.91	+ 2.39
7.7a2			383.50	
7.7bl			381.21	
7.7b3			378.77	
7.7b4			382.25	
7.7b5			380.86	
7.7b6			379.63	
7.8b2			380.96	
7.8b3			381.87	
10.5a	406.54	406.0	410.20	+4.20
11.4c	399.74	401.57		
12.5d	405.12	404.73	408.57	+3.84
13.7f	404.60	403.27	408.14	+4.87
14.3f			405.47	
14.6h	400.96			
15.5c	397.85	396.52	402.10	+5.58
15.5e		403.52	408.63	+5.11
16.7a	392.72	395.12		
17.2g	391.45	395.54	397.63	+ 2.09
17.7hl			386.69	
17.7h2			389.39	
18.6hl			386.40	
18.6h2			385.30	
18.6h3			386.96	
18.6h4			387.10	
19.7d	391.46	396.25	400.53	+ 4.28
19.8fl	395.00	390.06		
19.8f2		391.30	396.28	+ 4.98
23.1e	408.18	406.70	410.88	+ 4.18
24.6e	408.02	406.10	410.42	+4.32
26.7e	407.23	405.55	408.69	+3.14
28.3a	399.73			
28.4g			408.91	
29.8f	398.84	400.65	405.01	+ 4.36
33.1e		395.53		
34.4h	405.40	404.68	407.57	+ 2.89
STC 2N8W-				
6.1e	398.67	399.27	399.76	+ 0.49
6.5a		409.80	401.33	- 8.47
6.5h	403.09			
7.2h3	401.70			

Water Level Data for Wells (Concluded)

Well number	Water-level elevation (feet above msl) Nov 1977	Nov 1980	Nov 1985	Water-level change (feet) Nov 1980 to Nov 1985
STC 1N10W-				
2.8e	404.84			
4.1g	391.80	388.41	393.90	+ 5.49
4.2e	391.58	388.48	393.36	+ 4.88
4.3c	391.44	385.78		
4.7b	390.25	381.34	390.81	+ 9.47
8.2h	388.82	387.68	390.33	+ 2.65
8.5c	388.65	389.22	390.84	+ 1.62
8.7a	388.70	388.02	390.36	+ 2.34
9.1f	393.14	390.41	395.21	+ 4.80
9.2h	393.01	391.47	395.36	+ 3.89
9.4h	391.22		392.92	
10.1c	395.64	394.47		
10.4c	394.00	394.67		
12.5b	396.76	396.02	398.61	+ 2.59
13.3h	396.73	398.01	397.74	- 0.27
16.2g	394.62	394.05	397.63	+ 3.58
16.6h			395.60	
17.1e	391.98	392.35		
17.5g		390.20		
17.8b	396.25	393.74	399.64	+ 5.90
19.6f	387.09		390.40	
20.4c			390.91	
20.5f	391.11	394.15		
20.6a		392.08		
21.1a	389.20			
21.4f	388.73	391.19	392.72	+ 1.53
30.6h	386.95	386.38	390.50	+ 4.12
32.3e			395.30	
STC 1N9W-				
4.5e	401.20	400.86		
8.8h	398.67	398.44	401.28	+ 2.88
MON 1N10W-				
30.8b	386.58	382.62	391.51	+ 8.89
31.4d	DRY		393.28	
31.7c	387.40	388.32		
31.8d			397.04	
32.5d	386.68	388.42	393.24	+ 4.82