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Illinois State Water Survey Division

GROUND-WATER SECTION

SWS Contract Report 456

SUMMARY REPORT:

REGIONAL ASSESSMENT OF THE GROUND-WATER RESOURCES IN EASTERN KANKAKEE AND NORTHERN IROQUOIS COUNTIES

by Stuart J. Cravens, Steven D. Wilson, and Robert C. Barry

Prepared for the
Illinois Department of Energy and Natural Resources
and the Illinois Department of Transportation,
Division of Water Resources

Champaign, Illinois

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ENR Illinois Department of Energy and Natural Resources

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This report summarizes some of the information to be provided in an upcoming Illinois State Water Survey Report of Investigation on the ground-water resources in eastern Kankakee and northern Iroquois counties. This summary is provided as an aid to the planning and development of ground-water resources in this region of Illinois.

INTRODUCTION

The ground-water resources in eastern Kankakee and northern Iroquois Counties, Illinois, have been extensively used for irrigation. Irrigation in this part of Illinois has a long history, with the first development reported as early as 1926 and with 100 irrigation systems in place by 1950. Irrigation development is continuing, as nine new irrigation wells were drilled in this area in 1988.

As irrigation activity increases, conflicts with other ground-water users, especially those with domestic and livestock wells, will inevitably occur. Reports of ground-water supply interruptions began surfacing in the early 1980s. These temporary interruptions, lasting for periods of hours to months, have resulted in well owners having to lower pump intakes, deepen their wells, or find an alternate source of supply.

In addition to domestic supply interruptions in Illinois, the Kankakee-Iroquois area lies adjacent to Jasper and Newton Counties in Indiana. An intensive irrigation project in the dolomite aquifer in these two counties affected nearly 130 domestic wells on nearby properties between 1981 and 1984. These problems resulted in litigation and legislation protecting Indiana owners of small wells.

In response to continued irrigation development in Illinois, and in recognition of the fact that the problems in the Kankakee-Iroquois area have interstate implications, the Illinois State Water Survey and the Illinois State Geological Survey began a two-year study of the ground-water resources in this area in 1986. Funding for the Water Survey was provided by the Illinois Department of Energy and Natural Resources (ENR) and the Division of Water Resources of the Illinois Department of Transportation. Funding for the Geological Survey was provided by ENR.

The objectives of the study were to build a base of reliable hydrogeologic data and to develop a solid conceptual understanding of the ground-water system. The domestic supply interruption problems and other resource management questions were addressed as by-products of this study.

Geography and Climate

The study area comprises 414 square miles of eastern Kankakee and northern Iroquois Counties, located in the southern part of northeastern Illinois and adjacent to the Illinois-Indiana state line (figure 1). Greatest emphasis in this study was given to the area south of the Kankakee River and east of the Iroquois River.

Agriculture is the predominant land use in the study area. The lands not under cultivation are primarily urban or forested. Forest covers much of the east-central part of the area, adjacent to the state line. This forested tract is characterized by extensive windblown dune deposits with local relief of up to 50 feet.

The population in the 414 square miles encompassing the study area (as estimated from 1987 projections based on 1980 population census data published by the U.S. Department of Commerce) is about 28,460. An estimated 21,480 people, or 75 percent of the total population, live in rural areas outside incorporated municipalities.

The study area is classified as within the humid climate zone of the United States. The mean annual precipitation in eastern Kankakee and northern Iroquois Counties, as measured for the period 1967-1987 at the Kankakee station by the National Weather Service, is 37.75 inches. Figure 2 shows the mean monthly precipitation at the Kankakee station for this period, along with the monthly precipitation for 1987 and most of 1988. The mean summer precipitation for the months of June through August is 12.00 inches, or about 32 percent of the mean yearly precipitation. In 1987, summer rainfall accounted for 11.21 inches of the 35.15 inches received during the entire year. Summer rainfall during the record drought year of 1988 amounted to only 5.24 inches.

Geology

The principal bedrock aquifer underlying the unconsolidated deposits of the study area is fractured dolomite of Silurian age. Dolomite of Middle Devonian age appears near the southern edge of the study area. Unconsolidated deposits overlying the dolomite are composed of a complex sequence of clay, silt, and sand deposited by successive glacial advances and retreats. The dominant soil parent material, and the primary material on which irrigation development has occurred, is composed of thick, sandy, Wisconsinan outwash and Aeolian deposits. Approximately 43 percent of the study area is mantled by these deposits.

Hydrology of the Silurian Dolomite Aquifer

Movement of ground-water within the Silurian dolomite may be significantly affected by fractures. Flow occurs primarily through horizontal separations in the form of bedding planes, and through vertical joints. These openings occur predominantly in the upper 100 feet of the bedrock. Although the openings are a major factor in water flow within the dolomite, several aquifer tests show that over long time periods and large distances, the response of the aquifer to pumpage is uniform in all directions, or isotropic.

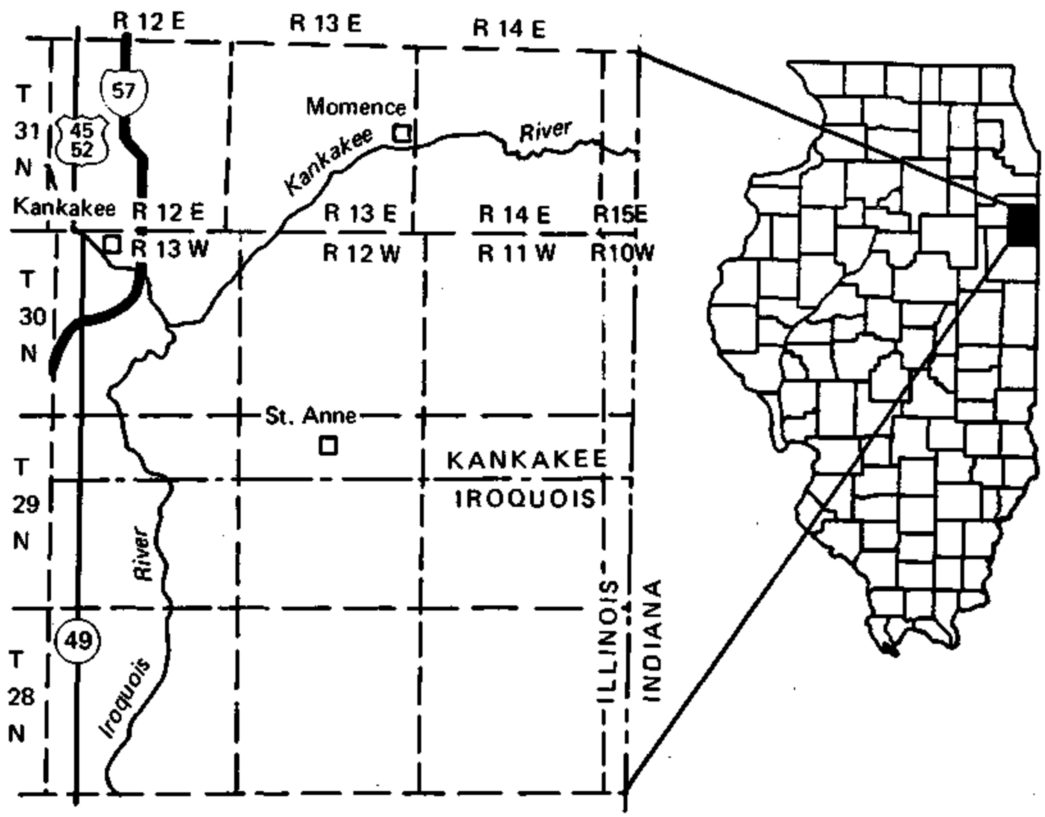

Figure 1. Location of the ground-water study area

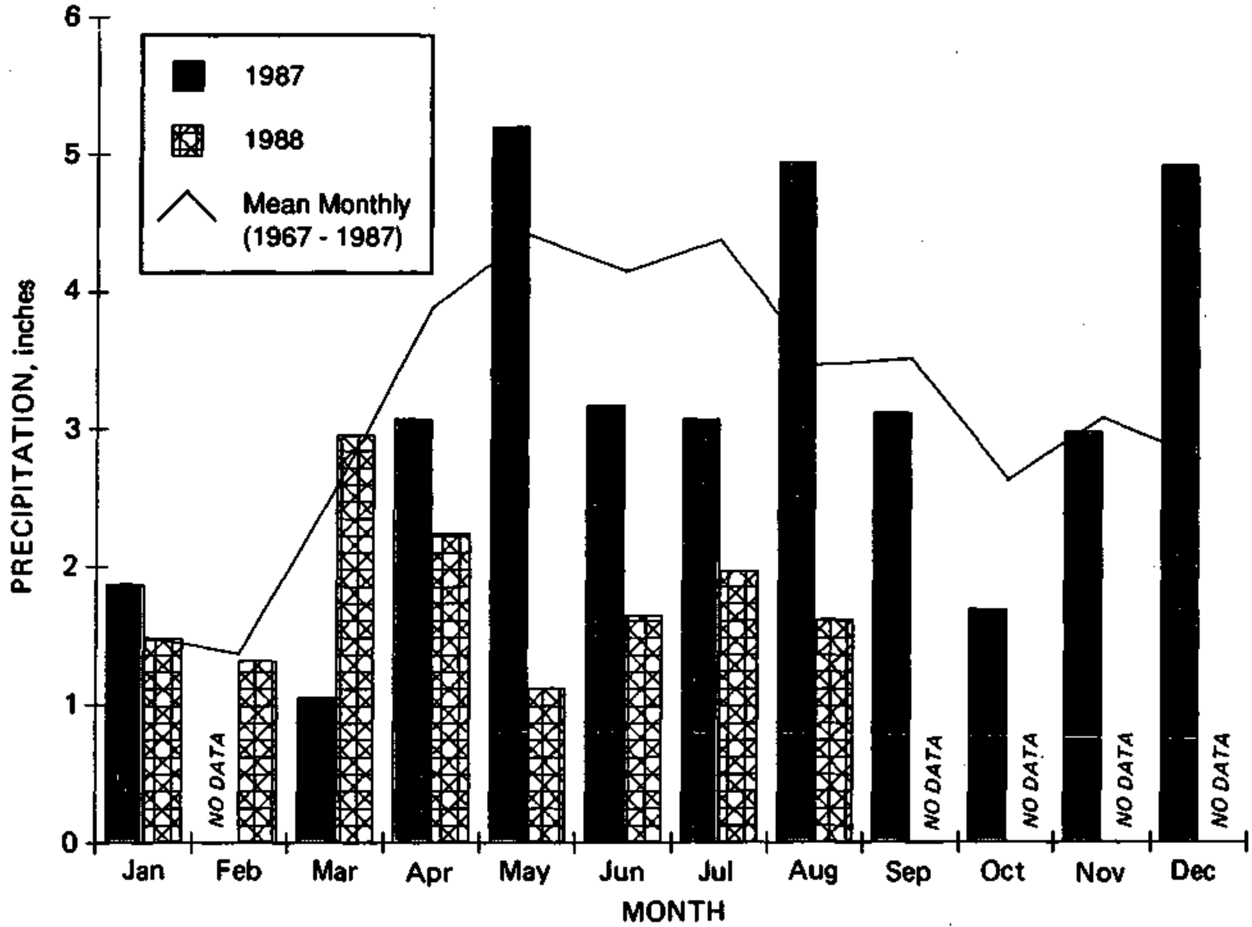

Figure 2. Mean monthly precipitation for 1967-1987, and monthly precipitation for 1987 and 1988, at Kankakee, Illinois

Recharge of the Silurian dolomite aquifer is derived primarily from vertical leakage of ground water from overlying unconsolidated deposits. Flow-net analyses show that recharge to the Silurian dolomite from vertical leakage in 1987 and 1988 ranged from about 86,000 to 126,000 gallons per day per square mile (gpd/sq mile) for areas with thick confining layers of clay or till, and from 245,000 to 285,000 gpd/sq mile for areas with predominantly coarser-grained materials with thin to absent confining layers. The average recharge rates required to balance pumpage within the irrigated region in 1987 and 1988 were 144,000 and 180,000 gpd/sq mile, respectively. Some recharge also occurs along influent stretches of the Kankakee and Iroquois Rivers.

Ground-Water Use

Ground-water use in eastern Kankakee and northern Iroquois Counties is predominantly from the bedrock, with a small percentage of water for rural-domestic use obtained from unconsolidated materials near the land surface. Of the 2,434 documented water wells within the study area, only 71 wells, or less than 3 percent, obtain their water from unconsolidated materials. A more accurate determination of the number of wells being supplied from unconsolidated materials would take into account the large number of undocumented sandpoint (driven) wells installed throughout the study area, particularly in Pembroke Township.

Irrigation accounted for an estimated 63 percent (2.1 billion gallons) of the total ground-water use within the study area in 1987. The distribution of the 1987 pumpage for other ground-water uses was as follows: public water supply systems accounted for 15 percent, or 527 million gallons; domestic pumpage was 17 percent, or 586 million gallons; industrial pumpage was 1 percent, or 55 million gallons; and livestock pumpage was 2 percent, or 70 million gallons.

In 1987, 96 irrigation wells were used to irrigate 10,278 acres of diverse crops. During the 1988 drought, 133 irrigation wells applied ground water to 12,143 acres (figure 3). Because of the drought, ground-water use for irrigation in 1988 increased to an estimated 5.6 billion gallons. Field corn is the most frequently irrigated crop in the region. Approximately 58 and 61 percent of the acreage irrigated with ground water in 1987 and 1988, respectively, was for field corn. After corn, the crops that are most frequently irrigated are vegetables and sod, each of which accounted for 9 to 12 percent of irrigated acreage in 1987 and 1988. Other major crops irrigated in the region are gladioli, potatoes, melons, and nursery products.

EFFECTS OF GROUND-WATER DEVELOPMENT

Changes in Ground-Water Levels

Mass water-level measurements of as many as 226 dolomite wells were conducted on five occasions during the spring and summer of 1987 and 1988 to assess the effects of pumpage on the potentiometric surface of the dolomite aquifer. The potentiometric surface represents the static head in an aquifer, as defined by the

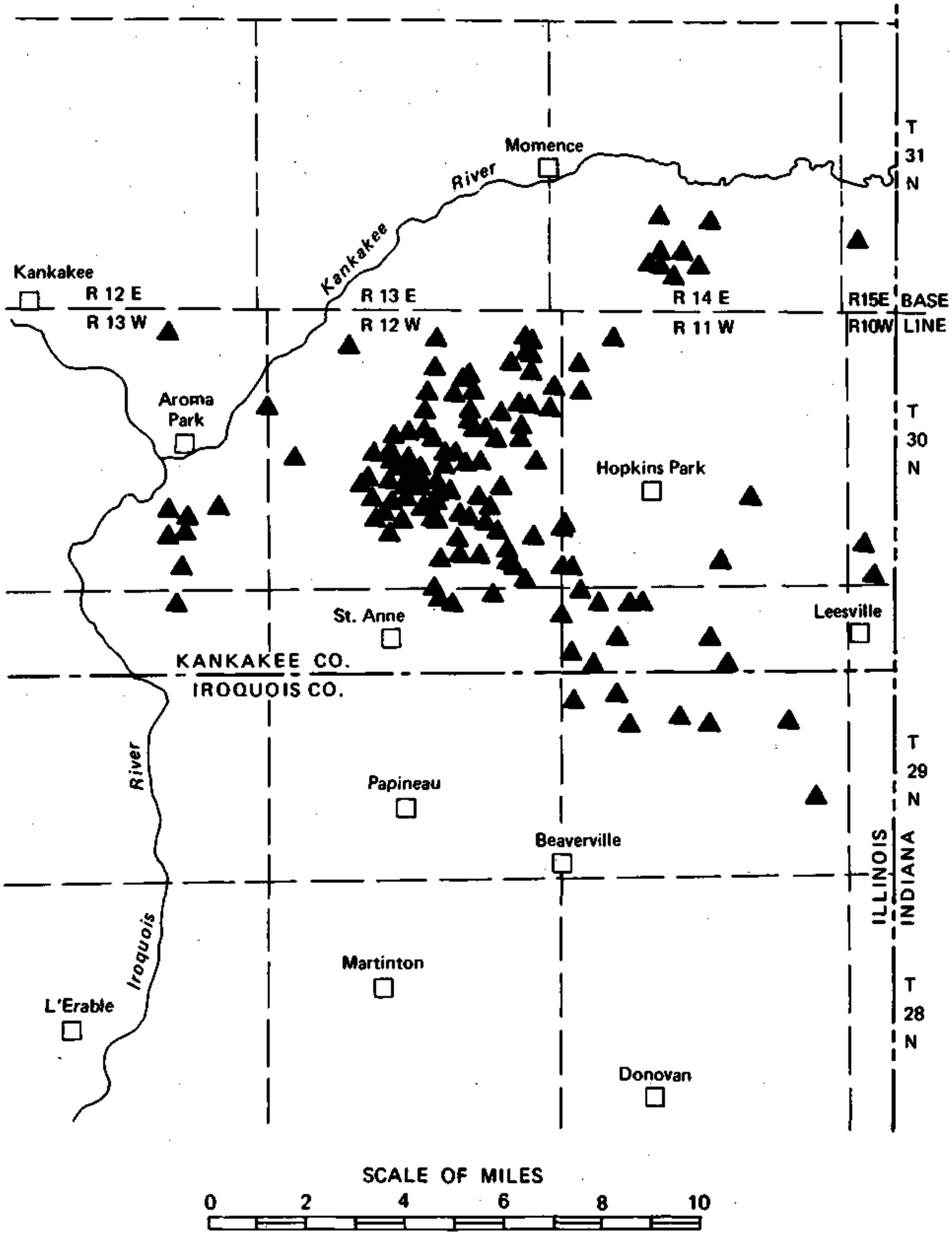

Figure 3. Locations of active irrigation wells during the 1988 growing season

levels to which water will rise in tightly cased wells. Figure 4 shows the water-level declines in the potentiometric surface within the dolomite aquifer between May 28 and August 19, 1987.

Although water-level declines in excess of 44 feet were recorded south of Leesville during the summer of 1987, the potentiometric surface did not decline below the top of the Silurian dolomite aquifer. Thick confining layers of semi-permeable to impermeable clays and tills limit the downward movement of ground water to recharge the dolomite aquifer in this area. In the heavily irrigated areas of Township 30N., Range 12W. (north of St. Anne) and Township 31N., Range 14E. (southeast of Momence), water-level declines were generally between 4 and 8 feet. Larger declines in water levels did not occur because the bedrock aquifer in these areas is from semi-confined to unconfined. In addition, the close proximity of the Kankakee River, which in some stretches is hydraulically connected to the Silurian dolomite, serves to dampen water-level changes within the aquifer.

Declines in water levels within the dolomite aquifer between April 5 and September 2, 1988, were substantially greater than the water-level declines recorded in 1987 (figure 5). During the drought of 1988, the potentiometric surface of the dolomite aquifer declined as much as 72 feet between St. Anne and Leesville. Increased discharge from the dolomite aquifer during the drought resulted in a rapid lowering of the potentiometric surface. However, most of the decline in water levels occurred before July. Increased ground-water recharge from leakage through overlying unconsolidated deposits and a larger area of ground-water diversion to the irrigated region were two of the major factors contributing to the decelerated decline of ground-water levels midway through the irrigation season. Dewatering of the dolomite aquifer in some areas also contributed to the decelerated decline of ground-water levels.

Although no dewatering of the dolomite aquifer occurred in 1987, the potentiometric surface of the bedrock aquifer was near or below the top of the bedrock in an estimated 18 to 20 square miles in 1988. Dewatering of the bedrock aquifer in 1988 occurred predominantly in confined areas near points of substantial ground-water discharge. Although localized dewatering of the bedrock may have occurred in scattered parts of the study area near high-capacity wells, most of the dewatering occurred within three to four miles of the Kankakee-Iroquois county line in Ranges 10W., 11 W., and the eastern end of 12W. The rate of water-level declines in wells decreased sharply once the potentiometric surface reached the bedrock, limiting further declines to less than a few feet.

Ground-Water Hydrographs

A ground-water hydrograph shows changes in water levels over a period of time in a well penetrating an aquifer. Sixteen observation wells penetrating the Silurian dolomite (figure 6) were monitored during the study. Three of the wells — D4, D5, and D11 — were already being monitored as part of the Water Survey's statewide ground-water observation well network. The remaining wells were provided for use during the study by cooperating land owners.

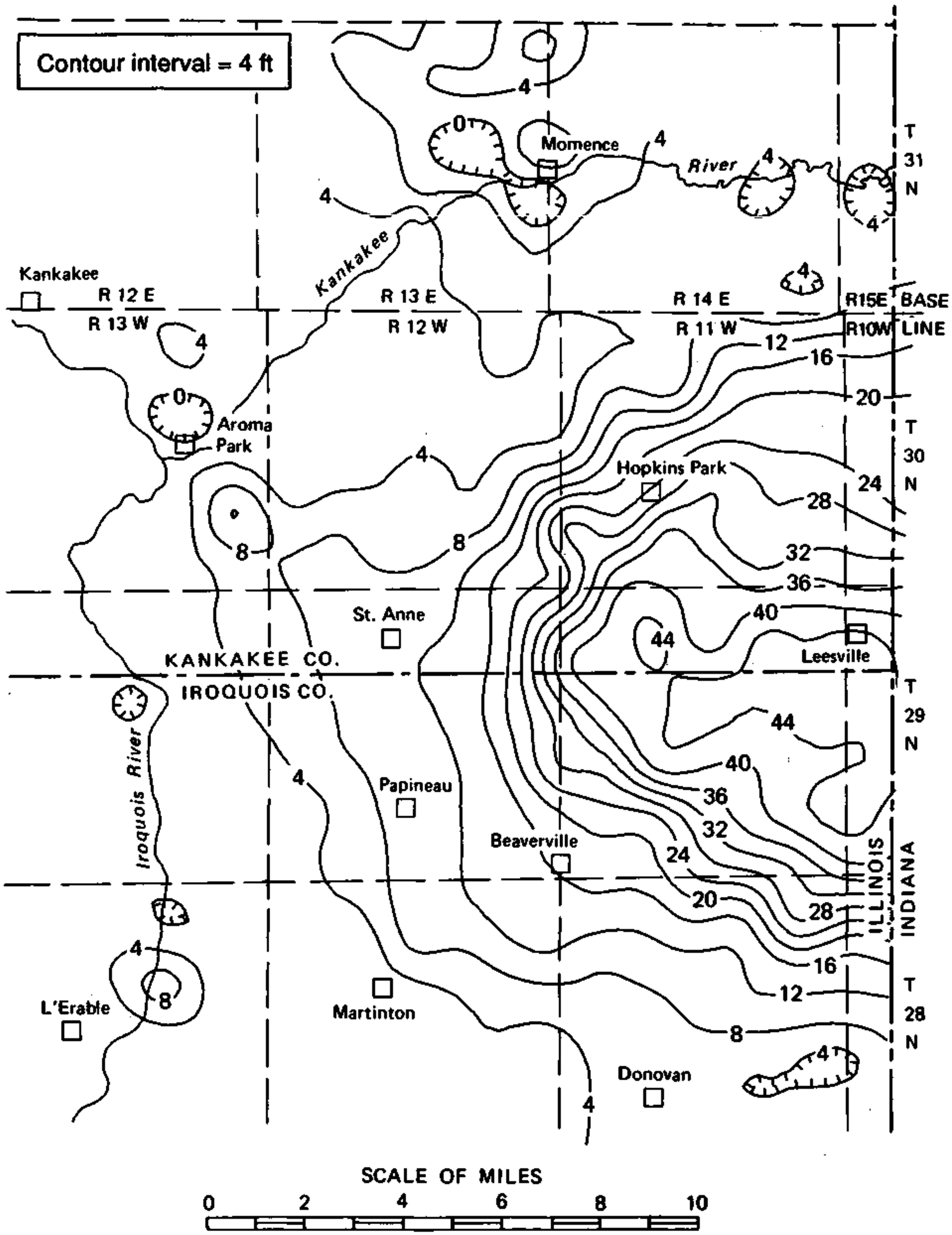

Figure 4. Water-level declines in the potentiometric surface of the dolomite aquifer between May 28 and August 19, 1987

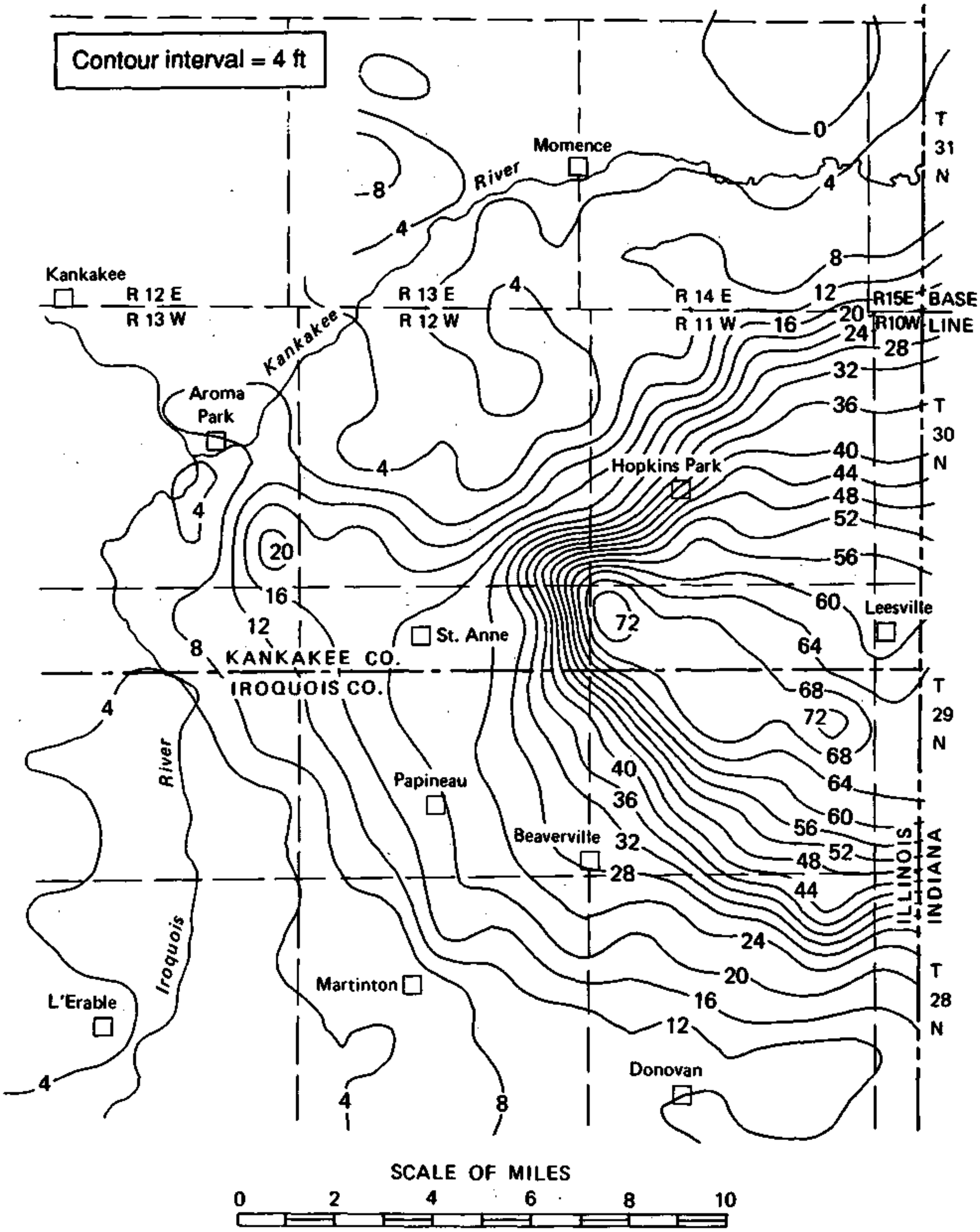

Figure 5. Water-level declines in the potentiometric surface of the dolomite aquifer between April 5 and September 2, 1988

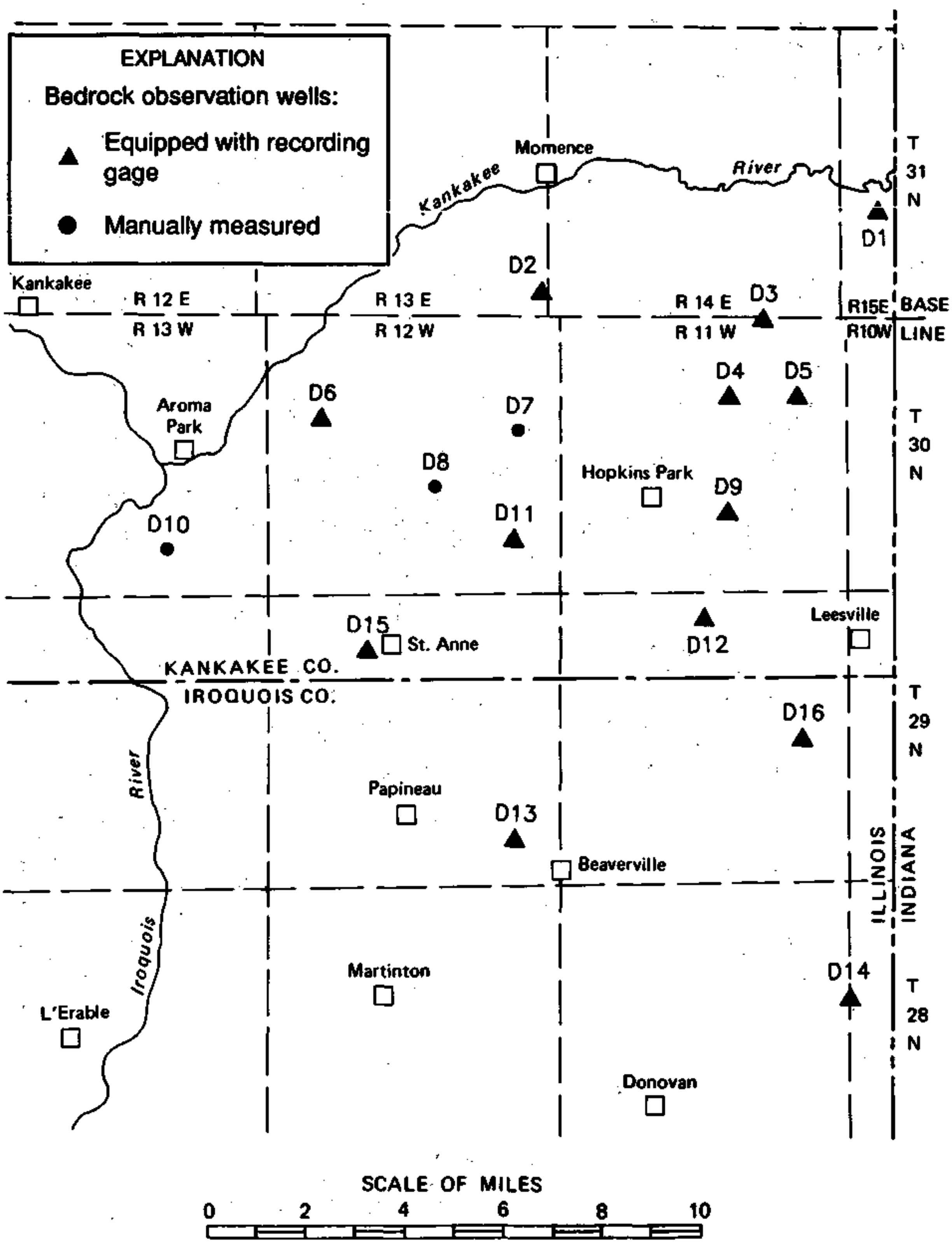

Figure 6. Locations of Silurian dolomite observation wells

Observation well D11, centrally located in the study area, has been monitored continuously since 1968, providing a historical look at water-level changes in the irrigated region of southeastern Kankakee County. As seen in figure 7, water levels in the Silurian dolomite aquifer at this location have fluctuated seasonally since monitoring began. The hydrograph pattern of summer drawdown and subsequent fall, winter, and spring recovery of water levels is repeated each year. This cyclical pattern of drawdown and recovery occurs chiefly in response to ground-water withdrawals by irrigation wells followed by recharge of the aquifer.

In addition to short-term fluctuations observed in the observation well in response to seasonal irrigation, the hydrograph also shows long-term trends. Long-term trends of water levels in observation well D11 occur in response to changes in precipitation and temperature, new installations of irrigation systems, changing crop types, and numerous other factors that determine the amount of water discharging and recharging the aquifer each year.

The amount of precipitation occurring during the year is the primary factor affecting both the magnitude of water-level declines during the summer and the recovery of water levels during the ensuing fall, winter, and spring. The low summer precipitation that occurred in 1982 through 1986 resulted in a five-year trend of declining water levels. Water levels recovered in 1987 and then declined again in the record drought year of 1988.

In addition to the network of dolomite observation wells, eight shallow sand-and-gravel observation wells were measured weekly during 1988. The data show that in areas where a thick clay or till confining layer is present, high-capacity dolomite wells do not cause any significant drawdown in water wells installed in the shallow sand and gravel. Water levels in these shallow wells decline as a result of the natural recession of the water table from the late spring to early fall, when evapotranspiration and ground-water runoff generally exceed recharge from precipitation. Where the clay and till confining layers are scattered or absent, a neighboring high-capacity dolomite well may cause additional drawdown in a sahd-and-gravel well, depending on the proximity between the two wells and the degree of interconnection between the dolomite and the overlying sand and gravel.

GROUND-WATER MODELING

Ground-water modeling efforts were restricted to two-dimensional digital modeling using PLASM (Prickett-Lonnquist Aquifer Simulation Model). The model was designed to simulate the dolomite aquifer in the study area from May through August 1987. The deviation of the model simulation from the actual potentiometric surface map measured in mid-August 1987 was less than 5 feet over most of the study area. Deviations of from 5 to 20 feet occurred in two areas of 16 and 23 square miles, respectively, within the irrigated region. Model simulations were also conducted to evaluate the effects of two pumping wells located in hydrologically different locations within the study area. As shown in figure 8, a hypothetical well located in the area of high recharge and high transmissivity (near the Kankakee River) has

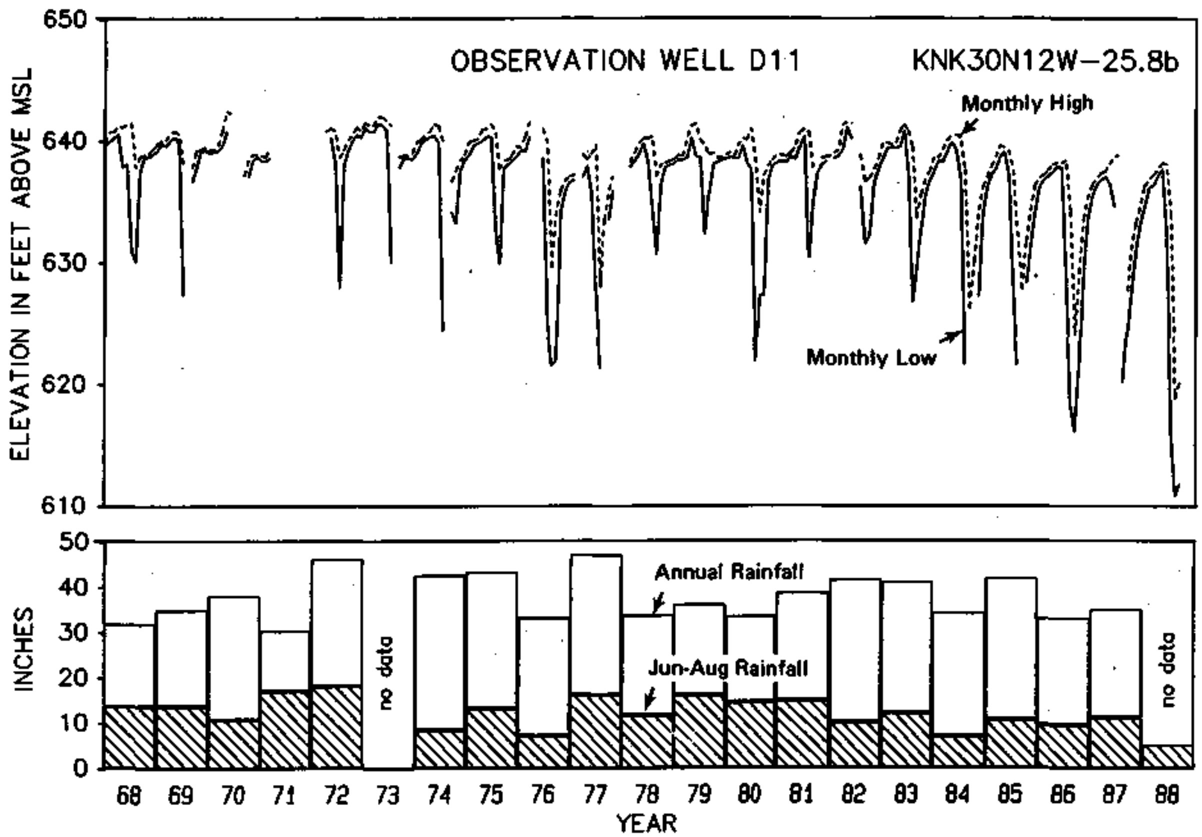

Figure 7. Hydrograph of ground-water levels at observation well D11 versus precipitation, 1968-1988

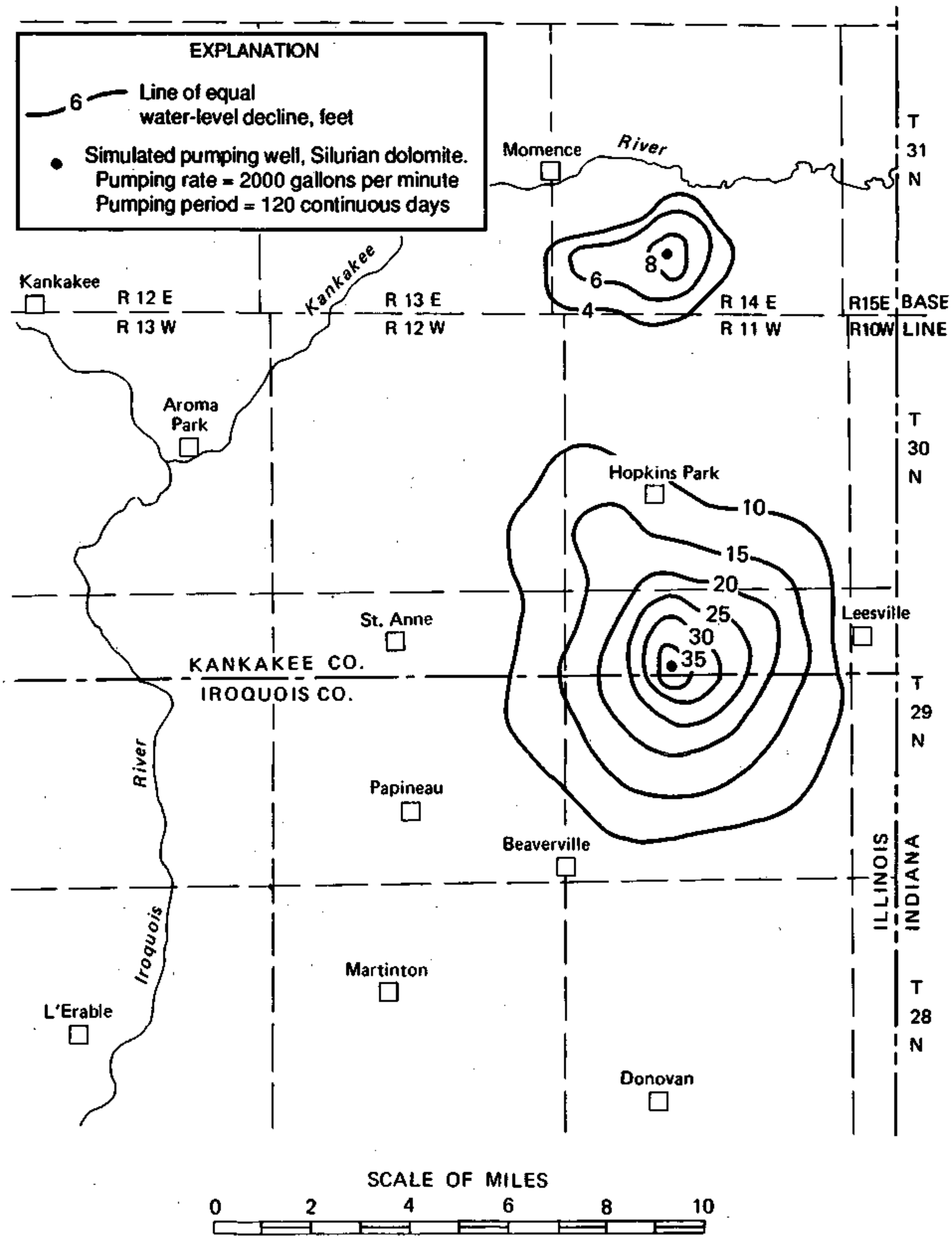

Figure 8. Model-simulated water-level declines around two hypothetical pumping wells

substantially less drawdown both areally and vertically than a well located in the area of lower recharge and transmissivity (near the Kankakee-Iroquois County line).

GROUND-WATER MANAGEMENT

Water Use Act of 1983

To address public concern over present and future ground-water use in Illinois, the Water Use Act of 1983 was drafted and enacted (P.A. 83-700). It establishes that the "rule of reasonable use" shall apply to ground-water withdrawals. The rule of reasonable use is defined as "the use of water to meet natural wants and a fair share for artificial wants. It does not include water used wastefully or maliciously." The act provides mechanisms for 1) notification of proposed new high-capacity wells, 2) review of ground-water resource impacts from the new wells, and 3) public notification regarding the new wells and their estimated impacts on ground-water resources. As originally passed, the act relied on the public notification process to resolve potential conflicts in use caused by proposed large ground-water withdrawals.

In 1987, the Water Use Act was amended. The amendments established a means for conflict resolution between users of ground water in Iroquois, Kankakee, Tazewell, and McLean Counties, with possible restrictions of ground-water withdrawals under emergency conditions. They also provided for the development of recommended well-construction guidelines and mandatory registration procedures for existing high-capacity wells in these four counties.

Water-Well Supply Interruptions

Reports of domestic water-well supply interruptions in eastern Kankakee and northern Iroquois Counties have been occurring since the early 1980s. Until 1988, no accurate figures were maintained on the occurrence of water-well supply interruptions. In accordance with the amended Water Use Act of 1983, the Illinois State Water Survey and Geological Survey began investigating supply interruptions during the drought of 1988.

Approximately 120 complaints of water-well supply interruptions were filed in the study area in eastern Kankakee and northern Iroquois Counties in 1988. Most of the complainants lived in the major impact area near Papineau, Leesville, and Hopkins Park. The lowered water levels in the wells, and the resultant supply interruptions, originated as a result of three factors: 1) regional drawdown, 2) well interference, and 3) drought.

Ground-Water Management Options

One of the conclusions that many persons hoped would emerge from the hydrogeologic studies conducted in Kankakee and Iroquois Counties was a number for the "safe yield," or "long-term sustained yield," of the dolomite aquifer. Historically, safe yield has been regarded as the amount of water that could be pumped regularly on a long-term basis without seriously depleting the storage reservoir. Through the spring of 1987, no long-term or excessive depletion of the ground-water resource occurred over the irrigated region. The potentiometric surface did not drop below the top of the dolomite bedrock, and no significant long-term declines in water levels occurred. However, during the drought of 1988, water levels dropped to record seasonal lows, with water levels at or below the top of the dolomite over an area of up to 20 square miles.

A safe yield for the dolomite aquifer will vary under different patterns of pumping and development. A high-capacity well in northeastern Iroquois County will cause significantly greater drawdowns than the same well located near St. Anne or near the Kankakee or Iroquois River. Under the current pumping distribution, the amount of ground water that can be safely withdrawn from the dolomite aquifer for irrigation, without causing long-term declines or dewatering of the bedrock, is greater than the 2.1 billion gallons pumped for irrigation in 1987. The amount of ground water that may be withdrawn from the dolomite in excess of 2.1 billion gallons is dependent on the distribution of the withdrawals and how much seasonal drawdown is acceptable, especially in the high-impact area.

Because of the general lack of consensus regarding a safe yield, the term "optimal yield" is preferable for use in the evaluation of ground-water management in Kankakee and Iroquois Counties. The optimal yield must be determined by selecting the most favorable ground-water management scheme from a set of possible alternatives. This requires balancing the interests of all ground-water users. To achieve an optimal yield, management of the drilling and use of irrigation wells must be considered. Limits on the drilling of new wells may be needed along the Kankakee-Iroquois county line area between Leesville and St. Anne, where the greatest seasonal drawdowns in water levels are observed. Additional development might be permitted north of St. Anne and along the Kankakee River east of Momence, where regional drawdowns from irrigation withdrawals are less than 8 feet.

Before management options for eastern Kankakee and northern Iroquois Counties can be determined, goals for managing the dolomite aquifer must be established. Following are several aquifer management goals to be considered:

1) Limit long-term declines in the potentiometric surface of the Silurian dolomite aquifer.

2) Protect owners of domestic and other wells from excessive regional drawdown and well interferences from high-capacity wells.

3) Allow for continued "reasonable use" and controlled development of the ground-water resource.

4) Plan for regional ground-water use in accordance with climatic conditions, such as drought.

Numerous plans can be developed to manage the ground-water resources of eastern Kankakee and northern Iroquois Counties, depending on the management goals to be achieved. Currently, under the amended Water Use Act of 1983, a mechanism is available that allows for continued ground-water development but that will prevent or limit long-term depletion of the resource. Central to this plan is the registration of all high-capacity wells and the use of recommended well construction guidelines for rural domestic wells. The objective of the well construction guidelines is to promote construction of new domestic wells that will provide an uninterrupted supply of water while allowing for reasonable development of the aquifer. Should a well meeting the guidelines fail to furnish its normal supply of water, a complaint is filed and an investigation of the problem initiated. If the complaint is deemed valid, restrictions can be placed on the quantity of water extracted from any high-capacity well within the boundaries of the counties.

The amended Water Use Act of 1983 is *reactive* management of the ground-water resource; no actions are taken to limit withdrawals from the aquifer until water supply interruptions begin occurring. Several *proactive* alternatives that should be considered to manage the ground-water resource are:

1) Limit further development of ground water in areas highly susceptible to dewatering of the dolomite bedrock.
2) Institute a ground-water use fee based on amount pumped. The fee would promote water conservation and provide a contingency fund for remedying water-supply problems of domestic well owners, by either lowering their pumps or drilling new wells.
3) Establish a minimum ground-water elevation, such as the top of the dolomite bedrock, as a trigger mechanism for the initiation of ground-water use restrictions.
4) Establish a more stringent permitting system for construction of new high-capacity wells in the management area. Uncontrolled development of new irrigation systems will certainly lead to overdevelopment of the ground-water resource. Well-drilling permits for high-capacity wells must be evaluated on the basis of the intended quantity and timing of ground-water use.

CONCLUSIONS

The ground-water resources of eastern Kankakee and northern Iroquois Counties are adequate to provide ground water to all present users without causing long-term depletion of the resource. Through 1988, no long-term depletion of the ground-water resource occurred. Wells penetrating the dolomite aquifer that have appropriate pump-intake elevations continued to supply water while experiencing seasonal water-level declines. Although record declines occurred during the drought of 1988, long-term depletion of the resource will occur only if irrigation development continues unregulated and if below-normal precipitation continues beyond 1988.