State Water Survey Division

GROUND WATER SECTION

ENR
Illinois Department of
Energy and Natural Resources

SWS Contract Report 352A

PART A. GROUND WATER LEVELS AND PUMPAGE

for the study

GROUND WATER LEVEL ANALYSIS BY COMPUTER MODELING: AMERICAN BOTTOMS GROUND WATER STUDY

by

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PREFACE

Groundwater Level Analysis by Computer Modeling is an in-depth investigation of groundwater flow in the American Bottoms area. There were five objectives to this study. They were 1) to compile current hydrologic data pertaining to the area, 2) to develop a computer model that could simulate the movement of groundwater, 3) to analyze existing and future groundwater levels in the area, 4) to present alternatives to lower or maintain groundwater levels at specified elevations in a designated area of interest and 5) to provide documentation of the model including a user's guide.

The five objectives of this study are addressed in five separate reports that may be used independently or conjunctively.

Part	Title
A	Groundwater Levels and Pumpage
B	American Bottoms Digital Groundwater Flow Model
C	Existing and Future Groundwater Levels
D	Evaluation of Alternative Measures
E	Digital Flow Model Description and User's Guide

A brief summary of each part of the study is given here. Each part has an introduction, an explanation of methods, results and references. Part E, the model user's guide, includes attachments for data and program listings.

Acknowledgments

A project of this size required the cooperation of many Illinois State Water Survey employees. Their efforts were important in the completion of this project. Noteworthy contributions were made by James D. Miller in gathering background information for Part A, by Mark C. Collins in modifying the ISWS aquifer model for Part B and by Anne Klock in making groundwater level probability exceedance calculations for Part C. Graphics were done by John Brother, Bud Motherway and Linda Riggin. Word processing was done by Pamela Lovett and Kathy Brown. A special appreciation was gained for the timely assistance of consultants at the University of Illinois Computer Services Office and the Boeing Computer Service Customer Service.

SUMMARY OF STUDIES

Groundwater Levels and Pumpage

The American Bottoms is a 175 square mile area of the Mississippi River valley lowlands that includes the urban industrial areas of East St. Louis, Granite City and Alton. Groundwater is a major source of water for the area and is used for industrial, public and irrigation supplies. Groundwater levels prior to industrial and urban development were near land surface. Intensive industrial development and construction of a system of drainage ditches, levees, and canals to protect developed areas have altered the water resources in the area. In recent years, water level rises due to reductions in pumpage, high river stages, and high precipitation producing favorable recharge conditions have caused damage to underground structures. The U.S. Army Corps of Engineers, St. Louis District has sponsored this study to examine groundwater flow in the area and its relationship to Mississippi River stage and precipitation.

Water levels and pumpage information collected over many years by the State Water Survey have been summarized and are presented in Part A. Pumpage is presented for major and minor pumping centers and is classified as public, industrial, domestic or irrigation. Hydrographs are presented for ten different observation wells for their period of record. Mississippi River stages, precipitation at St. Louis airport and pumpage at Granite City are included with the hydrographs to illustrate their interdependence. Piezometric surface maps are presented for five different groundwater conditions.

Groundwater Flow Model

The groundwater model used was a modified form of the Illinois State Water Survey aquifer model (Prickett and Lonnquist, 1971). Modifications were made to incorporate the dynamic effects of river stage and precipitation. The model was calibrated by historically matching two five-year periods with constant one-month time steps. Hydrographs of actual and simulated water levels at ten observation wells and the nearest model cell for the two five-year periods are presented. Two piezoraetric surface maps of actual and simulated water levels are also presented. The model was found to consistently calculate water levels within two feet of the actual measured water level within a specified area of interest.

Existing and Future Conditions

Groundwater conditions were evaluated by simulating historical Mississippi River stage and precipitation and constant pumpage for a thirty-year period. Pumpage was simulated as 1) constant for the thirty-year period at historical 1980 rates and locations, 2) forecast 2000 rates and locations and 3) no pumpage except for a dewatering site maintained by the Illinois Department of Transportation.

Groundwater levels were evaluated with the aid of groundwater level exceedance probability plots. Groundwater level exceedance probability plots were constructed for ten model cells by compiling the maximum yearly water level from monthly simulated values. Plots were based on simulation of the thirty-year period from 1951 to 1980. The Weibold formula was used for probability calculations.

Mississippi River stage and precipitation records were available from 1905 to the present. One simulation was conducted for a period of 75 years to compare the period of simulation with the length of the exceedance plot. The longer period of record was desirable; however, because low river stages as well as high river stages and low and high precipitation occur during the thirty-year period from 1951 to 1980, the impact on exceedance is minimal. Also, the cost of simulations dictated use of the shorter period.

Alternative Measures

Pumpage systems and gravity drainage collectors to maintain water levels were evaluated by the same methods used in evaluation of existing and future conditions. Two pumpage and one gravity collector systems were designed to meet three specified groundwater levels. Systems were designed for forecast 2000 pumpage and no pumpage conditions. In all, twenty systems were simulated. Systems were designed to meet the specified target elevation in all cells for 90 percent of the months simulated. Exceedance probability was calculated for ten cells, but is illustrated for only five cells. Piezometric surface maps are presented for June 1973 conditions for designs with year 2000 pumpage.

Digital Flow Model Description and User's Guide

The computer model is documented by sections describing model capabilities, theory and assumptions. Explanation for preparing data files and understanding output is also included, as are three sample problems. Four attachments are provided to: 1) list and explain file names supplied on magnetic tape, 2) list data of all inputs to the model, 3) list the Fortran V source code for the model, and 4) define all variables in the computer code.

The text for Part A, Groundwater Levels and Pumpage, follows.

PART A. GROUNDWATER LEVELS AND PUMPAGE

INTRODUCTION

This report on groundwater levels and pumpage was prepared by the Illinois State Water Survey as part of the study entitled Groundwater Level Analysis by Computer Modeling, American Bottoms Groundwater Study funded by the U.S. Department of the Army, St. Louis District, Corps of Engineers. This report is Part A of the final report.

The American Bottoms (figure 1) is one of the most heavily populated and industrialized areas in Illinois. The groundwater resources of a sand and gravel aquifer underlying the area have been developed extensively.

In 1965 the State Water Survey issued Report of Investigation 51 (Schicht, 1965) which described in detail the groundwater resources of the area. The geology and hydrology of the sand and gravel aquifer, the yields of wells, and the possible consequences of future groundwater development were discussed in detail. 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. The groundwater geology of the area had been described by the State Geological Survey (Bergstrom and Walker, 1956).

In order to validate predictions of the consequence of future groundwater development and to delineate problem areas, intensive data collection in the area has been continued.

This report summarizes water levels and pumpage in State Water Survey reports that are pertinent to this study.

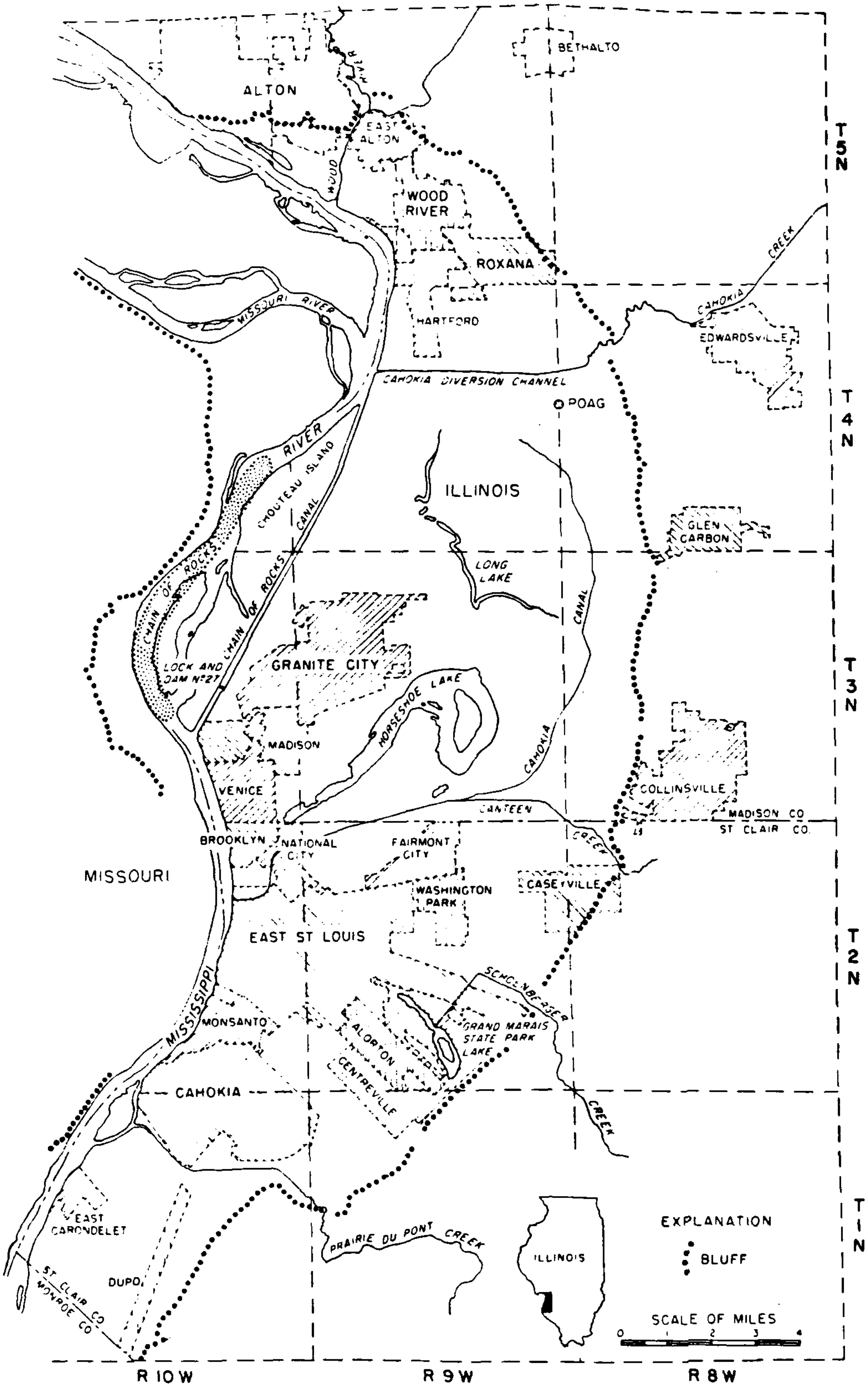
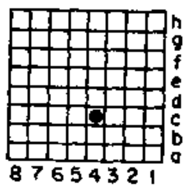


Figure 1. Location of study area.

Well-Number System

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.

PUMPAGE FROM WELLS

Data on groundwater withdrawals in the East St. Louis area have been collected by State Water Survey staff since the early 1940's. Information on withdrawals prior to the early 1940's was estimated from data in Survey, industry, and municipal files; from interviews with industry and municipal officials; by making evaluations based on the number of wells, their reported yields, time of construction, and the number of hours in production per day; by taking into consideration population growth and per capita consumption; and by correlating production data with water use. Data on groundwater withdrawals have been published in the State Water Survey publications listed in the reference section of this report. A summary of this data is given in this report and brought up to date through 1980. William H. Baker, State Water Survey Field Hydrologist in the East St. Louis area from 1967 to 1976, did extensive work in evaluation of withdrawal data and minor discrepancies may exist between data in this report and data in reports listed in the references.

Pumpage use data are classified in this report according to four main categories: 1) public, including municipal and institutional; 2) industrial, 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 use. For example, 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 any water pumped by an industry and furnished to a municipality is included in the public use category.

Industrial and Municipal Pumpage

Groundwater withdrawals for industrial and municipal use from 1890 to 1980 are shown in figure 2. The first significant withdrawal of groundwater in the East St. Louis area started in the late 1890's. Prior to 1900 groundwater was primarily used for domestic and farm supplies; since 1900 pumpage has been mostly for industrial use. Estimated pumpage from wells increased from 1.0 mgd in 1900 to 104.0 mgd in 1956. Pumpage declined sharply from 104 mgd in 1956 to 92.0 mgd in 1958. Withdrawal of groundwater declined after World War II.

Pumpage increased from 94.5 mgd in 1960 to 97.0 mgd in 1961, and increased sharply to 105.2 mgd in 1962. For the period 1962 through 1966 pumpage changed little and was 104.6 mgd in 1966. Pumpage was greatest in 1964 when 108.2 mgd was withdrawn. Pumpage declined steadily during the period 1967-1977, from 104.6 mgd to 62.1 mgd. Pumpage increased to 68.2 mgd in 1978. A significant decline in pumpage occurred in 1979 when only 56.8 mgd was withdrawn. The decline continued into 1980 when 54.0 mgd was withdrawn from municipal and industrial use.

The reduction in groundwater withdrawals since the middle 1960's has been mainly due to a decrease in withdrawals for industrial use. Municipal use, however, increased from 3.2 mgd in 1940 to 10.2 mgd in 1980. In 1960, 94.5 mgd

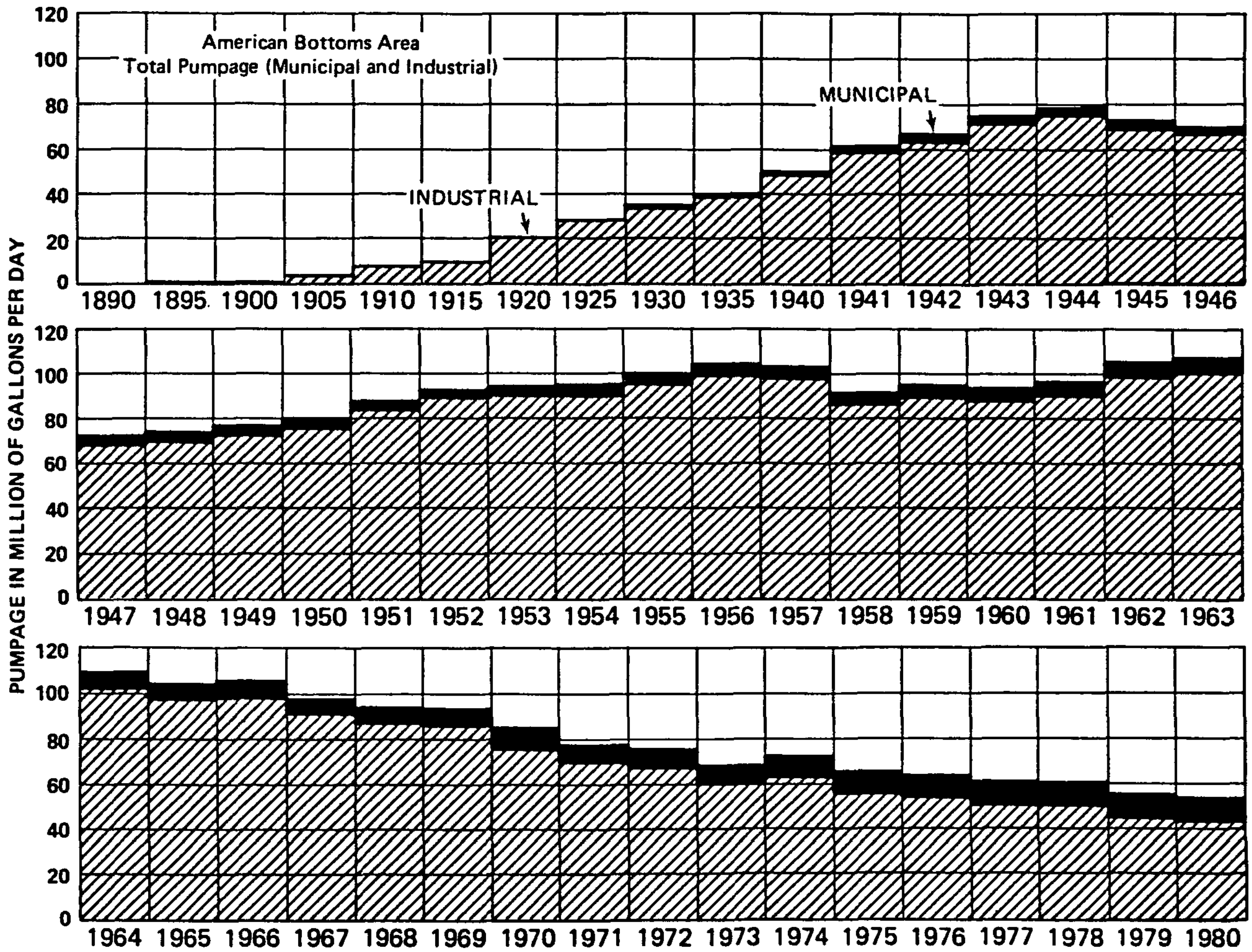


Figure 2. Estimated municipal and industrial pumpage 1890 through 1980.

was withdrawn for municipal and industrial use; 5.9 mgd or 6.2 percent was for municipal use. Of the 54.0 mgd withdrawn in 1980, 10.2 mgd or 18.9 percent was for municipal use.

Irrigation Pumpage

Development of groundwater for irrigation on a significant scale started in 1954 during a severe drought extending from 1952 through 1956 (Hudson and Roberts, 1955). Pumpage for irrigation is seasonal and varies considerably from year to year, depending on climatic conditions. Estimated irrigation pumpage for the period 1961-1980 is given in Table 1.

Table 1. Estimated Pumpage for Irrigation (gpd) 1961-1980.

Year	Pumpage	Year	Pumpage
1961	100,000	1971	600,000
1962	200,000	1972	677,000
1963	220,000	1973	364,000
1964	540,000	1974	587,000
1965	190,000	1975	406,000
1966	869,000	1976	790,000
1967	363,000	1977	845,000
1968	597,000	1978	450,000
1969	304,000	1979	Not available
1970	480,000	1980	Negligible

Domestic Pumpage

Rough estimates of pumpage for domestic use indicate that domestic pumpage increased uniformly from about 1 mgd in 1900 to 2.4 mgd in 1960 and has averaged 2.4 mgd since 1960.

Distribution of Pumpage

Pumpage is concentrated in five major pumping centers: the Alton, Wood River, Granite City, National City, and Monsanto areas. Also there are five minor pumping centers: The Fairmont City, Caseyville, Poag, Troy, and Glen Carbon areas. The locations of the pumping centers are shown in figure 3.

Alton Area

Groundwater withdrawals in the Alton area are largely from wells owned by industries. Pumpage in the Alton area increased from about 0.2 mgd in 1910 to 12.7 mgd in 1960 as shown in figure 4. Pumpage increased sharply from 7.5 mgd in 1955 to 12.7 mgd in 1960. From 1961 to 1974 pumpage ranged from a low of 13.2 mgd in 1961 to high of 15.4 mgd in 1969. After 1974 pumpage declined and was 6.0 mgd in 1980.

Wood River Area

Groundwater withdrawals in the Wood River area is largely for industrial use although 6 municipalities withdraw groundwater in the area.

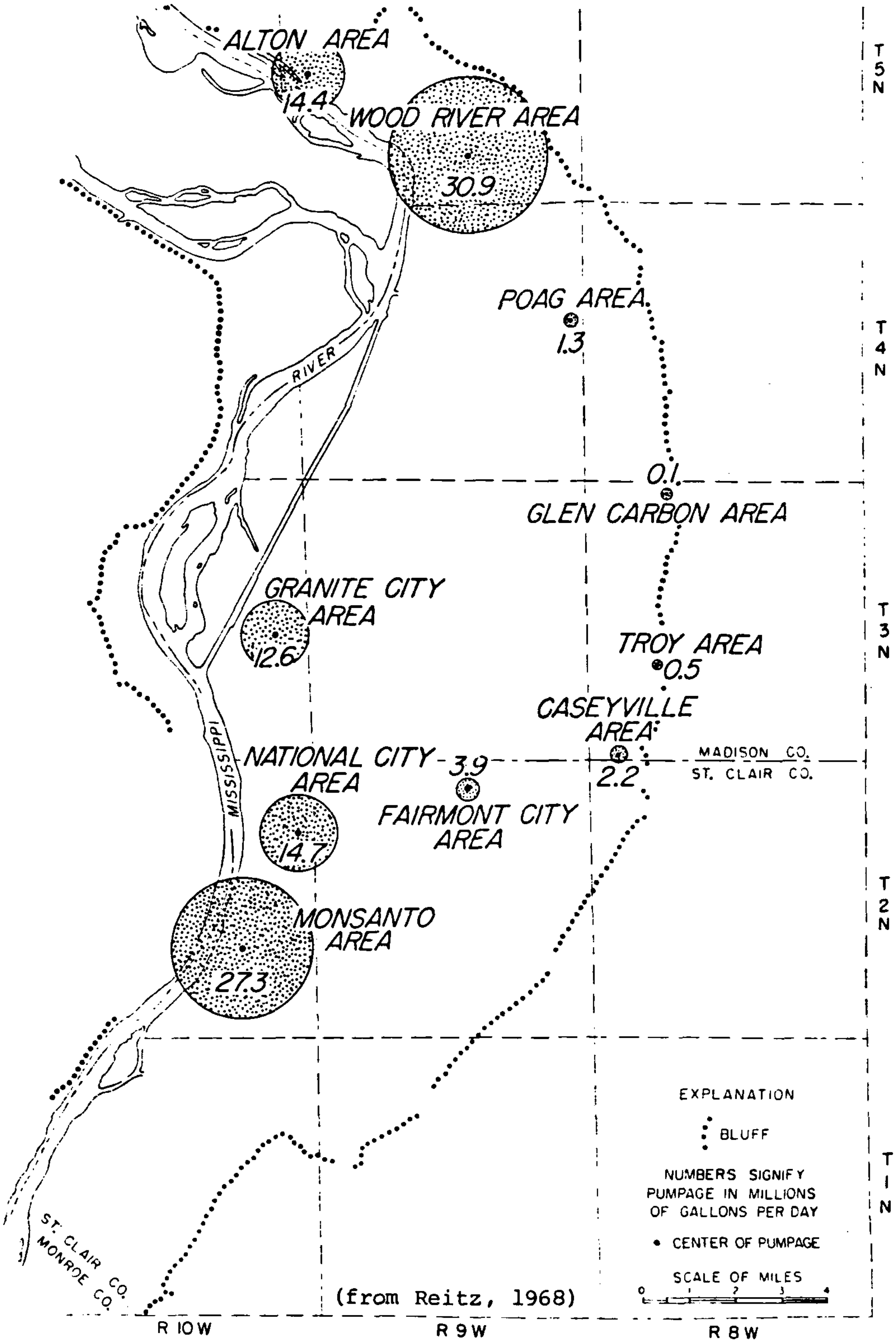


Figure 3. Distribution of estimated pumpage in 1966.

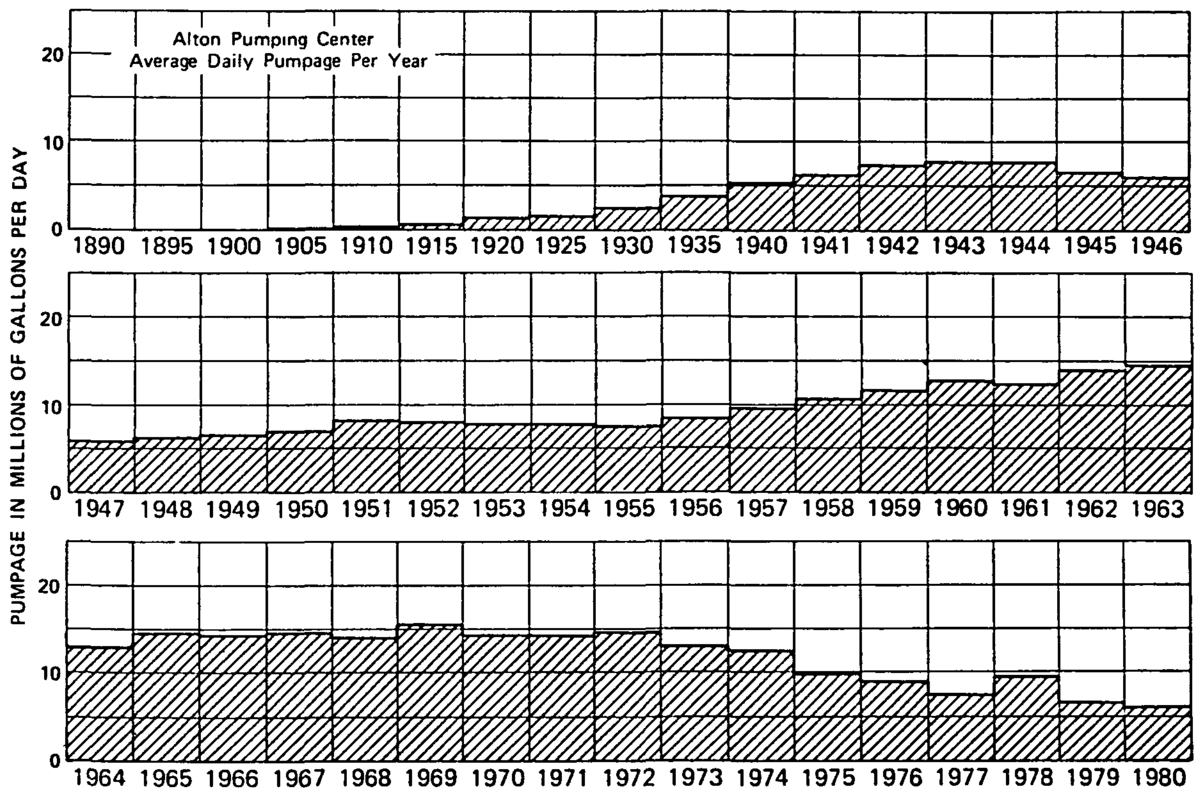


Figure 4. Estimated pumpage Alton area, 1890-1980.

Estimated pumpage in the Wood River area increased from less than 100,000 gpd in 1900 to 15.6 mgd in 1960 shown in figure 5.

Pumpage during the periods 1956 to 1980 ranged from 23.5 mgd in 1956 to 30.3 mgd in 1966. Pumpage was .26.4 mgd in 1980.

Granite City Area

Groundwater withdrawals in the Granite City area are largely from wells owned by industry. As shown in figure 6, pumpage increased gradually from 0.4 mgd in 1895 to about 18.6 mgd in 1944. Pumpage declined to 15.3 mgd in 1948 and then increased to a peak withdrawal rate of 26.1 mgd in 1953. Pumpage declined significantly in 1958 to 8.0 mgd, the result of an industry changing from groundwater to the Mississippi River as a source of supply. Pumpage increased to 14.5 mgd in 1964 and then declined to 4.6 mgd in 1980.

National City Area

Groundwater withdrawals in the National City area were largely from wells owned by industries until recent years when dewatering wells along the interstate highway system started withdrawing significant quantities of groundwater.

As shown in figure 7, pumpage increased in the National City area from 1.8 mgd in 1905 to 14.5 mgd in 1957. Pumpage decreased rapidly during the next three years to 10.7 mgd in 1960 as the demand for water by industry diminished. Pumpage peaked at 14.7 mgd in 1964 then declined to 10 mgd in 1970. Between

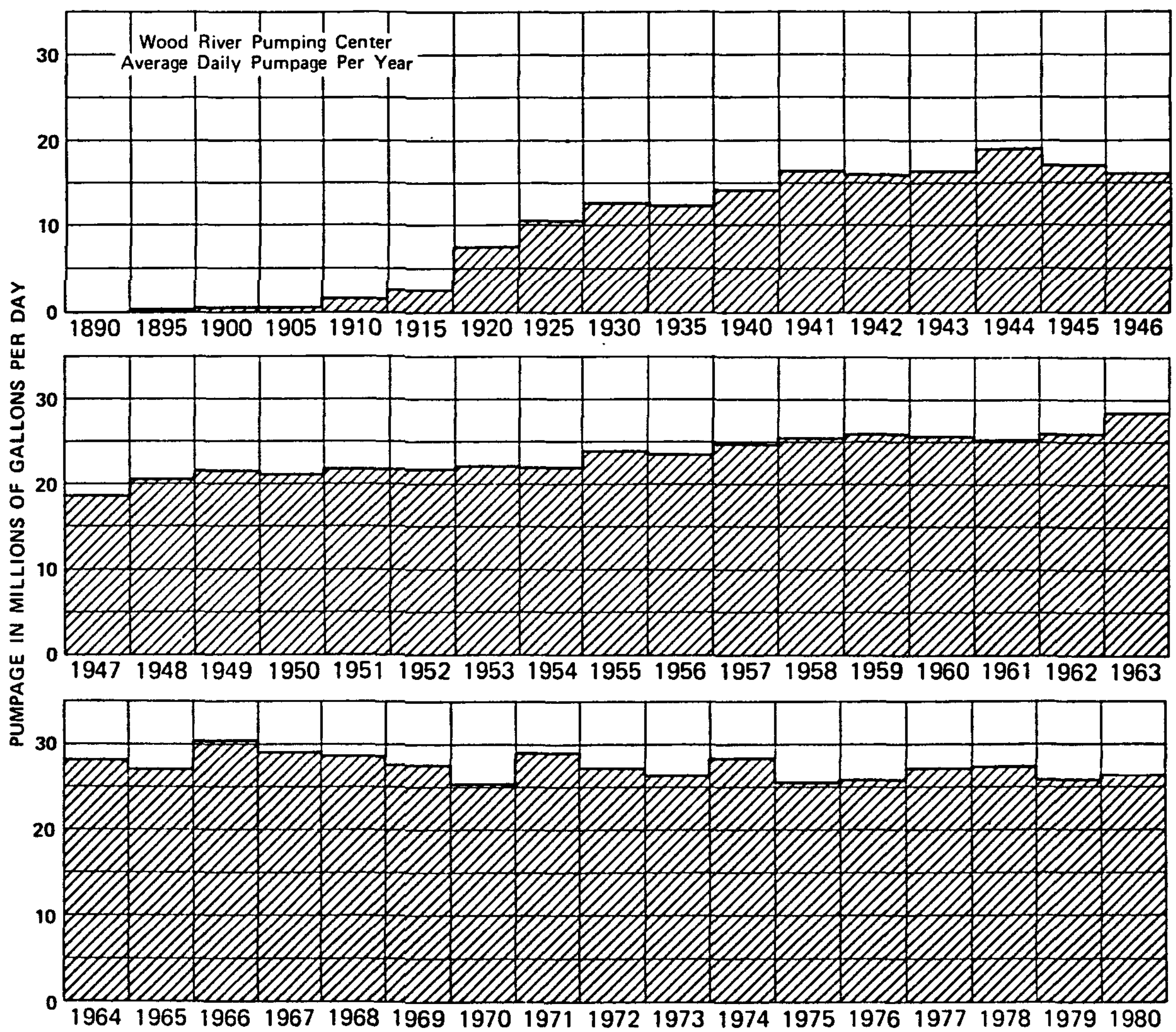


Figure 5. Estimated pumpage in the Wood River area, 1890-1980.

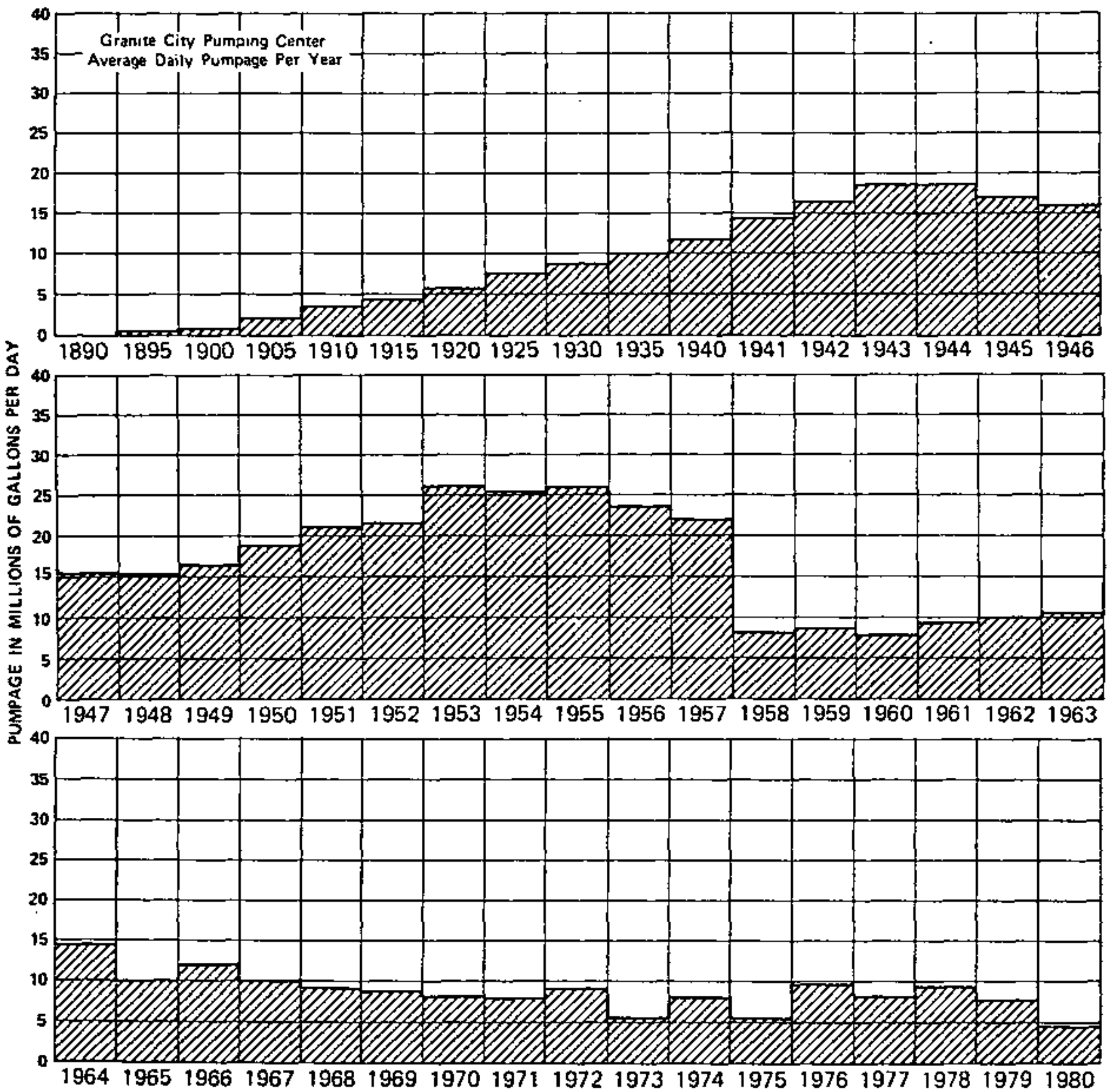


Figure 6. Estimated pumpage in the Granite City area, 1890-1980.

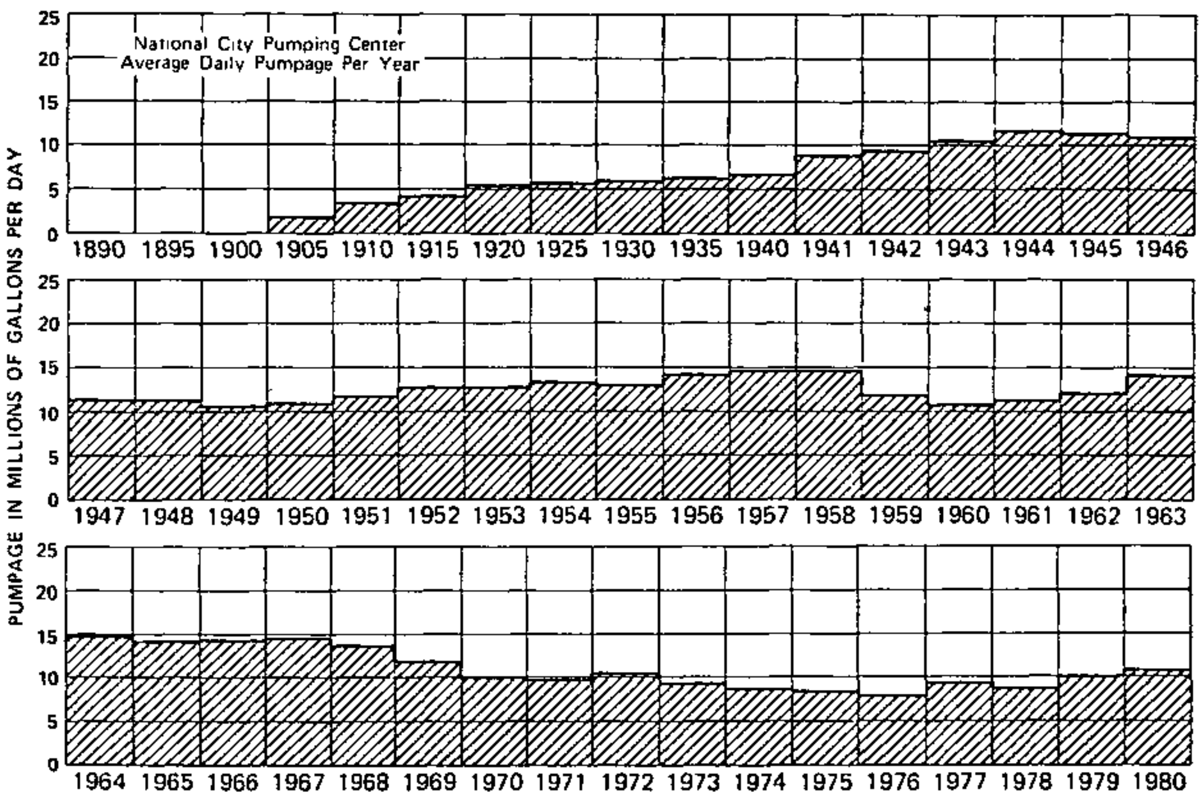


Figure 7. Estimated pumpage in the National City area, 1890-1980.

1970 and 1980 pumpage ranged from 8.0 mgd in 1976 to 10.6 mgd in 1980. Pumpage from highway dewatering wells increased gradually from 1.8 mgd in the middle 1960's to 7.2 mgd in 1980.

Monsanto Area

Groundwater withdrawals in the Monsanto area are largely from wells owned by industries. As shown in figure 8, pumpage in the Monsanto area increased considerably from less than 100,000 in 1905 to 31.0 mgd in 1960. Pumpage growth was fairly uniform from 1905 to 1940, accelerated sharply during World War II, and continued to climb with only minor interruptions after World War II. In 1962 groundwater pumpage was 35.5 mgd.

From 1962 to 1965 groundwater pumpage decreased to 30.4 mgd as a result of increased conservation of water at one industry by recirculating instead of pumping to waste after the initial use.

Estimated groundwater withdrawals in the Monsanto area decreased to 21.2 mgd in 1970 and to 12.1 mgd in 1971. These large decreases were due to the closing down of two major groundwater-using industries.

Estimated groundwater withdrawals in the Monsanto area decreased from 12.1 mgd in 1971 to 9.8 mgd in 1972. From 1972 to 1975 pumpage increased to 11.3 mgd then decreased significantly, dropping to 4.7 mgd in 1977. These large decreases are due to the conversion by industries to the Mississippi River as a source of water. Groundwater withdrawals continued to decline and were only 0.5 mgd in 1980.

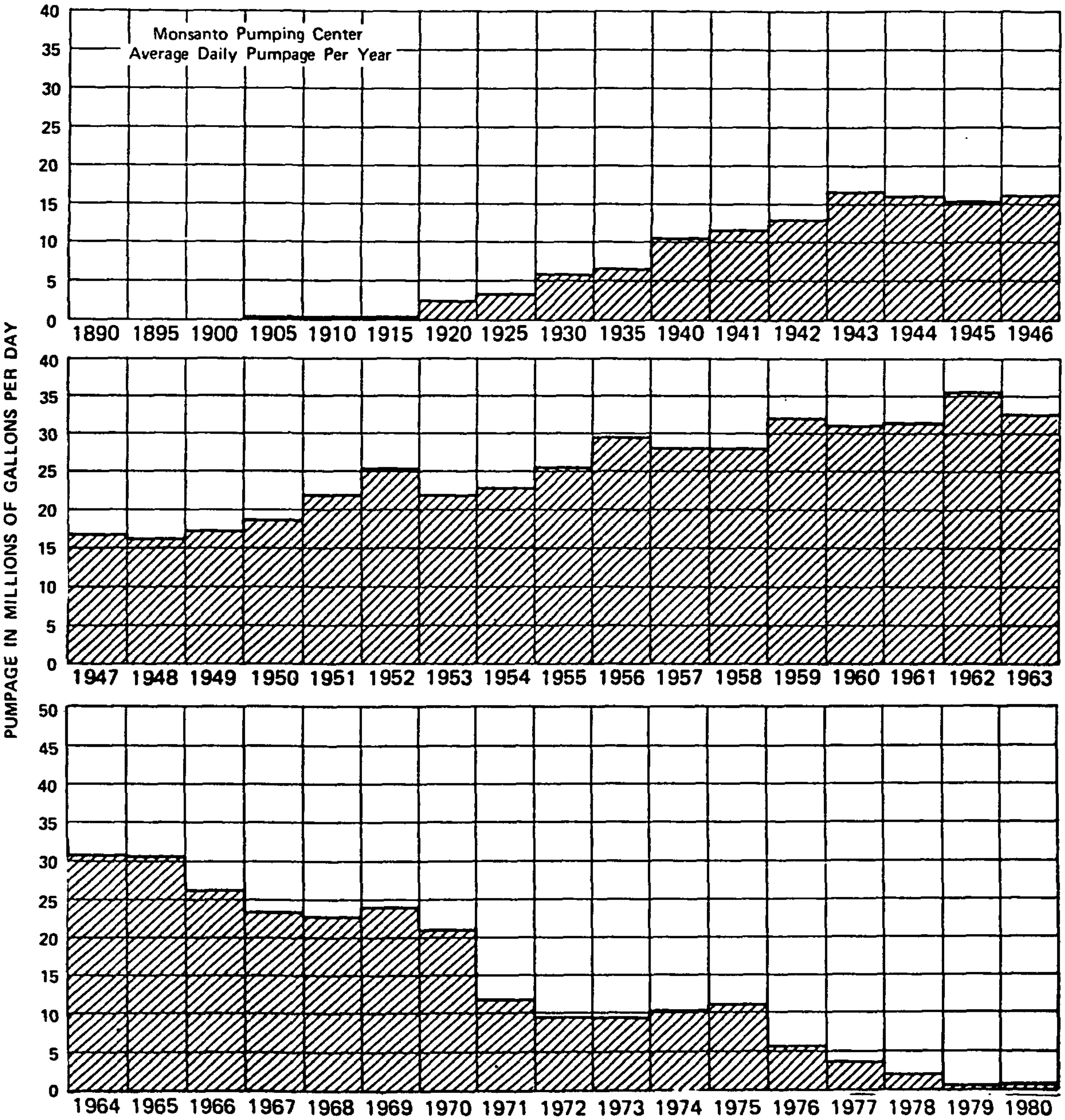


Figure 8. Estimated pumpage in the Monsanto area, 1890-1980.

Minor Pumping Centers

Pumpage from wells in minor pumping centers are shown in figures 9-13. Pumpage in the Fairmont City area is industrial; pumpage from the Caseyville, Poag, Troy and Glen Carbon areas is mostly for municipal supplies. Pumpage in the Fairmont City area increased from less than 100,000 gpd in 1915 to a peak of 4.7 mgd in 1962. After 1962 pumpage gradually declined to about 0.1 mgd in 1980. Pumpage in the Poag, Troy, and Glen Carbon areas increased gradually during the period of record to 1.7, 0.8, and 0.9 mgd in 1980, respectively. Pumpage in the Caseyville area reached a peak 3.1 mgd in 1977 and then declined to 2.4 mgd in 1980 mainly due to a reduction in industrial pumpage.

Pumpage From Wells Adjacent the Mississippi River

Prior to 1953 pumpage from wells was concentrated in areas at distances of 1 mile or more from the Mississippi River. During and after 1953 pumpage from wells at distances within a few hundred feet from the river increased greatly in the Alton, Wood River and Monsanto areas. A summary of pumpage from wells near the river for selected years is given below.

	Pumpage (mgd)		
Year	Alton Area	Wood River Area	Monsanto Area
1961	6.3	6.8	10.5
1966	6.5	15.7	9.3
1971	8.1	13.1	5.7
1980			Negligible

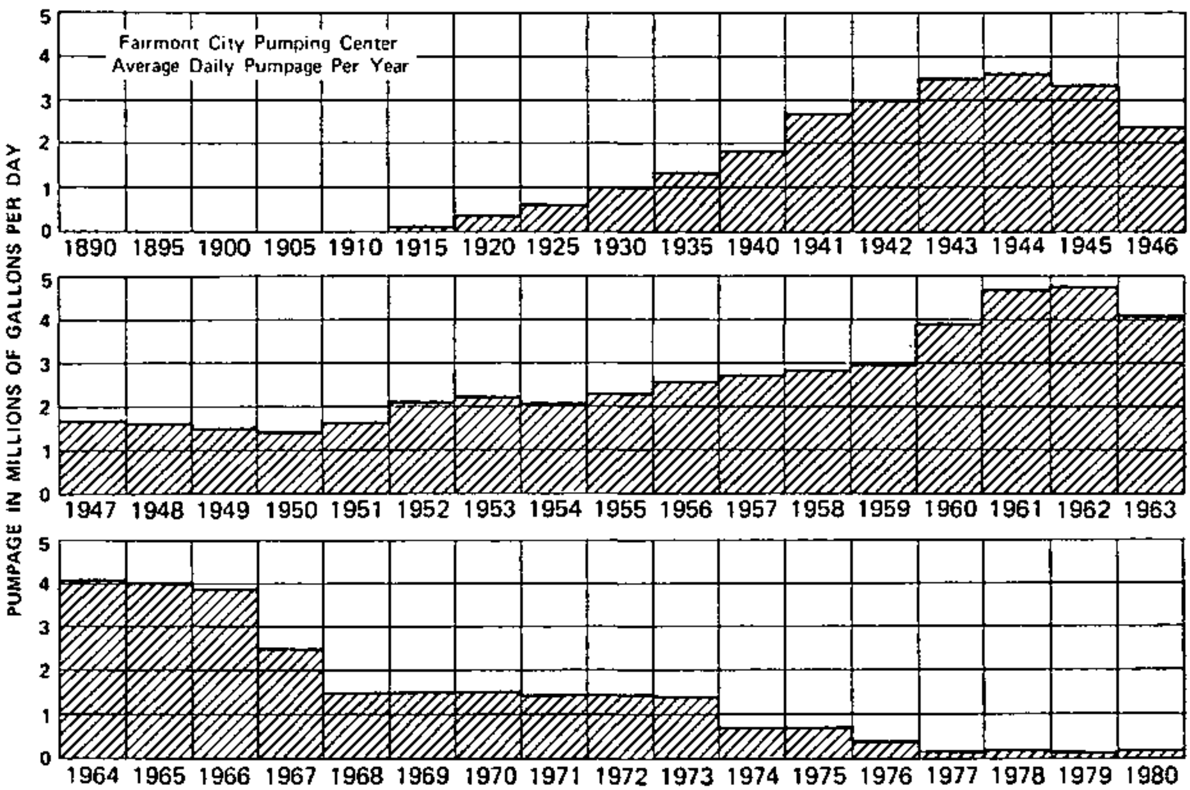


Figure 9. Estimated pumpage in the Fairmont City area, 1890-1980.

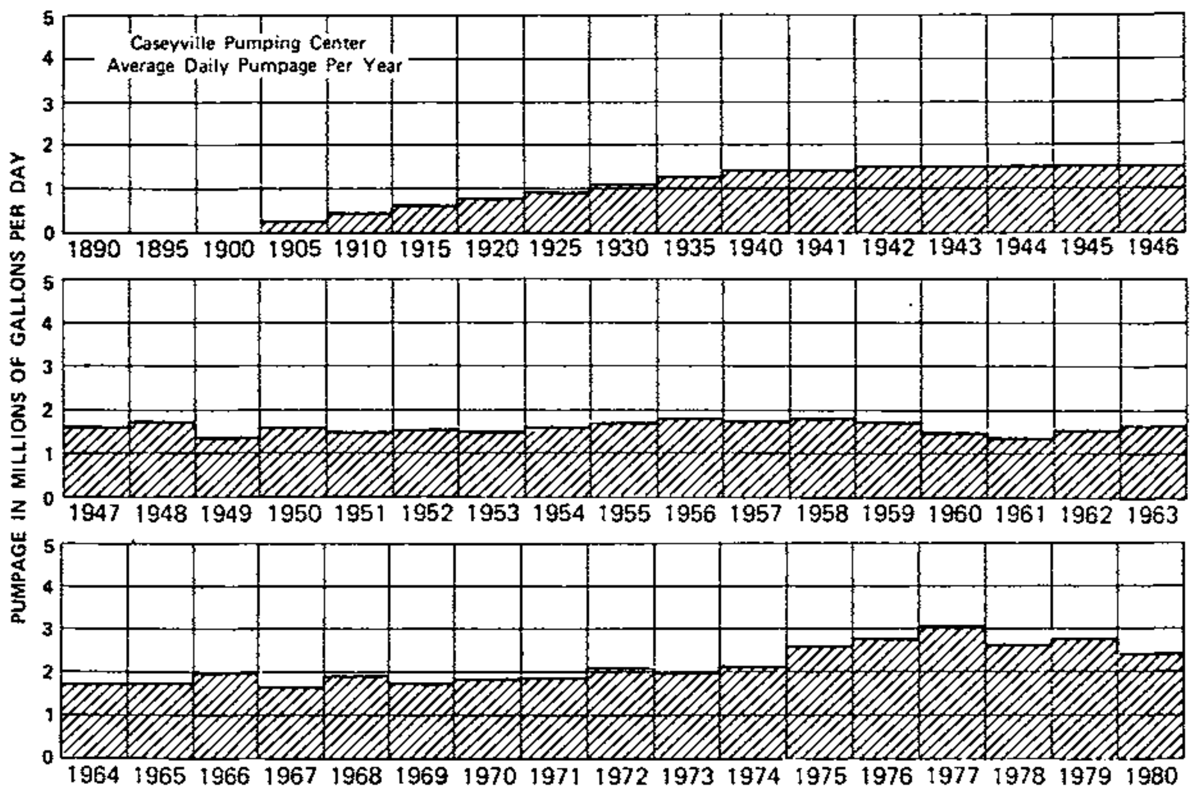


Figure 10. Estimated pumpage in the Caseyville area, 1890-1980.

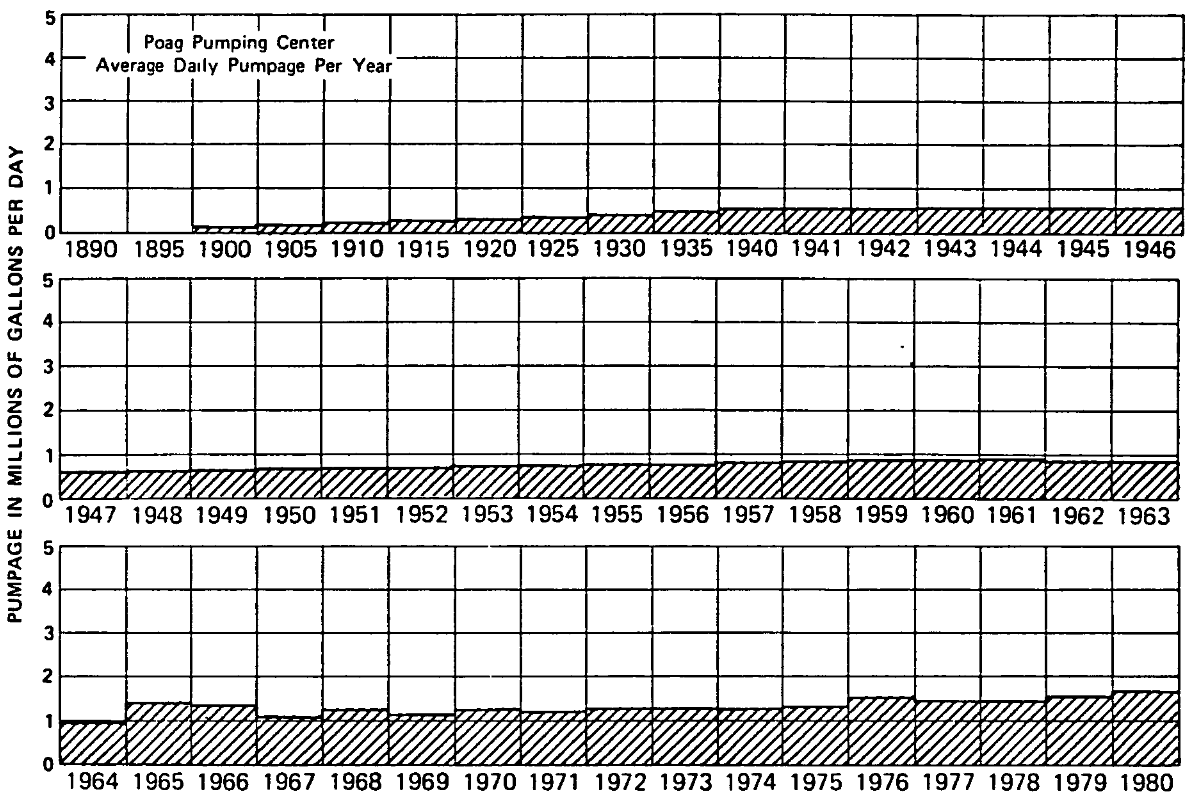


Figure 11. Estimated pumpage in the Poag area, 1890-1980.

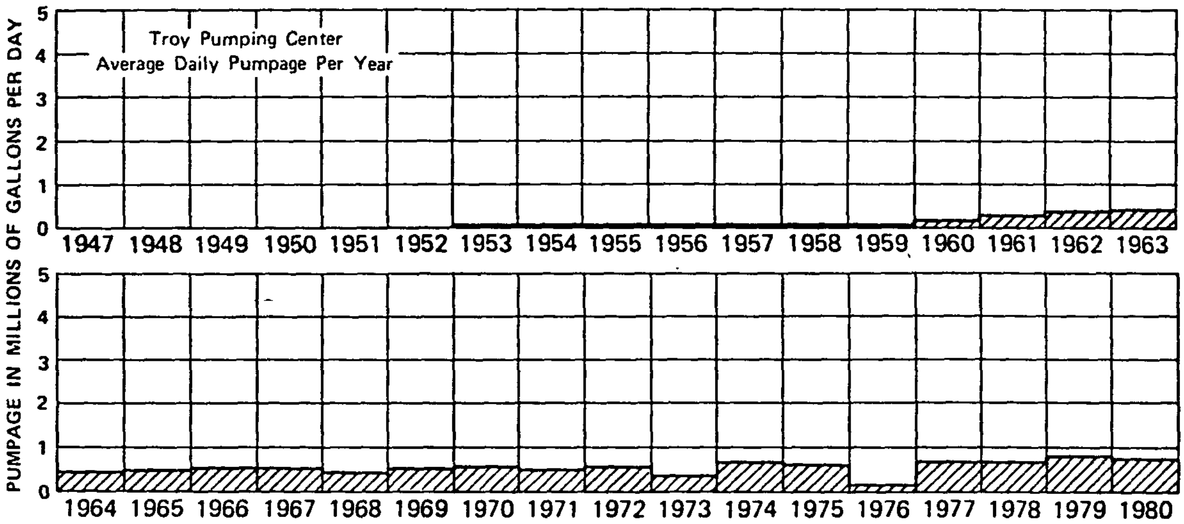


Figure 12. Estimated pumpage in the Troy area, 1890-1980.

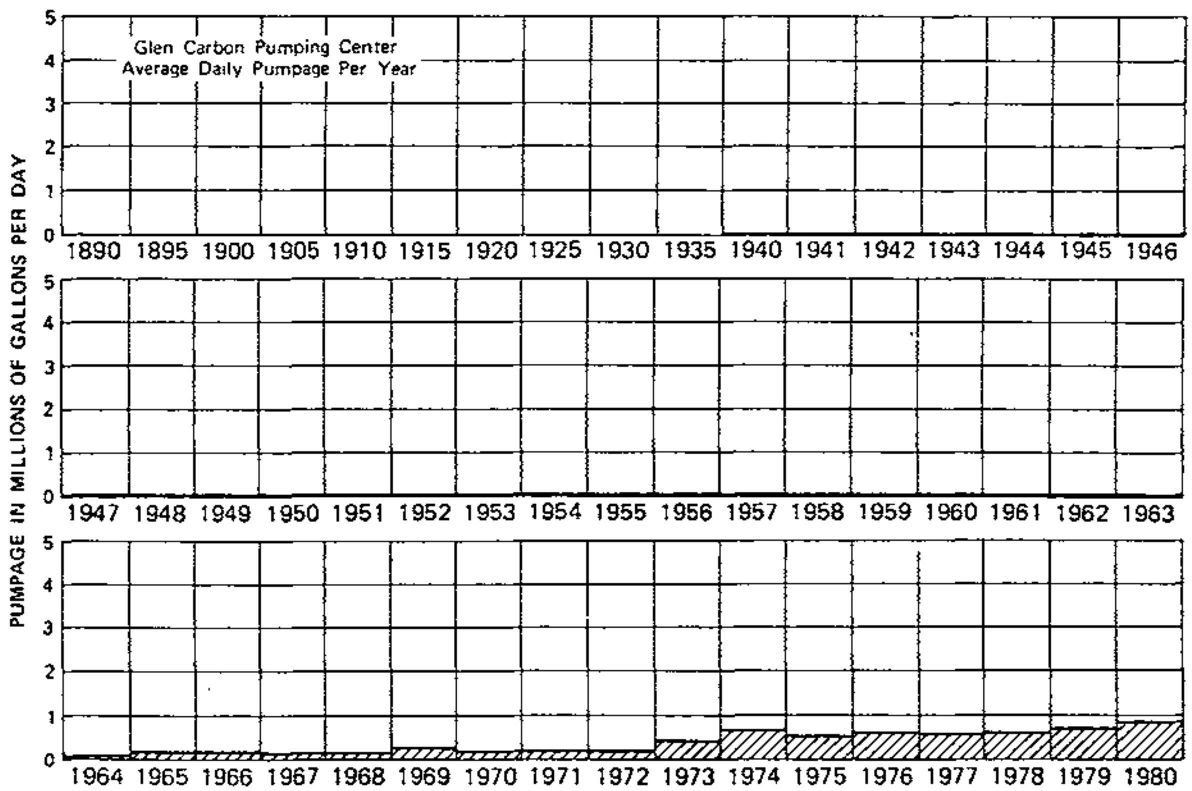


Figure 13. Estimated pumpage in the Glen Carbon area, 1890-1980.

WATER LEVELS IN WELLS

Water levels in wells have been measured periodically for more than 40 years by the State Water Survey and by industries and municipalities in the East St. Louis area. It wasn't until the 1950's, however, that a network of observation wells was established with the main objective of providing data on long-term trends in groundwater levels. Locations of wells in the network are shown in figure 14.

For this report data from 10 observation wells were selected to show effects of pumpage, river stage, and climatic conditions on groundwater levels.

Water levels in the East St. Louis area generally recede in the late spring, summer, and early fall when discharge from the groundwater reservoir by evapotranspiration, by groundwater runoff into streams, and by pumping from wells is greater than recharge from precipitation and induced infiltration of surface water from the Mississippi River and other streams. Water levels generally begin to recover in the early winter when conditions are favorable for the infiltration of rainfall to the water table. The recovery of water levels is especially pronounced during the spring months when the groundwater reservoir receives most of its annual recharge. Maximum and minimum annual water levels are recorded at different times of the year. Water levels are frequently highest in May and lowest in December, depending primarily upon climatic conditions, pumping, and the stage of the Mississippi River.

Most summer and early fall rains have little or no effect on water levels because evapotranspiration and soil-moisture requirements have first priority on rainfall and are often in excess of precipitation. Water levels do rise during some summer months, however, when precipitation is excessive.

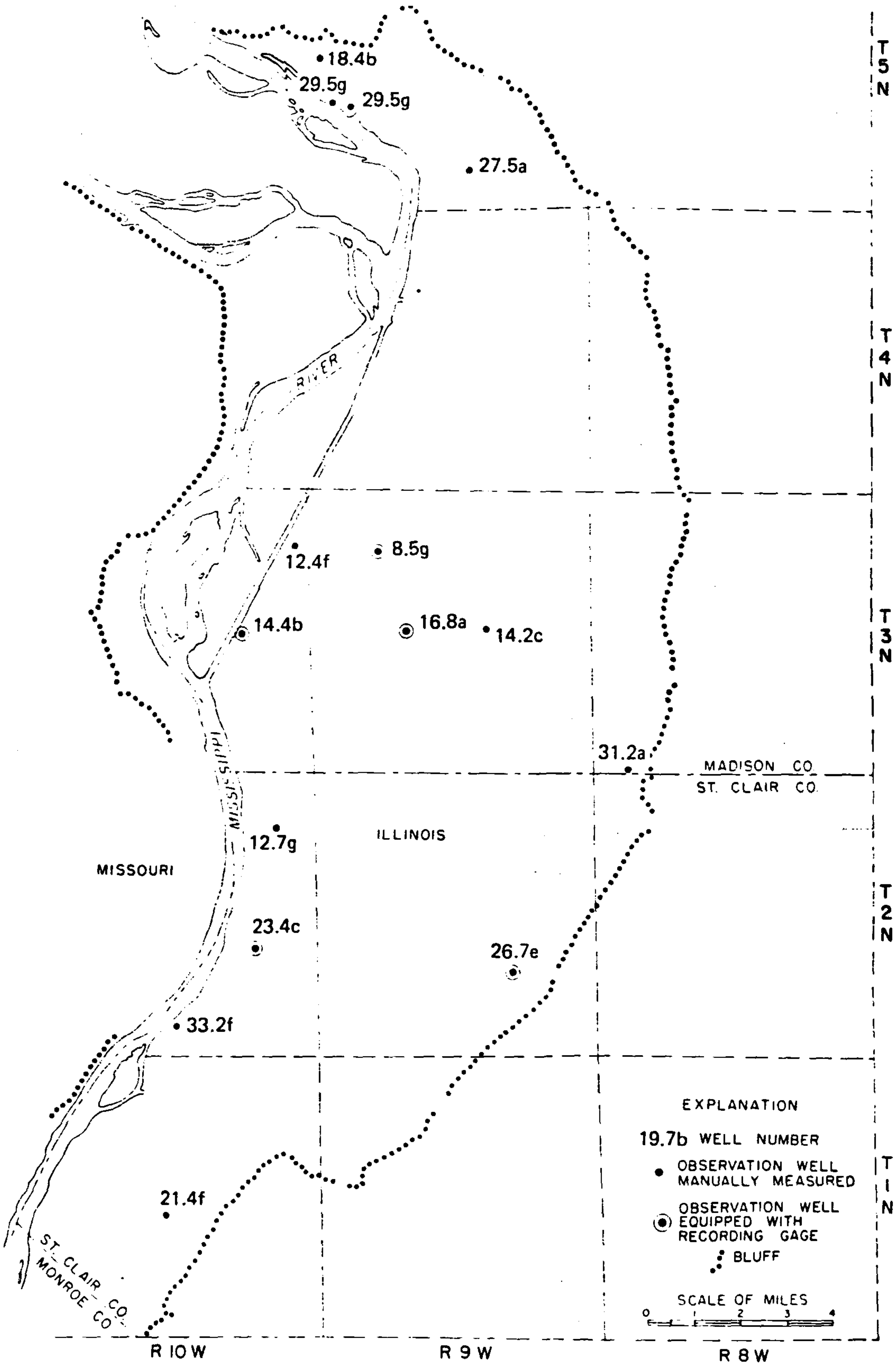


Figure 14. Location of observation wells.

Water levels in three observation wells, Weils MAD 3N8W-31.2a, MAD 3N9W-14.2c, and STC 2N9W-26.7e, reflect changes in water levels mainly due to climatic conditions.

Water levels in Well MAD 3N8W-31.2a have been measured since the summer of 1941 (figure 15). The well is located about 1/2 mile from the bluffs and near the Collinsville Municipal Well Field. Water level records consist of monthly measurements from 1953 to the present. Less frequent measurements were made from 1941-1953. Water levels in this well are affected by climatic conditions and nearby pumpage in the Caseyville area (mainly the Collinsville Municipal Well Field). Pumpage in the area has increased only gradually during the period of water level record and long-term water-level, trends reflect primarily climatic conditions. The effects of drought conditions on water levels are clearly shown during 1952-1956, 1962-1966, 1976-1977, 1980.

Water levels in Well MAD 3N9W-14.2c and monthly precipitation records from the National Weather Service weather stations at Lambert Field in St. Louis are shown in figure 16 for the period 1956-80. Groundwater levels in this well are measured monthly. Water levels reflect climatic conditions although the well is used as an irrigation supply. Measurements are made while the well is inoperative: water levels recover quickly after shut down.

Water levels clearly show the effects of drought conditions in 1956, 1962-1966, 1976-1977, and 1980-1981.

The hydrograph for Well STC 2N9W-26.7e is shown in figure 17. Water levels have been measured since just prior to the 1952-56 drought. The well is equipped with an automatic water level recorder and was drilled for the purpose

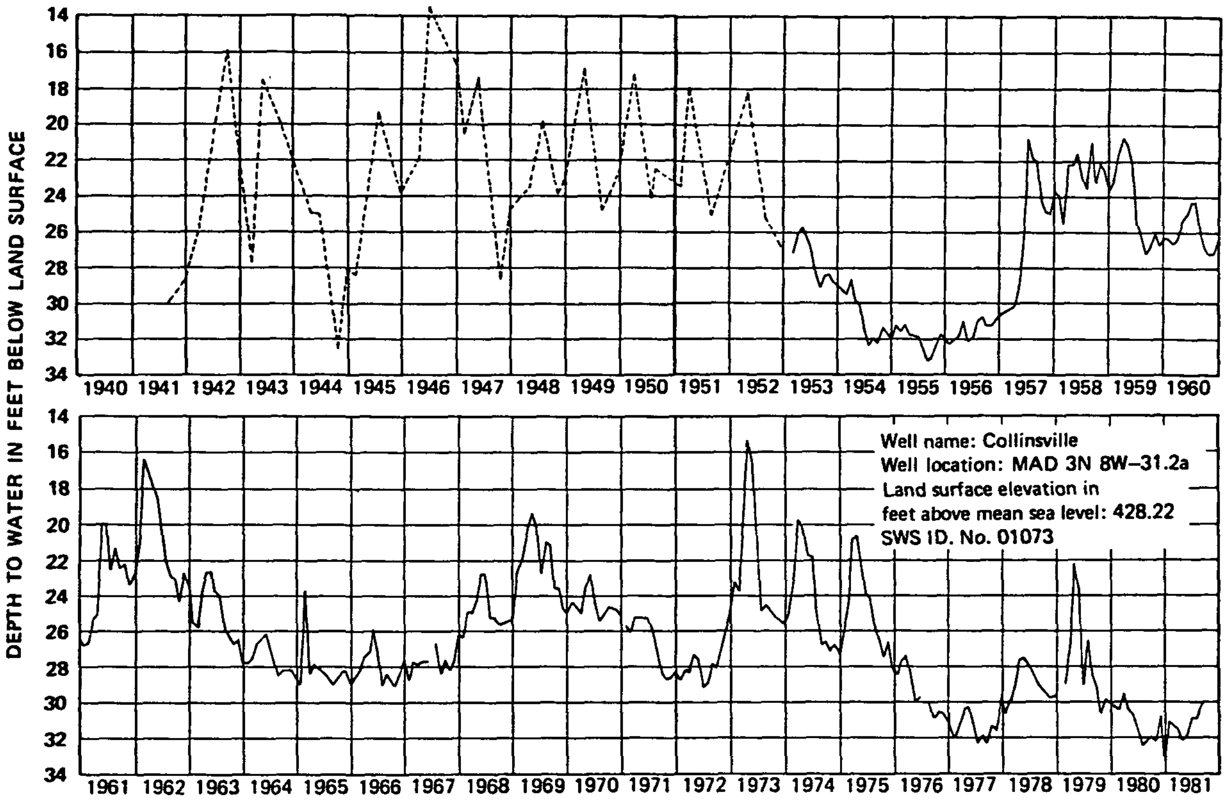


Figure 15. Water levels In Well MAD 3N8W-31.2a, 1940-1981.

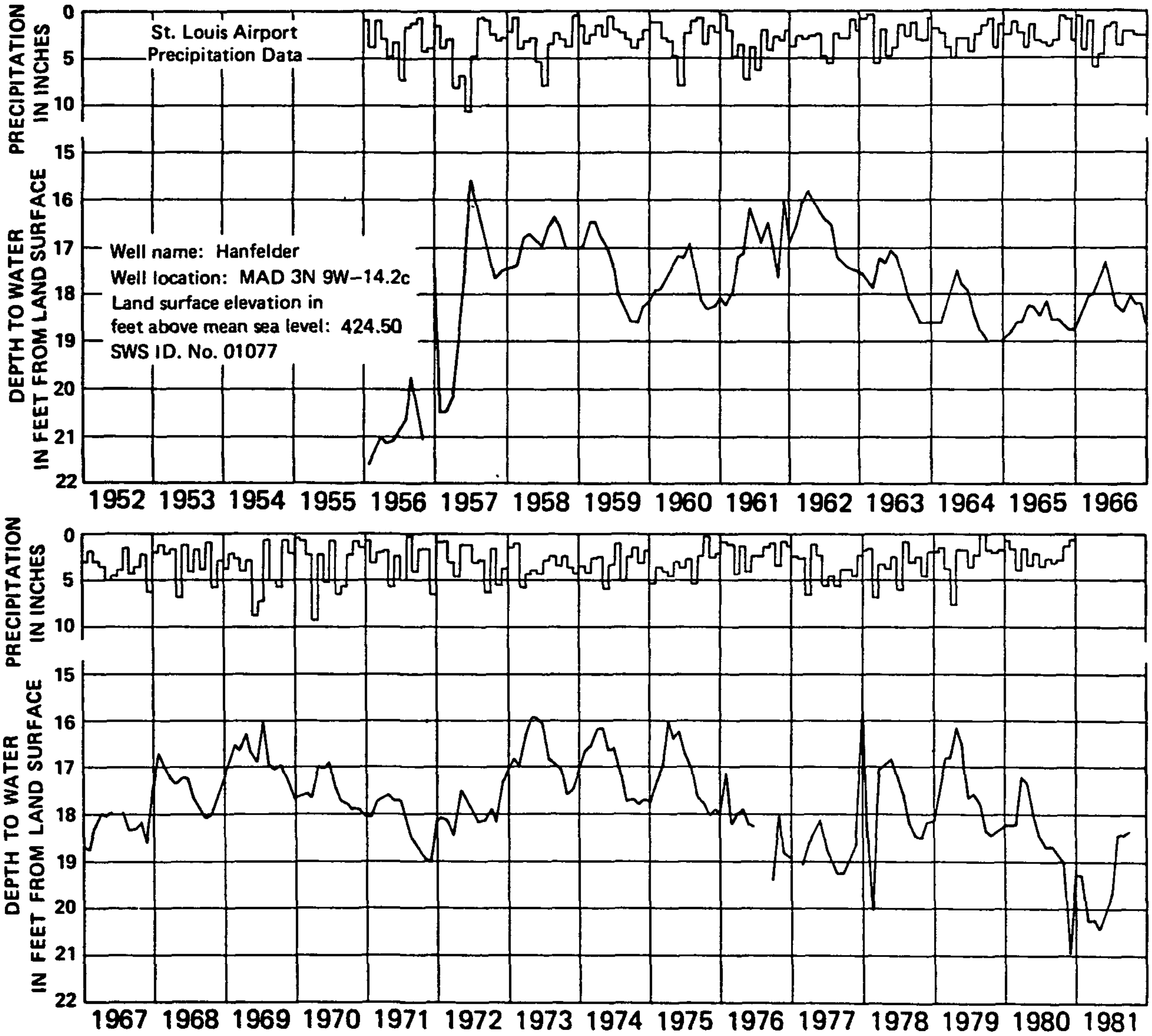


Figure 16. Water levels in Well MAD 3N9W-14.2c and precipitation at St. Louis Airport, 1956-1981.

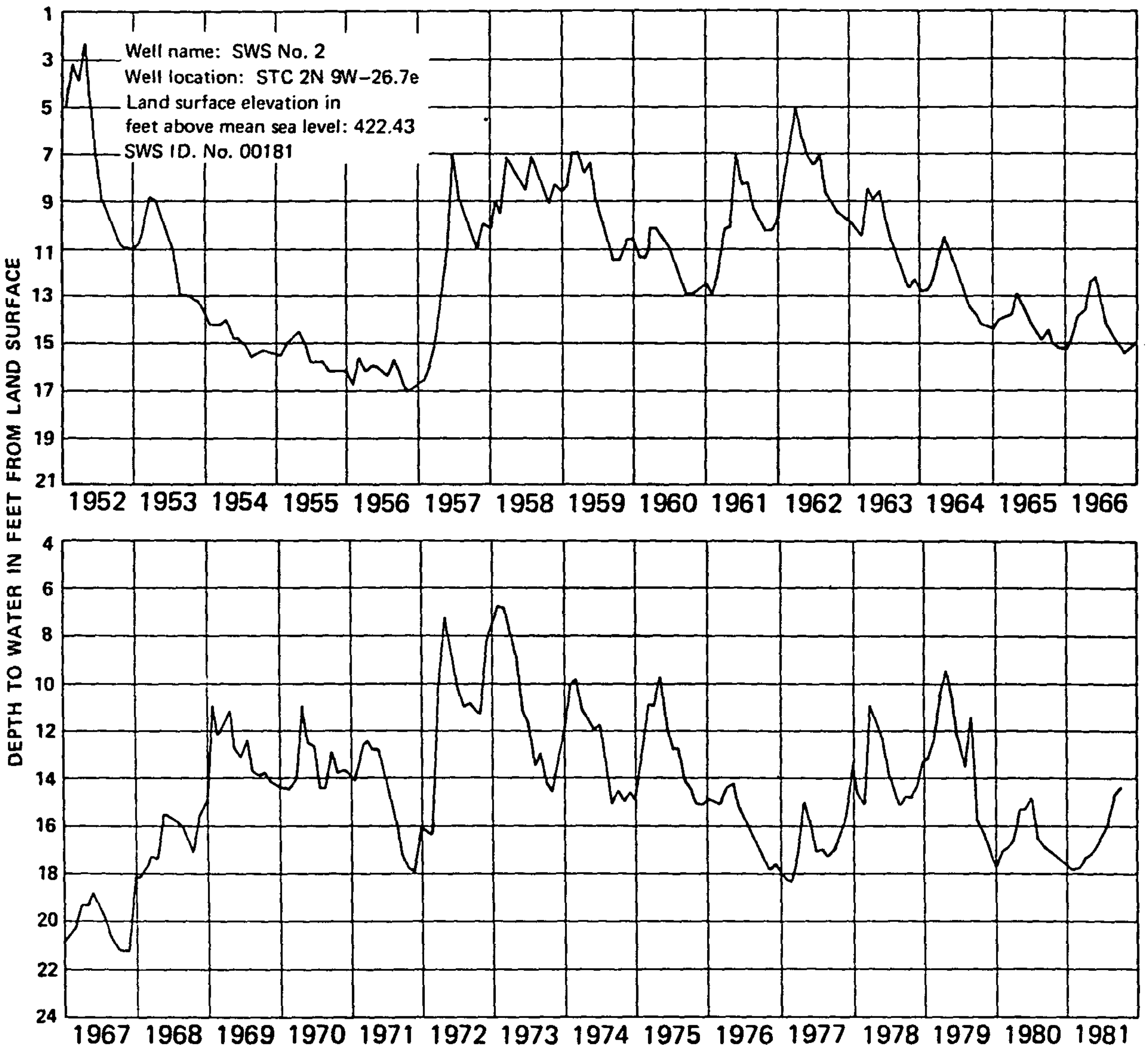


Figure 17. Water levels in Well STC 2N9W-26.7e, 1952-1981.

of observing water levels. It is located about 3/4 of a mile from the bluff. The effects of below normal precipitation from 1952-1956, 1962-1966, 1975-1976, and 1980 are evident.

Water levels in three observation wells, Wells MAD 5N9W-29.4f, MAD 3N10W-12.4f, and STC 2N10W-33.2f, reflect changes in water levels mainly due to changes in river stage.

Observation Well MAD 5N9W-29.4f, a relief well, is located 300 yards from the Mississippi River. It has been equipped with an automatic water level recorder since 1956. A hydrograph of groundwater levels for this well is shown in figure 18. Although near a large pumping center water levels in this well largely reflect changes in the stage of the Mississippi River. Annual water level fluctuations have ranged from a low of 6 feet per year in 1968 to a high of 19 feet in 1960. Water levels were probably above land surface during the 1973 flood. The lowest water level on record was measured early in 1957.

Observation Well MAD 3N10W-12.4f is a relief well located approximately 100 yards from the Chain of Rocks Canal. Water level records consist of monthly measurements from 1953 to the present. Water levels (figure 19) in this well largely reflect changes in river stage. The lowest annual water level fluctuations was recorded in 1968, 2 1/4 feet, the highest was recorded in 1960, about 13 feet; the same years as for Well MAD 5N9W-29.4f. Groundwater levels as a result of high river stages were above land surface in 1960, 1961, 1969, 1970, 1973, 1974, and 1975. The lowest water level was recorded in 1957.

Water levels measured in Observation Well STC 2N10W-33.2f from the latter part of 1950 to the present are shown in figure 20. Records consist of monthly

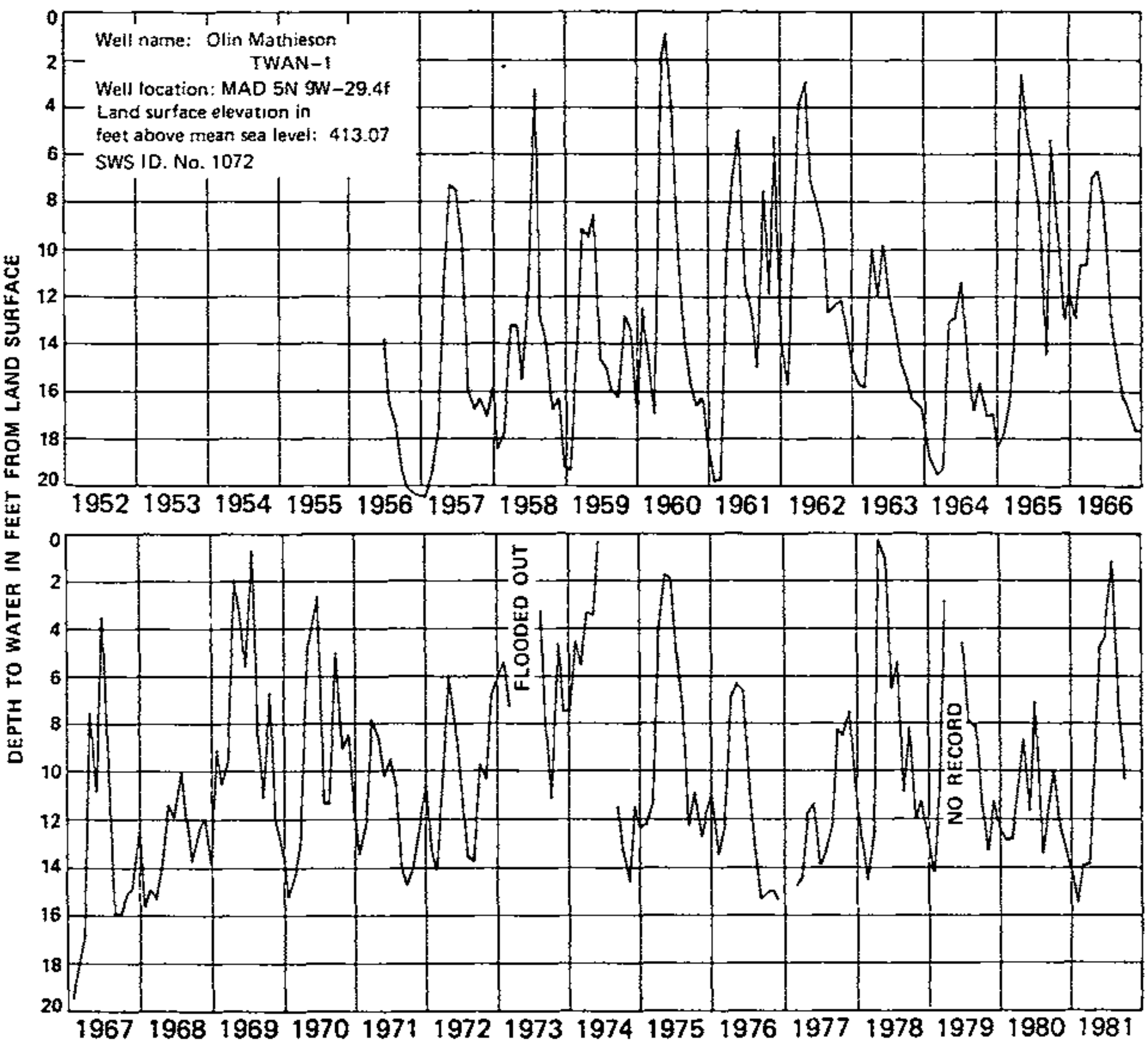


Figure 18. Water levels in Well MAD 5N9W-29.4f, 1956-1981.

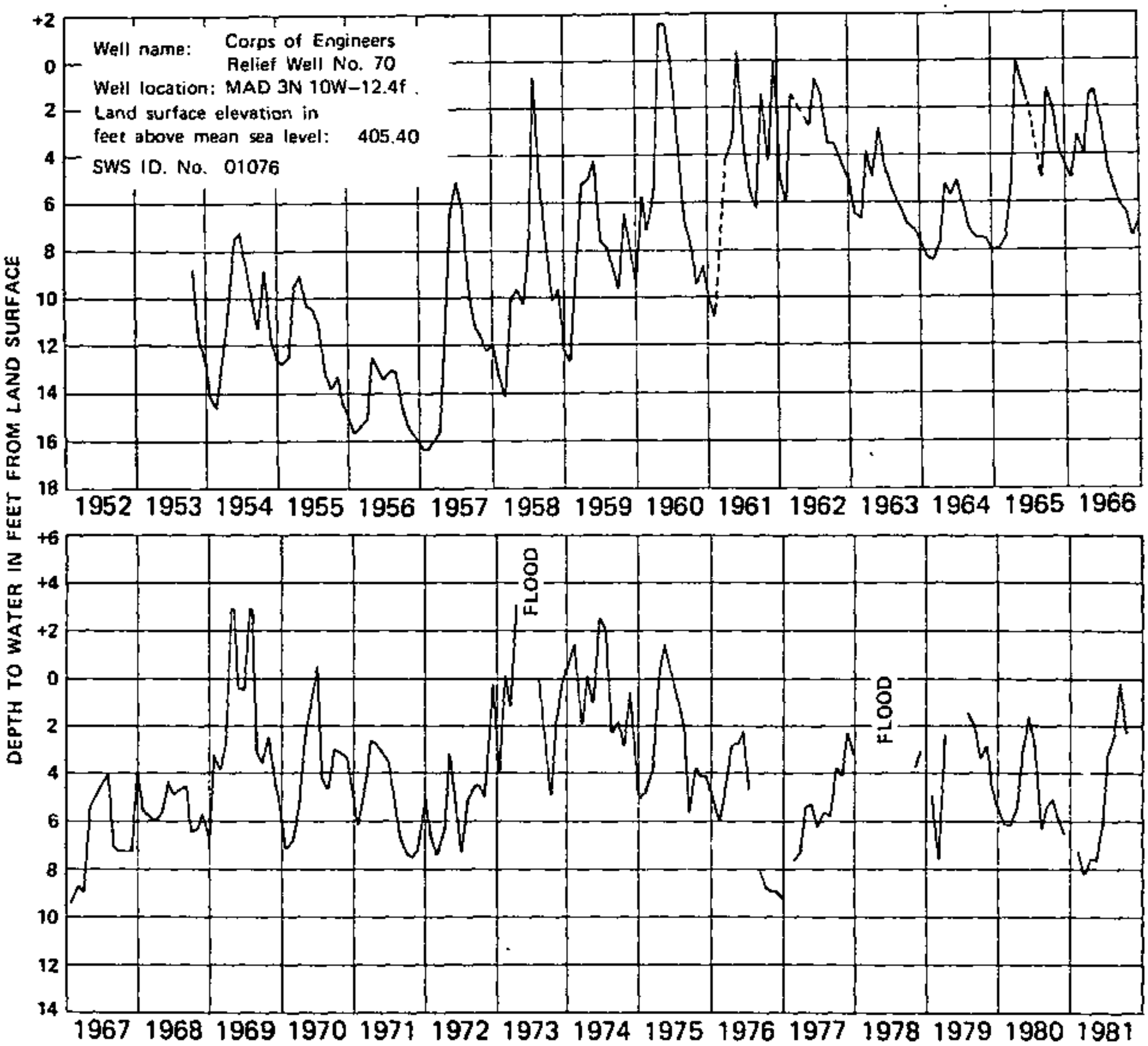


Figure 19. Water levels in Well MAD 3N10W-12.4f, 1953-1981.

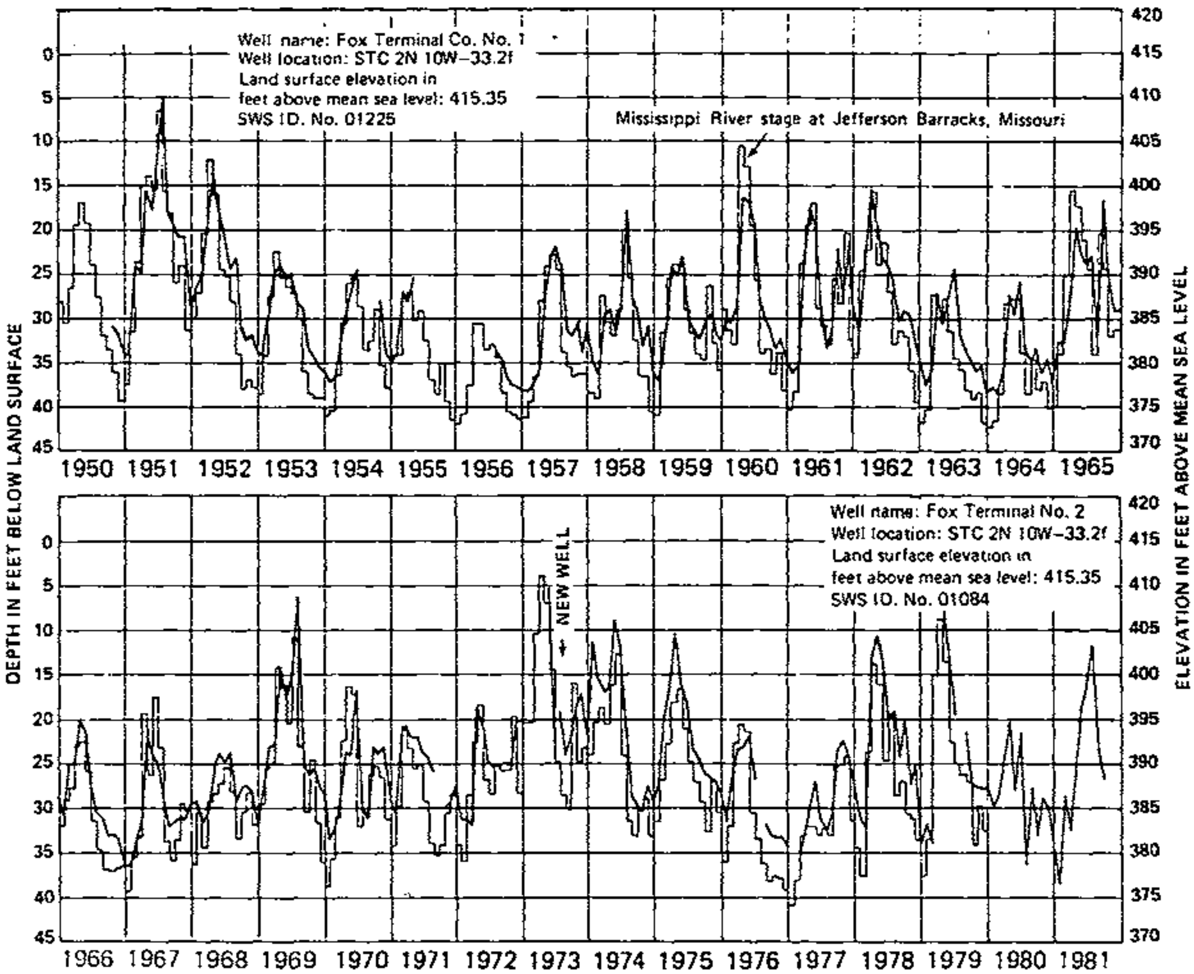


Figure 20. Water levels in Well STC 2N10W-33.2f and Mississippi River stages at Jefferson Barracks, 1950-1981.

water level measurements. The well is a supply well, that is used infrequently, located approximately 100 yards from the river. The maximum annual recorded fluctuation, 30 feet, occurred in 1951. The minimum 18 feet occurred in 1968. The highest recorded level, less than 5 feet below land surface, occurred in 1973. The lowest, 38 feet below land surface, occurred in 1964 and 1981.

A comparison with river stages measured near Jefferson Barracks shows the relationship between river stages and groundwater levels in an area remote from a large pumping center. During periods of high river stages, groundwater levels are generally at a lower elevation than the river. The opposite is generally true during periods of low river stage.

Observation Well MAD 3N9W-8.5g is located about 2 1/2 miles northeast of the Granite City Pumping Center. The well was constructed for the State of Illinois for the purpose of observing water levels and has been equipped with an automatic water level recorder since 1952. A new well, SWS No. 3 (P3B), was drilled in 1979 to replace SWS No. 3. SWS No. 3 was filled to allow paving for a parking lot. The wells were measured concurrently for several months to detect differences in water levels. There were no measurable differences. The hydrograph of water levels in the well is shown in figure 21. Water levels in Well 8.5g are affected mainly by climatic conditions and pumpage at Granite City. The lowest recorded water levels occurred in the late winter of 1957 after the drought of 1952-56 and during the peak period of pumpage at Granite City. Groundwater levels recovered after 1957 as recharge from precipitation increased and pumpage at Granite city declined. The highest groundwater levels were recorded in 1973, 1974, and 1975 due to above normal recharge conditions.

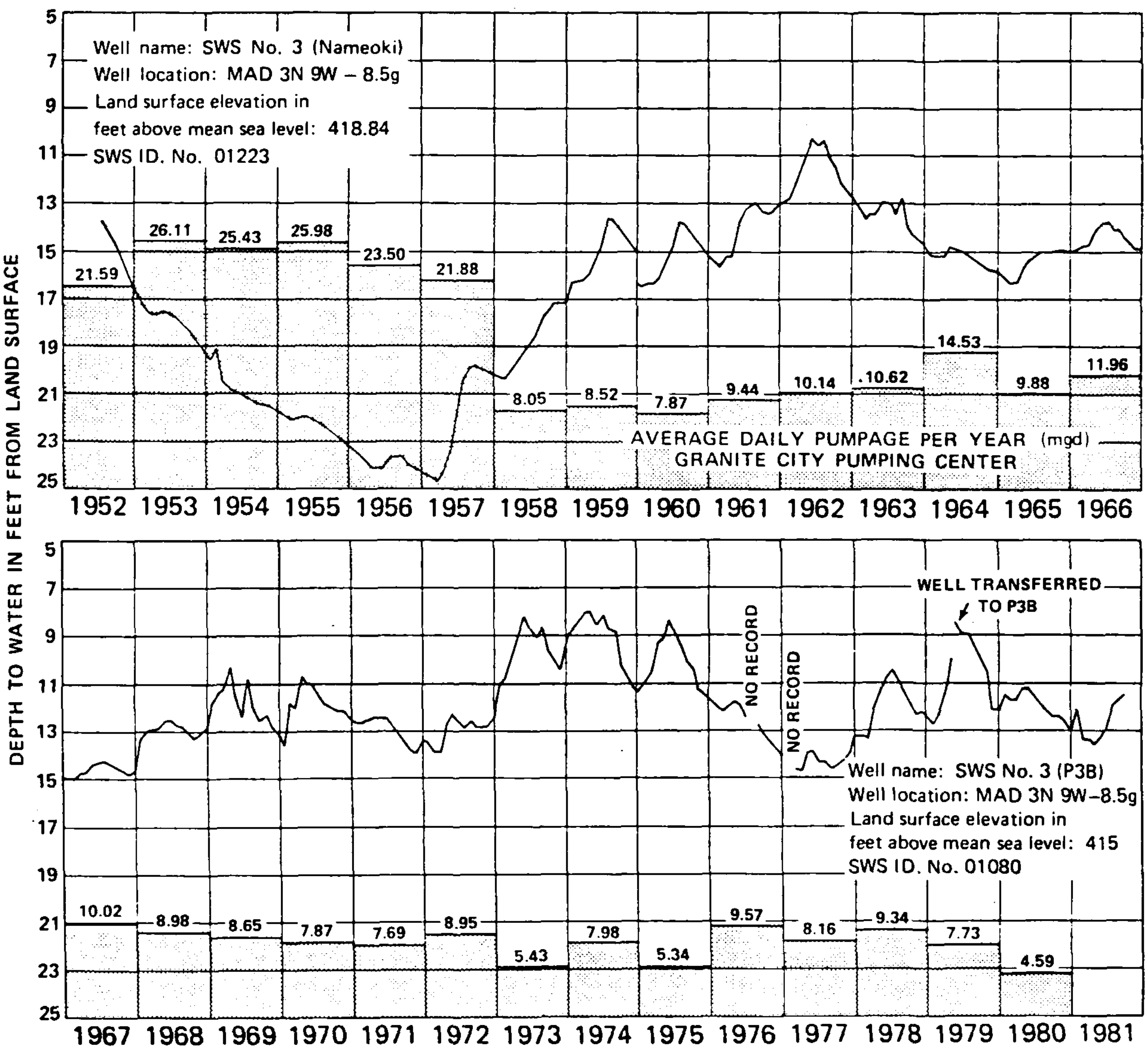


Figure 21. Water levels in Well MAD 3N9W-8.5g and pumpage in Granite City, Pumping Center, 1952-1981.

Well 14.4b is a relief well equipped with an automatic water level recorder since 1953 and is located about 150 yards from the Chain of Rocks Canal. It is near Locks and Dam 25 and about 1 mile west of the Granite City Pumping Center. Groundwater levels shown in figure 22 reflect changes in river stage and pumpage. Groundwater levels declined from 1953 to the early part of 1957 due to low river stages and increased pumpage in Granite City. As pumpage at Granite City declined from 1957-1960 water levels recovered. The highest groundwater levels were recorded in 1974. Water levels were probably higher during 1973, however, because of flooding conditions. During part of the year the well was not accessible and water levels were not measured.

Observation Well STC 2N10W-12.7g, an abandoned supply well, is located in the National City Pumping Center about 3/4 of a mile from the Mississippi River. Water level records consist of measurements made monthly. Water levels (figure 23) are affected by climatic conditions, nearby groundwater withdrawals, and changes in river stage. The effects of river stage changes on water levels are less evident compared to Wells 29.4f, 12.4f, 14.4b, and 33.2f because of the greater distance from the river. Groundwater levels were highest in 1973 and 1979. The lowest recorded water level was recorded in the late winter of 1957. The highest water level was recorded in May 1973.

Observation Weil STC 2N10W-23.4c, an abandoned supply well, was located approximately 1/2 mile from the Mississippi River and immediately west of the Monsanto Pumping Center. The well was equipped with an automatic water level recorder. Water levels are affected by climatic conditions, nearby groundwater withdrawals, and changes in river stage. Water level records for the period 1943 through 1974 are shown in figure 24. Unfortunately, the well was

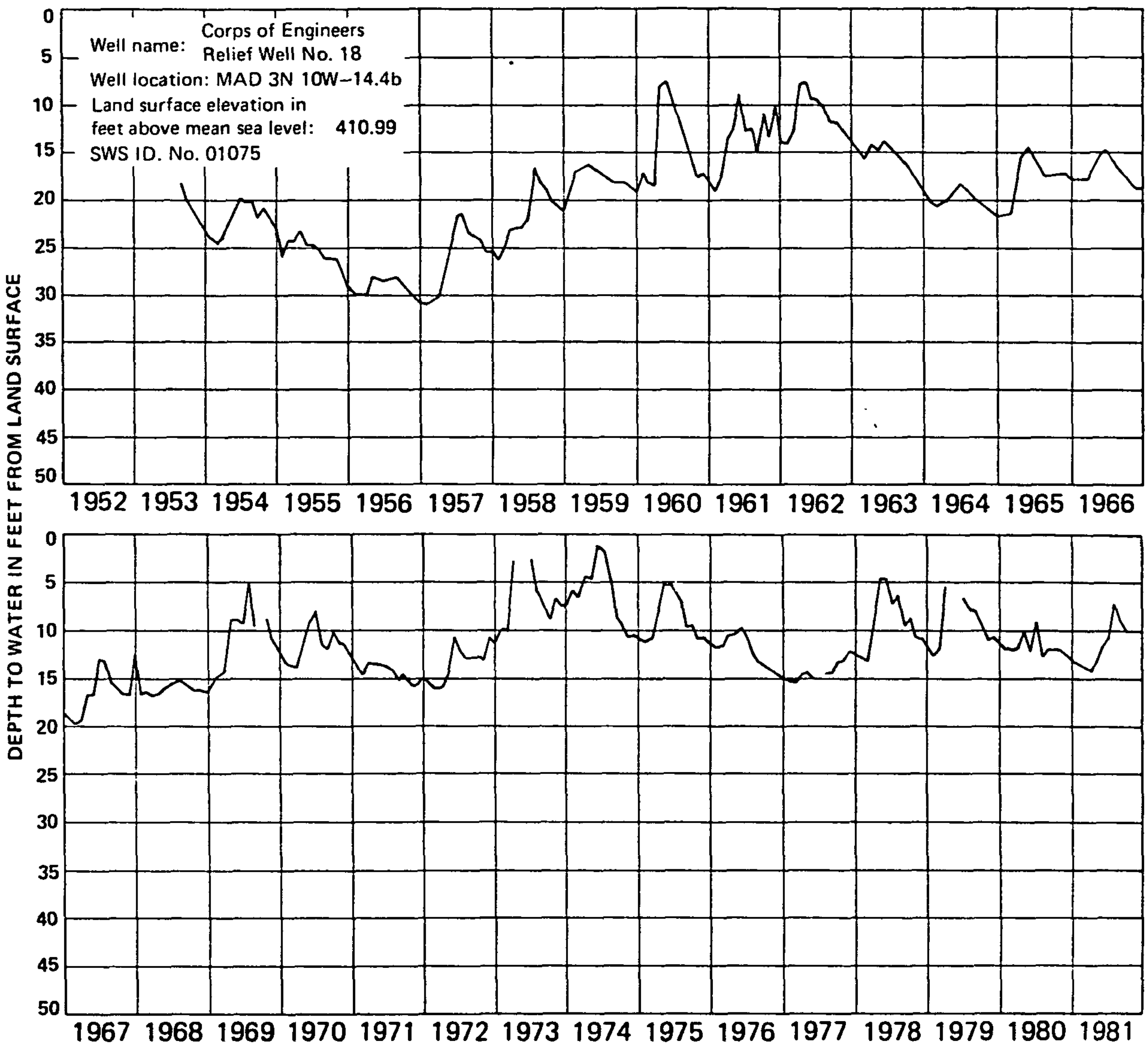


Figure 22. Water levels in Well MAD 3N10W-14.4b, 1952-1981.

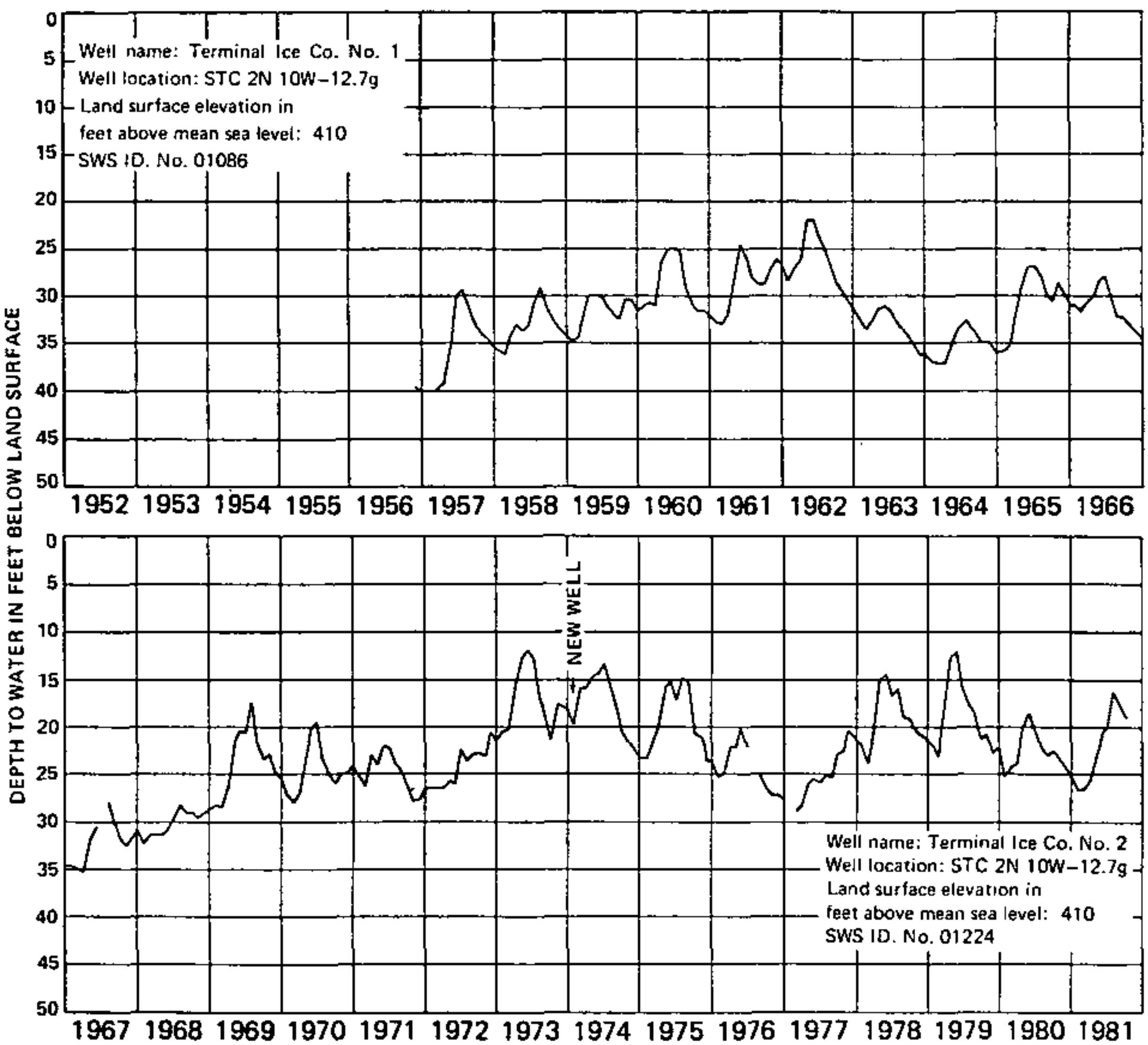


Figure 23. Water levels in Well STC 2N10W-12.7g, 1956-1981.

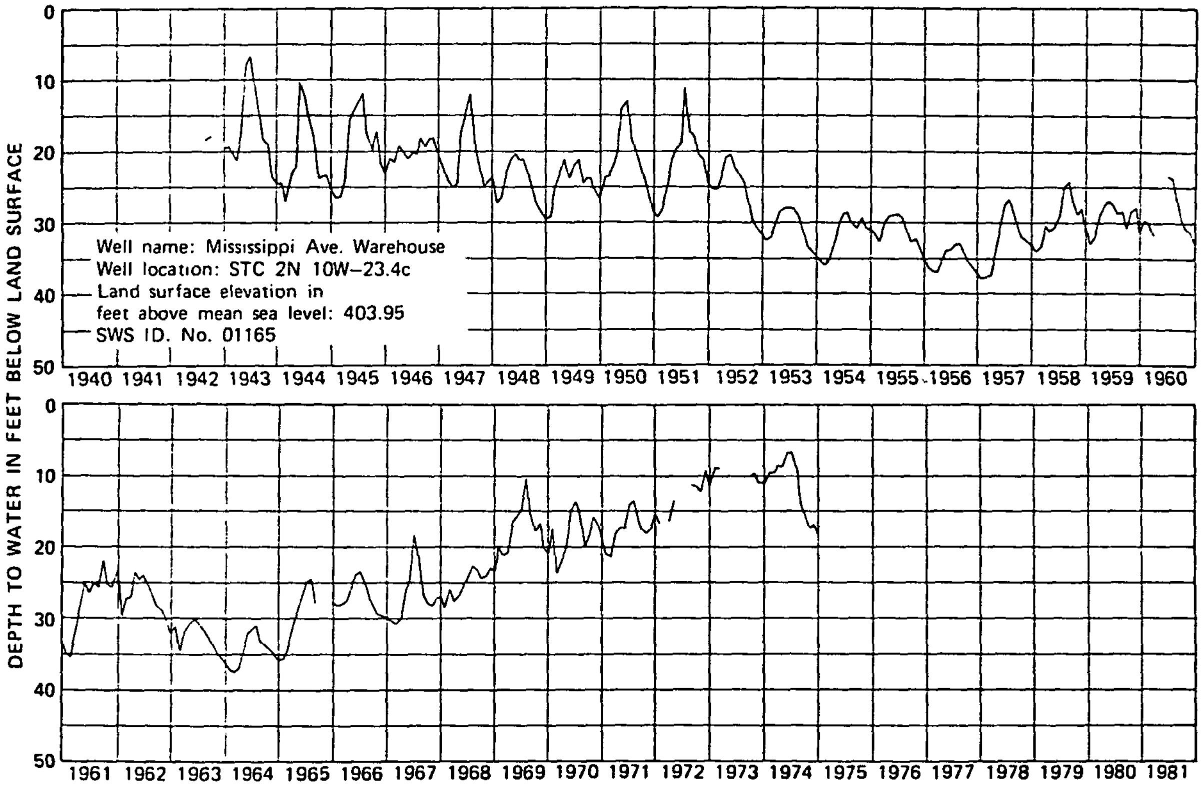


Figure 24. Water levels in Well STC 2N10W-23.4c, 1943-1974.

destroyed in 1975. Water levels in Well 23.4c reflect changes in river stage, groundwater withdrawals, and climatic conditions.

LONG-TERM PRECIPITATION AND RIVER STAGE RECORDS

Annual precipitation at Edwardsville and St. Louis Airport and river stages from 1940-80 are shown in figures 25, 26 and 27 respectively.

PIEZOMETRIC SURFACES

The piezometric surface of the sand and gravel aquifer in the East St. Louis area is known from interpretation of nonpumping water levels measured in wells by State Water Survey staff. Thirteen piezometric surfaces are available. The dates for which piezometric surface maps are available are given below.

Date	Reference
November, 1951	Bruin and Smith (1953)
December, 1956	Schicht and Jones (1962)
June, 1961	Schicht and Jones (1962)
November, 1961	Schicht and Jones (1962)
June, 1962	Schicht (1964)
November, 1966	Reitz (1968)
November, 1971	Baker (1972)
June, 1973	Schicht (1974)
September, 1973	Schicht (1974)
June, 1974	Water Survey Files
September, 1974	Water Survey Files
November, 1977	Emmons (1977)
November, 1980	Richards and Sanderson (in review)

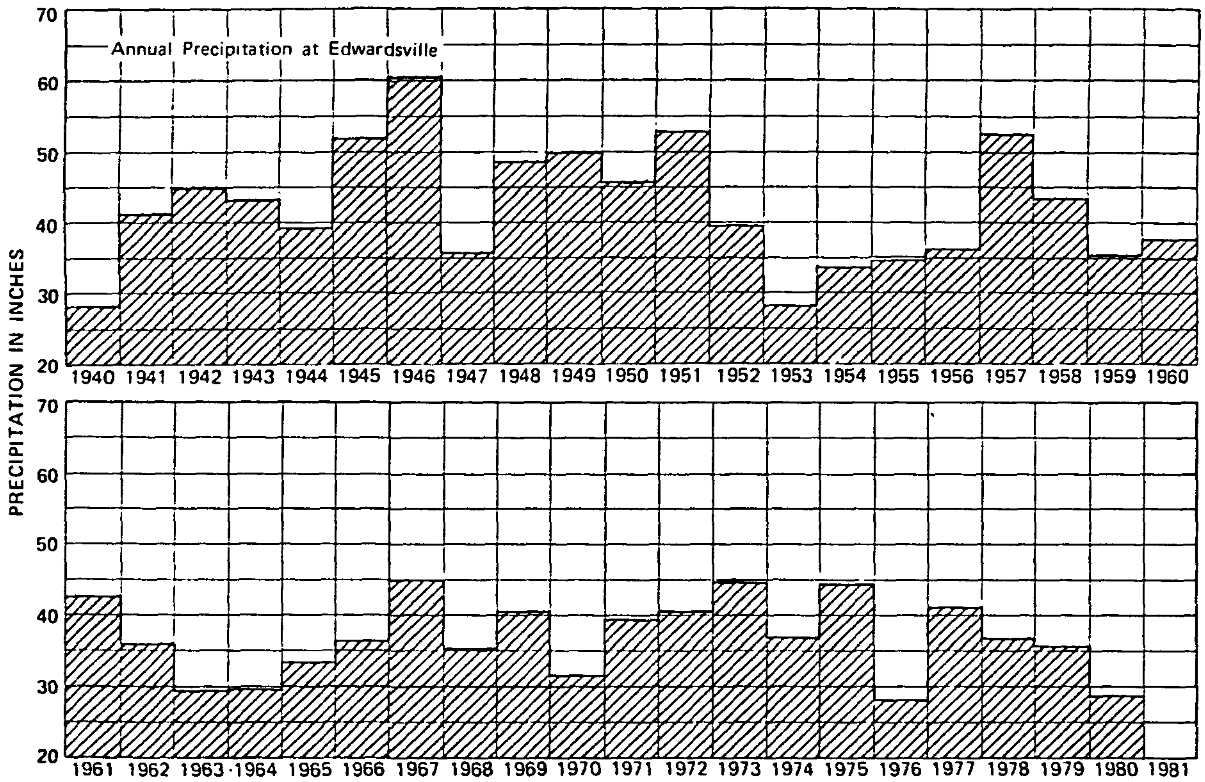


Figure 25. Annual precipitation at Edwardsville, 1940-1980.

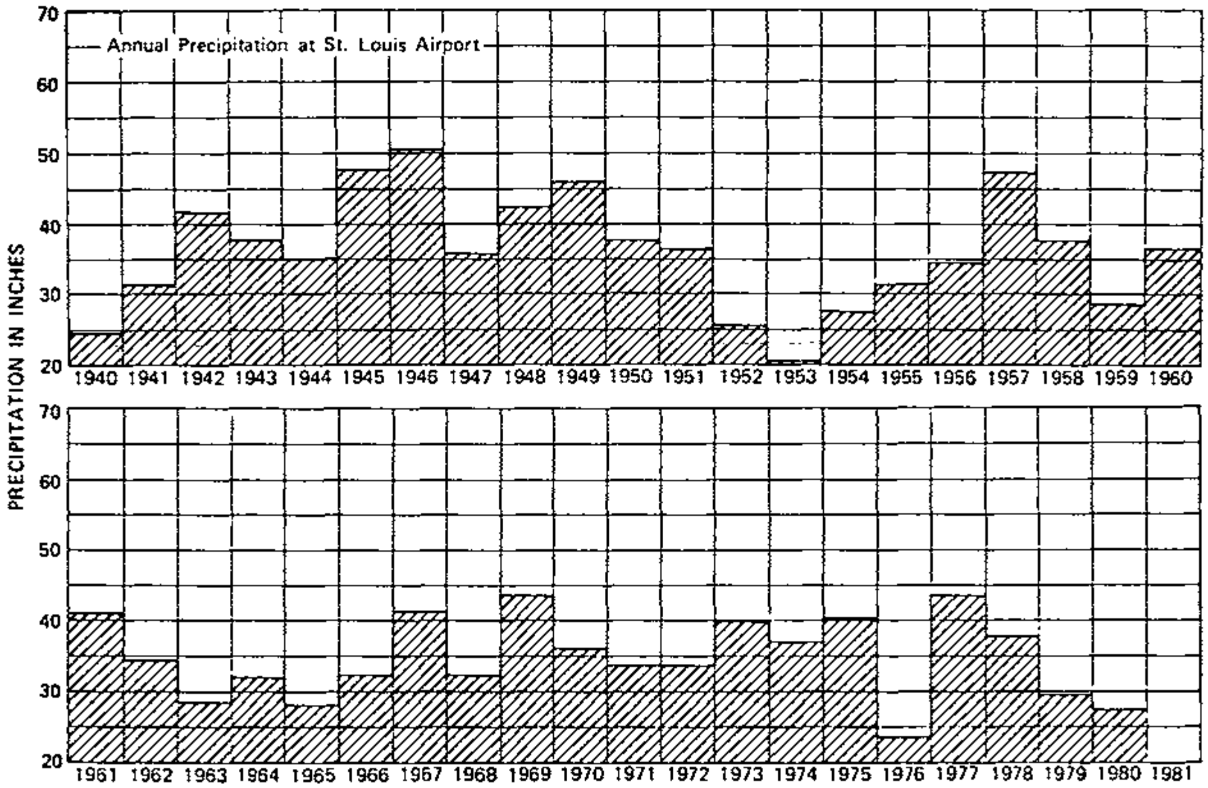


Figure 26. Annual precipitation at St. Louis Airport, 1940-1980.

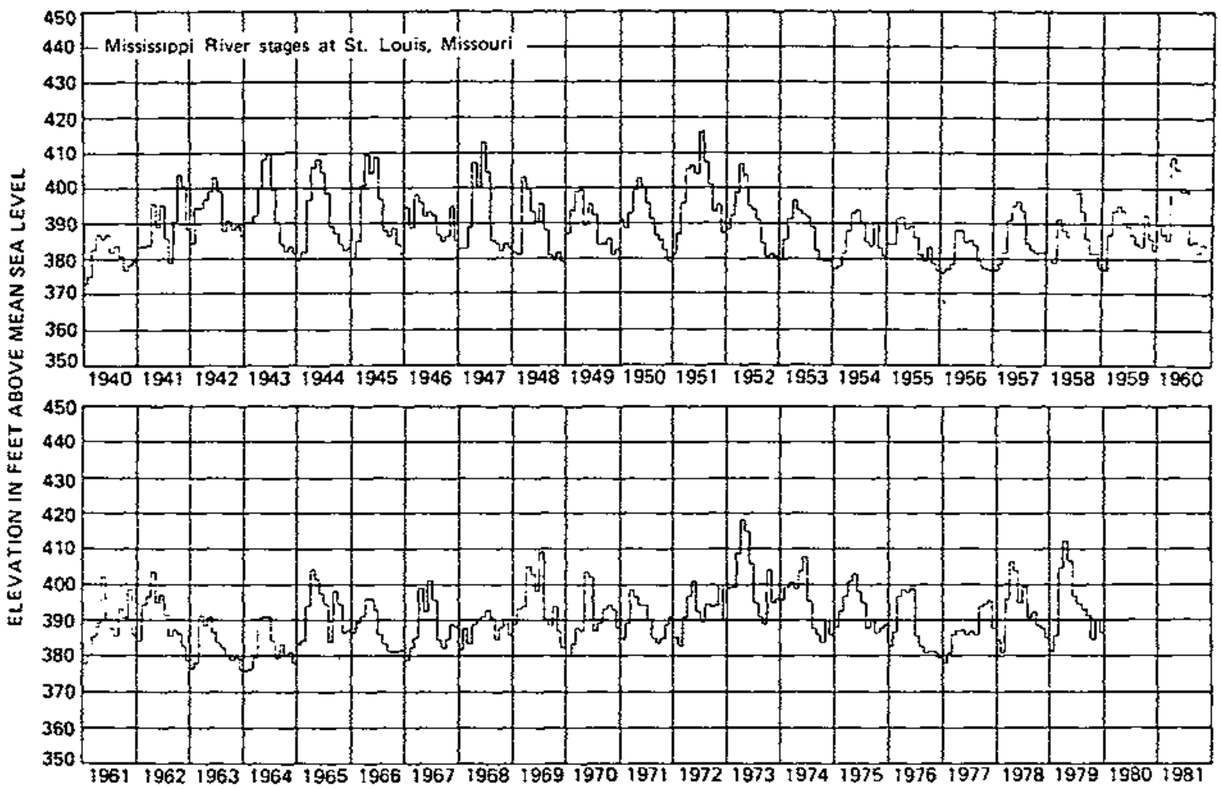


Figure 27. Monthly Mississippi River stages at St. Louis, 1940-1980.

A 14th piezometric surface map (figure 28) is available (Schicht and Jones, 1962), showing the estimated elevation of the piezometric surface maps about 1900. This map was based on interpretation of the early drainage system and data in Bowman and Reeds (1907).

Prior to the settlement of the East St. Louis area, the water table was very near the surface and shallow lakes, ponds, swamps, and poorly drained areas where widespread. Flood waters from the Mississippi River, Wood River, Cahokia Creek, Canteen Creek, Schoenberger Creek, and Prairie Du Pont Creek frequently inundated large sections of the lowlands. The general direction of movement of groundwater was west and south toward the Mississippi River and other streams and lakes.

Figure 28 depicts the surface drainage system in 1900 and the estimated piezometric surface prior to heavy industrial development. The piezometric surface sloped from an estimated elevation of about 420 feet near the bluffs to about 400 feet near the Mississippi River. The average slope of the piezometric surface was about 3 feet per mile; however, the slope ranged from 6 feet per mile in the Alton area to 1 foot per mile in the Dupo area. The slope of the piezometric surface was greatest near the bluffs.

Development of the East St. Louis area led to the construction of levees and drainage ditches and subsequent change in groundwater levels. The present drainage system is shown in figure 29. Bruin and Smith (1953) estimated that the natural lake area has been reduced by more than 40 percent between 1907 and 1950 and that probably 40 miles of improved drainage ditches had been constructed during the same period. They further estimated that these developments caused lowering of groundwater levels by 2 to 12 feet. In addition, the establishment of industrial centers and the subsequent use of large quantities of groundwater by industries and municipalities has lowered

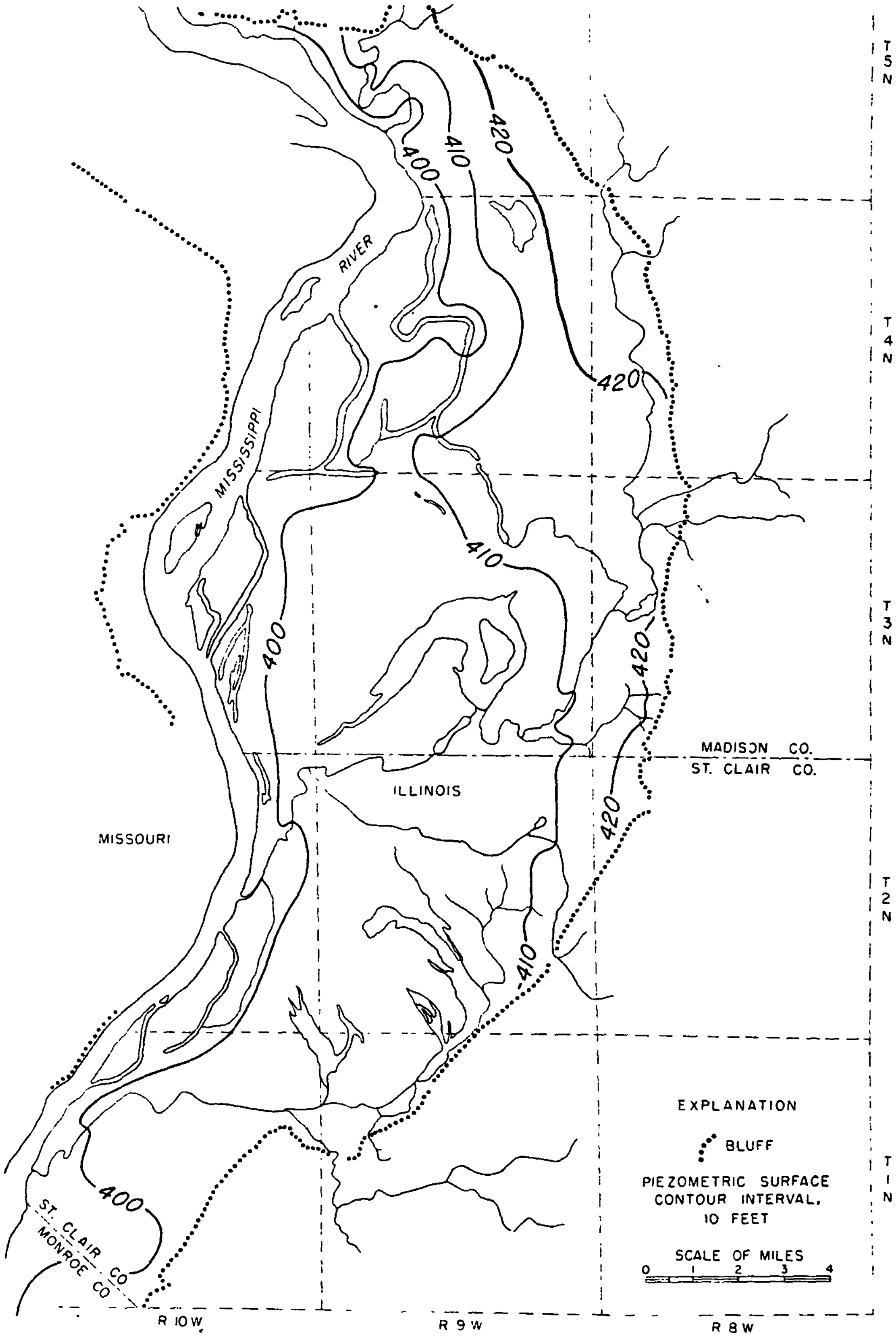


Figure 28. Drainage system and estimated elevation of piezometric surface about 1900.

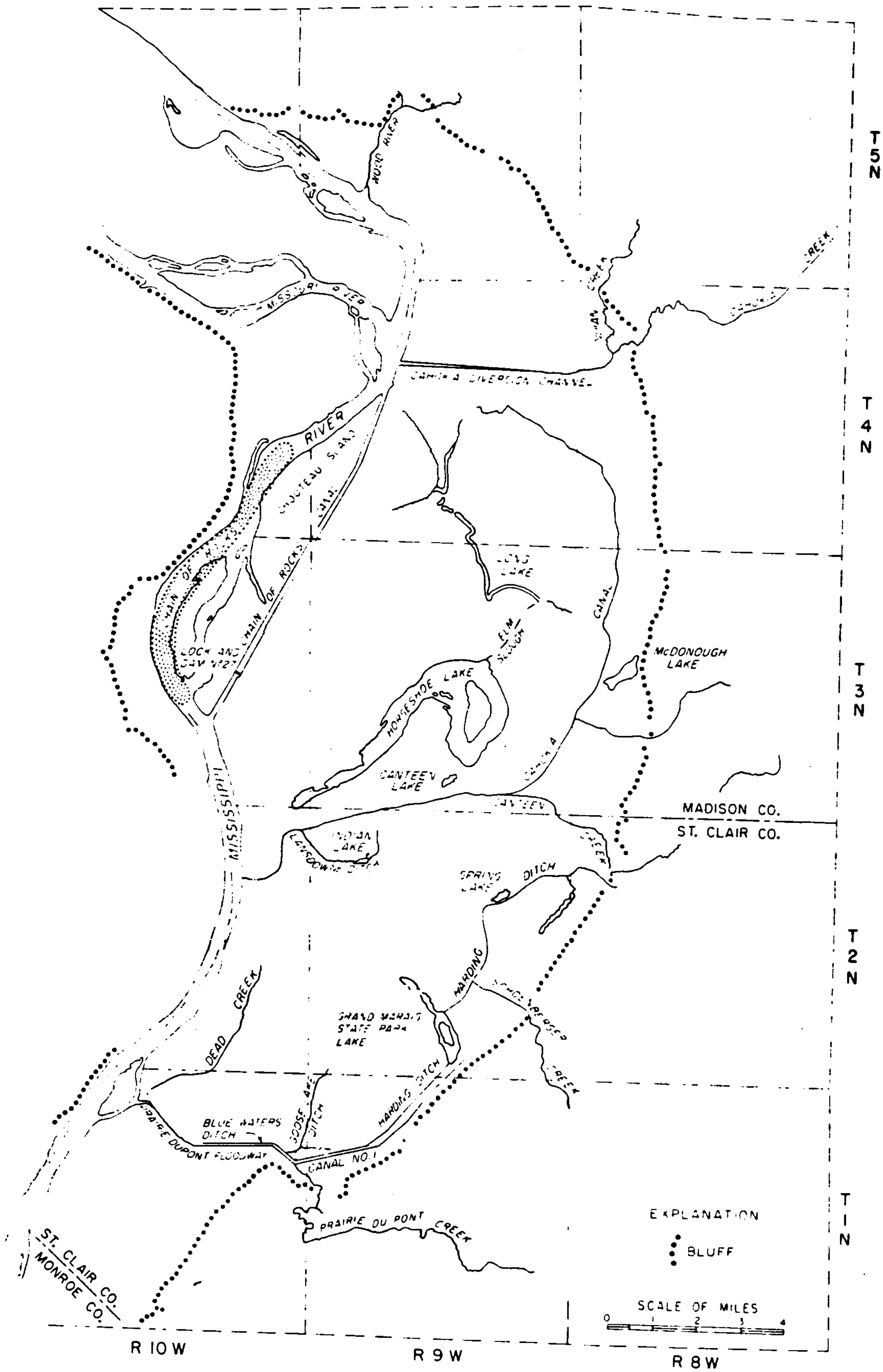


Figure 29. Drainage system.

water levels appreciably in the Alton, Wood River, Granite City, National City, East St. Louis, and Monsanto areas. Lowering of water levels caused by withdrawals of groundwater has also been experienced in the Poag, Caseyville, Glen Carbon, Troy, and Fairmont City areas.

From 1952 to 1956 water levels declined appreciably in the East St. Louis area as the result of drouth conditions, low Mississippi River stages, and record high groundwater withdrawals. Figure 30 shows the piezometric surface in December 1956, when water levels were at record low stages at many places.

The illustration shows clearly the cones of depression in the piezometric surface which have developed as the result of heavy pumping. It will be noted that a considerable lowering has taken place in the piezometric surface since 1900. In 1956 the deepest cone of depression was in the Granite City area. Other pronounced cones are centered in major pumping centers.

The piezometric surface map for November 1961 (figure 31) is similar in many respects to the piezometric surface map for December 1956. A significant difference is that the cone of depression in the Granite City area was much deeper in 1956 than 1961. Largely due to a significant reduction in groundwater pumpage in the vicinity of Granite City (Schicht and Jones, 1962) groundwater levels recovered more than 50 feet. Other differences are that groundwater levels were generally lower in the vicinity of streams and lakes in 1956 than they were in 1961 and the development of a small deep cone of depression about 1.5 miles west of the main Monsanto cone of depression due to the establishment of a new pumping center.

The features of the November 1961 and November 1966 (figure 32) maps were generally the same except in the vicinity of the Monsanto area. In November 1961 two cones of depression were located in the Monsanto area. Water

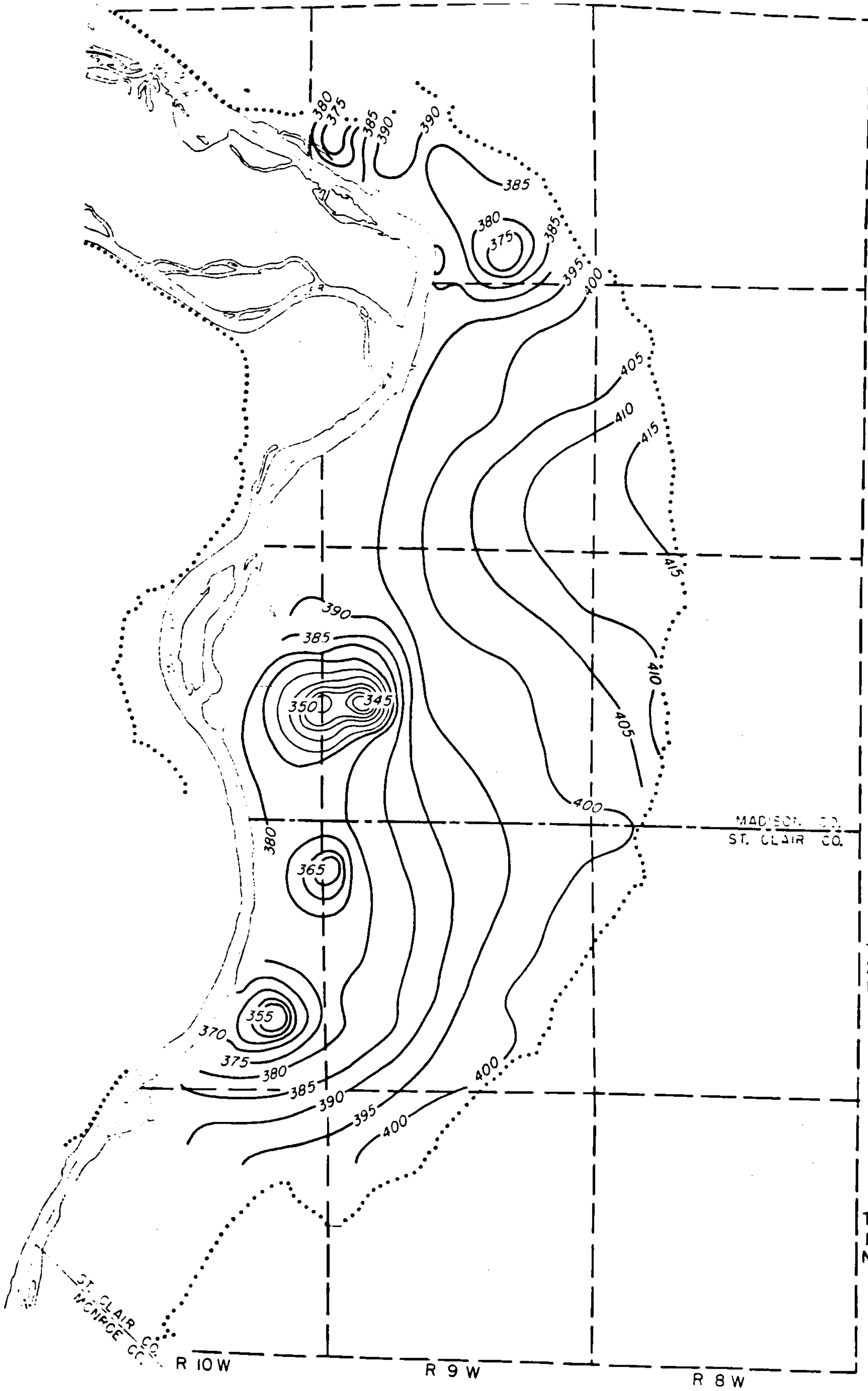


Figure 30. Approximate elevation of piezometric surface, December 1956.

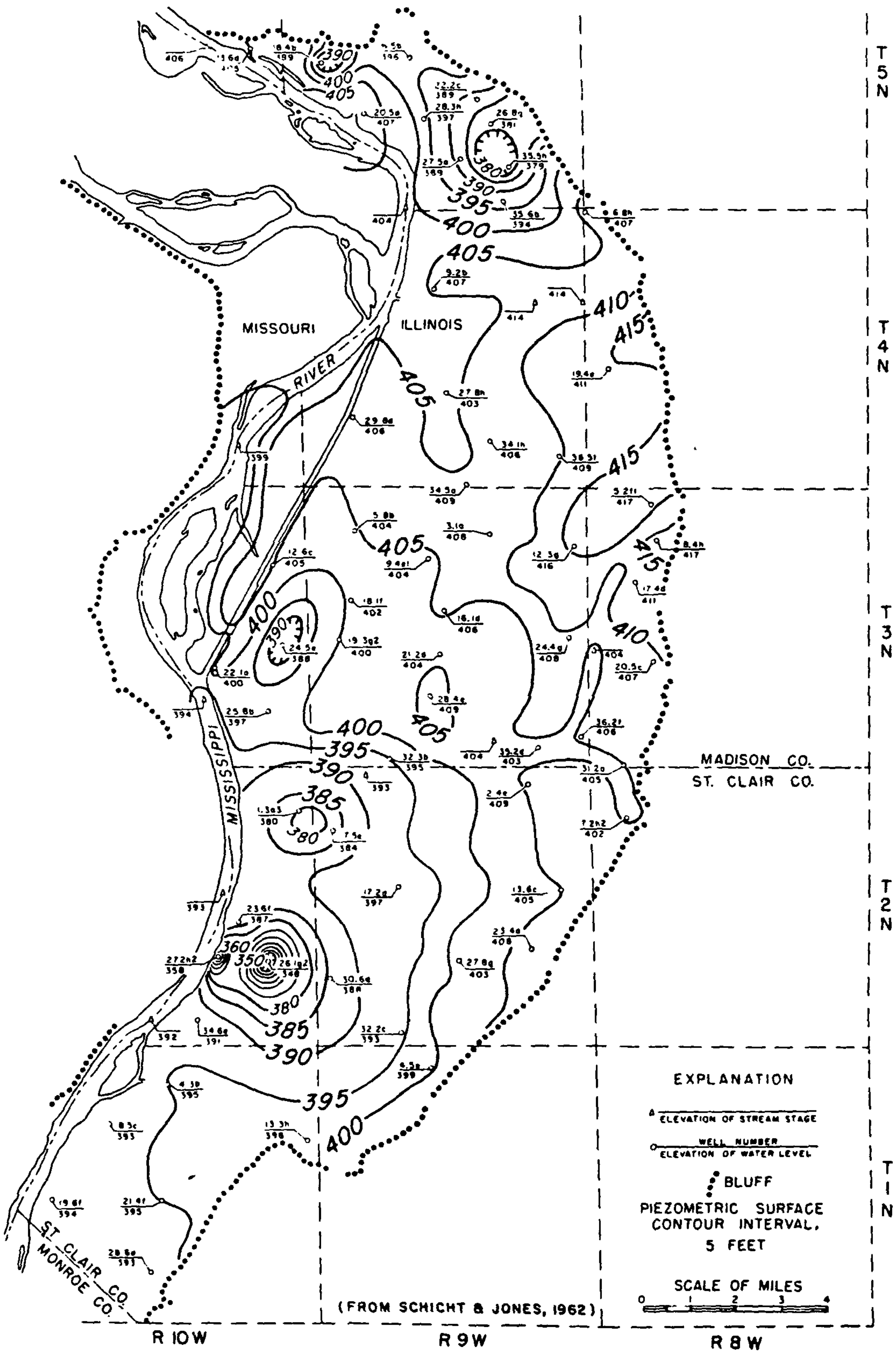


Figure 31. Approximate elevation of piezometric surface, November 1961.

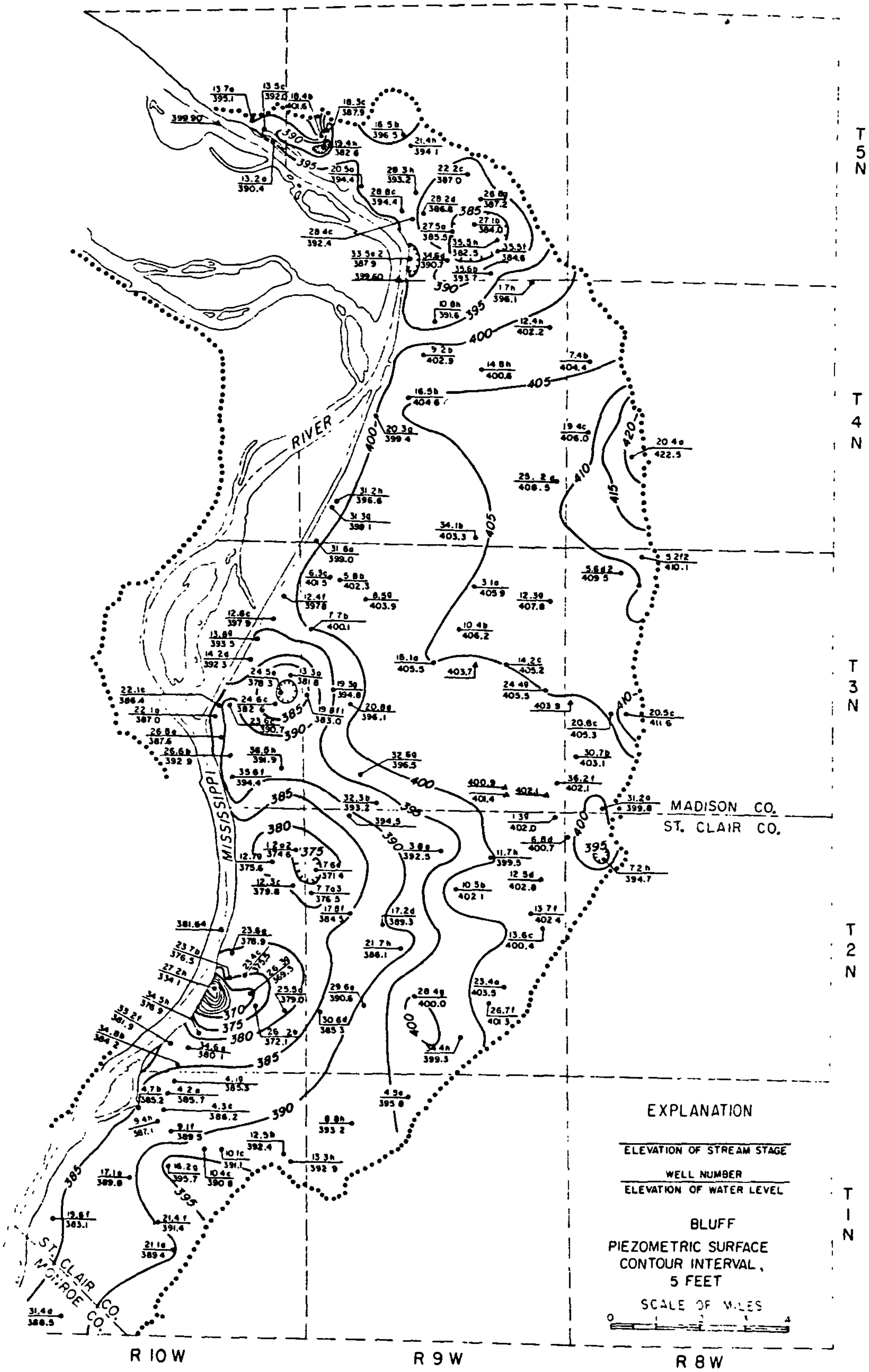


Figure 32. Approximate elevation of piezometric surface, November 1966.

levels were at an elevation of 360 feet in the cone adjacent to the Mississippi River and 350 feet in the cone approximately 1.5 miles east. In 1966 a reduction in pumpage caused water levels away from the river to recover. Water levels in the cone adjacent to the river declined to an elevation of 335 feet primarily as the result of below normal precipitation and lower river stages.

A comparison of the November 1966 and November 1971 (figure 33) maps indicate major changes in the Wood River, Alton, and Monsanto areas. In November 1966 one well-defined cone of depression was located in the Wood River area, and water levels were at elevations of 385 feet. By 1971 a reduction in pumpage by one industry and an increase in pumpage by another industry caused water levels to recover in one area and decline in another area. Water levels in the Wood River cone declined to an elevation of 375 feet. In the Alton area a shift in the center of pumpage moved the cone of depression a few miles to the northwest. In the Monsanto area two cones of depression are evident in 1971 as a result of changing patterns in groundwater withdrawals.

There were significant changes between the November 1971 and June 1973 (figure 34) maps. Groundwater levels in June 1973 were at record high stages largely due to the prolonged period of high river stages during the 1973 floods. From November 1971 to June 1973 groundwater levels rose 15 feet or more along the Mississippi River and Chain of Rocks Canal. Rises from 10 to 15 feet extended 1 to 3 miles from the river and canal. Much of the area experienced rises from 5 to 10 feet. In the Wood River area a major shift in pumpage occurred resulting in the reestablishment of the main cone of depression 2 miles to the east. A well field was abandoned immediately adjacent to the Mississippi River near Monsanto resulting in the disappearance of a deep, small cone of depression associated with the well field.

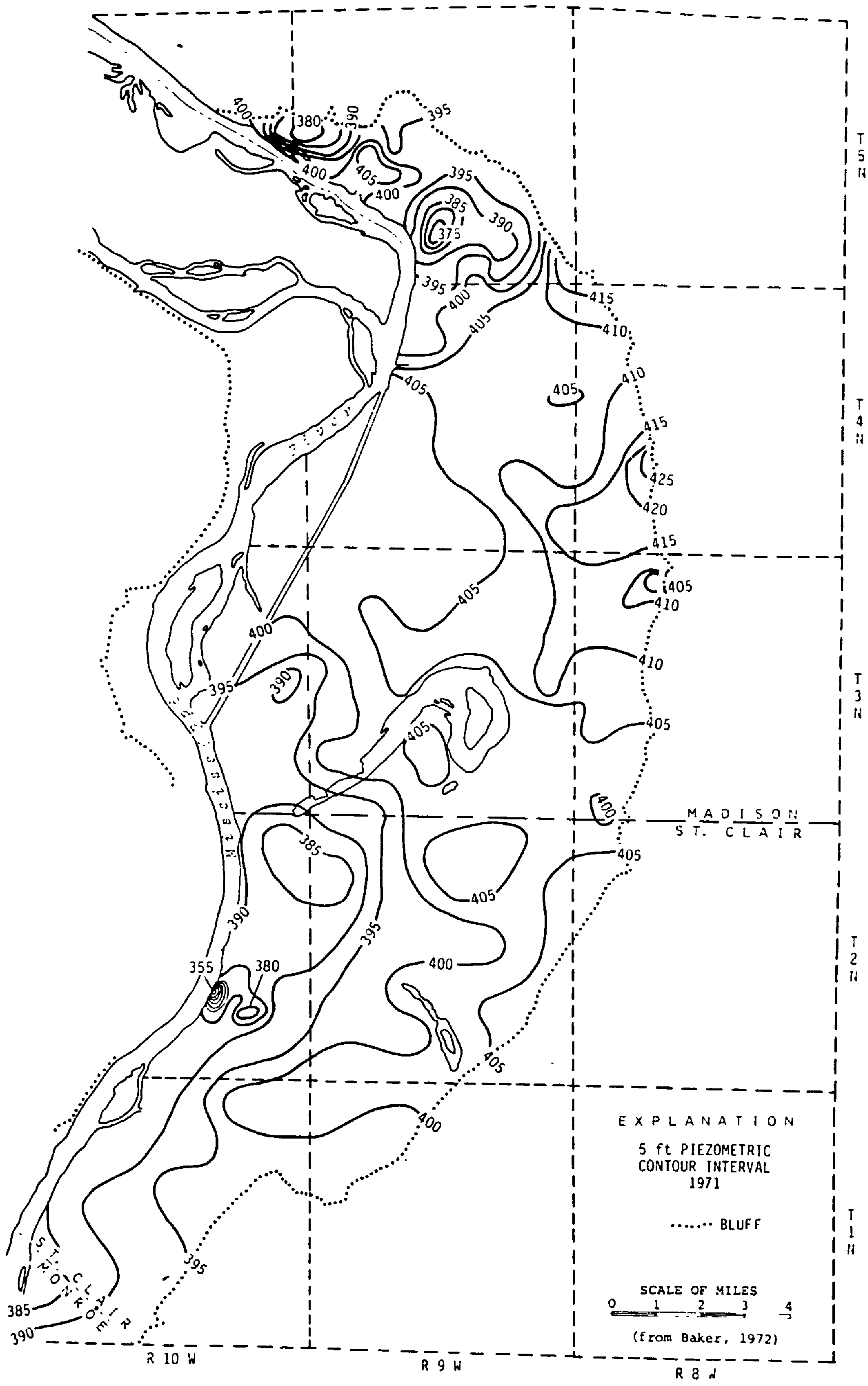


Figure 33. Approximate elevation of piezomaetric surface, November 1971.

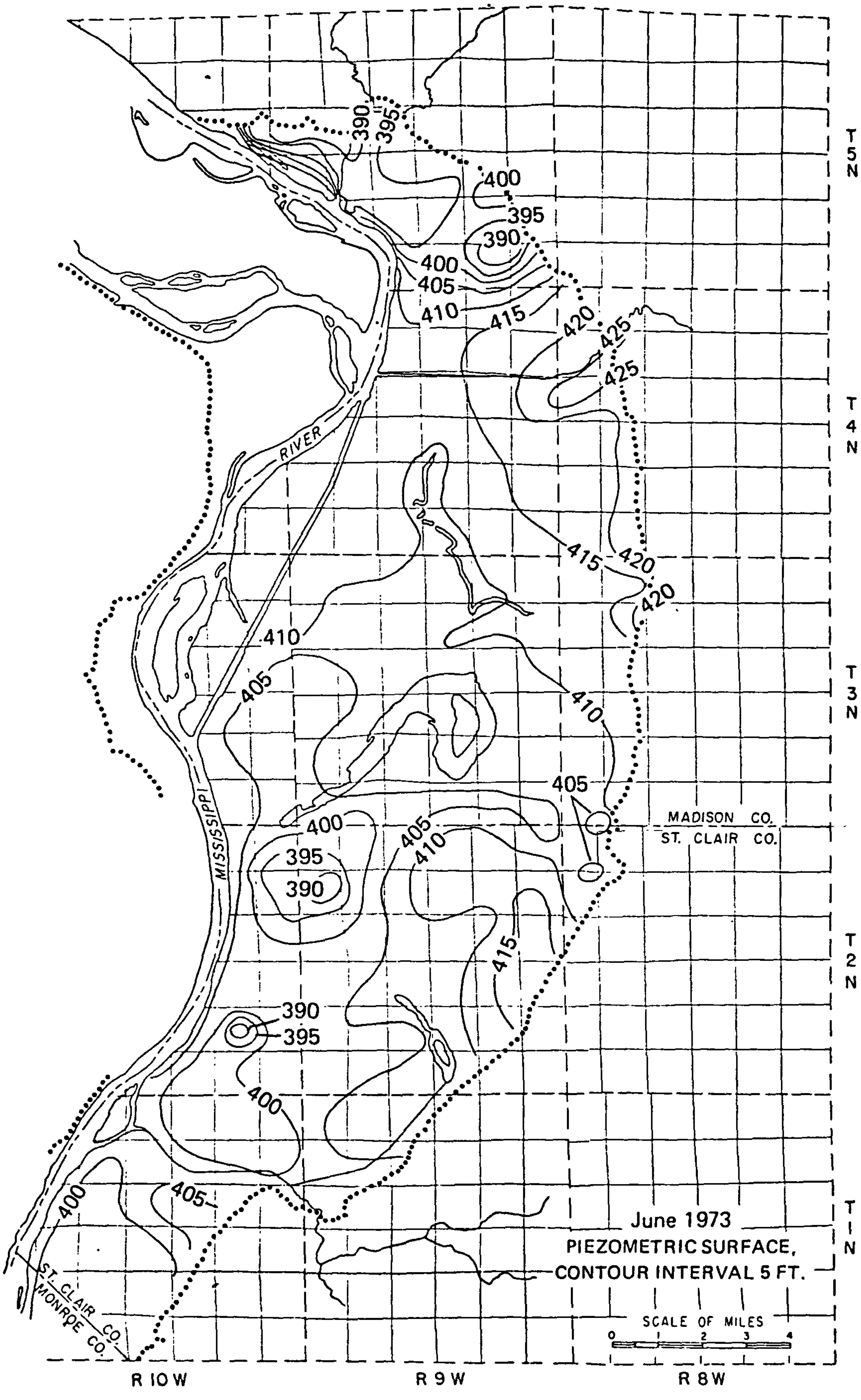


Figure 34. Approximate elevation of piezometric surface map, June 1973.

A comparison of the June 1973 and November 1977 (figure 35) maps shows that as expected water levels were generally lower in 1977 as a result of recharge returning to a more normal condition. The Wood River and Monsanto cones of depression were large, although at approximately the same elevation, 1977. Instead of the trough of low water levels in the vicinity of Granite City in 1973 a distinct cone of depression was evident in 1977. A significant change should be noted in the vicinity of the National City cone of depression. The cone has expanded to the southwest and southeast as a result of dewatering wells operated by the Illinois Division of Highway necessary to keep water levels below interstate highway pavements constructed below land surface.

The features of the November 1977 and November 1980 (figure 36) maps are generally the same. The November 1980 map is a preliminary map and is still subject to further interpretation.

WATER LEVEL CHANGES

Available water level change maps are given below:

Date	References
1900 to November 1961	Schicht and Jones 1962)
December 1956 to November 1961	Schicht and Jones (1962)
June 1961 to November 1961	Schicht and Jones (1962)
June 1961 to June 1962	Schicht (1964)
November 1961 to June 1962	Schicht (1964)
November 1961 to November 1966	Reitz (1968)
November 1966 to November 1971	Baker (1972)
December 1956 to June 1973	Schicht (1974) (revised for this report)
November 1971 to November 1976	Emmons (1978)

Maps showing seasonal, annual, 5-year, and long-term water level changes are described below.

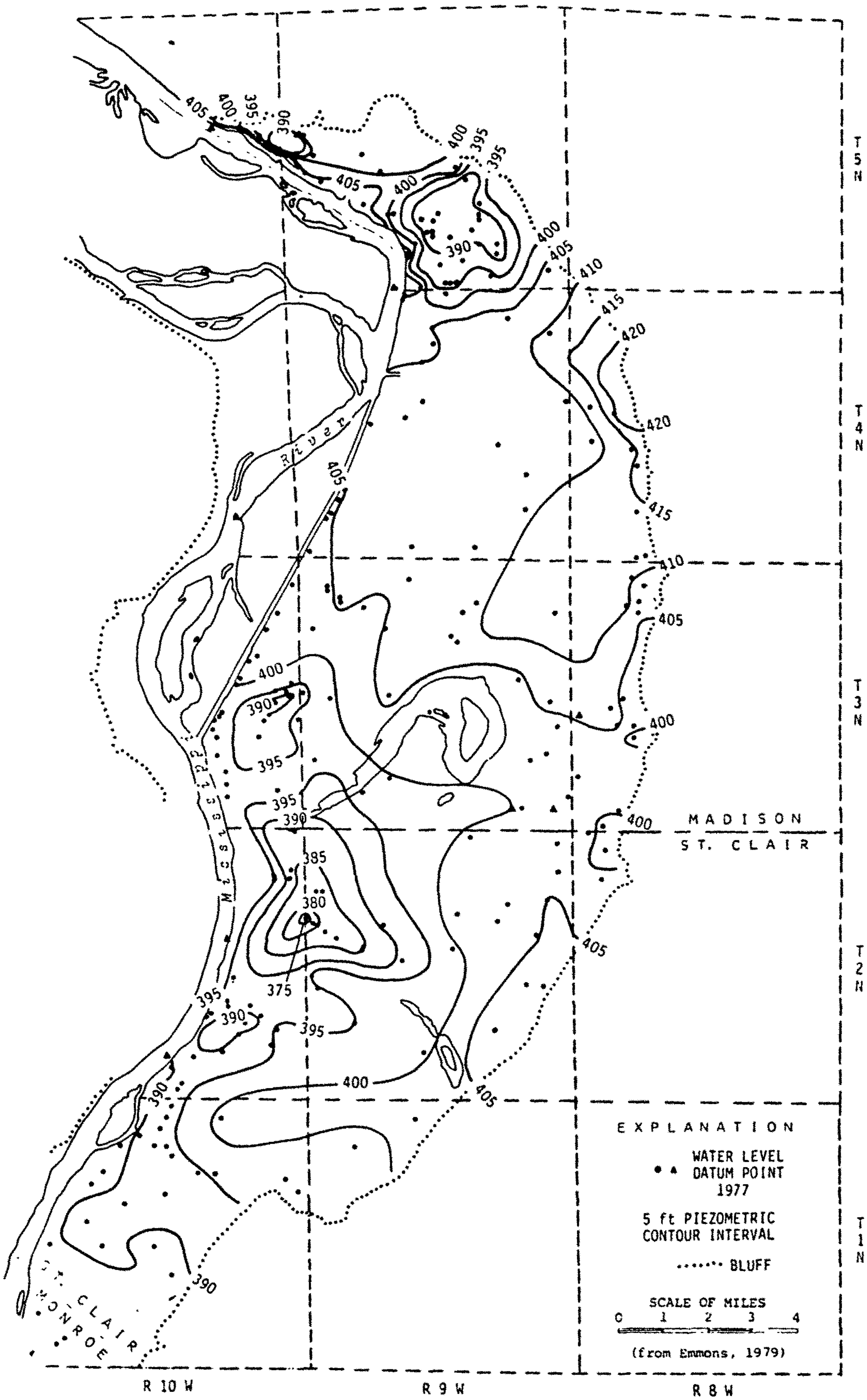


Figure 35, Approximate elevation of piezometric surface, November 1977.

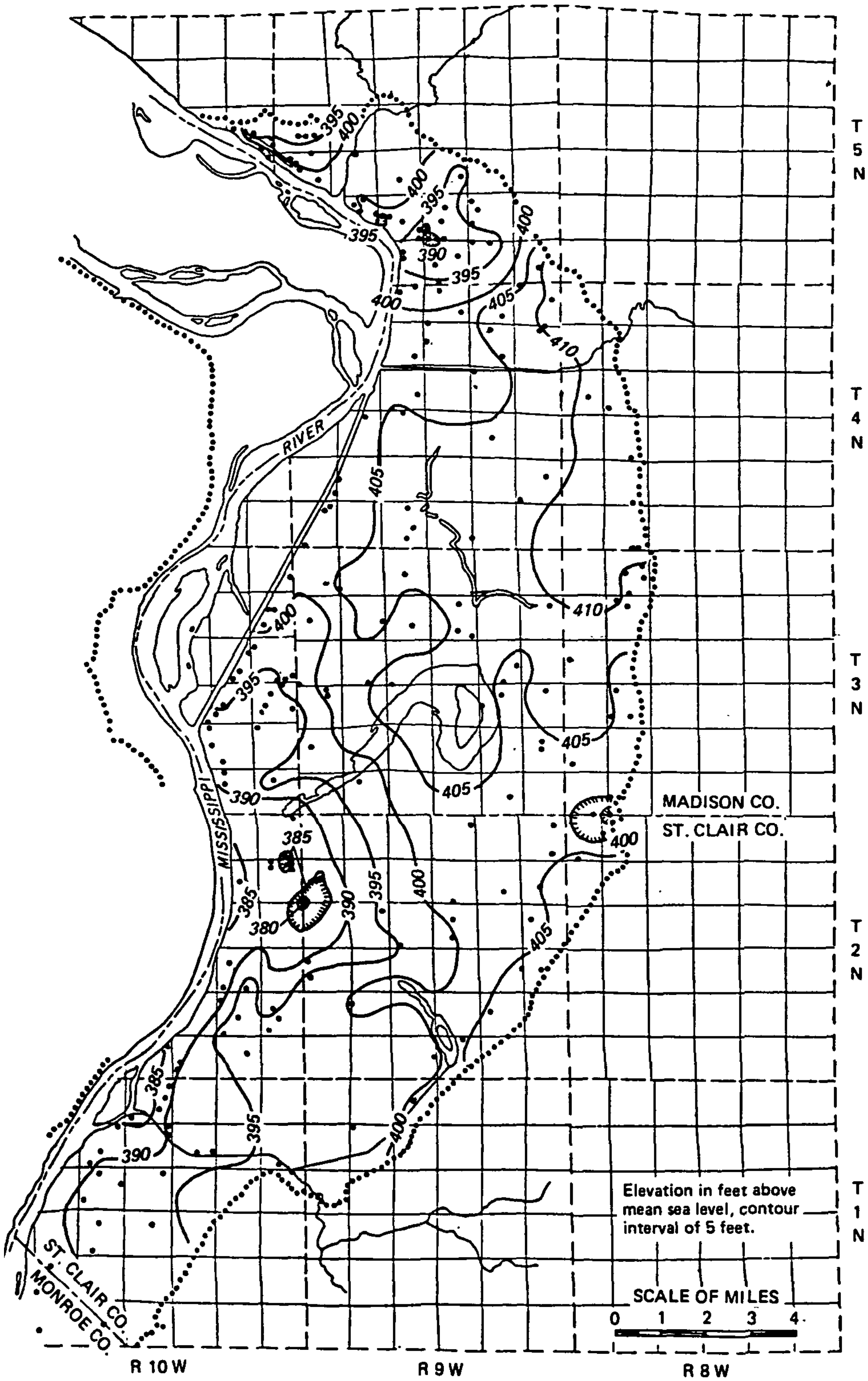


Figure 36. Approximate elevation of piezometric surface November 1980.

The November 1961 to June 1962 map change (figure 37) is typical of seasonal changes in groundwater levels. Water levels are frequently highest in the late spring and lowest in the late fall or early winter depending upon climatic conditions, pumping, and the stage of the Mississippi River. Groundwater levels rose appreciably because Mississippi River stages were higher in June 1962 than in November 1961. During the winter and early spring months, conditions were favorable for the infiltration of rainfall to the groundwater. Groundwater levels rose appreciably along the bluffs, the rise exceeding 7 feet in places. Groundwater level rises along the Mississippi River exceeded 5 feet east of Wood River and east of National City; groundwater level rises exceeded 5 feet at the northern end of Long Lake and near Dupo. Water levels declined less than 1 foot around Horseshoe Lake and between 1 and 2 feet in a small area near Monsanto.

The June 1961 to June 1962 (figure 38) water level change map is typical of annual changes in groundwater levels. The stage of the Mississippi River was higher during June 1962 than in June 1961, and as a result groundwater levels rose appreciably in most places along the Mississippi River and Chain of Rocks Canal. Water levels declined more than a foot near Monsanto along the Mississippi River as a result of heavy pumping. Water levels declined less than a foot in the Horseshoe Lake area and in places along the bluffs; water levels also declined in a strip west of Dupo. Water levels rose in excess of 5 feet along the Mississippi River in the Alton and Wood River areas and along the northern reach of Chain of Rocks Canal. Immediately east of Dupo water levels rose in excess of 4 feet.

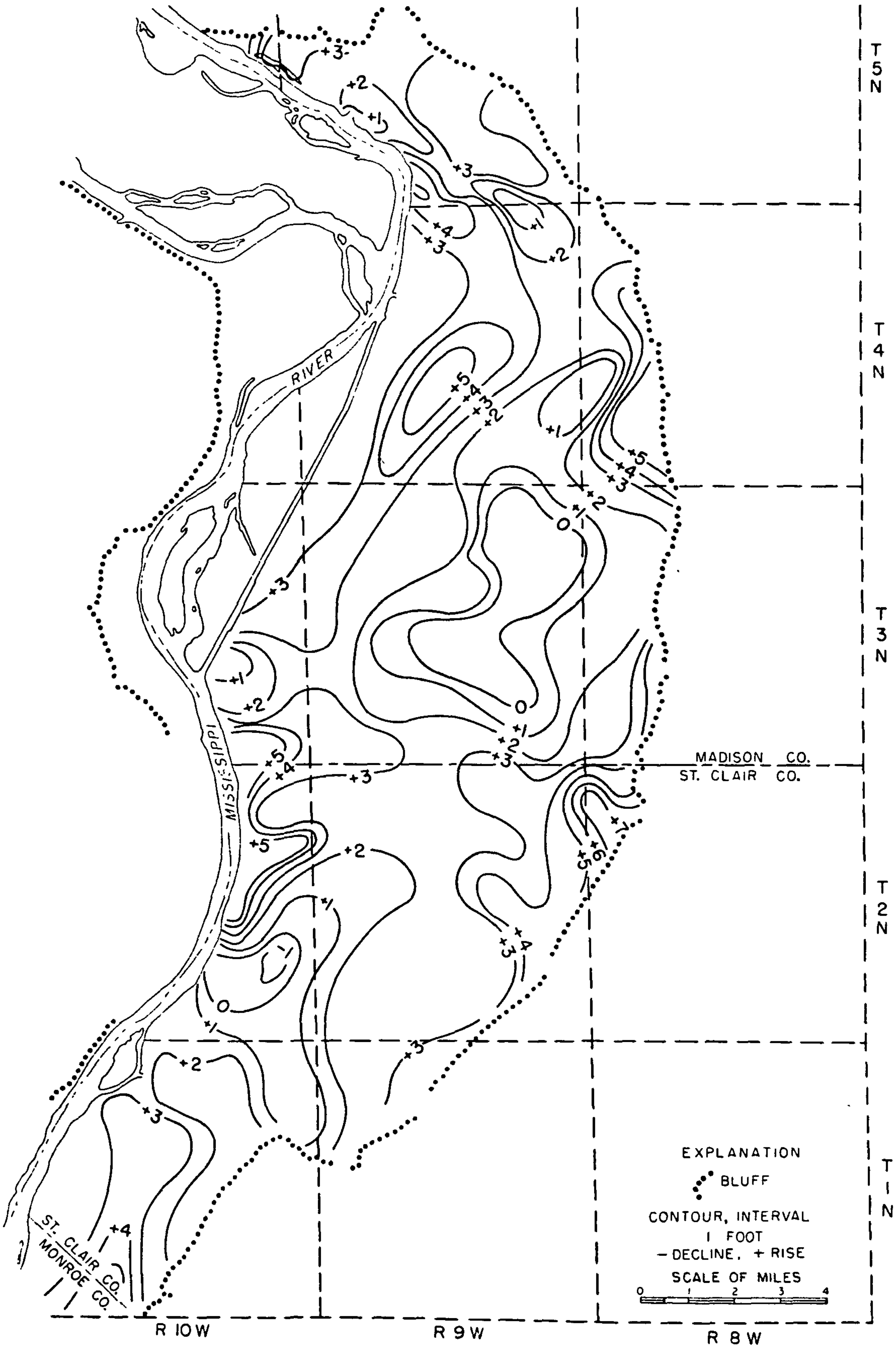


Figure 37. Estimated change on water levels, November 1961 to June 1962.

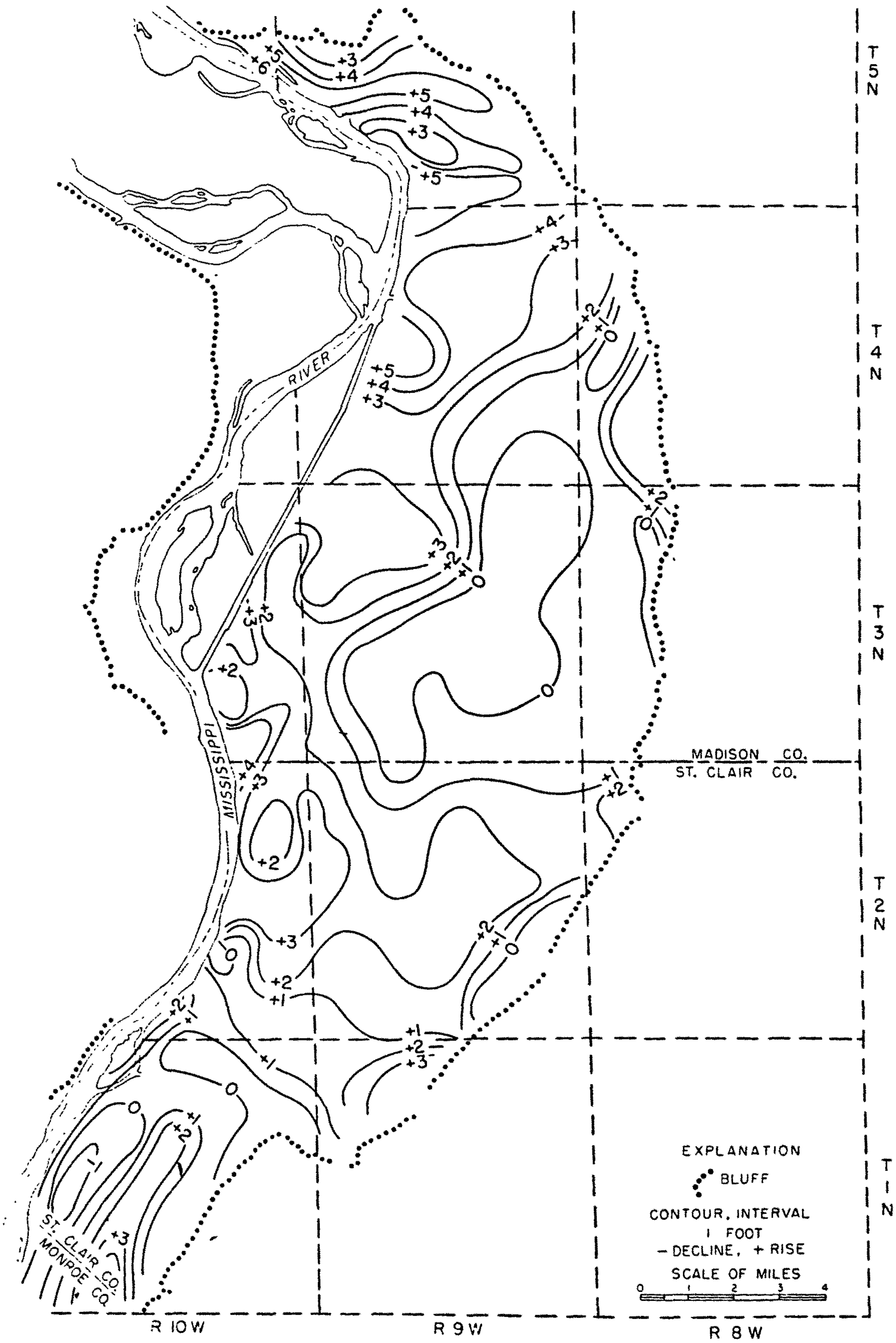


Figure 38. Estimated change in water levels, June 1961 to June 1962.

The water level change map for the period 1900 to November 1961 (figure 39) illustrates changes in water levels over a long period mainly due to effects of groundwater withdrawals. The greatest declines occurred in the major pumping centers and were as follows: 50 feet in the Monsanto area, 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. Water levels rose more than 5 feet along the Chain of Rocks Canal behind the locks of the Canal where the stage of surface water in 1961 was above the estimated piezometric surface in 1900. In areas remote from major pumping centers and the Mississippi River, water levels declined an average of about 5 feet. Water levels did not change appreciably in the area around Horseshoe Lake.

Water level changes for a 5-year period are illustrated by the change map for the period November 1961 to November 1966 (figure 40). The greatest water level changes occurred in the five major pumping centers. Water levels in the Alton area declined 10 feet in an area near the Mississippi River because of low river stages and below normal precipitation. About 0.5 miles to the north-east of this area water levels rose in excess of 10 feet because of a reduction in pumpage. Water levels in the Wood River, Granite City, National City and Caseyville areas declined 10 feet. Near the Mississippi River in the Monsanto area water levels declined 25 feet primarily because of low river stages and below normal precipitation. Approximately 1 mile east of this area water levels rose as a result of a reduction in pumpage. Water levels declined an average of 5 feet in areas generally unaffected by heavy pumpage.

The piezometric surface map for December 1956 (near record low groundwter stages) was compared, with the June 1973 piezometric surface map (record high groundwater stages). Water level changes are shown in figure 41. The greatest

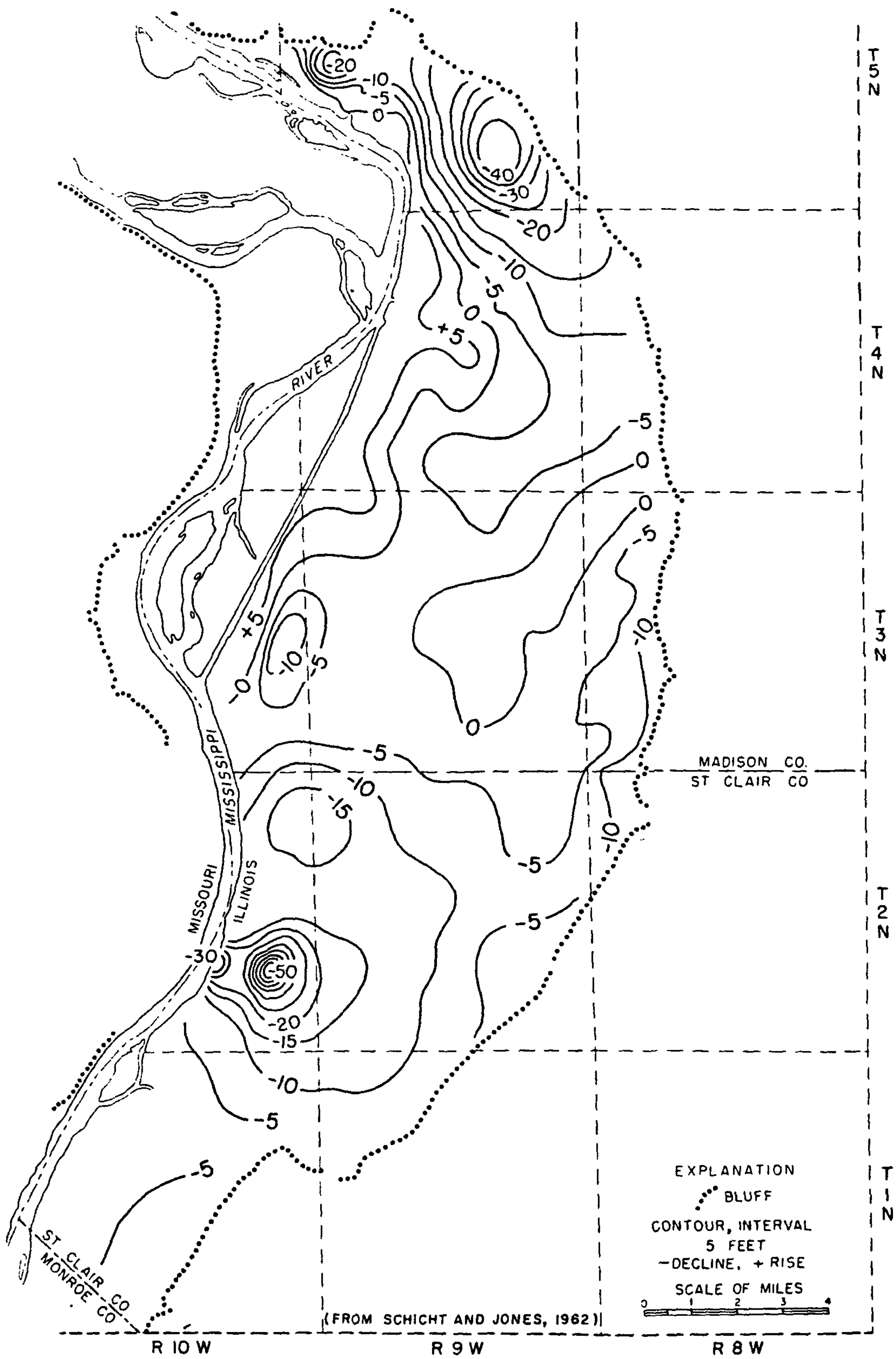


Figure 39. Estimated change in water levels, 1900 to November 1961.

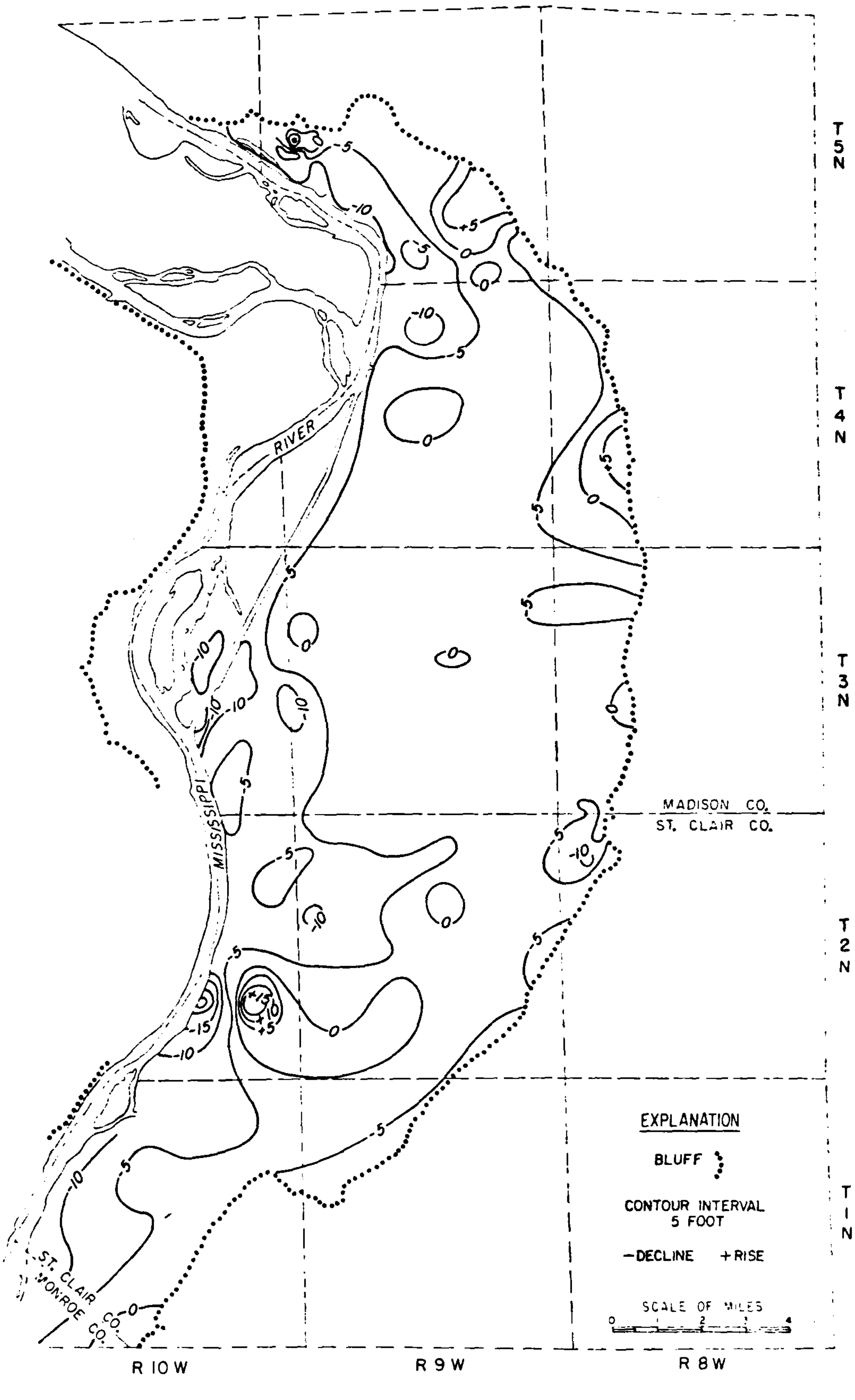


Figure 40. Estimated change in water levels, November 1961 to November 1966.

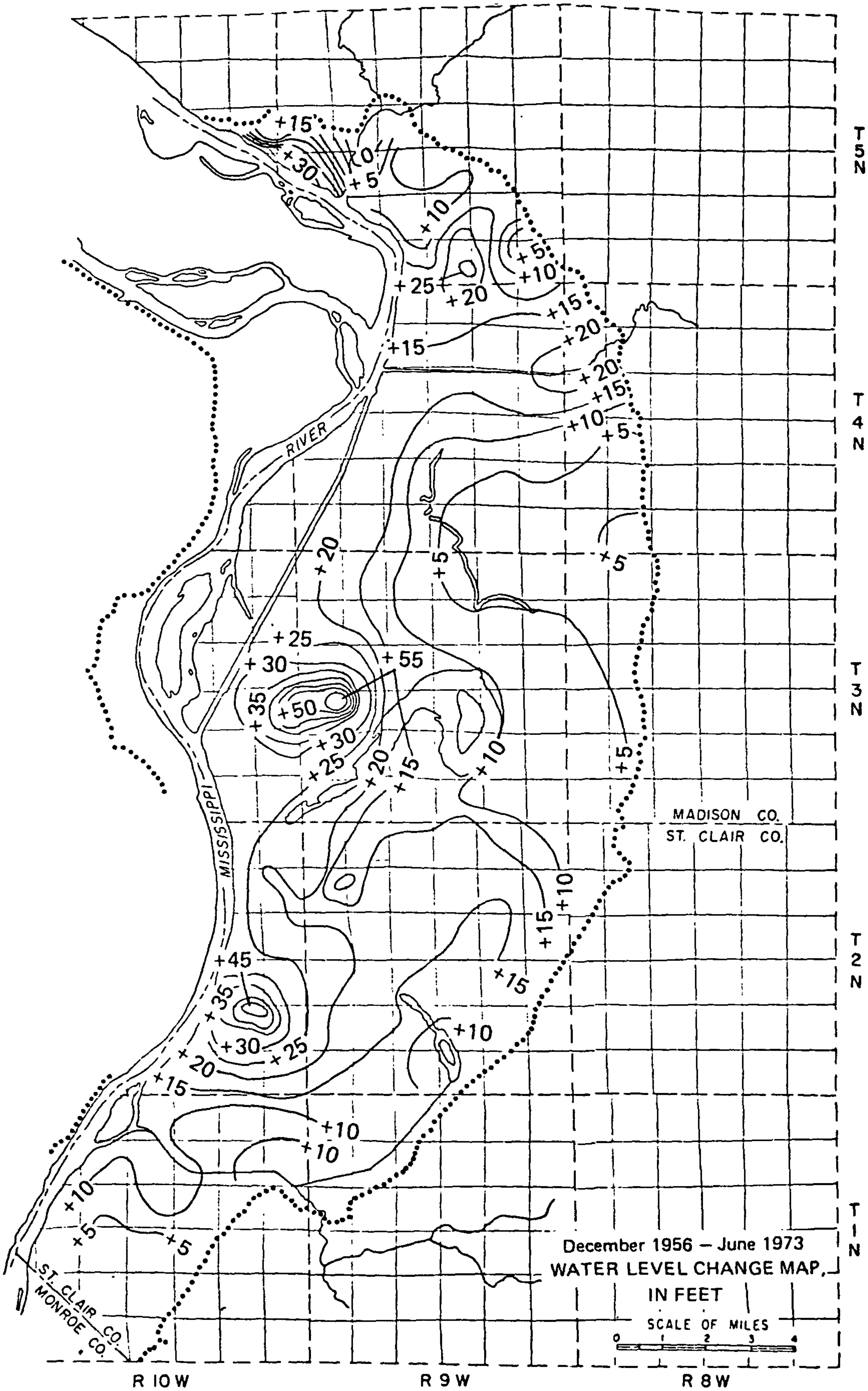


Figure 41. Estimated change in water levels, December 1956 to June 1973.

changes occurred in the Granite City area where groundwater levels recovered more than 55 feet due to the reduction in pumpage after 1957 and high river stages and favorable conditions for recharge during 1973. Groundwater levels recovered more than 45 feet in the vicinity of Monsanto also due to a reduction in pumpage (after 1970) and high river stages and favorable conditions for recharge during 1973. Other water level rises are mainly due to the high river stages and favorable conditions for recharge.

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