12-1990

Groundwater Levels in Nebraska, 1989

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The Conservation and Survey Division of the University of Nebraska-Lincoln is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources.

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UNITED STATES GEOLOGICAL SURVEY
Dallas L. Peck, Director

Water Resources Division, Nebraska District
Michael V. Shulters, District Chief

December 1990

Contents

Illustrations

(except hydrographs of key observation wells)

Hydrographs of Key Observation Wells

Factors for Converting English System to the International System of Units (SI)

Multiply English units	by	To obtain SI units
Length		
inches	25.4	millimeters
feet	.3048	meters
miles	1.609	kilometers
Area		
acres	4047	square meters
square miles	2.590	square kilometers
Volume		
acre-feet	1233	cubic meters
Flow		
gallons per minute	.00006309	cubic meters per second

This report on Nebraska's groundwater levels summarizes the water-level changes in 1989 on a statewide basis and by major divisions of the state.

Introduction

In 1930, the Conservation and Survey Division of the University of Nebraska and the U.S. Geological Survey began a cooperative water-level measurement program to observe and document, on a continuing basis, the changes in groundwater levels throughout Nebraska. This program includes evaluation of the adequacy and accuracy of the water-level information collected and provides a means for its storage, retrieval, and dissemination in an easily understood format.

This report, the 36th annual report on Nebraska's groundwater levels, summarizes the significant historic changes in water levels and the water-level changes during 1989. These changes are shown on maps and hydrographs. For the readers' convenience, water-level hydrographs are explained at the end of the report. This report also describes the availability of water-level data, provides information on changes in the water-level measurement program, and summarizes data on the two major causes of water-level changes: precipitation and groundwater use.

The period of record for many observation wells is too short to adequately determine long-term changes in water levels. Where possible, however, an individual comparison is made between 1989 water levels and estimated predevelopment water levels. An estimated predevelopment water level is the approximate average water level at a well site prior to any human development that significantly affected water levels near the well. All available water-level data collected prior to or during the early stages of development are used to estimate predevelopment water levels.

Data on groundwater levels can be used in conjunction with other data to:

1) Determine the volume of groundwater in storage and its availability for use.
2) Assess the water-supply outlook by determining changes in the volume of groundwater in storage.
3) Identify areas where changes in groundwater levels might have an economic impact.
4) Assist state and local agencies in the formulation and administration of resource-management programs.
5) Determine or estimate the rate and direction of groundwater movement, specific yield of aquifers, base flow of streams, sources and volumes of recharge, and locations and volumes of discharge.
6) Assess the validity of hydrogeologic interpretations and the assumptions used in developing models of a groundwater system.

Nebraska's water-level measurement program includes the collection of many more data than are presented in this report. These additional data are available on request from the Conservation and Survey Division or the Nebraska District of the U.S. Geological Survey.

Water levels declined throughout most of Nebraska during 1989.

Changes in Water Levels, 1989

During 1989, water levels generally declined throughout most of Nebraska. Most of the declines were the result of a drought that started in 1988. This drought ended a 7-year trend of rising water levels that started in 1981. The trend of rising water levels probably was most directly a result of normal or greater-than-normal precipitation occurring each year from 1981 through 1987. In 1988, however, precipitation was less than normal in the eastern one-third of the state, slightly less than normal in the central one-third of the state, and normal to slightly greater than normal in the western one-third of the state. During 1989, precipitation generally was below normal throughout most the state. This change in the distribution of precipitation during 1989 caused significant water-level declines from the water levels measured in 1988.

Throughout large areas in the Northeast, East South-Central, Central, East North-Central, Southwest, and Panhandle divisions, fall 1989 water levels were 1 to 5 feet lower than they were in 1988. As a result of these declines, many fall 1989 water levels were more than 5 feet below estimated predevelopment water levels. In the Northeast and Central divisions, it was possible to map many scattered small areas where declines of more than 5 feet developed. In the East South-Central, Central, Southwest, and Panhandle divisions, most of the declines in 1989 were in or near the large areas where declines of more than 5 feet from estimated predevelopment levels have existed for many years. During 1989, the size of the decline area in the East South-Central Division increased by about 92,000 acres, and the size of the decline areas in the Central Division, particularly in Hall, Buffalo, Dawson, and southwestern Custer counties, increased by about 80,000 acres.

Although most water levels declined in the large decline areas in the Perkins, Chase, and Dundy counties area in the Southwest Division and in the Box Butte County area in the Panhandle Division, most of the change in size of these decline areas is due primarily to the use of additional observation-well data to better define water-level changes. No comparison can be made between the 1988 and 1989 sizes of these areas because of these added wells.

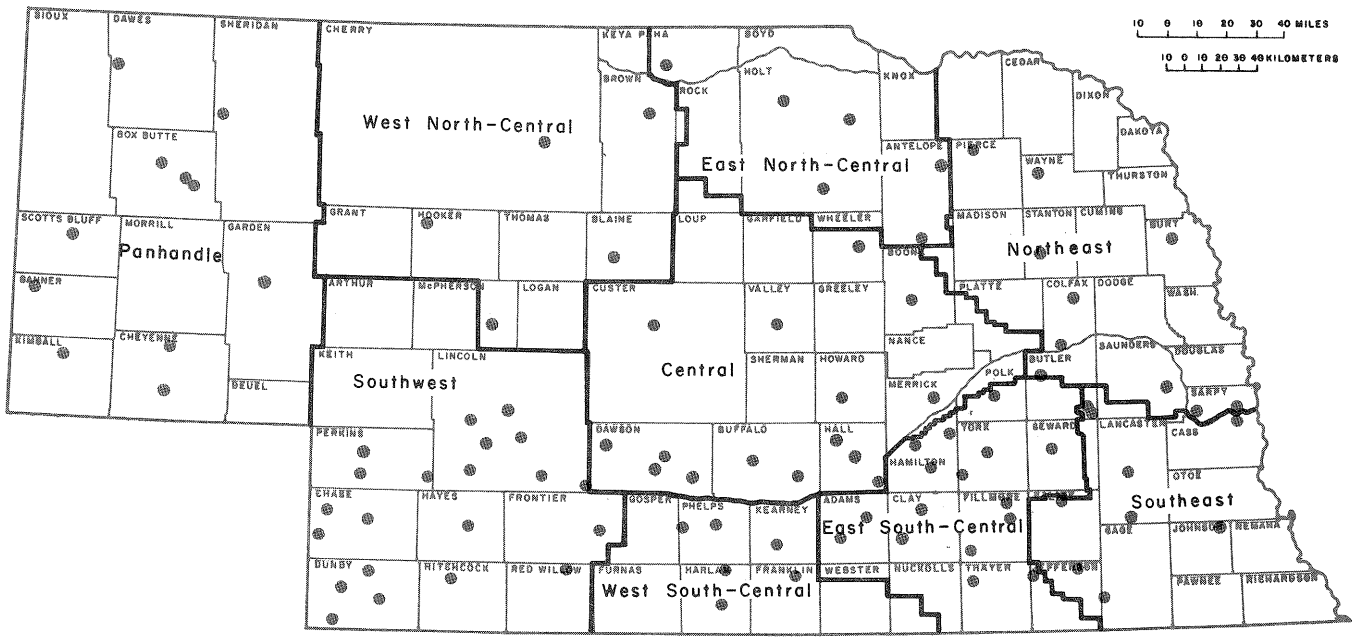
Where no significant declines or rises from estimated predevelopment water levels have occurred, the hydrologic system usually is in an approximate state of equilibrium. That is, natural recharge to the aquifer is balanced by natural discharge from the aquifer.

Comparison of estimated predevelopment water levels with fall 1989 water levels allows for the delineation of most areas where significant long-term declines or rises in water levels have resulted from the development of water resources. Declines of 5 feet or more have occurred under about 3.43 million acres and rises of 10 feet or more have occurred under about 1.44 million acres. Water-level data collected by natural resources districts in 1989 permitted the delineation of some areas where water-level changes have occurred that otherwise might not have been detected. The water-level data collected in 1989 are sufficient to define the major areas where significant water-level declines or rises have occurred.

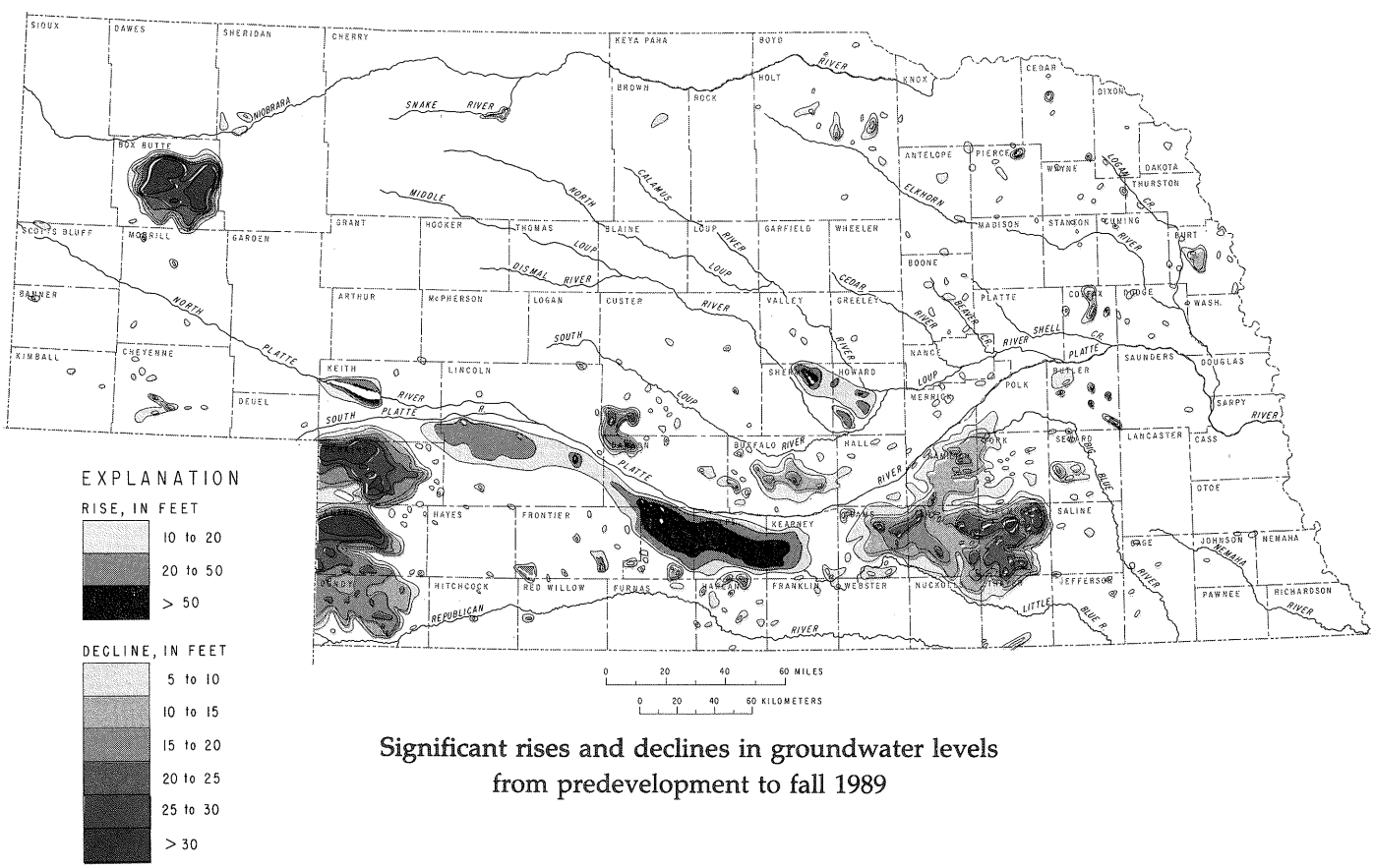
In order to describe water-level changes in detail, the state has been divided into nine parts: Southeast Division, Northeast Division, East South-Central Division, West South-Central Division, Central Division, East North-Central Division, Southwest Division, West North-Central Division, and Panhandle Division. Division boundaries coincide with natural resources district boundaries, and each division includes the areas of two or more natural resources districts. Selected observation wells have been designated as key observation wells that provide representative water-level information for various parts of each division. Hydrographs showing water-level fluctuations in these wells are included in the descriptions of water-level changes in each division.

Before development by humans, most groundwater systems were near equilibrium conditions; that is, long-term recharge was about equal to long-term discharge. In Nebraska, the natural equilibrium of groundwater systems has been altered by 1) increased discharge from irrigation wells; 2) recharge from infiltration of surface water applied to irrigated crops; 3) recharge due to deep percolation of seepage from irrigation storage and distribution systems; 4) discharge to constructed drainage systems; and 5) changes in land use that affect the volume of recharge an aquifer receives. In many parts of the state, water-level fluctuations resulting from natural conditions may be either masked or accentuated by water-level fluctuations resulting from human activities. Therefore, judgment needs to be exercised when evaluating the significance of water-level changes.

In Nebraska, where use of water for irrigation causes the most significant water-level fluctuations, most observation wells are measured in the spring and late fall. Spring measurements are useful for determining volumes of groundwater in storage each year before irrigation starts. Fall measurements are useful for evaluating the effects of annual water use for irrigation and for delineating problem areas, or the potential for them, more accurately; fall measurements are used in this report to document the long-term changes in water levels. In the summaries of water-level changes in the East South-Central and the Southwest Divisions, changes between estimated predevelopment water levels and spring 1989 water levels also are described because they provide information useful in the management of the groundwater-control areas located in these divisions.



Location of key observation wells and boundaries of divisions



Significant rises and declines in groundwater levels
from predevelopment to fall 1989

Spring 1989 water levels were lower than spring 1988 water levels in 84 percent of the observation wells in Nebraska.

Differences Between 1988 and 1989 Water Levels

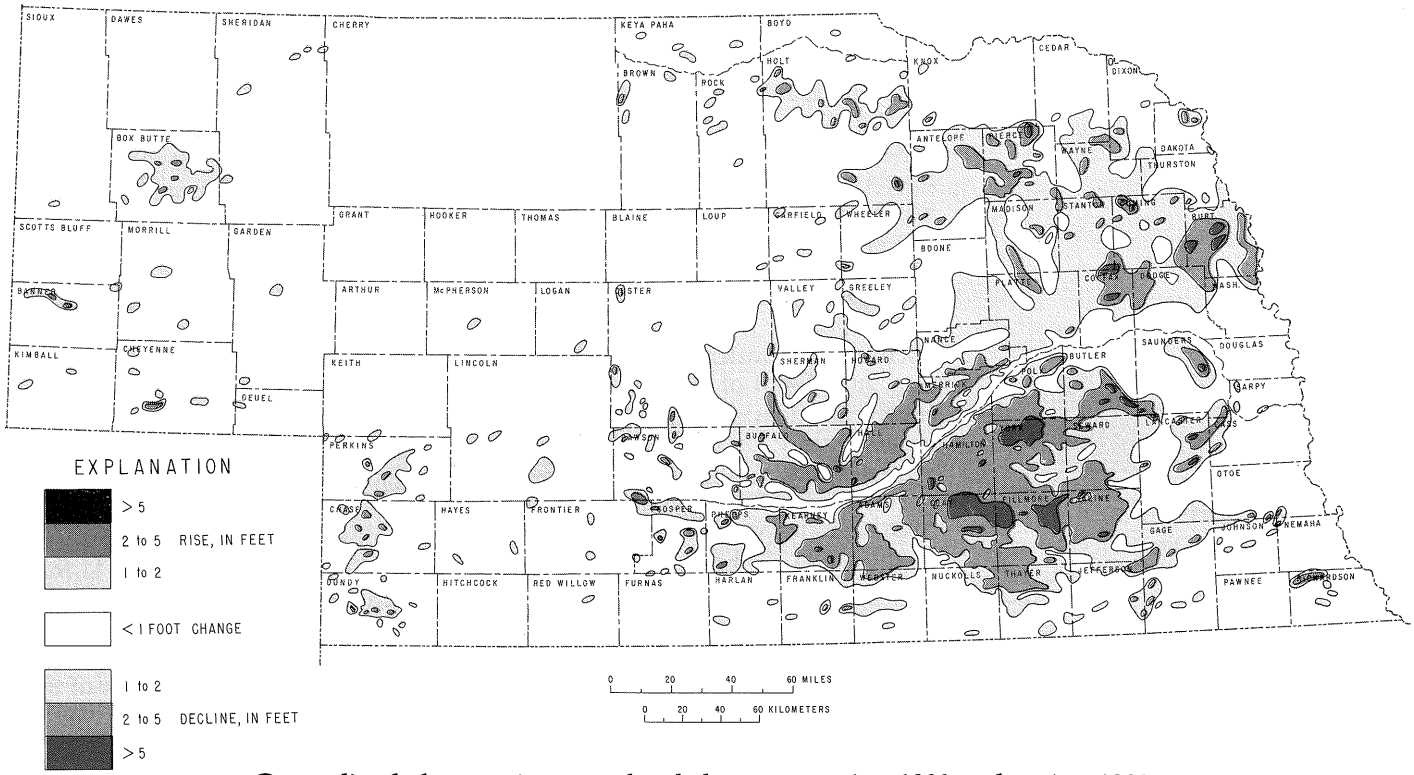
In most parts of Nebraska, groundwater levels measured in observation wells in the spring and fall of 1989 were significantly lower than water levels measured in the spring and fall of 1988. Spring 1989 water levels were lower than spring 1988 water levels in about 84 percent of the wells measured. The average spring 1989 water level was 1.51 feet lower than the average spring 1988 water level. Fall 1989 water levels were lower than fall 1988 water levels in about 72 percent of the observation wells, with the fall 1989 water levels averaging 0.89 foot lower than the fall 1988 water levels.

Most of the water levels measured in observation wells in eastern Nebraska in the spring of 1989 were more than 1 foot lower than the water levels measured in the spring of 1988. In the Northeast, East South-Central, and Central Divisions, there were large areas where most spring 1989 water levels ranged between 2 and 5 feet lower than spring 1988 water levels. In the Northeast and East South-Central Divisions, areas where spring 1989 water levels were more than 5 feet lower than spring 1988 water levels were common.

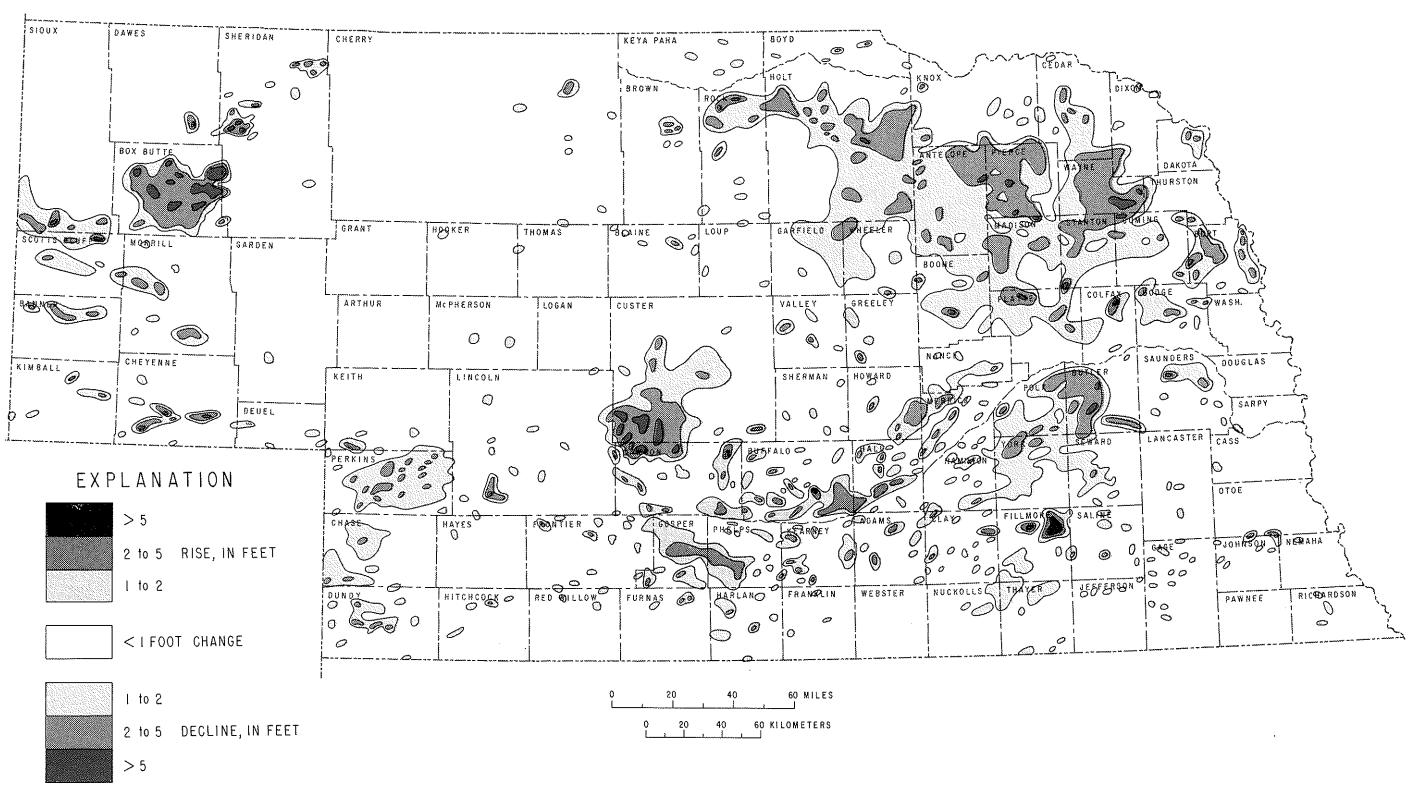
In the western part of Nebraska, most water levels measured in observation wells in the spring of 1989 ranged between 1 foot lower to 1 foot higher than the spring 1988 water levels. There were many small areas in the western part of the state, however, where spring 1989 water levels were between 1 and 2 feet higher than the spring 1988 water levels. In Box Butte County in the Panhandle Division, most water levels measured in observation wells in the spring of 1989 were between 1 and 2 feet lower than the water levels measured in the spring of 1988.

Water levels measured in observation wells in the fall of 1989 generally were lower than water levels measured in the fall of 1988, except in the southern part of the East South-Central Division and parts of the West South-Central and Central divisions, where there were several areas where fall 1989 water levels were more than 1 foot higher than fall 1988 water levels. In southwestern Custer and northwestern Dawson counties in the Central Division and in Box Butte County, many fall 1989 water levels were between 2 and 5 feet lower than fall 1988 water levels; in some observation wells in these areas, fall 1989 water levels were between 10 and 15 feet lower than fall 1988 water levels.

Generally, water-level changes from spring or fall of one year to spring or fall of the next year are less than 1 foot, unless natural conditions or human activities significantly affect the water levels. Human activities can cause significant water-level changes, but more commonly such activities accentuate changes caused by natural conditions. During a drought, groundwater levels generally decline because the small volume of water available to recharge the aquifer is less than the natural discharge through evapotranspiration and seepage. Increased use of groundwater for irrigation, public, and domestic supplies during a drought causes further declines in water levels. Conversely, when precipitation during a growing season is greater than normal, water levels tend to rise, or at least decline at a slower rate, because natural recharge to the aquifer equals or exceeds natural discharge through evapotranspiration and seepage. At the same time, less groundwater is used to supply human needs, so the effect of pumpage on water levels is less.



Generalized changes in water levels between spring 1988 and spring 1989



Generalized changes in water levels between fall 1988 and fall 1989

Southeast Division

Groundwater levels in the Southeast Division generally were lower during 1989 than they were during 1988. About 82 percent of the water levels measured in the spring of 1989 were lower than levels measured in the spring of 1988. Most spring 1989 water levels were between 1 and 2 feet lower than spring 1988 water levels, but water levels 7 to 8 feet lower occurred in Butler and Saline counties. In the fall of 1989, groundwater levels in most parts of the division were slightly lower than the fall 1988 water levels. About 65 percent of the water levels measured in the fall of 1989 were lower than those measured in the fall of 1988. Most fall 1989 water levels were less than 1 foot lower than fall 1988 water levels.

In the Southeast Division 82 percent of the water levels measured in the spring of 1989 were lower than those measured in the spring of 1988.

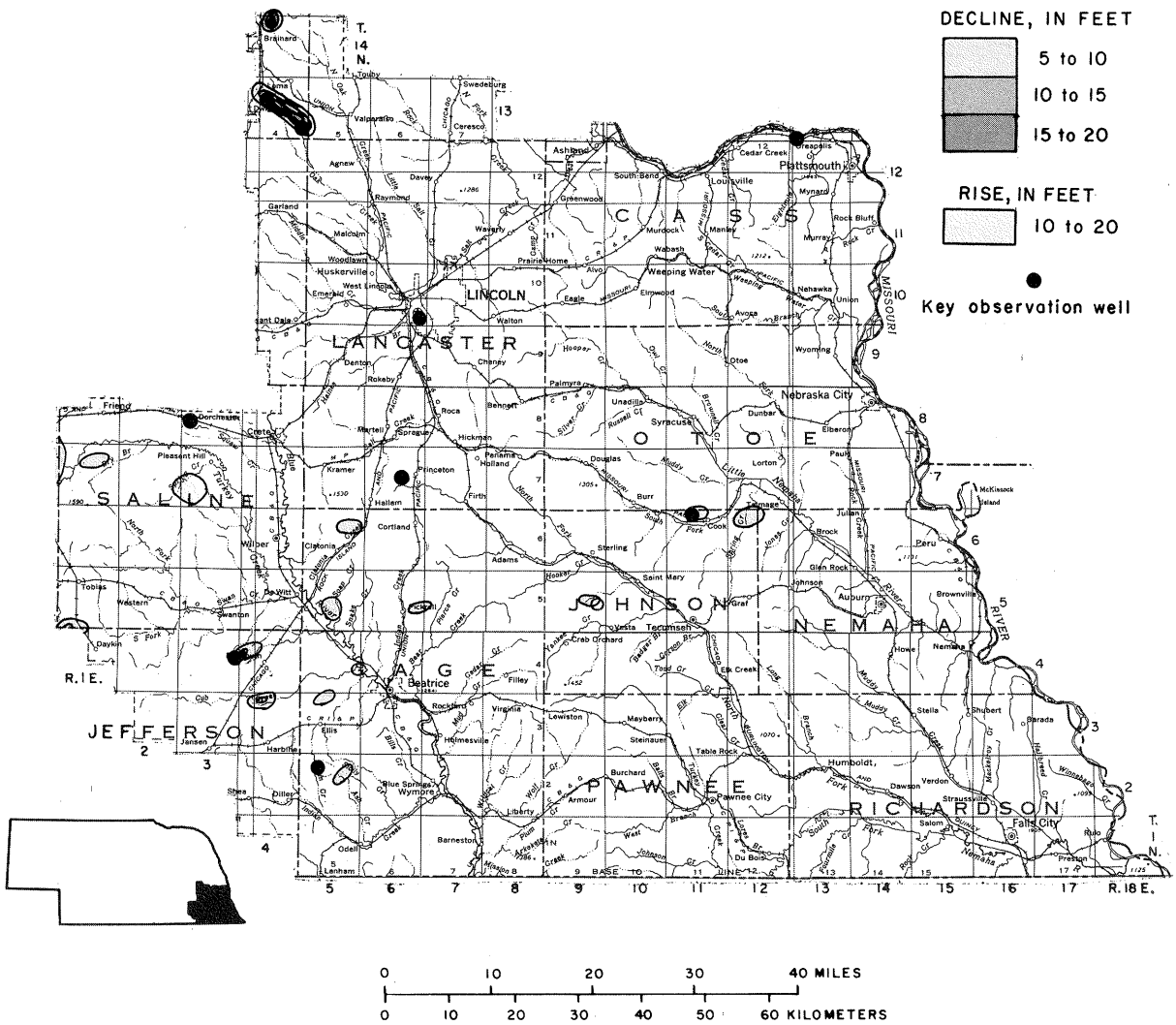
Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	138	18	−1.56	−1.43
Fall	146	35	− .40	− .50

The availability of groundwater supplies that are adequate for supporting irrigation development is limited primarily to areas in the western part of the division. About 88 percent of the approximately 2,100 irrigation wells in the division are located in Gage, Jefferson, Lancaster, and Saline counties. Seventeen new irrigation wells located in Gage, Jefferson, Johnson, Lancaster, and Saline counties were drilled and registered in the division during 1989. (Numbers of registered irrigation wells used in this report are based on computer records of the Nebraska Department of Water Resources. Revisions occasionally are made in these records to reflect adjustments to new information.)

In the fall of 1989, water-level declines of more than 5 feet from estimated predevelopment levels occurred in a number of small areas throughout the division. The sum of these areas, which generally coincides with areas where groundwater is used for irrigation, is about 25,000 acres. In 1987, in response to greater-than-normal precipitation, groundwater levels in the central and western parts of Saline County rose more than 10 feet from predevelopment water levels under an area of about 52,000 acres. Natural discharge has reduced the mounding and in the fall of 1989, the size of the area where this groundwater mound occurs was about 21,000 acres.

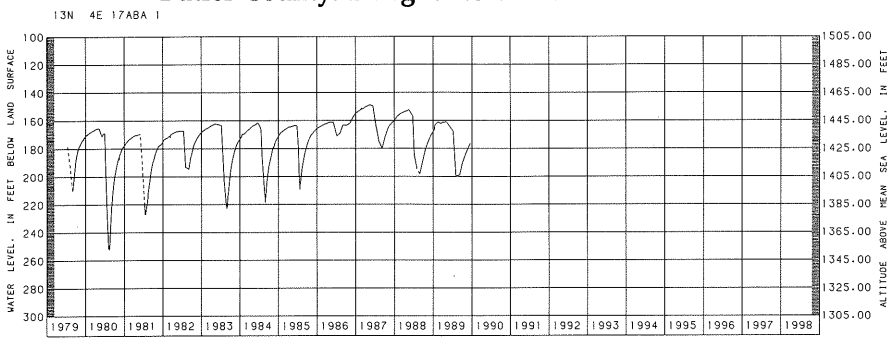
Estimated predevelopment water levels in the division are based on water levels measured prior to 1951. Data needed to determine predevelopment levels are sufficient only in the western part of the division. Water levels measured by the Lower Big Blue, Lower Platte South, and Nemaha natural resources districts, along with those measured by the U.S. Geological Survey and the Conservation and Survey Division, provide sufficient data for determining current water-level changes in most of the division.



Areas of significant water-level change in the Southeast Division from 1950 to fall 1989

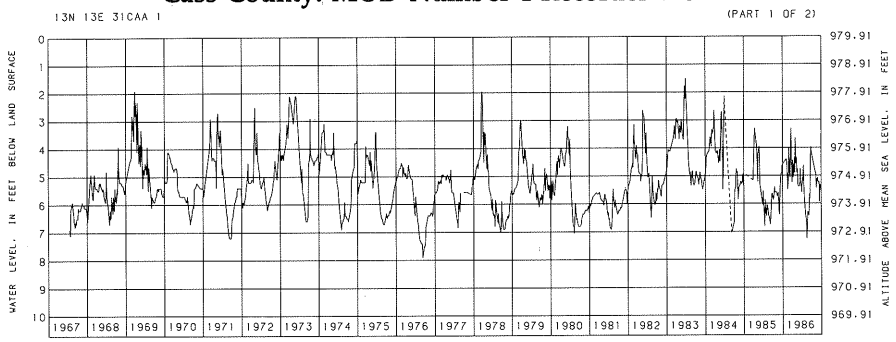
Butler County: Dwight North Recorder Well

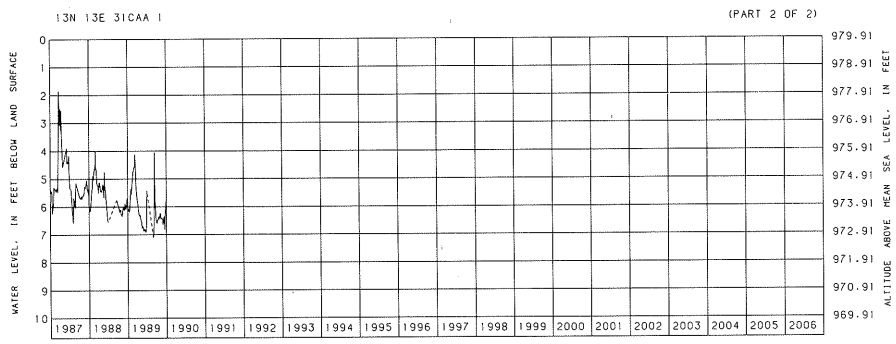
Estimated predevelopment water level: 163 feet
Net water-level change in 1989: −7.58 feet
Net water-level change since 1979: −3.12 feet



Cass County: MUD Number 4 Recorder Well

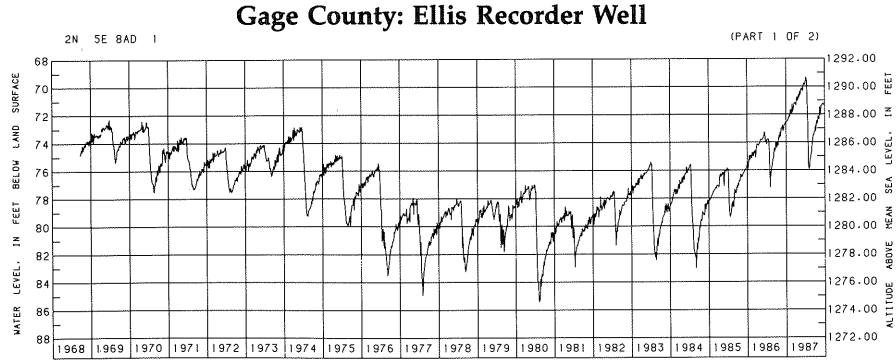
Estimated predevelopment water level: 4.5 feet
Net water-level change in 1989: +0.32 foot
Net water-level change since 1967: +0.78 foot



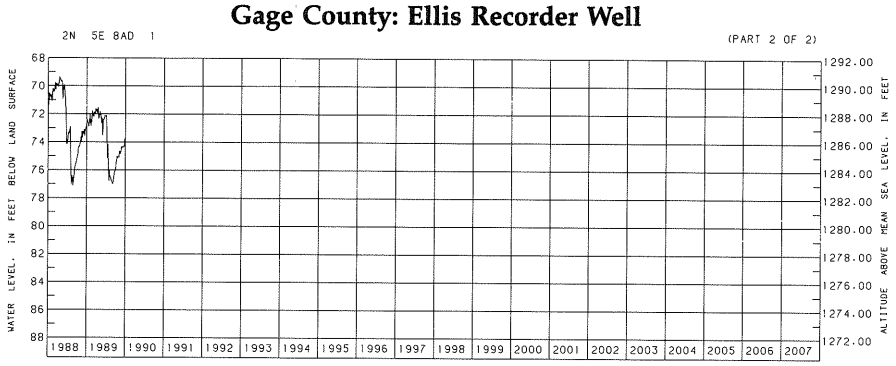


Gage County: Ellis Recorder Well

Estimated predevelopment water level: 73 feet
Net water-level change in 1989: −1.21 feet
Net water-level change since 1968: +0.20 foot

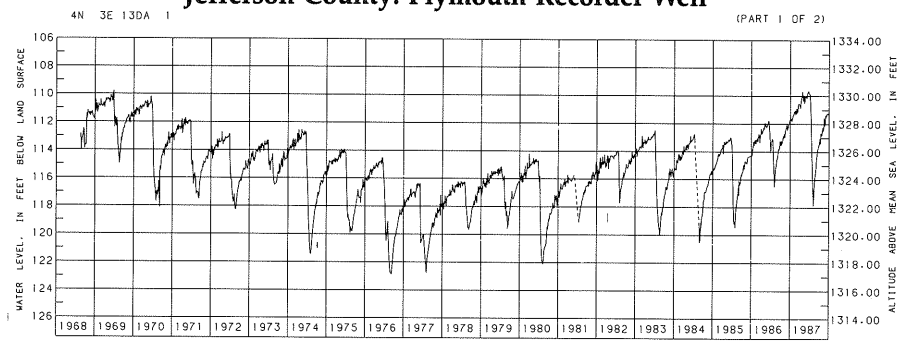


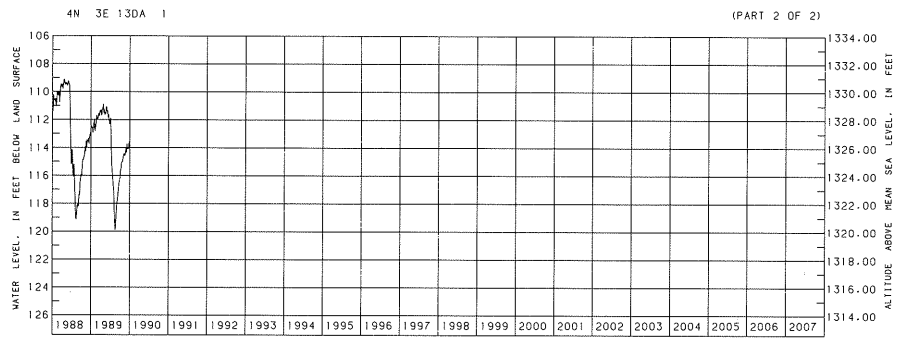
Gage County: Ellis Recorder Well



Jefferson County: Plymouth Recorder Well

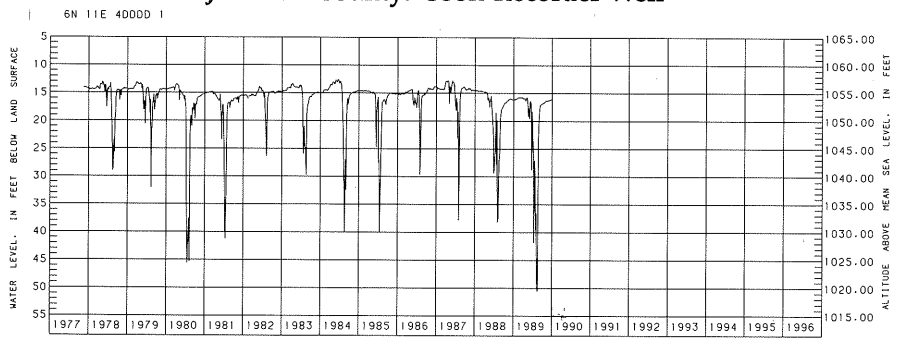
Estimated predevelopment water level: 107 feet
Net water-level change in 1989: −0.86 foot
Net water-level change since 1968: -2.05 feet





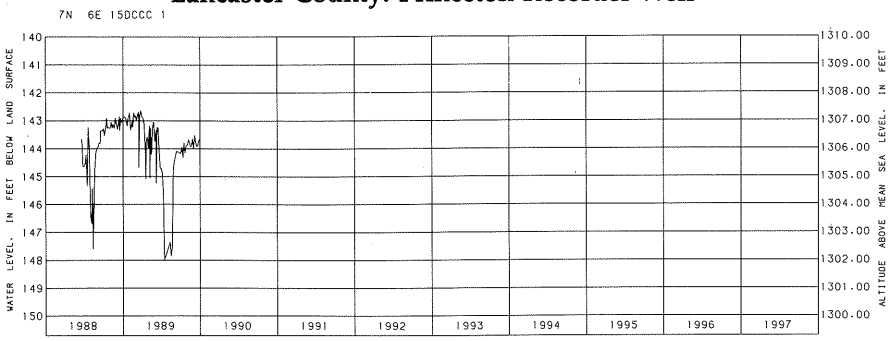
Johnson County: Cook Recorder Well

Estimated predevelopment water level: 13 feet
Net water-level change in 1989: +0.10 foot
Net water-level change since 1977: −1.77 feet



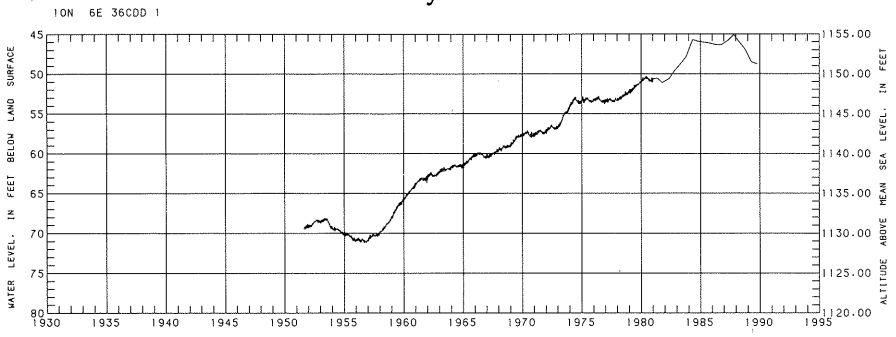
Lancaster County: Princeton Recorder Well

Estimated predevelopment water level: 143 feet
Net water-level change in 1989: −0.73 foot
Net water-level change since 1988: −0.73 foot



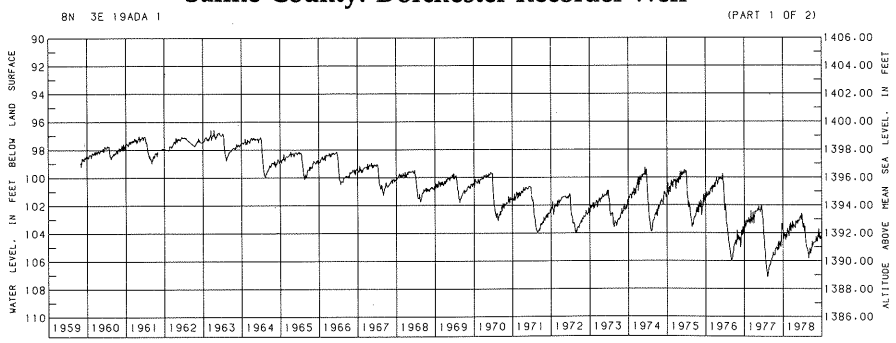
Lancaster County: Van Dorn Well

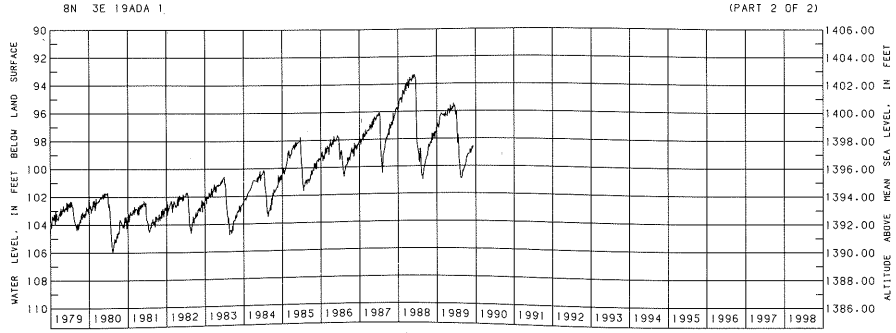
Measured annually
Estimated predevelopment water level: 35 feet
Net water-level change, fall 1988 to fall 1989: −1.83 feet
Net water-level change since 1951: +20.46 feet



Saline County: Dorchester Recorder Well

Estimated predevelopment water level: 97 feet
Net water-level change in 1989: −1.31 feet
Net water-level change since 1959: −0.32 foot





Northeast Division

Groundwater levels measured in the Northeast Division in the spring and fall of 1989 generally were lower than those that were measured in the spring and fall of 1988. Water levels in 96 percent of the 388 wells measured in the spring of 1989 were lower than those measured in the spring of 1988. Most of the declines ranged from 1.5 to 4 feet, and the greatest declines, about 10 feet, were in Dodge and Stanton counties. In the fall of 1989, water levels in 88 percent of the 461 wells measured were lower than those measured in the fall of 1988. Most of the declines in the fall of 1989 were between 1 and 2 feet. Declines of 5 to 10 feet, however, were common, and in Cumming County declines of as much as 14 feet occurred.

Spring 1989 water levels in the Northeast Division averaged 2.10 feet lower than spring 1988 water levels.

Differences between water levels measured in 1989 and those measured in 1988 were:

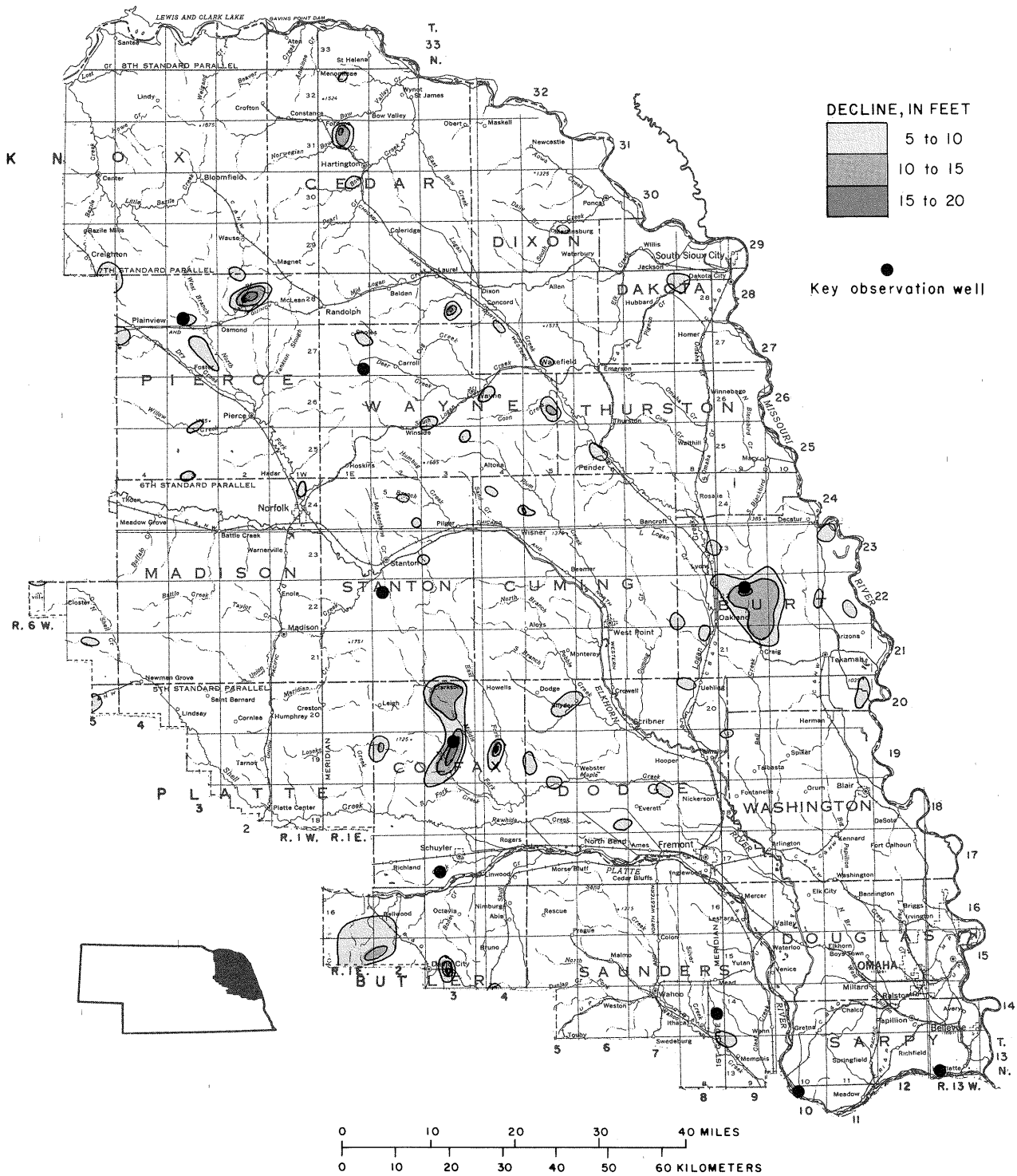
Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	388	4	−2.10	−1.83
Fall	461	12	−1.80	−1.60

Fall 1989 water-level measurements indicate that declines of more than 5 feet from estimated predevelopment levels occurred in almost all of the counties included in the Northeast Division. Most of these declines are small and cannot be delineated accurately from existing water-level data. The largest area where fall 1989 water levels declined 5 feet or more from estimated predevelopment water levels is about 30,000 acres. The largest water-level decline from the estimated predevelopment level was about 34 feet in a well located in north-central Pierce County.

Development of groundwater resources for irrigation began in the 1930s and accelerated in the early 1950s and mid-1970s because of droughts during those periods. During the 40-year period from 1950 through 1989, the number of irrigation wells installed and registered increased from about 300 to approximately 7,800. Less-than-normal precipitation during the growing season and favorable economic conditions generally encouraged installation of new irrigation wells in 1989, and 115 new irrigation wells were installed and registered in the division last year.

Declines from estimated predevelopment water levels, in most parts of the Northeast Division, usually are the result of pumpage during the irrigation season. Past spring measurements show that such declines generally are seasonal, and the water levels generally recover to near estimated predevelopment levels by the start of the next irrigation season. If a prolonged drought causes a large increase in water pumped and a large decrease in recharge to the aquifer, however, progressive declines in water levels might occur in these areas.

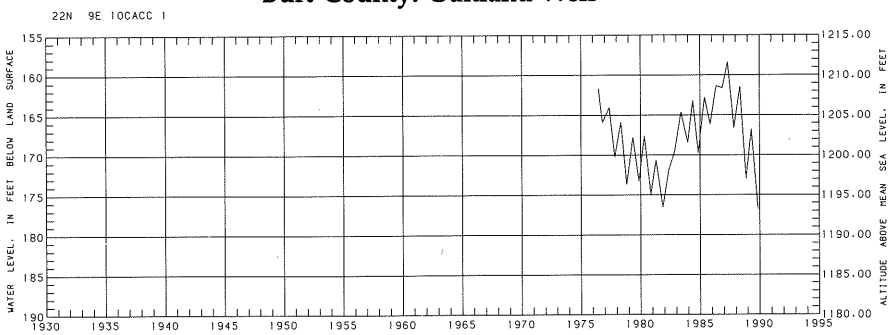
Sufficient data are available to provide reasonably good estimates of predevelopment water levels and current water-level changes throughout most of this division. Water-level measurements were made by the Lewis and Clark, Lower Elkhorn, Lower Platte North, and Papio-Missouri River natural resources districts, as well as by the Conservation and Survey Division and the U.S. Geological Survey.



Areas of significant water-level change in the Northeast Division from 1950 to fall 1989

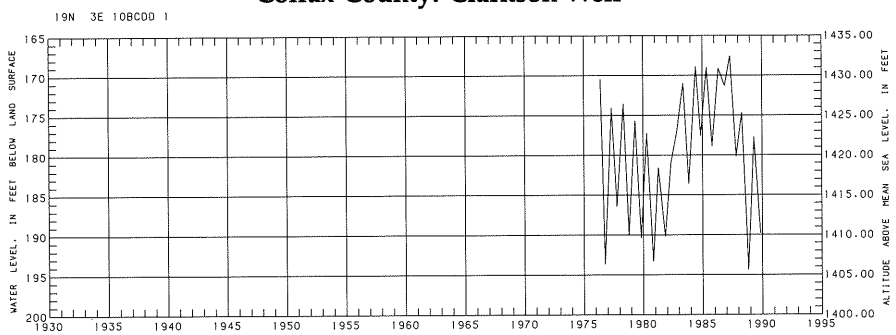
Burt County: Oakland Well

Measured semiannually
Estimated predevelopment water level: 161 feet
Net water-level change, fall 1988 to fall 1989: −3.77 feet
Net water-level change since 1976: −10.83 feet



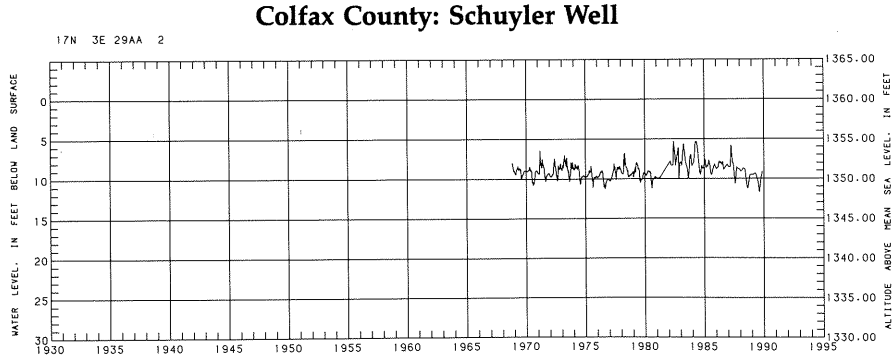
Colfax County: Clarkson Well

Measured semiannually
Estimated predevelopment water level: 169 feet
Net water-level change, fall 1988 to fall 1989: +4.56 feet
Net water-level change since 1976: +3.85 feet



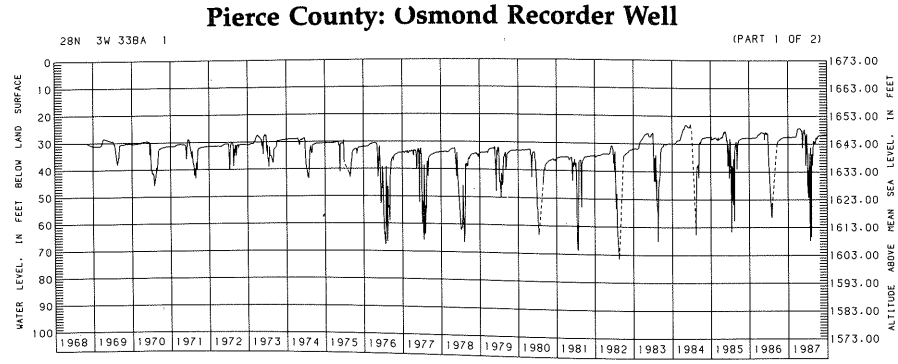
Colfax County: Schuyler Well

Measured monthly
Estimated predevelopment water level: 7.5 feet
Net water-level change in 1989: +0.39 foot
Net water-level change since 1968: −0.20 foot

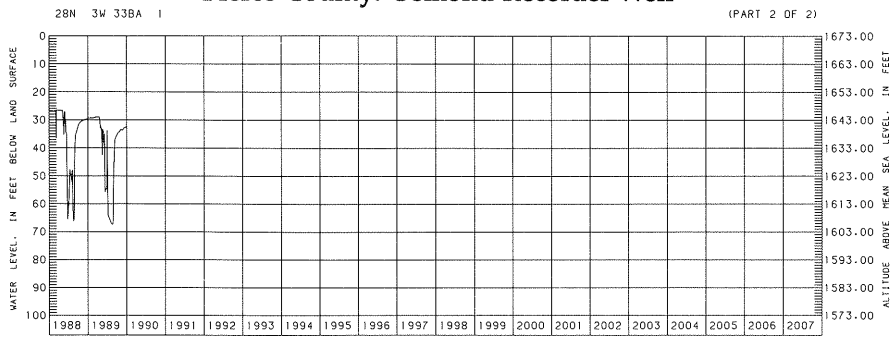


Pierce County: Osmond Recorder Well

Estimated predevelopment water level: 29 feet
Net water-level change in 1989: −2.94 feet
Net water-level change since 1968: −1.32 feet

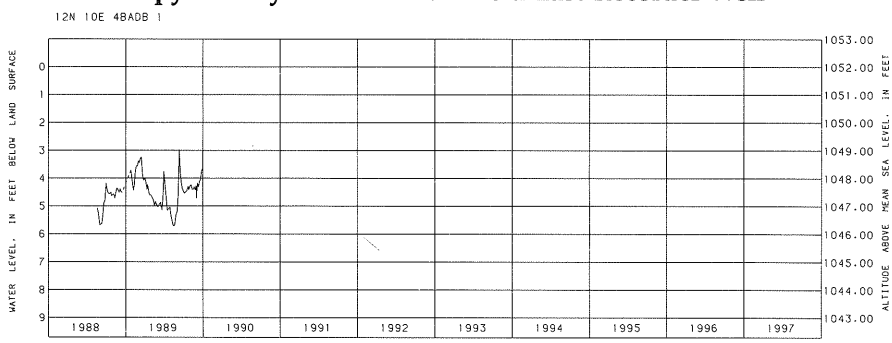


Pierce County: Osmond Recorder Well



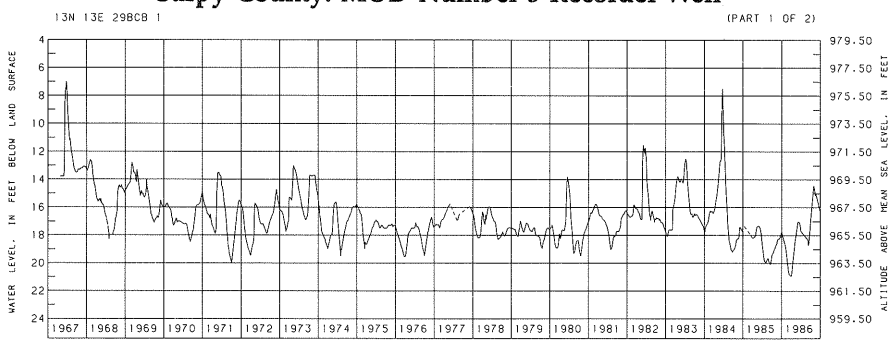
Sarpy County: Lincoln Well Field East Recorder Well

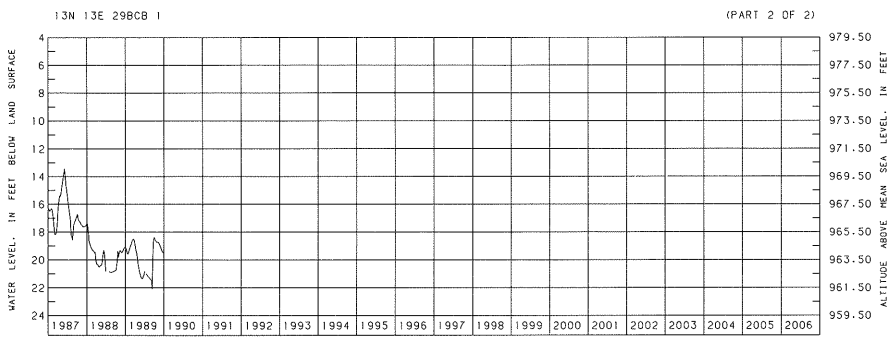
Estimated predevelopment water level: 3.5 feet
Net water-level change in 1989: +0.81 foot
Net water-level change since 1988: +0.81 foot



Sarpy County: MUD Number 3 Recorder Well

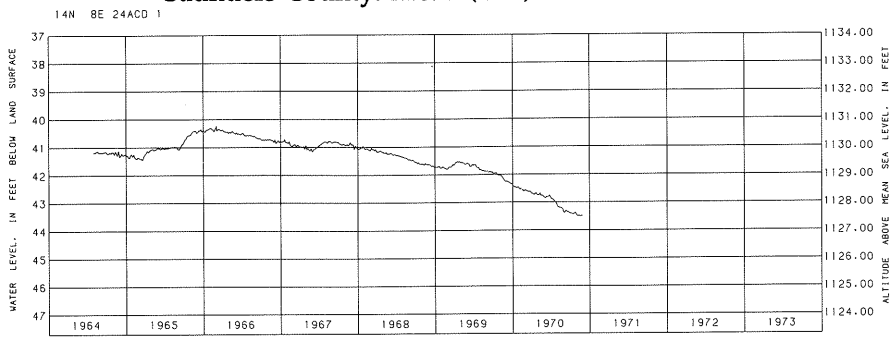
Estimated predevelopment water level: 13 feet
Net water-level change in 1989: −0.52 feet
Net water-level change since 1967: −6.29 feet





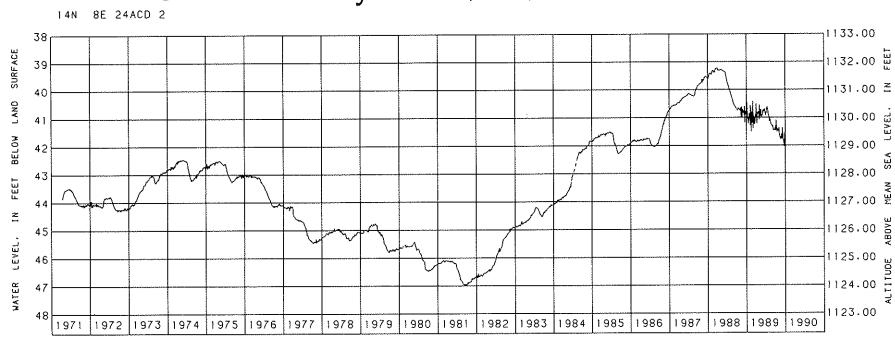
Saunders County: Mead (Old) Recorder Well

Estimated predevelopment water level: 40 feet
Well abandoned in 1970
Net water-level change from 1964 to 1970: −1.99 feet



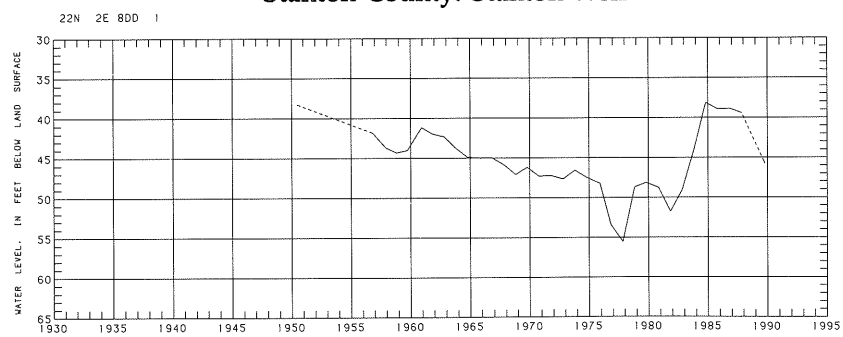
Saunders County: Mead (New) Recorder Well

Estimated predevelopment water level: 40 feet
Net water-level change in 1989: −0.99 foot
Net water-level change since 1971: +2.43 feet



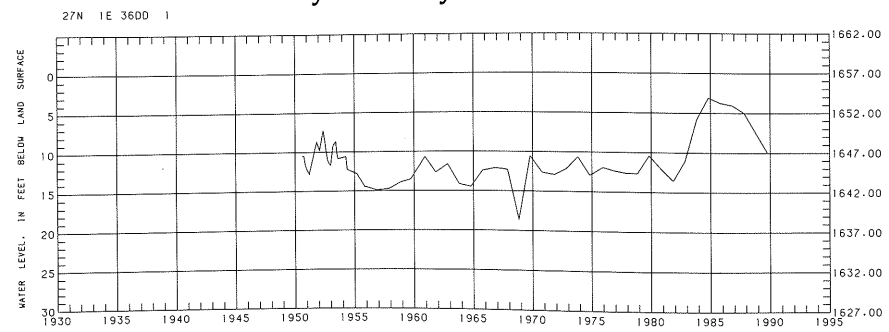
Stanton County: Stanton Well

Measured annually
Estimated predevelopment water level: 38 feet
Net water-level change, fall 1988 to fall 1989: −15.85 feet
Net water-level change since 1950: −7.67 feet



Wayne County: Carroll Well

Measured annually
Estimated predevelopment water level: 10.6 feet
Net water-level change, fall 1988 to fall 1989: −2.54 feet
Net water-level change since 1950: +1.58 feet



In the East South-Central Division 98 percent of the water levels measured in the spring of 1989 were lower than those measured in the spring of 1988.

East South-Central Division

In the East South-Central Division, 98 percent of the groundwater levels measured in 899 observation wells were lower in the spring of 1989 than they were in the spring of 1988. Most of these declines, which ranged from 1.5 to 5 feet, probably were in response to drought conditions during the 1988 growing season and the 1988-89 dormant season. Precipitation in the division during 1989 generally was less than normal, except in January, June, and September, when precipitation ranged from normal to greater than normal in most of the division. Because of the drought conditions during the 1989 growing season, less-than-normal recharge was available and greater-than-normal amounts of water were pumped for irrigation, which resulted in fall 1989 water levels being lower than the fall 1988 water levels in 72 percent of the 882 wells that were measured.

Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	899	2	−2.74	−2.24
Fall	882	28	− .60	− .71

Pumping for irrigation during the past 39 years has caused water levels to decline more than 5 feet below the estimated predevelopment water levels in an area of about 1.48 million acres. In 1989 the maximum decline, 42 feet, occurred in two wells located in Fillmore County.

Approximate areas of significant declines from estimated predevelopment water levels to fall 1989 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	520,000
10-15	453,000
15-20	271,000
20-25	175,000
25-30	48,000
30 or more	8,400

Sufficient data are available to provide reasonable definition of estimated predevelopment water levels throughout most of the division. Data collected by the Blue River Association of Ground Water Conservation Districts, the Clay County Ground Water Conservation District, and the Upper Big Blue and Little Blue natural resources districts are sufficient to evaluate current water-level changes.

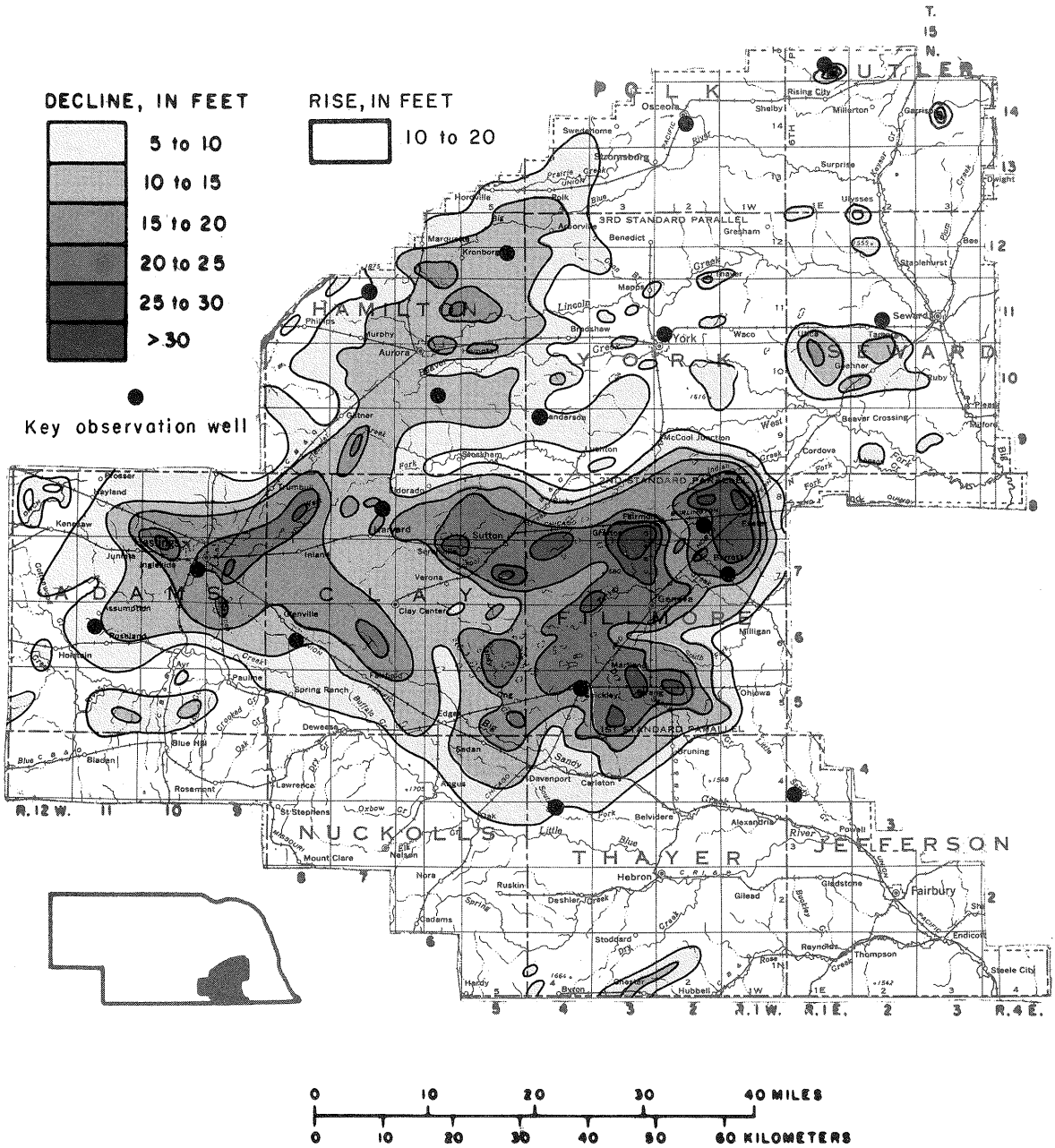
In this division, estimated predevelopment water levels are representative of the approximate average water levels that occurred in 1950. Although about 700 irrigation wells had been drilled prior to 1950, they were widely distributed, and significant water-level declines had occurred in only a few small localities. Widespread development of groundwater for irrigation occurred between 1953 and 1956 because of drought conditions, and by 1957 about 6,400 irrigation wells had been drilled. This intensive groundwater development, coupled with drought conditions, started widespread water-level declines in irrigated areas. Generally favorable economic conditions between 1957 and 1976 encouraged continued development of groundwater for irrigation at a moderate rate.

Drought conditions from 1973 to 1976 resulted in significant increases in the installation of new irrigation wells, and in the rate of water-level declines. Greater-than-normal precipitation and unfavorable economic conditions between 1977 and 1987 caused a decrease in the rate of new irrigation well installations. Less-than-normal precipitation during 1988 and 1989, however, resulted in a significant increase in the rate of irrigation well installations. During 1987, only 20 new wells were installed; but 71 new wells were installed during 1988, and 113 new wells were installed during 1989. By the end of 1989, there were about 15,400 registered irrigation wells in the division. Irrigation wells have been drilled in almost all parts of this division where groundwater supplies are adequate and where development is not limited by other factors such as land use, soil type, or topography.

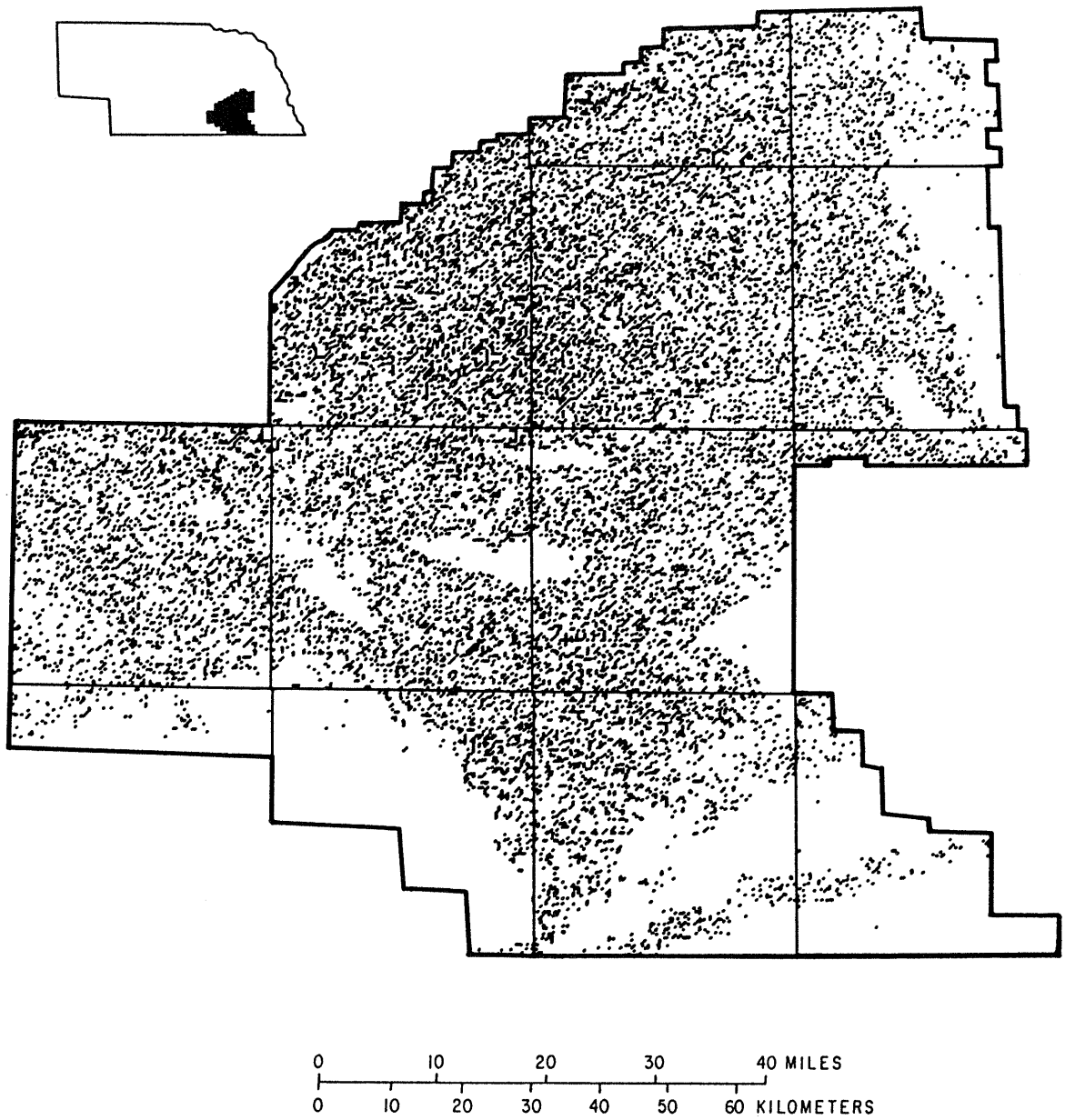
Because the Upper Big Blue and Little Blue groundwater control areas are in this division, information on water-level changes from estimated predevelopment levels to the spring of 1989 also is provided. The spring 1989 water levels declined 5 feet or more from estimated predevelopment levels in areas totaling about 1.15 million acres.

Approximate areas of significant declines from estimated predevelopment to spring 1989 water levels were:

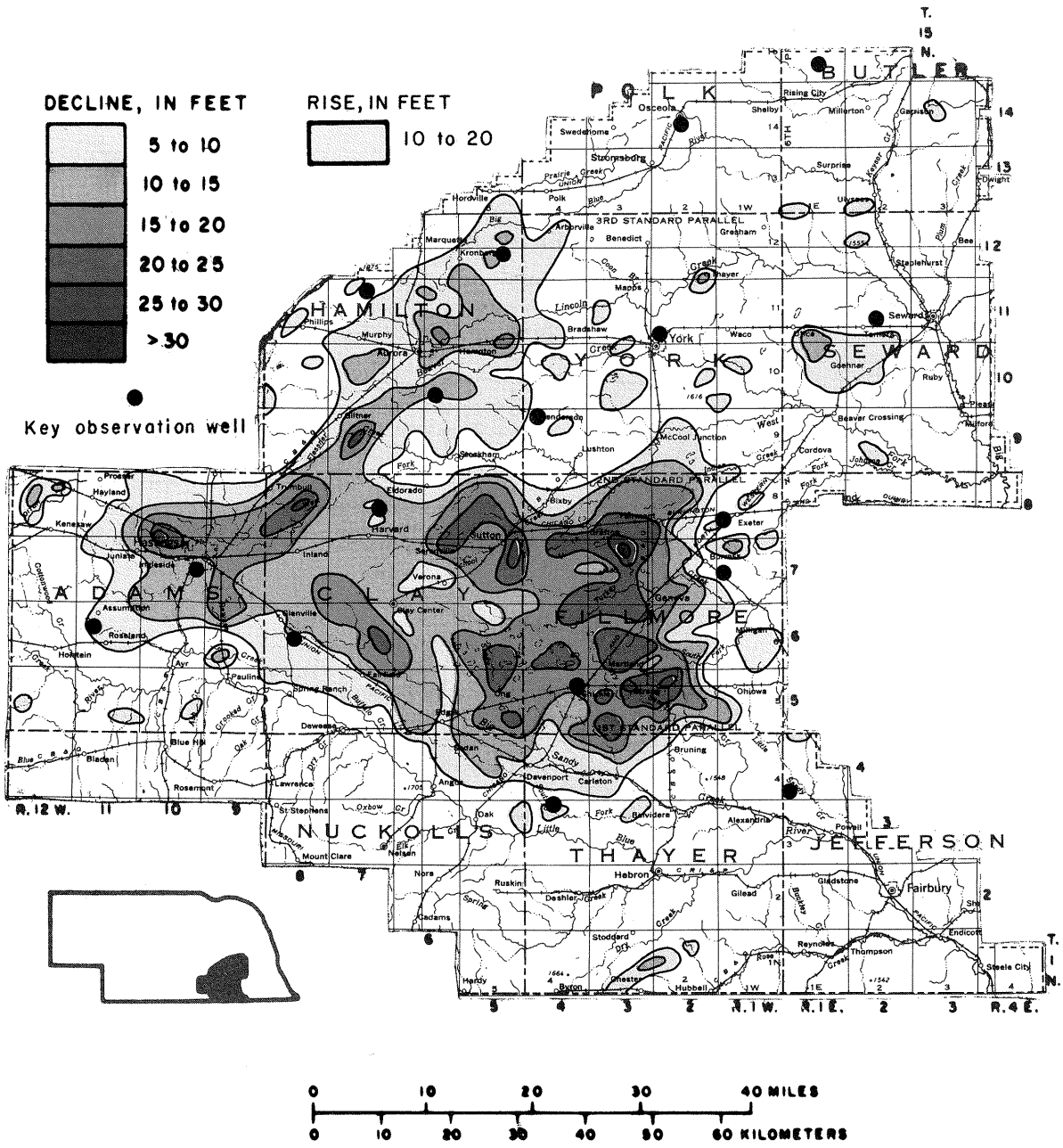
Range of decline, in feet	Approximate area of decline, in acres
5-10	466,000
10-15	343,000
15-20	232,000
20-25	99,000
25-30	7,300
30 or more	600



Areas of significant water-level change in the East South-Central Division from 1950 to fall 1989



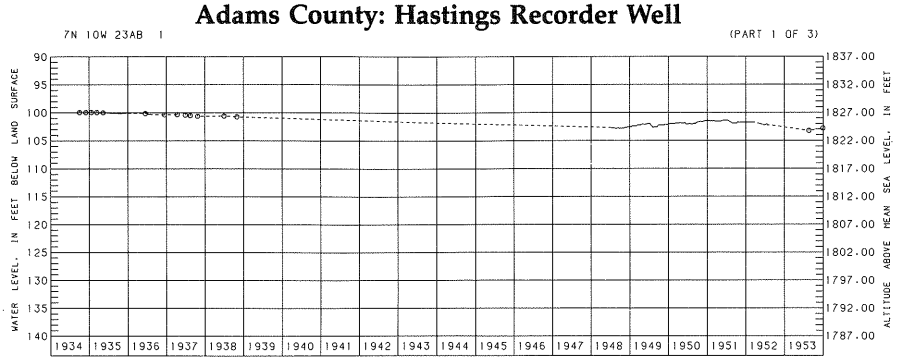
Location of registered irrigation wells in the East South-Central Division as of December 31, 1989

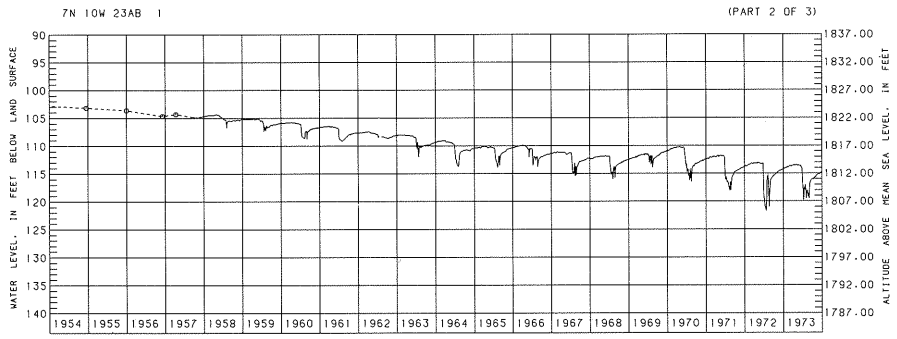


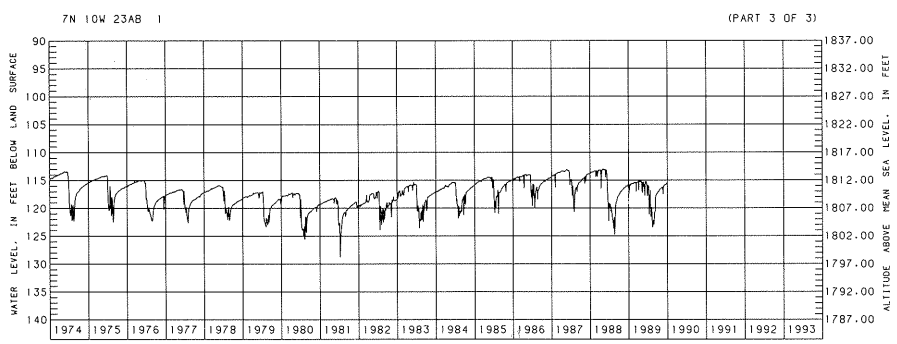
Areas of significant water-level change in the East South-Central Division from 1950 to spring 1989

Adams County: Hastings Recorder Well

Estimated predevelopment water level: 102 feet
Net water-level change in 1989: +0.22 foot
Net water-level change since 1934: −15.56 feet

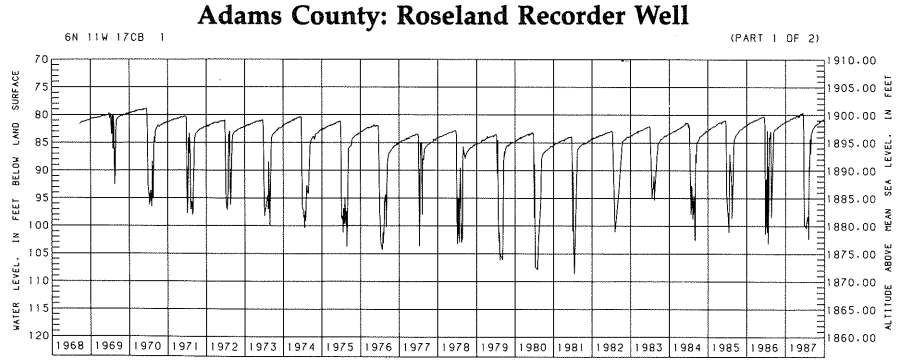




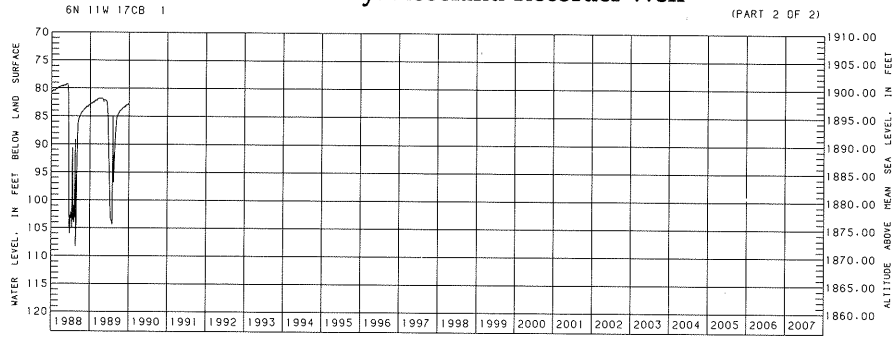


Adams County: Roseland Recorder Well

Estimated predevelopment water level: 77 feet
Net water-level change in 1989: +0.13 foot
Net water-level change since 1968: −1.97 feet

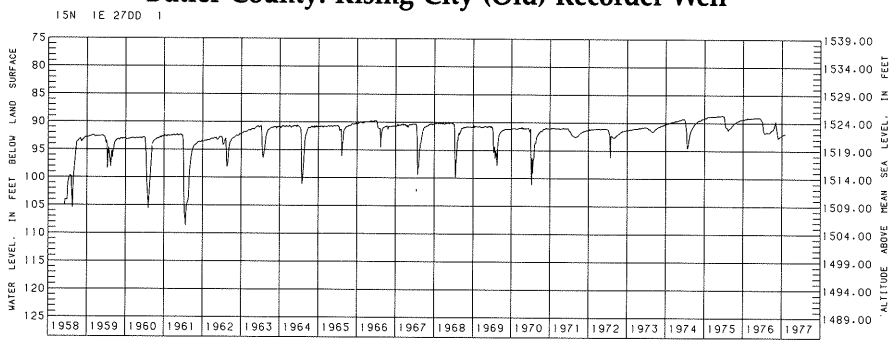


Adams County: Roseland Recorder Well



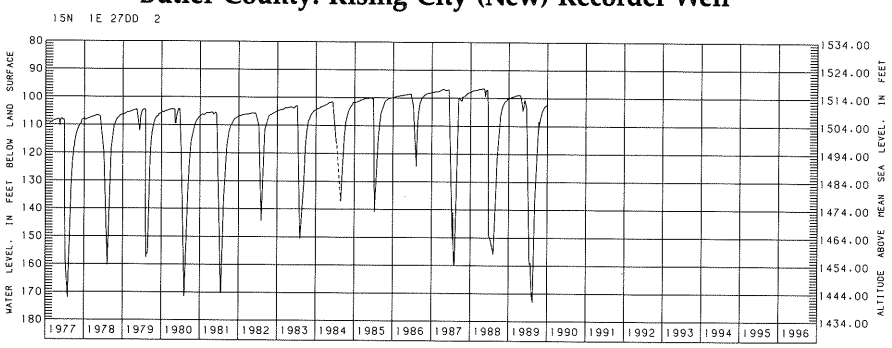
Butler County: Rising City (Old) Recorder Well

Estimated predevelopment water level: 108 feet
Well abandoned in 1977
Net water-level change from 1958 to 1976: +0.62 foot



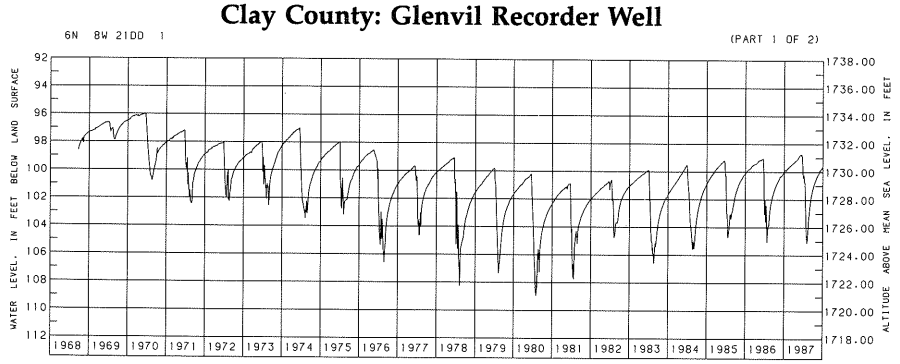
Butler County: Rising City (New) Recorder Well

Estimated predevelopment water level: 108 feet
Net water-level change in 1989: −1.98 feet
Net water-level change since 1977: +5.81 feet

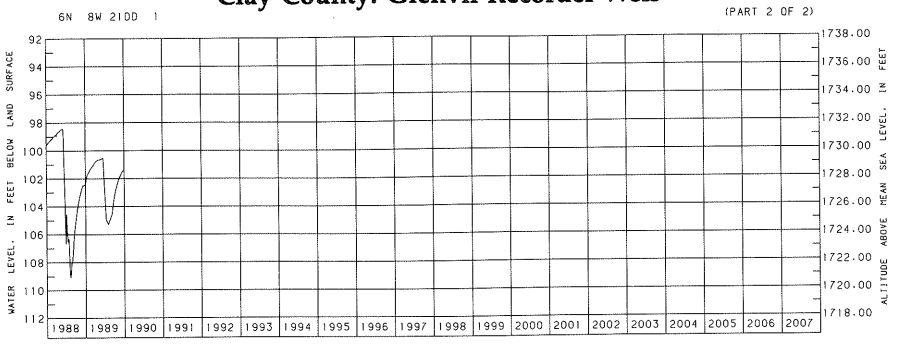


Clay County: Glenvil Recorder Well

Estimated predevelopment water level: 93 feet
Net water-level change in 1989: +1.15 feet
Net water-level change since 1968: −3.92 feet

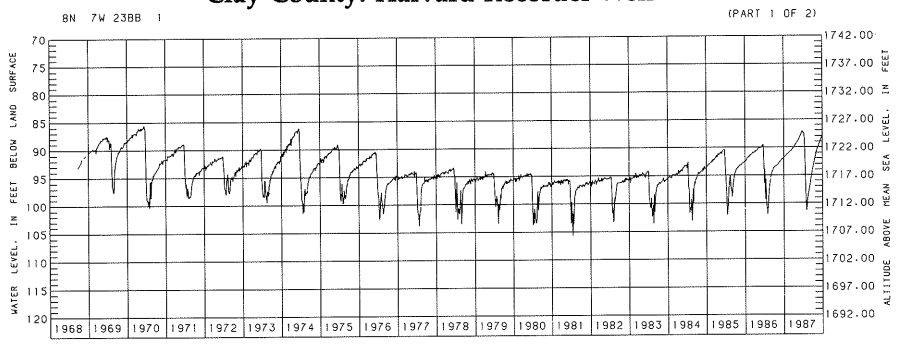


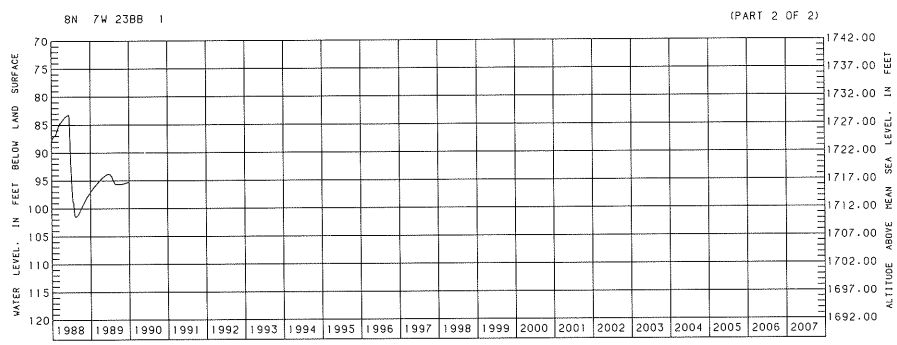
Clay County: Glenvil Recorder Well



Clay County: Harvard Recorder Well

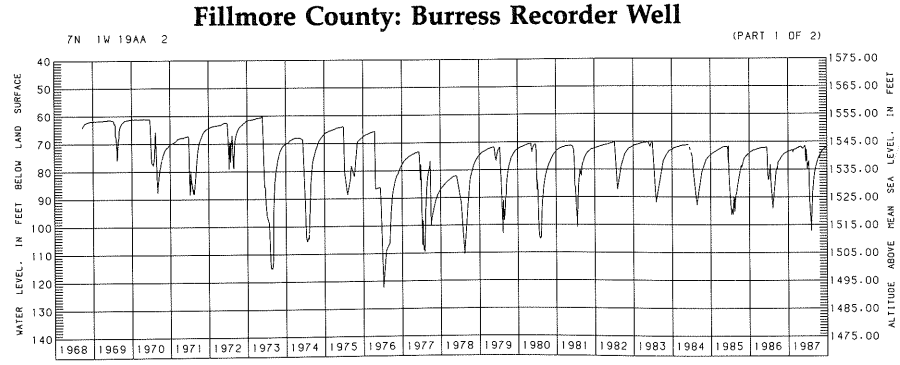
Estimated predevelopment water level: 79 feet
Net water-level change in 1989: +1.86 feet
Net water-level change since 1968: −4.72 feet



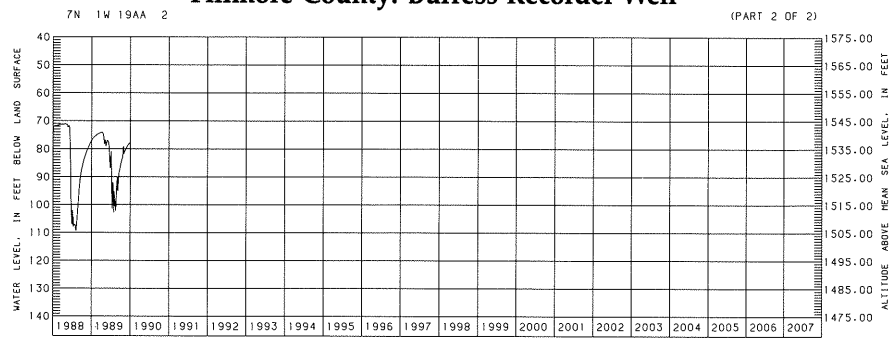


Fillmore County: Burress Recorder Well

Estimated predevelopment water level: 57 feet
Net water-level change in 1989: −0.41 foot
Net water-level change since 1968: −15.57 feet

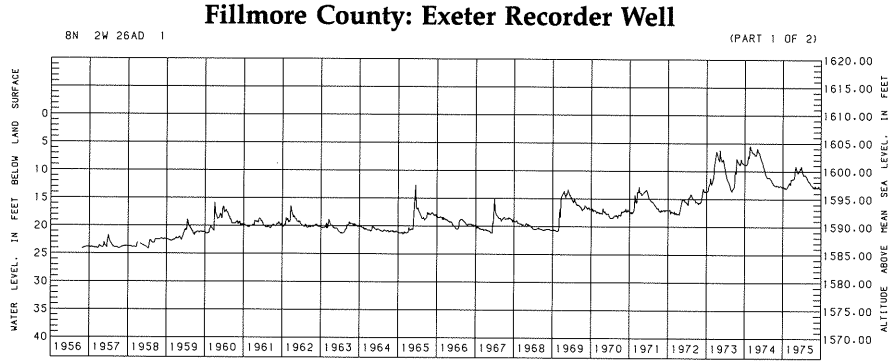


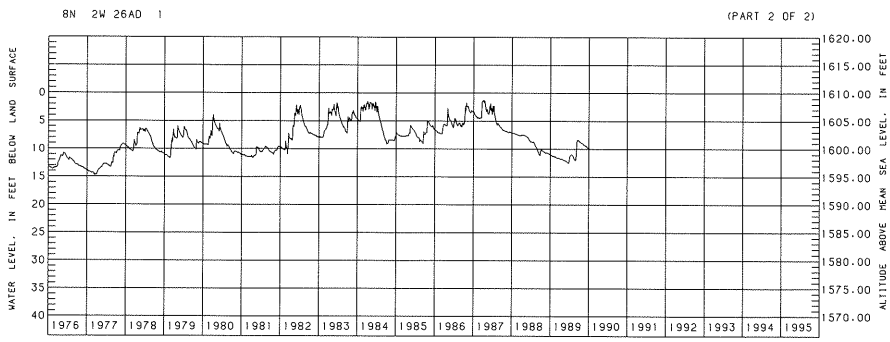
Fillmore County: Burress Recorder Well



Fillmore County: Exeter Recorder Well

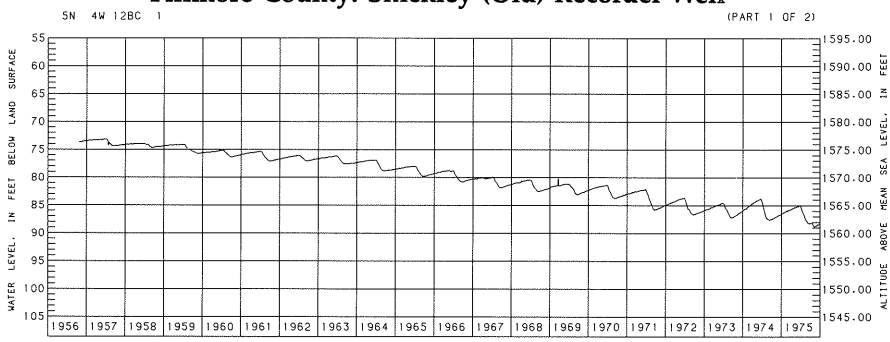
Estimated predevelopment water level: 24 feet
Net water-level change in 1989: +1.10 feet
Net water-level change since 1956: +14.01 feet



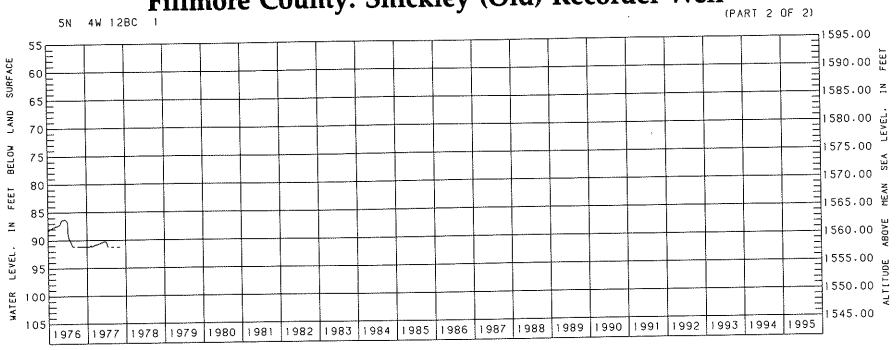


Fillmore County: Shickley (Old) Recorder Well

Estimated predevelopment water level: 73 feet
Well abandoned in 1977
Net water-level change from 1956 to 1976: −14.83 feet

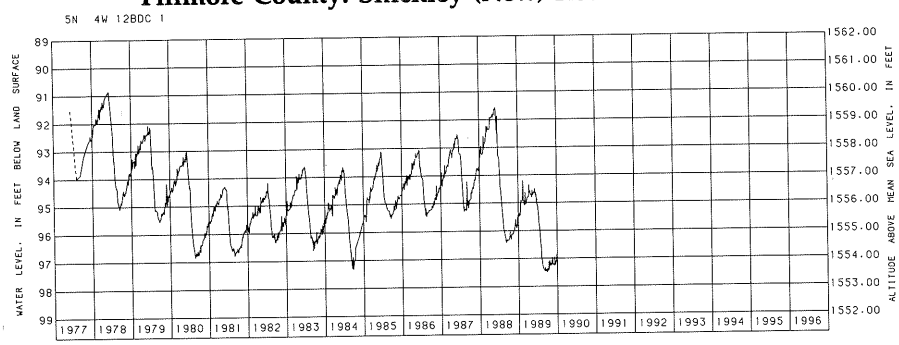


Fillmore County: Shickley (Old) Recorder Well



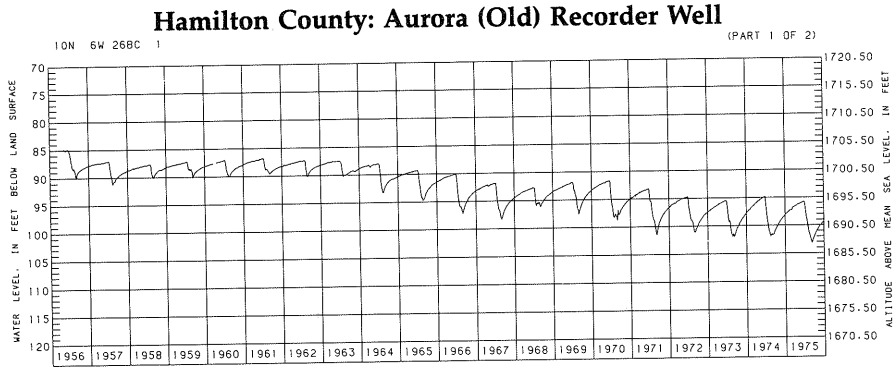
Fillmore County: Shickley (New) Recorder Well

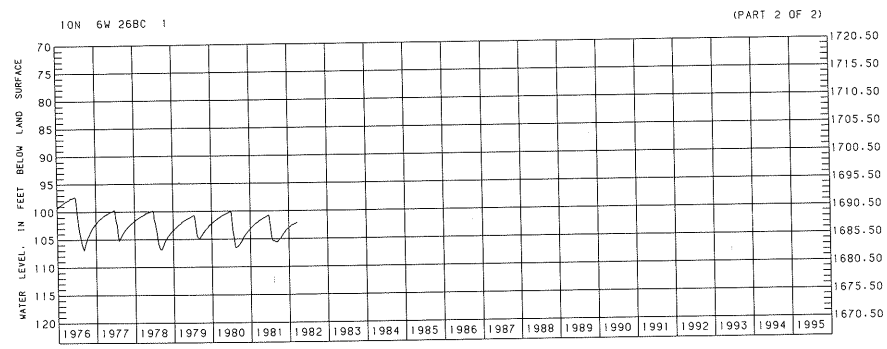
Estimated predevelopment water level: 72 feet
Net water-level change in 1989: −1.45 feet
Net water-level change since 1977: −4.34 feet



Hamilton County: Aurora (Old) Recorder Well

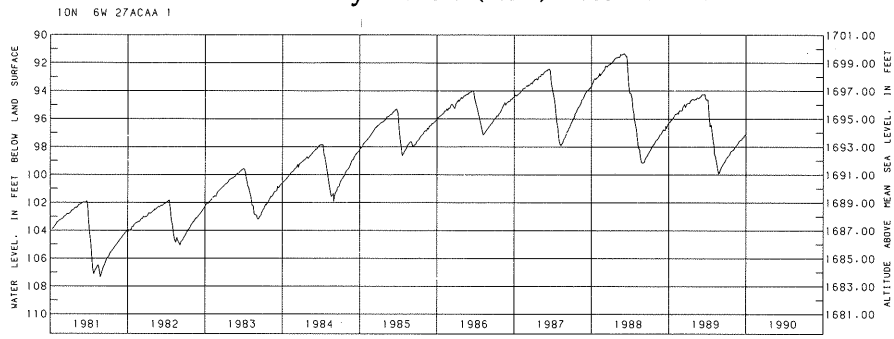
Estimated predevelopment water level: 83 feet
Well abandoned in 1981
Net water-level change from 1956 to 1981: −15.20 feet





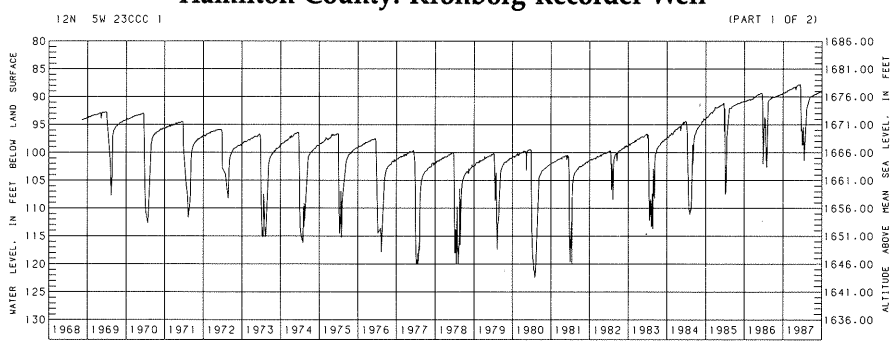
Hamilton County: Aurora (New) Recorder Well

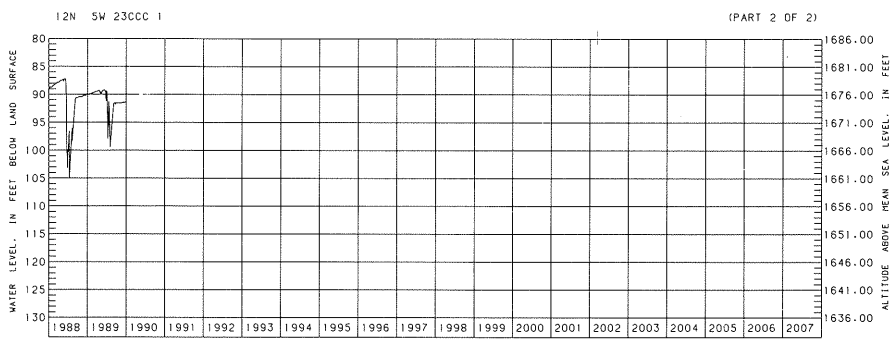
Estimated predevelopment water level: 84 feet
Net water-level change in 1989: −0.82 foot
Net water-level change since 1980: +7.01 feet



Hamilton County: Kronborg Recorder Well

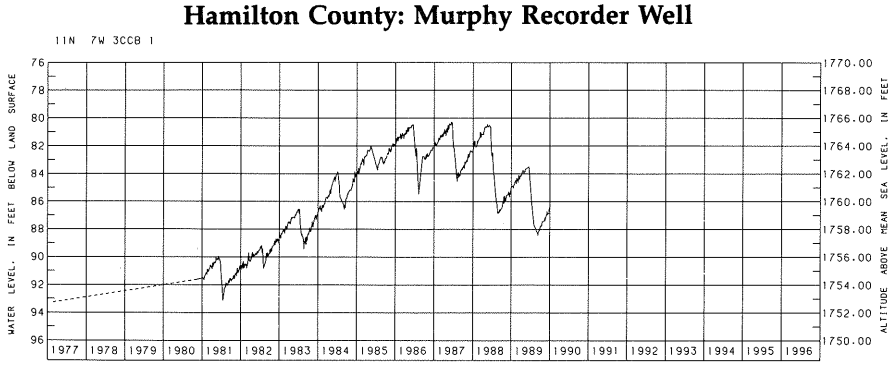
Estimated predevelopment water level: 81 feet
Net water-level change in 1989: −1.38 feet
Net water-level change since 1968: +2.55 feet





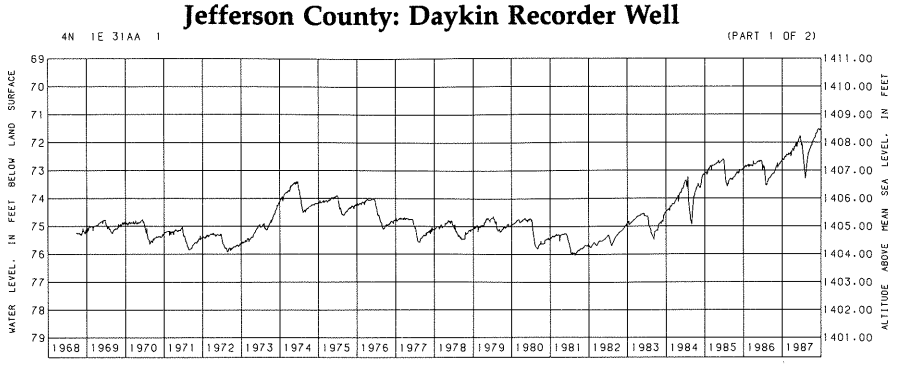
Hamilton County: Murphy Recorder Well

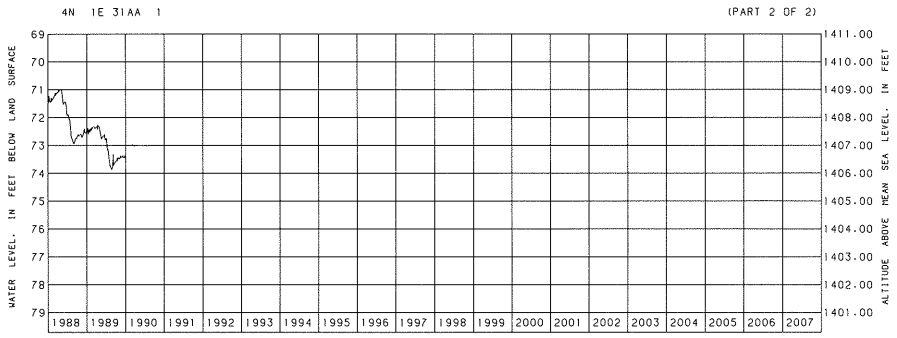
Estimated predevelopment water level: 83 feet
Net water-level change in 1989: −1.52 feet
Net water-level change since 1977: +6.80 feet



Jefferson County: Daykin Recorder Well

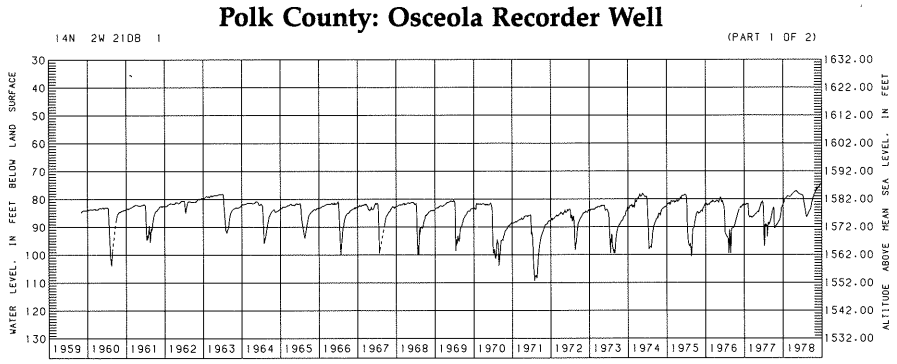
Estimated predevelopment water level: 74 feet
Net water-level change in 1989: −0.98 foot
Net water-level change since 1968: +1.89 feet

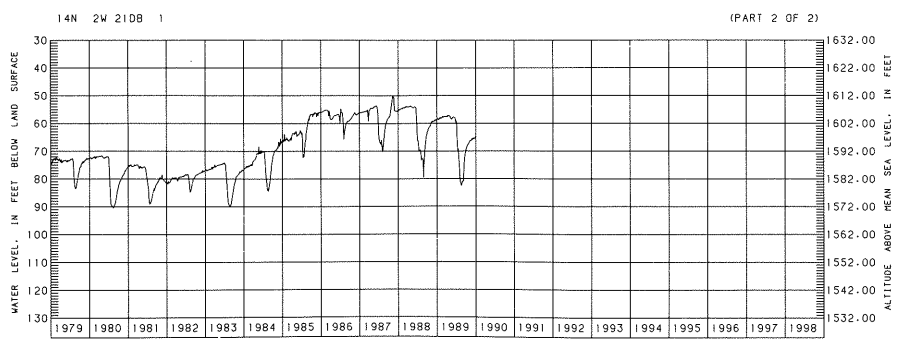




Polk County: Osceola Recorder Well

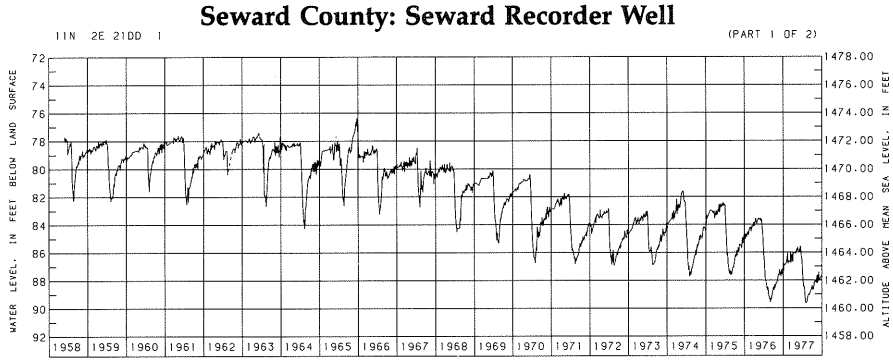
Estimated predevelopment water level: 80 feet
Net water-level change in 1989: −6.59 feet
Net water-level change since 1959: +18.99 feet
Lower part of casing may have collapsed.

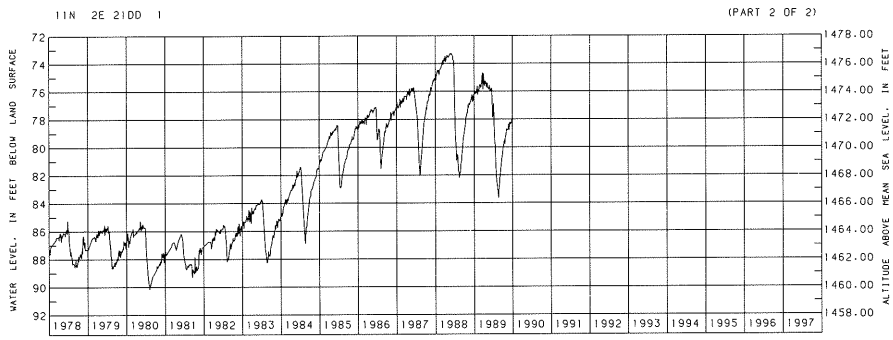




Seward County: Seward Recorder Well

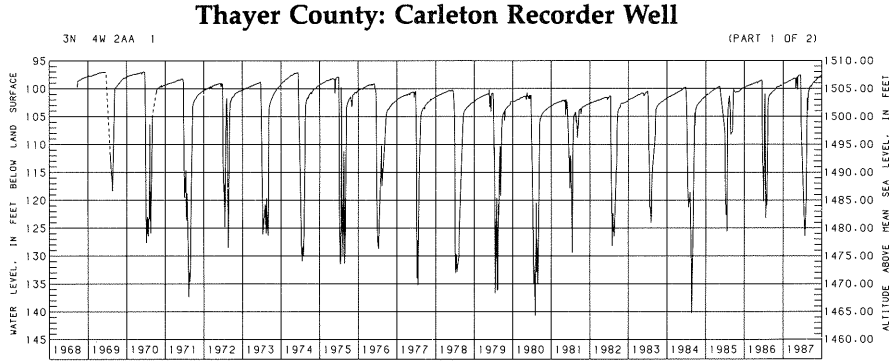
Estimated predevelopment water level: 74 feet
Net water-level change in 1989: −1.76 feet
Net water-level change since 1958: +0.78 foot

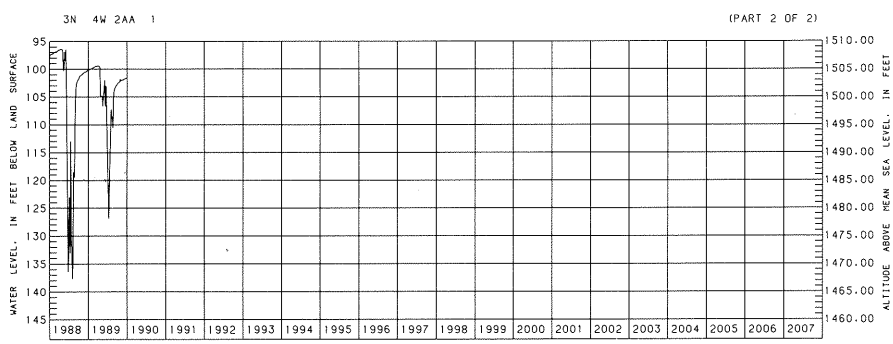




Thayer County: Carleton Recorder Well

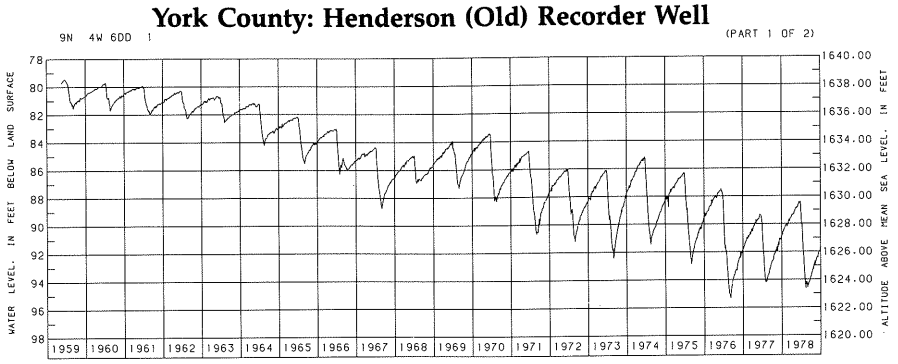
Estimated predevelopment water level: 95 feet
Net water-level change in 1989: −1.45 feet
Net water-level change since 1968: −3.70 feet

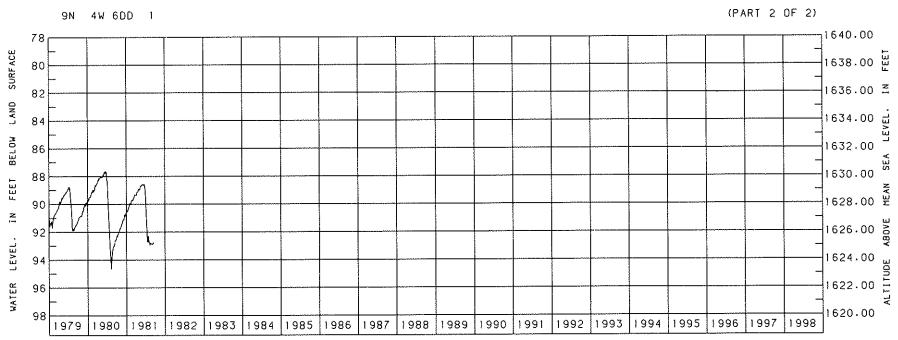




York County: Henderson (Old) Recorder Well

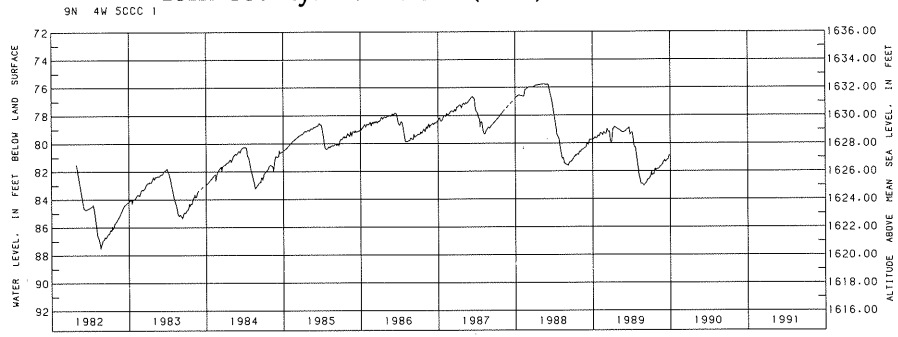
Estimated predevelopment water level: 80 feet
Well destroyed in 1981
Net water-level change from 1959 to 1981: −10.02 feet





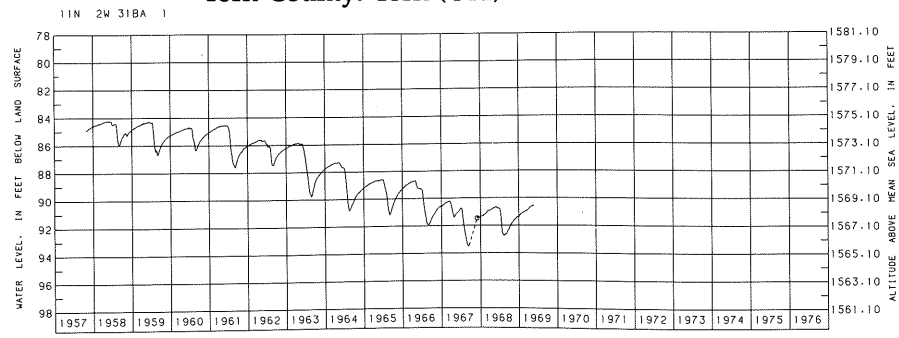
York County: Henderson (New) Recorder Well

Estimated predevelopment water level: 70 feet
Net water-level change in 1989: −1.15 feet
Net water-level change since 1982: +3.27 feet



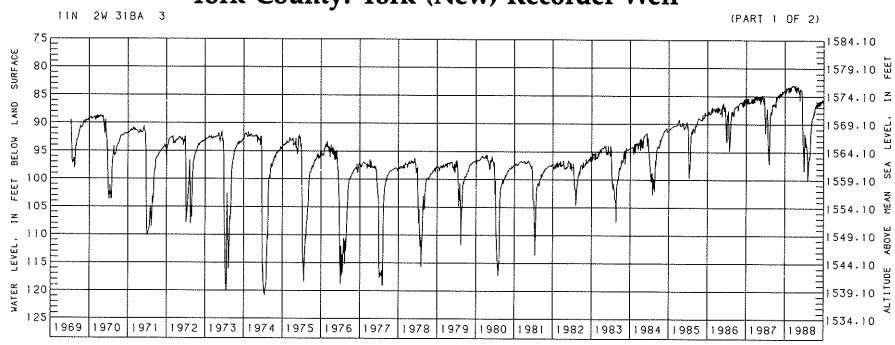
York County: York (Old) Recorder Well

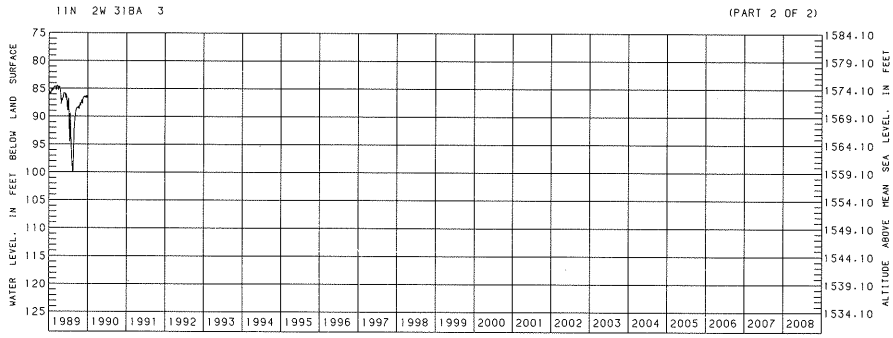
Estimated predevelopment water level: 84 feet
Well abandoned in 1969
Net water-level change from 1957 to 1968: −6.78 feet



York County: York (New) Recorder Well

Estimated predevelopment water level: 85 feet
Net water-level change in 1989: +0.02 foot
Net water-level change since 1969: +2.76 feet





West South-Central Division

Groundwater levels in the spring of 1989 generally were lower in the West South-Central Division than they were in the spring of 1988. Water levels in most of wells measured ranged between 0.2 and 1 foot lower; but in Kearney and Phelps counties most spring 1989 water levels were 1 to 3 feet lower than spring 1988 water levels. In the fall of 1989, water levels in 54 percent of the 289 measured observation wells were lower than water levels measured in the fall of 1988. Most water-level measurements in the fall of 1989 were between 1 foot higher and 1 foot lower than in the fall of 1988.

Water levels in most observation wells in the West South-Central Division were lower in the fall of 1989 than they were in the fall of 1988.

Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	270	20	−0.85	−0.89
Fall	289	46	− .13	− .10

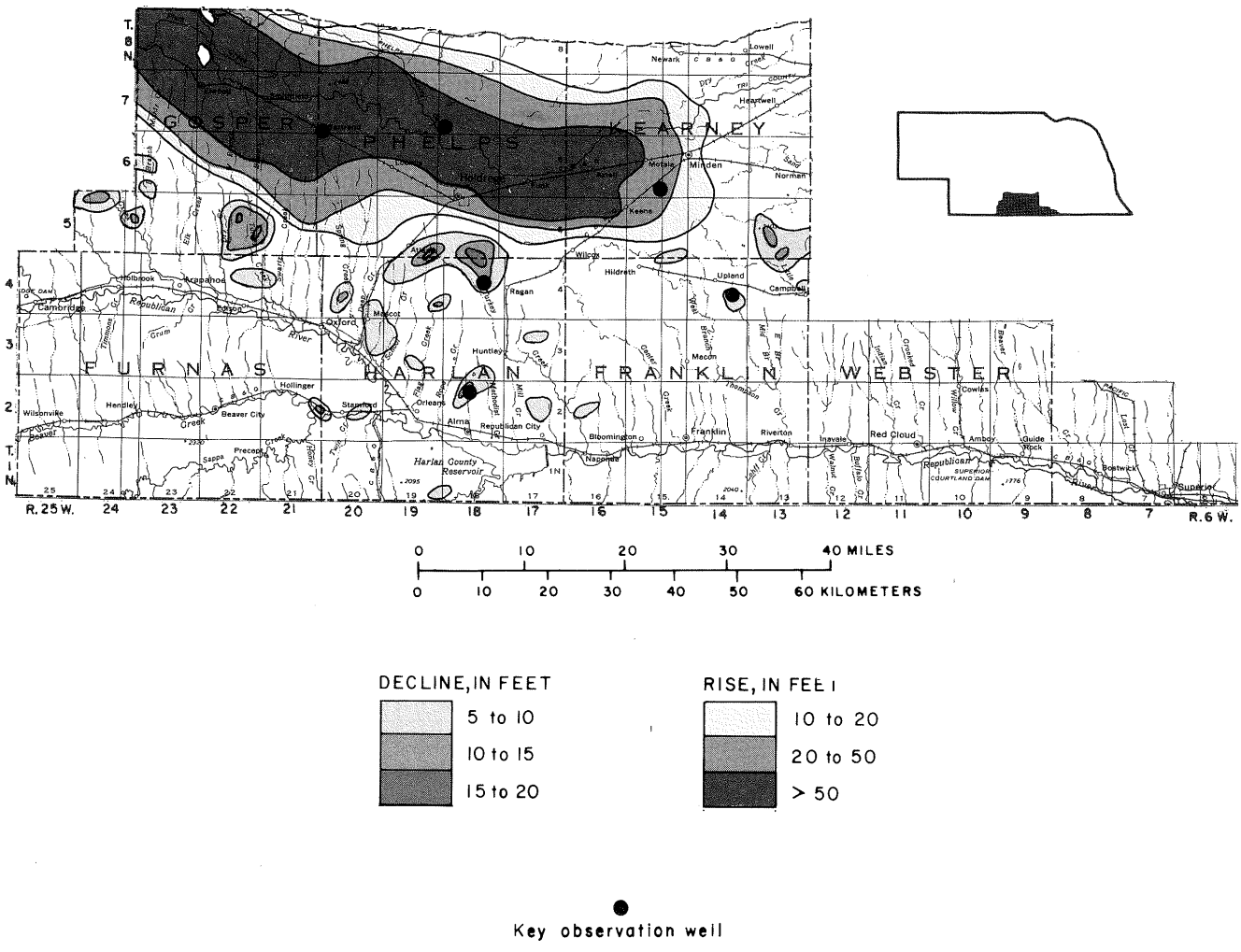
The water-level rise since predevelopment in Gosper, Kearney, and Phelps counties is the greatest in Nebraska. In this area, water released from storage in Lake McConaughy and subsequently diverted from the Platte River near North Platte has been used for irrigation since 1941. Deep percolation of water from the irrigation distribution systems and from water applied to crops has raised the water table 10 feet or more from its estimated predevelopment level beneath about 588,000 acres. The greatest known water-level rises from predevelopment are about 114 feet 6 miles north of Bertrand in Phelps County, about 101 feet 4.2 miles northwest of Elwood in Gosper County, and about 68 feet 1.1 miles north of Axtell in Kearney County. Estimated predevelopment water levels in Gosper, Kearney, and Phelps counties are about equal to average water levels prior to 1940.

Approximate areas of significant water-level rises from estimated predevelopment to fall 1989 were:

Range of rise, in feet	Approximate area of rise, in acres
10-20	120,000
20-50	162,000
50 or more	306,000

In Gosper, Kearney, and Phelps counties, use of groundwater for irrigation has decreased the rate of water-level rise in many areas. Also, where the water table has risen enough, natural discharge through evapotranspiration and groundwater discharge into streams and wetlands contributes to stabilizing water levels. Elsewhere in the division, increased use of groundwater for irrigation in recent years has caused water levels to decline below estimated predevelopment levels in a number of small areas. Declines of more than 5 feet have occurred in areas totaling about 106,000 acres. At the end of 1989 there were about 6,700 registered irrigation wells in the division, 52 of which were drilled in 1989.

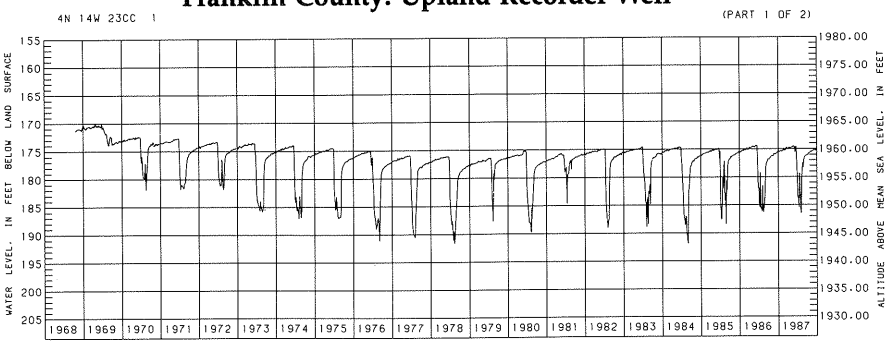
Data for estimating predevelopment water levels generally are adequate. Since 1947, water-level measurement programs have provided enough data for an adequate evaluation of long-term water-level changes and also for the definition of current water-level changes. Water-level data are collected by the Tri-Basin and Lower Republican natural resources districts, the Central Nebraska Public Power and Irrigation District, the Frenchman-Cambridge and Bostwick irrigation districts, the Harlan County and Furnas County extension agents, and the U.S. Geological Survey.

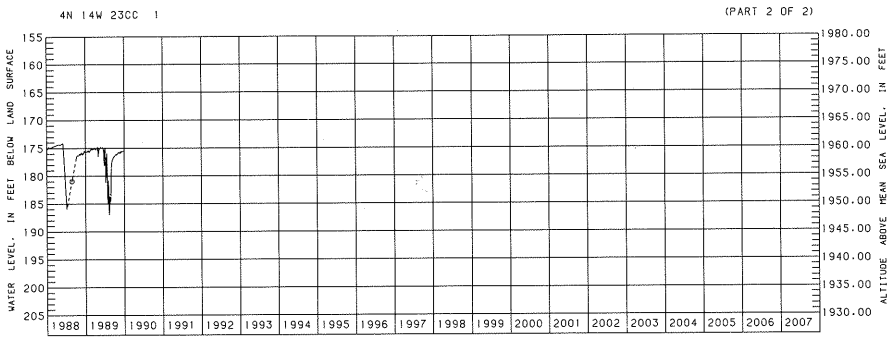


Areas of significant water-level change in the West South-Central Division from 1940 to fall 1989

Franklin County: Upland Recorder Well

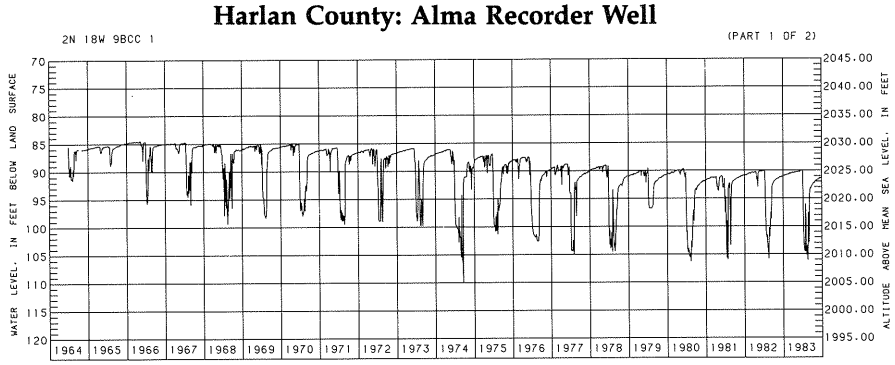
Estimated predevelopment water level: 170 feet
Net water-level change in 1989: +0.36 foot
Net water-level change since 1968: −4.98 feet

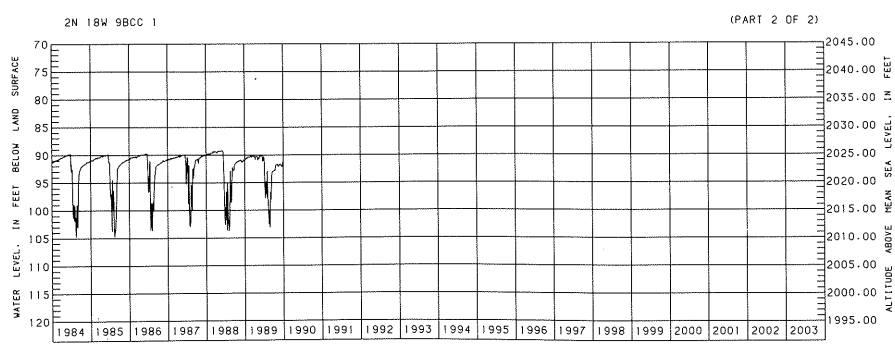




Harlan County: Alma Recorder Well

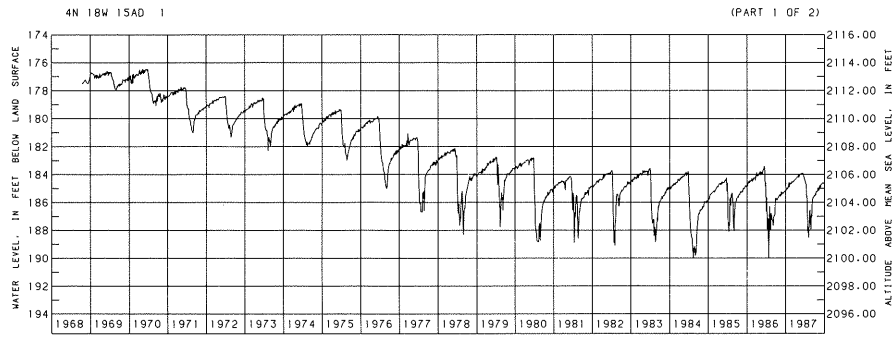
Estimated predevelopment water level: 85 feet
Net water-level change in 1989: −0.33 foot
Net water-level change since 1964: −5.30 feet

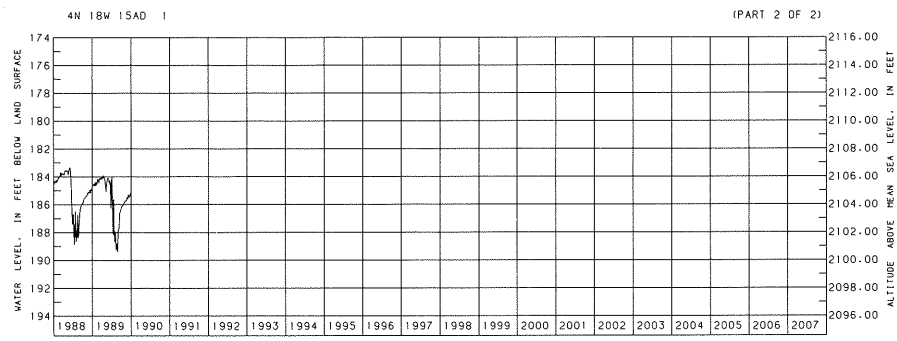




Harlan County: Ragan Recorder Well

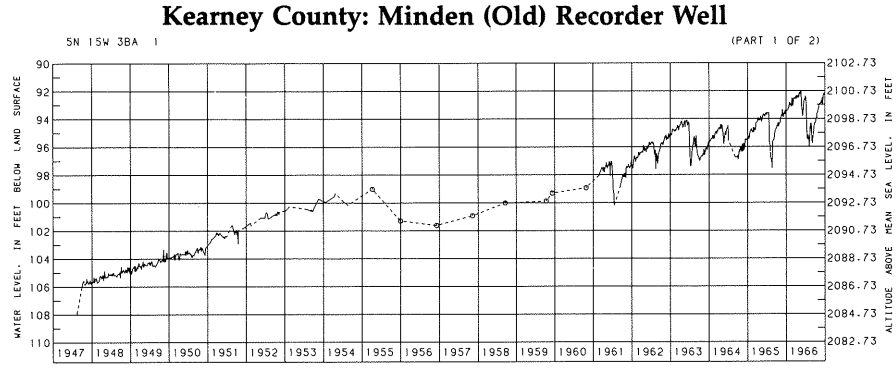
Estimated predevelopment water level: 176 feet
Net water-level change in 1989: −0.55 foot
Net water-level change since 1968: −8.21 feet

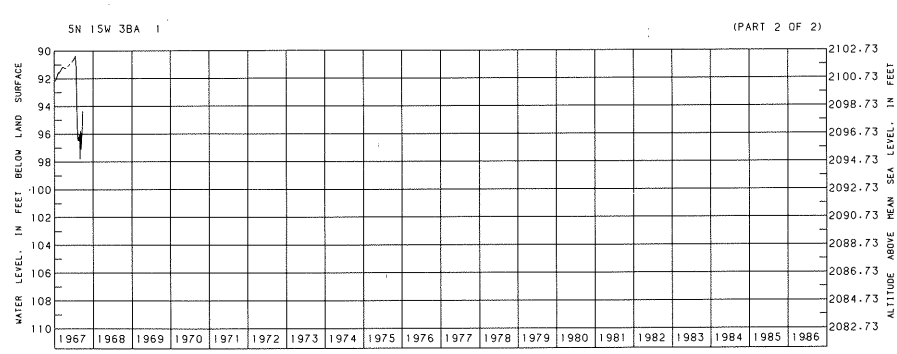




Kearney County: Minden (Old) Recorder Well

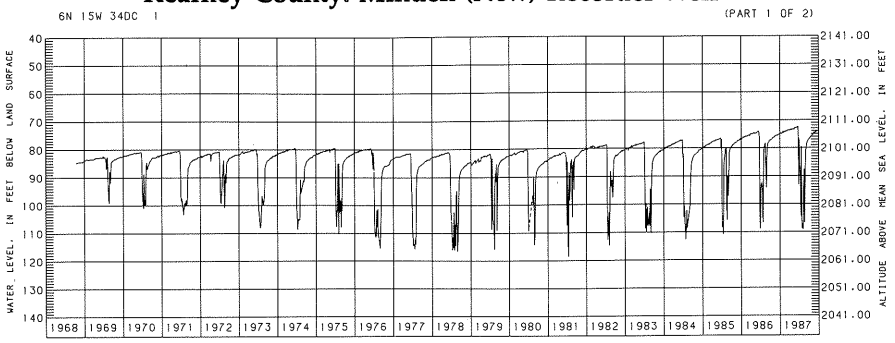
Estimated predevelopment water level: 113 feet
Well abandoned in 1967
Net water-level change from 1947 to 1966: +13.49 feet

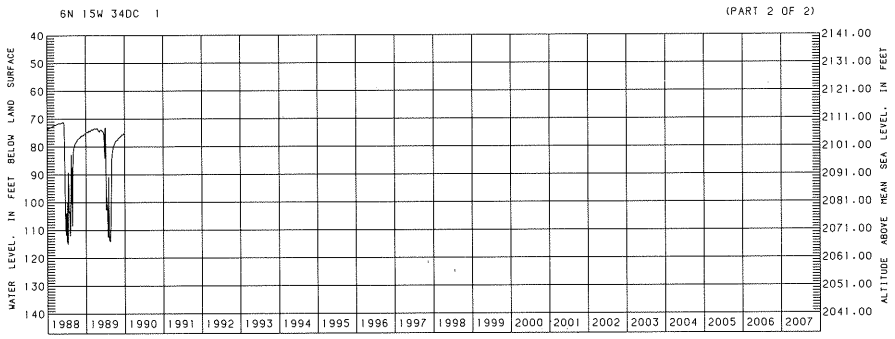




Kearney County: Minden (New) Recorder Well

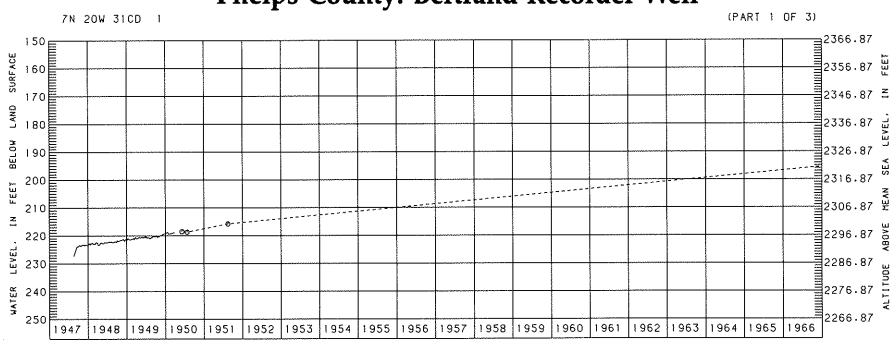
Estimated predevelopment water level: 103 feet
Net water-level change in 1989: −0.13 foot
Net water-level change since 1968: +8.83 feet

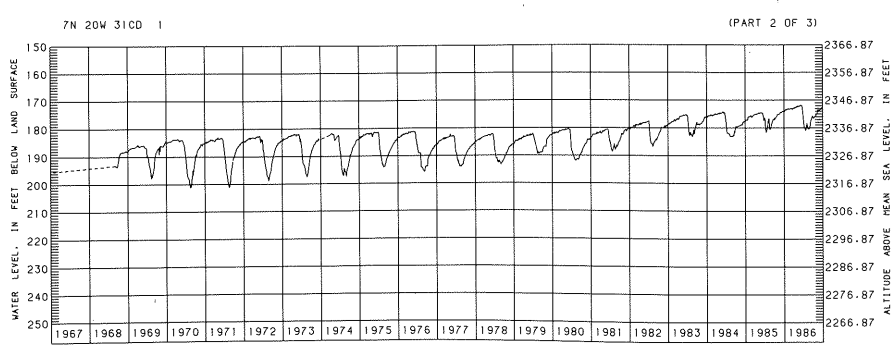




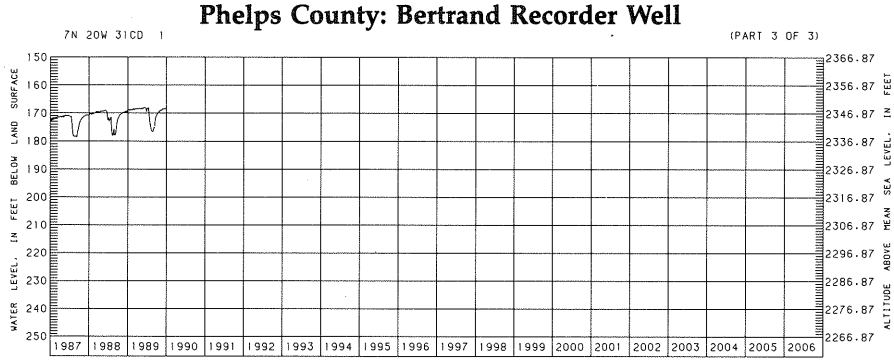
Phelps County: Bertrand Recorder Well

Estimated predevelopment water level: 232 feet
Net water-level change in 1989: +0.80 foot
Net water-level change since 1947: +55.05 feet

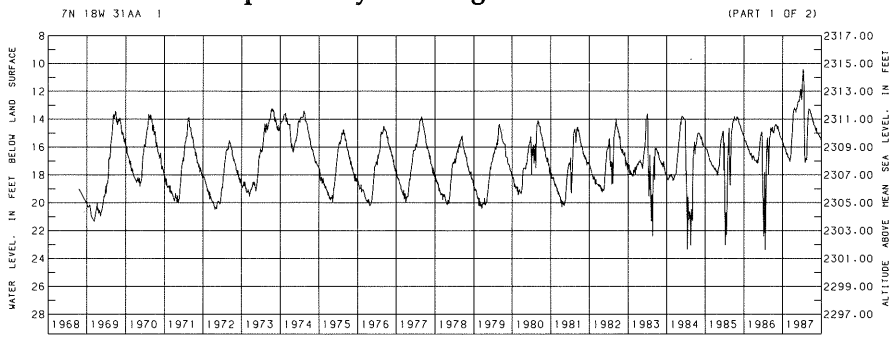




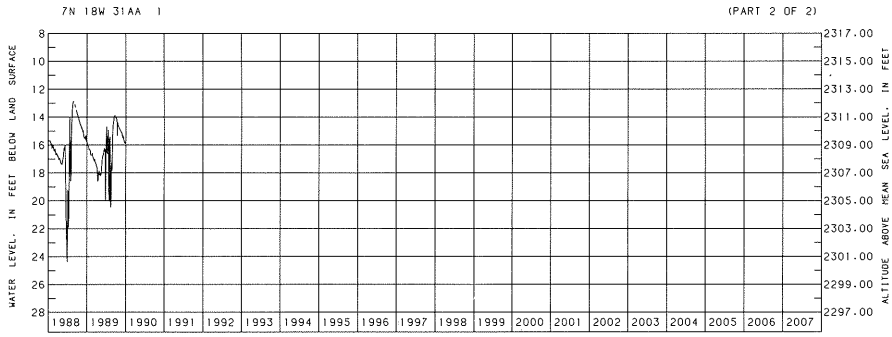
Phelps County: Bertrand Recorder Well



Phelps County: Holdrege Recorder Well



Estimated predevelopment water level: 100 feet
Net water-level change in 1989: −0.08 foot
Net water-level change since 1968: +4.13 feet



In the Central Division, many of the water levels along the Platte River valley were 1 to 4 feet higher in the fall of 1989 than they were in the fall of 1988.

Central Division

Groundwater levels in the Central Division generally were lower during 1989 than they were during 1988. Along the Platte River valley and in Howard, Merrick, and eastern Custer counties, most water levels measured in the spring of 1989 were 1 to 3 feet lower than the water levels measured in the spring of 1988, and declines greater than 5 feet occurred in only a few wells. In the fall of 1989, most of the water levels measured along the Platte River valley in Buffalo, Dawson, and Hall counties were 1 to 3 feet higher than the water levels measured in the fall of 1988. Fall 1989 water levels, measured in an area located in southwestern Custer County and northwestern Dawson County ranged from 10 to 21 feet lower than fall 1988 water levels.

Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	773	18	−1.22	−1.07
Fall	824	42	− .44	− .25

In the fall of 1989, declines of 5 feet or more from estimated predevelopment water levels occurred in an area of about 345,000 acres in Buffalo, Dawson, and Hall counties. Water levels were 25 to 30 feet lower than predevelopment levels in some wells on the uplands in southwestern Custer and northwestern Dawson counties, where use of groundwater for irrigation has resulted in large water-level declines during the past two years.

In Buffalo, Dawson, and Hall counties, approximate areas of significant water-level declines from estimated predevelopment water levels to fall 1989 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	193,000
10-15	86,000
15-20	54,000
20-25	11,000
25-30	1,500

In the central part of Valley County, pumping for irrigation has caused water-level declines of more than 5 feet from estimated predevelopment levels in an area of about 4,700 acres. In the fall of 1989, the maximum decline from predevelopment levels was about 6 feet. Estimated predevelopment water levels for Valley County are the approximate water levels that occurred prior to 1957.

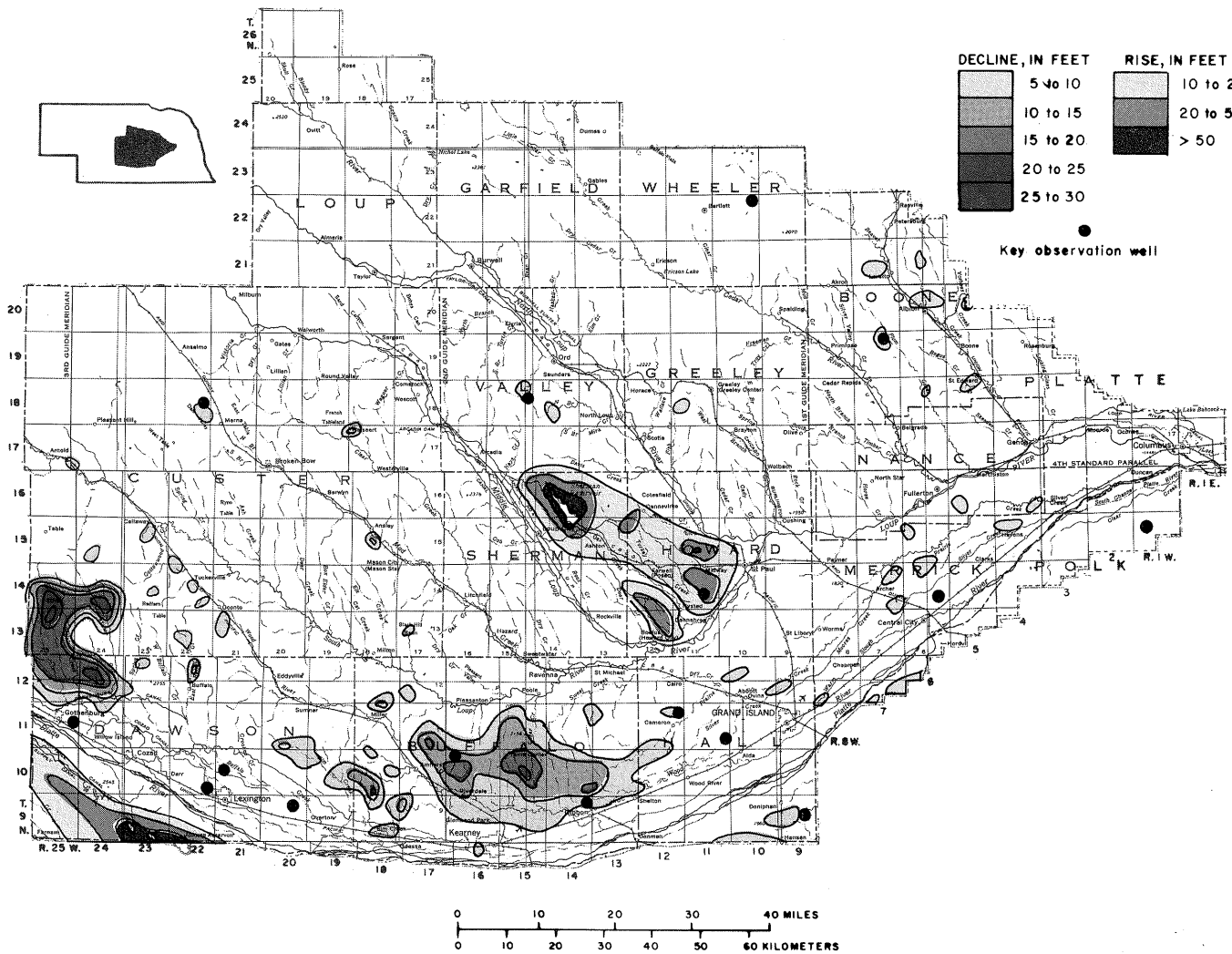
Water-level rises of 10 feet or more from estimated predevelopment levels have occurred beneath about 181,000 acres in the Farwell area of Howard and Sherman counties. The water-level rises in this area have resulted from water losses from irrigation canals, seepage from Sherman Reservoir, and deep percolation of water applied to crops in the Farwell Irrigation Project. The greatest water-level rises—about 70 feet—are near Sherman Reservoir. Estimated predevelopment water levels in the area of the Farwell Irrigation Project are the approximate water levels prior to 1963.

Approximate areas of significant rises from estimated predevelopment to fall 1989 water levels were:

Range of rise, in feet	Approximate area of rise, in acres
10-20	126,000
20-50	46,000
50 or more	9,000

At the end of 1989, there were about 21,400 registered irrigation wells in the division; 133 of these wells were drilled and registered during 1989.

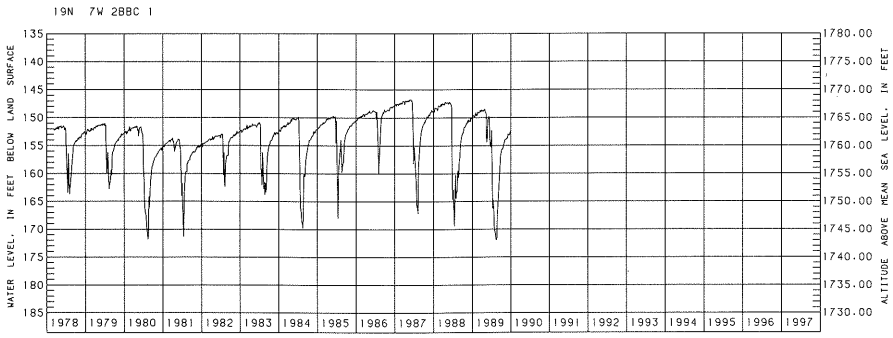
Data available for the Central Division provide a good basis for estimating predevelopment water levels, water-level changes since predevelopment, and current water-level changes. Water-level data are collected by the Central Platte and Lower Loup natural resources districts, the U.S. Bureau of Reclamation, and the U.S. Geological Survey.



Areas of significant water-level change in the Central Division from 1951 to fall 1989

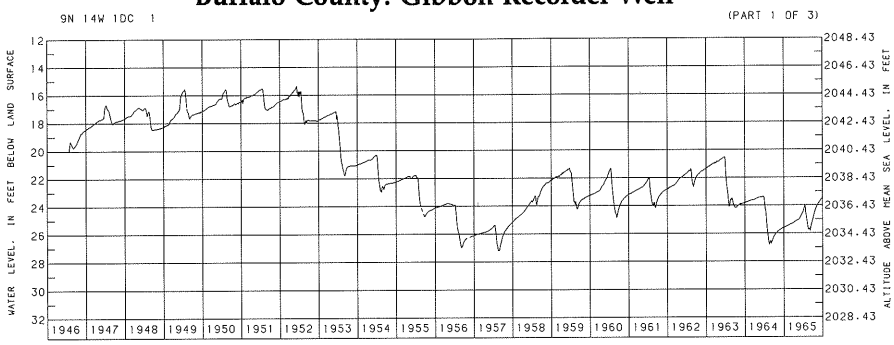
Boone County: Albion Recorder Well

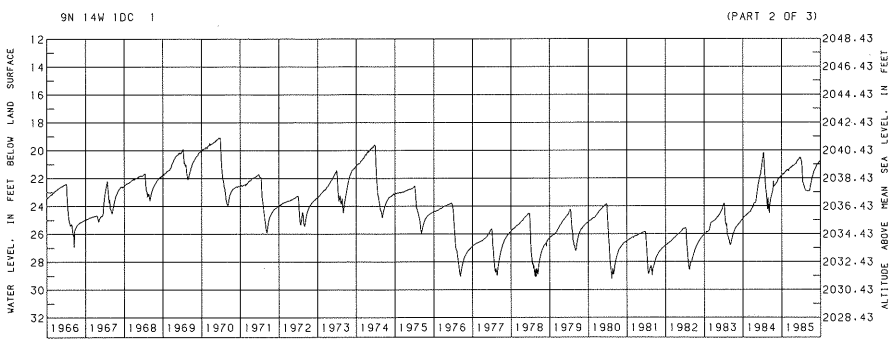
Estimated predevelopment water level: 150 feet
Net water-level change in 1989: −2.71 feet
Net water-level change since 1978: +0.45 foot

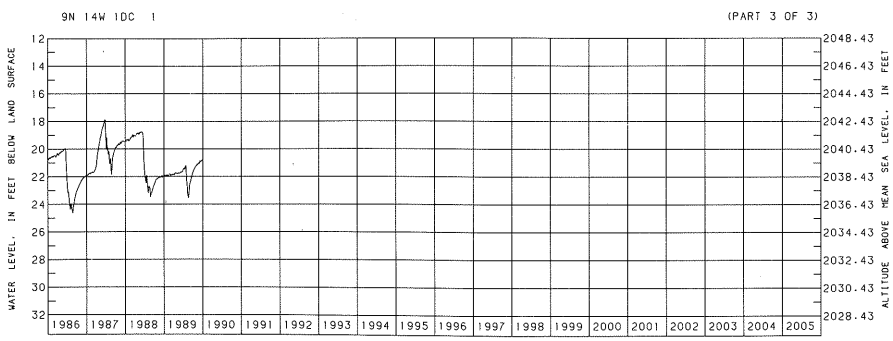


Buffalo County: Gibbon Recorder Well

Estimated predevelopment water level: 17 feet
Net water-level change in 1989: +1.14 feet
Net water-level change since 1946: −2.29 feet

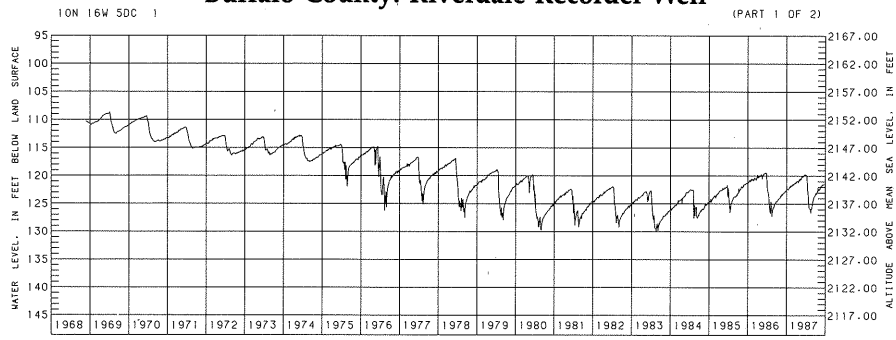


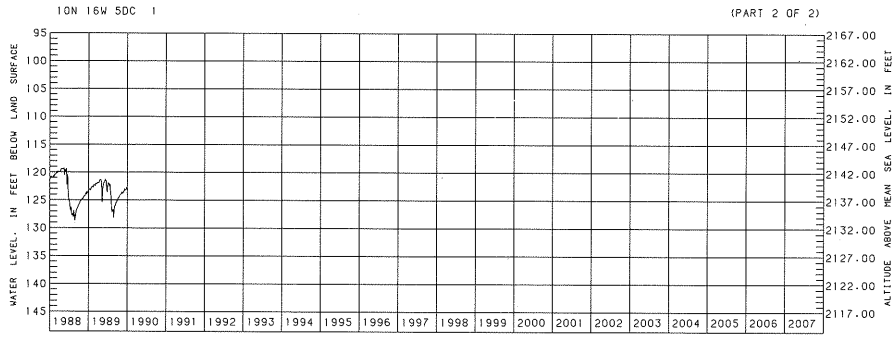




Buffalo County: Riverdale Recorder Well

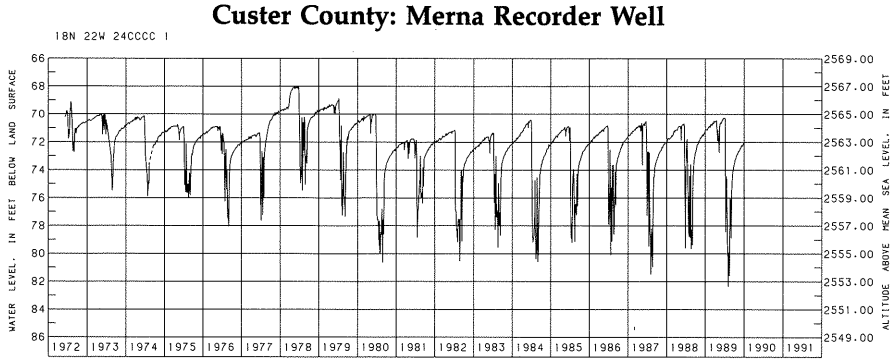
Estimated predevelopment water level: 107 feet
Net water-level change in 1989: +0.47 foot
Net water-level change since 1968: −11.72 feet





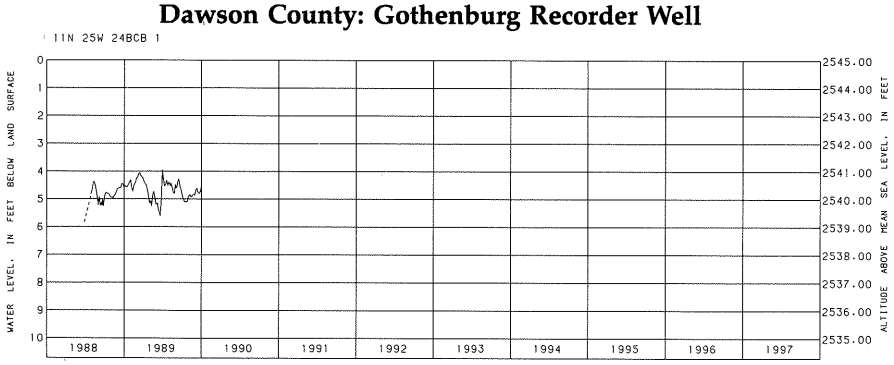
Custer County: Merna Recorder Well

Estimated predevelopment water level: 68 feet
Net water-level change in 1989: −0.84 foot
Net water-level change since 1972: −1.43 feet



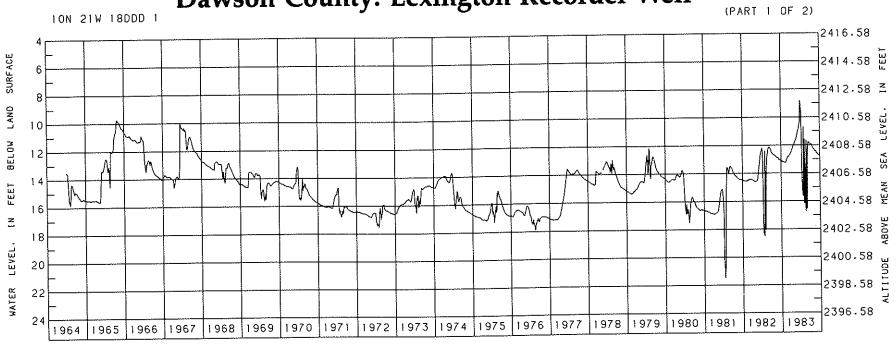
Dawson County: Gothenburg Recorder Well

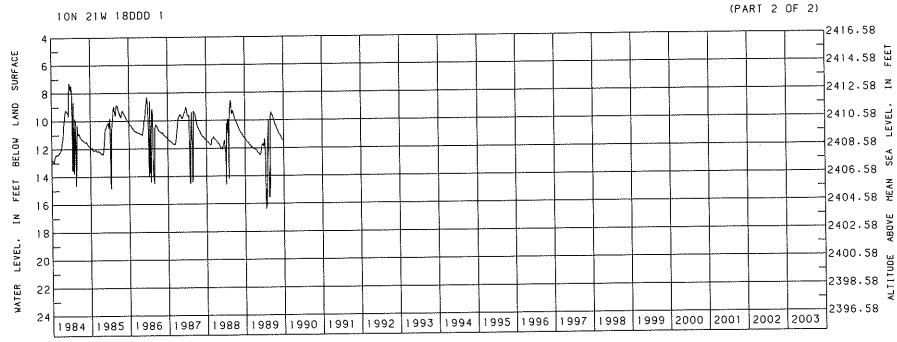
Estimated predevelopment water level: 4 feet
Net water-level change in 1989: +0.05 foot
Net water-level change since 1988: +0.05 foot



Dawson County: Lexington Recorder Well

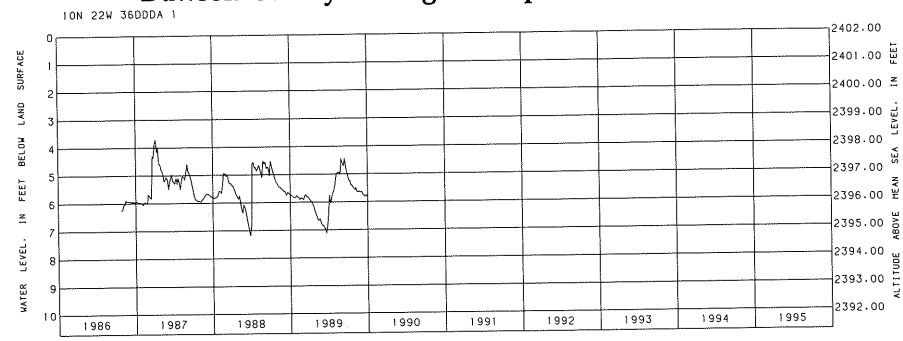
Estimated predevelopment water level: 11 feet
Net water-level change in 1989: −0.17 foot
Net water-level change since 1964: +4.02 feet





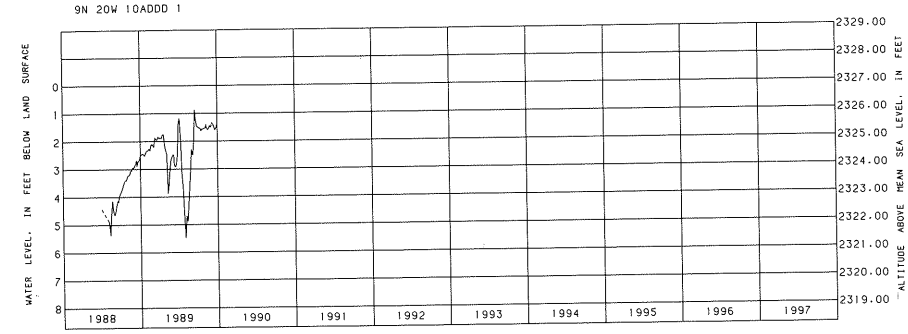
Dawson County: Lexington Airport Recorder Well

Estimated predevelopment water level: 4.5 feet
Net water-level change in 1989: −0.09 foot
Net water-level change since 1986: +0.14 foot



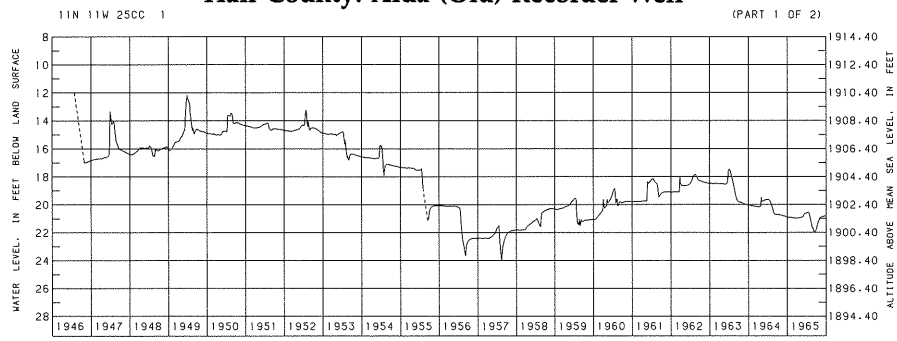
Dawson County: Overton Recorder Well

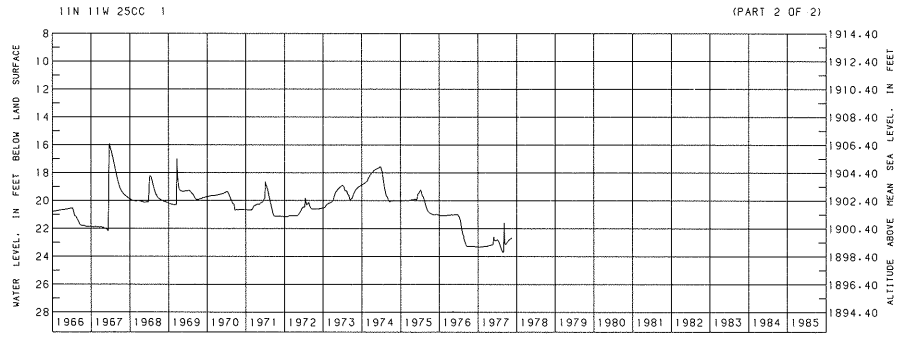
Estimated predevelopment water level: 1.5 feet
Net water-level change in 1989: +1.17 feet
Net water-level change since 1988: +1.17 feet



Hall County: Alda (Old) Recorder Well

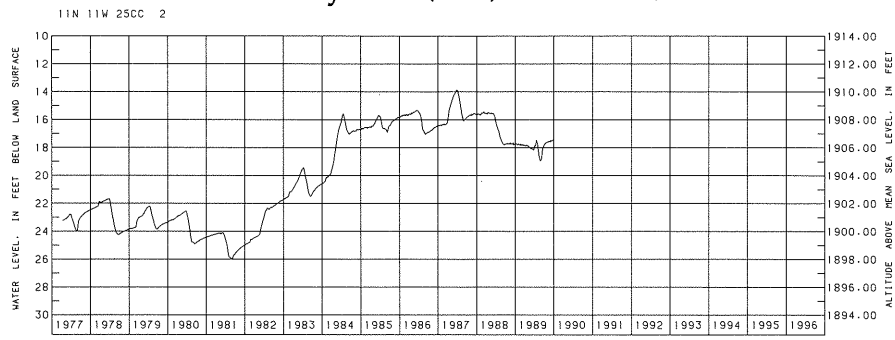
Estimated predevelopment water level: 15 feet
Well abandoned in 1977
Net water-level change from 1946 to 1976: −6.51 feet





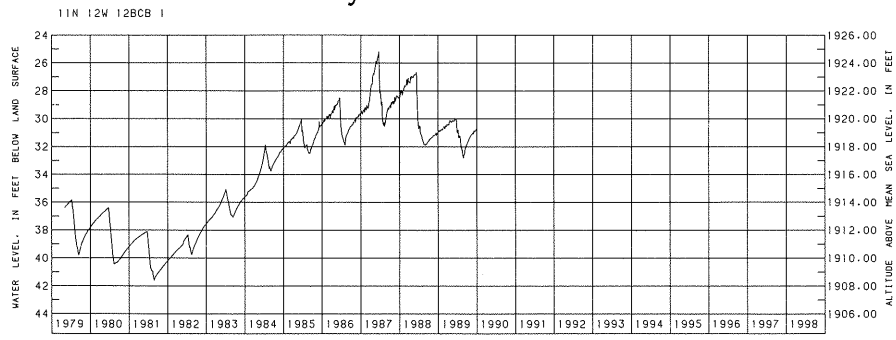
Hall County: Alda (New) Recorder Well

Estimated predevelopment water level: 15 feet
Net water-level change in 1989: +0.27 foot
Net water-level change since 1977: +5.02 feet



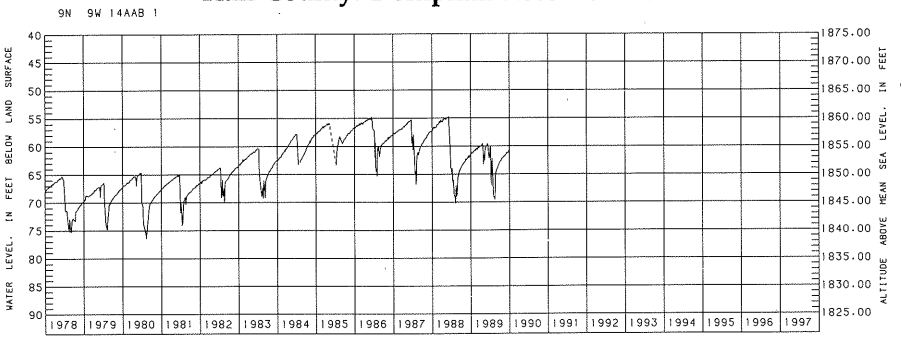
Hall County: Cameron Recorder Well

Estimated predevelopment water level: 27 feet
Net water-level change in 1989: +0.19 foot
Net water-level change since 1979: +7.07 feet



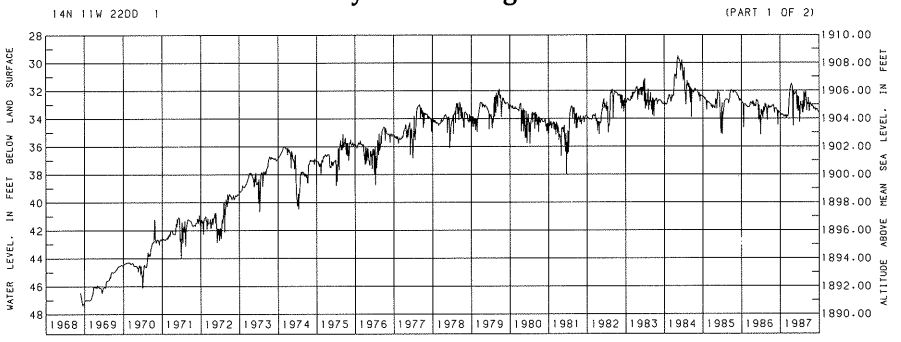
Hall County: Doniphan Recorder Well

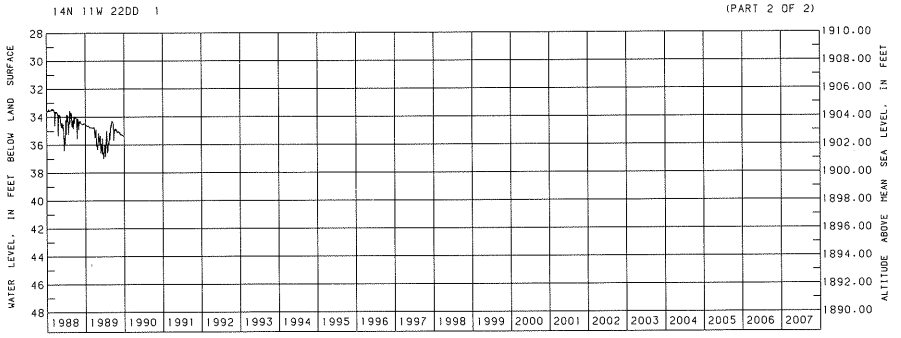
Estimated predevelopment water level: 63 feet
Net water-level change in 1989: +0.62 foot
Net water-level change since 1977: +6.97 feet



Howard County: Dannebrog Recorder Well

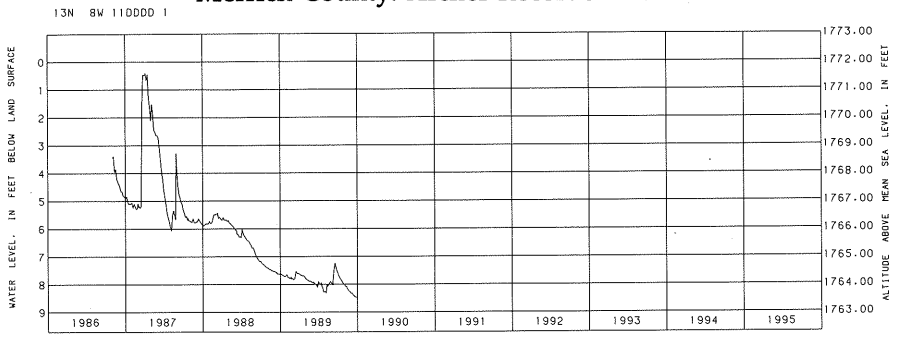
Estimated predevelopment water level: 62 feet
Net water-level change in 1989: −0.86 foot
Net water-level change since 1968: +11.71 feet





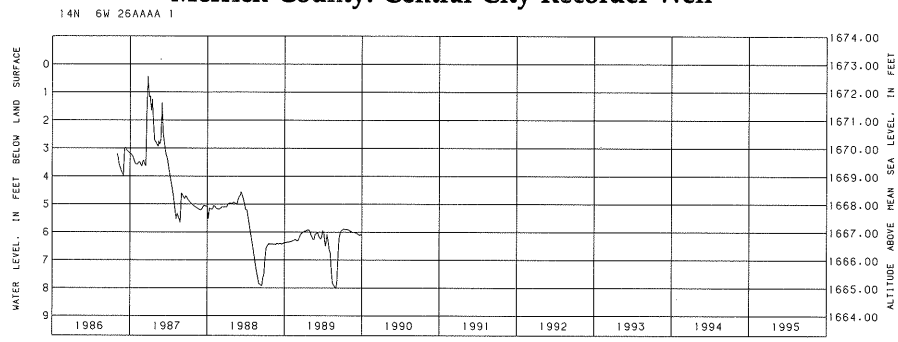
Merrick County: Archer Recorder Well

Estimated predevelopment water level: 3.5 feet
Net water-level change in 1989: −0.85 foot
Net water-level change since 1986: −3.58 feet



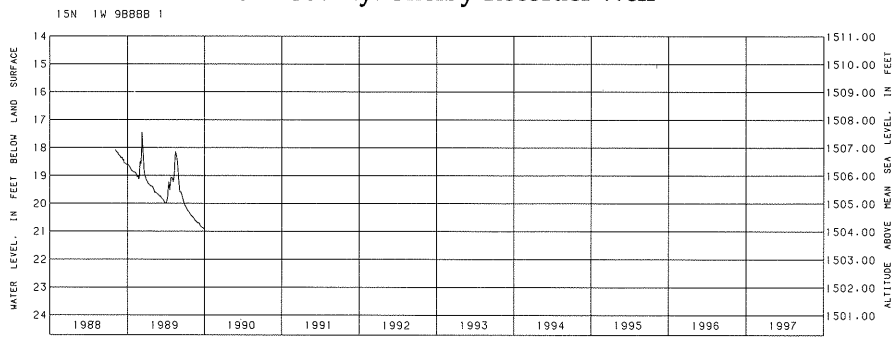
Merrick County: Central City Recorder Well

Estimated predevelopment water level: 2.5 feet
Net water-level change in 1989: +0.26 foot
Net water-level change since 1986: −2.92 feet



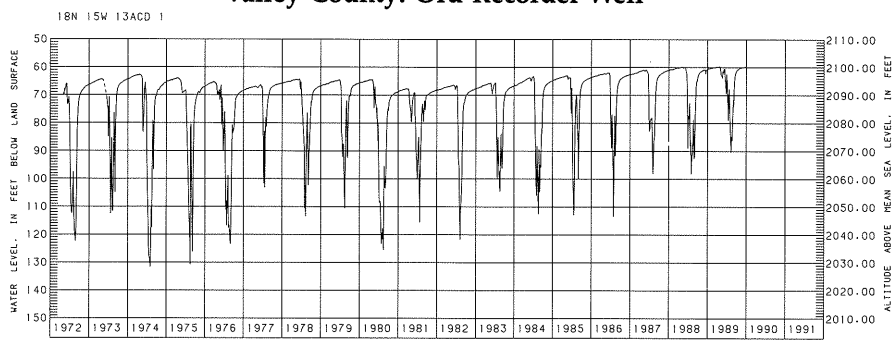
Polk County: Shelby Recorder Well

Estimated predevelopment water level: not determined
Net water-level change in 1989: −2.33 feet
Net water-level change since 1988: −2.33 feet



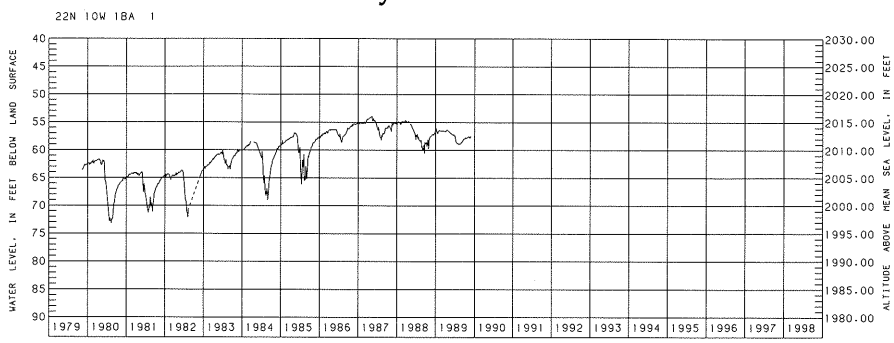
Valley County: Ord Recorder Well

Estimated predevelopment water level: 51 feet
Net water-level change in 1989: +0.93 foot
Net water-level change since 1972: +6.53 feet



Wheeler County: Bartlett Recorder Well

Estimated predevelopment water level: 56 feet
Net water-level change in 1989: −1.31 feet
Net water-level change since 1979: +4.98 feet



About 90 percent of groundwater levels measured in the East North-Central Division during 1989 were lower than those measured in 1988.

East North-Central Division

In the spring and fall of 1989, most groundwater levels in the East North-Central Division generally were lower than they were in the spring and fall of 1988. Water levels in 84 percent of the 146 wells measured in the spring of 1989 were lower than they were in the fall of 1988. Most spring 1989 water levels were between 1 and 3 feet lower than spring 1988 water levels, but declines of 4 to 5 feet occurred in parts of Antelope and Holt counties. In the fall of 1989 water levels in 95 percent of the wells measured were lower than those measured in the fall of 1988.

Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	146	16	−1.27	−1.37
Fall	165	5	−1.91	−1.91

In the fall of 1989, water-level declines of 5 feet or more from estimated predevelopment levels occurred in a total area of about 54,000 acres in northern Holt County. The largest decline—about 18 feet—occurred in a well northeast of O'Neill. Water-level declines of 5 to 17 feet occurred in other areas in the northern part of the county. Estimated predevelopment water levels in the East North-Central Division are the approximate water levels prior to 1957.

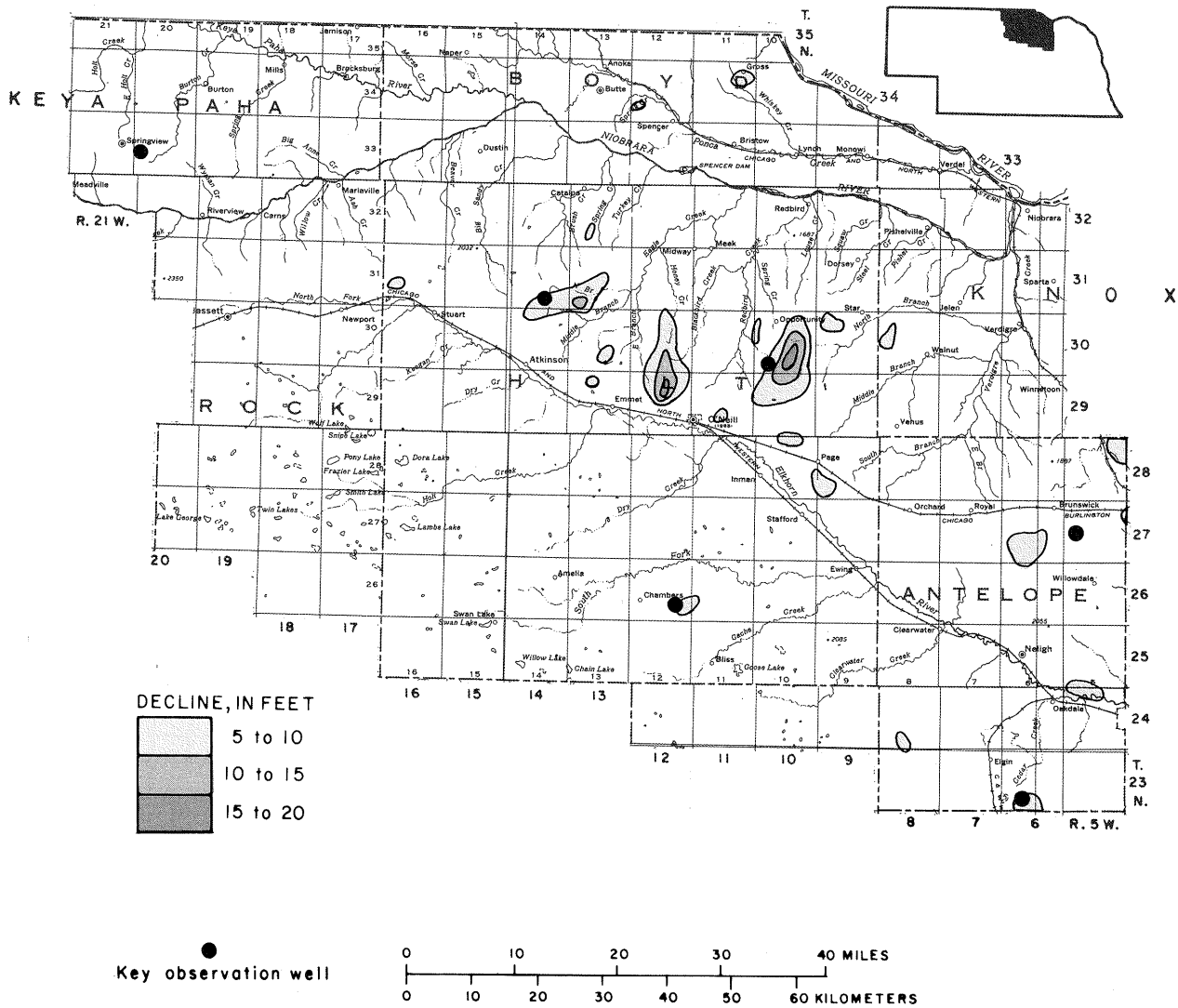
In the Holt County area the approximate areas of significant declines from estimated predevelopment to fall 1989 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	42,000
10-15	10,000
15-20	2,200

Withdrawal of water for irrigation has caused progressive water-level declines in some parts of the division since 1964. However, recharge from precipitation during periods of greater-than-normal precipitation occasionally has resulted in short-term water-level rises or lessening of the rate of water-level decline. Available data indicate that the water level in some wells declined 5 feet or more during the drought of the mid-1950s, that water levels in many wells rose more than 2 feet between 1970 and 1973, and that water levels in many wells rose as much as 10 feet between 1981 and 1987, when annual precipitation generally was greater than normal. In much of the area, groundwater withdrawals for irrigation are large enough to cause net water-level declines in most years when annual precipitation amounts are about equal to or less than normal.

At the end of 1989, there were about 4,400 registered irrigation wells in the division. Most of these wells are located in Antelope County and in the northern part of Holt County. During 1989, 46 new wells were drilled and registered.

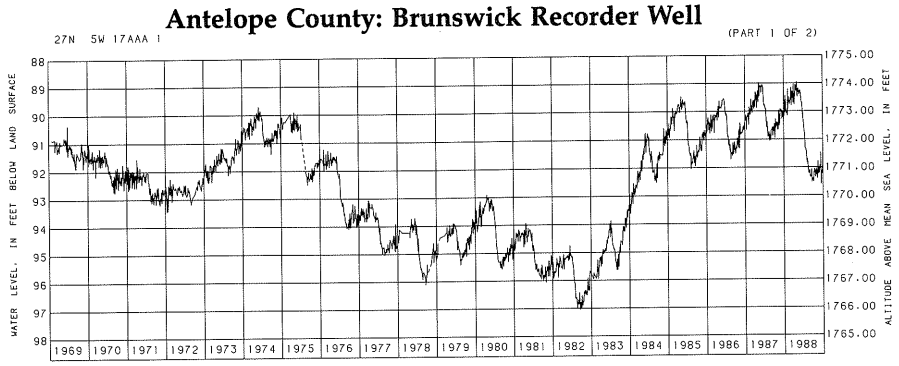
Sufficient data are available for a fairly good estimation of predevelopment water levels in the division, and the existing observation-well networks provide adequate data for evaluation of current water-level changes in most of the division. Prior to 1975, however, observation wells were too few to define the water-level changes adequately. Since 1975, water-level data collected by the Lower Niobrara and Upper Elkhorn natural resources districts have supplemented the data networks of the U.S. Bureau of Reclamation and the U.S. Geological Survey.

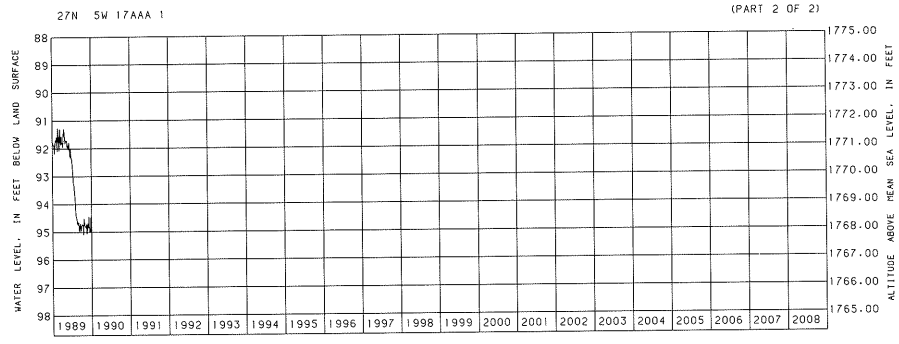


Areas of significant water-level change in the East North-Central Division from 1957 to fall 1989

Antelope County: Brunswick Recorder Well

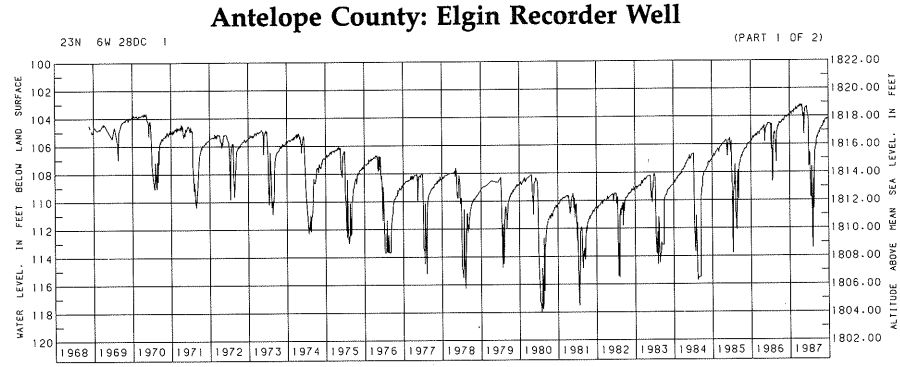
Estimated predevelopment water level: 90 feet
Net water-level change in 1989: −2.92 feet
Net water-level change since 1969: −3.39 feet

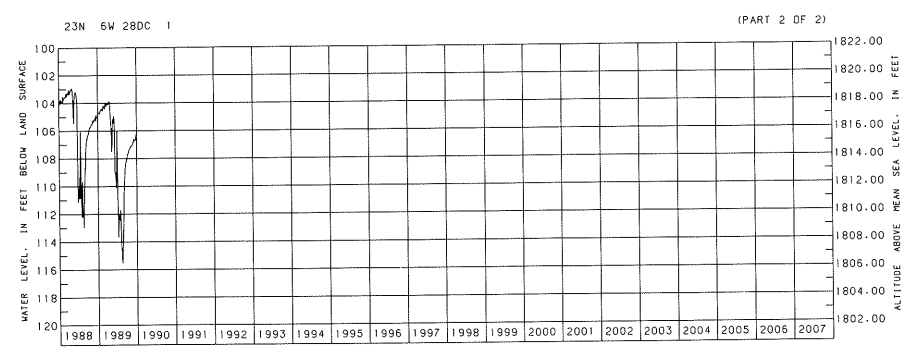




Antelope County: Elgin Recorder Well

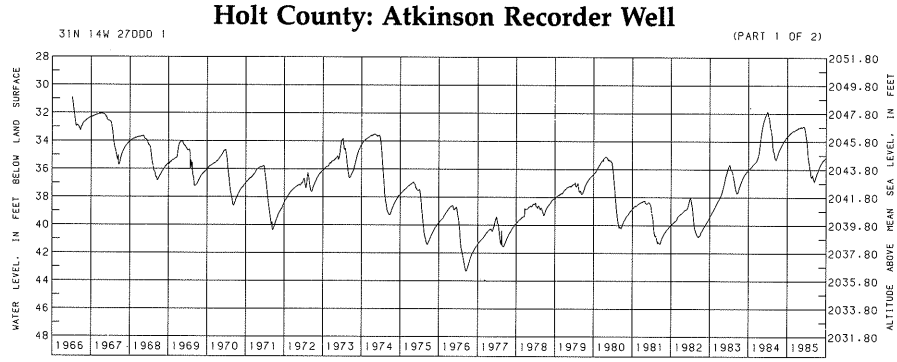
Estimated predevelopment water level: 102 feet
Net water-level change in 1989: −1.65 feet
Net water-level change since 1968: −1.58 feet

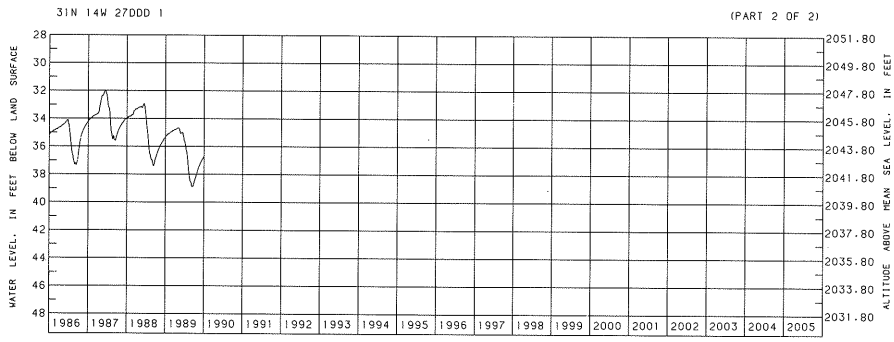




Holt County: Atkinson Recorder Well

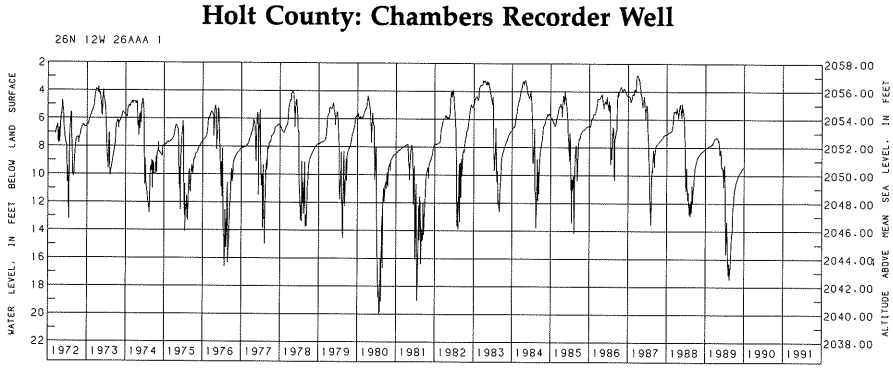
Estimated predevelopment water level: 32 feet
Net water-level change in 1989: −1.39 feet
Net water-level change since 1966: −4.40 feet





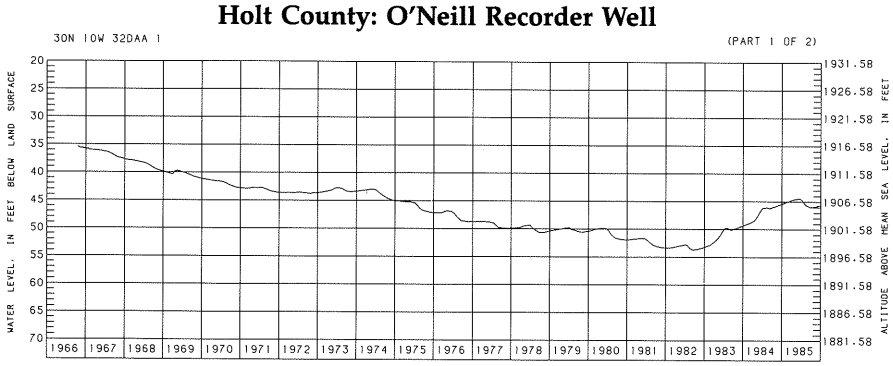
Holt County: Chambers Recorder Well

Estimated predevelopment water level: 6 feet
Net water-level change in 1989: −1.26 feet
Net water-level change since 1972: −2.92 feet

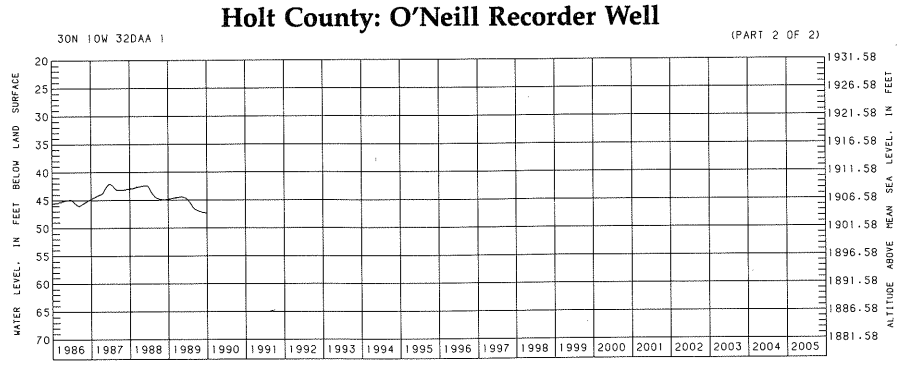


Holt County: O'Neill Recorder Well

Estimated predevelopment water level: 35 feet
Net water-level change in 1989: −2.51 feet
Net water-level change since 1966: −11.55 feet

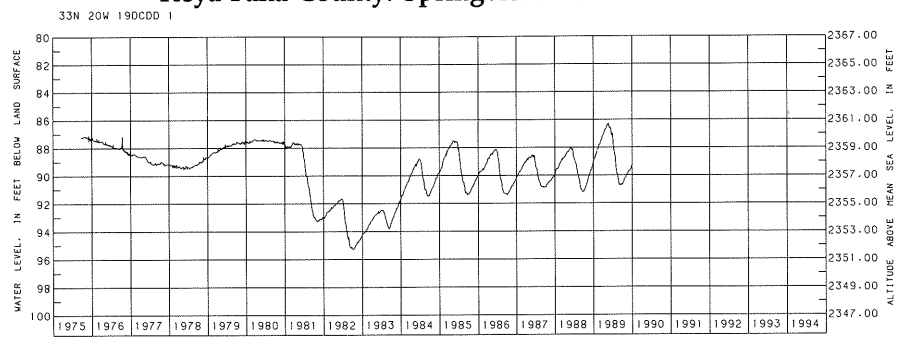


Holt County: O'Neill Recorder Well



Keya Paha County: Springview Recorder Well

Estimated predevelopment water level: 87 feet
Net water-level change in 1989: −0.23 foot
Net water-level change since 1975: −1.98 feet



In the Southwest Division, 1989 water levels in Perkins, Chase, and Dundy counties generally were lower than 1988 levels; elsewhere in the division most 1989 water levels ranged between 1 foot higher and 1 foot lower than 1988 water levels.

Southwest Division

Spring 1989 water levels in the Southwest Division generally ranged between 1 foot higher and 1 foot lower than spring 1988 water levels. Most wells in which spring 1989 water levels were lower are located in Perkins, Chase, and Dundy counties. In southern Lincoln County and in parts of Frontier and Hayes counties many of the spring 1989 water levels were slightly higher than spring 1988 water levels. Most of the water levels measured in the fall of 1989 also generally ranged between 1 foot higher and 1 foot lower than those measured in the fall of 1988. Many of the fall 1989 water levels in Perkins, Chase, and Dundy counties, however, ranged between 1 and 3 feet lower than the fall 1988 water levels.

Differences between water levels measured in 1989 and in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	392	35	−0.16	−0.27
Fall	417	23	− .61	− .53

Water-level rises of 10 feet or more from predevelopment water levels have occurred in an area of about 417,000 acres south of the South Platte and Platte rivers in Frontier, Keith, Lincoln and Perkins counties. Seepage from Sutherland Reservoir, Lake Maloney, and their associated canals caused water levels to start rising in that part of the area west of North Platte in about 1935. East of North Platte, water levels began rising in about 1940 as a result of seepage from the Tri-County Supply Canal and Jeffrey Reservoir. This groundwater mounding steepened the water-table gradient toward the north and has increased groundwater discharge in the South Platte River and Platte River valleys. Water levels have risen as much as 34 feet in a well north of Dickens in Lincoln County, and in the immediate vicinity of Sutherland Reservoir, Lake Maloney, and Jeffrey Reservoir, water levels have risen about 50 feet. Since the mid-1970s, increased use of groundwater for irrigation has caused water-level declines in some wells within this large-rise area. For example, data for the Lake Maloney well in Lincoln County shows a decline of 6.33 feet since 1978, but the water levels in the well are still about 21 feet higher than the estimated predevelopment level.

Approximate areas of significant rises from estimated predevelopment to fall 1989 water levels were:

Range of rise, in feet	Approximate area of rise, in acres
10-20	225,000
20-50	189,000
50 or more	3,000

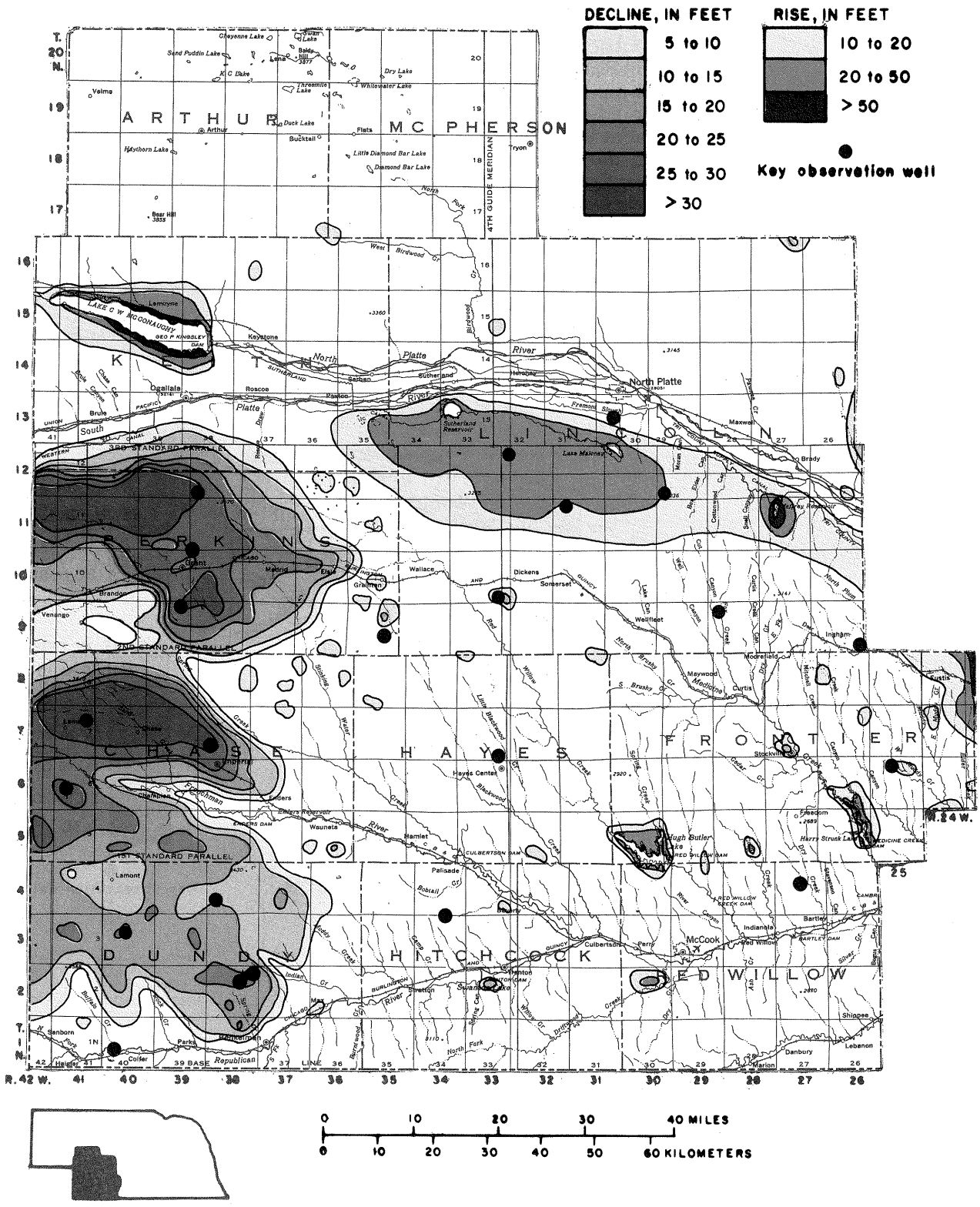
Storage of water in Lake McConaughy started in 1941, and seepage losses caused water-level rises of as much as 60 feet in nearby observation wells. Water levels generally had stabilized by about 1950 and since then have fluctuated in response to changes in reservoir levels and precipitation. Data provided by the Central Nebraska Public Power and Irrigation District made it possible to delineate the water-level rise around Lake McConaughy. Surface-water developments in Frontier, Hayes, Hitchcock, and Red Willow counties have caused local water-level rises, but data are inadequate for accurately delineating areas of the rises.

Declines of 5 feet or more from estimated predevelopment levels have occurred in about 1.19 million acres in Perkins, Chase, and Dundy counties. In the fall of 1989, declines ranged from 5 to 30 feet in most of the area, but local declines of as much as 30 feet occurred in parts of Chase and Perkins counties. In this area of water-level declines, estimated predevelopment water levels are based on data collected prior to 1953.

As of fall 1989, the approximate areas of water-level declines from estimated predevelopment water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	176,000
10-15	225,000
15-20	345,000
20-25	158,000
25-30	138,000
30 or more	147,000

Available data indicate that as a result of intensive use of groundwater for irrigation, a trend of declining water levels started about 1966 in Perkins, Chase, Dundy and southern Keith counties. Interruption of these progressive water-level declines occurred during 1981 and 1982, when levels rose in most wells because greater-than-normal precipitation lessened the need for pumping groundwater for irrigation. With the return of near-normal or less-than-normal precipitation in 1983, water-level declines have resumed.



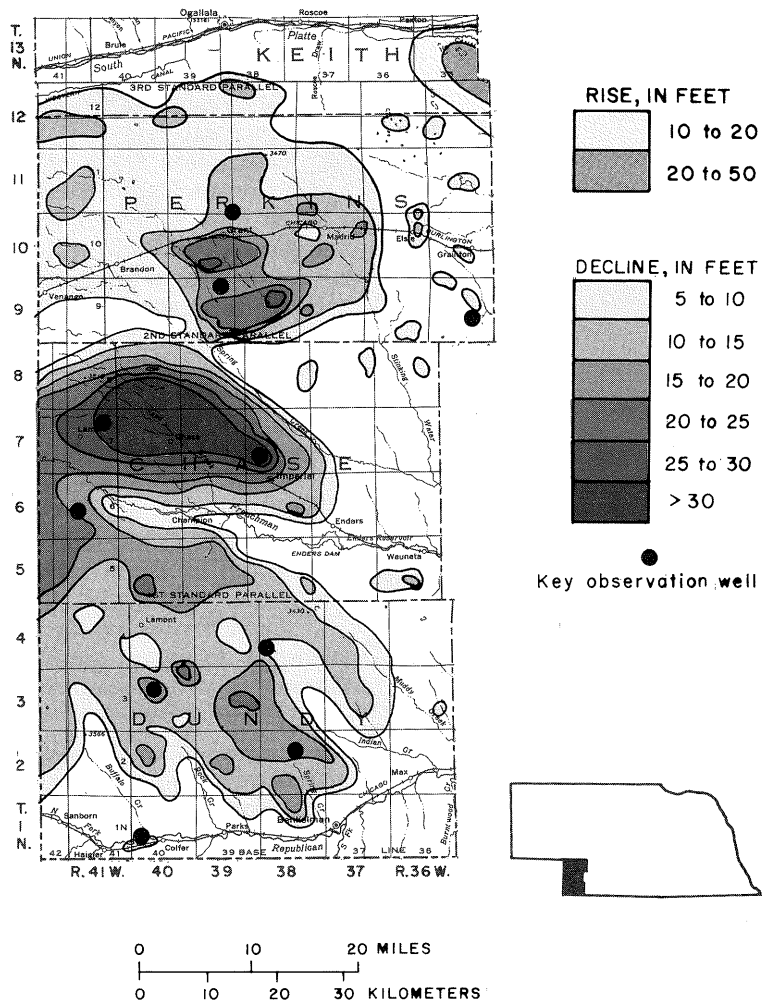
Areas of significant water-level change in the Southwest Division from 1936 to fall 1989

In most of the division, data are sufficient to make fairly good estimates of predevelopment water levels, and measurements made by the Upper Republican, Middle Republican, and Twin Platte natural resources districts and the U.S. Geological Survey provide adequate data for determining current water-level changes.

In the Upper Republican Ground Water Control Area, spring 1989 water levels were 5 feet or more lower than the estimated predevelopment levels in an area of about 1.07 million acres.

Approximate areas of water-level declines from estimated predevelopment water levels in the spring of 1989 were:

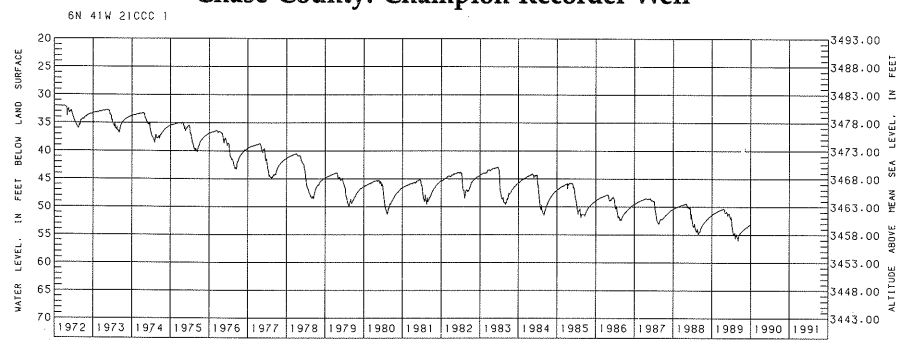
Range of decline, in feet	Approximate area of decline, in acres
5-10	362,000
10-15	378,000
15-20	154,000
20-25	94,000
25-30	28,000
30 or more	50,000



Areas of significant water-level change in Perkins, Chase, Dundy and southern Keith counties from 1936 to spring 1989

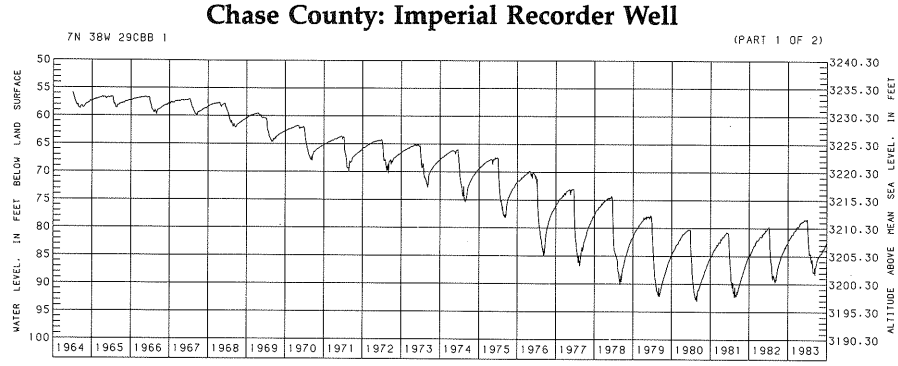
Chase County: Champion Recorder Well

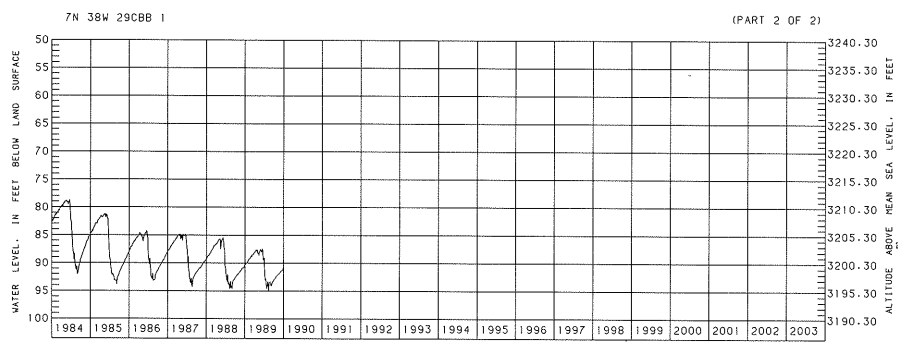
Estimated predevelopment water level: 30 feet
Net water-level change in 1989: −1.67 feet
Net water-level change since 1972: −19.74 feet



Chase County: Imperial Recorder Well

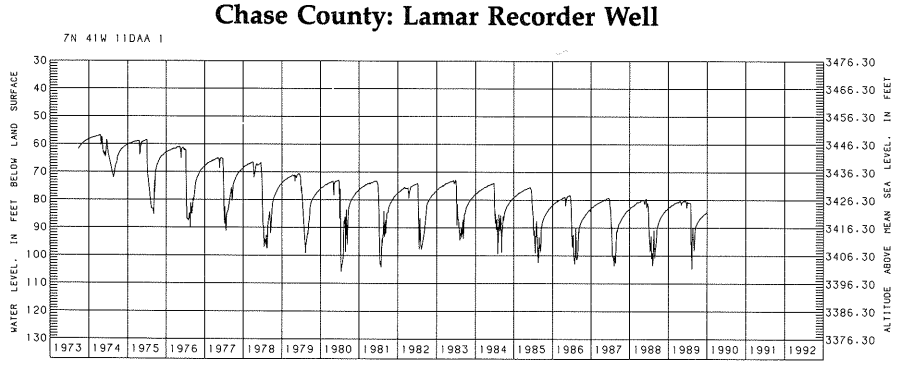
Estimated predevelopment water level: 56 feet
Net water-level change in 1989: −0.60 foot
Net water-level change since 1964: −33.54 feet





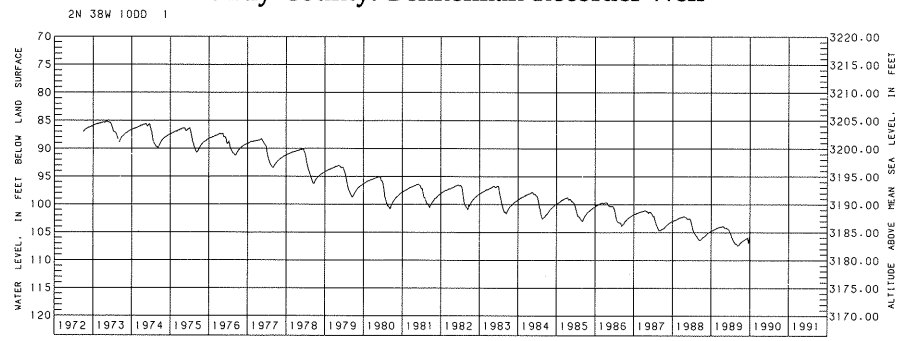
Chase County: Lamar Recorder Well

Estimated predevelopment water level: 50 feet
Net water-level change in 1989: −1.49 feet
Net water-level change since 1973: −26.03 feet



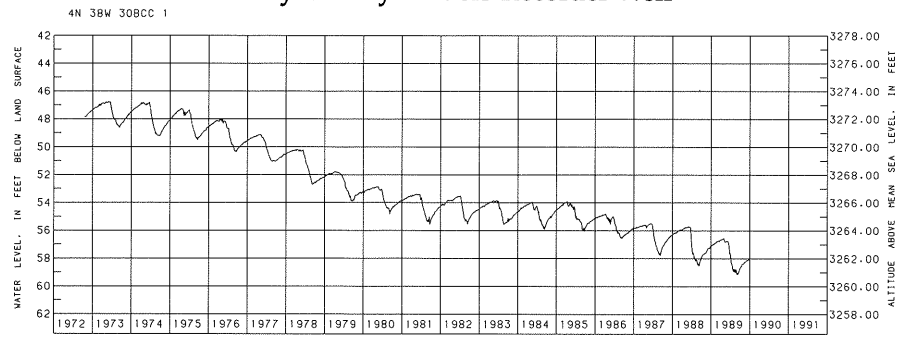
Dundy County: Benkelman Recorder Well

Estimated predevelopment water level: 84 feet
Net water-level change in 1989: −0.01 foot
Net water-level change since 1972: −19.72 feet



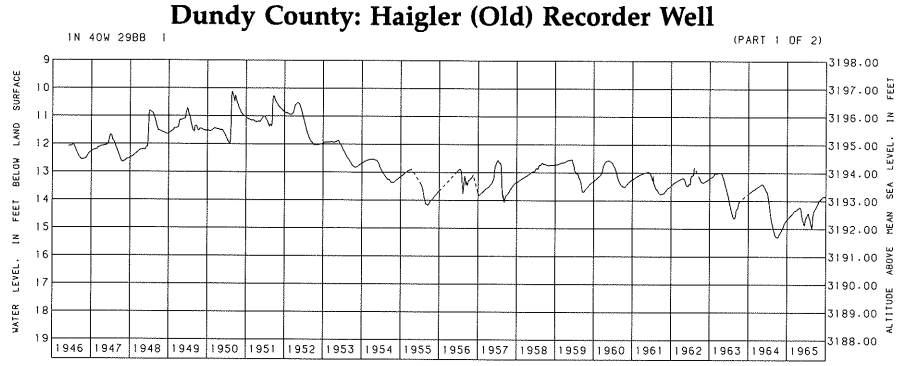
Dundy County: Enders Recorder Well

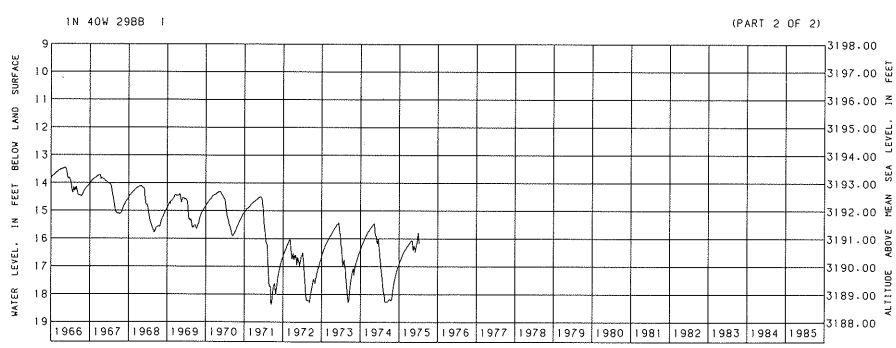
Estimated predevelopment water level: 46 feet
Net water-level change in 1989: −0.92 foot
Net water-level change since 1972: −10.68 feet



Dundy County: Haigler (Old) Recorder Well

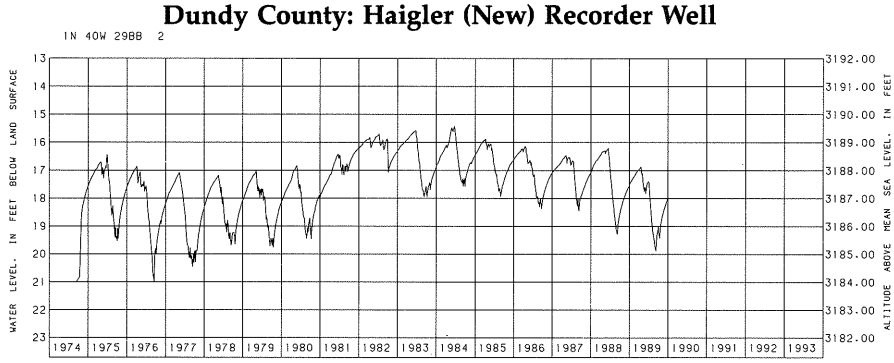
Estimated predevelopment water level: 12 feet
Well abandoned in 1975
Net water-level change from 1946 to 1975: −4.63 feet





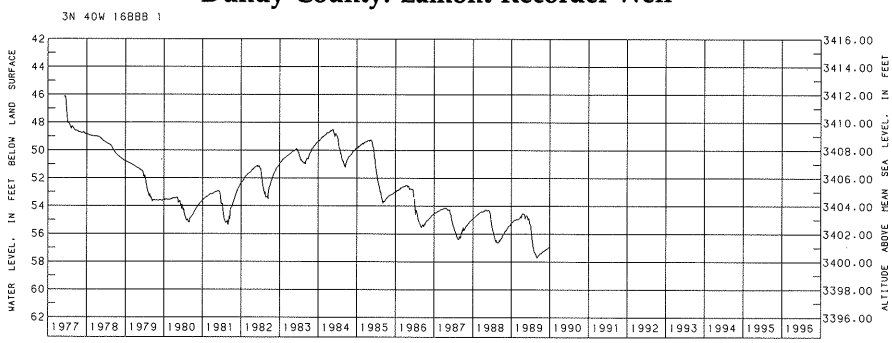
Dundy County: Haigler (New) Recorder Well

Estimated predevelopment water level: 10 feet
Net water-level change in 1989: −0.47 foot
Net water-level change since 1974: −0.42 foot



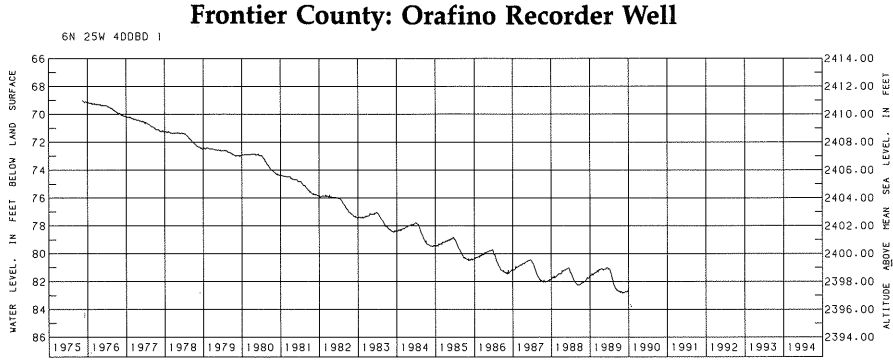
Dundy County: Lamont Recorder Well

Estimated predevelopment water level: 38 feet
Net water-level change in 1989: −1.70 feet
Net water-level change since 1977: −8.06 feet



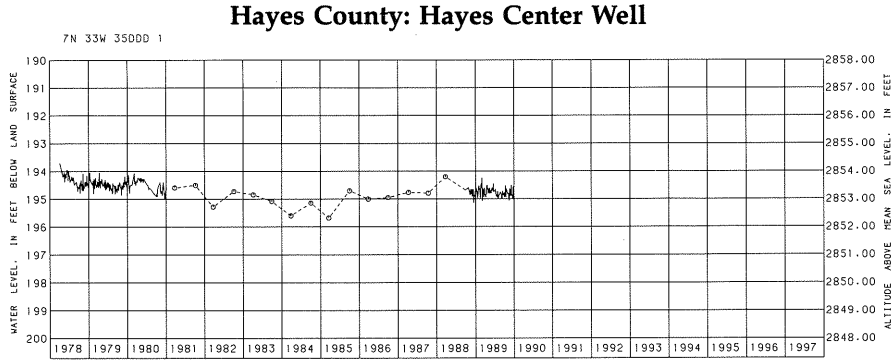
Frontier County: Orafino Recorder Well

Estimated predevelopment water level: 65 feet
Net water-level change in 1989: −1.03 feet
Net water-level change since 1975: −13.44 feet



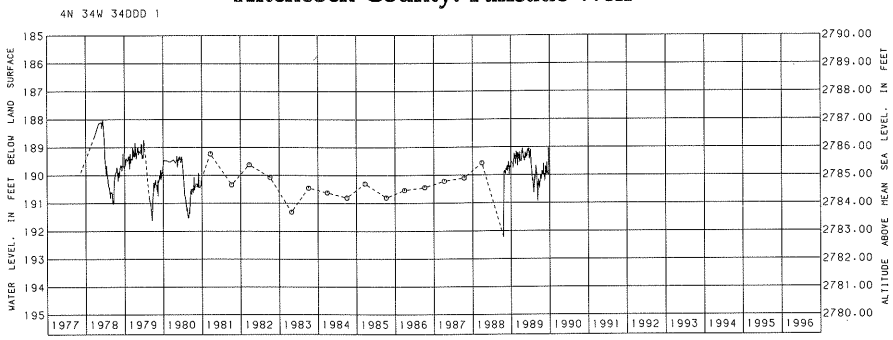
Hayes County: Hayes Center Well

Measured semiannually
Estimated predevelopment water level: 189 feet
Net water-level change, fall 1988 to fall 1989: −0.04 foot
Net water-level change since 1978: −0.06 foot



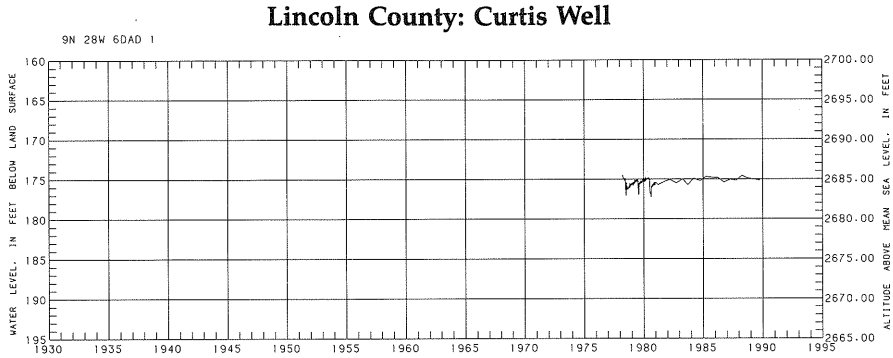
Hitchcock County: Palisade Well

Measured semiannually
Estimated predevelopment water level: 186 feet
Net water-level change, fall 1988 to fall 1989: −0.19 foot
Net water-level change since 1977: +0.36 foot



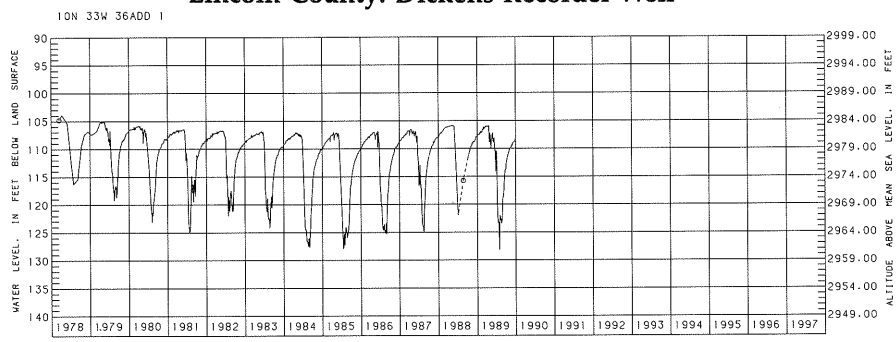
Lincoln County: Curtis Well

Measured semiannually
Estimated predevelopment water level: 169 feet
Net water-level change, fall 1988 to fall 1989: −0.25 foot
Net water-level change since 1978: −0.20 foot



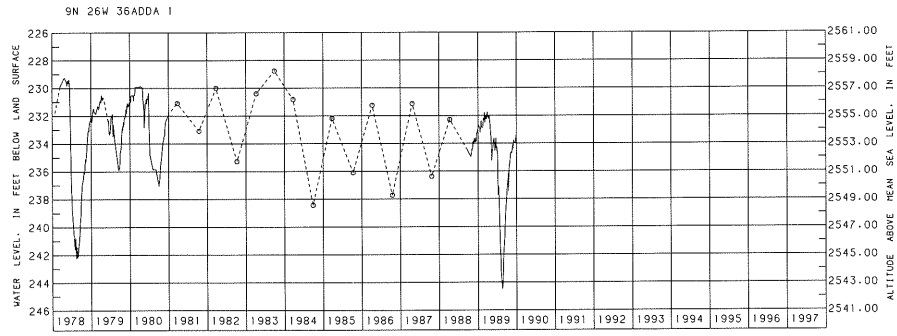
Lincoln County: Dickens Recorder Well

Estimated predevelopment water level: 105 feet
Net water-level change in 1989: −0.54 foot
Net water-level change since 1978: −1.05 feet



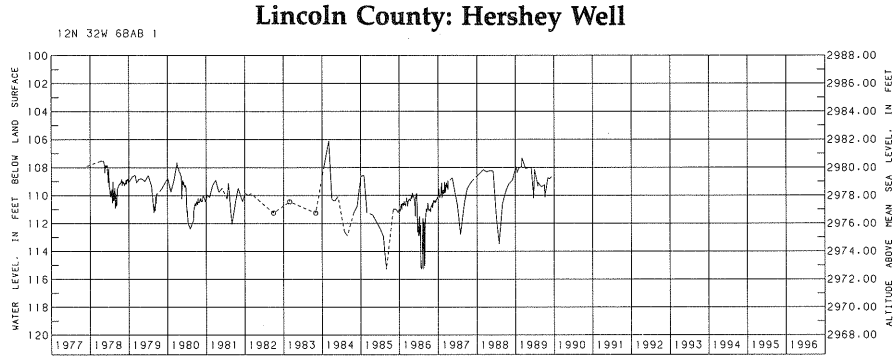
Lincoln County: Farnam Well

Measured semiannually
Estimated predevelopment water level: 243 feet
Net water-level change, fall 1988 to fall 1989: −0.48 foot
Net water-level change since 1978: +4.15 feet



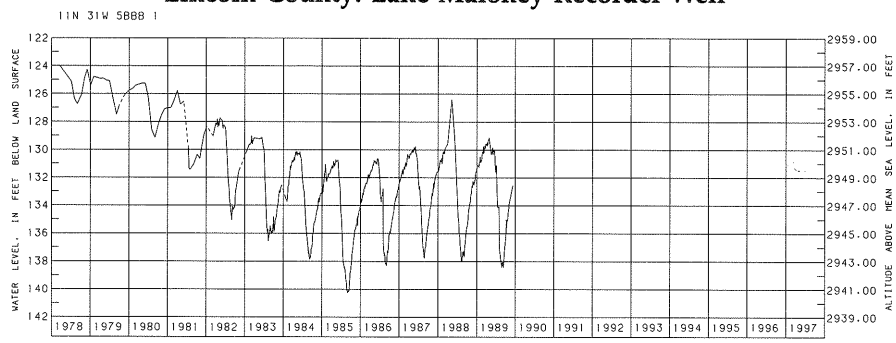
Lincoln County: Hershey Well

Measured monthly
Estimated predevelopment water level: 131 feet
Net water-level change in 1989: −1.76 feet
Net water-level change since 1977: −1.82 feet



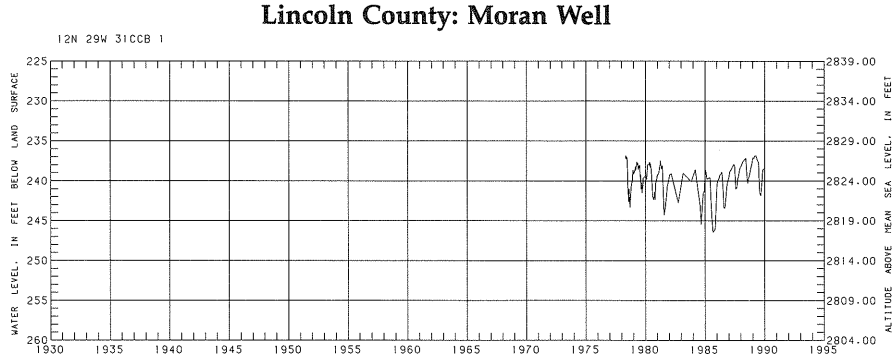
Lincoln County: Lake Maloney Recorder Well

Estimated predevelopment water level: 153 feet
Net water-level change in 1989: +0.54 foot
Net water-level change since 1978: −6.33 feet



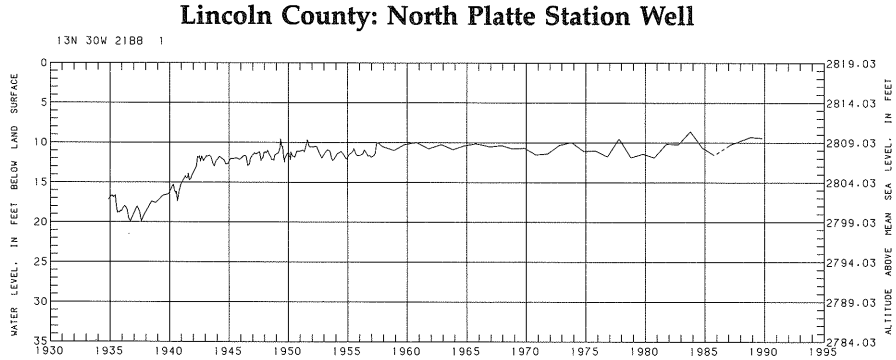
Lincoln County: Moran Well

Measured monthly
Estimated predevelopment water level: 254 feet
Net water-level change in 1989: −0.61 foot
Net water-level change since 1978: +1.32 feet



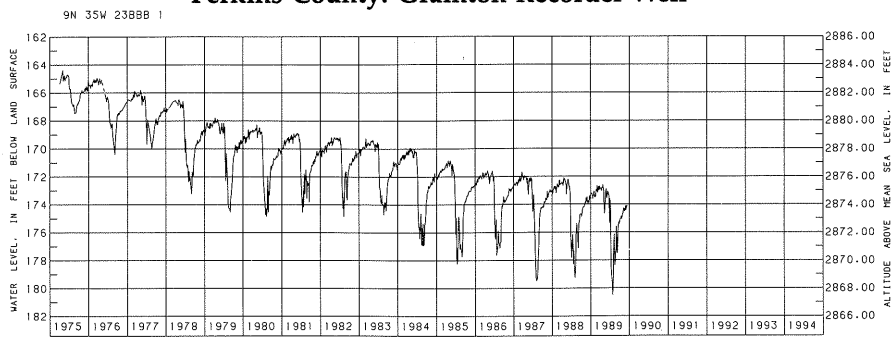
Lincoln County: North Platte Station Well

Measured annually
Estimated predevelopment water level: 17.8 feet
Net water-level change, fall 1988 to fall 1989: −0.13 foot
Net water-level change since 1934: +7.71 feet



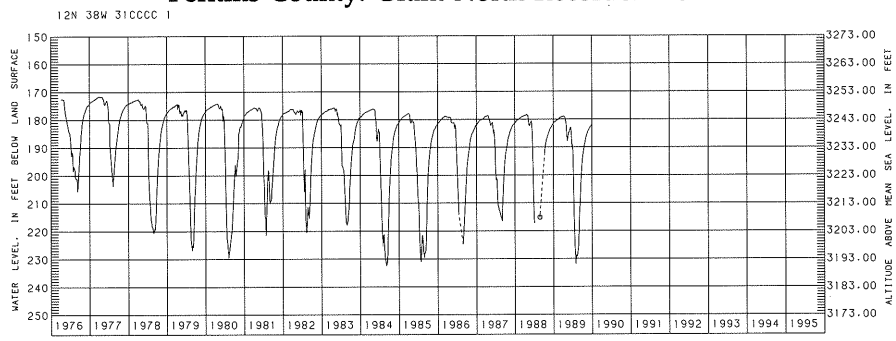
Perkins County: Grainton Recorder Well

Estimated predevelopment water level: 165 feet
Net water-level change in 1989: −0.54 foot
Net water-level change since 1975: −8.68 feet



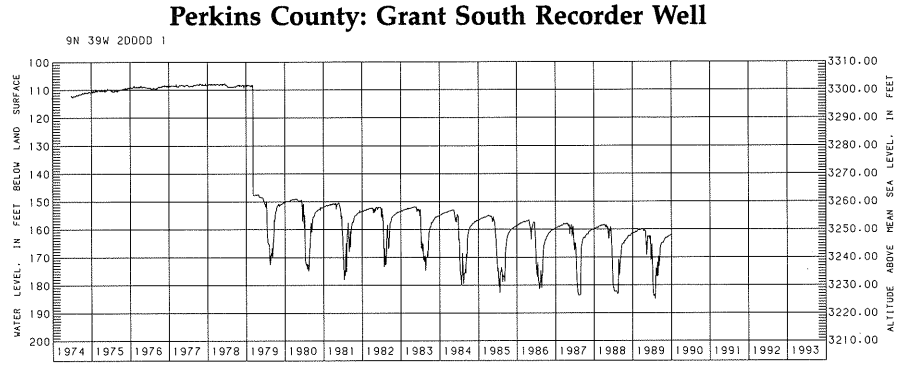
Perkins County: Grant North Recorder Well

Estimated predevelopment water level: 173 feet
Net water-level change in 1989: −0.34 foot
Net water-level change since 1976: −7.75 feet



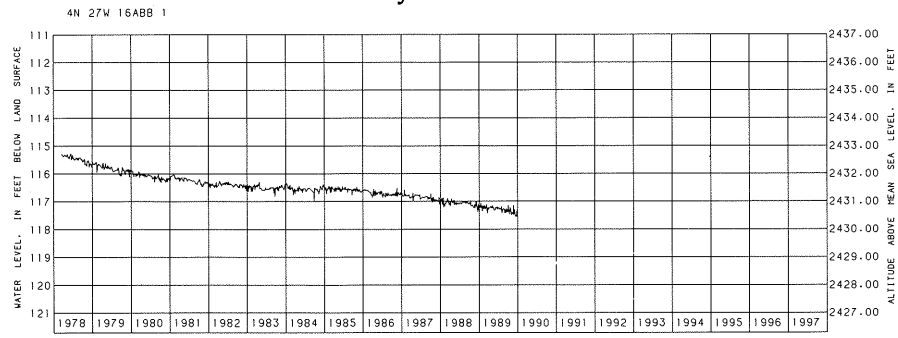
Perkins County: Grant South Recorder Well

Estimated predevelopment water level: 135 feet
Net water-level change in 1989: −0.29 foot
Net water-level change since 1979: −11.35 feet
See 1980 groundwater level report for explanation of well redevelopment.



Red Willow County: Indianola Recorder Well

Estimated predevelopment water level: 115 feet
Net water-level change in 1989: −0.34 foot
Net water-level change since 1978: −1.80 feet



West North-Central Division

Groundwater levels in the West North-Central Division generally were slightly lower in 1989 than they were in 1988. Throughout most of the division, water levels measured in 1989 generally ranged from 1 foot higher to 1 foot lower than water levels measured in 1988.

Differences between water levels measured in 1989 and those measured in 1988 were:

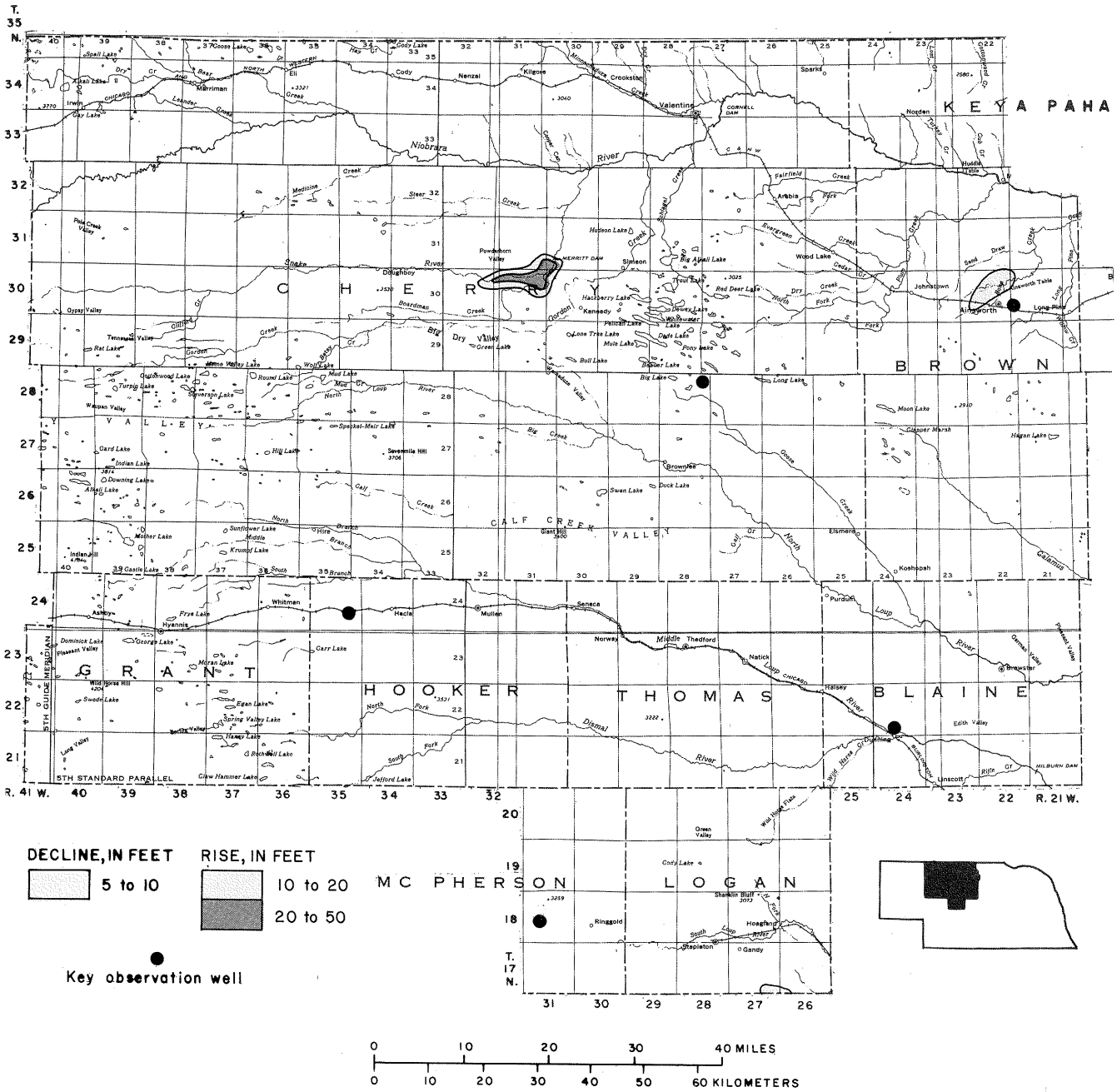
Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	18	61	−0.13	−0.12
Fall	98	28	− .58	− .58

Groundwater levels in the West North-Central Division generally were slightly lower in 1989 than they were in 1988.

Available water-level data are insufficient to determine accurately areas of long-term rise or decline in the division, except for an area north of Ainsworth in Brown County. In this area, surface water diverted from the Snake River at Merritt Reservoir is used for irrigation. Deep percolation of seepage losses from the irrigation distribution system and of water applied to crops has caused water-level rises of almost 17 feet since 1965. Water levels also have risen near Merritt Reservoir, but the delineated area of rise is only an approximation because data are limited.

Long-term water-level records indicate that withdrawals of groundwater for irrigation have not caused any long-term declines in water levels in this division, even though the number of registered irrigation wells increased from 104 in 1955 to 1,359 in 1989. No new irrigation wells were drilled in the division during either 1986 or 1987; one new well was drilled in 1988, and six new wells were drilled in 1989. The average density of wells in the division is about one well per 8.5 square miles.

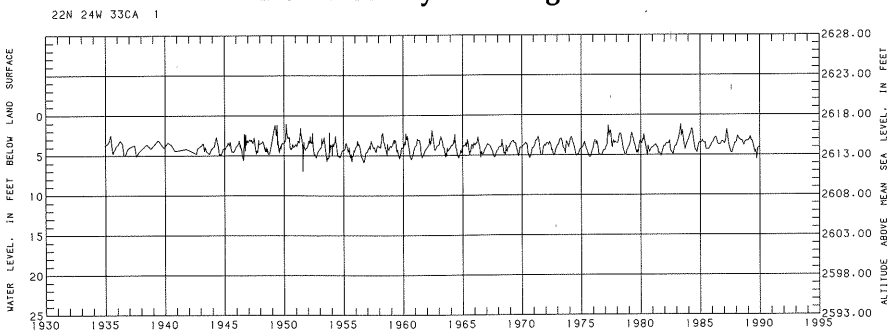
Water levels in the division are measured by the Middle Niobrara and Upper Loup natural resources districts, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey.



Areas of significant water-level change in the West North-Central Division from 1951 to fall 1989

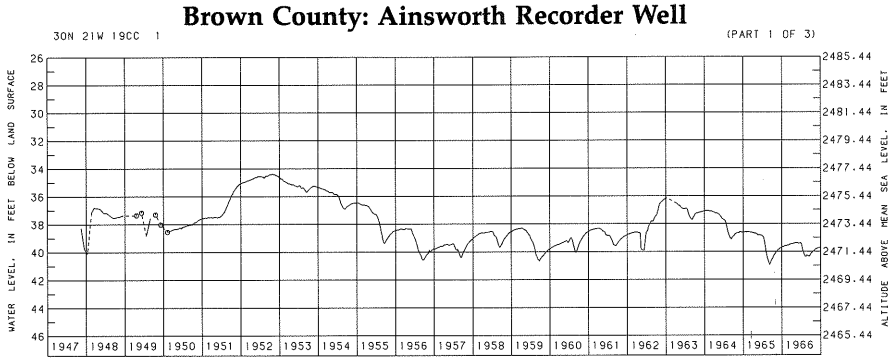
Blaine County: Dunning Well

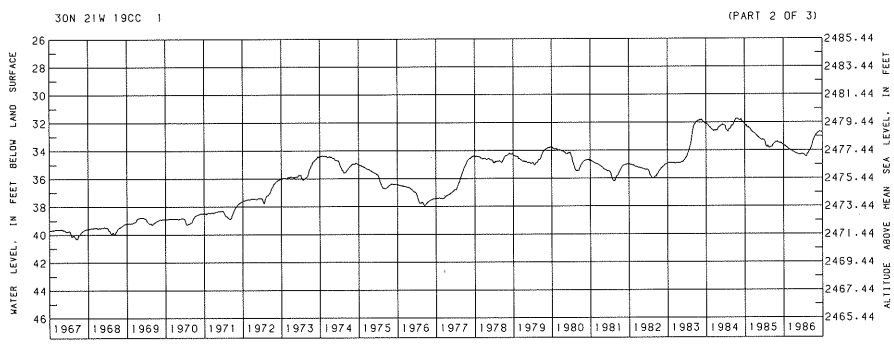
Measured monthly
Estimated predevelopment water level: 4 feet
Net water-level change in 1989: −0.76 foot
Net water-level change since 1934: −0.30 foot

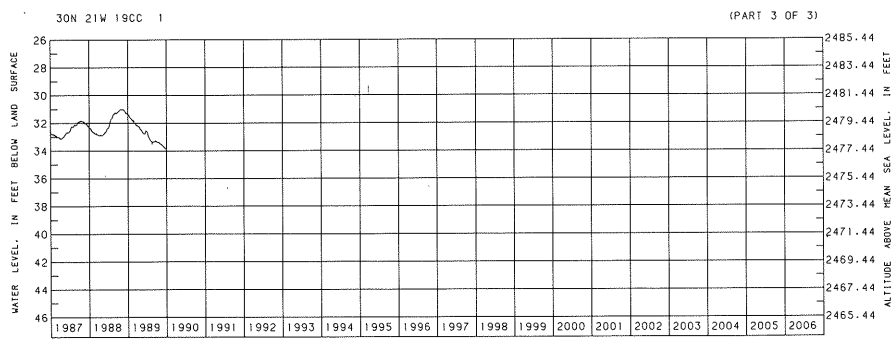


Brown County: Ainsworth Recorder Well

Estimated predevelopment water level: 37 feet
Net water-level change in 1989: −2.51 feet
Net water-level change since 1947: +6.07 feet

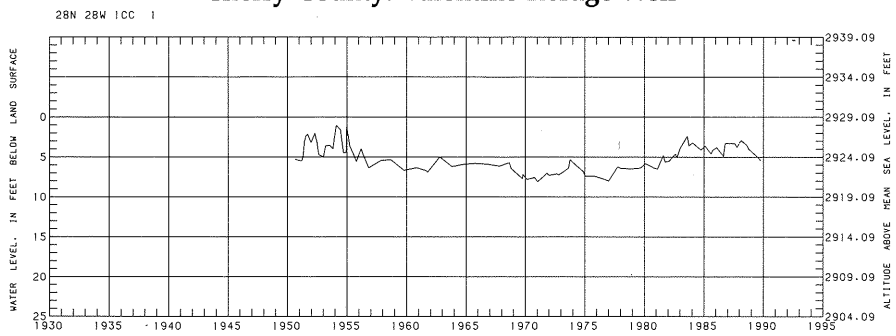






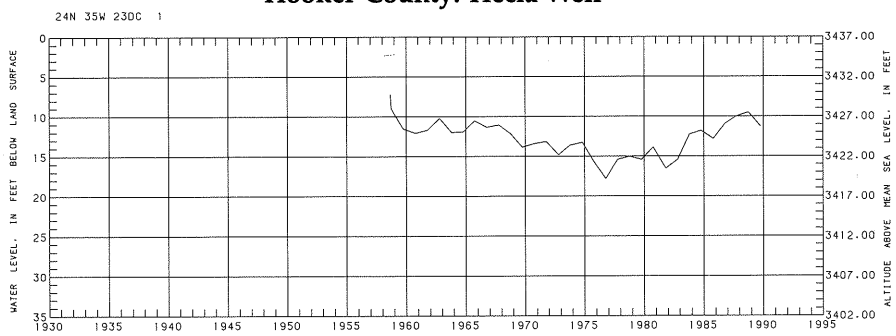
Cherry County: Valentine Refuge Well

Measured triannually
Estimated predevelopment water level: 4 feet
Net water-level change, fall 1988 to fall 1989: −1.31 feet
Net water-level change since 1950: −0.02 foot



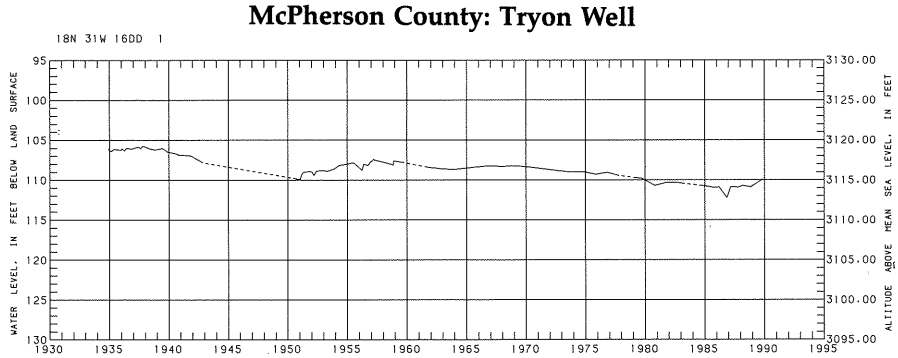
Hooker County: Hecla Well

Measured annually
Estimated predevelopment water level: 4 feet
Net water-level change, fall 1988 to fall 1989: −1.74 feet
Net water-level change since 1958: −2.23 feet



McPherson County: Tryon Well

Measured semiannually
Estimated predevelopment water level: 108.8 feet
Net water-level change, fall 1988 to fall 1989: +0.50 foot
Net water-level change since 1934: −4.30 feet



In the Panhandle Division, 91 percent of the water levels measured in observation wells during the fall of 1989 were lower than those measured in the fall of 1988.

Panhandle Division

Groundwater levels measured in the Panhandle Division in the spring of 1989 generally ranged between 1 foot higher and 1 foot lower than those measured in the spring of 1988. In Box Butte County, however, many water levels were 2 to 3 feet lower than those measured in the spring of 1988. In the fall of 1989, 91 percent of the water levels measured in observation wells were lower than those measured in the fall of 1988. Most fall 1989 water levels were between 1 and 3 feet lower than fall 1988 water levels. In Box Butte County, however, some water levels measured in the fall of 1989 were as much as 14 feet lower than those measured in the fall of 1988.

Differences between water levels measured in 1989 and those measured in 1988 were:

Season	Number of wells measured	Wells with higher water levels in 1989, in percent	Average water-level difference, in feet	Median water-level difference, in feet
Spring	254	35	−0.26	−0.25
Fall	281	9	−2.58	−1.60

Intensive groundwater development for irrigation in Box Butte County has caused water-level declines of more than 5 feet from estimated predevelopment levels in an area of about 428,000 acres since 1950. A long-term decline of almost 60 feet has been measured in the Berea observation well, which is located about 3 miles north of Alliance. Estimated predevelopment water levels in Box Butte County are the approximate water levels that occurred prior to about 1947.

As of fall 1989, the approximate areas of significant water- level declines from estimated predevelopment water levels in Box Butte County were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	61,000
10-15	50,000
15-20	50,000
20-25	69,000
25-30	80,000
30 or more	118,000

Sufficient historical water-level data are available for making good estimates of predevelopment water levels in Box Butte County, and existing water-level measurement programs provide sufficient data for fairly good determination of current water-level changes throughout most of the county. Water-level data are collected by the Upper Niobrara-White Natural Resources District, the Conservation and Survey Division, and the U.S. Geological Survey.

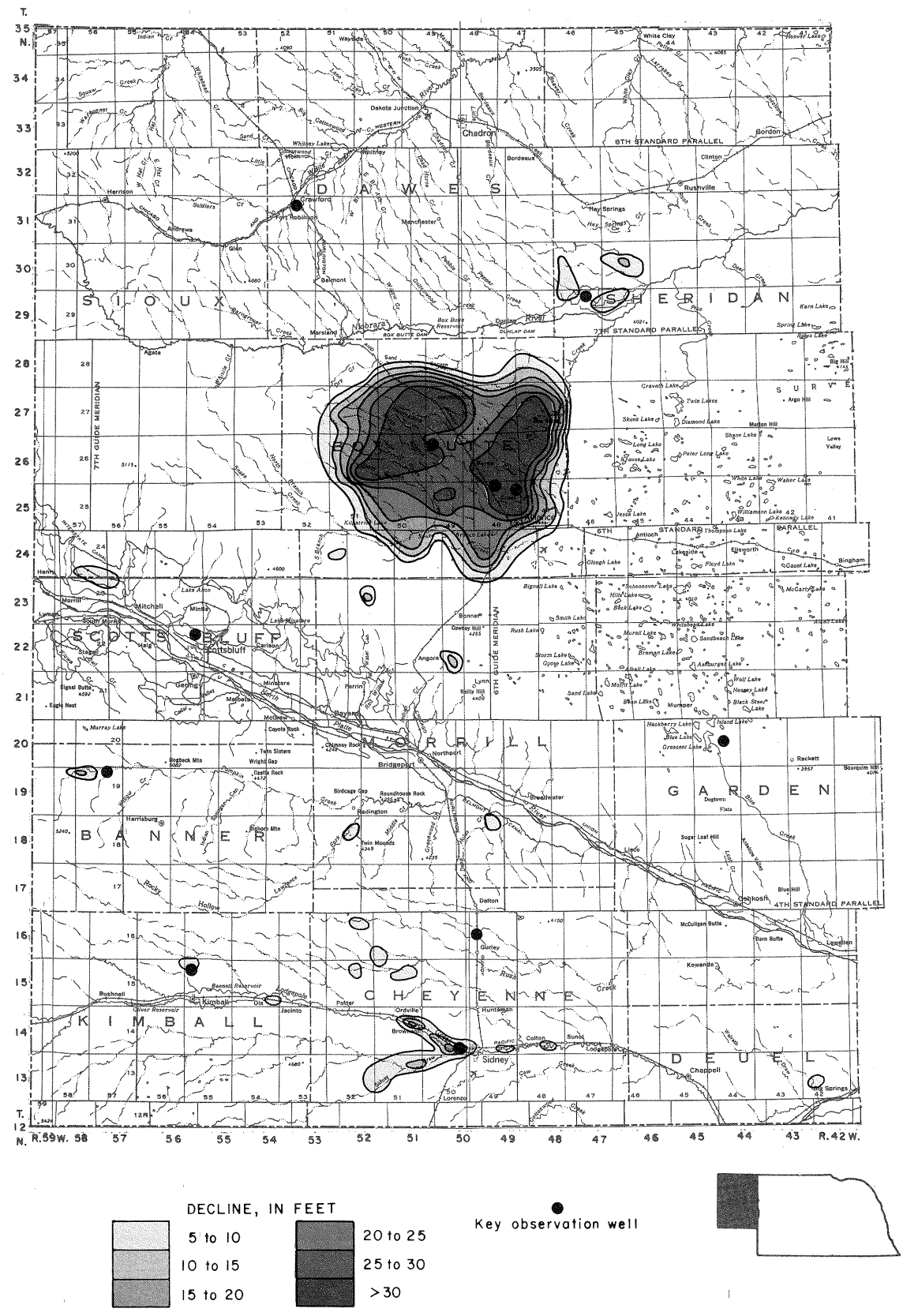
Another area in the Panhandle Division where significant declines from predevelopment water levels have occurred is along the Lodgepole Creek valley and in the Sidney Draw area southwest of Sidney in Cheyenne County. Groundwater withdrawals for irrigation have resulted in declining water levels in most years since 1969. Declines of 5 feet or more have occurred in an area of about 36,000 acres. Declines of 15 to 20 feet from the estimated predevelopment level were measured in several observation wells in the Lodgepole Creek valley west of Sidney. During periods of above-normal precipitation, such as 1982-83 and 1986-87, water levels have risen in many wells. Estimated predevelopment water levels in the Lodgepole Creek valley and Sidney Draw are the approximate water levels prior to 1950. Water-level data collected by the Conservation and Survey Division in cooperation with South Platte Natural Resources District and the U.S. Geological Survey are used for determining these water-level changes.

In the fall of 1989, the approximate areas of significant water-level declines from estimated predevelopment water levels in the Lodgepole Creek valley and Sidney Draw were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	29,000
10-15	6,000
15-20	1,000

Water-level declines of more than 5 feet from estimated predevelopment levels also have occurred in upland areas in Cheyenne, Deuel, Kimball, Scotts Bluff, Sheridan, and Sioux counties and along Pumpkin Creek and its tributaries in Banner and Morrill counties. Available data are not sufficient for accurate delineation of most of these areas of decline, but they probably comprise about 54,000 acres.

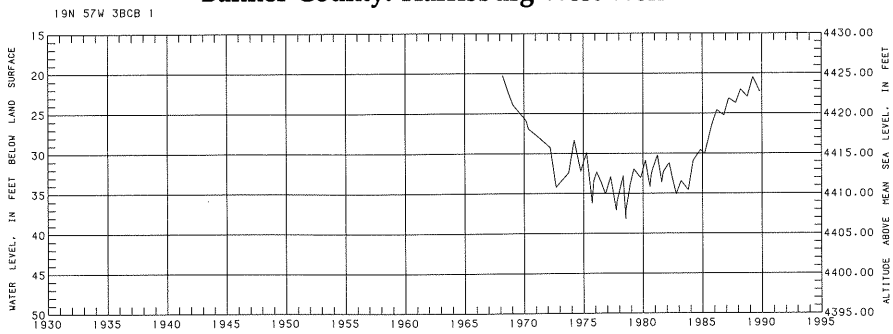
At the end of 1989, there were about 4,400 registered irrigation wells in the division. During 1989, 84 new irrigation wells were drilled and registered in the division. In addition to the districts already mentioned, the North Platte Natural Resources District also cooperated in the collection of the water-level data for this division.



Areas of significant water-level change in the Panhandle Division from 1946 to fall 1989

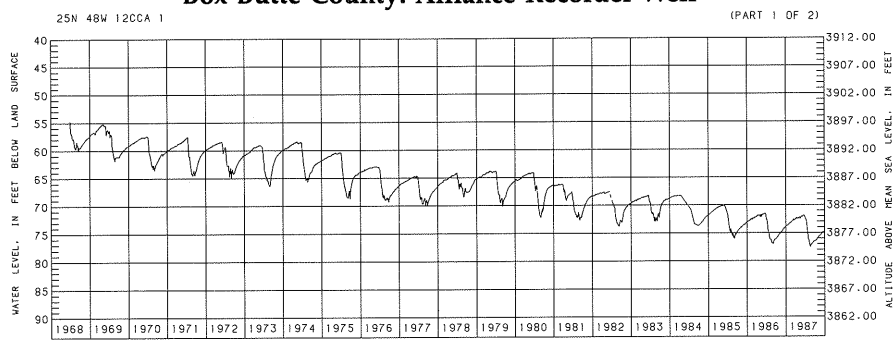
Banner County: Harrisburg West Well

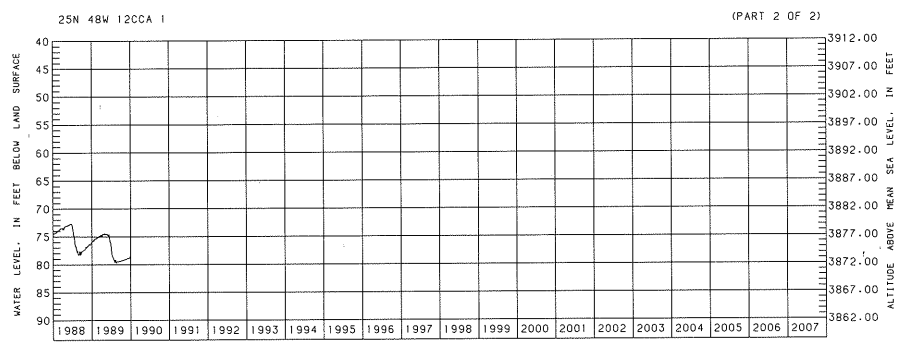
Measured semiannually
Estimated predevelopment water level: 19 feet
Net water-level change, fall 1988 to fall 1989: +0.67 foot
Net water-level change since 1968: +0.20 foot



Box Butte County: Alliance Recorder Well

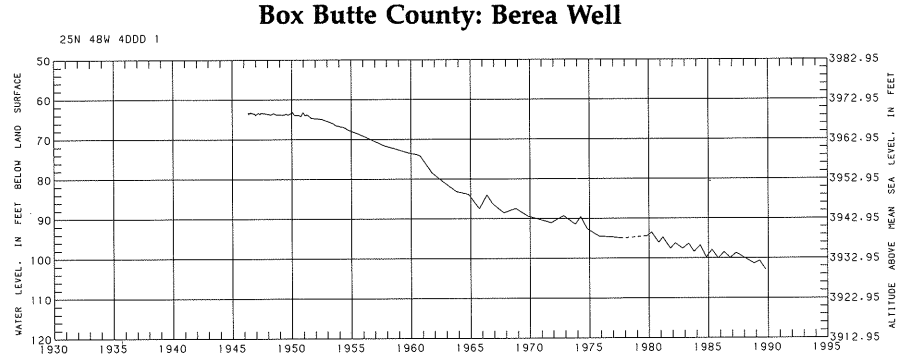
Estimated predevelopment water level: 17 feet
Net water-level change in 1989: −2.53 feet
Net water-level change since 1968: −21.14 feet





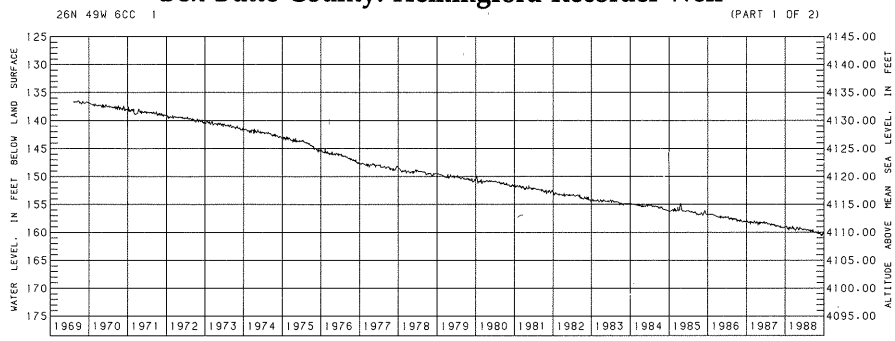
Box Butte County: Berea Well

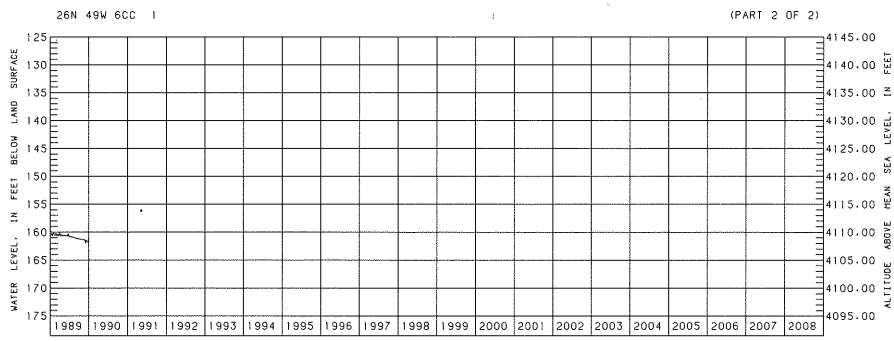
Measured semiannually
Estimated predevelopment water level: 63 feet
Net water-level change in 1989: −0.01 foot
Net water-level change since 1968: −39.33 feet



Box Butte County: Hemingford Recorder Well

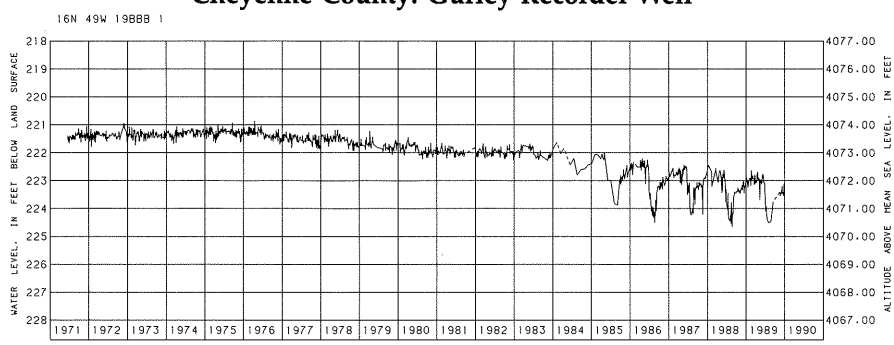
Estimated predevelopment water level: 134 feet
Net water-level change in 1989: −1.57 feet
Net water-level change since 1969: −24.91 feet





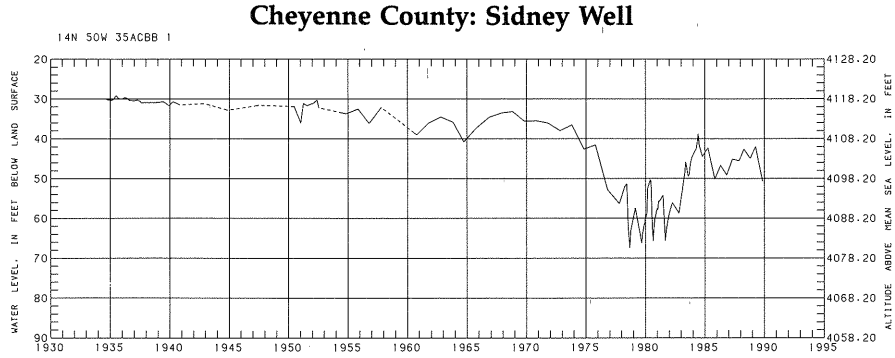
Cheyenne County: Gurley Recorder Well

Estimated predevelopment water level: 221 feet
Net water-level change in 1989: −0.25 foot
Net water-level change since 1971: −1.72 feet



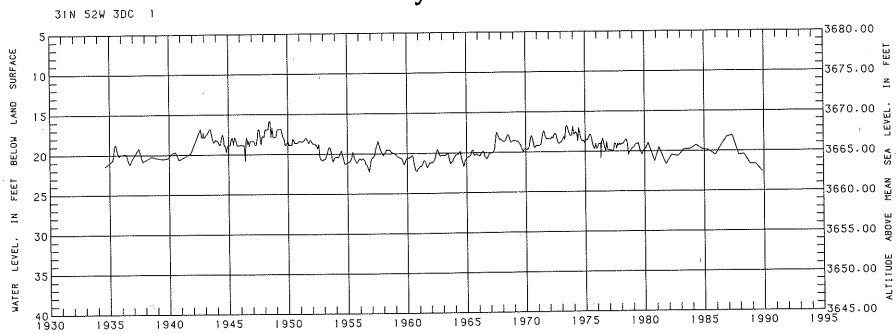
Cheyenne County: Sidney Well

Measured semiannually
Estimated predevelopment water level: 31 feet
Net water-level change, fall 1988 to fall 1989: −5.70 feet
Net water-level change since 1934: −20.35 feet



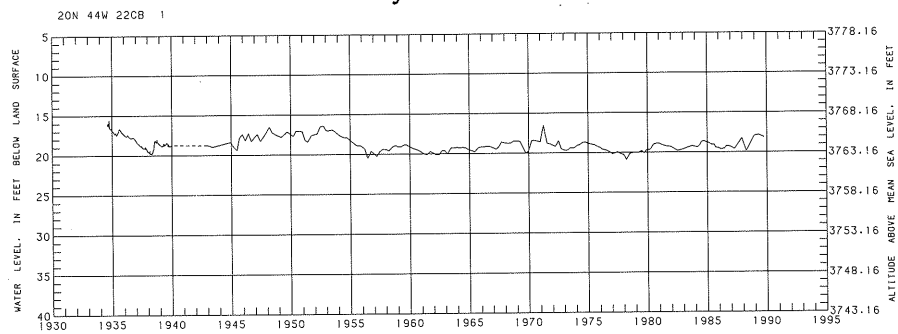
Dawes County: Crawford Well

Measured semiannually
Estimated predevelopment water level: 19.5 feet
Net water-level change, fall 1988 to fall 1989: −0.92 foot
Net water-level change since 1934: −1.40 feet



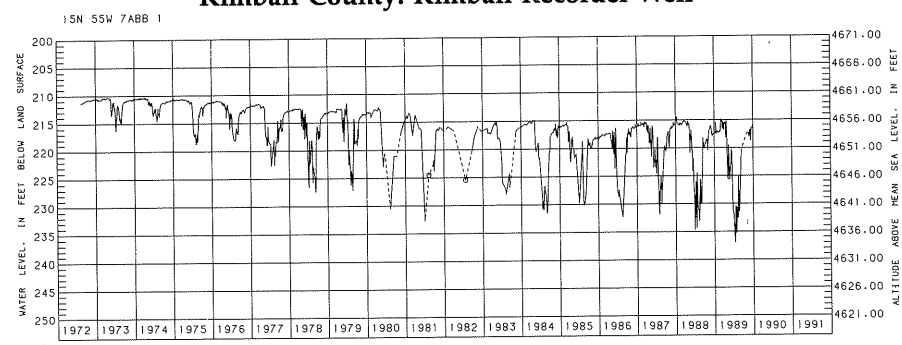
Garden County: Crescent Lake Well

Measured monthly
Estimated predevelopment water level: 17.5 feet
Net water-level change in 1989: −0.17 foot
Net water-level change since 1934: −1.29 feet



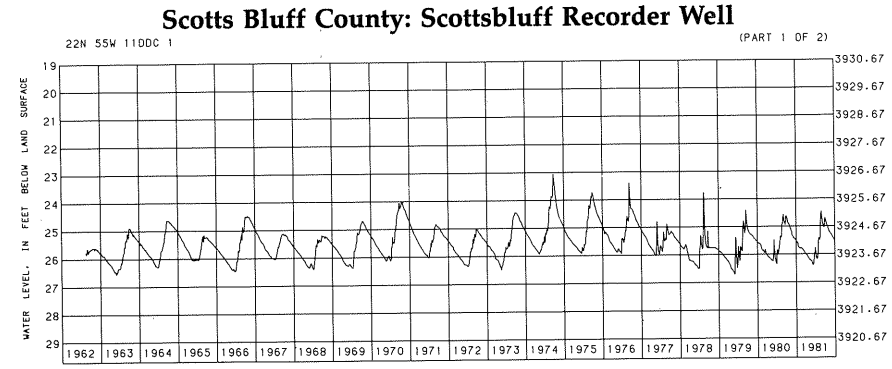
Kimball County: Kimball Recorder Well

Estimated predevelopment water level: 210 feet
Net water-level change in 1989: +1.35 feet
Net water-level change since 1972: −5.42 feet

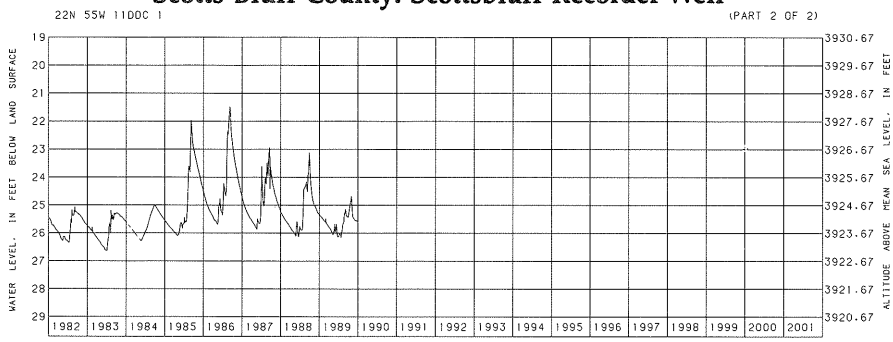


Scotts Bluff County: Scottsbluff Recorder Well

Estimated predevelopment water level: 26 feet
Net water-level change in 1989: −0.35 foot
Net water-level change since 1962: +0.12 foot

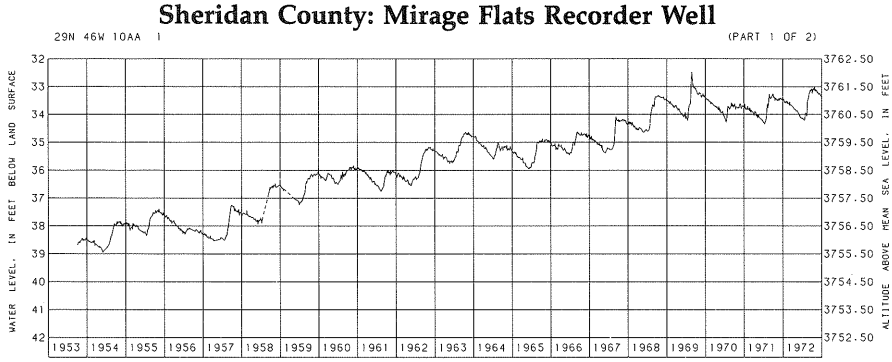


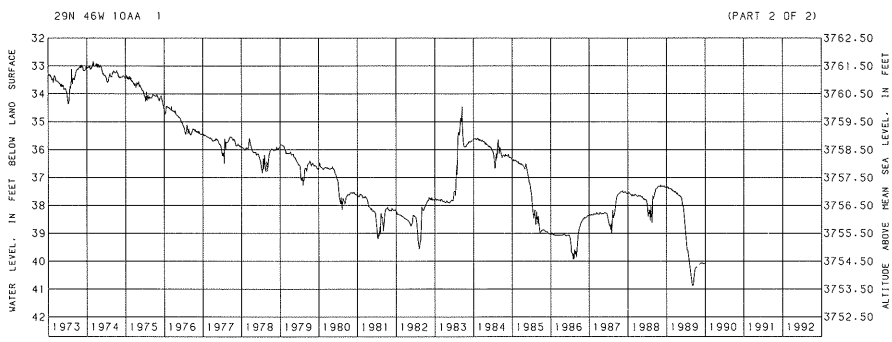
Scotts Bluff County: Scottsbluff Recorder Well



Sheridan County: Mirage Flats Recorder Well

Estimated predevelopment water level: 38.5 feet
Net water-level change in 1989: −2.73 feet
Net water-level change since 1953: −1.61 feet





Thirty-eight agencies collected water-level measurements that serve as basic data for this report.

Water-Level Measurement Program, 1989

Observation-well networks operated by 38 federal, state, and local agencies and municipalities provided the water-level data used in preparing this report. Water-level measurements are made for a variety of needs; therefore, the distribution of observation wells in the state is nonuniform. The number of observation wells per county ranges from one or two in several counties to about 150 in others, with the greatest density in areas where significant changes in water levels have been recognized. However, water-level changes in some areas may not be detected or accurately delineated because of insufficient data.

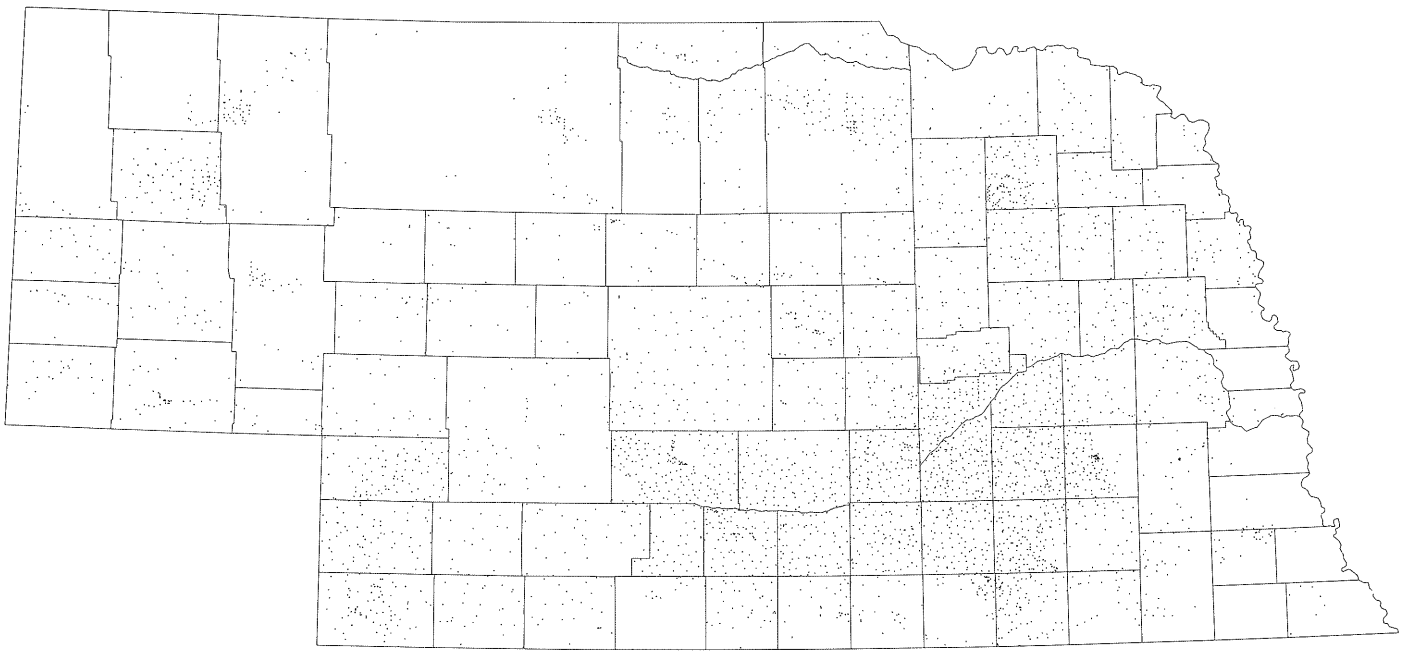
The locations of all observation wells from which data were used in the preparation of this report are shown on the accompanying map. Measurements made in these wells are included in a computer file of historical water-level records maintained by the U.S. Geological Survey and the Conservation and Survey Division. As of December 31, 1989, this computer file contained records of about 480,000 water-level measurements made in about 17,000 wells. The number of water-level records available for each well is variable, depending on the length of time water levels were measured in a well and the frequency of measurements. For some of these wells, there are records of only one or two measurements made in a single year, whereas for other wells there are several thousand records of measurements made during a 40- to 60-year period. Records of water-level measurements included in the file can be obtained, on request, from the U.S. Geological Survey, Room 406, Federal Building, 100 Centennial Mall North, Lincoln, Nebraska 68508, or from the Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, Nebraska 68588-0517.

As part of the cooperative groundwater program of the U.S. Geological Survey and the Conservation and Survey Division, a statewide water-level measurement program was begun in 1930. Initially, this program consisted of an observation-well network to provide long-term data on changes in the volume of groundwater in storage and to detect areas where changes in water levels indicated that problems might occur. The original observation-well network was designed to provide data only for a generalized appraisal of the state's groundwater resources. In time, a need to obtain detailed water-level data for specific areas resulted in the establishment of a number of local observation-well networks.

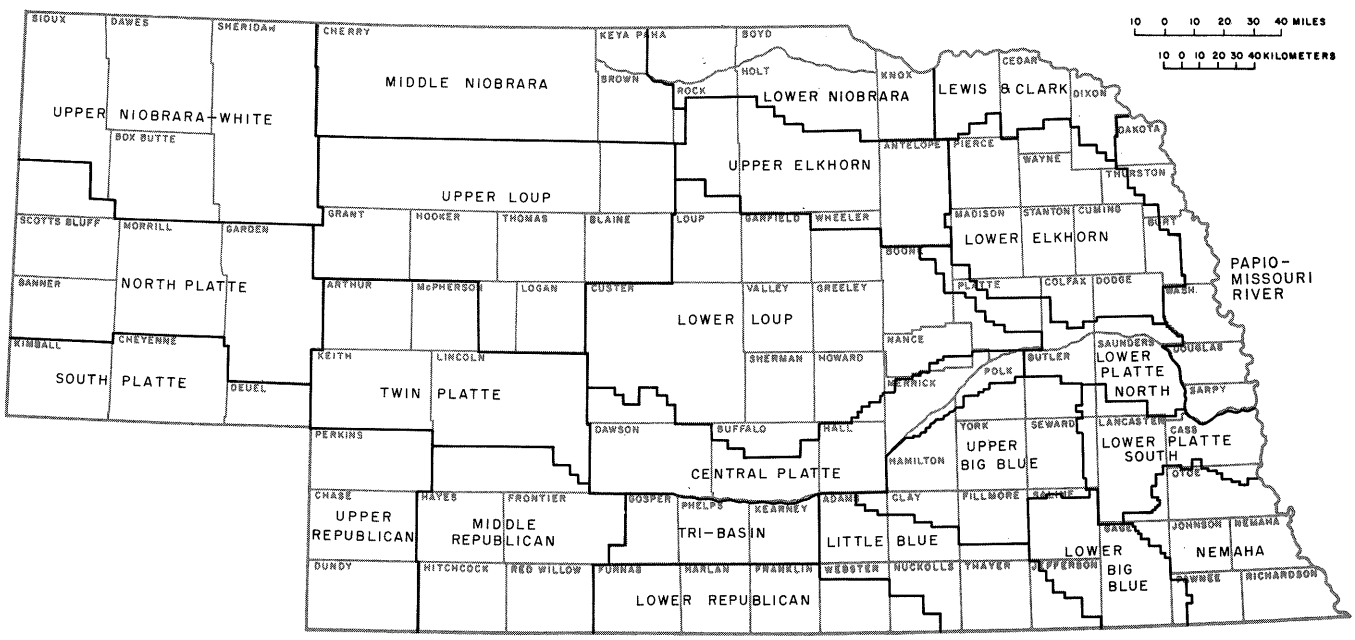
The need for water-level data to use in planning and evaluating the development of Nebraska's groundwater resources has changed the original cooperative water-level measurement program considerably. Currently, the program provides not only for the operation of a statewide observation-well network, but also for assistance and advice to other agencies and associations in the establishment and operation of local observation-well networks, the operation and maintenance of a computer storage system for water-level data from all networks, and the evaluation and dissemination of water-level data.

About 12,000 water-level measurements made in about 3,700 observation wells were entered in the computer file of the cooperative water-level measurement program during 1989. Records from nearly all agencies in Nebraska making water-level measurements were compiled and entered into the file. The processing of these data and supporting information was a major activity of the cooperative program.

The cooperation and assistance of the following agencies and associations in collecting and providing water-level data during 1989 is gratefully acknowledged: U.S. Bureau of Reclamation; U.S. Fish and Wildlife Service; Central Nebraska Public Power and Irrigation District; Harlan County extension office; Nebraska Public Power District; groundwater conservation districts in Clay, Fillmore, Hamilton, Seward, and York counties; Omaha Metropolitan Utilities District; Lincoln Water System; and the following natural resources districts: Lower Republican, Middle Republican, Upper Republican, Upper Big Blue, Little Blue, Lower Big Blue, Lower Platte South, Lower Platte North, Central Platte, Twin Platte, North Platte, South Platte, Lower Niobrara, Middle Niobrara, Upper Niobrara-White, Lower Loup, Upper Loup, Lower Elkhorn, Upper Elkhorn, Papio-Missouri River, Lewis and Clark, Nemaha, and Tri-Basin.



Location of water-level observation wells in Nebraska



Location of Nebraska natural resources districts

Drought conditions during 1989 resulted in groundwater-level declines occurring throughout most of Nebraska

Effect of Precipitation on Groundwater Levels During 1989

During 1989, most groundwater levels throughout Nebraska were significantly affected by less-than-normal precipitation. As a result of the less-than-normal precipitation, less-than-normal recharge filled aquifers and greater-than-normal withdrawals of groundwater were needed to supply domestic, municipal, and agricultural needs, which caused water levels to decline significantly throughout the state.

During 1989, precipitation was moderately less than normal in three of Nebraska's eight climate divisions and slightly less than normal in the other five divisions. The boundaries of these climate divisions, established by the National Oceanic and Atmospheric Administration, generally do not coincide with those of the divisions used in this report for describing water-level changes. (Divisions are identified by initials in parentheses following division names.)

During the 1989 growing season, precipitation ranged from moderately less than normal in the North-Central Division to near normal in the Central, South-Central, Southwest, and Southeast divisions. Because precipitation during March, April, and May generally ranged from substantially to moderately less than normal, many irrigators applied water to their fields prior to planting. Water-level data indicate that this widespread early pumping of groundwater resulted in water levels starting to decline in April or May instead of June or July, as occurs most years. During the 1988-89 dormant season, precipitation ranged from substantially less than normal in the South-Central Division to moderately less than normal in the other seven climatic divisions.

Most of the dormant-season precipitation occurred during November of 1988 and January of 1989. Precipitation ranged from substantially less than normal to moderately less than normal in all eight climate divisions during March, April, May, October, and November. Near-normal or greater-than-normal precipitation did not occur in all eight climate divisions during any single month of 1989, but precipitation was normal to above normal in seven of the eight divisions during January; the Panhandle Division was the exception.

For the Panhandle Division (P), the greatest positive monthly departure from normal precipitation was during September (+1.44 inches), and the greatest negative monthly departure from normal precipitation was during June (-2.10 inches).

The greatest negative monthly departure from normal precipitation for the North-Central Division (NC) occurred during May (-1.83 inches), and no positive monthly departures from normal precipitation occurred during 1989. December was the only month that a negative monthly departure from normal precipitation did not occur (0.50 inches or 100 percent of normal). This division received the smallest percentage of normal annual precipitation (65 percent), and the smallest percentage of normal precipitation during the growing season (66 percent).

In the Northeast Division (NE), the greatest negative monthly departure from normal precipitation occurred during May (−2.29 inches). The greatest positive monthly departure from normal precipitation occurred during September (+1.04 inches).

The Central Division (C) recorded the largest negative monthly departure from normal precipitation in April (−2.24 inches) and the greatest positive monthly departure from normal in June (+1.87 inches).

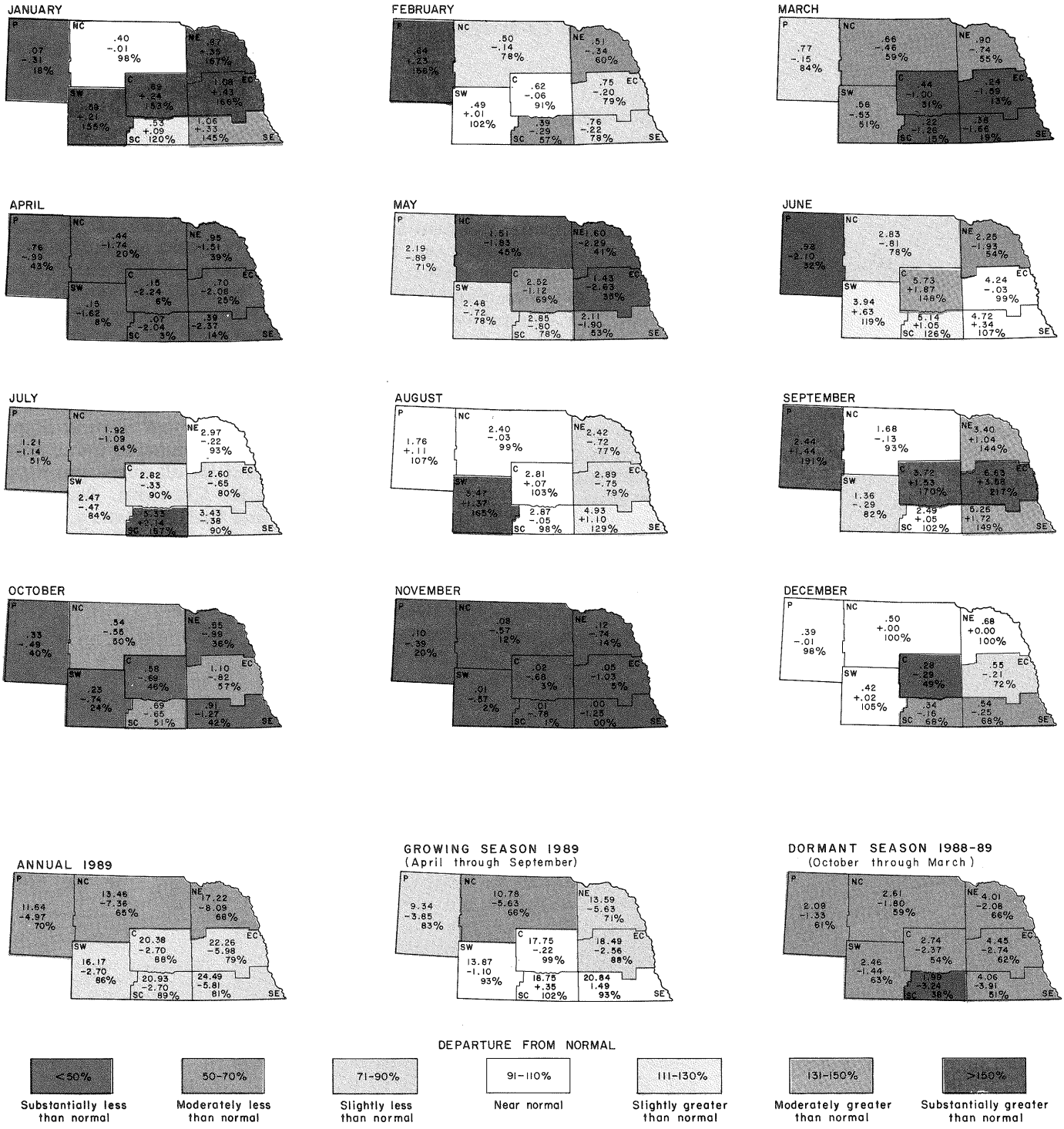
The greatest negative monthly departure from normal precipitation in the East-Central Division (EC) occurred during May (−2.63 inches). The division's largest positive monthly departure from normal precipitation occurred during September (+3.58 inches).

The Southwest Division (SW) had the greatest negative monthly departure from normal precipitation during April (−1.62 inches) and the greatest positive monthly departure from normal precipitation during August (+1.37 inches).

The South-Central Division (SC) had the greatest negative monthly departure from normal precipitation during April (−2.04 inches) and the largest positive monthly departure from normal precipitation during July (+2.14 inches). This division received the greatest percentage of normal annual precipitation (89 percent), the greatest percentage of normal precipitation during the growing season (102 percent), and the smallest percentage of normal precipitation during the dormant season (38 percent).

The greatest negative monthly departure from normal precipitation in the Southeast Division (SE) was during April (−2.37 inches). The greatest positive monthly departure from normal precipitation was during September (+1.72 inches).

Almost all recharge to aquifers in Nebraska comes from precipitation that infiltrates into the ground near where it falls. In some localities, however, seepage from streams, lakes, irrigation canals, and applied irrigation water might be a more important source of recharge than precipitation. No precise quantitative relationship between precipitation and the resultant groundwater-level changes in the state has been determined, but a general correlation between water-level fluctuations and precipitation can be noted from most of the records. Precipitation amounts can also affect water levels indirectly, because the quantities of water pumped for irrigation and municipal use generally are less during wet periods and greater during dry periods.



Summary of monthly, seasonal, and total precipitation in 1989 for eight National Weather Service divisions of Nebraska showing average precipitation in inches, positive or negative departure from normal precipitation in inches, and the percentage of normal precipitation

Groundwater Use and Development

Distribution of Irrigation Wells

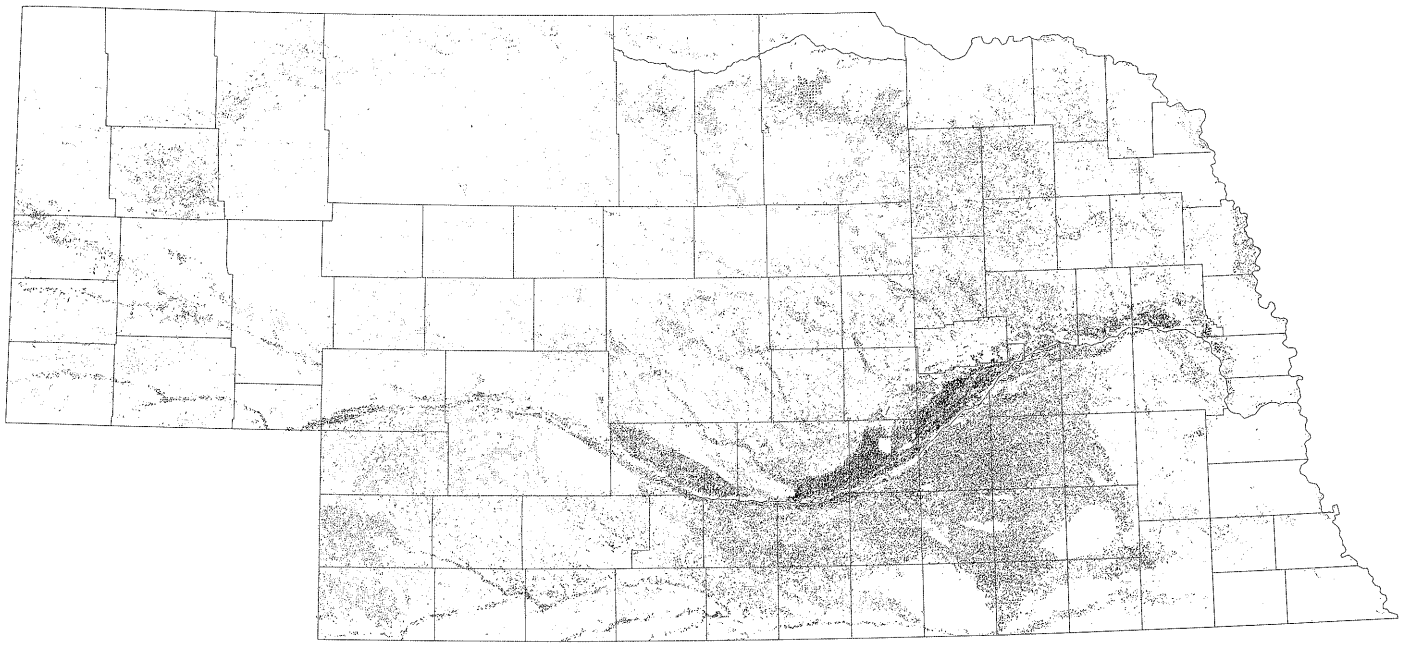
The estimated 7 million acre-feet of groundwater used for irrigation in 1989 is about 16 times the volume of groundwater used for all other purposes in Nebraska.

At the end of 1989, a total of 72,919 irrigation wells had been registered in Nebraska. These wells are the source of water for irrigating about 86 percent of the estimated 7.5 million acres of irrigated land in the state. The volume of groundwater pumped for irrigation each year has not been determined, but during 1989, it is estimated to have been about 7 million acre-feet. This volume was about 16 times the total volume of groundwater pumped for domestic, livestock, municipal, industrial, and other uses.

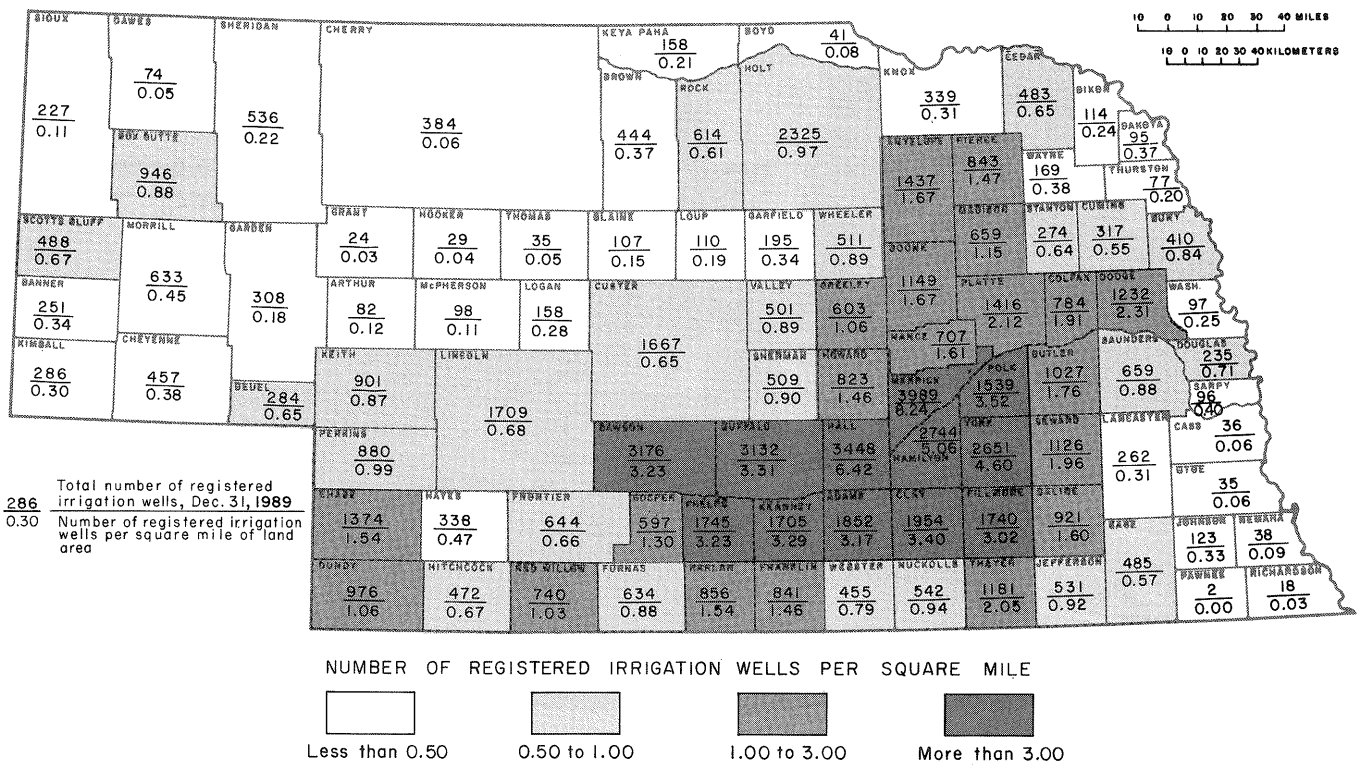
Although irrigation wells have been drilled in each of Nebraska's 93 counties, their number and density differ greatly from one county to another because of variations in land use, distribution of irrigable land, and availability of groundwater. About 46 percent of the registered irrigation wells are concentrated in a 16-county area comprising the upper part of the Big Blue River and Little Blue River basins, and the central part of the Platte River valley. Buffalo, Dawson, Hall, Hamilton, Merrick, and York counties have more than 2,600 irrigation wells each and the nearby counties—Adams, Butler, Clay, Fillmore, Kearney, Phelps, Platte, Polk, Seward, and Thayer—have more than 1,000 irrigation wells each. Antelope, Boone, Chase, Custer, Dodge, Holt, and Lincoln counties are the only other counties in the state that have more than 1,000 irrigation wells each.

Although the total number of irrigation wells in a county provides some indication of the degree of groundwater development that has taken place, the number of irrigation wells per square mile of land area in a county is a better index of the degree of development. A high density of irrigation wells in a county generally indicates both a large percentage of irrigable land and large volumes of available groundwater. Very low densities generally characterize counties where development is limited either by little irrigable land or by aquifers that yield only small volumes of water to wells, or both. Merrick County, with an average of 8.24 irrigation wells per square mile of land, has the highest well density of any county in the state. Pawnee County, which has only two irrigation wells in its 433 square miles of land, has the lowest well density—an average of about one irrigation well per 216.5 square miles.

By far the largest use of groundwater in Nebraska is for irrigation, and most of the concern about changes in water levels and availability of groundwater is related to irrigation development. However, use of groundwater for rural domestic, livestock, industrial, and municipal supplies is also important. Groundwater is used for almost all rural domestic supplies; for almost all industrial supplies; and for all municipal supplies except for Crawford, Beaver Lake, Blair, and part of Omaha's, Crofton's, and Chadron's supplies.



Location of registered irrigation wells in Nebraska as of December 31, 1989



Total number and density of registered irrigation wells in Nebraska, by county, as of December 31, 1989

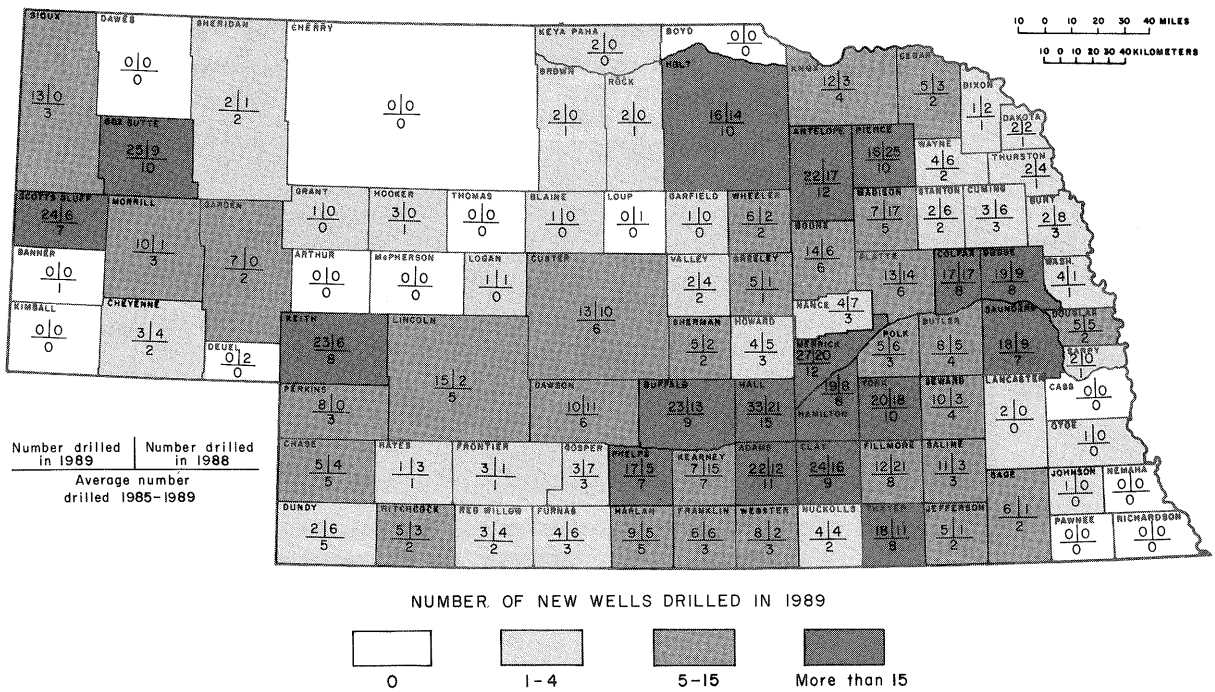
Trends in Groundwater Development

The 702 new irrigation wells drilled during 1989 almost equals the total number of wells drilled during 1986, 1987, and 1988.

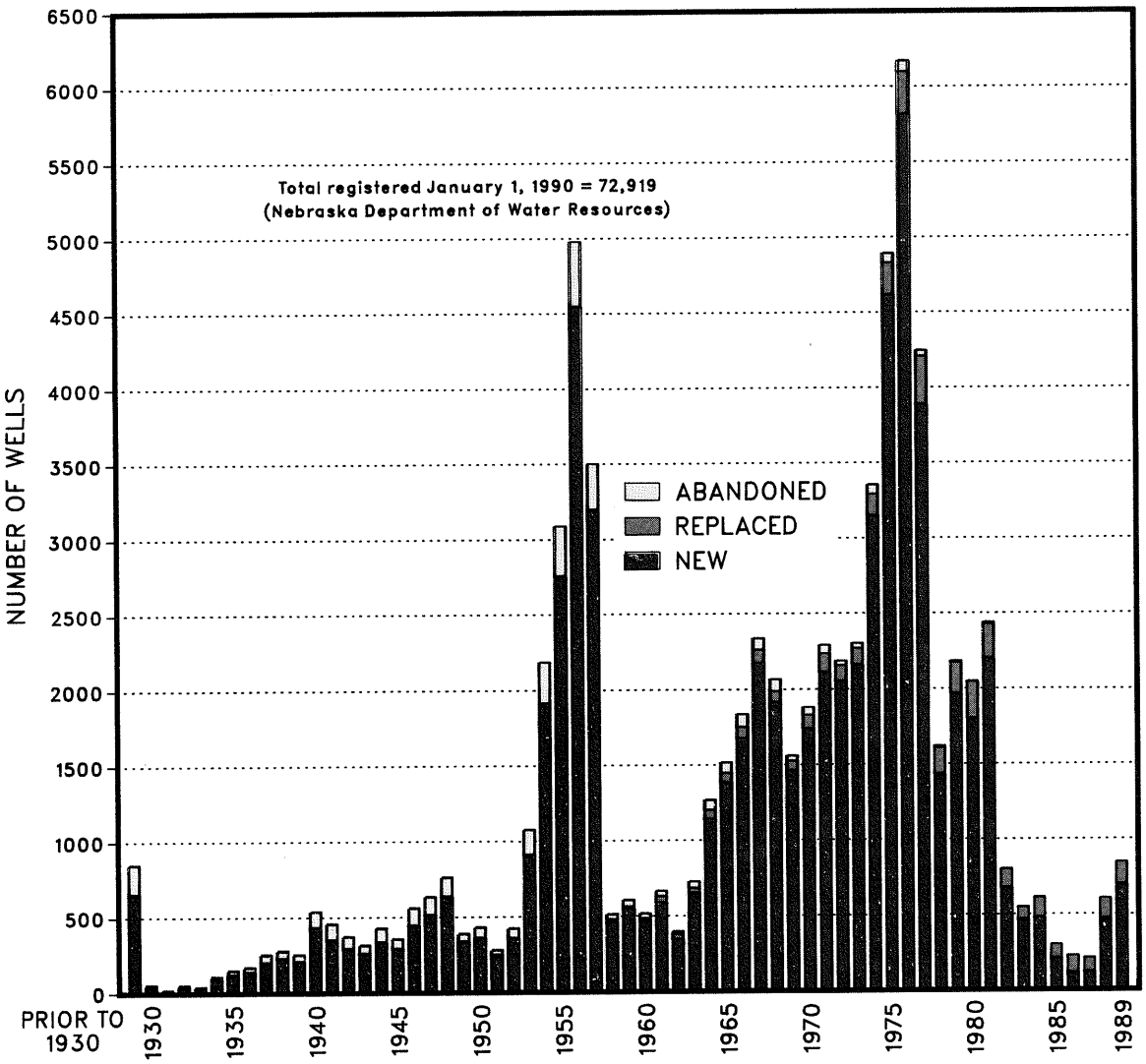
Irrigation has been one of the most important factors in making Nebraska a leading state in agricultural productivity. During the past three decades, groundwater use to meet agricultural demands has more than tripled, so that now about 70 percent of the water used for irrigation is pumped from wells. During 1989, 702 new irrigation wells were drilled in Nebraska, which is almost equal to the total number of wells drilled between January 1, 1986, and December 31, 1988. These new wells were drilled in 79 of the state's 93 counties. Thirty-three of the new wells were drilled in Hall County, and more than 20 new wells were drilled in nine other counties (Adams, Antelope, Box Butte, Buffalo, Clay, Keith, Merrick, Scotts Bluff, and York).

A combination of economic, climatic, and technological factors account for annual variations in the number of irrigation wells drilled. During periods of less-than-normal precipitation, such as during the growing seasons in 1953-56, the number of irrigation-well installations increased markedly. Increased drilling commonly continues for a year or more after a drought. Starting in the mid-1960s, increased development was affected by short droughts, the availability of center-pivot irrigation systems, and favorable economic conditions, especially during 1973-75.

The large number of irrigation wells installed in 1989 can be explained in part by drought conditions in the central, south-central, and eastern parts of the state during 1988 and drought conditions throughout the state during 1989.



Number of registered irrigation wells drilled in Nebraska in 1989, 1988, and 1985-89, by county.



Annual installation of irrigation wells in Nebraska through 1989 (estimated from historical surveys and irrigation- well registrations)

A water-level hydrograph provides a graphic representation of water-level fluctuations.

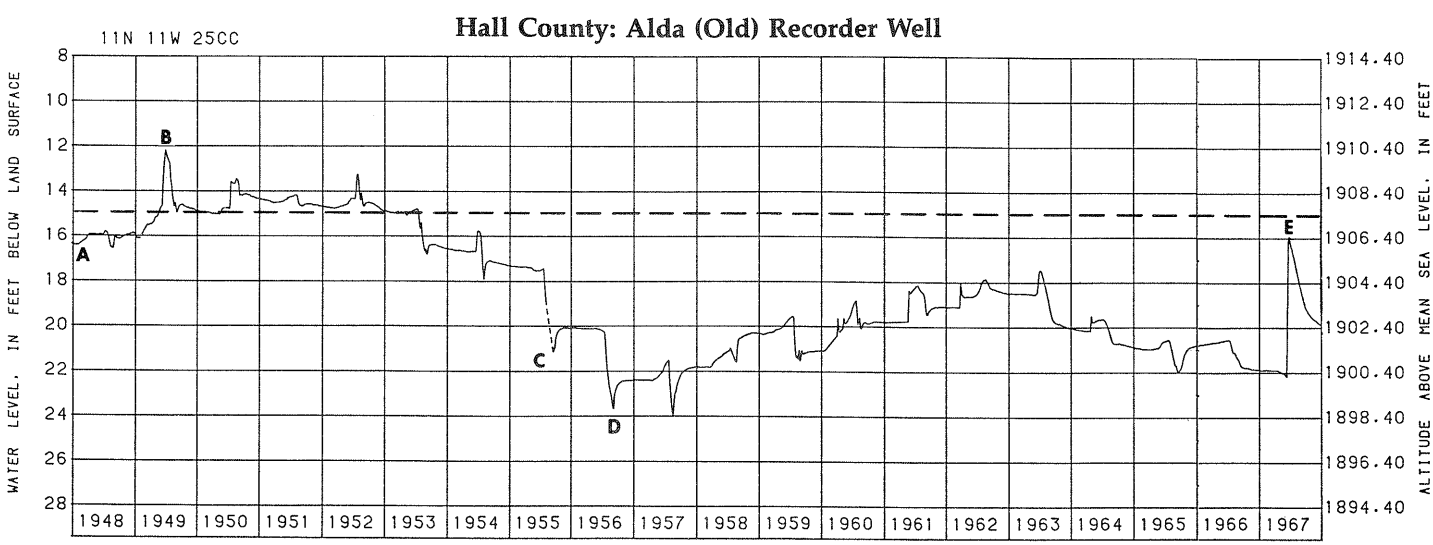
Explanation of Water-Level Hydrographs

Hydrographs are used to illustrate seasonal and long-term water-level fluctuations in key wells that represent hydrologic conditions at various locations in each division. The observation wells selected include those with continuous recorders and others that are measured periodically. In recorder wells, a float system or an electronic sensor is used to detect depths to water, which are recorded graphically on a chart or digitally on punched tape or in an electronic data logger. Periodic measurements are made annually (in the fall), semiannually (in the spring and fall), or monthly. Only limited data from continuous recorders can be stored, so only the lowest daily value for every fifth day and the end of the month is stored in computer files. Hydrographs for recorder wells provide a detailed record of the water-level changes. Hydrographs of wells measured periodically may not show extremes in water-level fluctuations as well as those with continuous recorders, but they provide important information on long-term water-level trends. The bottom of a hydrograph, of course, does not represent the bottom of the aquifer. The full range of water-level fluctuations, in most wells, usually is only a fraction of the thickness of the aquifer.

An annotated hydrograph of a 20-year segment (1948-67) of the record for the Alda (old) recorder well is used to show some of the interpretations possible with hydrographs. This well is located in Hall County about 2 miles west-northwest of Alda. The complete record of this well and the Alda (new) recorder well is in the section on the Central Division. Water-level rises in this well were due principally to recharge from infiltrating precipitation. Except for small volumes of water withdrawn occasionally to ensure that the well screen was clear, water was not pumped from this well, so declines were due to pumping from nearby wells and natural discharge. In this well, as in many wells in Nebraska, water levels generally were highest in late spring, declined during the growing season, and began to rise again in October or November. When large volumes of water were pumped from nearby wells, the growing-season declines and fall recoveries were more pronounced. When the water level is higher at the end of the year than at the beginning, the difference indicates a net gain in groundwater storage; conversely, when the water level is lower, the difference indicates a net loss. Changes in water levels are not equal to changes in the volume of groundwater stored. Because groundwater occurs only in the pore spaces between the rock grains of the aquifer (about 30 to 35 percent by volume), a 3-foot change in water levels is equal to about a 1-foot change in the volume of water stored.

At the beginning of the annotated hydrograph shown for the Alda (old) recorder well, the depth to water was a little greater than 16 feet (A), or a little more than 1 foot lower than the estimated predevelopment water level (bold dashed line). Abrupt water-level rises occurred near the middle of many years, such as 1949 (B) and 1967 (E), because of major precipitation. On June 15, 1967, 7-10 inches of rain fell and caused the 1967 rise; it also caused flooding in the area. During the first 5 years of water-level records, depths to water at the end of each year were nearly the same as at the beginning. This indicates that discharge from the aquifer by natural processes and by pumping from wells was about equal to recharge from infiltrating precipitation. From 1953 through 1956, a drought, water-level declines due to natural discharge and to pumping for irrigation exceeded recharge from precipitation. As a result, year-end depths to water were lower than at the start of each year; during this period, the net water-level decline was 7.5 feet. Both 1955 and 1956 were very dry, and fall water-level recoveries were small following large water-level declines caused by irrigation pumping (C and D). During the following 6 years (1957-62), recharge from ample precipitation and less irrigation pumping combined to result in a net water-level rise of about 4 feet. During 1963-66, year-end depths to water again were progressively lower; but in 1967 the year-end water level was 2 feet higher than at the beginning of the year. Although water levels in the Alda (new) recorder well were as low as 26 feet in 1981, by the end of 1986 they were almost the same as the 1948 levels in the Alda (old) recorder well. Readers interested in examples of hydrographs that show confined, unconfined and perched aquifers should see the section, "Examples of Water-Level Hydrographs," in the 1987 report, "Groundwater Levels in Nebraska, 1986."

Bob Hansen, basic-data supervisor with the Conservation and Survey Division, gets ready to make a water-level measurement.



Annotated example of a water-level hydrograph

Reports Containing Water-Level Information

Year of observation	Publication and number	Author(s) and year published
pre-1954	U.S. Geol. Survey Open-File Rpt. 54-138	Keech, C.F.; Case, R.L., 1954
1954	U.S. Geol. Survey Open-File Rpt. 55-80	Keech, C.F.; Case, R.L., 1955
1955	U.S. Geol. Survey Open-File Rpt. 56-70	Keech, C.F.; 1956
1956	U.S. Geol. Survey Open-File Rpt. 57-61	Keech, C.F., 1957
1957	Nebraska Water Survey Paper 4*	Keech, C.F., 1958
1958	Nebraska Water Survey Paper 5*	Keech, C.F., 1959
1959	Nebraska Water Survey Paper 6	Keech, C.F., 1960
1960	Nebraska Water Survey Paper 9	Keech, C.F., 1961
1961	Nebraska Water Survey Paper 12	Keech, C.F.; Hyland, J.B., 1962
1962	Nebraska Water Survey Paper 13	Emery, P.A.; Malhoit, M.M., 1963
1963	Nebraska Water Survey Paper 14	Emery, P.A.; Malhoit, M.M., 1964
1964	Nebraska Water Survey Paper 17	Emery, P.A.; Malhoit, M.M., 1965
1965	Nebraska Water Survey Paper 18	Emery, P.A.; Malhoit, M.M., 1966
1966	Nebraska Water Survey Paper 20*	Keech, C.F., 1967
1967	Nebraska Water Survey Paper 23	Keech, C.F., 1968
1968	Nebraska Water Survey Paper 24*	Keech, C.F.; Svoboda, G.R., 1969
1969	Nebraska Water Survey Paper 26*	Keech, C.F., 1970
1970	Nebraska Water Survey Paper 28*	Keech, C.F., 1971
1971	Nebraska Water Survey Paper 33	Keech, C.F., 1972
1972	Nebraska Water Survey Paper 34	Ellis, M.J., 1973
1973	Nebraska Water Survey Paper 36	Ellis, M.J., 1974
1974	Nebraska Water Survey Paper 40*	Ellis, M.J., 1975
1975	Nebraska Water Survey Paper 43*	Ellis, M.J.; Pederson, D.T., 1976
1976	Nebraska Water Survey Paper 44	Ellis, M.J.; Pederson, D.T., 1977
1977	Nebraska Water Survey Paper 45	Ellis, M.J.; Pederson, D.T., 1978
1978	Nebraska Water Survey Paper 49	Pederson, D.T.; Johnson, M.S., 1979
1979	Nebraska Water Survey Paper 50	Johnson, M.S.; Pederson, D.T., 1980
1980	Nebraska Water Survey Paper 51	Johnson, M.S.; Pederson, D.T., 1981
1981	Nebraska Water Survey Paper 52	Johnson, M.S.; Pederson, D.T., 1982
1982	Nebraska Water Survey Paper 56	Johnson, M.S.; Pederson, D.T., 1983
1983	Nebraska Water Survey Paper 57	Johnson, M.S.; Pederson, D.T., 1984
1984	Nebraska Water Survey Paper 59	Ellis, M.J.; Pederson, D.T., 1985
1985	Nebraska Water Survey Paper 61	Ellis, M.J.; Pederson, D.T., 1986
1986	Nebraska Water Survey Paper 62	Ellis, M.J.; Dreeszen, V.H., 1987
1987	Nebraska Water Survey Paper 65	Ellis, M.J.; Wigley, P.B., 1988
1988	Nebraska Water Survey Paper 66	Ellis, M.J.; Steele, G. V.; and Wigley, P.B., 1989

* Out of print

U.S. Geological Survey Open-File Reports may be obtained from:

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