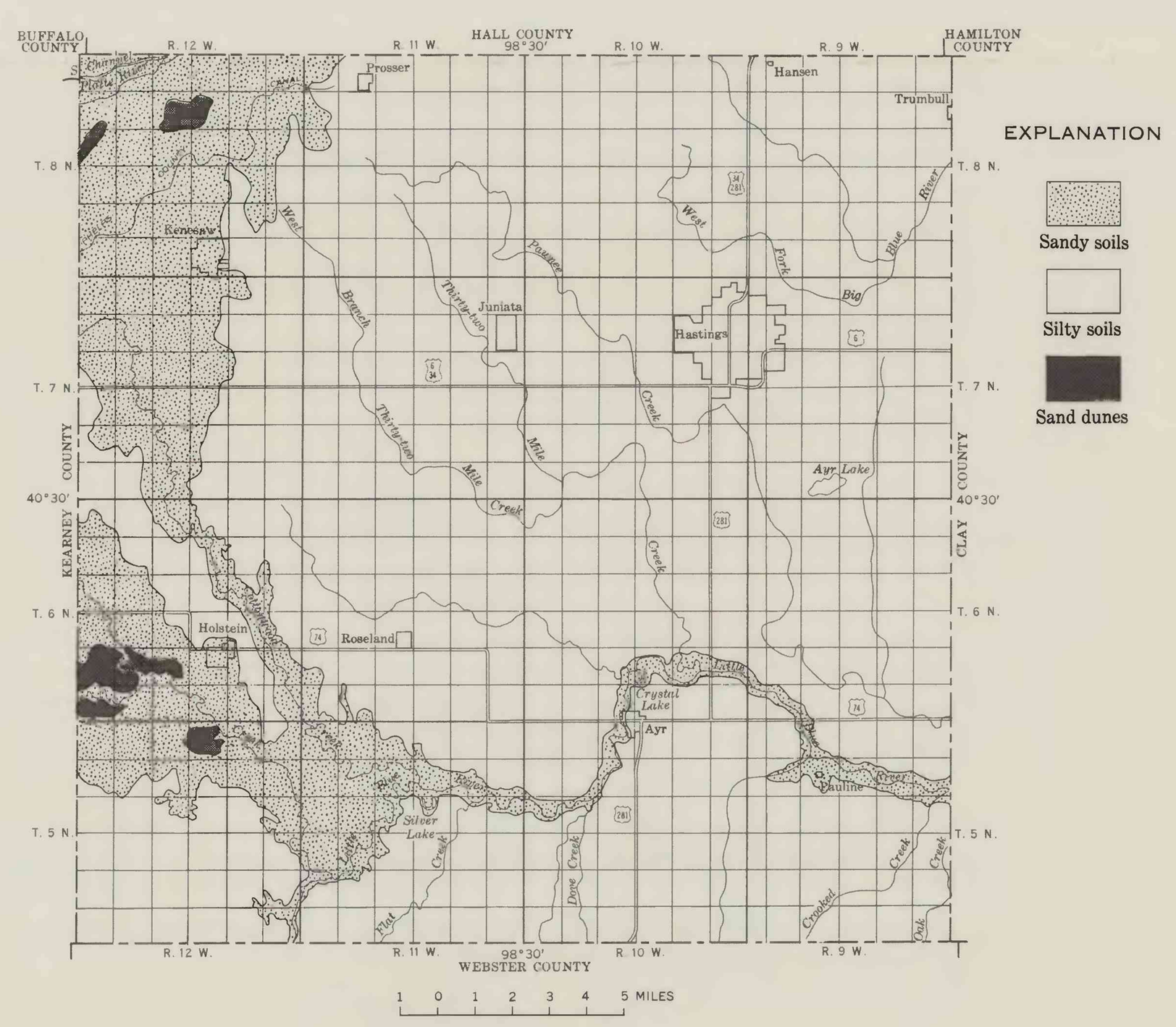
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

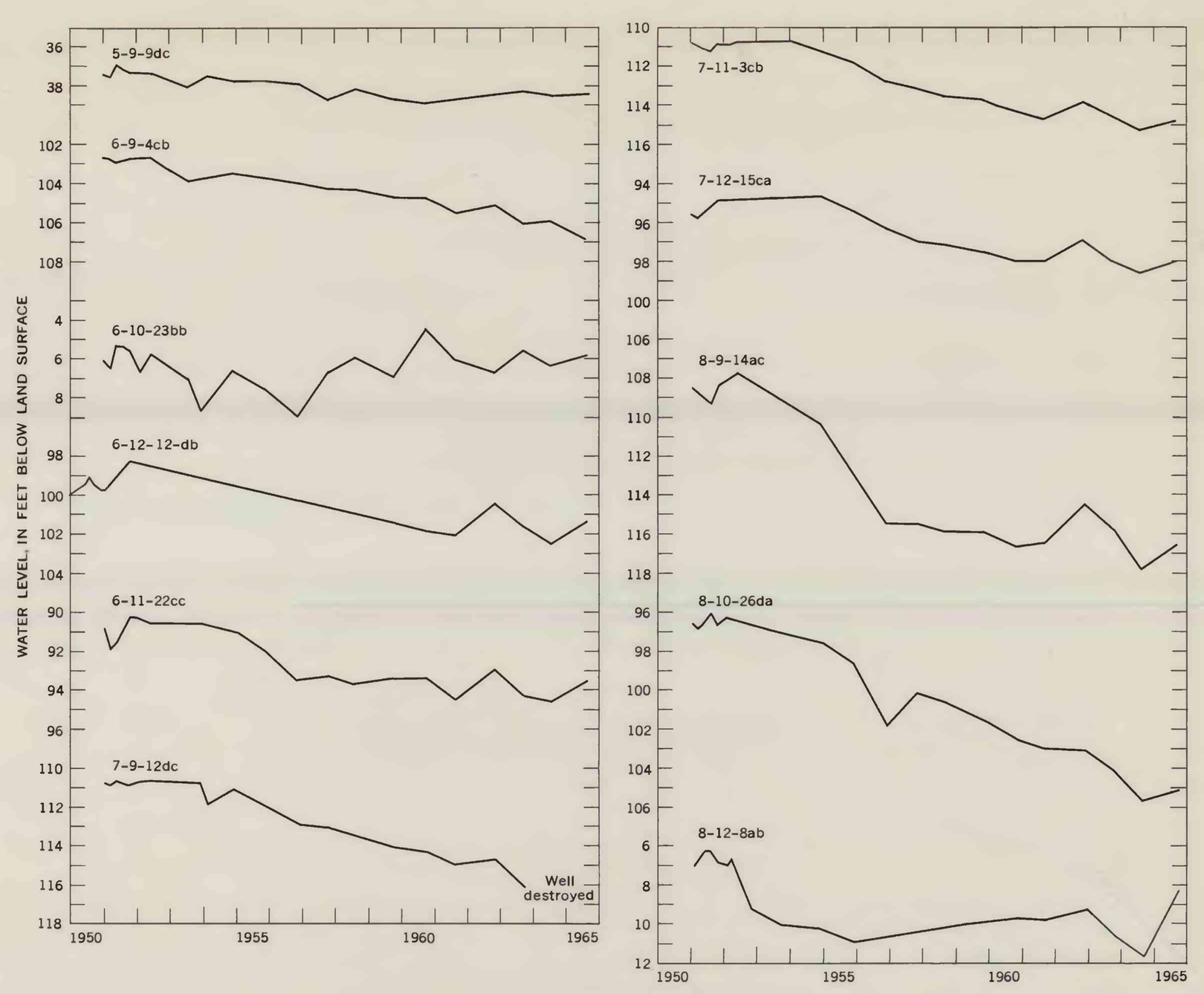
PREPARED IN COOPERATION WITH THE
CONSERVATION AND SURVEY DIVISION
OF THE UNIVERSITY OF NEBRASKA

HYDROLOGIC INVESTIGATIONS
ATLAS HA-287

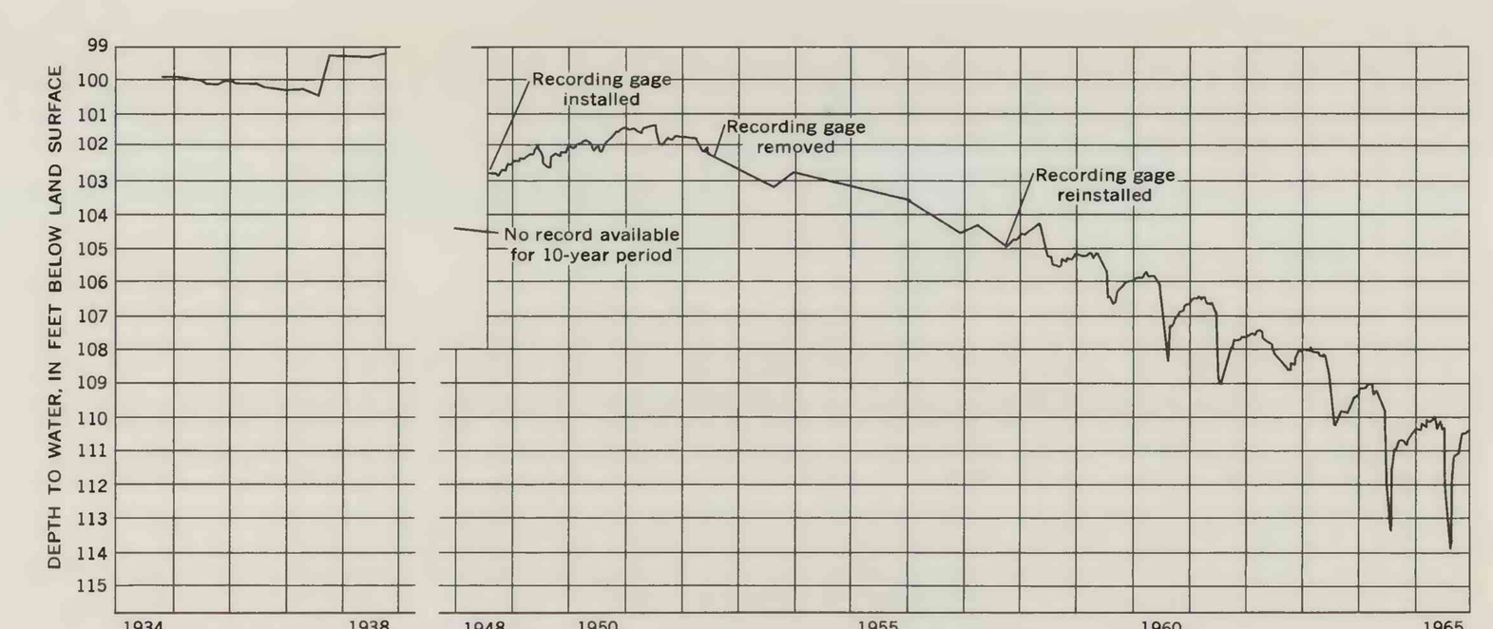
LOCATION MAP



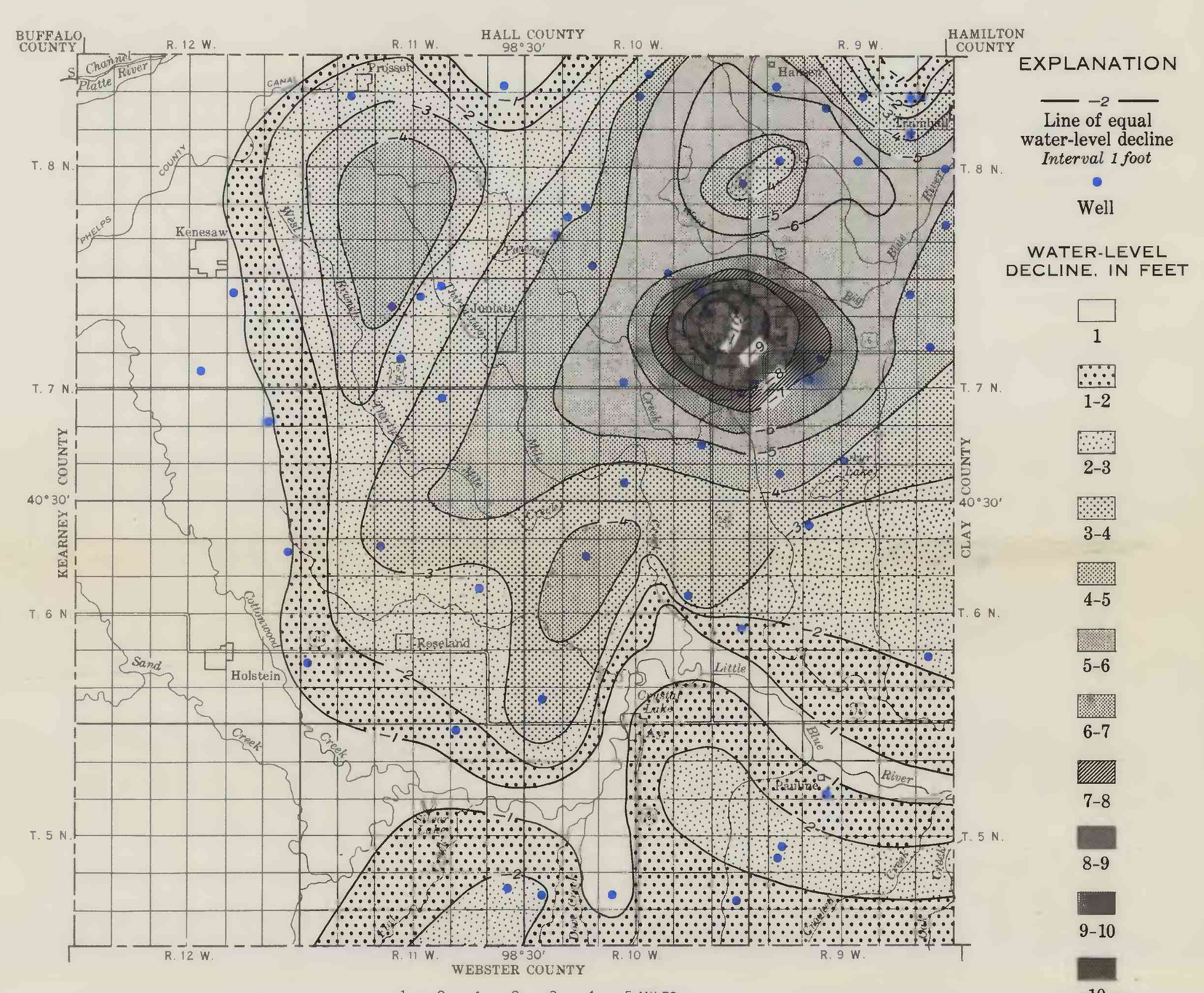
GENERALIZED SOILS MAP



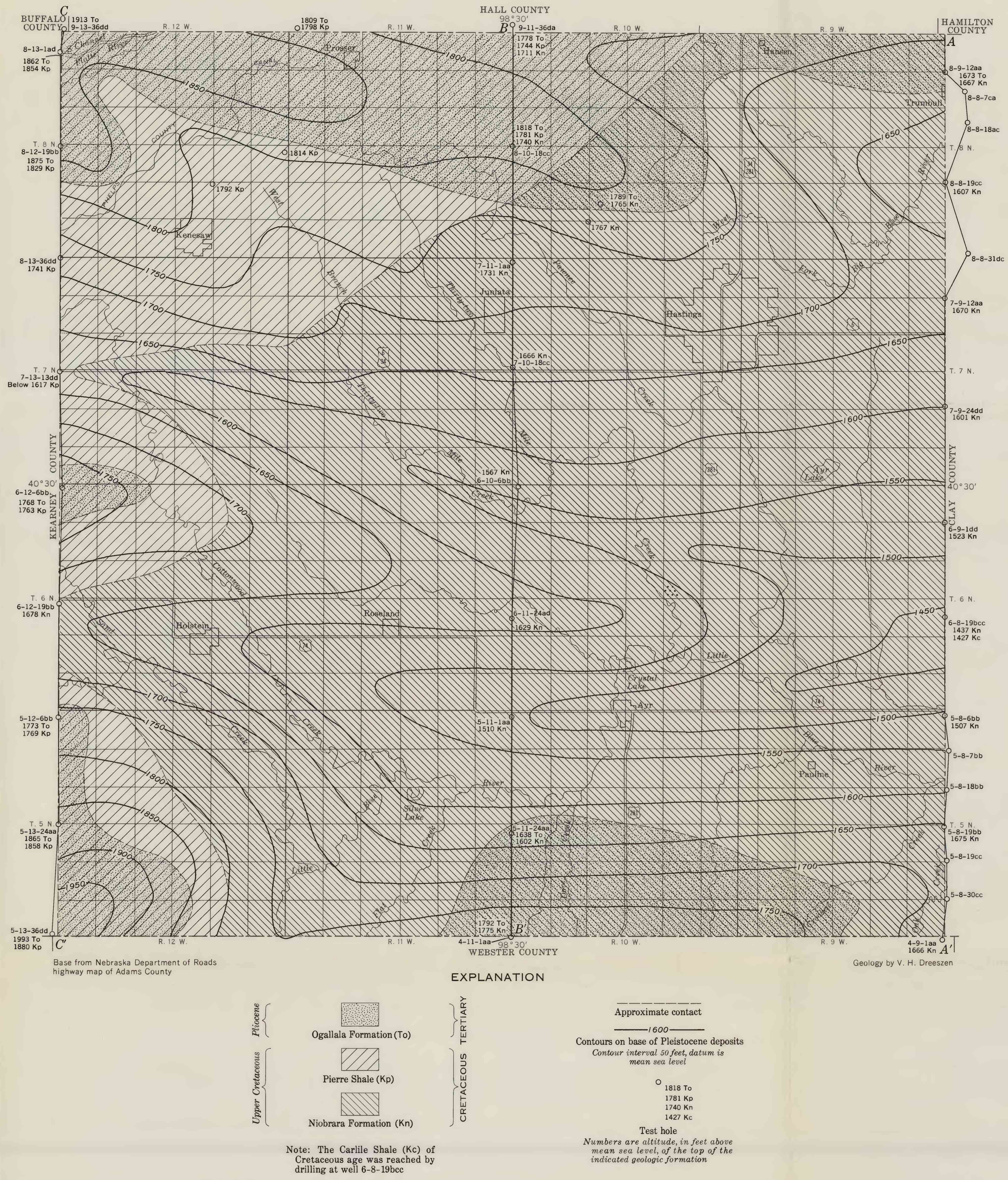
WELL HYDROGRAPHS



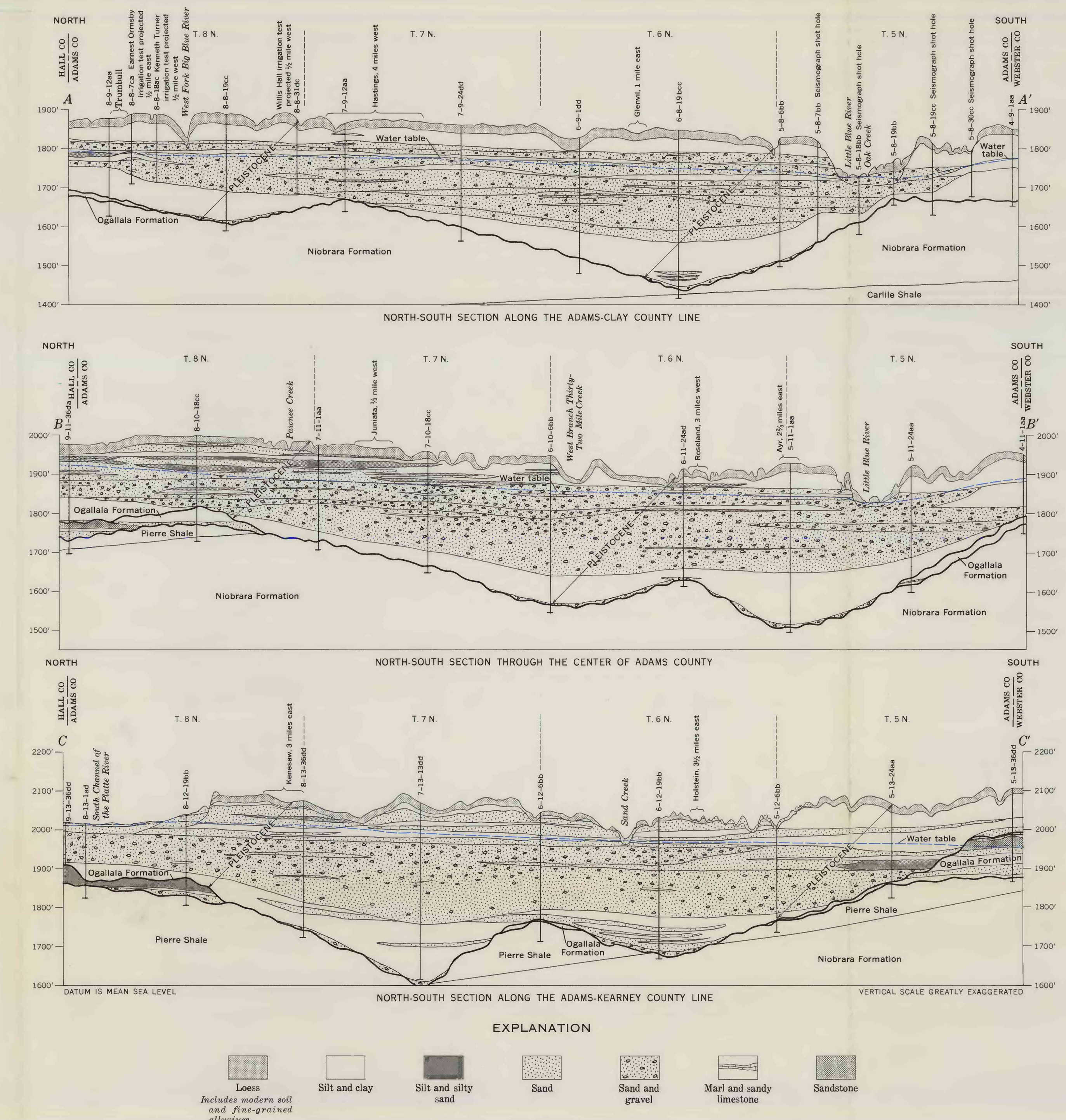
HYDROGRAPH OF WELL 7-10-23ab



MAP SHOWING NET WATER-LEVEL DECLINE, SPRING 1949 TO FALL 1963

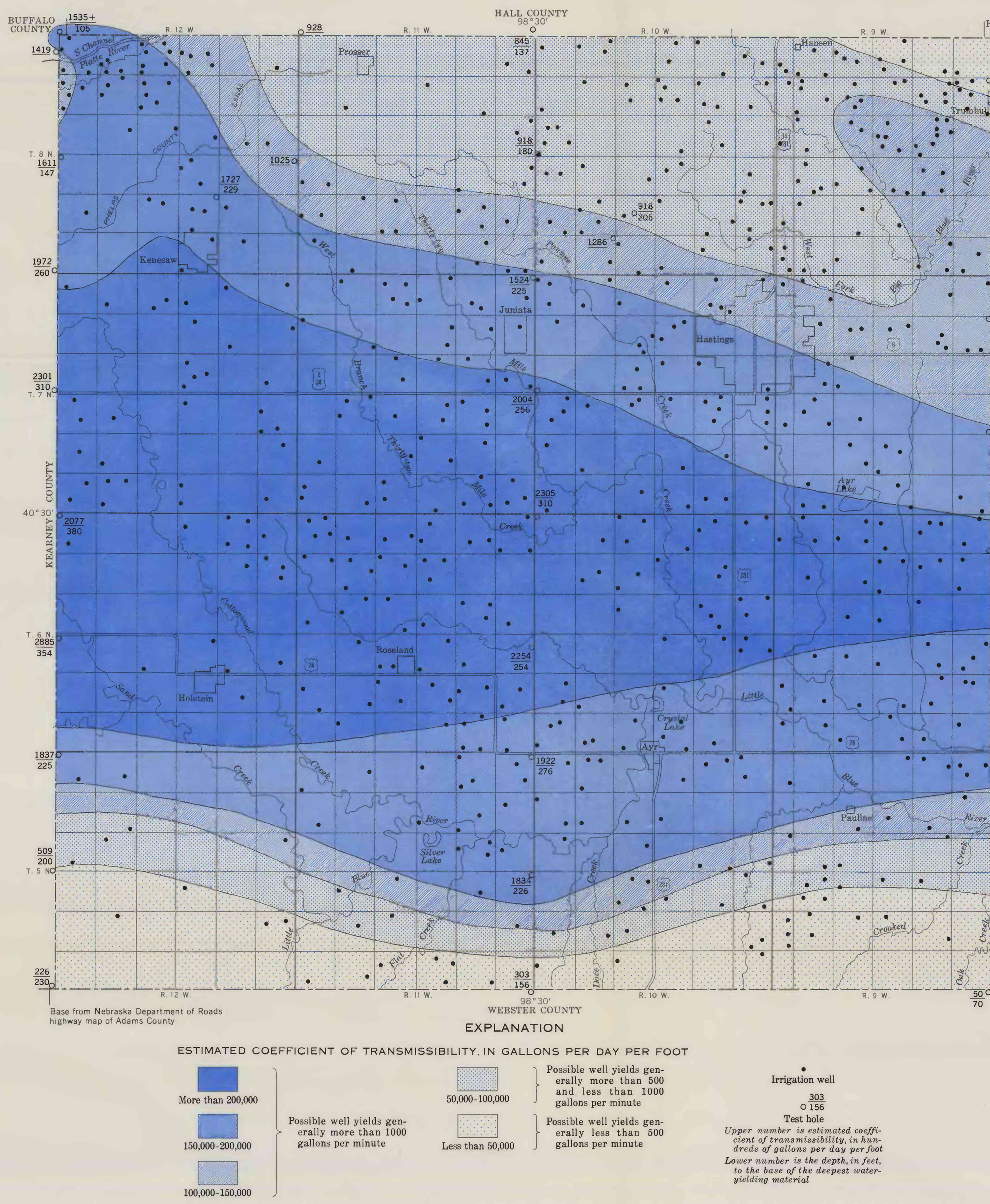


MAP SHOWING CONFIGURATION OF BASE OF PLEISTOCENE DEPOSITS AND DISTRIBUTION OF PRE-PLEISTOCENE ROCKS



GEOLOGIC SECTIONS

MAP SHOWING DEPTH TO WATER AND WATER-TABLE CONFIGURATION



MAP SHOWING LOCATIONS OF TEST HOLES AND IRRIGATION WELLS AND AVAILABILITY OF GROUND WATER

Introduction

This appraisal of the ground-water resources of Adams County relates the occurrence of ground water to geologic conditions, documents the current state of ground-water development, and indicates problems relating to development.

Adams County, an area of about 565 square miles, is situated in the south-central part of Nebraska. The terrain is nearly level and has been dissected by stream erosion. More than four-fifths of the county drains to the Little Blue River; the remainder drains to the West Fork of the Big Blue River and to the Platte River.

Much of Adams County is well suited to irrigation. The slope of the land is gentle and the soil is deep and well drained. As of 1964, nearly 65,000 acres were irrigated with water pumped from wells; the area irrigated with water diverted from streams was negligible. The Central Nebraska (Tri-County) Public Power and Irrigation District constructed the Phelps County Canal to deliver irrigation water from the North Platte River to part of the upland of Adams County, but this canal was never used because litigation resulted in a court order that forbade transporting water from one drainage basin to another, in this case from the Platte to the Blue River basin.

Climate

The climate of Adams County is subhumid. According to the 71-year record of the U.S. Weather Bureau at Hastings, the annual precipitation averages 25 inches and varies considerably from year to year. The driest years were 1890 (13.18 in.), 1934 (15.59 in.), 1936 (11.72 in.), 1943 (13.88 in.), and 1956 (16.76 in.). The wettest were 1902 (39.01 in.) and 1915 (40.60 in.). Summer precipitation generally is in the form of local thundershowers and, when favorably distributed, is ample for growing crops. Oftentimes, however, rains do not occur when needed and crop growth under natural conditions is impaired. Therefore, to prevent low yields or crop failures irrigation may be necessary even in years of above-normal precipitation.

Soils

Although most precipitation is carried away by surface runoff or is lost to evapotranspiration, some water is absorbed into the soil. The physical characteristics of the soil determine the amount of water that may be absorbed for potential recharge to the ground-water reservoir.

As shown by the soils map, the soils in about one-fourth of Adams County are sandy, ranging from dune sand to sandy loam. Thus a considerable part of the water absorbed by the soil can filter to the water table. The sand dunes along the Platte River valley and near Sand Creek, southwest of Holstein, are especially good natural recharge areas.

Other soils in the county are silt loams. Generally, the silty soils are less permeable than the sandy soils and many have subsoils that are heavy and compact. Only a very small part of the precipitation can filter through these soils to the zone of saturation. Where silty soils are on steep slopes, precipitation runs off rapidly, and where the uneroded upland surface is characterized by scattered closed basins, precipitation collects in temporary ponds from which most evaporates. Even though they transmit little recharge to the ground-water reservoir, many silty soils contain a high content of organic matter that gives them a friable texture and good capacity for storage of moisture. Soils are particularly suited to irrigation because they produce good yields with a minimum of supplemental water.

Geology

Adams County is underlain by unconsolidated deposits of Pleistocene (Quaternary) age and semiconsolidated deposits of Pliocene (Tertiary) age, having a combined thickness of about 100 to 500 feet. Underlying these deposits is a thick sequence of consolidated rocks of Cretaceous and other ages, considered here as bedrock.

The bedrock formations consist chiefly of marine deposits of sandstone, shale, chalk, and limestone and dip gently to the northwest. The bedrock surface is a buried erosional terrain developed on the Niobrara Formation and Pierre Shale of late Cretaceous age; it slopes to the east.

The Ogallala Formation of Tertiary age overlies the bedrock in about one-fifth of the county. This formation consists largely of lenticular deposits of sand, silt, and clay, some of which are poorly cemented. Originally these sediments probably extended throughout the area, but subsequent erosion by streams removed them from most of the central part of the county. The greatest known thickness of Ogallala in Adams County--about 113 feet--was penetrated in drilling test hole 5-13-36dd.

Deposits of unconsolidated clay, silt, sand, and gravel of Pleistocene age are found everywhere in the entire county. In some places, these deposits rest on erosional remnants of the Ogallala Formation; in other places, they rest directly on the Niobrara Formation or Pierre Shale. As shown on the geologic sections, the Pleistocene sediments deposited in bedrock channels may lie at greater depths than Ogallala sediments. The greatest thickness of Pleistocene sediments probably is in the vicinity of test hole 7-13-13dd, where bedrock was not reached at a depth of 450 feet.

In parts of the county Recent deposits of Quaternary age overlie the Pleistocene sediments. These deposits consist of alluvial clay, silt, sand, and gravel or of eolian silt and sand and are so thin and widely scattered that they are not shown on the geologic sections.

The thickness, lithic character, and water-supply characteristics of the Cretaceous, Tertiary, and Quaternary deposits are summarized in the accompanying table.

Ground water

Most of the ground water in Adams County is within the Pliocene and Pleistocene deposits. Some water is available in deeper formations, but generally this water is too highly mineralized for most uses.

The depth to water is greatest beneath the uplands and shallowest in the valleys. In most places on the upland, the depth ranges from about 110 to 125 feet, but in a well about 3 miles west of Juniata is as much as 150 feet. On the flood plains of the Platte and Little Blue Rivers the depth to water is commonly less than 15 feet.

Ground water moves in the direction of the water-table slope (see water-table configuration map). It moves into Adams County from adjoining areas to the north, west, and south, and as it passes beneath the county, it is augmented by recharge from precipitation and applied irrigation water and is depleted by withdrawals from wells. Within the southern part of the county, ground water moves toward the valley of the Little Blue River where it is discharged through evapotranspiration or by seepage into the river channel. Ground water passing beneath the northern part of the county leaves by underflow to Clay County on the east. All water pumped from wells within the county is water that under natural conditions eventually would be discharged by evapotranspiration, seepage into the Little Blue River, or by subsurface outflow to the east. As the total amount pumped each year now greatly exceeds the average annual recharge within the county, the excess is derived from storage.

The available long-term records of water-level fluctuations in Adams County are shown by the hydrographs for 12 wells. Three of the wells (6-10-23bb, 8-12-8ab, and 5-9-9dc) are in valleys, and the remaining nine are on the uplands. During the period 1951-63, the water levels in the valley wells showed no progressive trend whereas those in the upland wells declined nearly every year. The greatest rate of decline was about one-half foot per year in wells 8-9-14ac and 8-10-26da, both of which are in the northeastern part of the county. The nature of the decline is shown best by the hydrograph for well 7-10-23ab, which was equipped with a continuous recording gage for two periods--1948-52 and 1957-65. During the earlier period, water-level fluctuations were minor and the overall trend was upward. During the later period, each year was marked by a sharp water-level decline during the irrigation season and in no year did the water level recover after the irrigation season to the highest level of the preceding spring; the result is a continuation of the downward trend that began in 1952.

The greatest net lowering of the water table that has occurred since large-scale pumping for irrigation and for municipal and industrial use began has been a little more than 10 feet (see map showing net decline). This decline indicates that the rate of withdrawal exceeds the rate of recharge to the ground-water reservoir. However, the decline is small in view of the magnitude of ground-water development and indicates that the dewatered sediments have a large storage capacity. If the lowering of water levels continues, it eventually will result in increased cost to pump water. Where the decline is greatest, pumps may need to be reset at greater depths and wells may require deepening. Where the water table has not been lowered appreciably, additional use of ground water probably will not seriously reduce the amount in storage for many years.

The maximum potential rate at which water can be pumped from a well is limited by the capacity of the aquifer to transmit water. The coefficient of transmissibility is a measure of that capacity. In Adams County the sediments having the highest water-transmitting capacity underlie a broad eastward-narrowing band, as shown on the availability map, that extends across the central part of the county. Throughout this band, well yields of more than 1,000 gpm (gallons per minute) generally are possible; considerably greater yields--as much as 2,500 gpm--can be obtained in parts of the band. Elsewhere in the county the maximum yields are somewhat less than 1,000 gpm and in the extreme southeastern part are as small as 50 gpm.

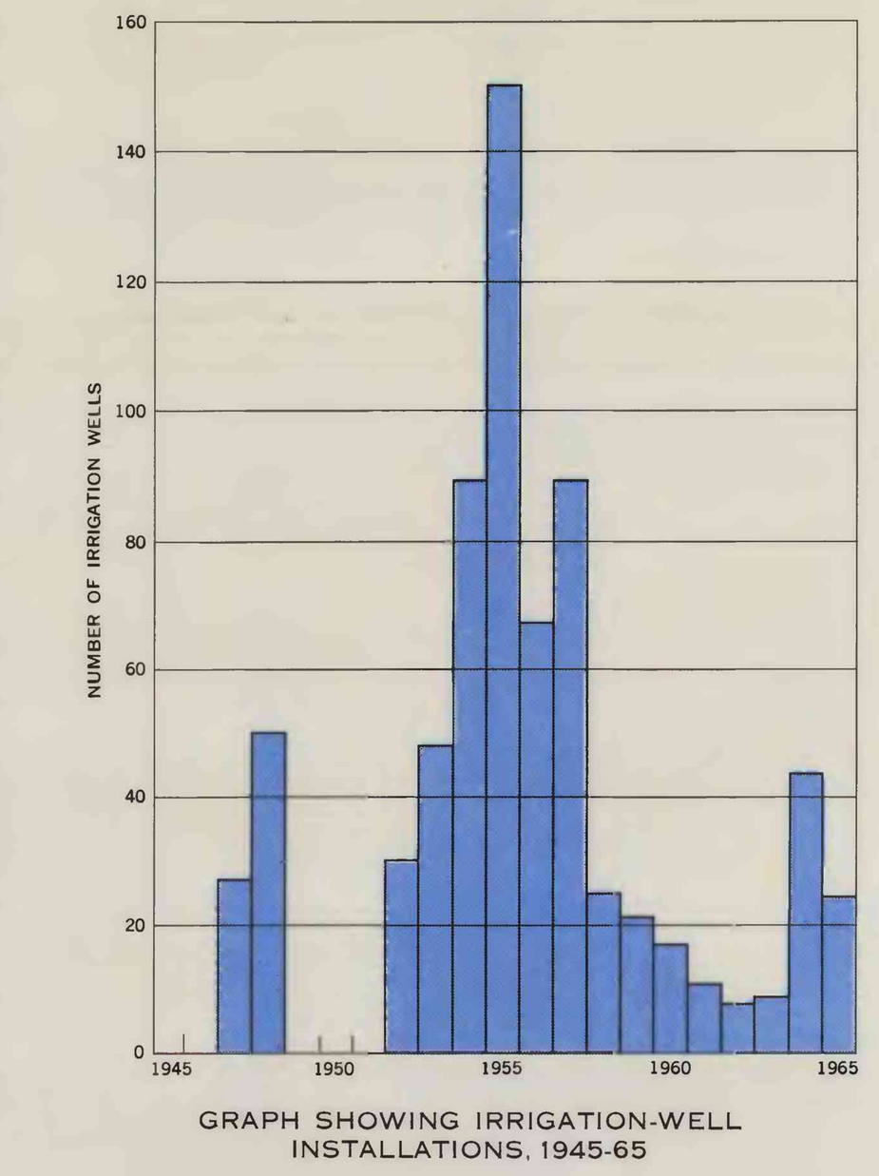
Ground water is the source of virtually all water supplies for irrigation and for industrial, municipal, domestic, and livestock uses. The greatest withdrawals are for irrigation and in the last few years probably have averaged about 50,000 acre-feet per year. Corn is grown on nearly 75 percent of the irrigated land; grain sorghums, alfalfa, soybeans, pasture, and miscellaneous crops make up the remainder. In 1963, withdrawals for municipal use in Hastings averaged 5.4 million gallons per day, or about 6,000 acre-feet for the year. All other uses are estimated to total about 2,000 acre-feet per year.

The amount of ground water pumped for irrigation varies greatly from season to season but has increased considerably over the years. Seasonal differences in climate are the most important factors contributing to the variability. The amount and distribution of precipitation prior to and during the growing season have a marked effect, but the occurrence of hot winds may prompt heavier-than-usual applications of irrigation water even in seasons of above-average precipitation. The increasing number of irrigation wells is, of course, the principal factor contributing to the upward trend in ground-water withdrawals. Concurrent with the increase in number of wells has been the greater use of commercial fertilizers that stimulate plant growth and thereby increase the water requirement. On the other hand, irrigation practices are becoming more efficient and less water is wasted now than when irrigation was new.

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

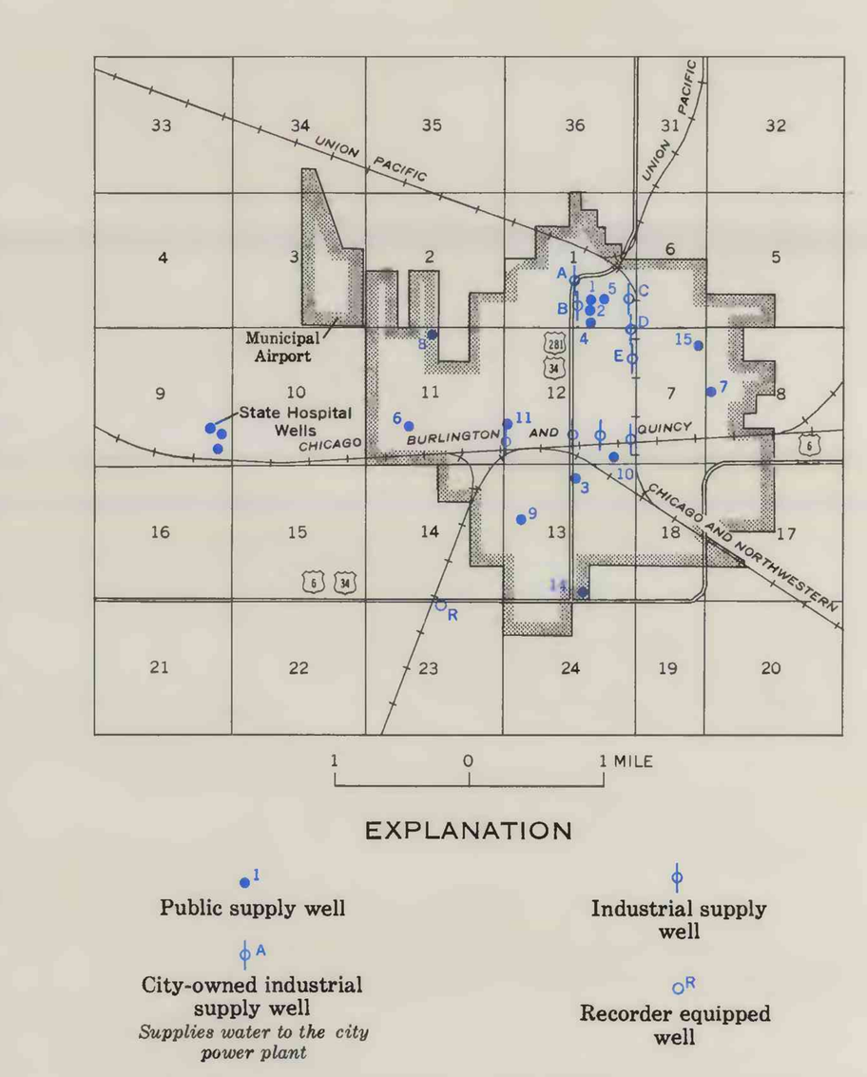
System	Series	Stratigraphic unit	Thickness (feet)	Character and distribution	Water Supply
Quaternary	Recent	Surficial alluvium, loess, and soil	0-5±	Flood-plain deposits of clay, silt, sand, and gravel; isolated windblown deposits of silt and clay.	Significant only in that it transmits recharge to the ground-water reservoir.
	Pleistocene	Unconsolidated deposits	80-470	Wind-deposited clay, silt, and sand; stream-deposited sand and gravel containing layers of clay and silt of wind and stream origin. Underlie the entire county.	Principal source of water to wells in the county; yield abundant supplies about in proportion to the saturated thickness of the sand and gravel deposits. Deposits above the water table are significant in transmitting recharge to the ground-water reservoir.
Tertiary	Pliocene	Ogallala Formation	0-120	Continental deposits of sand, silty sand, sandy clay, and marl; in part consolidated; olive to brownish-gray and white. Underlies the northern part of the county and occurs as buried knobs in the extreme western and southern parts of the county.	Known to yield water to wells only in the extreme southwestern part of Adams County.
Cretaceous	Upper Cretaceous	Pierre Shale	0-390	Gray to black marine shale and chalky shale; uppermost layers consist of weathered shale and gray silty clay. Underlies the northwest third and southwestern corner of the county.	Not a source of water supply in Adams County.
		Niobrara Formation	10-380	Yellow and light- to dark-gray marine chalky shale and chalk. Underlies the entire county.	Do.
		Carlile Shale	280-290	Medium- to dark-gray marine shale, calcareous in the lower part. Underlies the entire county.	Do.
		Greenhorn Limestone	25-35	Marine deposits of gray fossiliferous limestone interbedded with calcareous shale. Underlies the entire county.	Do.
		Graneros Shale	40-75	Dark-gray marine shale, calcareous in the upper part. Underlies the entire county.	Do.
	Lower Cretaceous	Dakota Sandstone	470-600	Marine and continental deposits of clay shale, sandy shale, and sandstone. Underlies the entire county.	Contains mineralized water. No well in Adams County is deep enough to reach this formation.

The first irrigation wells in Adams County were drilled in 1931 in the Platte River valley, where the water table is within a few feet of the land surface. A few more wells were drilled in 1942, but the shortage of materials during World War II delayed further irrigation developments until 1947-48, when nearly 80 wells were drilled. As the years 1949-51 were wetter than average, no additional wells were drilled during that period. However, drought conditions during 1952-56 prompted a great surge in well-drilling activity; about 475 irrigation wells were added during those years (see graph of annual well installations). Since the drought ended, the annual rate of installations averaged about 22 per year, bringing the total to 756 by the end of 1965.



GRAPH SHOWING IRRIGATION-WELL INSTALLATIONS, 1945-65

The combined withdrawals for municipal and industrial use in Hastings (see map for locations of wells in Hastings and vicinity) and for irrigation in the outskirts of Hastings so greatly exceed the rate of recharge that the water table has been lowered there more than in any other part of the county. Although the map showing the net water-table change indicates a maximum decline of a little more than 10 feet, it is likely that the change near some of the more heavily pumped wells may be even greater. As opportunities for increasing the rate of recharge in the Hastings vicinity are small, the lowering probably will continue until the gradient of the water table steepens enough for the rate of ground-water movement into this area to equal the average rate of withdrawals. The amount of ground water beneath the Hastings area is so large that there is no immediate threat to the supply. However, if the present rate of withdrawal is maintained or increased, it may prove to be necessary either to deepen the existing wells or drill additional wells.



MAP SHOWING LOCATIONS OF WELLS IN HASTINGS

Chemical quality

The ground water in the unconsolidated deposits beneath Adams County is excellent for most purposes. Well water sampled ranged from less than 100 to a little more than 300 ppm (parts per million) dissolved solids. It is more dilute in sandy areas where the rate of recharge from precipitation is greater than in areas having heavy soils.

The water is of the calcium bicarbonate type. It meets all standards for chemical characteristics recommended by the U.S. Public Health Service and, except that most of it is hard, is suitable for all domestic purposes. Most of the hardness is caused by calcium and magnesium. Hardness is the characteristic of water recognized by the increased quantity of soap required to produce a lather or by the deposits of insoluble salts formed when water is heated or evaporated. Calcium and magnesium in irrigation water are favorable to the soil because they tend to flocculate the fine soil particles and thus improve tilth and permeability.

Selected references

Condra, G. E., and Reed, E. C., 1943, The geological section of Nebraska: Nebr. Geol. Survey Bull. 14, 82 p.
Condra, G. E., Reed, E. C., and Gordon, E. D., 1950, Correlation of the Pleistocene deposits of Nebraska (revised): Nebr. Geol. Survey Bull. 15A, 74 p.
Hayes, F. A., and Hyde, D. F., 1929, Soil survey of Adams County, Nebr.: U.S. Dept. Agriculture, Bur. Chem. and Soils, p. 1375-1422, map.
Johnson, C. R., 1960, Geology and ground-water in the Platte-Republican Rivers watershed and the Little Blue River basin above Angus, Nebraska, with a section on the chemical quality of the water by Robert Brennan: U.S. Geol. Survey Water-Supply Paper 1489, 142 p.
Johnson, C. R., and Keech, C. F., 1959, Geology and ground-water resources of the Big Blue River basin above Crete, Nebr., with a section on the chemical quality of the water by Robert Brennan: U.S. Geol. Survey Water-Supply Paper 1474, 94 p.
Lugn, A. L., and Wenzel, L. K., 1938, Geology and ground-water resources of south-central Nebraska, with special reference to the Platte River valley between Chapman and Gothenburg: U.S. Geol. Survey Water-Supply Paper 779, 242 p.
Reed, E. C., 1948, Maps and profile sections of the ground-water resources of Adams County, Nebr.: Nebraska Univ., Conserv. and Survey Div., open-file report, 6 figs.

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AVAILABILITY OF GROUND WATER IN ADAMS COUNTY, NEBRASKA

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