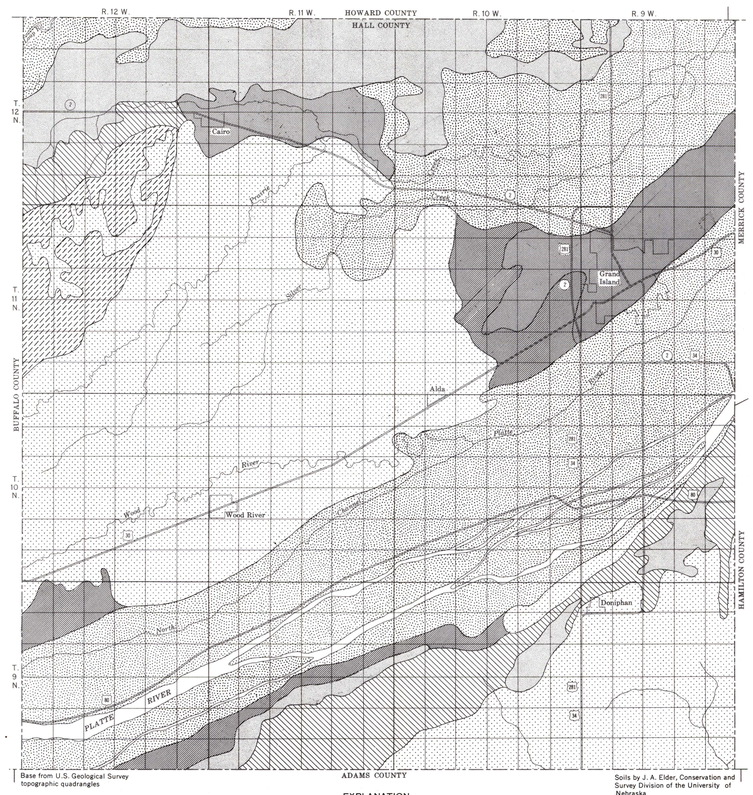
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

HYDROLOGIC INVESTIGATIONS
ATLAS HA-131



Base from U.S. Geological Survey topographic quadrangles

Soils by J. A. Elder, Conservation and Survey Division of the University of Nebraska

EXPLANATION

Silty soils on gentle slopes
Soils with moderately low permeability which retain a high percentage of the infiltrating water from precipitation and irrigation. A small amount of water moves through the soil and substratum to the water table

Silty soils on steep slopes
Soils with moderate permeability which retain a high percentage of the infiltration but lose a large amount of the total precipitation in runoff. A very small amount of water moves through the soil and substratum to the water table

Sandy soils, gentle slopes
Soils with moderately high permeability which permit a large part of the precipitation to infiltrate but retain only part of the water, allowing a moderate amount to move to the water table. Infiltrating irrigation water is only partially retained and adds to the quantity of water moving to the water table

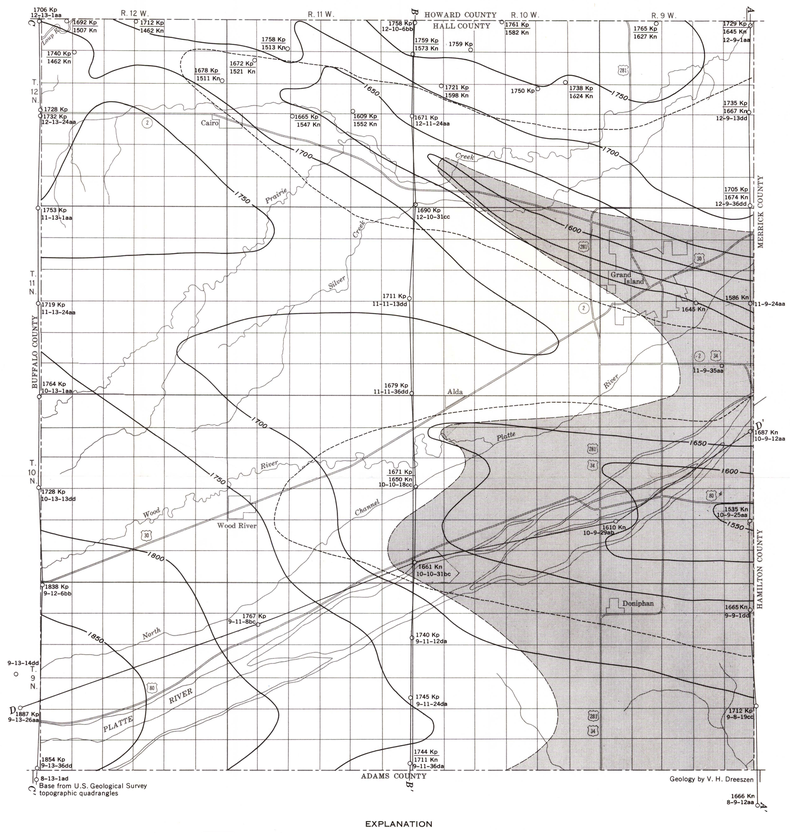
Silty soils on rolling slopes
Soils with moderate permeability which retain a high percentage of the infiltrating precipitation but lose much of the total precipitation in run off. A very small amount of water moves through the soil and substratum to the water table

Silty and sandy soils, shallow water table
Moderately permeable soils with highly permeable substratum. They retain a moderate amount of the precipitation and permit a considerable part to move to the water table

Sandy soils, rolling slopes
Soils with relatively high permeability which permit nearly all the precipitation to infiltrate but do not retain all the water absorbed, allowing a moderate amount to move to the water table

Very sandy soils
Very permeable soils which permit most of the precipitation to infiltrate but retain a small percentage of the water, allowing the excess to move to the water table

FIGURE 1.—GENERALIZED SOIL MAP OF HALL COUNTY, NEBRASKA



Base from U.S. Geological Survey topographic quadrangles

Geology by V. H. Dreeszen

EXPLANATION

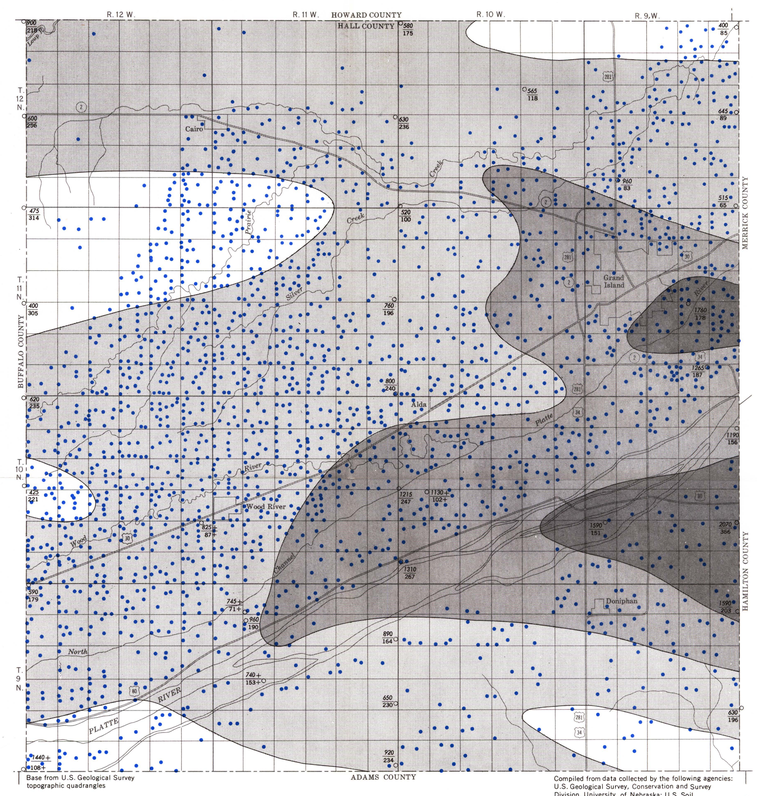
Upper Cretaceous / CRETACEOUS
- Pierre Shale
- Niobrara Formation
- Approximate contact

—1800— Contour on bedrock
Drawn on top of the Cretaceous bedrock. Contour interval 50 feet. Datum is mean sea level

Eastern boundary of the Ogallala Formation of Pliocene age

1740 Kp / 1762 Kn — Test hole
Upper number is altitude of Pierre Shale, in feet; lower number is altitude of Niobrara Formation; 8-9-12aa indicates number of the well

FIGURE 3.—MAP OF HALL COUNTY, NEBRASKA, SHOWING THE EASTERN BOUNDARY OF THE OGALLALA FORMATION, AREAL DISTRIBUTION AND CONFIGURATION OF ROCKS OF CRETACEOUS AGE, AND LOCATION OF TEST HOLES AND GEOLOGIC SECTIONS A–A', B–B', C–C', AND D–D'



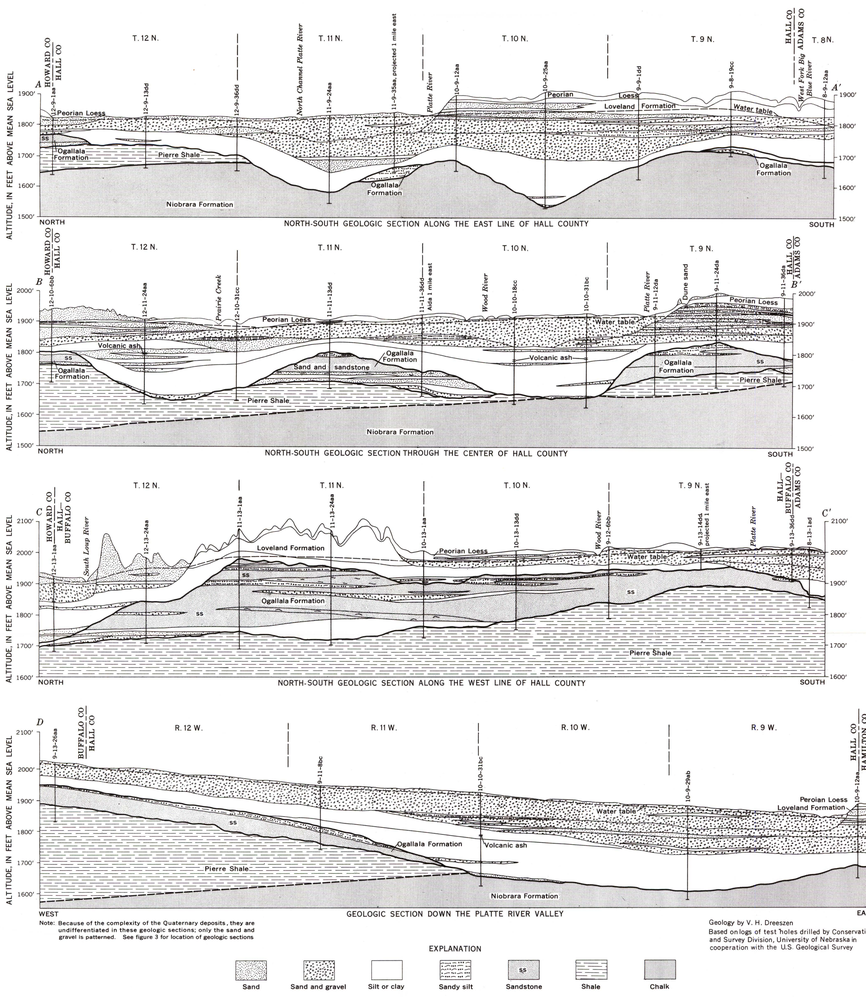
Base from U.S. Geological Survey topographic quadrangles

Compiled from data collected by the following agencies: U.S. Geological Survey, Conservation and Survey Division, University of Nebraska; U.S. Soil Conservation Service; Agriculture Extension Service, University of Nebraska, 1958

EXPLANATION

- Area in which the potential yield of wells is 1500 or more gallons per minute
- Area in which the potential yield of wells is 1000 to 1500 gallons per minute
- Area in which the potential yield of wells is 500 to 1000 gallons per minute
- Area in which the potential yield of wells is less than 500 gallons per minute
- Irrigation well
- 630 / 230 — Test hole
  Upper number is estimated coefficient of transmissibility, in hundreds of gallons per day per foot. It is approximately the potential yield of the aquifer in wells, in gallons per minute. Lower number is depth, in feet, to the base of deepest water-yielding material

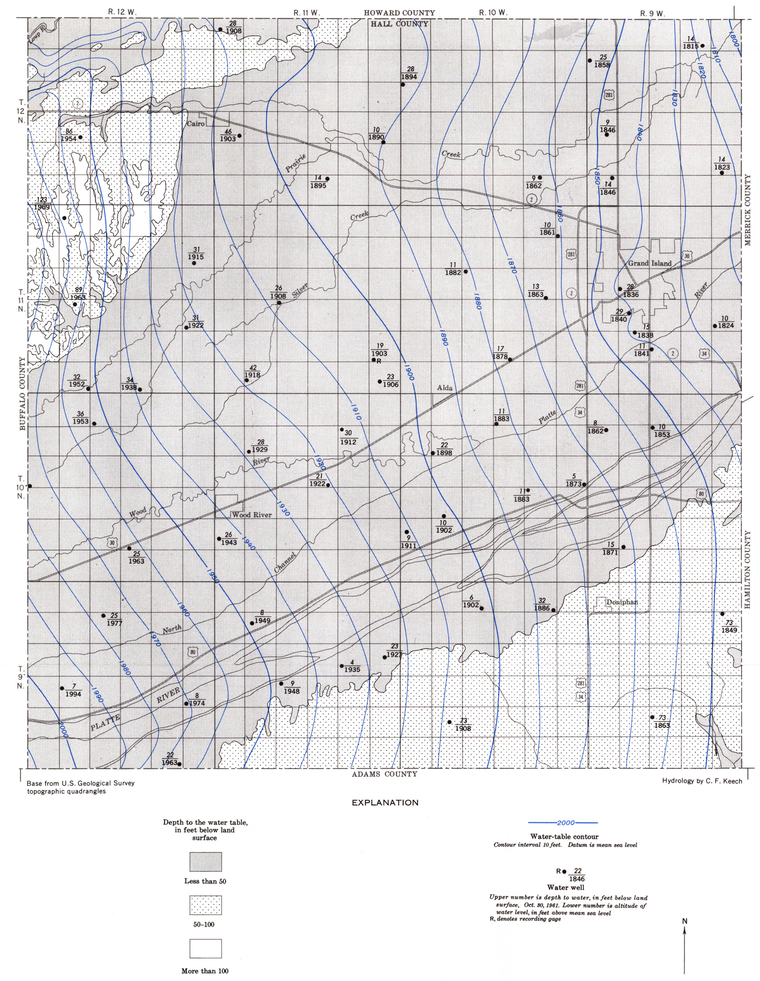
FIGURE 5.—MAP OF HALL COUNTY, NEBRASKA, SHOWING AVAILABILITY OF GROUND WATER IN ROCKS OF TERTIARY AND PLEISTOCENE AGE AND THE LOCATION OF IRRIGATION WELLS



Note: Because of the complexity of the Quaternary deposits, they are undifferentiated in these geologic sections; only the sand and gravel is patterned. See figure 3 for location of geologic sections

Geology by V. H. Dreeszen
Based on logs of test holes drilled by Conservation and Survey Division, University of Nebraska in cooperation with the U.S. Geological Survey

FIGURE 2.—GEOLOGIC SECTIONS ACROSS HALL COUNTY, NEBRASKA



Base from U.S. Geological Survey topographic quadrangles

Hydrology by C. F. Keech

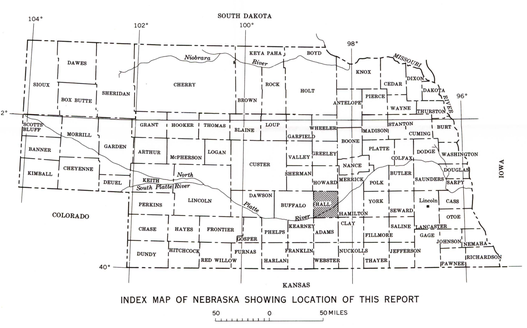
EXPLANATION

Depth to the water table, in feet below land surface
- Less than 50
- 50–100
- More than 100

—2000— Water-table contour
Contour interval 10 feet. Datum is mean sea level

R● 27 / 1846 — Water well
Upper number is depth to water, in feet below land surface, Oct. 30, 1961. Lower number is altitude of water level, in feet above mean sea level
R, denotes recording gage

FIGURE 4.—WATER-TABLE MAP OF HALL COUNTY, NEBRASKA SHOWING DEPTH TO WATER



System	Series	Stratigraphic unit	Thickness (feet)	Character and distribution	Water supply
Quaternary	Recent	Surficial alluvium, loess, and soil	0-5±	Widespread soils; 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, undifferentiated	30-430	Windblown deposits of clay and silt; water-laid and windblown stratified deposits of silt, clay, sand, and gravel; 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. Those deposits above the water table are significant principally as a transmitting medium for recharge to the ground-water reservoir.
Tertiary	Pliocene	Ogallala Formation	0-240	Brownish-gray and gray silt, sandy silt, and clayey silt containing lenses of sand, and locally a basal gravel; partly cemented but principally unconsolidated.	Yields water to wells in the western part of Hall County.
Cretaceous	Upper Cretaceous	Pierre Shale	0-350	Gray to black marine shale and chalky shale overlain by weathered shale and gray silty clay; underlies all but the southeastern part of the county.	Not a source of water supply in Hall County.
		Niobrara Formation	250-380	Yellow and light- to dark-gray marine chalky shale and chalk; underlies much of the county.	Do.
		Carlile Shale	130-285	Medium- to dark-gray marine shale, calcareous in the lower part; underlies the entire county.	Do.
		Greenhorn Limestone	25-30	Gray fossiliferous limestone interbedded with calcareous shale; underlies the entire county.	Do.
		Graneros Shale	40-65	Dark-gray shale, calcareous in the upper part; underlies the entire county.	Do.
	Lower Cretaceous	Dakota Sandstone	300-400	Interbedded clay shale, sandy shale, and sandstone; underlies the entire county.	Contains mineralized water. No well in Hall county is sufficiently deep to reach this formation.

TABLE 1.—GENERALIZED SECTION OF THE GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES, HALL COUNTY, NEBRASKA

AVAILABILITY OF GROUND WATER IN HALL COUNTY, NEBRASKA

By
C. F. Keech and V. H. Dreeszen

SCALE 1:125 000

2 0 2 4 6 8 10 MILES
2 0 2 4 6 8 10 KILOMETERS
DATUM IS MEAN SEA LEVEL

1964

AVAILABILITY OF GROUND WATER IN HALL COUNTY, NEBRASKA

This report is based on ground-water investigations made in cooperation with the Conservation and Survey Division of the University of Nebraska. The cooperation, which began in 1930, has resulted in a wealth of information about ground-water conditions in the State which has been of immeasurable value in the development of the water resources. Much of the information obtained has been made available to the public through publication; basic data not yet in published form may be examined at the offices of the Conservation and Survey Division, University of Nebraska, Room 113, Nebraska Hall, Lincoln, and the U.S. Geological Survey, Room 135, Nebraska Hall.

During the period of the cooperative program, the development of ground-water supplies in Nebraska, particularly for irrigation use, has increased tremendously--from the irrigation of only a few acres in 1930 to more than 2,600,000 acres in 1961. In 1961, more than one-third of the land in Hall County was irrigated with water pumped from more than 2,000 wells. In addition to the withdrawal of ground water for irrigation, all public, industrial, domestic, and rural supplies in the county are obtained from ground water. The largest user is the city of Grand Island, an urban population center of about 30,000.

Heavy withdrawal of ground water at Grand Island has made a local depression in the water table. This depression, which has existed since the early 1930's, was first reported by Lugn and Wenzel (1938) and was subsequently investigated in greater detail by Wenzel (1940). To alleviate the locally overdeveloped condition, Grand Island is now (1963) developing a well field about 6 miles south of town on an island in the Platte River, where pumping will induce recharge from the river and thus insure a stable supply.

Climate

The climate in Hall County is subhumid; the average annual precipitation is about 24 inches, and the mean annual temperature 51°F. About 80 percent of the precipitation occurs in the spring and summer; of that, more than half falls as thunderstorms. The spring and early summer rains usually are well distributed, although droughts are not uncommon, but the late summer and early autumn storms are less uniform. The average annual snowfall is about 25 inches, and the greatest amount usually falls during February and March.

The prevailing wind is from the south in summer and from the northwest in winter; however, wind from other directions is common. The wind usually is moderate to strong during the summer and often is accompanied by high temperature and low humidity, both of which cause rapid loss of soil moisture and a high rate of evapotranspiration. The thunderstorms are accompanied frequently by strong wind and occasionally by hail that damages crops and property.

Soils

The soils of Hall County, which range from silty to very sandy, directly influence the amount of recharge to the ground-water reservoir (see fig. 1). In about two-thirds of the county the soils are relatively permeable, allowing a considerable amount of the precipitation to infiltrate to the water table. Some of these soils are very sandy and permit most of the precipitation to infiltrate.

About one-third of the land has silty soils, which permit only a small part of the precipitation to infiltrate the surface; and where these soils are on rolling slopes, most of the precipitation runs off to the drainageways.

The agricultural practices also influence recharge. About 70 percent of the land is tilled and nearly 60 percent of this is irrigated, principally with ground water. By careful management, irrigators attempt to add only enough water to maintain optimum soil moisture; but because of uncontrollable factors, this is not always possible. It is estimated that between 5 and 15 percent of the applied water seeps to the water table.

Geology

Hall County is underlain by moderately to highly permeable unconsolidated deposits of Quaternary age. Ranging in thickness from about 30 to 430 feet (fig. 2 and table 1), these deposits rest either on the moderately permeable semiconsolidated Ogallala Formation of Tertiary age or, where the Ogallala is absent, on the relatively impermeable bedrock of Late Cretaceous age. The unconsolidated Quaternary deposits consist of sand and gravel deposited by streams from the west and silt and clay laid down partly by wind and partly by water.

The Ogallala Formation underlies the Quaternary deposits in about three-fourths of the county. Originally it probably extended throughout the county and some distance to the east, but during the later development of stream valleys across the county it was removed from progressively wider areas, extending eastward from a point near the town of Wood River and southeastward from a point about 2 miles northwest of Cairo (fig. 3). The greatest known thicknesses of the Ogallala--about 240 feet--were penetrated in the drilling of test holes 11-13-1aa and 11-13-24aa, both of which are on the west boundary of the county. The formation is composed largely of lenticular and shoestring deposits of sand, silt, clay, and poorly cemented sandstone, siltstone, and claystone.

The bedrock surface on which the semiconsolidated Tertiary and unconsolidated Quaternary deposits rest is one of moderate relief (fig. 3). The part underlying the Ogallala Formation was shaped by erosion before the Ogallala was deposited, and the part mantled by only Quaternary deposits was shaped first by pre-Ogallala erosion and reshaped later by post-Ogallala erosion.

The bedrock formations dip gently northwestward and all are of marine origin. The youngest present in the county is the Pierre Shale of Late Cretaceous age. It underlies all the western half of the county and extends as broad salients into the eastern half (fig. 3). Where the Pierre Shale is absent, the next older Niobrara Formation forms the bedrock surface. The Carlile Shale, Greenhorn Limestone, and Graneros Shale--successively older formations of Late Cretaceous age--underlie the Niobrara. None of the Late Cretaceous rocks are permeable enough to be a source of water supply, but beds in the Dakota Sandstone of Early Cretaceous age, which underlies the Graneros, are permeable enough to yield water to wells. Because the water in the Dakota probably is too mineralized for most uses and because ample water supplies can be obtained at shallow depth from the unconsolidated and semiconsolidated rocks, no wells for water supplies have been drilled to this deep-lying aquifer. As rocks older than the Dakota are not likely to contain potable water, they are not described here.

Ground Water

Throughout Hall County the water table, or top of the zone of saturation, is within the Quaternary deposits (fig. 2). As shown in figure 4, the depth to the water table is greatest beneath the uplands and the divides between streams and is shallowest beneath the lowlands bordering the streams. The greatest measured depths to water--a little more than 120 feet--were in wells on the uplands southwest of Cairo, and the least depths--10 feet or less--were in wells on the flood plains of the Platte and Loup Rivers.

The configuration of the water table is somewhat similar to that of the land surface but is much smoother and has less relief. Under natural conditions ground water moves in a direction perpendicular to the water-table contour lines shown in figure 4. It moves into Hall County from the west. Except in the extreme northwestern part of the county, where ground water moves northward toward the Loup River, the general direction of movement within the county is eastward or northeastward. Although the upstream flexures of the water-table contour lines as they cross Prairie Creek indicate that some ground water discharges into that stream, most of the ground water in the county moves parallel to the course of the Platte River. The flexures of the contour lines of the south side of the Platte River indicate that some ground water moves away from the river and passes beneath the upland area in southeastern Hall County. Almost all the ground water not intercepted by pumping from wells or discharged naturally by evapotranspiration or by seepage into streams within the county moves eastward or northeastward into Hamilton and Merrick Counties. A small fraction of the total ground-water outflow from the county moves southeastward into northern Adams County, and an even smaller fraction moves northeastward into the extreme southeast corner of Howard County.

Most wells tap only the Quaternary deposits but some in the central and western parts of the county tap the underlying Ogallala Formation also. As shown in figure 5, the potential yield of properly constructed and carefully developed wells ranges from about 400 gpm (gallons per minute) to as much as 2,000 gpm. The thickness of the saturated permeable material at a given location in the county can be determined by subtracting the depth to water (fig. 4) from the depth to the base of the deepest water-bearing material (fig. 5) at that location. The slope of the land and the type of soil (fig. 1), the depth to water (fig. 4), and the water-yielding capacity (transmissibility) of the saturated permeable materials (fig. 5) are the main factors which, in combination, govern the distribution and density of irrigation wells within the county.

By the end of 1962, 2,112 irrigation wells had been registered with the Nebraska Department of Water Resources. From the registration records, the average yield of the irrigation wells is computed to be 907 gpm, the average depth of the wells to be 80 feet, and the average area irrigated from a single well to be 72 acres. The amount of water pumped for irrigation varies considerably from year to year and is governed by the variations in amount and distribution of rainfall. Although only a few irrigation wells were drilled in the 5-year period that ended in 1962, the total irrigated area increased progressively. In 1961 an estimated 150,000 acre-feet of ground water was applied to the 126,000 acres of irrigated cropland in Hall County.

In 1961 pumpage for the municipal supply of Grand Island was about 12,000 acre-feet. The per capita use varies considerably with the amount of precipitation but it averages about 100 gpd (gallons per day) in February and 200 gpd in August.

The ground water in Hall County is of fairly uniform chemical quality. Well water sampled shows a range from about 300 to 550 ppm (parts per million) dissolved solids and averages about 400 ppm. The water is of the calcium bicarbonate type. It meets all standards of chemical characteristics recommended by the Public Health Service and, except that it is hard, is suitable for all domestic purposes.

According to the Health Department of the city of Grand Island, some of the ground water from local wells was found to be polluted with detergents and coliform bacteria. The soils generally are quite porous and the water table is relatively shallow; thus pollutants can readily reach the ground-water reservoir if safe methods of waste disposal are not practiced.

References

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.

Wenzel, L. K., 1940, Local overdevelopment of ground-water supplies, with special reference to conditions at Grand Island, Nebr.: U.S. Geol. Survey Water-Supply Paper 836-E, p. 233-281.

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For sale by U.S. Geological Survey, price 50 cents