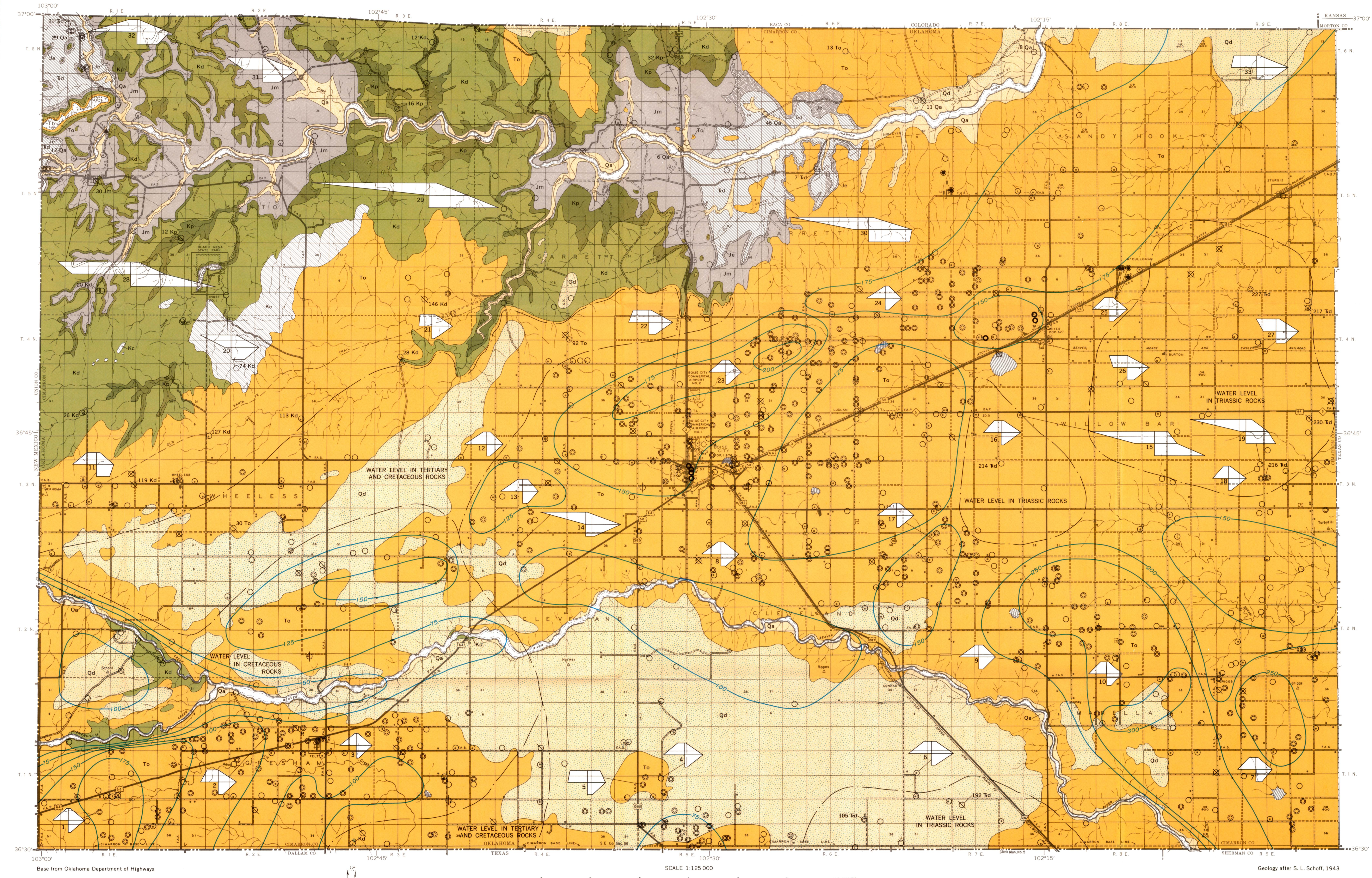


Base from Oklahoma Department of Highways

Geology after S. L. Schoff, 1943

SCALE 1:125 000

DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1973

GEOHYDROLOGIC MAP

EXPLANATION

QUATERNARY — *Pleistocene to Holocene*

Qd — Dune sand

Fine- to medium-grained sand 0 to 40 feet thick. Deposits are above water table and not saturated; they are moderately to highly permeable allowing precipitation to move downward to the ground-water reservoir

Qa — Alluvium

Clay, silt, sand, and gravel 0 to 100± feet thick. These deposits are moderately permeable and generally yield enough water for stock. Where the saturated thickness is great enough, yields are adequate for irrigation. The water is probably low in dissolved solids and suitable for most purposes in areas where alluvium directly overlies the Ogallala Formation. In some parts of the area where alluvium directly overlies Jurassic and Triassic formations, or where surface water entering the alluvium flows over these formations, the water is high in dissolved solids and unsuitable for irrigation or domestic use

TERTIARY — *Pliocene*

Tb — Basalt

Dark, dense to vesicular volcanic rock 50 to 85± feet thick forming cap rock of Black Mesa. Yields no water to wells in Cimarron County

To — Ogallala Formation

Generally unconsolidated clay, silt, sand, gravel, and caliche 0 to 400 feet thick. Moderately permeable and will yield as much as 1,000 gpm where sufficient saturated materials are penetrated. The water is generally very hard, calcium bicarbonate type, and low in dissolved solids

CRETACEOUS

Kc — Colorado Group

Total thickness 0 to 200± feet

Greenhorn Limestone: Gray fossiliferous limestone and calcareous shale. Not known to yield water but might provide small supplies where sufficient saturated thickness is present

Graneros Shale: Dark-gray shale. Not known to yield water

Kd — Dakota Sandstone

Buff to light-brown, fine- to medium-grained, thin bedded to massive sandstone with interbedded shale. Moderately to highly permeable and will yield as much as 200 gpm. Water is low in dissolved solids but locally the sodium content may make the water unsuitable for irrigation

Kp — Purgatoire Formation

Kiowa Shale Member: Gray to black fossiliferous shale with sandstone in the upper part. Thickness ranges from 0 to 50± feet. Not known to yield water to wells

Cheyenne Sandstone Member: Massive, white to buff, fine- to medium-grained sandstone, containing some conglomerate in the lower part, from 0 to 120± feet thick. Locally yields quantities of water adequate for irrigation where saturated thickness is sufficient. In some places excessive sodium may make water unsuitable for irrigation

JURASSIC

Jm — Morrison Formation

Varicolored fine-grained sandstone, limestone, dolomite, shale, and conglomerate 0 to 470± feet thick. The formation has low permeability but locally yields water for stock and domestic use

Je — Exeter (Entrada) Sandstone

Massive, white to buff, fine- to medium-grained sandstone 0 to 50± feet thick. The sandstone has low permeability but yields small quantities of water for domestic and stock use. In some places, the water is unsuitable for irrigation or other uses because of excessive sodium and sulfate

TRIASSIC

Ɍd — Dockum Group

Total thickness 0 to 600± feet

Upper shale unit: Varicolored siltstone or claystone, conglomerate, fine-grained sandstone, and limestone. Original permeability low but fractures and solution openings provide enough water for domestic and stock use locally. Chemical quality of water is variable and in some areas high dissolved-solids content limits the use of the water except for stock

Lower sandstone unit: Varicolored, fine- to coarse-grained sandstone with some clay and interbedded shale. Availability of water from this unit unknown. Data from oil and gas test holes suggest the water is low in dissolved solids

Permian rocks, consisting of more than 1,000 feet of interbedded red and yellow fine-grained sandstone, shale, gypsum, limestone, and dolomite, underlie all of Cimarron County at varied depths. Water is probably unsuitable for any use because of excessive dissolved-solids content

Contact

Approximate line of equal depth to water in January 1967

Interval 25 and 50 feet. Datum is land surface

Boundary outlining areas in which the depth to water is measured in wells penetrating Triassic or Cretaceous rocks. In areas outside boundaries water levels are in Tertiary or Quaternary rocks

Domestic or stock well

Irrigation well

Municipal or public-supply well

Industrial well

Dry or destroyed well

Unused or abandoned well

Monthly observation well

Observation well equipped with continuous recorder

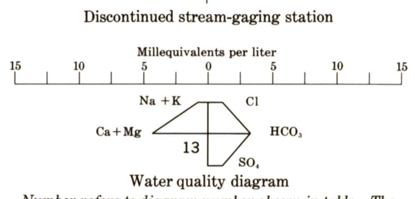
20 Kd

Well data

Number is depth to water, in feet below land surface. Letter symbol indicates geologic formation that yields water to the well

Active stream-gaging station

Discontinued stream-gaging station



Water quality diagram

Number refers to diagram number shown in table. The area of the diagram is an indication of the dissolved-solids content—a larger area reflects a greater dissolved-solids content. Differences in shape of the diagram reflect differences in the chemical quality of ground water

INTRODUCTION

Cimarron County, in the Oklahoma Panhandle, depends almost entirely on ground water for its water supply. Where present, the Ogallala Formation is the principal aquifer. The western half of the county is also underlain by the Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation, both of which may yield enough water for irrigation. In some places, these sandstones are the only sources of ground water. Alluvial deposits and Triassic rocks yield water, but their potential for supply of irrigation water is not known.

As a result of accelerated development of ground water for irrigation that began in 1955, water levels in the Ogallala have declined in a few areas of the county. Continued rapid increase in ground-water development from the Ogallala could cause widespread excessive lowering of the water table. Because of locally declining water levels, possible salt-water contamination, and other problems, the Oklahoma Water Resources Board requested the U.S. Geological Survey to provide basic data needed for efficient development and management of the ground-water resources. This report summarizes general information on the availability and chemical quality of ground water in the county. Although the maps in this report show only approximate conditions, they will be useful in planning further development of ground-water supplies. Additional studies are needed to determine the volume and chemical quality of available water stored in the major aquifers, annual changes in water levels, the rate of water-level decline in heavily pumped areas, and the estimated long-term yield of the major aquifers.

GROUND WATER

OCCURRENCE

Ground water in the Ogallala and other aquifers of Cimarron County occurs in the pores between the sand and gravel particles, or in rock fractures and other openings. In most of the county, water in the Ogallala is unconfined, and the water level in wells does not rise above the water table. Locally, however, the aquifer is overlain by fine-grained material, such as clay, so that the water is under artesian pressure, and the water level in wells rises above the saturated zone. The level to which water rises in wells penetrating the artesian aquifers is the potentiometric level or surface.

Water in alluvium is unconfined. In aquifers below the Ogallala the water is both confined and unconfined, depending on the local geologic conditions.

RECHARGE

Recharge of ground water to aquifers in Cimarron County is primarily from precipitation percolating down from land surface to the water table. Precipitation records at Boise City, which date back to 1908, show that the wettest year was 1919 (38.97 inches), and the wettest month was October 1930 (9.77 inches). The driest year was 1956 (6.95 inches). The graph of average monthly distribution of precipitation shows that about 74 percent falls during the spring and summer; mostly during intense thunderstorms of short duration on areas of only a few square miles. The graph showing wet and dry periods indicates when precipitation was above the 1926–65 average (wet) or below this average (dry).

An accurate determination of total recharge from precipitation cannot be made at this time. However, in Grant and Stanton Counties in southwestern Kansas where the Ogallala aquifer is geologically and hydrologically similar, annual recharge from precipitation is about one-third inch (Fader and others, 1964, p. 46). Assuming that recharge in Cimarron County is one-fourth to one-half inch, annual recharge would be 20 to 40 thousand acre-feet.

The time it takes downward-percolating water to reach the water table depends upon the permeability or ability of rock materials to transmit water and the depth to the water table. Recharge from precipitation may take as long as 7 years to reach the water table in the Ogallala (Marine, 1963, p. 9).

Other sources of recharge include ponds or lakes, water applied for irrigation, streamflow, and subsurface inflow from adjacent areas.

Rising water levels in wells adjacent to lakes and ponds filled with water show that some recharge is derived from this source (Schoff, 1943, p. 234). Most of these lake bottoms are relatively impermeable, so the amount of recharge by lake-bottom seepage probably is small.

Recharge from flood-irrigated land is highly variable depending upon the duration of flooding, type of soil, and other factors. Recharge from sprinkler-irrigated lands is probably insignificant.

The amount of recharge from streamflow depends on the rate and duration of flow, amount and type of sediment in the water, permeability and gradient of the streambed, and distance of the stream surface above the water table. Recharge from both the North Canadian and Cimarron Rivers occurs in the eastern half of the county (Schoff, 1943, p. 235–236), but the amount is unknown.

Recharge by subsurface inflow is mainly from adjacent parts of New Mexico. The amount of subsurface inflow is unknown, but data from aquifer tests in adjacent areas provide a basis for estimating the rate of movement through the Ogallala Formation at about 100 feet per year and through the Dakota Sandstone at about 10 feet per year.

DISCHARGE

Pumpage from irrigation wells accounts for the largest part of ground-water discharge in Cimarron County. Records show that during 1966 about 70,300 acres were irrigated with ground water. Assuming an average application of 1.2 acre-feet per year per acre, ground-water pumpage for irrigation during 1966 was estimated to be 80,000 acre-feet. This estimate illustrates the magnitude of increase in pumpage over the 175 acre-feet per year estimated for 1938–40 (Schoff, 1943, p. 246).

Streams that have cut their channels below the water table receive water from the ground-water reservoir. The quantity of ground water discharged into the Cimarron River in the northwestern part of the county was estimated to be 720 acre-feet per year during October 1938 to September 1940. Discharge of springs into ravines and draws in other parts of the county was estimated to be 640 acre-feet per year (Schoff, 1943, p. 243).

Ground water is discharged by evaporation and transpiration in areas where water levels are close to the land surface on stream flood plains. These areas are easily identified by abundant growths of cottonwood trees and other phreatophytes. An estimate of this discharge cannot be made until additional data are available.

Most of the ground water discharged by subsurface outflow moves eastward into Texas County. A small quantity may move into Texas and Kansas as shown by a contour map of the water table for the Ogallala aquifer (Schoff, 1943, p. 174).

STORAGE

Changes in ground-water storage are reflected by changes in water levels. When recharge exceeds discharge, ground-water storage increases and water levels rise; conversely, when ground-water is taken from storage, water levels decline. Measurements of water levels in Cimarron County began in July 1938 near the end of the 1931–40 drought. At the end of the drought, water levels in many wells were at an all-time low and the amount of water in storage was considerably reduced. During 1941–51, when precipitation generally was above average, water levels rose, as shown by hydrographs 2, 5, 7, and 8 indicating a substantial increase in ground-water storage. Water levels in some wells, shown by hydrograph 6, did not rise because pumpage from nearby wells removed water as fast as or faster than it could be added to storage.

Although precipitation during 1952–57 was below average, water levels in the Ogallala aquifer continued to rise, as shown by hydrographs 4 and 7, indicating that precipitation that had fallen during the previous wet period was still being added to storage. This delayed rise also continued in some areas underlain by the Dakota Sandstone and the Dockum Group, as shown by hydrographs 2, 5, and 8. The lack of correlation between water-level fluctuations and precipitation in the Morrison Formation, shown by hydrograph 10, may be the result of the very slow rate of increase in storage because of low permeability.

Ground-water storage in the alluvium varies in response to streamflow. Thus, water-level fluctuations are highly erratic, shown by hydrographs 3A, 3B, and 9, and the long-term general trends are obscure. Similar erratic fluctuations of water levels in the Ogallala Formation are caused by the pumping of irrigation wells.

CHEMICAL QUALITY

The suitability of water for domestic, municipal, stock, industrial, or irrigation use is, in part, determined by the dissolved-solids content. Standards governing the chemical quality of water for domestic or municipal use have been established by the U.S. Public Health Service (1962). These standards place an upper limit of 500 mg/l (milligrams per liter) on the dissolved-solids content of drinking water where better quality water is not available and also place maximum limits on concentrations of fluoride and other selected constituents. In some parts of Cimarron County the dissolved-solids and fluoride content of ground water exceed these standards.

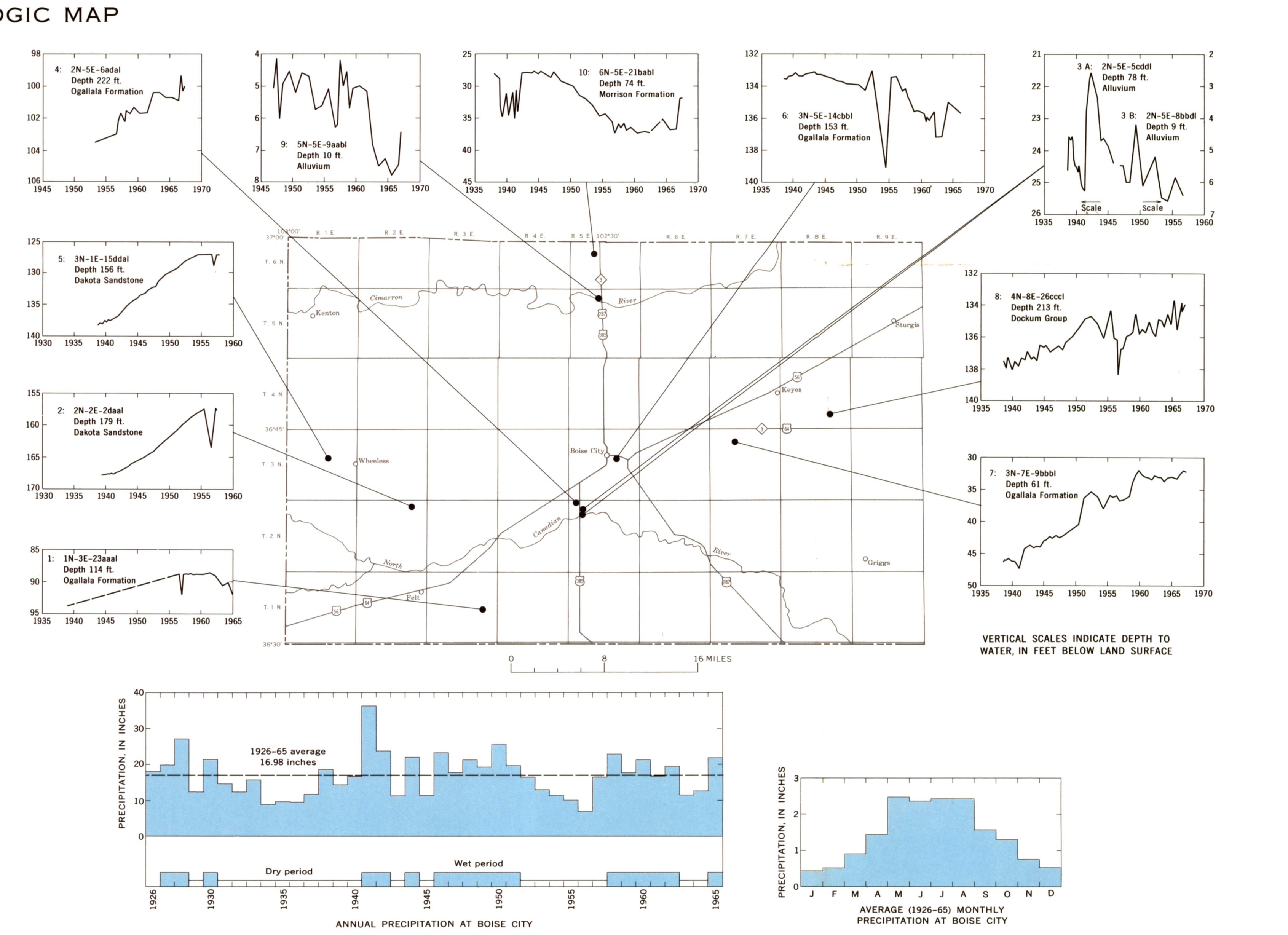
Water for stock is subject to the same quality limitations as those established for human consumption. However, most animals apparently can tolerate water that would be considered unsatisfactory for human beings (Hem, 1970, p. 324).

The usefulness of water for irrigation is governed by its chemical quality (Hem, 1970, p. 324–333). The dissolved-solids content or the specific electrical conductance (EC) along with the relative proportion of sodium to calcium plus magnesium (called sodium-adsorption ratio or SAR) are used to evaluate the suitability of water for irrigation. Generally, water with an EC and SAR less than 2,000 and 5, respectively, is classed as having a low sodium hazard. Some constituents, such as boron, in irrigation water may have a toxic effect on certain crops, but this has not been a problem in Cimarron County.

CHEMICAL QUALITY OF GROUND WATER

Diagram number	Well location	Well depth (feet)	Geologic source[1]	Dissolved solids (mg/l)	Specific conductance (micromhos per cm. at 25°C)	Sodium-adsorption ratio (SAR)	Total hardness as calcium carbonate (mg/l)
1	1N–1E–28dbb	358	Kp, Kd	225	386	0.2	172
2	1N–2E–10bdd	470	Kp, Kd	273	442	.8	192
3	1N–2E–12dba	132	To	234	------	.3	165
4	1N–5E–20aaa	78	To	299	------	.8	213
5	1N–5E–20bcd	245	Ɍd, To	311	515	2.6	200
6	1N–7E–18dcc	129	To	387	566	.9	232
7	1N–9E–15bab	273	To	307	------	.8	200
8	2N–5E– 2daa	243	To	321	516	.6	210
9	2N–7E–26aac	375	To	334	490	.6	208
10	2N–8E–28aaa	263	To	305	------	.9	192
11	3N–1E–20aaa	184	Kp(?), Kd	432	------	1.3	252
12	3N–3E–12cdd	120	To	333	------	.5	237
13	3N–4E–28abc	195	To	337	531	.6	232
14	3N–4E–33bcc	415	Kp, Kd, To	553	869	22.8	16
15	3N–7E– 2aaa	274	Ɍd	1,185	------	9.3	225
16	3N–7E– 3bbb	100	To	293	------	1.1	195
17	3N–7E–32bdd	187	To	304	472	.5	205
18	3N–9E–16aaa	206	To	241	------	.9	172
19	3N–9E–16aaa	330	Ɍd	784	1,210	20.3	32
20	4N–2E– 8a	-----	Kp(?)	487	789	7.2	86
21	4N–3E–12c	205	Kp	277	------	2.2	142
22	4N–5E–15bbb	215	Kp	392	------	2.2	206
23	4N–5E–36cbb	288	To	300	452	.6	192
24	4N–7E– 5bbc	304	To	276	449	.4	208
25	4N–8E– 3b (Composite of 4 wells)	252, 280, 282 & 316	To	398	450	.8	196
26	4N–8E–27c	280	Ɍd	384	640	3.1	144
27	4N–9E–22bcc	273	Ɍd	412	------	3.5	149
28	5N–1E– 4ca	29(?)	Qa, Jm	1,750	2,320	6.1	615
29	5N–2E– 1c	96	Je	1,649	------	43.2	33
30	5N–5E–12c	15	Qa, Ɍd	1,162	------	13.4	149
31	6N–1E–13	70	Jm(?), Kp, Kd	630	1,030	5.5	185
32	6N–1E–17bdd	35	Qa, Ɍd	681	1,010	.7	500
33	6N–9E–14a	205	To	573	891	2.9	268

[1]Symbols are defined in the explanation of the geohydrologic map.



WATER LEVEL AND PRECIPITATION GRAPHS

SELECTED REFERENCES

Baldwin, H. L., and McGuinness, C. L., 1963, A primer on ground water: U.S. Geol. Survey Misc. Rept., 26 p.

Cronin, J. G., 1964, A summary of the occurrence and development of ground water in the southern High Plains of Texas: U.S. Geol. Survey Water-Supply Paper 1693, 88 p.

Fader, S. W., Gutentag, E. D., Lobmeyer, D. H., and Meyer, W. R., 1964, Geohydrology of Grant and Stanton Counties, Kansas: Kansas Geol. Survey Bull. 168, 147 p.

Hart, D. L., Jr., 1963, Ground-water levels in observation wells in Oklahoma, 1956–60: Oklahoma Water Resources Board, p. 71–76.

———1967, Ground water levels in observation wells in Oklahoma, 1965–66: Oklahoma Water Resources Board, p. 13–18.

Hem, J. D., 1970, Study and interpretation of chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 363 p.

Leopold, L. B., and Langbein, W. B., 1960, A primer on water: U.S. Geol. Survey Misc. Rept., 50 p.

Marine, I. W., 1963, Correlation of water-level fluctuations with climatic cycles in the Oklahoma Panhandle: U.S. Geol. Survey Water-Supply Paper 1669–K, 10 p.

McLaughlin, T. G., 1954, Geology and ground-water resources of Baca County, Colorado: U.S. Geol. Survey Water-Supply Paper 1256, 232 p.

Murphy, R. S., Abernathy, E. J., Allgood, F. P., Warth, P. R., Meinders, H. C., Wammack, L. W., and Icenhower, J. C., 1960, Soil survey of Cimarron County, Oklahoma: U.S. Dept. of Agriculture, ser. 1956, no. 11, 53 p.

Schoff, S. L., 1943, Geology and ground-water resources of Cimarron County, Oklahoma: Oklahoma Geol. Survey Bull. 64, 317 p.

Swenson, H. A., and Baldwin, H. L., 1965, A primer on water quality: U.S. Geol. Survey Misc. Rept., 27 p.

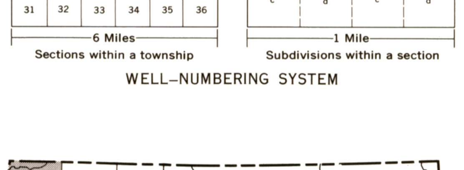
U.S. Department of Agriculture, 1955, The yearbook of agriculture, 1955, water: U.S. Dept. of Agriculture, 751 p.

U.S. Public Health Service, 1962 (revised), Drinking water standards: U.S. Public Health Service Pub. 956, 61 p.

Wood, P. R., 1965, Ground-water levels in observation wells in Oklahoma, 1963–64: Oklahoma Water Resources Board, p. 22–24.

Wood, P.R., and Hart, D. L., Jr., 1967, Availability of ground water in Texas County, Oklahoma: U.S. Geol. Survey Hydrol. Inv. Atlas HA–250.

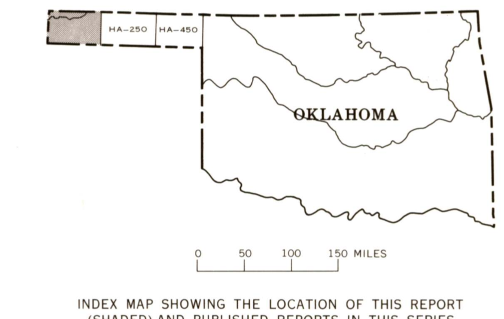
Wood, P. R., and Moeller, M. D., 1964, Ground-water levels in observation wells in Oklahoma, 1961–62: Oklahoma Water Resources Board, p. 45, 46.



Sections within a township

Subdivisions within a section

WELL-NUMBERING SYSTEM



INDEX MAP SHOWING THE LOCATION OF THIS REPORT (SHADED) AND PUBLISHED REPORTS IN THIS SERIES

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973

RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF CIMARRON COUNTY, OKLAHOMA

By
D. B. Sapik, and R. L. Goemaat
1973

For sale by U. S. Geological Survey, price $1.25 per set