EXPLANATION

RECHARGE AREAS

Patterns of red lines on the map show known or potential recharge areas for the various bedrock aquifers.

Recharge Areas. This pattern shows areas that are known to be part of the recharge area for a bedrock aquifer: includes outcrops of the aquifer and of overlying porous and permeable rocks hydraulically connected with the aquifer.

Potential Recharge Areas. This pattern shows areas that may be part of the recharge area for a bedrock aquifer: includes areas where confining strata may contain pathways for downward movement of water to the aquifer, and safety zones (generally extending 4 miles beyond the known limits of the aquifer) that may overlie unknown extensions of the aquifer or rocks hydraulically connected with the aquifer.

BEDROCK AQUIFERS

Colored areas on the map show distribution of bedrock aquifers, which are the rock units generally considered favorable or moderately favorable for development of ground-water resources. Bedrock aquifers are listed below by geologic age from oldest to youngest. References, listed at the end of each aquifer description, include Hydrologic Atlases (HA) and Other Reports that provide more detailed information. All references are given in the 4-page pamphlet that accompanies this map.

Og — Ogallala Formation (Tertiary in age). Loosely cemented layers of fine- to medium-grained sand, silt, clay, and gravel in western Oklahoma and Panhandle; locally contains thin beds of caliche. Thickness generally ranges from 100 to 700 ft. in Panhandle and 100 to 400 ft. elsewhere. Wells commonly yield 25 to 1,500 gpm of water that is of good quality (generally less than 500 mg/L dissolved solids). Recharge areas include all areas where Ogallala crops out or is covered by younger porous and permeable sediments. References: HA-5, HA-8, HA-250, HA-373, HA-450; also Other Reports 12, 13, 17, 21, 22, 23, 24, 25, 26, 28, 30, 31, 32, 33, 40, 42, 43, 52, 54, 55, 61, 66.

An — Antlers Sandstone (Cretaceous in age). Loosely cemented fine-grained sand and sandstone with some layers of shale and clay in southeastern Oklahoma. The aquifer includes underlying Holly Creek Formation in T. 6 S., Rs. 24-27 E., of eastern McCurtain County. Antlers aquifer typically ranges from 200 to 700 ft. thick. Wells commonly yield 10 to 50 gpm, but in some areas they may yield up to 400 gpm. The water is of good quality (generally 200 to 1,000 mg/L dissolved solids). Recharge areas include outcrops of Antlers Sandstone and overlying Goodland Limestone; potential recharge areas include areas where aquifer underlies younger Cretaceous strata in the south. References: HA-3, HA-9; also Other Reports 9, 20, 33, 61.

El — Elk City Sandstone (Permian in age). Fine-grained sandstone with minor amounts of silt and clay in southwestern Oklahoma. Maximum thickness is about 185 ft. Wells commonly yield 25 to 300 gpm of water that is of good quality (generally less than 500 mg/L dissolved solids). Recharge areas include all outcrops of Elk City Sandstone. References: HA-5; also Other Reports 33, 47, 61.

RM — Rush Springs Sandstone and Marlow Formation (Permian in age). Fine-grained sandstone with some layers of gypsum, shale, and dolomite in western Oklahoma. The amount of shale increases in Dewey County and farther north. Thickness of aquifer ranges from 400 ft. in the south to 200 ft. in the north. Wells commonly yield 25 to 300 gpm of water that is of good quality (generally 200 to 1,000 mg/L dissolved solids), although in some areas of Dewey County and farther north the water locally is of fair to poor quality (1,500 to 4,000 mg/L dissolved solids). Recharge areas include Rush Springs and Marlow outcrops and extend to limits of outcrop on south and east; recharge areas also include outcrops of gypsum and other rocks of overlying Cloud Chief Formation in parts of Caddo, Custer, and Washita Counties. Potential recharge areas in the west extend 4 miles beyond the western limit of the aquifer. References: HA-3, HA-5, HA-6, HA-8; also Other Reports 6, 7, 15, 19, 33, 41, 46, 50, 53, 61, 64, 69.

BD — Blaine and Dog Creek Formations (Permian in age). Gypsum and dolomite layers (locally fractured or cavernous) interbedded with shale in southwestern Oklahoma. The total thickness of the aquifer (the lower part of the Dog Creek Formation and the entire Blaine Formation) is about 250 ft. Wells commonly yield 300 to 2,500 gpm of water that is of fair to poor quality (generally 1,500 to 6,000 mg/L dissolved solids). Recharge areas are outcrops of Blaine, Dog Creek, Rush Springs, and Marlow Formations that overlie the aquifer. Potential recharge areas include other outcrops of Rush Springs, Marlow, Dog Creek, and Blaine strata that dip toward the aquifer. References: HA-5, HA-6; also Other Reports 33, 56, 61, 62.

Ce — Cedar Hills Sandstone (Permian in age). Fine-grained sandstone interbedded with layers of siltstone and shale in northwestern Oklahoma. Thickness typically is about 180 ft. Wells commonly yield 150 to 300 gpm of water that is of good to poor quality (generally 500 to 3,000 mg/L dissolved solids). Recharge areas include Cedar Hills outcrops and extend to limits of outcrop on east; potential recharge areas in south and west extend 4 miles beyond the limits of aquifer. References: HA-7, HA-8; also Other Reports 15, 57, 63.

GW — Garber Sandstone and Wellington Formation (Permian in age). Fine-grained sandstone irregularly interbedded with shale and siltstone in central Oklahoma; grades into shale to north and south. Thickness of aquifer ranges from about 300 ft. in the south to about 800 ft. in the north. Wells commonly yield 25 to 400 gpm of water that is of good quality (generally 200 to 1,000 mg/L dissolved solids). Recharge areas consist of outcrops of the aquifer and extend eastward to the approximate top of shales that make up much of the lower one-third of the Wellington Formation. Potential recharge areas include areas in the west where aquifer underlies younger Permian strata; also areas that extend 4 miles south, west, and north of aquifer limits. References: HA-4; also Other Reports 4, 5, 29, 33, 61, 67, 68.

Os–a — Oscar Group (Early Permian or Late Pennsylvanian in age). Area designated a consists of fine-grained sandstone interbedded with shale and siltstone in central Oklahoma; contains some conglomerate in the south. Main part of aquifer is in lower half of Oscar Group; upper half of Oscar is predominantly shale. Thickness of aquifer ranges from about 150 ft. in south to 300 ft. in north. Wells commonly yield 25 to 50 gpm of water that is of good quality (generally 300 to 1,000 mg/L dissolved solids). Recharge areas include outcrops of Oscar Group; also included are outcrops of shales and sandstones in lower part of overlying Wellington Formation that appear to be hydraulically connected with either the Oscar or the Garber-Wellington aquifer. Potential recharge areas extend 4 miles north, east, and south of aquifer limits. References: HA-4.

Os–b — Oscar Group (Early Permian or Late Pennsylvanian in age). Areas designated b consist of interbedded sandstones and shales in south-central Oklahoma. Total thickness is 300 to 500 ft. Wells commonly yield 50 to 180 gpm of water that is of good to fair quality (generally 500 to 1,500 mg/L dissolved solids). The Oscar Group does not crop out where it is an aquifer, and thus its recharge area is uncertain. Potential recharge areas include, and extend 4 miles beyond, the known limits of the aquifer. References: HA-3, HA-6; also Other Reports 33, 61.

VA — Vamoosa Formation and Ada Group (Pennsylvanian in age). Fine- to coarse-grained sandstone interbedded with shale and siltstone in central and northern Oklahoma; contains some conglomerate in the south. Mapped aquifer locally includes sandstones and shales of overlying Vanoss Group that are hydraulically connected with Vamoosa-Ada aquifer. Boundaries of aquifer shown here represent maximum extent reported on HA-4 and HA-7, or by D'Lugosz, McClaflin, and Marcher (1981). Thickness of aquifer ranges from about 200 ft. in the south to about 500 to 800 ft. elsewhere. Wells commonly yield 25 to 150 gpm, and locally yield as much as 300 gpm, of water that is of good quality (generally 200 to 1,000 mg/L dissolved solids). Recharge areas include outcrops of aquifer and, locally, some hydraulically connected rocks. Potential recharge areas extend 4 miles beyond the aquifer limits. References: HA-3, HA-4, HA-7; also Other Reports 3, 10, 11, 14, 15, 33, 38, 61.

No — Noxie Sandstone (Pennsylvanian in age). Coarse-grained sandstone with some shale layers in northeastern Oklahoma. Thickness ranges from about 50 to 100 ft. Wells commonly yield 10 to 50 gpm of water that is of good quality (generally less than 1,000 mg/L dissolved solids). Recharge areas include outcrops of aquifer and overlying sandstones and shales of Chanute Formation. Potential recharge areas include areas in west where aquifer underlies younger Pennsylvanian rocks; also areas that extend 4 miles south of aquifer limits. References: HA-2; also Other Reports 14, 33, 38.

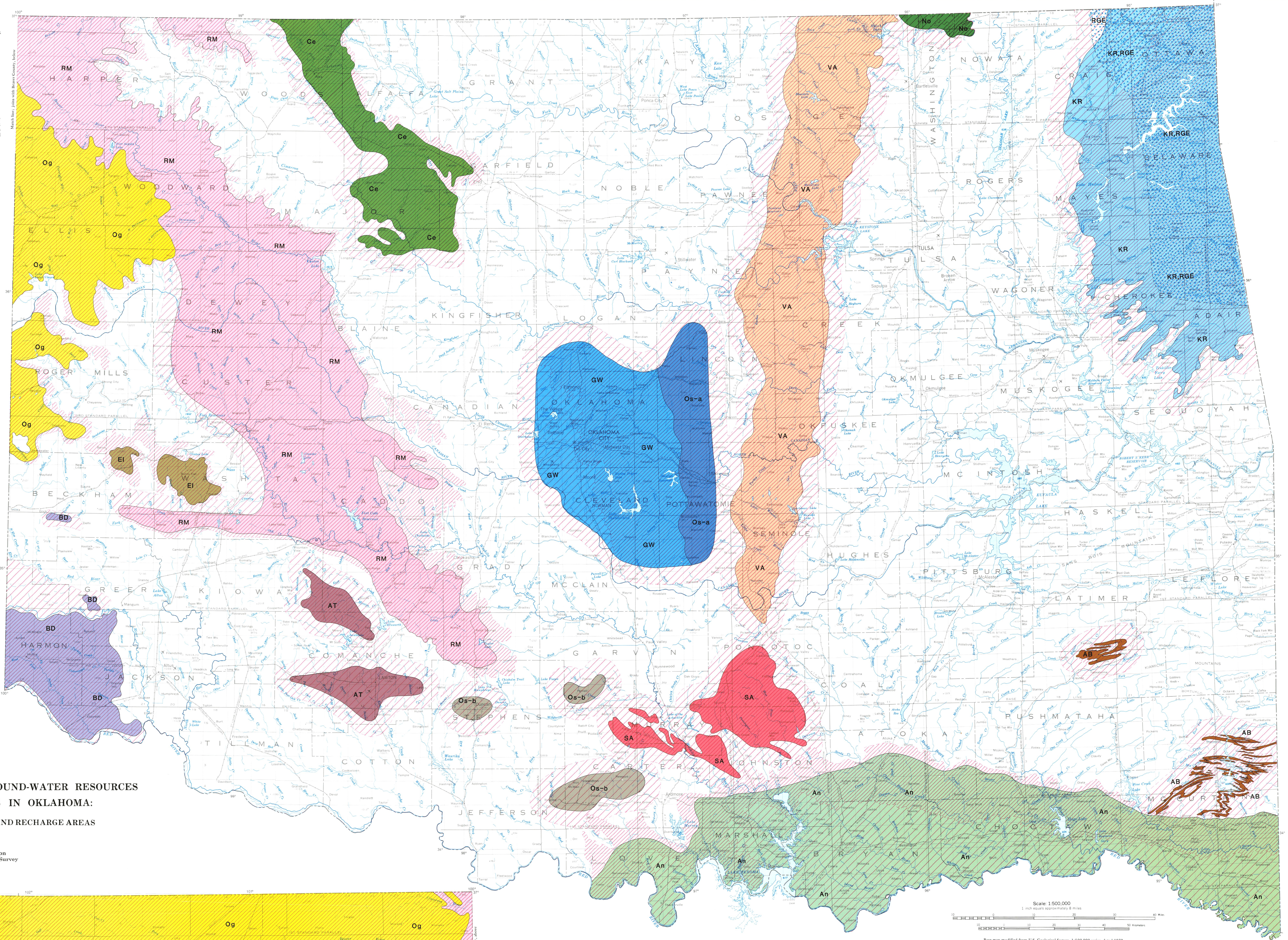
KR — Keokuk and Reeds Spring Formations (Mississippian in age). This northeastern Oklahoma unit, also referred to as the "Boone Formation" or "Boone Chert," consists of limestone and cherty limestone beds that locally are fractured or cavernous. Thickness ranges from 250 ft. in south to about 400 ft. in north. Wells consistently yield more than 3 gpm, and some yield as much as 50 gpm. Water is of good quality (generally less than 500 mg/L dissolved solids) although typically it is hard. Recharge areas include outcrops of aquifer and of overlying Mississippian limestones and shales above aquifer. Potential recharge areas include areas in northwest where aquifer underlies younger Pennsylvanian rocks; also areas that extend 4 miles west and south of aquifer limits. References: HA-1, HA-2; also Other Reports 33, 38, 44, 49, 51, 61.

AB — Arkansas Novaculite and Bigfork Chert (Mississippian through Ordovician in age). Highly fractured novaculite and chert with some interbedded shale and sandstone in southeastern Oklahoma. Total thickness is 850 to 1,200 ft. Wells commonly yield 10 to 50 gpm of water that is of good quality, (generally less than 500 mg/L dissolved solids). Recharge areas include outcrops of aquifer and immediately adjacent strata; potential recharge areas extend 4 miles beyond limits of aquifer. References: HA-9.

RGE — Roubidoux, Gasconade, and Eminence Formations (Ordovician and Cambrian in age). Cherty dolomite with some interbedded sandstone in northeastern Oklahoma. Thickness generally ranges from 200 to 500 ft. Wells commonly yield 50 to 250 gpm, locally as much as 1,000 gpm. Water is of good to fair quality (generally 150 to 1,500 mg/L dissolved solids). Aquifer does not crop out in Oklahoma, and thus there is no known recharge area in the State. Potential recharge areas include, and extend 4 miles beyond, the known limits of the aquifer. References: HA-2; also Other Reports 33, 51.

SA — Simpson and Arbuckle Groups (Ordovician and Cambrian in age). Limestone and dolomite with beds of loosely cemented sandstone in Arbuckle Mountains region of south-central Oklahoma. Maximum thickness is about 5,000 to 6,000 ft. Wells commonly yield 25 to 600 gpm of water that is of good quality (generally less than 500 mg/L dissolved solids). Recharge areas include outcrops of Simpson and Arbuckle strata; potential recharge areas extend 4 miles beyond aquifer limits. References: HA-3; also Other Reports 8, 16, 33, 61.

AT — Arbuckle and Timbered Hills Groups (Ordovician and Cambrian in age). Limestone and dolomite interbedded with some sandstone and shale in the Wichita Mountains-Lawton region of southwestern Oklahoma. Maximum thickness is about 5,000 to 6,000 ft. Wells commonly yield 25 to 600 gpm of water that is of good to fair quality (generally 300 to 2,000 mg/L dissolved solids). Recharge areas are outcrops of aquifer in limestone hills of Wichita Mountains (Caddo-Comanche-Kiowa County area). Potential recharge areas include area underlain by aquifer around Lawton (aquifer does not crop out), and other areas that extend 4 miles beyond limits of the aquifer. References: HA-6; also Other Reports 27, 33, 61.

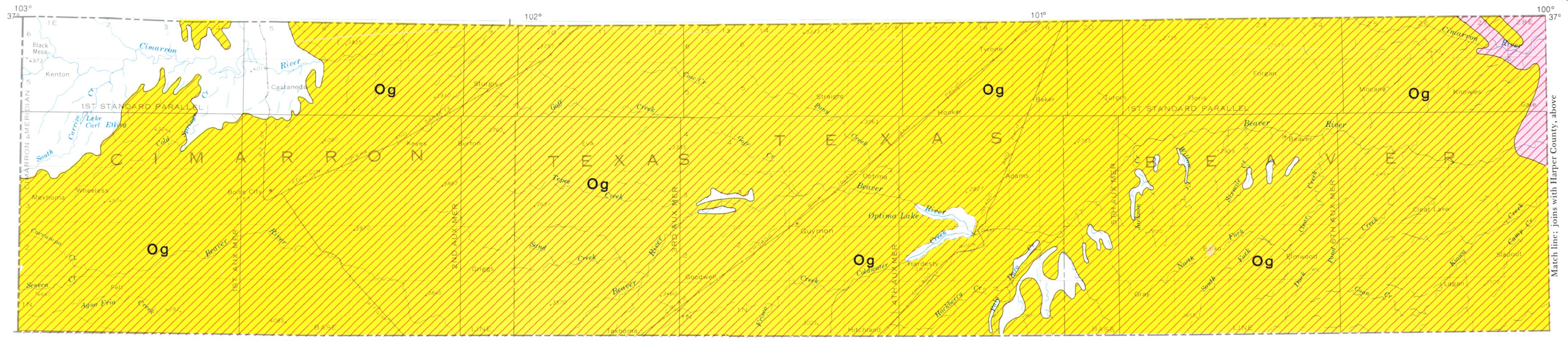


Base map modified from U.S. Geological Survey, 1:500,000 series, dated 1972

MAPS SHOWING PRINCIPAL GROUND-WATER RESOURCES AND RECHARGE AREAS IN OKLAHOMA:

SHEET 2 - BEDROCK AQUIFERS AND RECHARGE AREAS

Compiled by
Kenneth S. Johnson
Oklahoma Geological Survey
1983



Cartography by David M. Deering

This map shows the distribution of the principal bedrock aquifers in Oklahoma, and also shows the known and potential recharge areas of these aquifers. The term "aquifer" refers to those rocks and sediments that are saturated with good- to fair-quality water and are sufficiently permeable generally to yield significant volumes of water from wells. The bedrock aquifers shown on this map are limited to those rock units and sediments that are of Tertiary age or older, and do not include the much younger, unconsolidated alluvium and terrace deposits of Quaternary age that overlie many parts of the bedrock aquifers and are shown on Sheet 1. The term "recharge areas" refers to those portions of the land surface where surface water (precipitation, surface runoff, streams, rivers, and lakes) enters the subsurface and eventually migrates downward to the zone of saturation in an aquifer.

Oklahoma's bedrock aquifers are widespread in distribution and differ in composition. Most of the aquifers are sands or sandstones (Ogallala, Antlers, Elk City, Rush Springs-Marlow, Cedar Hills, Garber-Wellington, Oscar, Vamoosa-Ada, and Noxie aquifers), some are mainly limestones or dolomites (Keokuk-Reeds Spring, Roubidoux-Gasconade-Eminence, Simpson-Arbuckle, and Arbuckle-Timbered Hills aquifers), one is predominantly gypsum (Blaine-Dog Creek aquifer), and one is mainly novaculite and chert (Arkansas Novaculite-Bigfork aquifer). The aquifers range in thickness from 100 to several thousand feet. The depths at which fresh ground water can be obtained range from less than 100 feet in some aquifers to more than 1,000 feet in others.

Fresh water stored in Oklahoma's bedrock aquifers results from downward movement of surface waters that have entered each of the aquifers at its recharge areas and displaced any saline waters that originally may have occupied that portion of the aquifer. The system is dynamic inasmuch as these aquifers are still being recharged by continual downward percolation of surface waters to the zone of saturation. The rate of ground-water movement in the State's various aquifers has not been fully determined, but it probably ranges from about 5 to 1,000 feet per year in most aquifers and locally may exceed 1,000 feet per year under certain geologic and hydrologic conditions.

In some areas, bedrock aquifers also may be recharged where the aquifer is overlain by confining strata, such as shales and siltstones, that have low permeabilities and normally prevent or inhibit the movement of ground water. Such recharge may occur where the confining strata contain one or more of the following: (1) continuous or discontinuous layers with higher permeability, (2) joints, fractures, faults, or other structural discontinuities, and (3) boreholes, mine shafts, or other man-made excavations. Any of these natural or artificial features that penetrate the confining strata into the underlying aquifer represent a potential pathway for surface waters locally to enter the aquifer.

Known or potential recharge areas for the various bedrock aquifers shown on this map are based upon data concerning the surface geology of Oklahoma and the relationship of outcropping rocks to ground-water aquifers. On the accompanying map, those areas characterized as *recharge areas* include the following: (1) outcrops of the aquifer itself, and (2) outcrops of overlying porous and permeable rocks that are hydraulically connected with the aquifer. *Potential recharge areas* shown on the accompanying map include the following: (1) areas where an aquifer is overlain by confining strata that may contain natural or artificial pathways that could permit downward movement of surface water to the aquifer, and (2) additional safety zones that generally extend 4 miles beyond the known limits of an aquifer. The safety zones extend an arbitrary, yet conservatively reasonable distance from the aquifers: they include areas that may possibly have a hydrogeologic impact on the recharge of the aquifer as well as those areas that may overlie unknown lateral extensions of the aquifer.

Because the known and potential recharge areas are critical to the State's bedrock aquifers, special care must be taken in the utilization of these lands. In particular, special attention must be exercised in the storage or disposal of waste materials that contain leachable or liquid contaminants that could degrade the quality of water within or flowing across the potential recharge areas. Even greater care must be exercised to protect the quality of water within or flowing across the known recharge areas.

The quality of water in an aquifer commonly is affected by the nature and mineral content of the rock itself, because all ground waters contain various minerals dissolved from the rocks that the water moves over or through. The quality of water in Oklahoma's principal bedrock aquifers is generally acceptable for most purposes: most of the waters are of good to fair quality [300 to 2,000 mg/L (milligrams per liter) of dissolved solids], although locally some are of poor quality (2,000 to 6,000 mg/L dissolved solids). Water in the sand, sandstone, or limestone aquifers typically is of good to fair quality, whereas water in gypsum aquifers and in parts of some sandstone and limestone aquifers is of fair to poor quality. Although poor-quality waters with 2,000 to 6,000 mg/L dissolved solids may not be suitable for drinking purposes, they still may be well suited for irrigation and (or) industrial purposes.

The quantity of water produced from wells completed in the principal bedrock aquifers is highly variable, but many wells produce from 10 to 500 gpm (gallons per minute). Some wells completed in loosely cemented sand and gravel, or in cavernous or fractured gypsum, limestone, or dolomite, may produce several thousand gpm.

The accompanying map of bedrock aquifers and recharge areas has been compiled mainly from a series of hydrologic atlases prepared cooperatively by the Oklahoma Geological Survey and the U.S. Geological Survey (see References listed on the 4-page pamphlet that accompanies this map). The boundaries of the aquifers, as shown on the accompanying map, include the areas shown as being favorable or moderately favorable for development of ground-water resources (yields generally more than 25 gpm) on the hydrologic atlases. The atlases, which are reconnaissance studies of the water resources of Oklahoma, may be referred to by the reader for more detailed information on the distribution and character of the aquifers and their recharge areas, and on the quality and quantity of water that is available from the aquifers. Mapping in the three Panhandle counties is mainly from hydrologic atlases prepared cooperatively by the U.S. Geological Survey and the Oklahoma Water Resources Board (see References pamphlet), and from work done by the Oklahoma Geological Survey released as part of the Perryton and Dalhart Sheets of the *Geologic Atlas of Texas.*

Hydrologic reports dealing specifically with the various bedrock aquifers have been prepared mainly by the Oklahoma Water Resources Board, the U.S. Geological Survey, and the Oklahoma Geological Survey, and these are listed as "Other Reports" in the References pamphlet. Additional county and area reports dealing in part with one or more of the aquifers are also included in the References pamphlet as "Other Reports."