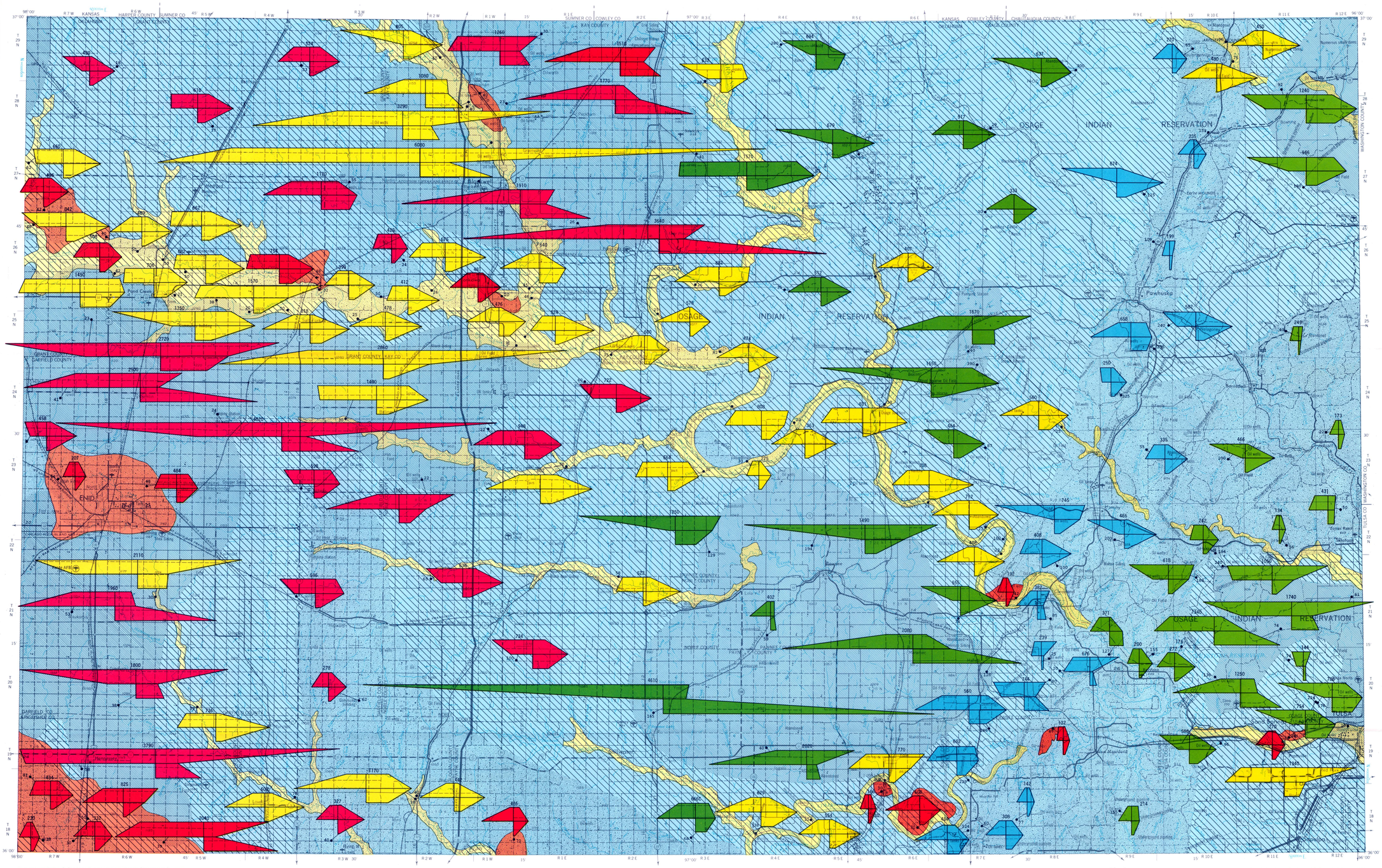


Base modified from U.S. Geological Survey 1:250,000 series: Enid quadrangle, 1966

Compiled by Roy H. Bingham, U.S. Geological Survey, 1973

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 Kilometers

DATUM: MEAN SEA LEVEL

Figure 7. Map showing chemical quality of ground water in the Enid quadrangle.

EXPLANATION

Chemical Quality of Ground Water

Note: Locally, the concentration of dissolved solids might be more or less than indicated on the map.

Concentrations of 500 mg/l or less dissolved solids

Concentrations of 500 to 1,000 mg/l dissolved solids

Concentrations of 1,000 mg/l or more dissolved solids

Aquifers

Alluvium

Analyses indicate that water from most of the alluvium contains less than 1,000 mg/l dissolved solids. Locally, the alluvium along the Chikaskia River and Salt Fork of the Arkansas River and along some of the minor streams yields water containing more than 1,000 mg/l dissolved solids. The large variation in water quality may be partly the result of contamination by oil-field brines or by pumpage of water from the alluvium, which increases inflow of poor-quality water into the aquifer from the stream nearby. The areal extent, duration, and amounts of change in water quality caused by pumpage effects have not been determined.

Terrace deposits

Water from the terrace deposits generally contains less than 500 mg/l dissolved solids, but concentrations locally may exceed 1,000 mg/l.

Bedrock

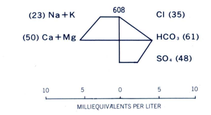
Water from bedrock aquifers contains variable amounts of dissolved solids. Dissolved-solids concentrations range from about 60 to 4,610 mg/l; however, concentrations of 500 to 2,000 mg/l are more common. Water containing 2,000 to 4,600 mg/l dissolved solids generally is limited to small local areas. Numerous shallow wells in the bedrock aquifers yield water with dissolved-solids concentrations between 60 and 500 mg/l.

Approximate boundary of aquifers.

Water-Quality Diagrams

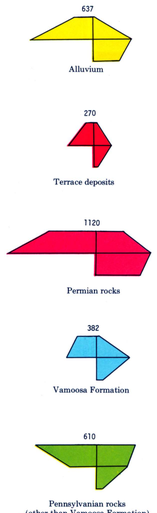
Diagrams based on chemical analyses can be used to show the general character of ground water from wells indicated on the map. Concentrations, in milliequivalents per liter, are plotted for sodium plus potassium (Na+K), calcium plus magnesium (Ca+Mg), chloride (Cl), bicarbonate (HCO_3), and Sulfate (SO_4). Anions are plotted to the right of the center line and cations to the left. Differences in shape of the diagram show the variations in the chemical character and the relative proportions of chemical constituents. The size of the diagram is an indication of the dissolved-solids concentrations: larger diagrams indicate greater concentrations of dissolved solids. The number above the diagram is dissolved solids, in milligrams per liter. A number followed by the letter "C" indicates that the dissolved-solids concentration was calculated.

The numbers in parentheses are the factors used to convert the ionic concentration from milliequivalents per liter to milligrams per liter. The scale is used to read the value in milliequivalents per liter of a particular ion, or combination of ions. Multiply the value by the number beside the ion. The resulting number for Cl, HCO_3, or SO_4 ions indicates concentration in milligrams per liter of the ions, and the resulting number for Na+K is the concentration as Na. The resulting number of Ca+Mg is the hardness as $CaCO_3$.



30 Well from which water sample was collected; number indicates well depth, in feet

Geologic Sources of Water



CHEMICAL CHARACTERISTICS OF GROUND WATER

Chemical characteristics of ground water in the Enid quadrangle differ considerably within short distances. In most parts of the quadrangle, the water is hard or very hard and locally contains sulfate and chloride in excess of 250 mg/l (milligrams per liter). Samples of water from some shallow wells contain more than 45 mg/l nitrate, indicating possible pollution. The dissolved-solids concentrations of water samples analyzed range from 60 to 6,000 mg/l and average about 650 mg/l.

To provide data on the chemical characteristics of ground water in the Enid quadrangle, samples from 128 wells were collected during the project and analyzed by the U.S. Geological Survey (fig. 7). Other water-quality data used in the preparation of this report were taken from analyses in the files of the U.S. Geological Survey. Laboratory determinations were made for calcium and magnesium hardness, chloride, bicarbonate, carbonate, sulfate, nitrate, and dissolved solids. Sodium and potassium were calculated.

Sulfate in ground water is derived from such minerals as gypsum and anhydrite. When combined with calcium, sulfate may cause hard scale in boilers, water heaters, pipes, and plumbing fixtures.

Chloride is derived from halite and brines and from human, animal, and industrial wastes. Small amounts of chloride have little effect on the usability of water for most purposes; however, water containing chloride in concentrations of several hundred milligrams per liter has a salty taste.

Sodium and potassium are found in most ground water, but small to moderate quantities have little effect on the usefulness of water. The ratio of sodium content to that of calcium plus magnesium in water is expressed as SAR(sodium-absorption ratio); water with high SAR values may be unsatisfactory for irrigation. (See sheet 4 for figures showing SAR values in Enid quadrangle.)

Nitrate in water is considered to be a final oxidation product of nitrogenous material, and when present in concentrations greater than about 45 mg/l, may indicate contamination by sewage and other organic matter. Chemical fertilizers also may be a source of nitrate. The quantity of nitrate present in natural, unpolluted water generally is only a few milligrams per liter.

Calcium is dissolved from many rocks, but higher concentrations generally are found in water that has been in contact with limestone, dolomite, or gypsum; magnesium is dissolved primarily from dolomite rocks. Calcium and magnesium hardness is expressed in terms of an equivalent quantity of calcium carbonate ($CaCO_3$). Hardness in water reduces the cleaning action of soap and detergents and has scale-forming properties. Water having a hardness less than 60 mg/l commonly is classified as soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; and more than 180 mg/l, very hard.

Dissolved solids consist principally of dissolved minerals and organic matter in the water. For this report, the dissolved solids are the residues that remained after a measured quantity of the water was evaporated by heating. Water containing 500 mg/l or less of dissolved solids is generally considered satisfactory for most domestic and industrial uses; 500 mg/l is considered the maximum for drinking water.

Some mineralization of ground water in the Enid quadrangle might be due to contamination by oil-well brines, particularly in the vicinity of oil fields. Such contamination may be the result of seepage from waste pits, defective well casing, defective well plugging, water-flooding operations, or improper brine disposal.

The following tables summarize results of chemical analyses of ground water from wells in the Enid quadrangle.

Summary of 46 chemical analyses of water from alluvium

	CONCENTRATIONS (IN MILLIGRAMS PER LITER)				
	MAXIMUM	UPPER QUARTILE[1]	MEDIAN[2]	LOWER QUARTILE[3]	MINIMUM
Hardness as $CaCO_3$	2,760	620	295	340	7
Sulfate (SO_4)	730	120	86	50	5
Chloride (Cl)	2,580	270	71	40	11
Nitrate (NO_3)	300	20	3.8	0.6	0
Dissolved solids (Residue on evaporation at 180°C)	6,080	1,320	724	524	363

Summary of 27 chemical analyses of water from terrace deposits

	CONCENTRATIONS (IN MILLIGRAMS PER LITER)				
	MAXIMUM	UPPER QUARTILE[1]	MEDIAN[2]	LOWER QUARTILE[3]	MINIMUM
Hardness as $CaCO_3$	940	352	270	171	54
Sulfate (SO_4)	760	63	39	25	7.9
Chloride (Cl)	480	100	39	23	5.4
Nitrate (NO_3)	180	39	25	10	3.0
Dissolved solids (Residue on evaporation at 180°C)	2,040	708	484	275	132

Summary of 25 chemical analyses of water from Permian rocks

	CONCENTRATIONS (IN MILLIGRAMS PER LITER)				
	MAXIMUM	UPPER QUARTILE[1]	MEDIAN[2]	LOWER QUARTILE[3]	MINIMUM
Hardness as $CaCO_3$	2,000	1,015	540	230	74
Sulfate (SO_4)	1,700	595	150	42	13
Chloride (Cl)	1,600	350	124	48	12
Nitrate (NO_3)	728	130	21	6.4	1.7
Dissolved solids (Residue on evaporation at 180°C)	4,020	1,990	1,025	490	278

Summary of 23 chemical analyses of water from the Vamoosa Formation

	CONCENTRATIONS (IN MILLIGRAMS PER LITER)				
	MAXIMUM	UPPER QUARTILE[1]	MEDIAN[2]	LOWER QUARTILE[3]	MINIMUM
Hardness as $CaCO_3$	560	318	205	100	15
Sulfate (SO_4)	250	94	51	28	7.0
Chloride (Cl)	360	110	37	20	5.0
Nitrate (NO_3)	83	9.9	1.5	0.4	0
Dissolved solids (Residue on evaporation at 180°C)	998	658	408	239	60

Summary of 42 chemical analyses of water from Pennsylvanian rocks other than Vamoosa Formation

	CONCENTRATIONS (IN MILLIGRAMS PER LITER)				
	MAXIMUM	UPPER QUARTILE[1]	MEDIAN[2]	LOWER QUARTILE[3]	MINIMUM
Hardness as $CaCO_3$	1,400	340	200	98	5.6
Sulfate (SO_4)	740	150	66	27	3.5
Chloride (Cl)	618	200	64	25	9.5
Nitrate (NO_3)	225	20	1.8	0.2	0
Dissolved solids (Residue on evaporation at 180°C)	4,610	1,240	636	402	134

[1]Upper quartile—25 percent of the samples had a concentration greater than the amount shown and 75 percent had less.
[2]Median—50 percent of the samples had a concentration greater than the amount shown and 50 percent had less.
[3]Lower quartile—25 percent of the samples had a concentration less than the amount shown and 75 percent had more.

RECONNAISSANCE OF THE WATER RESOURCES OF THE ENID QUADRANGLE, NORTH-CENTRAL OKLAHOMA

By

Roy H. Bingham and DeRoy L. Bergman

U.S. Geological Survey

1980