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U.S. BUREAU OF INDIAN AFFAIRS

TABLE 1. Significance and occurrence of chemical constituents and characteristics of the ground water for public-supply, livestock, and irrigation use

Limits accompanied by an asterisk (*) are primary (mandatory) limits and by a plus (+) are secondary (recommended) limits as set forth by the U.S. Environmental Protection Agency (1976, 1977a, and 1977b). Limits without symbols are arbitrary limits based on those suggested for public-supply, livestock, and irrigation use (National Academy of Sciences and National Academy of Engineering, 1973; Gough and others, 1979). Limits for some constituents have not been established (†). The unit, milligram per liter (mg/L), is approximately equivalent to parts per million (ppm) for water that contains less than 7,000 mg/L of dissolved solids.

Constituent or characteristic	Limits, in milligrams per liter	Number of wells: Total analyzed for constituent[1]	Number of wells: Percent exceeding limit[2]	Significance and occurrence
Silica (SiO_2)	50	271	25	[illegible]
Iron (Fe)	.3+	171	20	[illegible]
Manganese (Mn)	.05+	139	19	[illegible]
Calcium (Ca) and Magnesium (Mg)	†	285	—	[illegible]
Sodium (Na)	270	285	8	[illegible]
Bicarbonate (HCO_3)	†	295	—	[illegible]
Sulfate (SO_4)	250+	287	4	[illegible]
Chloride (Cl)	250+	292	8	[illegible]
Fluoride (F)	1.4*	287	30	[illegible]
Nitrate (NO_3)	45*	247	7	[illegible]
Nitrate (NO_3 as N)	10*			
Boron (B)	.75+	113	10	[illegible]
Dissolved solids (DS)	500+	285	33	[illegible]
Hardness as $CaCO_3$	180	262	41	[illegible]
Aluminum (Al)	1.0+	17	0	[illegible]
Arsenic (As)	.05*	160	11	[illegible]
Barium (Ba)	1.0*	81	0	[illegible]
Cadmium (Cd)	.01*	93	1	[illegible]
Chromium (Cr^{+6})	.05*	83	2	[illegible]
Copper (Cu)	1.0+	167	0	[illegible]
Lead (Pb)	.05*	79	3	[illegible]
Lithium (Li)	2.5+	36	3	[illegible]
Mercury (Hg)	.002*	80	0	[illegible]
Selenium (Se)	.01*	80	5	[illegible]
Silver (Ag)	.05*	74	5	[illegible]
Vanadium (V)	1+	36	0	[illegible]
Zinc (Zn)	5.0+	157	1	[illegible]

[1]Total number of wells in which the water was analyzed for the indicated constituent or characteristic.
[2]Percentage of total wells in which water exceeded the limit for the indicated constituent or characteristic.

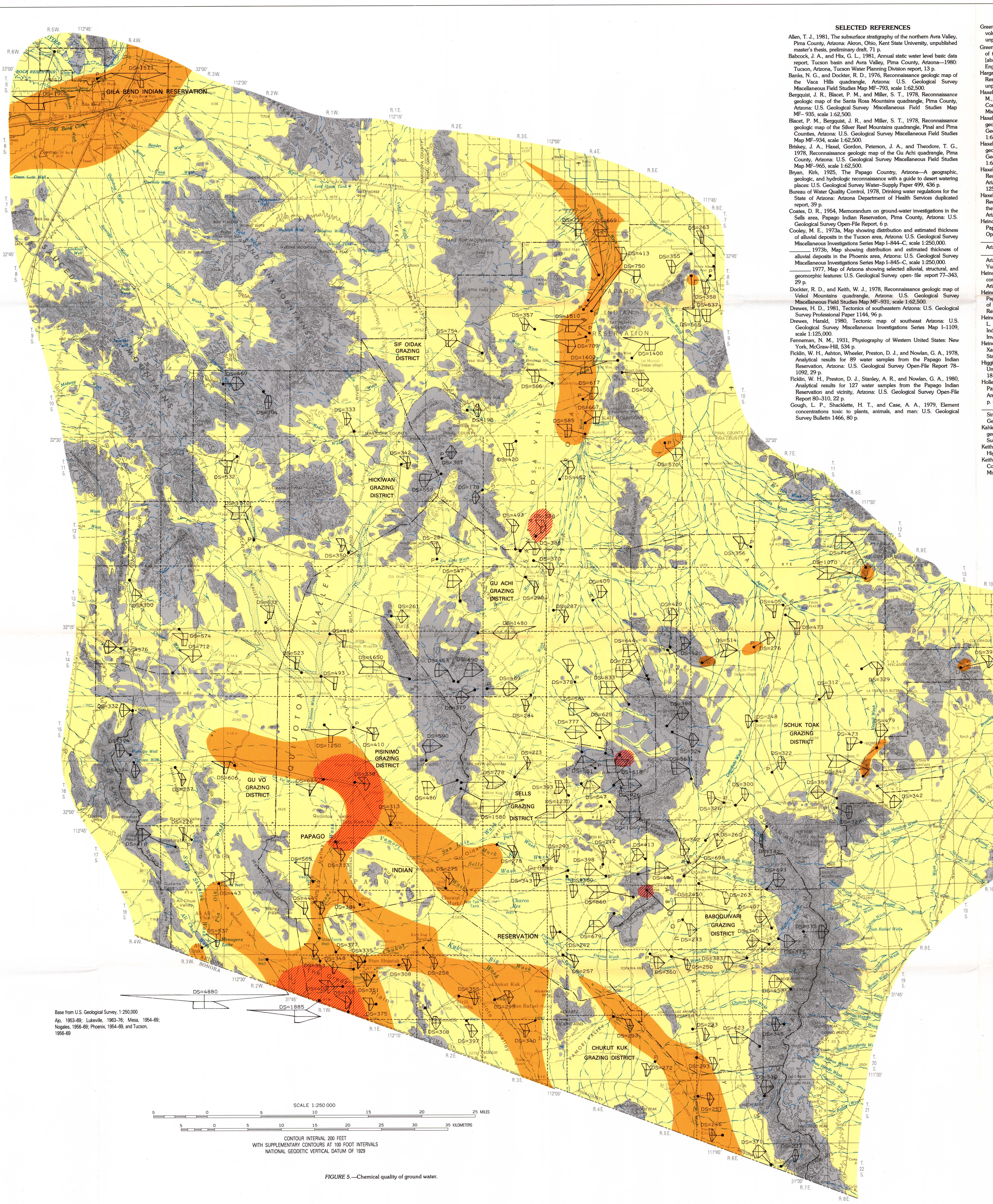

FIGURE 5.—Chemical quality of ground water.

EXPLANATION

(See table 1 for significance and occurrence of chemical properties)

Basin-fill deposits—Clay, silt, sand, and gravel and small amounts of evaporites; main water-bearing unit

Bedrock of the mountains—Crystalline and interlayered sedimentary rocks; includes some shallow sedimentary deposits in narrow mountain passes and valleys

Approximate area in which fluoride concentration in the ground water is more than 1.4 milligrams per liter

Approximate area in which arsenic concentration in the ground water is more than 0.05 milligram per liter

oP **Well from which water sample was collected in 1978–81**—Letter, P, indicates sample was collected prior to 1978. Data are shown for selected wells in areas of high well density

Chemical-quality diagram—Shows major ionic chemical constituents in milliequivalents per liter. The diagrams, by their differing shapes and sizes, graphically depict the different amounts of cations and anions that characterize the ground water

Milliequivalents per liter
Cations — Aanions
30 20 10 0 10 20 30
Sodium — Chloride
Calcium — Bicarbonate
Magnesium — Sulfate

Multiply milliequivalents per liter by factor (F) to obtain milligrams per liter

Sodium, F=23 — Chloride, F=35.5
Calcium, F=20 — Bicarbonate, F=61
Magnesium, F=12 — Sulfate, F=48

DS=1885 **Dissolved solids**—Number, 1885, is dissolved solids in milligrams per liter

Reservation boundary

Grazing-district boundary—Papago Tribe of Arizona administrative districts

CHEMICAL QUALITY OF GROUND WATER

The importance of the various chemical constituents in water depends not only on the amount of constituent present but also on the use of the water. On the reservations, ground water is used for irrigation, public supply, and livestock. Water used for public supply has the most stringent water-quality criteria.

The U.S. Environmental Protection Agency (1977a, 1977b) has established national regulations and guidelines for the quality of water provided by public water systems. Primary (mandatory) drinking-water regulations govern constituents in drinking water that have been shown to affect human health. Secondary (recommended) drinking-water regulations apply to constituents that affect esthetic quality. The primary regulations are enforceable either by the Environmental Protection Agency or by the States; in contrast, the secondary regulations are intended as guidelines and are not Federally enforceable. The regulations express limits as "maximum contaminant levels," where contaminant means any chemical, biological, or radiological substance or matter in water. Many of the limits shown in table 1 are based on these criteria. In general, water from wells that tap the bedrock is primarily of calcium magnesium bicarbonate ionic composition; whereas water from wells that tap the basin-fill deposits is primarily of sodium bicarbonate ionic composition (fig. 5). For a few wells that may tap evaporites in the basin-fill deposits, analyses indicate a sodium chloride sulfate ionic composition with large concentrations of dissolved solids. Study of 613 analyses from 297 wells shows that most well water is acceptable for human consumption, mine, livestock, or irrigation use. The concentrations of the major ions that comprise the waters are depicted in figure 5 by the differing shapes and sizes of the chemical-quality diagrams.

The maximum recommended contaminant level for dissolved solids in public water supplies is 500 mg/L (milligrams per liter), as proposed in the secondary drinking-water regulations of the U.S. Environmental Protection Agency (1977b, p. 17146). Dissolved-solids concentrations range from 178 to 4,880 mg/L; most public water supplies within the reservations contain less than 500 mg/L of dissolved solids (fig. 5).

The maximum contaminant level for dissolved solids in irrigation water is not as easily defined as that for public supplies. For the classification of salinity hazards in irrigation water, the dissolved-solids limits are arbitrary because it is related not only to the total dissolved solids but to individual ions, type of soil, crop, and reduction in crop yield. The following guidelines for dissolved-solids values for irrigation water are modified from the National Academy of Sciences and National Academy of Engineering (1973, p. 335).

Classification	Dissolved solids (milligrams per liter)
Water for which no detrimental effects are usually noticed	Less than 500
Water that can have detrimental effects on sensitive crops.	500–1,000
Water that can have adverse effects on many crops; requires careful management practices.	1,000–2,000
Water that can be used for tolerant plants on permeable soils with careful management practices.	2,000–5,000

Generally, the irrigable soils of the reservations are fine grained and poorly drained. Large concentrations of sodium and bicarbonate ions in water can further impair the physical structure of the soils and reduce the permeability. Therefore, use of water with large sodium and bicarbonate concentrations for irrigation necessitates more careful soil-management practices than is indicated by the relatively low dissolved-solids concentrations.

The concentrations of individual constituents discussed in table 1 vary widely throughout the reservations; however, some general trends are evident. Water in wells that tap the bedrock generally has larger concentrations of trace metals and silica and contains significantly more dissolved solids than water in the basin-fill deposits. The ionic exchange of calcium and magnesium for sodium as the water passes from the bedrock of the mountains to the basin-fill deposits reduces the hardness. Arsenic and fluoride tend to be concentrated in particular areas of the reservations (fig. 5). High arsenic levels are mainly in a few basin areas where wells probably tap thick sequences of basin-center clay. Large concentrations of fluoride, unlike those of arsenic, tend to have a wider distribution; however, no particular rock type or reservation area is indicated as the source for the fluoride in the water.

SUMMARY AND CONCLUSIONS

The maps presented in this report are intended to provide a general description of the geohydrologic conditions in the Papago, San Xavier, and Gila Bend Indian Reservations—lands of the Papago Tribe of Arizona—and to provide information useful in developing and using the ground water.

Surface-water resources are not of sufficient quantity to be of use for irrigation, mining, and public supply. Some surface water, however, is used for livestock.

The main water-bearing unit in the three reservations is the basin-fill deposits. A saturated volume of sediment more than 200 ft thick in a zone of the basins where the basin fill ranges from 500 to 2,000 ft thick generally will yield more than 2,000 gal/min of ground water to properly designed and constructed wells. About 12 million acre-ft of ground water is available from the uppermost 100 ft of the saturated basin fill. Ground-water availability from the basin centers is variable, but generally is reliable for small villages and livestock uses. Surficial deposits that overlie the pediments generally are not a reliable source of ground water.

Water is available from the bedrock, but the bedrock generally does not provide a dependable source of water supply because of seasonal availability, high variability in water yields, and poor chemical quality.

Pumping of ground water on the reservations has been minimal. Pumping in areas adjacent to some parts of the reservations, however, has resulted in significant water-level declines on the reservations.

The chemical quality of the water from the basin-fill deposits generally is acceptable for public supply except in areas where fluoride and arsenic concentrations exceed established limits. Large sodium and bicarbonate concentrations in the ground water used for irrigation may require careful soil-management practices to preclude detrimental alteration of soils.

CONVERSION FACTORS

For readers who prefer to use the International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain (SI) unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

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