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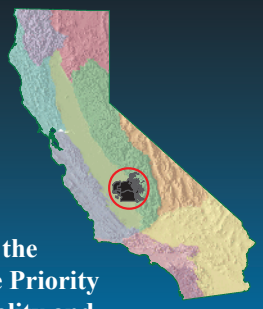
CALIFORNIA Water Boards

U.S. Geological Survey and the California State Water Resources Control Board

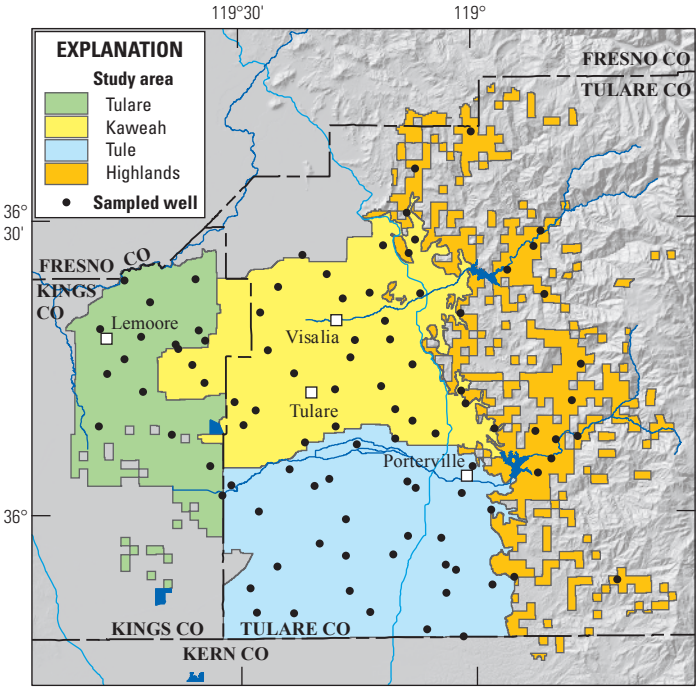
Groundwater Quality in the Shallow Aquifers of the Tulare, Kaweah, and Tule Groundwater Basins and Adjacent Highlands areas, Southern San Joaquin Valley, California



Groundwater provides more than 40 percent of California's drinking water. To protect this vital resource, the State of California created the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The Priority Basin Project of the GAMA Program provides a comprehensive assessment of the State's groundwater quality and increases public access to groundwater-quality information. The shallow aquifers of the Tulare, Kaweah, and Tule groundwater basins and adjacent highlands areas of the southern San Joaquin Valley constitute one of the study units being evaluated.

The Tulare Shallow Aquifer Study Unit

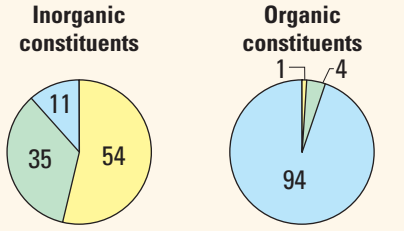
The Tulare Shallow Aquifer study unit covers approximately 2,320 square miles and consists of the Tulare, Kaweah, and Tule groundwater basins of the southern San Joaquin Valley and adjacent highlands of the Sierra Nevada (California Department of Water Resources, 2003; Bennett and others, 2017). The freshwater aquifer system in the groundwater basins is composed of Quaternary-age alluvial and fluvial sediments primarily derived from the Sierra Nevada to the east and is divided into upper and lower zones by a clay-rich lacustrine unit, the Corcoran Clay (Faunt, 2009). The highlands have fractured-rock aquifers composed primarily of Mesozoic-age granitic rocks. The hydrology of the southern San Joaquin Valley has been extensively altered by human activity, especially by agricultural development (Faunt, 2009). This study examined the quality of groundwater resources used for domestic drinking-water supply. Domestic wells in the study unit typically are drilled to depths of 150 to 500 feet (Bennett and others, 2017), which is shallower than the depths of public-supply wells in the same area (typically 300 to 1,400 feet deep; Burton and others, 2012). Water quality varies with depth in the groundwater system.



Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal Area Conic Projection, standard parallels are 29° 30" and 45° 30"; North American Datum of 1983

This study was designed to provide a statistically representative assessment of groundwater resources used for domestic drinking water (Bennett and others, 2017). A total of 96 wells, distributed across the study unit, were sampled between November 2014 and April 2015. Previous groundwater studies in this area have found that nitrate, fumigants, microbial indicators, and several trace elements are present at elevated concentrations in some domestic wells (Burow and others, 1998; Jurgens and others, 2010; Harter and Lund, 2012; California State Water Resources Control Board, 2016).

Overview of Water Quality



Values indicate percentages of the area of the groundwater resources used for domestic drinking water with concentrations in the specified categories.

GAMA's Priority Basin Project evaluates the quality of untreated groundwater. For context, however, concentrations measured in groundwater are compared to benchmarks established for drinking-water quality, such as maximum contaminant levels (MCL). A concentration above a benchmark is defined as high. Benchmarks and definitions of moderate and low concentrations are discussed in the inset box on page 3.

Many inorganic constituents are present naturally in groundwater, and their concentrations can be affected by natural processes as well as by human activities. In the Tulare Shallow Aquifer study unit, one or more inorganic constituents were present at high concentrations in about 54 percent of the groundwater resources used for domestic drinking water.

Organic constituents are found in products used in the home, business, industry, and agriculture and can enter the environment through normal usage, spills, or improper disposal. Some organic constituents also can have natural sources, such as petroleum deposits. In this study unit, organic constituents were present at high concentrations in about 1 percent of the groundwater resources used for domestic drinking water.

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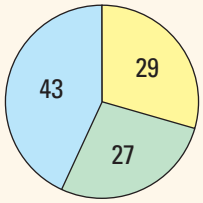
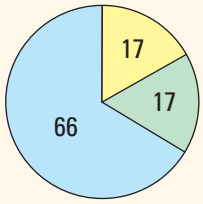
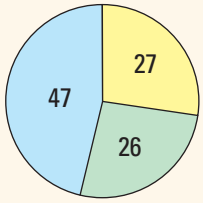
INORGANIC CONSTITUENTS



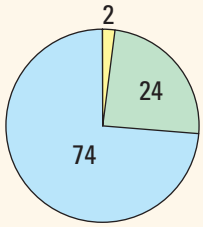
Trace elements



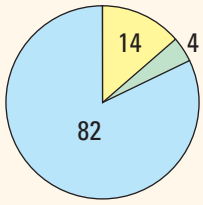
Uranium and radioactive constituents



Nitrates



Total dissolved solids



Manganese or iron

Inorganic Constituents with Human-Health Benchmarks

Trace elements are naturally present in the minerals of rocks and sediments and in the water that comes into contact with those materials. In the Tulare Shallow Aquifer study unit, one or more trace elements were present at high concentrations in about 29 percent of the groundwater resources used for domestic drinking water. Four trace elements were present at concentrations above benchmarks: arsenic (19 percent), molybdenum (8 percent), vanadium (4 percent), and manganese (3 percent).

Radioactivity is the release of energy or energetic particles during spontaneous decay of unstable atoms. Most of the radioactivity in groundwater comes from the decay of isotopes of uranium and thorium in minerals in aquifer materials. Radioactive constituents were at high levels in about 17 percent of the groundwater resources used for domestic drinking water. Uranium, gross beta-particle activity, and adjusted gross alpha-particle activity were the radioactive constituents present at high levels.

Nutrients, including nitrate, are naturally present at low concentrations in groundwater, and high concentrations generally result from human activities. Common sources of nutrients include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nitrate was present at high concentrations in about 27 percent of the groundwater resources used for domestic drinking water.

Inorganic Constituents with Non-Health Benchmarks

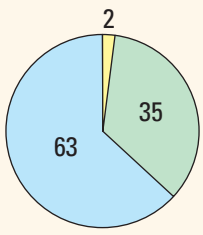
(Not included in water-quality overview charts shown on the front page)

Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents were non-regulatory secondary maximum contaminant level benchmarks.

Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater, and all water naturally contains TDS as a result of the weathering and dissolution of minerals in rocks and sediments. The State of California has a recommended and an upper limit for TDS in drinking water. TDS concentrations were high (greater than the upper limit) in about 2 percent of the groundwater resources used for domestic drinking water.

Anoxic conditions (low amounts of dissolved oxygen) can result in release of manganese, iron, and other associated trace elements from minerals into groundwater. The non-health benchmark for manganese has a lower concentration than the health-based benchmark (table on bottom of next page). Manganese or iron was present at concentrations above benchmarks set for aesthetic concerns in about 14 percent of the groundwater resources used for domestic drinking water.

SPECIAL-INTEREST CONSTITUENT



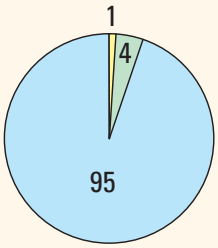
Perchlorate

Perchlorate

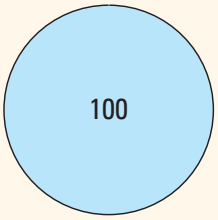
(Not included in water-quality overview charts shown on the front page)

Perchlorate is an inorganic constituent that has been regulated in California drinking water since 2007. It is an ingredient in rocket fuel, fireworks, safety flares, and some fertilizers and also can be naturally present at low concentrations in groundwater. Perchlorate was present at high concentrations in about 2 percent of the groundwater resources used for domestic drinking water.

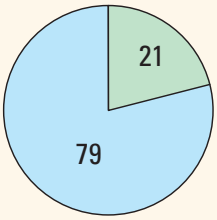
ORGANIC CONSTITUENTS



Fumigants



Other VOCs and Pesticides



Total coliforms

Organic Constituents with Human-Health Benchmarks

The Priority Basin Project uses laboratory methods that can detect low concentrations of volatile organic compounds (VOCs) and pesticides, far below human-health benchmarks. Pesticides and VOCs detected at these very low concentrations can be used to help trace water from the landscape into the aquifer system.

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens, lawns, around buildings, and along roads to help control unwanted vegetation, insects, fungi, and other pests. In the Tulare Shallow Aquifer study unit, fumigants were present at high concentrations in about 1 percent of the groundwater resources used for domestic drinking water. 1,2-Dibromo-3-chloropropane (DBCP) was present at high and moderate concentrations, and ethylene dibromide (EDB) was present at moderate concentrations. The use of DBCP as a soil fumigant was discontinued in California in 1977, and the use of EDB ended in 1983. No other pesticide compounds were found at high or moderate concentrations.

Many household, commercial, and industrial products, including solvents, gasoline components, and refrigerants, contain VOCs. Except for fumigants, no VOCs were found at high or moderate concentrations.

Microbial Indicator Constituents

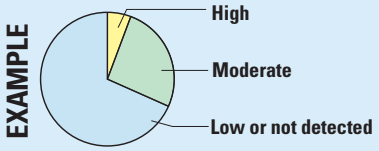
(Not included in water-quality overview charts shown on the front page)

Microbial indicator constituents are used to evaluate the potential for fecal contamination of water sources. In the Tulare Shallow Aquifer study unit, total coliforms were detected at 21 percent of the wells sampled. Total coliforms have natural and human sources. *Escherichia coli* (*E. coli*) were not detected.

BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

GAMA's Priority Basin Project uses benchmarks established for drinking water to provide context for evaluating the quality of groundwater. The quality of drinking water can differ from the quality of groundwater because of contact with household plumbing, exposure to the atmosphere, or water treatment. Federal and California regulatory benchmarks for protecting human health (maximum contaminant level, MCL) are used when available. Otherwise, non-regulatory benchmarks for protecting human health (lifetime health advisory level, HAL, and notification level, NL) and non-regulatory benchmarks for protecting aesthetic properties, such as taste and odor (secondary maximum contaminant level, SMCL) are used.

CONSTITUENT CONCENTRATIONS



Pie-chart slice sizes correspond with percentages of the area of the groundwater resources used for domestic drinking water with concentrations in the specified categories.

High, moderate, and low concentrations are defined relative to benchmarks

Concentrations are considered high if they are greater than a benchmark. For inorganic constituents, concentrations are moderate if they are greater than one-half of a benchmark. For organic constituents, concentrations are moderate if they are greater than one-tenth of a benchmark. Low concentrations include non-detections and values less than moderate concentrations. Methods for evaluating water quality are discussed by Burton and others (2012) and Bennett and others (2017).

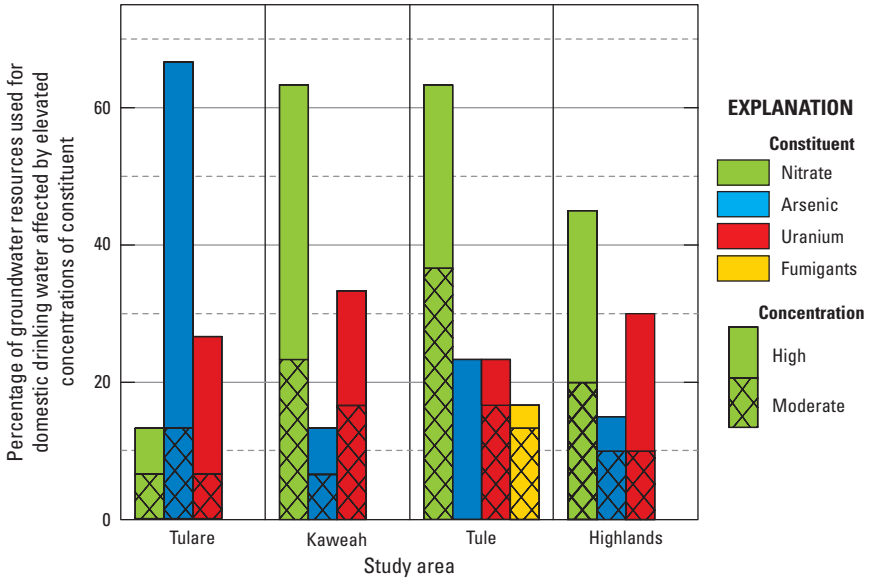
Benchmark type and value for selected constituents.

[**Benchmark types**: California, State Water Resources Control Board Division of Drinking Water; Federal, U.S. Environmental Protection Agency; HAL, lifetime health advisory; MCL, maximum contaminant level; NL, notification level; SMCL, secondary maximum contaminant level. **Abbreviations**: pCi/L, picocuries per liter; ppb, parts per billion or micrograms per liter (µg/L); ppm, parts per million or milligrams per liter (mg/L)]

Constituent	Benchmark		Constituent	Benchmark	
	Type	Value		Type	Value
Arsenic	Federal MCL	10 ppb	Nitrate, as nitrate	Federal MCL	45 ppm
Molybdenum	Federal HAL	40 ppb	Total dissolved solids (TDS)	California SMCL	1,000 ppm
Vanadium	California NL	50 ppb	Iron	California SMCL	300 ppb
Manganese	Federal HAL	300 ppb	Manganese	California SMCL	50 ppb
Uranium	Federal MCL	30 ppb	Perchlorate	California MCL	6 ppb
Gross beta particle activity	Federal MCL	50 pCi/L	DBCP	Federal MCL	0.2 ppb
Gross alpha particle activity	Federal MCL	15 pCi/L	EDB	Federal MCL	0.05 ppb

Factors that Affect Groundwater Quality

Nitrate, arsenic, uranium, and fumigants were the constituents present at high or moderate concentrations in the largest percentages of the groundwater resources used for domestic drinking water in the Tulare Shallow Aquifer study unit. Nitrate and uranium concentrations in San Joaquin Valley groundwater have increased as land-use and water-use patterns have changed (Burow and others, 1998; Jurgens and others, 2010); groundwater resources with moderate concentrations currently could be susceptible to high concentrations in the future. The Tulare study area had the greatest percentage of the groundwater resource with high or moderate concentrations of arsenic, whereas the Kaweah and Tule study areas had the greatest percentages with high or moderate concentrations of nitrate. The percentages with high or moderate concentrations of uranium were similar in the four study areas, and only the Tule study area had high or moderate concentrations of fumigants. These differences in water quality reflect differences among the four study areas in the composition of the rocks or sediments that compose the aquifers, geochemical conditions in the aquifers that affect mobility of constituents, agricultural practices on the land overlying the aquifers, and other factors.



By Miranda S. Fram

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Priority Basin Assessments

GAMA's Priority Basin Project (PBP) assesses water quality in groundwater resources used for drinking-water supply. This study in the Tulare, Kaweah, and Tule groundwater basins and adjacent highlands areas focused on groundwater resources used for domestic drinking water. Domestic wells typically tap shallower parts of aquifer systems than public-supply wells, and water quality can vary with depth in aquifer systems. Ongoing assessments are being carried out in more than 120 basins and areas outside of basins throughout California.

The PBP assessments compare constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic concerns. The PBP does not evaluate the quality of drinking water.

The PBP uses two scientific approaches for assessing groundwater quality. The first approach uses a network of wells to statistically assess the status of groundwater quality. The second approach combines water-quality, hydrologic, geographic, and other data to help assess the factors that affect water quality. In the Tulare Shallow Aquifer study unit, data were collected by the PBP in 2014–2015. The PBP includes chemical analyses not generally available as part of regulatory compliance monitoring, including measurements at concentrations lower than human-health benchmarks and measurement of constituents that can be used to trace the sources and movement of groundwater.

For more information

Technical reports and hydrologic data collected for the GAMA Program may be obtained from:

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Telephone number: (916) 278-3000
WEB: *http://ca.water.usgs.gov/gama*

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