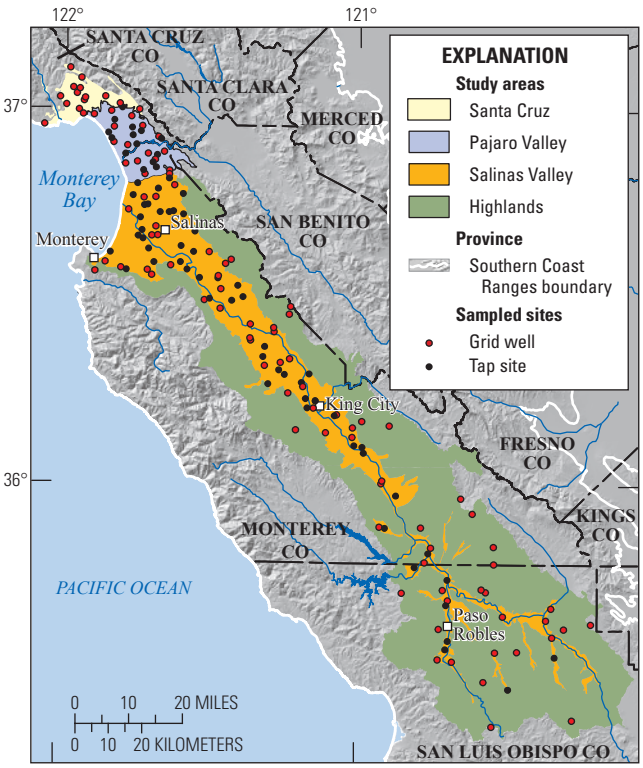
U.S. Geological Survey and the California State Water Resources Control Board

Groundwater Quality in the Shallow Aquifers of the Monterey Bay, Salinas Valley, and Adjacent Highland Areas, 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 groundwater basins around Monterey Bay, the Salinas Valley, and the highlands adjacent to the Salinas Valley constitute one of the study units.

The Monterey-Salinas Shallow Aquifer Study Unit

The Monterey-Salinas Shallow Aquifer study unit covers approximately 7,820 square kilometers (km^2) in Santa Cruz, Monterey, and San Luis Obispo Counties in the Central Coast Hydrologic Region of California. The study unit was divided into four study areas—Santa Cruz, Pajaro Valley, Salinas Valley, and Highlands. More than 75 percent of the water used for drinking-water supply in the Central Coast Hydrologic Region of California is groundwater, and there are more than 8,000 well driller's logs for domestic wells (California Department of Water Resources, 2013).

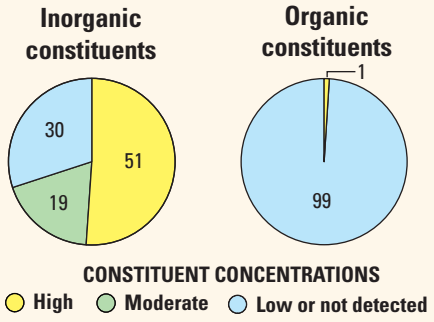


Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal-Area Conic projection, standard parallels are 29°30' N. and 45°30' N.; North American Datum of 1983

The source of groundwater in the shallow aquifer system in Santa Cruz, Pajaro Valley, and Salinas Valley study areas is primarily sediments in the Purisima Formation, the Aromas Sand, the Monterey Formation, and Holocene alluvial deposits; the source of groundwater in the Highlands study area is aquifers in granitic, metamorphic, or lithified sedimentary rocks (California Department of Water Resources, 2003; Hanson, 2003).

This study was designed to provide a statistically representative assessment of the quality of groundwater resources used for domestic drinking water. A total of 100 wells and 70 household tap sites were sampled between October 2012 and May 2013 (Goldrath and others, 2016). Domsetic wells in the study unit typically were drilled to depths of 7–275 meters (Goldrath and others, 2016), which is shallower than the depths of public-supply wells in the same area (typically 20–600 meters deep; Kulongoski and Belitz, 2011). Previous studies in the area have indicated water-quality issues, including seawater intrusion and elevated concentrations of nitrate, arsenic, boron, molybdenum, and gross alpha radioactivity (Hanson, 2003; Kulongoski and Belitz, 2011; Harter and others, 2012).

Overview of Water Quality



Values are a percentage of the area of the groundwater resources used for domestic drinking water with concentrations in the three specified categories.

The GAMA Priority Basin Project evaluates the quality of untreated groundwater. For context, 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 on page 3.

Many inorganic constituents are natural in groundwater, and their concentrations can be affected by natural processes as well as by human activities. In the Monterey-Salinas Shallow Aquifer study unit, one or more inorganic constituents were present at high concentrations in about 51 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. Organic constituents were present at high concentrations in less than 1 percent of the groundwater resources used for domestic drinking water.

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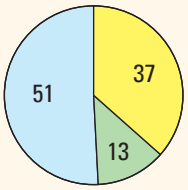
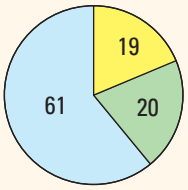
INORGANIC CONSTITUENTS

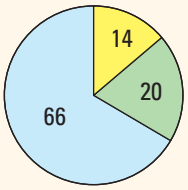
Trace elements



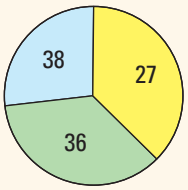
Uranium and radioactive constituents



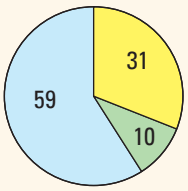
Nitrates



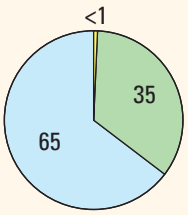
Total dissolved solids



Manganese or iron



Perchlorate



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 Monterey-Salinas Shallow Aquifer study unit, one or more trace elements were present at high concentrations in about 37 percent of the groundwater resources used for domestic drinking water. Six trace elements were present at concentrations above benchmarks: arsenic (4 percent), boron (2 percent), molybdenum (14 percent), selenium (3 percent), strontium (10 percent), and manganese (6 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 natural isotopes of uranium and thorium in minerals in the aquifer materials. Radioactive constituents were at high levels in about 19 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 are a result of 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 14 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 (SMCL) benchmarks.

Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater, and all water naturally contains TDS from 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 (see next page). Concentrations of TDS were high (greater than the upper limit) in about 27 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 (SMCL) benchmark for manganese has a lower concentration than the health-based screening level (HBSL; see table on next page). Manganese or iron was present at high concentrations in about 31 percent of the groundwater resources used for domestic drinking water.

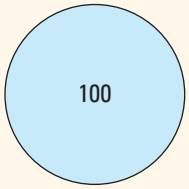
Perchlorate

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

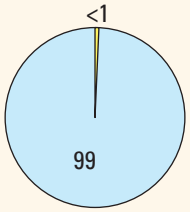
Perchlorate is an inorganic constituent that has been regulated in California drinking water since 2007. It is an ingredient in rocket fuel, fireworks, safety flares, and some fertilizers and also exists naturally in groundwater at low concentrations. Perchlorate was present at high concentrations in less than 1 percent of the groundwater resources and was present at moderate concentrations in about 35 percent of the groundwater resources used for domestic drinking water.

ORGANIC CONSTITUENTS

Volatile organic compounds



Pesticides



Organic Constituents with Human-Health Benchmarks

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

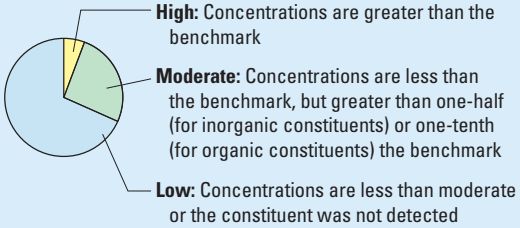
Volatile organic compounds, including solvents, gasoline components, and refrigerants, are present in many household, commercial, and industrial products. No VOCs were detected at high or moderate concentrations in the groundwater resources used for domestic drinking water in the Monterey-Salinas Shallow Aquifer study unit. Low concentrations of VOCs consist of detections of VOCs in 17 percent of the groundwater resources and were not detected in 83 percent.

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. Pesticides were not detected at high concentrations in the groundwater resources used for domestic drinking water. Fumigants are VOCs, but were grouped with the pesticides because of how they are used. The fumigant 1,2-dichloropropane was detected at moderate concentrations in 0.7 percent of the groundwater resource.

Methods for Evaluating Groundwater Quality

This study compared benchmarks established for drinking water to analytical results 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. The U.S. Environmental Protection Agency and California State Water Resources Control Board Division of Drinking Water regulatory benchmarks for the protection of human health (maximum contaminant level, MCL) were used for comparison when available. Otherwise, non-regulatory benchmarks for protection of aesthetic and technical properties, such as taste and odor (secondary maximum contaminant level, SMCL), and non-regulatory benchmarks for the protection of human health (health-based screening level, HBSL) and lifetime-health advisory levels (HAL) were used. Water quality in domestic wells is not regulated in California.

Pie diagrams are used to summarize groundwater-quality results. The pie slices represent the percentages of the groundwater resources with high, moderate, and low concentrations of a constituent. Methods for calculating these percentages are discussed by Burton and Wright (2018).



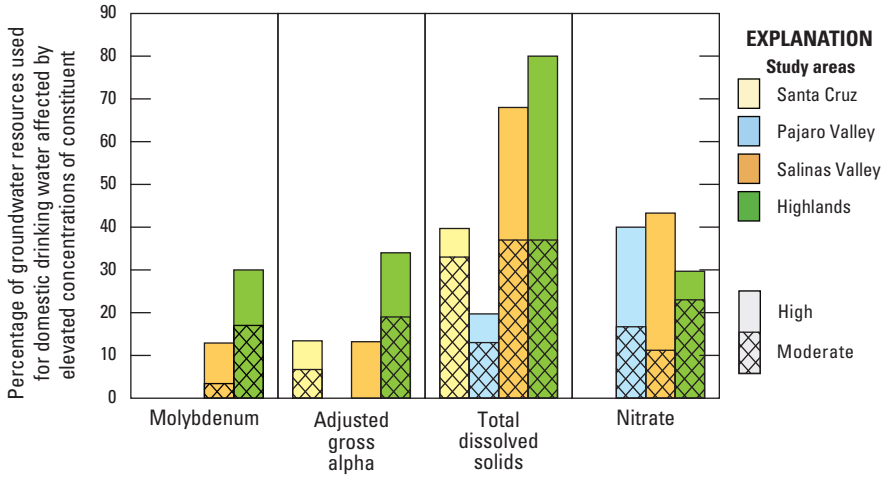
Benchmark type and value for selected constituents.

[Constituents are listed in the order in which they are discussed in this fact sheet. **Benchmark types:** CA, California State Water Resources Control Board Division of Drinking Water; EPA, U.S. Environmental Protection Agency; Federal HBSL, health-based screening level; HAL, lifetime-health advisory level; MCL, maximum contaminant level; SMCL, secondary maximum contaminant level. **Abbreviations:** pCi/L, picocuries per liter; ppb, parts per billion (equivalent to micrograms per liter); ppm, parts per million (equivalent to milligrams per liter]

Constituent	Benchmark		Constituent	Benchmark	
	Type	Value		Type	Value
Arsenic	EPA MCL	10 ppb	Nitrate as nitrogen	EPA MCL	10 ppm
Boron	Federal HBSL	6,000 ppb	Total dissolved solids (TDS) (upper and recommended)	CA MCL	1,000 ppm
Molybdenum	EPA HAL	40 ppb			500 ppm
Selenium	EPA MCL	50 ppb	Manganese	CA SMCL	50 ppb
Strontium	EPA HAL	4,000 ppb		Federal HBSL	300 ppb
Uranium	EPA MCL	30 ppb	Iron	CA SMCL	300 ppb
Gross alpha particle activity	EPA MCL	15 pCi/L	1,2-Dichloropropane	EPA MCL	5 ppb
Gross beta particle activity	CA MCL	50 pCi/L	Perchlorate	CA MCL	6 ppb

Factors that Affect Groundwater Quality

Nitrate, total dissolved solids (TDS), molybdenum, and adjusted gross alpha radioactivity were the constituents present at high or moderate concentrations in the greatest percentages of the groundwater resources used for domestic drinking water in the Monterey-Salinas Shallow Aquifer study unit. The Highlands study area had the greatest percentage of the groundwater resource with high or moderate concentrations of molybdenum, adjusted gross alpha radioactivity, and TDS, whereas the Pajaro Valley and Salinas Valley study areas had the greatest percentages with high or moderate concentrations of nitrate. The Santa Cruz study area had the smallest percentages of high and moderate concentrations of molybdenum and nitrate. 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. Nitrate concentrations in the Salinas Valley groundwater increased in response to irrigated agriculture and the use of nitrate fertilizers and animal waste (Moran and others, 2011; Harter and others, 2012); groundwater resources that have moderate concentrations could be susceptible to high concentrations in the future. Molybdenum, gross alpha radioactivity, and TDS were constituents naturally present in the minerals of rocks and sediments and in the water that comes into contact with those materials.



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Priority Basin Assessments

The GAMA Priority Basin Project (PBP) assesses water quality in groundwater resources used for public and domestic drinking-water supplies. This study of the groundwater basins around Monterey Bay, the Salinas Valley, and the adjacent highlands focused on groundwater resources used for domestic drinking water. 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 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 Monterey-Salinas Shallow Aquifer study unit, data were collected by the PBP in 2012–13. The PBP includes chemical analyses not generally available as part of regulatory compliance monitoring, including measurements at concentrations much lower than human-health benchmarks and measurements 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
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