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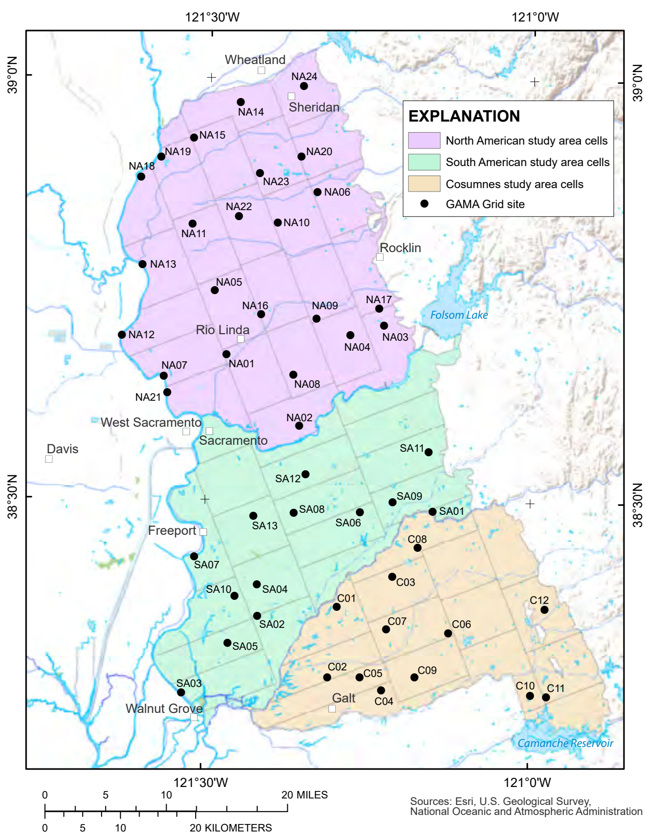
U.S. Geological Survey and the California State Water Resources Control Board

Groundwater Quality in the Sacramento Metropolitan Shallow Aquifer, 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 assesses the quality of groundwater resources used for drinking water supply and increases public access to groundwater-quality information. Many households in the Sacramento metropolitan area rely on private wells for their drinking water supplies.

The Sacramento Metropolitan Groundwater Basins

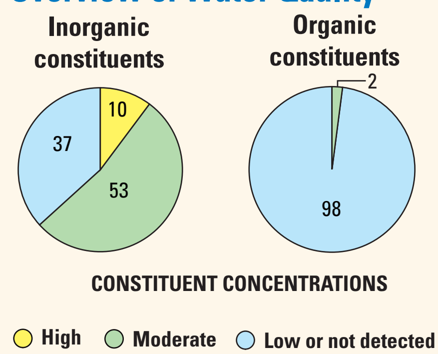
The Sacramento metropolitan (SacMetro) study unit covers approximately 3,250 square kilometers of the Central Valley along the eastern edge of the northern and southern ends of the San Joaquin and Sacramento Valleys, respectively. Groundwater withdrawals supply a significant portion of the water-resource needs of the region. In the southern portion of the study unit, groundwater accounts for nearly 90 percent of water demand in the area (South Area Water Council, 2011).



Groundwater sampled in the SacMetro study unit comes from alluvial aquifers primarily composed of sediments derived from the Sierra Nevada Mountains to the east. Recharge to the groundwater system is primarily from the streams draining the Sierra Nevada, and from precipitation and infiltration of applied irrigation water (California Department of Water Resources, 2003). The public-supply aquifer system assessments of this area in 2005 found elevated concentrations of inorganic constituents including arsenic, iron, and manganese as well as of solvents in some wells (Bennett and others, 2010; 2011).

This study was designed to provide a statistically representative assessment of the quality of groundwater resources used for domestic drinking water in the SacMetro study unit. A complete listing of what was measured, including the sampling results, are presented in Bennett and others, 2019. A total of 49 wells were sampled between July 2017 and November 2017 (Bennett and others, 2019). The wells in the study were 32–160 meters deep, and water levels were 1–62 meters below land surface.

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.

GAMA's Priority Basin Project evaluates the quality of untreated groundwater. However, 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 in the pie diagram inset in this report.

Many inorganic constituents naturally occur in groundwater. The concentrations of the inorganic constituents can be affected by human activities as well as natural processes. In the SacMetro study unit, one or more inorganic constituents were present at high concentrations in about 10 percent of the groundwater resources used for domestic drinking water.

Man-made organic constituents are found in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal usage, spills, or improper disposal. Organic constituents were not present at high concentrations in the groundwater resources used for domestic drinking water in the SacMetro study unit.

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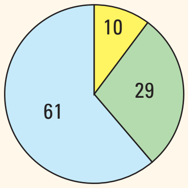
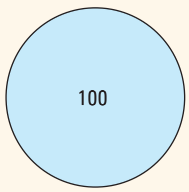
INORGANIC CONSTITUENTS

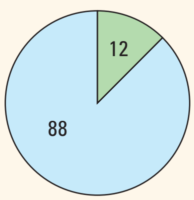
Trace elements



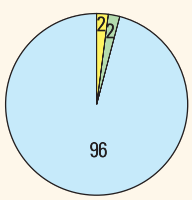
Uranium and radioactivity



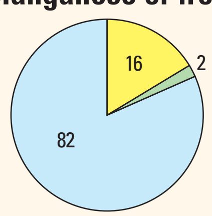
Nitrate



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 groundwater that comes into contact with those materials. About 10 percent of the groundwater resources used for domestic drinking water in the SacMetro study unit had high concentrations of trace elements and about 29 percent had moderate concentrations. Arsenic was present at high concentrations, and hexavalent chromium was present at moderate concentrations.

Most of the radioactivity in groundwater comes from the decay of naturally occurring isotopes of uranium, thorium, and potassium in minerals in aquifer materials. Radioactive constituents were not present at high or moderate levels in the groundwater resources used for domestic drinking water.

Nitrate is naturally present at low concentrations in groundwater, but moderate and high concentrations generally indicate contamination from human activities. Common sources of nutrients include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. High concentrations of nitrate were not detected in groundwater resources used for domestic drinking water in the SacMetro study unit. About 12 percent of the study unit had moderate concentrations.

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. 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. Total dissolved solids were present at high concentrations (greater than the upper limit) in about 2 percent, and at moderate concentrations (between the recommended and upper limits) in about 2 percent of the groundwater resources used for domestic drinking water.

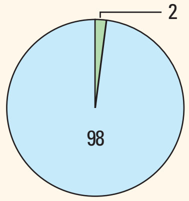
Anoxic conditions in groundwater (low amounts of dissolved oxygen) can result in the release of natural manganese, iron, and other associated trace elements from minerals into groundwater. Anoxic conditions also can promote degradation of nitrate and increases in dissolved arsenic.

Manganese or iron was present at high concentrations in about 16 percent of the groundwater resources used for domestic drinking water. High concentrations of manganese accounted for the majority of the high proportion category calculation.

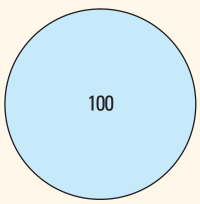
RESULTS: Groundwater Quality in the Sacramento Metropolitan Shallow Aquifer, California

ORGANIC CONSTITUENTS

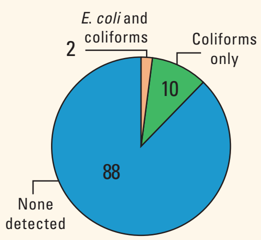
Volatile organic compounds



Pesticides



Microbial indicators



Organic Constituents with Human-Health Benchmarks

The Priority Basin Project used laboratory methods that can detect low concentrations of volatile organic compounds (VOCs) and pesticides that are 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 into the aquifer system.

Volatile organic compounds are present in many household, commercial, and industrial products. No VOCs were detected at high concentrations in the groundwater resources used for domestic drinking water in the SacMetro study unit, and only one moderate concentration of trichloromethane (chloroform) was detected. Low concentrations of VOCs present in commonly used solvents or in gasoline were detected in about 24 percent of the groundwater resources.

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 or moderate concentrations in the groundwater resources used for domestic drinking water. Low concentrations of insecticides or herbicides were detected in about 37 percent of the groundwater resources.

Microbial Indicators

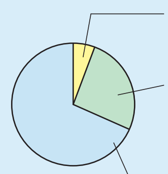
(*Not included in water-quality overview charts shown on the front page*)

Microbial indicators are used to evaluate the potential for fecal contamination of water sources. In the SacMetro, total coliforms and *Escherichia coli* (*E. coli*) were detected in 2 percent of the wells sampled, and total coliforms alone were detected in another 10 percent of the wells sampled. Total coliforms are naturally present in soils and in digestive tracts of animals, whereas *E. coli* specifically indicate contamination with animal (or human) fecal waste (California State Water Resources Control Board, 2016). The pie diagram for microbial constituents uses different colors than the other pie diagrams because the benchmarks for microbial constituents specify repeat sampling to confirm detections, which was not done in this study.

Methods 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. The U.S. Environmental Protection Agency (EPA) and California State Water Resources Control Board Division of Drinking Water (CA) regulatory benchmarks for protecting human health (maximum contaminant level; MCL, and treatment technique; TT) are used when available. Otherwise, non-regulatory benchmarks for protecting aesthetic and technical properties, such as taste and odor (secondary maximum contaminant level; SMCL) and non-regulatory benchmarks for protecting human health (notification levels; NL, lifetime health advisory levels; HAL, or USGS defined health-based screening level; HBSL) 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 Fram and Belitz (2014).



High: Concentrations are greater than the benchmark

Moderate: Concentrations are less than the benchmark, but greater than one-half (for inorganic constituents) or one-tenth (for organic constituents) of the benchmark

Low: Concentrations are less than moderate or the constituent was not detected

Benchmark type and value for selected constituents.

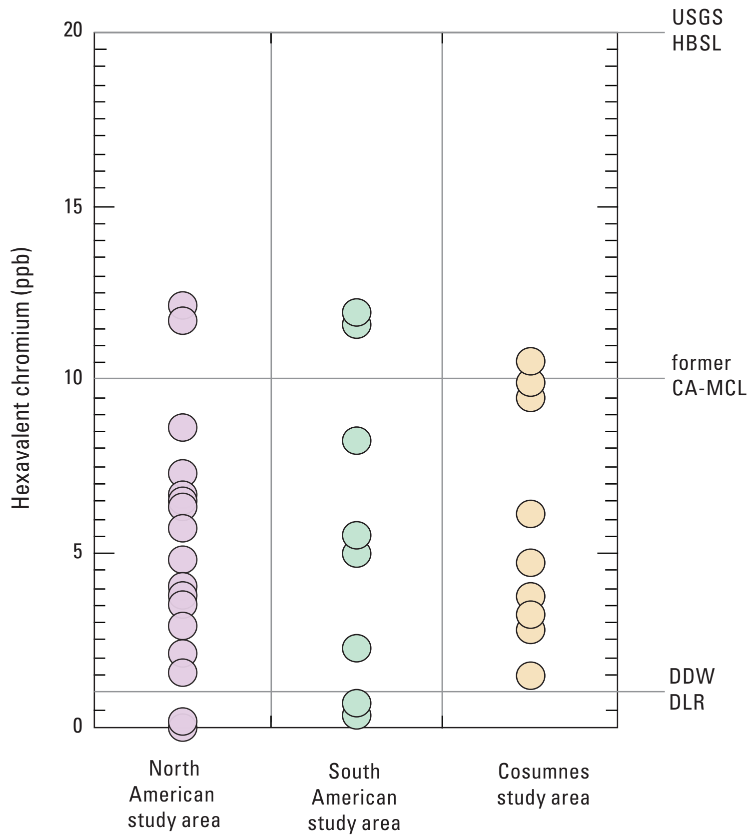
[**Benchmark types**: CA-MCL, California State Water Resources Control Board Division of Drinking Water (CA) maximum contaminant level; CA-SMCL, CA secondary maximum contaminant level; EPA-MCL, U.S. Environmental Protection Agency (EPA) maximum contaminant level; EPA-TT, EPA treatment technique; USGS-HBSL, U.S. Geological Survey health-based screening level. **Abbreviations**: ppb, parts per billion (equivalent to micrograms per liter); ppm, parts per million (equivalent to milligrams per liter); >, greater than]

Constituent	Benchmark		Constituent	Benchmark	
	Type	Value		Type	Value
Arsenic	EPA-MCL	10 ppb	Manganese	CA-SMCL	50 ppb
Hexavalent chromium	USGS-HBSL	20 ppb	Iron	CA-SMCL	300 ppb
Nitrate, as nitrogen	EPA-MCL	10 ppm	Total dissolved solids, upper	CA-MCL	1,000 ppm
			Total dissolved solids, recommended	CA-MCL	500 ppm
			Escherichia coli (*E. coli*)	EPA-MCL	Repeat detection at a site
			Total coliform	EPA-TT	>5 percent of samples with detections per month

Hexavalent Chromium Occurrence

Hexavalent chromium was detected at concentrations above the SWRCB DDW detection level for reporting (DLR) in samples from nearly all the SacMetro wells. During 2014–17, California had an MCL for hexavalent chromium of 10 parts per billion (California State Water Resources Control Board, 2017). Of the 49 wells sampled, 5 had concentrations greater than the former California maximum contaminant level (CA-MCL), and if the former CA-MCL were used as the comparison benchmark, about 10 percent of the groundwater resources used for domestic supply would have concentrations above the benchmark (high), and 25 percent between the benchmark and half of the benchmark (moderate).

Chromium is naturally present in some aquifer sediments, in particular, sediments derived from ultramafic rocks and serpentinites (Izbicki and others, 2015). Under anoxic conditions, chromium exists as trivalent chromium and is generally not very soluble in groundwater. Under oxic conditions, chromium exists as hexavalent chromium and can be soluble in groundwater. Anthropogenic uses of hexavalent chromium, including as a rust inhibitor, in manufacture of stainless steel, and other industrial processes, could also result in contamination of groundwater with hexavalent chromium (California State Water Resources Control Board, 2017).



By George L. Bennett V

References Cited

Bennett, G.L.V, Fram, M.S., Belitz, K., and Jurgens, B.C., 2010, Status and understanding of groundwater quality in the northern San Joaquin Basin, 2005—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2010–5175, 82 p., https://doi.org/10.3133/sir20105175.

Bennett, G.L.V, Fram, M.S., and Belitz, K., 2011, Status of groundwater quality in the southern, middle, and northern Sacramento Valley study units, 2005–2008—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2011–5002, 120 p., https://doi.org/10.3133/sir20115002.

Bennett, G.L., Shelton, J.L., and Jasper, M., 2019, Groundwater data for the Sacramento Metropolitan Shallow Aquifer study unit, California GAMA Priority Basin Project: U.S. Geological Survey Data Release, https://doi.org/10.5066/P9BPGEGH.

California Department of Water Resources, 2003, California's groundwater: California Department of Water Resources Bulletin 118, 246 p., https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/Statewide-Reports/Bulletin_118_Update_2003.pdf.

California State Water Resources Control Board, 2016, Groundwater information sheet—Bacterial indicators: State Water Resources Control Board Division of Water Quality GAMA Program, 7 p., https://www.waterboards.ca.gov/gama/docs/coc_bacteria_indicators.pdf.

California State Water Resources Control Board, 2017, Groundwater information sheet—Hexavalent chromium: State Water Resources Control Board Division of Water Quality GAMA Program, 8 p., https://www.waterboards.ca.gov/water_issues/programs/gama/docs/coc_hexchromcr6.pdf.

Fram, M.S., and Belitz, K., 2014, Status and understanding of groundwater quality in the Sierra Nevada Regional study unit, 2008—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2014–5174, 118 p., https://pubs.usgs.gov/sir/2014/5174/.

Izbicki, J.A., Wright, M.T., Seymour, W.A., McCleskey, R.B., Fram, M.S., Belitz, K., and Esser, B.K., 2015, Cr(VI) occurrence and geochemistry in water from public-supply wells in California: Applied Geochemistry, v. 63, p. 203–217, https://doi.org/10.1016/j.apgeochem.2015.08.007.

South Area Water Council, 2011, South basin groundwater management plan: South Area Water Council, 152 p., http://www.sscawa.org/sscawa/projectdocs/SOUTH_BASIN_GMP_FINAL_2011.pdf.

For more information

Technical reports and hydrologic data collected for the GAMA Program's Priority Basin Project may be obtained from:

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