Groundwater-Quality Data in the Bear Valley and Selected Hard Rock Areas Study Unit, 2010: Results from the California GAMA Program

Data Series 747

U.S. Department of the Interior
U.S. Geological Survey

Groundwater-Quality Data in the Bear Valley and Selected Hard Rock Areas Study Unit, 2010: Results from the California GAMA Program

By Timothy M. Mathany and Kenneth Belitz

A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Prepared in cooperation with the California State Water Resources Control Board

Data Series 747

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

Contents

Figures

Tables

Tables—Continued

Conversion Factors and Datums

Inch/Pound to SI

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
quart (qt)	0.9464	liter (L)
pound, avoirdupois (lb)	0.4536	kilogram (kg)

SI to Inch/Pound

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.2808	foot (ft)
kilometer (km)	0.6214	mile (mi)
square kilometer (km^2)	0.3861	square mile (mi^2)
liter (L)	1.0567	quart (qt)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound, avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F=(1.8×°C)+32.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Milligrams per liter is equivalent to parts per million (ppm), and micrograms per liter is equivalent to parts per billion (ppb).

Concentrations of radioactive constituents in water (except uranium) are given in picocuries per liter (pCi/L).

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Land-surface altitude, as used in this report, refers to distance above the vertical datum and is reported as feet above mean sea level (ft above msl).

Selected Terms and Symbols

α	significance level
x	activities of a radioactive constituent in a groundwater sample
y	activities of a radioactive constituent in a replicate sample
cm³ STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
$\delta^i E$	delta notation, the ratio of a heavier isotope of an element ($^i E$) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil
=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
x	multiplied by
N	normal (1-gram-equivalent per liter of solution)
—	not detected
p	p-value (probability)
pH	a measure of the acidity or basicity of a solution
$pK_{1,2}$	negative logarithms of the acid dissociation constants for carbonic acid
pK_w	negative logarithm of the acid dissociation constant of water
R	ratio
σ	sigma (standard deviation)
±	plus or minus
*	concentration greater than the benchmark level
**	concentration greater than the upper benchmark level

Abbreviations and Acronyms

AL	action level
AL-US	action level (USEPA)
APE	Alternate Place Entry program designed for USGS sampling
BEAR	Bear Valley and Selected Hard Rock Areas study unit
BEAR-G	Selected Hard Rock Areas study area (grid site)
BEAR-S	Bear Valley study area (grid site)
BEAR-U	Bear Valley and Selected Hard Rock Areas study unit (understanding site)

Abbreviations and Acronyms—Continued

CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment Program
GPS	global positioning system
HAL	lifetime health advisory level
HAL-US	lifetime health advisory level (USEPA)
IBSP	Inorganic Blind Sample Program (USGS)
I-MDL	interim method detection limit
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
MCL	maximum contaminant level
MCL-CA	maximum contaminant level (CDPH)
MCL-US	maximum contaminant level (USEPA)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
na	not available
NAD	normalized absolute difference (between replicate analyses for a radioactive constituent)
nc	not collected
NFM	National Field Manual (USGS)
NFQA	National Field Quality Assurance Program (USGS)
NL	notification level
NL-CA	notification level (CDPH)
np	no preference
ns	not spiked (groundwater sample)
nv	no measured value or no value in category
NWIS	National Water Information System (USGS)
PBP	Priority Basin Project
PCFF	Personal Computer Field Form program designed for USGS sampling
QA	quality assurance

Abbreviations and Acronyms—Continued

QC	quality control
RL	reporting level
RPD	relative percent difference
RSD	relative standard deviation
RSD5-US	risk-specific dose at a risk factor of 10^{-5} (USEPA)
SD	standard deviation
SMCL	secondary maximum contaminant level
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting level (concentration cutoff for applying the $\leq$ symbol in reporting results)
ssL_C	sample-specific critical level
UV	ultraviolet
VPDB	Vienna Pee Dee Belemnite (the international reference standard for carbon isotopes)
VSMOW	Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency)
WIC	wastewater indicator compound

Organizations

BQS	Branch of Quality Systems (USGS)
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
LLNL	Lawrence Livermore National Laboratory, Livermore, California
NAWQA	National Water-Quality Assessment Program (USGS)
NELAP	National Environmental Laboratory Accreditation Program
NIST	National Institute of Standards and Technology
NRP	National Research Program (USGS)
NWQL	National Water Quality Laboratory, Denver, Colorado (USGS)
SITL	Stable Isotope and Tritium Laboratory, Menlo Park, California (USGS)
SWRCB	California State Water Resources Control Board
TML	Trace Metal Laboratory, Boulder, Colorado (USGS)
USEPA	U.S. Environmental Protection Agency

Organizations—Continued

USGS   U.S. Geological Survey

Weck   Weck Laboratories, Inc., City of Industry, California

Selected Chemical Names

$CaCO_3$ calcium carbonate

CO_3^{2-} carbonate ion

CFC-11   trichlorofluoromethane

1,1-DCA   1,1-dichloroethane

1,1-DCE   1,1-dichloroethene

DOC   dissolved organic carbon

H_2O water

HCl   hydrochloric acid

HCO_3^- bicarbonate ion

MTBE   methyl *tert*-butyl ether

NDMA   *N*-nitrosodimethylamine

PCE   perchloroethene (tetrachloroethene)

SiO_2 silicon dioxide

1,1,1-TCA   1,1,1-trichloroethane

TCE   trichloroethene

1,2,3-TCP   1,2,3-trichloropropane

TDS   total dissolved solids

THM   trihalomethane

VOC   volatile organic compound

Groundwater-Quality Data in the Bear Valley and Selected Hard Rock Areas Study Unit, 2010: Results from the California GAMA Program

By Timothy M. Mathany and Kenneth Belitz

Abstract

Groundwater quality in the 112-square-mile Bear Valley and Selected Hard Rock Areas (BEAR) study unit was investigated by the U.S. Geological Survey (USGS) from April to August 2010, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP). The GAMA-PBP was developed in response to the California Groundwater Quality Monitoring Act of 2001 and is being conducted in collaboration with the SWRCB and Lawrence Livermore National Laboratory (LLNL). The BEAR study unit was the thirty-first study unit to be sampled as part of the GAMA-PBP.

The GAMA Bear Valley and Selected Hard Rock Areas study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer system and to facilitate statistically consistent comparisons of untreated groundwater quality throughout California. The primary aquifer system is defined as the zones corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the BEAR study unit. Groundwater quality in the primary aquifer system may differ from the quality in the shallow or deep water-bearing zones; shallow groundwater may be more vulnerable to surficial contamination.

In the BEAR study unit, groundwater samples were collected from two study areas (Bear Valley and Selected Hard Rock Areas) in San Bernardino County. Of the 38 sampling sites, 27 were selected by using a spatially distributed, randomized grid-based method to provide statistical representation of the primary aquifer system in the study unit (grid sites), and the remaining 11 sites were selected to aid in the understanding of the potential groundwater-quality issues associated with septic tank use and with ski areas in the study unit (understanding sites).

The groundwater samples were analyzed for organic constituents (volatile organic compounds [VOCs], pesticides and pesticide degradates, pharmaceutical compounds, and wastewater indicator compounds [WICs]), constituents of special interest (perchlorate, N-nitrosodimethylamine [NDMA], and 1,2,3-trichloropropane [1,2,3-TCP]), and inorganic constituents (trace elements, nutrients, dissolved organic carbon [DOC], major and minor ions, silica, total dissolved solids [TDS], alkalinity, and arsenic and iron species), and uranium and other radioactive constituents (radon-222 and activities of tritium and carbon-14). Isotopic tracers (of hydrogen and oxygen in water, of nitrogen and oxygen in dissolved nitrate, of dissolved boron, isotopic ratios of strontium in water, and of carbon in dissolved inorganic carbon) and dissolved noble gases (argon, helium-4, krypton, neon, and xenon) were measured to help identify the sources and ages of sampled groundwater. In total, groundwater samples were analyzed for 289 unique constituents and 8 water-quality indicators in the BEAR study unit.

Quality-control samples (blanks, replicate pairs, or matrix spikes) were collected at 13 percent of the sites in the BEAR study unit, and the results for these samples were used to evaluate the quality of the data from the groundwater samples. Blank samples rarely contained detectable concentrations of any constituent, indicating that contamination from sample collection or analysis was not a significant source of bias in the data for the groundwater samples. Replicate pair samples all were within acceptable limits of variability. Matrix-spike sample recoveries were within the acceptable range (70 to 130 percent) for approximately 84 percent of the compounds.

This study did not evaluate the quality of water delivered to consumers. After withdrawal, groundwater typically is treated, disinfected, and (or) blended with other waters to maintain water quality. Regulatory benchmarks apply to water that is delivered to the consumer, not to untreated groundwater. However, to provide some context for the results, concentrations of constituents measured in the untreated groundwater were compared with regulatory and non-regulatory health-based benchmarks established by the U.S. Environmental Protection Agency (USEPA) and CDPH, and to non-health-based benchmarks established for aesthetic concerns by CDPH. Comparisons between data collected for this study and benchmarks for drinking water are for illustrative purposes only and are not indicative of compliance or non-compliance with those benchmarks.

All concentrations of organic and special-interest constituents from grid sites sampled in the BEAR study unit were less than health-based benchmarks. In total, VOCs were detected in 17 of the 27 grid sites sampled (approximately 63 percent), pesticides and pesticide degradates were detected in 4 grid sites (approximately 15 percent), and perchlorate was detected in 21 grid sites (approximately 78 percent).

Inorganic constituents (trace elements, major and minor ions, nutrients, and uranium and other radioactive constituents) were sampled for at 27 grid sites; most concentrations were less than health-based benchmarks. Exceptions include one detection of arsenic greater than the USEPA maximum contaminant level (MCL-US) of 10 micrograms per liter (µg/L), three detections of uranium greater than the MCL-US of 30 µg/L, nine detections of radon-222 greater than the proposed MCL-US of 4,000 picocuries per liter (pCi/L), and one detection of fluoride greater than the CDPH maximum contaminant level (MCL-CA) of 2 milligrams per liter.

Concentrations of inorganic constituents with non-health-based benchmarks (iron, manganese, chloride, and TDS) were less than the CDPH secondary maximum contaminant level (SMCL-CA) in most grid sites. Exceptions include two detections of iron greater than the SMCL-CA of 300 µg/L and one detection of manganese greater than the SMCL-CA of 50 µg/L.

Introduction

About one-half of the water used for public and domestic drinking-water supply in California is groundwater (Kenny and others, 2009). To assess the quality of ambient groundwater in aquifers used for public drinking-water supply and to establish a baseline groundwater-quality monitoring program, the California State Water Resources Control Board (SWRCB), in cooperation with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program in 2000 (California Environmental Protection Agency, 2011, website at http://www.waterboards.ca.gov/water_issues/programs/gama/). The main goals of the GAMA Program are to improve groundwater monitoring and to increase the availability of groundwater-quality data to the public. The GAMA Program currently consists of four projects: (1) the GAMA Priority Basin Project (PBP) conducted by the USGS (U.S. Geological Survey, 2011a, California Water Science Center website at http://ca.water.usgs.gov/gama/); (2) the GAMA Domestic Well Project conducted by the SWRCB; (3) the GAMA Special Studies Project conducted by LLNL; and (4) GeoTracker GAMA, conducted by the SWRCB. The GAMA-PBP primarily focuses on the deep part of the groundwater resource, which is typically used for public drinking-water

supply. The GAMA Domestic Well Project generally focuses on the shallow aquifer systems, which may be particularly at risk as a result of surficial contamination. The GAMA Special Studies Project focuses on using research methods to help explain the source, fate, transport, and occurrence of chemicals that can affect groundwater quality. GeoTracker GAMA is an online database providing all published and quality-assurance/quality-control (QA/QC) approved analytical data from the GAMA Program (California State Water Resources Control Board, 2009, website at https://geotracker.waterboards.ca.gov/gama/). GeoTracker GAMA also stores groundwater-quality data and related reports collected by other State agencies, such as the California Department of Public Health (CDPH), California Department of Water Resources (CDWR), and California Department of Pesticide Regulation (CDPR), and data collected by the SWRCB and Regional Boards from groundwater monitoring wells at contaminated or remediated sites.

The GAMA Program was initiated by the SWRCB in 2000 and later expanded by the Groundwater Quality Monitoring Act of 2001 (State of California, 2001a, b, Sections 10780–10782.3 of the California Water Code, Assembly Bill 599). The GAMA-PBP assesses groundwater quality in key groundwater basins that account for more than 90 percent of all groundwater used for public supply in the State. For the GAMA-PBP, the USGS, in collaboration with the SWRCB, developed the monitoring plan to assess groundwater basins through direct and other statistically reliable sample approaches (Belitz and others, 2003; California State Water Resources Control Board, 2003). Additional partners in the GAMA-PBP include LLNL, CDPH, CDWR, CDPR, local water agencies, and well owners (Kulongoski and Belitz, 2004). Participation in the GAMA-PBP is entirely voluntary.

The GAMA-PBP is unique in California because it includes many chemical analyses that are not otherwise available in the statewide water-quality monitoring datasets. Groundwater samples collected for the GAMA-PBP are analyzed for approximately 300 chemical constituents by using methods with lower detection limits than required by the CDPH for regulatory monitoring of water from drinking-water wells. These analyses will be especially useful for providing an early indication of changes in groundwater quality. In addition, the GAMA-PBP analyzes samples for a suite of constituents more extensive than that required by the CDPH and for a suite of chemical and isotopic tracers for understanding hydrologic and geochemical processes. This understanding of groundwater composition is useful for identifying the natural and human factors affecting water quality. Understanding the occurrence and distribution of chemical constituents of significance to water quality is important for the long-term management and protection of groundwater resources.

The ranges of hydrologic, geologic, and climatic conditions in California were considered in this statewide assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics: Cascades and Modoc Plateau, Klamath Mountains, Northern Coast Ranges, Central Valley, Sierra Nevada, Basin and Range, Southern Coast Ranges, Transverse Ranges and selected Peninsular Ranges, Desert, and San Diego Drainages (fig. 1). These 10 hydrogeologic provinces include groundwater basins and subbasins designated by the CDWR (California Department of Water Resources, 2003).

Groundwater basins and subbasins generally consist of relatively permeable, unconsolidated deposits of alluvial origin. Eighty percent of California's approximately 16,000 active and standby drinking-water wells listed in the statewide database maintained by the CDPH (hereinafter referred to as CDPH wells) are located in CDWR-designated groundwater basins and subbasins within the 10 hydrogeologic provinces. Groundwater basins and subbasins were prioritized for sampling on the basis of the number of the CDPH wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and the number of registered pesticide applications (Belitz and others, 2003). Of the 472 basins and subbasins designated by the CDWR, 116 priority basins contain approximately 95 percent of the CDPH wells located in basins. In addition, some areas outside of the defined groundwater basins were included to represent the 20 percent of the CDPH wells not located in the groundwater basins. The priority basins, selected low-use basins, and selected areas outside of groundwater basins were grouped into 35 GAMA Priority Basin Project study units that together represent approximately 95 percent of all CDPH wells.

The data collected in each study unit are used for three types of water-quality assessments: (1) *Status*—assessment of the current quality of the groundwater resource; (2) *Understanding*—identification of the natural and human factors affecting groundwater quality; and (3) *Trends*—detection of changes in groundwater quality over time (Kulongoski and Belitz, 2004). The assessments are intended to characterize the quality of groundwater in the primary aquifer system of the study units, not the treated drinking water delivered to consumers by water purveyors. The primary aquifer system is defined as parts of aquifers corresponding to the perforation intervals of wells listed in the CDPH databases for the study units. The CDPH database lists wells and springs used for public drinking-water supplies and includes wells and springs from systems classified as community (such as those in cities, towns, and mobile-home parks), non-transient, non-community (such as those in schools, workplaces, and restaurants), and transient, non-community (such as those in campgrounds and parks). Collectively, the CDPH refers to these as "public-supply" wells and springs (hereinafter referred to as CDPH sites). Groundwater quality in the primary aquifer system may differ from the quality in the shallow or deep parts of the aquifer system. As a result, samples from shallow wells (such as many private domestic wells and groundwater monitoring wells) and springs can have greater concentrations of constituents (such as volatile organic compounds [VOCs], nitrate, and microbial indicators) from anthropogenic sources than samples from wells screened in the underlying primary aquifer system (U.S. Environmental Protection Agency, 2008a; Landon and others, 2010).

The Bear Valley and Selected Hard Rock Areas study unit (hereinafter referred to as the BEAR study unit) lies within the Transverse Ranges and selected Peninsular Ranges hydrogeologic province described by Belitz and others (2003) (fig. 1). Groundwater is a major source of public drinking-water supply for many of the communities located in the BEAR study unit (Big Bear Area Regional Wastewater Agency, 2011; Lake Arrowhead Community Services District, 2011a); therefore, the BEAR study unit was considered high priority for sampling to provide adequate representation of the Transverse Ranges and selected Peninsular Ranges hydrogeologic province.

This USGS Data Series Report is one of a series of reports presenting the water-quality data collected by the USGS in the BEAR study unit for the GAMA-PBP. Data Series Reports for each of the GAMA-PBP study units are available from the U.S. Geological Survey (2011b) at http://ca.water.usgs.gov/projects/gama/includes/GAMA_ publications.html.

Purpose and Scope

The purposes of this report are to describe (1) the hydrogeologic setting of the BEAR study unit, the study design, and the study methods; (2) the analytical results for groundwater samples collected in the BEAR study unit, and (3) the results of QC analyses. Groundwater samples were analyzed for water-quality indicators; organic, special-interest, and inorganic constituents; isotopic tracers; uranium and other radioactive constituents; and dissolved noble gases. The chemical data presented in this report were evaluated by comparison to State and Federal drinking-water standards. The health-based and non-health-based benchmarks considered for this report are those established by the U.S. Environmental Protection Agency (USEPA) and (or) the CDPH. Discussion of the factors that influence the distribution and occurrence of the constituents detected in groundwater samples will be the subject of subsequent publications.

Figure 1. Hydrogeologic provinces of California and the location of the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

Hydrogeologic Setting

The BEAR study unit is located in the eastern part of the San Bernardino National Forest in southern California, and covers 112 square miles (mi^2) in San Bernardino County, California (fig. 2). The BEAR study unit includes two study areas: the CDWR-defined groundwater basin of Bear Valley (California Department of Water Resources, 2003) and the USGS-defined Selected Hard Rock Areas.

The climate in the BEAR study unit is typical of mountainous areas in southern California, with warm summers and cold winters (PRISM Climate Group, 2011). General precipitation distribution in the study unit reflects a slight rain shadow effect from west to east due to the mountain peaks that separate the two study areas. Average annual rainfall totals in the study unit range from about 34 inches per year (in/yr) on the eastern slopes of the Selected Hard Rock Areas study area, to approximately 18 in/yr along the southeastern part of the Bear Valley study area (PRISM Climate Group, 2011; Western Regional Climate Center, 2011; Flint and Martin, 2012). Annual snow accumulation in the study unit averages approximately 54 in/yr at Big Bear Lake and 48 in/yr at Lake Arrowhead (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 2011; Western Regional Climate Center, 2011).

BEAR Study Unit—Bear Valley Study Area

The Bear Valley study area is 30.6 mi^2 in area and occupies the extent of the Bear Valley groundwater basin as defined by CDWR. The Bear Valley groundwater basin is an east-west trending alluvial valley surrounding Big Bear and Baldwin Lakes and is located at the base of a north-facing slope of the San Bernardino Mountains (California Department of Water Resources, 2004). The boundaries of the study area are approximately defined by the limit of Quaternary alluvial sediments of the Bear Valley groundwater basin (fig. 2).

The Bear Valley study area is surrounded by the San Bernardino Mountains, with land-surface altitudes ranging from approximately 6,700 feet above mean sea level (ft above msl) on the valley floor to over 10,200 ft above msl on the southern border. Two lakes—Big Bear and Baldwin—are the major water-body features in the study area. Big Bear Lake is a man-made lake that is used for public recreation as well as a water supply for the San Bernardino area (Big Bear Municipal Water District, 2011). The lake is fed by runoff from numerous creeks (Grout, Caribou, Rathbun, Metcalf, and Kidd) that drain the surrounding mountains and valley floor. Baldwin Lake (typically dry) receives occasional runoff from Caribou Creek and numerous intermittent streams originating from the surrounding mountains. The only significant surface-water outflow from any of the lakes is from Big Bear Lake to the west through the Bear Valley Dam and into Bear Creek, which flows into the Santa Ana River 8 miles (mi) to the south (Flint and Martin, 2012) (fig. 3A, B).

The primary aquifer system in the study area occurs in the upper and middle aquifers of a three-tiered alluvium-filled aquifer system that is underlain by basement rocks (California Department of Water Resources, 2004; Flint and Martin, 2012) (fig. 2). Recent gravity model results indicate that the alluvial deposits range from less than 500 feet (ft) thick on the edges of the study area and on the eastern end of Big Bear Lake to more than 1,500 ft thick beneath the center of Big Bear Lake and to the west of Baldwin Lake (Flint and Martin, 2012). The underlying basement rocks are of pre-Tertiary age and are principally made up of large granitic bodies and to a lesser extent metamorphosed sedimentary rock and gneiss. Fractured basement rock is known to make a small contribution to groundwater resources in the study area (California Department of Water Resources, 2004).

The upper aquifer is composed of gravel and sand deposits of Holocene age, which transmit groundwater readily. This aquifer is thin and unsaturated in the western part of the study area, but in the eastern part of the study area it reaches more than 200 ft thick (California Department of Water Resources, 2004; Flint and Martin, 2012). The middle aquifer consists of older fan deposits and older alluvium made up of various amounts of silt, gravel, sand, and clay. This aquifer is found throughout the study area and ranges from 150 ft to more than 800 ft thick. Groundwater found in the older alluvial sediments of the middle aquifer is generally confined under fine sediments, whereas groundwater found in older fan sediments are generally unconfined to semi-confined. The lower aquifer is made up of coarse sands, pebbles, gravels, and sandy clays and is likely restricted to the eastern part of the study area near Baldwin Lake (GEOSCIENCE Support Services, Inc., 2006). The deposits that make up the lower aquifer are up to 120 ft thick (California Department of Water Resources, 2004; Flint and Martin, 2012).

The general groundwater-flow direction in the study area is from the sides of the study area, following the topography of the valley towards Big Bear or Baldwin Lakes. A groundwater divide is present between Big Bear Lake and Baldwin Lake near Big Bear City. Faults may act as hydrologic barriers to groundwater movement in the study area (California Department of Water Resources, 2004).

Groundwater recharge in the study area occurs from direct percolation of precipitation, infiltration of runoff from the surrounding mountains, and underflow from fractured basement rocks (California Department of Water Resources, 2004; GEOSCIENCE Support Services, Inc., 2006; Flint and Martin, 2012). Where present, the permeable recent alluvium allows rapid infiltration of available rainfall and runoff (GEOSCIENCE Support Services, Inc., 2006; Flint and Martin, 2012).
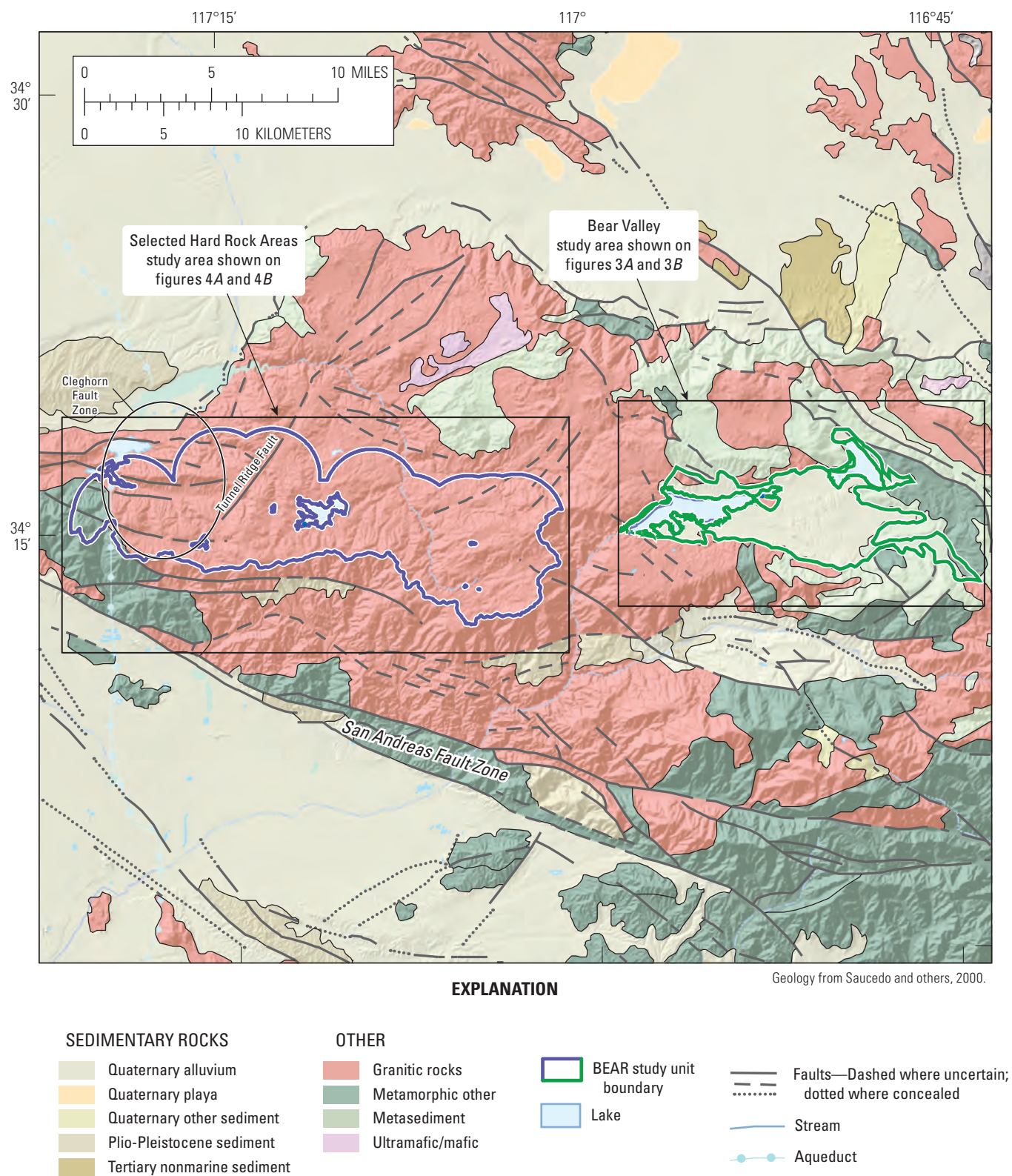
Figure 2.   Geology of the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit.
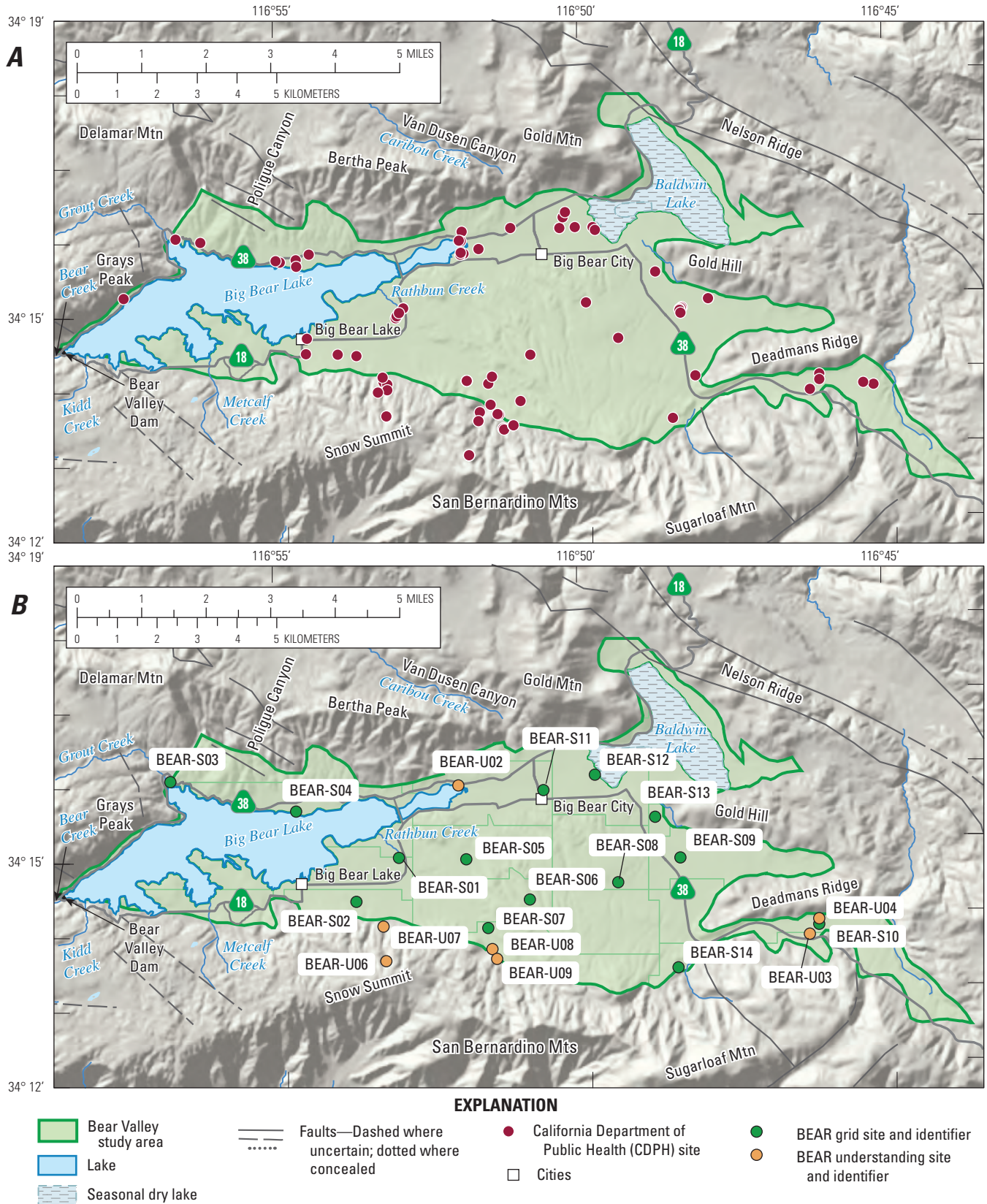
Figure 3. Boundaries of the Bear Valley study area, topographic features, major cities, major roads, and hydrologic features, (*A*) the location of California Department of Public Health (CDPH) sites, and (*B*) the distribution of the grid cells, and the location of sampled grid and understanding sites, Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

BEAR Study Unit—Selected Hard Rock Areas Study Area

The Selected Hard Rock Areas study area (hereinafter referred to as the Hard Rock study area) is 81.5 mi^2 in area, is located approximately 3 mi west of the Bear Valley study area, and is defined by the USGS as the granitic bedrock area surrounding Lake Arrowhead (fig. 2). Two major mountain peaks (Butler and Crafts) separate the eastern parts of the Hard Rock study area from the Bear Valley study area. The study area was derived from five surface-water watersheds that are in granitic bedrock (Silverwood Lake–West Fork Mojave River, Grass Valley Creek–West Fork Mojave River, Willow Creek, Upper Deep Creek, and Holcomb Creek; Watershed Boundary Dataset, U.S. Department of Agriculture–Natural Resources Conservation Service and others, 2013) located on the north-facing slope of the San Bernardino Mountains. The study area was defined as those parts of the five surface-water watersheds that are within 1.86-mi (3-kilometer [km]) radius buffers (circles) around the CDPH wells located in those watersheds (fig. 4) (additional discussion in the section titled "Study Design").

Land-surface altitudes in the study area range from approximately 3,200 ft above msl near Silverwood Lake in the western part of the study area, to more than 7,800 ft above msl at Keller Peak, in the San Bernardino Mountains. The western reaches of the study area are drained by the West Fork of the Mojave River to Silverwood Lake, north to the Mojave River Forks Reservoir. The eastern parts of the study area are drained by Deep Creek and its numerous tributaries northward to the Mojave River Forks Reservoir. Small ephemeral streams drain the central parts of the study area towards Lake Arrowhead (fig. 4). Two man-made lakes—Arrowhead and Silverwood—are the largest surface-water features in the study area. Lake Arrowhead, which provides some water supply to the local community and the San Bernardino area, is also a private recreational facility (Arrowhead Lake Association, 2011; Lake Arrowhead Community Services District, 2011b).

Silverwood Lake was created as part of the California State Water Project and is a water source for the communities in the nearby mountain and desert areas (California Department of Water Resources, 2011a, b).

The primary aquifer system in the study area consists of the fractured granite bedrock of the western part of the Bear Valley study area (fig. 2). The primary aquifer system is considered to be confined to semi-confined. In the Lake Arrowhead area, the hard rock aquifer is known to extend to a depth of 500 ft (GEOSCIENCE Support Services, Inc., 2008). In addition to the production wells that are drilled into the granitic bedrock, numerous springs and horizontal wells are a major source of water in the study area (Lake Arrowhead Community Services District, 2011a). These springs and horizontal wells flow under artesian conditions for all or most of the year (GEOSCIENCE Support Services, Inc., 2008; California Department of Public Health, 2009). Additionally, throughout the study area, a layer of thin alluvial deposits derived from weathering and erosion of the surrounding mountains overlies the granitic bedrock (GEOSCIENCE Support Services, Inc., 2008). The effect that these alluvial deposits have on the hard rock aquifer system is unknown.

Groundwater flow in the study area is through numerous fracture systems related to local and regional faults (fig. 2). The largest of these is the Cleghorn fault zone, which is located in the western part of the study area (Bryant, 2003). The Tunnel Ridge Fault (also known as the Tunnel Ridge Lineament) is a significant northeast-trending fault that is known to transport groundwater in the northern and central parts of the study area (Bryant, 1987). There are also unnamed faults in the northeastern part of the study area (fig. 4), but the effect of these faults on groundwater movement is not known.

Groundwater recharge in the study area occurs from the ambient recharge of runoff and snowmelt that penetrates the granitic bedrock through faults and fractures at high elevations in the surrounding mountains (Lake Arrowhead Community Services District, 2011c).
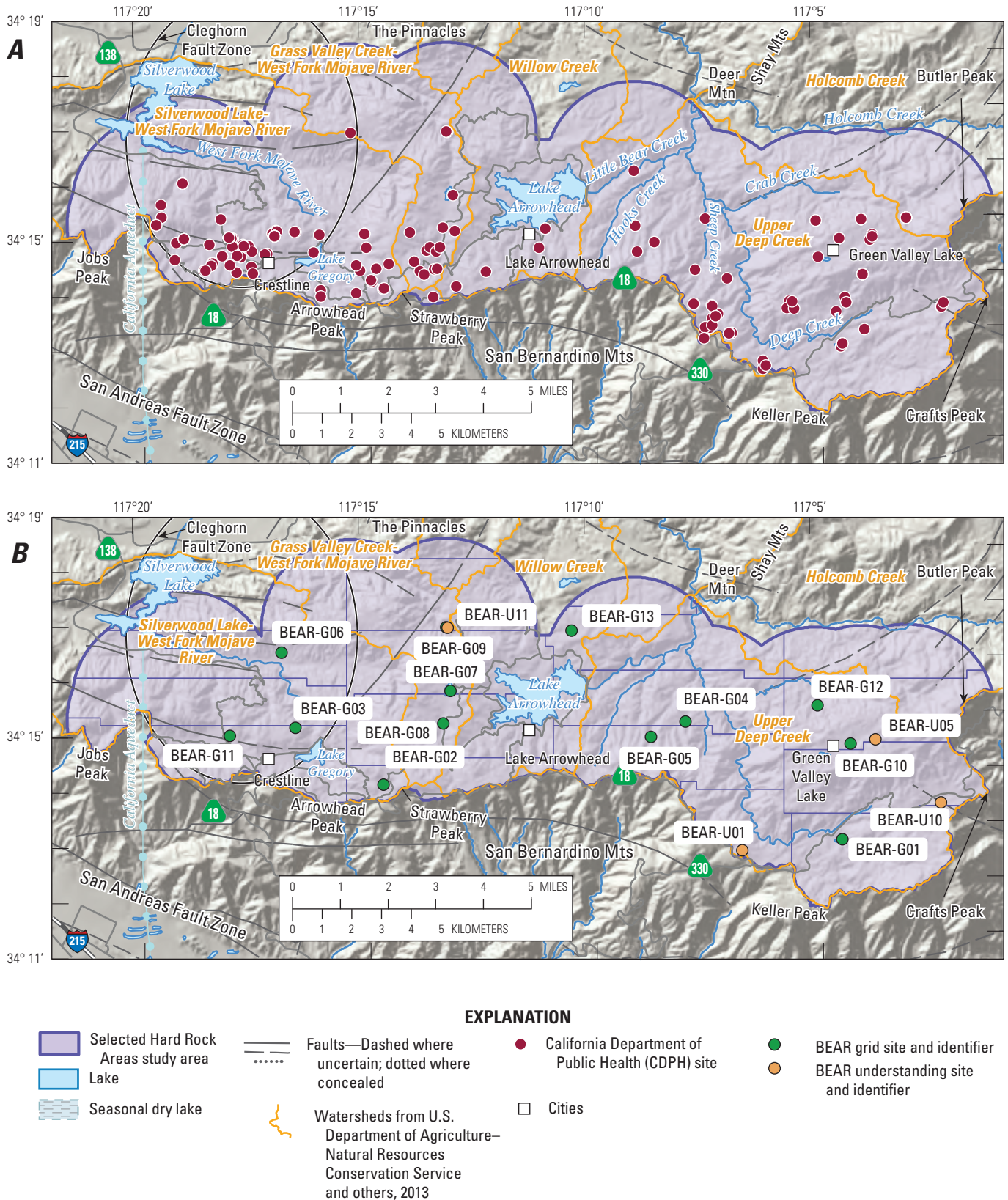
Figure 4. Boundaries of the Selected Hard Rock Areas study area, topographic features, major cities, major roads, hydrologic features, (*A*) the location of California Department of Public Health (CDPH) sites, and (*B*) the distribution of the grid cells, and the location of sampled grid and understanding sites, Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

Methods

Methods used for the GAMA-PBP were selected to achieve the following objectives: (1) collect groundwater samples that are statistically representative of the primary aquifer system in each study unit; (2) collect samples in a consistent manner; (3) analyze samples by using proven and reliable laboratory methods; (4) assure the quality of the groundwater data; and (5) maintain data securely and with relevant documentation. The appendix contains detailed descriptions of the sample-collection protocols, analytical methods, and the QC data analysis.

Study Design

The wells and springs (hereinafter referred to as "sites") selected for sampling in the BEAR study unit reflect the combination of two site-selection strategies. For the first strategy, 27 randomized sites were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater used for public drinking-water supply. Sites sampled as part of the spatially distributed, randomized grid-cell network, hereinafter, are referred to as "grid sites." For the second strategy, 11 non-randomized sites (hereinafter referred to as "understanding sites") were sampled in the Bear Valley and Hard Rock study areas to aid in the understanding of the groundwater-quality issues associated with septic tank use and also ski area land use.

The spatially distributed grid sites were selected by using a randomized grid-based method (Scott, 1990). The randomized grid-based method divides a study area into equal-area grid cells; however, geographic features may force a grid cell to be divided into multiple pieces to obtain the designated coverage area for each cell. For instance, a part of a grid cell may be located on either side of a mountain range, but the grid cell is still considered one grid cell.

In the BEAR study unit, the approach was to sample one available CDPH site located within each grid cell. If a grid cell contained more than one CDPH site, each was randomly assigned a rank. The highest ranking CDPH site that met basic sampling criteria (for example, sampling point located prior to treatment or capability to pump for several hours) was sampled. If a grid cell contained no accessible CDPH sites, then other types of sites, such as domestic or irrigation wells, were considered for sampling. These non-CDPH sites were identified from USGS well databases or by door-to-door canvassing. When applicable, non-CDPH wells with depths and screened intervals similar to those in CDPH wells in the area were selected.

The Bear Valley study area was divided into 15 equal-area grid cells, each approximately 1.6 mi^2 (approximately 4.2 square kilometers [km^2]) in area; grid sites in 14 of the 15 cells were sampled (fig. 3B). The Hard Rock study area was divided into 15 equal-area grid cells, each approximately 5.4 mi^2 (approximately 14.1 km^2) in area; grid sites in 13 of the 15 cells were sampled (fig. 4B).

The design of the grid cells varied between the Bear Valley and Hard Rock study areas because of differences in the distributions of CDPH sites. In the Bear Valley study area, CDPH sites are fairly evenly distributed throughout the entire study area (fig. 3A). Consistent with GAMA-PBP design in other study units with regularly distributed CDPH sites, the 15 grid cells cover the entire CDWR-defined Bear Valley groundwater basin (fig. 3B).

In contrast, CDPH sites in the surface-water watersheds in granitic rock on the north-facing slope of the San Bernardino Mountains are not evenly distributed over the area (fig. 4A). To minimize the number of cells without any sites, only parts of the watersheds near CDPH sites were included in the gridded area. A 1.86-mi (3-km) radius circle (buffer) was drawn around each CDPH site, and the collective area encompassed by the circles was divided into 15 grid cells (fig. 4B). This strategy has been used in other GAMA-PBP study units with few and (or) unevenly distributed CDPH sites (Fram and Belitz, 2007; Shelton and others, 2013).

The 27 grid sites (20 wells and 7 springs; table 1) sampled in the BEAR study unit were numbered in the order in which samples were collected in each study area with the suffix varying by geologic formations: "S" for the sedimentary deposits of the Bear Valley study area and "G" for the granitic rocks of the Hard Rock study area (figs. 3B, 4B).

The 11 understanding sites (6 wells and 5 springs; table 1) sampled as part of the BEAR study unit were not included in the statistical characterization of water quality because inclusion of these sites would lead to the overrepresentation of some grid cells. Of the understanding sites, four were selected specifically to gain information about possible occurrence of nitrate in groundwater due to septic system use. Five of the understanding sites were selected to investigate potential water-quality issues associated with ski areas. These 11 additional sites were numbered in the order of sample collection with the prefix: "BEAR-U" ("U" indicates "understanding") (figs. 3B, 4B).

The GAMA alphanumeric identification number for each sample, along with the date sampled, land-surface altitude, site type, and available construction information is shown in table 1. Groundwater samples were collected from 26 production wells (25 CDPH wells and 1 domestic well) and 12 springs (10 CDPH springs and 2 springs used for industrial activity) during the time period from April to August 2010.

Site locations were verified by using a global positioning system (GPS), 1:24,000-scale USGS topographic maps, existing well information in USGS and CDPH databases, and information provided by well owners, drillers' logs, and other sources of site information. Site and sample information was recorded in the field by hand on field sheets, and electronically on field laptop computers using the Alternate Place Entry (APE) program designed by the USGS. All information was verified and entered into the USGS National Water Information System (NWIS) database. Site owner, site use, and site location are not published.

Sample Collection and Analysis

Samples were collected in accordance with the USGS National Field Manual (NFM) (U.S. Geological Survey, variously dated) and modified USGS National Water-Quality Assessment (NAWQA) Program (Koterba and others, 1995) sampling protocols. These sampling protocols were followed so that samples representative of groundwater in the aquifer system were collected at each site and so that the samples were collected and handled in ways that minimized the potential for contamination. Use of the sampling protocols also allows comparison with data collected by GAMA-PBP throughout California and with other USGS projects in California and the Nation.

All 38 sites in the BEAR study unit were sampled for a standard constituent group (table 2). Groundwater samples were analyzed for 85 VOCs (table 3A); 83 pesticides and pesticide degradates (table 3B); 14 pharmaceutical compounds (table 3C); 3 constituents of special interest (table 3E); 25 trace elements (table 3F); 5 nutrients and dissolved organic carbon (DOC) (table 3G); 9 major and minor ions, silica, total dissolved solids (TDS), and laboratory alkalinity (table 3H); arsenic and iron species (table 3I); and 5 dissolved noble gases, 8 isotopic tracers, uranium, and 3 other radioactive constituents (table 3J). In addition, 9 of the BEAR-U sites were sampled for 60 wastewater indicator compounds (WICs) (table 3D), and 8 of the BEAR-U sites had field alkalinity measured (table 2). The methods used for sample collection and analysis are described in the appendix section titled "Sample Collection and Analysis."

Data Reporting

Many of the constituents presented in this report have different laboratory reporting conventions; additionally, some of the constituents were analyzed by different analytical laboratories or methods. The appendix section titled "Data Reporting" gives details about the laboratory reporting conventions for all constituents and the method preferences for those constituents that were analyzed by multiple methods or by multiple laboratories in the BEAR study unit.

Quality-Assurance Methods

The QA/QC procedures used for this study followed the protocols described in the NFM (U.S. Geological Survey, variously dated) and used by the NAWQA Program (Koterba and others, 1995). The QA plan followed by the National Water Quality Laboratory (NWQL), the primary laboratory used to analyze samples for this study, is described in Pirkey and Glodt (1998) and Maloney (2005). QC samples collected in the BEAR study unit are blank samples, replicate pair samples, and matrix- and surrogate-spike samples. QC samples were collected to evaluate potential contamination, as well as bias and variability of the data that may have resulted from sample collection, processing, storage, transportation, and laboratory analysis. QA/QC procedures and results are described in the appendix section titled "Quality-Assurance and Quality-Control Methods and Results."

Quality-Control Results

Results of QC analyses (blank samples, replicate pair samples, and matrix- and surrogate-spike samples) were used to evaluate the quality of the data for the groundwater samples. On the basis of detections in laboratory and field blank samples collected for this and for previous GAMA-PBP study units, the laboratory reporting levels (LRLs) for 19 constituents were raised in this report (Olsen and others, 2010; Fram and Belitz, 2011; Fram and others, 2012). The GAMA Program refers to these raised reporting levels as "study reporting levels" (SRLs). Detections of two VOCs (toluene and 1,2,4-trimethylbenzene), five pharmaceutical compounds (acetaminophen, caffeine, carbamazepine, 1,7-dimethylxanthine, and sulfamethoxazole) and one WIC [tris(2-butoxyethyl) phosphate] with concentrations less than their respective SRLs were reclassified as non-detections and not presented in this report to reduce the likelihood of reporting results that could be false positives. Detections of 11 inorganic constituents (chromium, cobalt, copper, iron, lead, manganese, nickel, tungsten, zinc, fluoride, and DOC) with concentrations less than their respective SRLs are flagged with a less than or equal to symbol ($\leq$) in this report because the concentrations of these constituents could be less than or equal to the reported value (see table A3 and additional discussion in the appendix section titled "Blank Samples"). Variability for all of the replicate pair samples for constituents detected in samples was within the acceptable limits. Results from the replicate pairs confirm that the procedures used to collect and analyze the samples did not introduce unacceptable levels of contamination or variability (see table A4A–C and additional discussion in the appendix section titled "Replicate Pairs"). Median matrix-spike sample recoveries for 37 of the 232 organic and special-interest constituents analyzed were outside of the acceptable range of between 70 and 130 percent. Constituents with low recoveries might not have been detected in some samples if they were present at concentrations near the LRLs, and constituents with high recoveries may indicate that reported values could be greater than what is in the sample (see table A5B-C and additional discussion in the appendix section titled "Matrix Spikes").

Comparison Benchmarks

Concentrations of constituents detected in groundwater samples were compared with USEPA and CDPH regulatory and non-regulatory drinking-water health-based benchmarks and benchmarks established for aesthetic purposes (California Department of Public Health, 2008a, b; U.S. Environmental Protection Agency, 2008b, c). The chemical data presented in this report are meant to characterize the quality of the untreated groundwater within the primary aquifer system of the BEAR study unit and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical composition of treated drinking water may differ from untreated groundwater because treated drinking water may be subjected to disinfection, filtration, mixing with other waters, and (or) exposure to the atmosphere prior to its delivery to consumers. Comparisons of untreated groundwater to benchmarks are for illustrative purposes only and are not indicative of compliance or non-compliance with drinking-water regulations. The following benchmarks were used for comparisons:

- **MCL–Maximum Contaminant Level.** Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which States are required to comply, and individual States may choose to set more stringent standards. The CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the benchmark concentrations for a number of constituents with MCLs established by the USEPA. In this report, a benchmark set by the USEPA and adopted by the CDPH is labeled "MCL-US," and one set by the CDPH that is more stringent than the MCL-US is labeled "MCL-CA." Well owners are notified when constituents are detected at concentrations greater than an MCL-US or MCL-CA benchmark in samples collected for the GAMA-PBP, but these detections do not constitute violations of the CDPH regulations.

- **AL–Action Level.** Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead greater than the action-level benchmarks trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and the CDPH are the same; thus, these benchmarks are labeled "AL-US" in this report.

- **SMCL–Secondary Maximum Contaminant Level.** Non-enforceable standards applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color, or the technical qualities of drinking water, such as scaling and staining. Both the USEPA and the CDPH define SMCLs, but unlike MCLs, SMCLs established by the CDPH are not required to be at least as stringent as those established by the USEPA. SMCLs established by the CDPH are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.

- **NL–Notification Level.** Health-based notification levels established by the CDPH (NL-CA) for some of the constituents in drinking water that lack MCLs. If a constituent is detected in drinking water at concentrations greater than its NL-CA, California State law requires timely notification of local governing bodies and recommends consumer notification.

- **HAL–Lifetime Health Advisory Level.** The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (L) (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person's exposure comes from drinking water.

- **RSD5–Risk-Specific Dose.** The concentration of a constituent in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at the 10^{-5} risk level (10^{-5} equals 1/100,000). RSD5s are calculated by dividing the 10^{-4} cancer-risk concentration established by the USEPA by 10 (RSD5-US).

For constituents with regulatory benchmarks, detections in groundwater samples were compared with the MCL-US, MCL-CA, or AL-US. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and total dissolved solids, the CDPH defines a "recommended" and an "upper" SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US levels for these constituents correspond to their recommended SMCL-CAs. Detected concentrations of constituents without a regulatory benchmark or an SMCL were compared with the NL-CA. For constituents without a regulatory benchmark, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents without a regulatory benchmark, SMCL, NL-CA,

or HAL-US, detected concentrations were compared with the RSD5-US. Note that using this hierarchy to select the comparison benchmark for a constituent with more than one type of established benchmark will not necessarily result in selection of the benchmark with the lowest concentration. For example, for zinc the SMCL-CA is 5,000 micrograms per liter (µg/L) and the HAL-US is 2,000 µg/L, but the comparison benchmark selected by this hierarchy is the SMCL-CA. The comparison benchmarks used in this report are listed in tables 3A–J for all constituents and in tables 4–14 for constituents detected in groundwater samples from the BEAR study unit. Not all constituents analyzed for this study have established benchmarks available. Detections of constituents at concentrations greater than the selected comparison benchmarks are marked with asterisks (*) in tables 4, 9, 11, 12, and 14.

Water-Quality Results

Results from analyses of groundwater samples from the BEAR study unit are presented in tables 4–14. Groundwater samples collected in the BEAR study unit were analyzed for 8 water-quality indicators and up to 289 unique constituents; 217 of those constituents were not detected in any of the samples, and 72 constituents were detected (tables 3A–J, 4).

Water-quality indicators measured in the field and at the NWQL are included in table 4. The results of groundwater analyses organized by compound classes are presented in tables 5–14:

- Organic constituents

  - Volatile organic compounds (table 5)

  - Pesticides and pesticide degradates (table 6)

  - Wastewater indicator compounds (table 7)

- Constituents of special interest (table 8)

- Inorganic constituents

  - Trace elements (table 9)

  - Nutrients and dissolved organic carbon (table 10)

  - Major and minor ions, silica, and total dissolved solids (table 11)

- Arsenic and iron species (table 12)

- Isotopic tracers (table 13)

- Uranium and other radioactive constituents (table 14)

Water-Quality Indicators (Field and Laboratory)

Measurements of turbidity, dissolved oxygen, pH, specific conductance, alkalinity, and associated parameters (water temperature and bicarbonate and carbonate concentrations) are presented in table 4. Turbidity and dissolved oxygen, alkalinity, bicarbonate, and carbonate concentrations are used as indicators of processes that affect water chemistry.

The pH value indicates the acidity of the water. Low pH in water may contribute to corrosion of pipes, and high pH in water may contribute to scaling. Field and laboratory pH values for 5 of the 27 of the grid sites sampled (1 in the Bear Valley study area and 4 in the Hard Rock study area) were outside of the SMCL-US range for pH (< 6.5 or > 8.5) (table 4). Three BEAR-U site samples also had pH values outside of the SMCL-US range for pH. Laboratory pH values may be dissimilar to field pH values because the pH of groundwater may change upon removal from the ambient environment and exposure to the atmosphere; therefore, the field measurements are preferred over the laboratory results.

Specific conductance is the measure of electrical conductivity of the water and is proportional to the amount of dissolved solids in the water. Field specific-conductance values for all 38 sites sampled in the BEAR study unit were at concentrations less than the recommended SMCL-CA of 900 microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C) (table 4).

Organic Constituents

VOCs are present in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water, and are characterized by their tendency to evaporate. VOCs generally persist longer in groundwater than in surface water because groundwater is isolated from the atmosphere.

Of the 85 VOCs analyzed in the BEAR study unit, 16 were detected in groundwater samples; all concentrations were less than health-based benchmarks (table 5). One or more VOCs were detected in 17 of the 27 grid sites sampled (about 63 percent detection frequency). VOCs were detected in 11 of the 14 grid sites sampled in the Bear Valley study area (approximately 79 percent). VOCs were detected in 6 of the 13 grid sites sampled in the Hard Rock study area (about 46 percent). One or more VOCs were detected in six BEAR-U site samples.

Chloroform (trichloromethane), methyl *tert*-butyl ether (MTBE), perchloroethene (PCE, tetrachloroethene), bromodichloromethane, 1,1,1-trichloroethane (1,1,1-TCA), and 1,2,4-trimethylbenzene were each detected in more than 10 percent of the grid sites in both the BEAR study unit and the Bear Valley study area. Chloroform was detected in more than 10 percent of the grid sites in the Hard Rock study area. Chloroform is a byproduct of drinking-water disinfection and

is among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006).

Pesticides are chemicals used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings, and include herbicides, insecticides, and fungicides. Pesticide degradates are the product of the environmental transformations of the parent pesticide, and they can have similar properties to the parent pesticide (Andreu and Pico, 2004).

Of the 83 pesticides and pesticide degradates analyzed in the BEAR study unit, 2 pesticides (simazine and prometon) were detected in groundwater samples; all concentrations were less than health-based benchmarks (table 6). Simazine was detected in 4 of the 27 grid sites sampled (about 15 percent detection frequency), and prometon was detected in 1 of the grid sites sampled in the BEAR study unit.

Specifically, simazine was detected in 3 of the 14 grid sites sampled (approximately 21 percent) and prometon was detected in 1 of the grid sites sampled in the Bear Valley study area. Simazine was detected in 1 of the 13 grid sites sampled in the Hard Rock study area. Additionally, simazine was detected in one BEAR-U site sample. Simazine is among the nation's most commonly detected pesticide compounds in groundwater (Gilliom and others, 2006).

Pharmaceutical compounds may enter the environment in many ways, including through leaking septic systems and sewer lines, discharge of treated wastewater, seepage from landfills, land application of manure fertilizers, and runoff from animal wastes (Fram and Belitz, 2011). Pharmaceutical compounds were not detected at concentrations greater than or equal to the SRLs defined by Fram and Belitz (2011) in any of the grid or understanding sites; therefore, a results table is not presented in this report.

WICs are usually found in urban wastewater and include detergents, fragrances, flame retardants, and other man-made compounds. WICs were not detected in any of the 27 grid sites sampled in the BEAR study unit. Tris(2-butoxyethyl) phosphate and phenol were detected in two BEAR-U site samples (table 7).

Constituents of Special Interest

Perchlorate, *N*-nitrosodimethylamine (NDMA), and 1,2,3-trichloropropane (1,2,3-TCP) are constituents of special interest in California because they may adversely affect water quality and recently have been detected in water supplies (California Department of Public Health, 2008b). NDMA and 1,2,3-TCP were not detected in any of the grid or understanding sites; as a result, these constituents are not included in table 8.

Perchlorate was detected in 21 of 27 grid sites sampled in the BEAR study unit (about 78 percent detection frequency). Perchlorate was not detected at concentrations greater than the MCL-CA of 6 µg/L in any of the grid or understanding sites sampled in the BEAR study unit.

Perchlorate was detected in 13 of the 14 grid sites sampled in the Bear Valley study area (approximately 93 percent) and in 8 of the 13 grid sites sampled in the Hard Rock study area (about 62 percent). Additionally, perchlorate was detected in eight BEAR-U samples.

Inorganic Constituents

Health-based or non-health-based benchmarks have been established for 22 of 25 trace elements analyzed in this study (tables 3F, H). Of the 16 trace elements with health-based benchmarks, most detected concentrations in the sites sampled in the BEAR study unit were less than established benchmarks, with the exception of one detection of arsenic greater than the MCL-US of 10 µg/L (BEAR-S04; table 9) and one detection of fluoride greater than the MCL-CA of 2 milligrams per liter (BEAR-S12; table 11).

The CDPH has established non-health-based secondary benchmarks (SMCL-CAs) that are based on aesthetic properties (such as taste, color, and odor) and technical properties (such as scaling and staining) of water, rather than on human-health concerns for iron, manganese, silver, zinc, chloride, sulfate, and TDS.

Iron and manganese are trace elements whose concentrations are affected by the oxidation-reduction state of the groundwater. Precipitation of minerals containing iron or manganese may cause orange, brown, or black staining of surfaces. Iron concentrations greater than the SMCL-CA of 300 µg/L were detected in two grid sites sampled in the Hard Rock study area, and a manganese concentration greater than the SMCL-CA of 50 µg/L was detected in one grid site sampled in the Hard Rock study area (table 9). Additionally, iron was measured at a concentration greater than the SMCL-CA in one BEAR-U site sample, and manganese was measured at concentrations greater than the SMCL-CA in two BEAR-U site samples. All silver, zinc, chloride, sulfate, and TDS concentrations detected in samples were less than the corresponding SMCL-CA benchmarks (tables 9, 11).

Nutrients (nitrogen and phosphorus) and DOC present in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Inorganic nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. All concentrations of nutrients in samples from the BEAR study unit were less than health-based benchmarks (table 10).

Arsenic and iron occur as different species depending on the oxidation–reduction state of the groundwater. The oxidized and reduced species have different solubilities in groundwater, and the relative proportions of the oxidized and reduced species of each element can be used in the interpretation of the oxidation–reduction conditions of the aquifer.

Concentrations of total arsenic and total iron reported by the NWQL in table 9 are considered to be more accurate than the concentrations reported by the USGS National Research Program (NRP) Trace Metal Laboratory (TML),

Boulder, Colorado, in table 12 (see the appendix section titled "Constituents Determined by Multiple Methods or Laboratories"). Iron concentrations (reported from the USGS NRP-TML) greater than the SMCL-CA of 300 µg/L were detected in samples from two grid sites and one understanding site (table 12).

Isotopic Tracers and Dissolved Noble Gases

The isotopic ratios, activities, and concentrations of many elements are used as tracers of hydrologic processes. Stable-isotope ratios of hydrogen and oxygen in water (δ^2H and δ^{18}O) aid in the interpretation of the sources of groundwater recharge. These stable-isotope ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface-water bodies or soils prior to infiltration into the aquifer or directly from groundwater close to land surface once in the aquifer system (Clark and Fritz, 1997). In the BEAR study unit, the stable-isotope ratios of hydrogen ranged from –99.3 to –49.6 per mil, and the stable isotope ratios of oxygen ranged from –13.55 to –5.72 per mil (table 13).

Stable-isotope ratios of nitrogen and oxygen in dissolved nitrate (δ^{15}N and δ^{18}O) can be used to aid in interpretation of sources and processes affecting nitrate in the groundwater (Clark and Fritz, 1997). The isotopic ratios of nitrogen and oxygen in dissolved nitrate ranged from –0.39 to 18.67 (table 13).

Stable-isotope ratios of boron in water (δ^{11}B) may be useful in distinguishing the sources of boron in groundwater. Natural sources include igneous rocks, evaporate minerals, seawater, and geothermal waters (Coplen and others, 2002; U.S. Geological Survey, 2004).

Isotopic ratios of strontium in water (^{87}Sr/^{86}Sr) reflect the amounts of strontium (and other inorganic constituents) the aquifer materials are contributing to the groundwater system. In regions that have diverse geology, isotopic ratios of strontium may aid in identifying groundwater-flow paths (Clark and Fritz, 1997). The isotopic ratios of strontium ranged from 0.70994 to 0.77499 (table 13).

Tritium activities and helium isotope ratios provide information about the age (time since recharge) of groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are produced continuously by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result of atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium greater than background levels generally indicate the presence of water recharged since the early 1950s. Helium isotope ratios can be used in conjunction with tritium concentrations to estimate ages for young groundwater (Clark and Fritz, 1997). Of the isotopic tracer constituents analyzed for this study, tritium is the only one with a health-based benchmark. All measured tritium activities in samples from the sites in the BEAR study unit were

more than three orders of magnitude less than the MCL-CA benchmark (table 14).

Carbon-14, a radioactive isotope of carbon, is an age-dating tracer. Low levels of carbon-14 are produced continuously by interaction of cosmic radiation with the Earth's atmosphere and are incorporated into atmospheric carbon dioxide. Carbon dioxide dissolves in precipitation, surface water, and groundwater exposed to the atmosphere, thereby entering the hydrologic cycle. Because carbon-14 decays with a half-life of approximately 5,700 years, low activities of carbon-14, relative to modern values, generally indicate a presence of groundwater that is several thousands of years old or more (Clark and Fritz, 1997). Carbon-14 activities ranged from 5.540 to 108.5 percent modern carbon, and the stable isotopes of carbon in dissolved inorganic carbon (δ^{13}C) ranged from –19.66 to –8.08 per mil (table 13).

Gases dissolve in water that is in contact with the atmosphere, and the solubilities of the different gas species vary with temperature. Concentrations of dissolved noble gases are used to estimate the conditions of groundwater recharge, particularly the temperature of the water at the time of recharge (Clark and Fritz, 1997).

Uranium and Other Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most radioactivity in groundwater comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of an aquifer. Uranium and thorium decay in a series of steps eventually forming stable isotopes of lead (Soddy, 1913; Faure and Mensing, 2005). Radon-222 is a radioactive isotope formed during the uranium or thorium decay series. In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha or a beta particle from its nucleus. For example, radium-226 emits an alpha particle and therefore turns into radon-222. Radium-228 decays to form actinium-228 by emission of a beta particle. The alpha and beta particles emitted during radioactive decay are hazardous to human health because these energetic particles may damage cells. Radiation damage to cell DNA may increase the risk of getting cancer.

Uranium concentrations greater than the MCL-US of 30 µg/L were detected in samples from three grid sites in the Hard Rock study area (table 14). Additionally, uranium was measured at a concentration greater than the MCL-US in a sample from one BEAR-U site.

Radon-222 activities greater than the proposed MCL-US of 4,000 picocuries per liter (pCi/L) were detected in samples from nine grid sites in the Hard Rock study area (table 14). Additionally, radon-222 activity was measured greater than the proposed MCL-US in five BEAR-U samples (one in the Bear Valley study area and four in the Hard Rock study area). The proposed MCL-US will apply if the state or local water agency

has an approved multimedia mitigation program to address radon levels in indoor air (U.S. Environmental Protection Agency, 1999).

Future Work

Subsequent reports for the BEAR study unit will be focused on assessment of the data presented in this report by using statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting groundwater quality in the BEAR study unit. Water-quality data contained in the CDPH databases will be used in combination with the data that are presented in this report. These subsequent reports will include results for the stable isotopes of boron in water and the LLNL results (dissolved noble gases, tritium activity, and helium isotope ratios) for the BEAR study unit.

Summary

Groundwater quality in the 112-square-mile Bear Valley and Selected Hard Rock Areas (BEAR) study unit was investigated by the U.S. Geological Survey (USGS) from April to August 2010, as part of the Priority Basin Project (PBP) of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Program was created to provide a comprehensive baseline of groundwater quality in the State of California. The GAMA-PBP was created as a result of the Groundwater Quality Monitoring Act of 2001 (Sections 10780–10782.3 of the California Water Code, Assembly Bill 599) to assess and monitor the quality of groundwater. The GAMA-PBP is being conducted by the USGS in cooperation with the SWRCB and Lawrence Livermore National Laboratory (LLNL).

The GAMA BEAR study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer system and to provide statistically consistent comparisons of groundwater quality throughout California. The primary aquifer system is defined as the zones corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the BEAR study unit. The quality of groundwater in the primary aquifer system may differ from that in shallow or deep water-bearing zones; shallow groundwater may be more vulnerable to surficial contamination.

This study did not evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, and blended with other waters to maintain acceptable water quality. The benchmarks used in this report apply to treated water that is served to the consumer, not to untreated groundwater. However, to provide context for the results, concentrations of constituents measured in these groundwater samples were compared with benchmarks established by the U.S. Environmental Protection Agency (USEPA) and the CDPH.

The BEAR study unit is located within the Transverse Ranges and selected Peninsular Ranges hydrogeologic province and includes one groundwater basin (Bear Valley) defined by the California Department of Water Resources. The BEAR study included analyses of the groundwater quality from 38 wells and springs (hereinafter referred to as sites) in San Bernardino County, California. A total of 27 sites were selected by using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking-water supplies (grid sites). In addition, 11 sites were selected to provide data to aid in the understanding of the effects of septic tank use and the potential groundwater-quality issues associated with ski areas in the study unit (understanding sites).

Groundwater samples were analyzed for water-quality indicators, organic constituents, constituents of special interest, inorganic constituents, and uranium and other radioactive constituents. Isotopic tracers and dissolved noble gases also were measured to provide a dataset that will be used to interpret the sources and ages of groundwater in a subsequent report. In total, 289 unique constituents and 8 water-quality indicators were measured. This report describes the sampling, analytical, and quality-assurance methods used in the study and presents the results of the chemical analyses of the groundwater samples.

Quality-control samples (blanks, replicates, and matrix spikes) were collected at 13 percent of the wells in the BEAR study unit, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Blanks rarely contained detectable concentrations of any constituent. Replicate samples were within acceptable limits of variability, and matrix-spike recoveries were generally within the acceptable range.

Organic and inorganic constituents were sampled at all 38 sites in the BEAR study unit, and most detections were measured at concentrations less than health-based benchmarks.

In the Bear Valley study area grid sites, one detection of arsenic was greater than the USEPA maximum contaminant level (MCL-US) and one detection of fluoride was greater than the CDPH maximum contaminant level (MCL-CA). In the Selected Hard Rock Areas study area grid sites, three detections of uranium were greater than the MCL-US, nine detections of radon-222 were greater than the proposed MCL-US, two detections of iron were greater than the CDPH secondary maximum contaminant level (SMCL-CA), and one detection of manganese was greater than the SMCL-CA.

In the BEAR study unit understanding sites, one detection of uranium was greater than the MCL-US, five detections of radon-222 were greater than the proposed MCL-US, and two detections of manganese were greater than the SMCL-CA.

Acknowledgments

The authors thank the following cooperators for their support: the California State Water Resources Control Board, California Department of Public Health, California Department of Water Resources, and Lawrence Livermore National Laboratory. We especially thank the site owners and water purveyors for allowing the U.S. Geological Survey to collect samples from their sites.

References Cited

American Public Health Association, 1998, Standard methods for the examination of water and wastewater (20th ed.): Washington, D.C., American Public Health Association, American Water Works Association, and Water Environment Federation, p. 3-37–3-43.

American Society for Testing and Materials, 1998, Water and environmental technology, *in* Annual book of ASTM standards: Philadelphia, Pa., American Society for Testing and Materials, section 11.02 (Water II), p. 664–666.

Anderson, R.L., 1987, Practical statistics for analytical chemists: New York, Van Nostrand Reinhold Company, Inc., 315 p.

Andreu, V., and Pico, Y., 2004, Determination of pesticides and their degradation products in soil—Critical review and comparison of methods. Trends in Analytical Chemistry, v. 23, no. 10–11, p. 772–789, accessed December 11, 2011, at http://www.uv.es/~pico/papers/35.pdf.

Arrowhead Lake Association, 2011, Home Page, accessed December 13, 2011, at http://www.ala-ca.org.

Belitz, Kenneth, Dubrovsky, N.M., Burow, K.R., Jurgens, Bryant, and Johnson, Tyler, 2003, Framework for a groundwater quality monitoring and assessment program for California: U.S. Geological Survey Water-Resources Investigations Report 03-4166, 78 p.

Big Bear Area Regional Wastewater Agency, 2011, Water supplies, accessed December 12, 2011, at http://bigbearwatersolutions.org/Water-Supplies.htm.

Big Bear Municipal Water District, 2011, Lake stabilization—In-Lieu Water Program, accessed December 12, 2011, at http://www.bbmwd.com/Lake_Stabilization.html.

Brenton, R.W., and Arnett, T.L., 1993, Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory—Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480, 12 p.

Bryant, W.A., 1987, Cleghorn and related faults, San Bernardino County: California Division of Mines and Geology Fault Evaluation Report FER-187, California Division of Mines and Geology Open-File Report 90-14, 13 p., accessed December 13, 2011, at ftp://ftp.consrv.ca.gov/pub/dmg/shezp/FER_187/042887.pdf.

Bryant, W.A., compiler, 2003, Fault number 108b, Cleghorn fault zone, Northern Cleghorn section, in Quaternary fault and fold database of the United States: U.S. Geological Survey, accessed December 15, 2011, at http://earthquakes.usgs.gov/regional/qfaults.

Bullen, T.D., Krabbenhoft, D.P., and Kendall, Carol, 1996, Kinetic and mineralogic controls on the evolution of groundwater chemistry and $^{87}Sr/^{86}Sr$ in a sandy silicate aquifer, northern Wisconsin, USA: Geochimica et Cosmochimica Acta, v. 60, no. 10, p. 1807–1821.

California Department of Public Health, 2008a, California drinking water-related laws—Drinking water-related regulations, Title 22: California Department of Public Health, accessed October 6, 2011, at http://www.CDPH.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx.

California Department of Public Health, 2008b, Drinking water notification levels—Notification levels: California Department of Public Health, accessed October 6, 2011, at http://www.CDPH.ca.gov/certlic/drinkingwater/Pages/NotificationLevels.aspx.

California Department of Public Health, 2009, Drinking Water Source Assessment and Protection Program site locations [digital data]: California Department of Public Health, Division of Drinking Water and Environmental Management, produced by the Information Center for the Environment, Davis, California.

California Department of Water Resources, 2003, California's groundwater update 2003: California Department of Water Resources Bulletin 118, 246 p., accessed October 25, 2011, at http://www.groundwater.water.ca.gov/bulletin118.

California Department of Water Resources, 2004, California's groundwater—Individual basin descriptions, Bear Valley Groundwater Basin: California Department of Water Resources Bulletin 118, accessed November 25, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/8-9.pdf.

California Department of Water Resources, 2011a, California State Water Project today, accessed December 5, 2011, at http://www.water.ca.gov/swp/swptoday.cfm.

California Department of Water Resources, 2011b, Locations: Silverwood Lake, accessed December 5, 2011, at http://www.water.ca.gov/recreation/locations/silverwood/.

California Environmental Protection Agency, 2011, GAMA—Groundwater Ambient Monitoring and Assessment Program: State Water Resources Control Board website, accessed October 14, 2011, at http://www.waterboards.ca.gov/water_issues/programs/gama/.

California State Water Resources Control Board, 2003, Report to the Governor and Legislature, A comprehensive groundwater quality monitoring program for California: Assembly Bill 599, March 2003, 121 p. accessed October 11, 2011, at http://www.waterboards.ca.gov/gama/docs/final_ab_599_rpt_to_legis_7_31_03.pdf.

California State Water Resources Control Board, 2009, Geotracker GAMA: State Water Resources Control Board database, accessed October 14, 2011, at https://geotracker.waterboards.ca.gov/gama/.

Childress, C.J.O., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method-detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99-193, 19 p.

Clark, I.D., and Fritz, P., 1997, Environmental isotopes in hydrogeology: Boca Raton, Florida, CRC Press LLC, 328 p.

Connor, B.F., Rose, D.L., Noriega, M.C., Murtagh, L.K., and Abney, S.R., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of 86 volatile organic compounds in water by gas chromatography/mass spectrometry, including detections less than reporting limits: U.S. Geological Survey Open-File Report 97-829, 78 p.

Coplen, T.B., 1994, Reporting of stable hydrogen, carbon, and oxygen isotopic abundances: Pure and Applied Chemistry, v. 66, p. 273–276.

Coplen, T.B., Hopple, J.A., Bohlke, J.K., Peiser, H.S., Rieder, S.E., Krouse, H.R., Rosman, K.J.R., Ding, T., Vocke, R.D., Jr., Révész, K.M., Lamberty, A., Taylor, P., and DeBierve, P., 2002, Compilation of minimum and maximum isotope ratios of selected elements in naturally occurring terrestrial materials and reagents: U.S. Geological Survey Water-Resources Investigations Report 01-4222, 98 p.

Coplen, T.B., Wildman, J.D., and Chen, J., 1991, Improvements in the gaseous hydrogen-water equilibrium technique for hydrogen isotope analysis: Analytical Chemistry, v. 63, p. 910–912.

Donahue, D.J., Linick, T.W., and Jull, A.J.T., 1990, Isotope-ratio and background corrections for accelerator mass spectrometry radiocarbon measurements: Radiocarbon, v. 32, book 2, p. 135–142.

Dwyer, G.S., and Vengosh A., 2008, Alternative filament loading solution for accurate analysis of boron isotopes by negative thermal ionization mass spectrometry: Eos Transactions AGU, v. 89, no. 53, Abstract H51C-0824.

Eaton, G.F., Hudson, G.B., and Moran, J.E., 2004, Tritium-helium-3 age-dating of groundwater in the Livermore Valley of California: American Chemical Society ACS Symposium Series, v. 868, p. 235–245.

Epstein, Samuel, and Mayeda, T.K., 1953, Variation of O-18 content of water from natural sources: Geochimica et Cosmochimica Acta, v. 4, p. 213–224.

Faires, L.M., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of metals in water by inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 92-634, 28 p.

Farrar, J.W., and Long, H.K., 1997, Report on the U.S. Geological Survey's evaluation program for standard reference samples distributed in September 1996—T-143 (trace constituents), T-145 (trace constituents), M-140 (major constituents), N-51 (nutrient constituents), P-27 (low ionic strength constituents), and Hg-23 (mercury): U.S. Geological Survey Open-File Report 97-20, 145 p.

Faure, Gunter, and Mensing, T.M., 2005, Isotopes—Principles and Applications (3d ed.): Hoboken, New Jersey, John Wiley & Sons, Inc., 897 p.

Fishman, M.J., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, 217 p.

Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Flint, L.E., and Martin, Peter, eds., with contributions by Brandt, Justin, Christensen, A.H., Flint, A.L., Flint, L.E., Hevesi, J.A., Jachens, Robert, Kulongoski, J.T., Martin, Peter, and Sneed, Michelle, 2012, Geohydrology of Big Bear Valley, California: Phase 1—Geologic framework, recharge, and preliminary assessment of the source and age of groundwater: U.S. Geological Survey Scientific Investigations Report 2012-5100, 112 p. (Also available at http://pubs.usgs.gov/sir/2012/5100/.)

Fram, M.S., and Belitz, Kenneth, 2007, Ground-water quality data in the Southern Sierra study unit, 2006—Results from the California GAMA Program: U.S. Geological Survey Data Series 301, 78 p. (Also available at http://pubs.usgs.gov/ds/301.)

Fram, M.S., and Belitz, Kenneth, 2011, Occurrence and concentrations of pharmaceutical compounds in groundwater used for public drinking-water supply in California: Science of the Total Environment, v. 409, no. 18, p. 3409–3417. (Also available at http://www.sciencedirect.com/science/article/pii/S0048969711005778.)

Fram, M.S., Olsen, L.D., and Belitz, Kenneth, 2012, Evaluation of volatile organic compound (VOC) blank data and application of study reporting levels to groundwater data collected for the California GAMA Priority Basin Project, May 2004 through September 2010: U.S. Geological Survey Scientific Investigations Report 2012-5139, 94 p.

Furlong, E.T., Werner, S.L., Anderson, B.D., and Cahill, J.D., 2008, Determination of human-health pharmaceuticals in filtered water by chemically modified styrene-divinylbenzene resin-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, sec. B, chap. B5, 56 p.

Gagnon, A.R., and Jones, G.A., 1993, AMS-graphite target production methods at the Woods Hole Oceanographic Institution during 1986–1991: Radiocarbon, v. 35, book 2, p. 301–310.

Garbarino, J.R., 1999, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of dissolved arsenic, boron, lithium, selenium, strontium, thallium, and vanadium using inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 99-093, 31 p.

Garbarino, J.R., Kanagy, J.R., and Cree, M.E., 2006, Determination of elements in natural-water, biota, sediment, and soil samples using collision/reaction cell inductively coupled plasma-mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B1, 88 p.

GEOSCIENCE Support Services, Inc., 2006, Geohydrologic evaluation of nitrate in ground water in the Lake William area, Baldwin Lake watershed, March 17, 2006: Official Report, 22 p.

GEOSCIENCE Support Services, Inc., 2008, Lake Arrowhead Community Services District results of drilling, construction, development and testing LACSD well no. 8, June 25, 2008: Official Well Report, 15 p.

Gilliom, R.J., Barbash, J.E., Crawford, C.G., Hamilton, P.A., Martin, J.D., Nakagaki, N., Nowell, L.H., Scott, J.C., Stackelberg, P.E., Thelin, G.P., and Wolock, D.M., 2006, The quality of our Nation's waters—Pesticides in the Nation's streams and groundwater, 1992–2001: U.S. Geological Survey Circular 1291, 172 p.

Gran, G., 1952, Determination of the equivalence point in potentiometric titration, Part II: Analyst, v. 77, p. 661.

Hahn, G.J., and Meeker, W.Q., 1991, Statistical intervals—A guide for practitioners: New York, John Wiley & Sons, 392 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p., 3 pls.

Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.

Kolpin, D.W., Furlong, E.T., Meyer, M.T., Thurman, E.M., Zaugg, S.D., Barber, L.B., and Buxton, H.T., 2002, Pharmaceuticals, hormones and other organic wastewater contaminants in U.S. streams, 1999–2000: Environmental Science & Technology, v. 36, no. 6, p. 1202–1211.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Groundwater data-collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95-399, 113 p.

Kulongoski, J.T., and Belitz, Kenneth, 2004, Ground-water ambient monitoring and assessment program: U.S. Geological Survey Fact Sheet 2004-3088, 2 p.

Lake Arrowhead Community Services District, 2011a, History—The history of the Lake Arrowhead water and wastewater system, accessed December 14, 2011, at http://www.lakearrowheadcsd.com/Index.aspx?page=25.

Lake Arrowhead Community Services District, 2011b, Water services, accessed December 14, 2011, at http://www.lakearrowheadcsd.com/Index.aspx?page=4.

Lake Arrowhead Community Services District, 2011c, Water services—Groundwater, accessed December 14, 2011, at http://www.lakearrowheadcsd.com/Index.aspx?page=46.

Landon, M.K., Belitz, Kenneth, Jurgens, B.C., Kulongoski, J.T., and Johnson, T.D., 2010, Status and understanding of groundwater quality in the Central–Eastside San Joaquin Basin, 2006: California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2009-5266, 97 p.

Lane, S.L., Flanagan, Sarah, and Wilde, F.D., 2003, Selection of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, accessed October 18, 2011, at http://pubs.water.usgs.gov/twri9A2/.

Lewis, M.E., 2006, Dissolved oxygen (ver. 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.2, accessed October 18, 2011, at http://pubs.water.usgs.gov/twri9A6.2/.

Lindley, C.E., Stewart, J.T., and Sandstrom, M.W., 1996, Determination of low concentrations of acetochlor in water by automated solid-phase extraction and gas chromatography with mass selective detection: Journal of AOAC International, v. 79, no. 4, p. 962–966.

Madsen, J.E., Sandstrom, M.W., and Zaugg, S.D., 2003, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—A method supplement for the determination of fipronil and degradates in water by gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 02-462, 11 p.

Maloney, T.J., ed., 2005, Quality management system, U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 2005-1263, accessed November 8, 2011, at http://pubs.usgs.gov/of/2005/1263/.

McCleskey, R.B., Nordstrom, D.K., and Ball, J.W., 2003, Metal interferences and their removal prior to the determination of As(T) and As(III) in acid mine waters by hydride generation atomic absorption spectrometry: U.S. Geological Survey Water-Resources Investigations Report 03-4117, 14 p.

McCurdy, D.E., Garbarino, J.R., and Mullin, A.H., 2008, Interpreting and reporting radiological water-quality data: U.S. Geological Survey Techniques and Methods, book 5, chap. B6, 33 p.

McLain, B., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of chromium in water by graphite furnace atomic absorption spectrophotometry: U.S. Geological Survey Open-File Report 93-449, 16 p.

McNichol, A.P., Gagnon, A.R., Jones, G.A., and Osborne, E.A., 1992, Illumination of a black box—Analysis of gas composition during graphite target preparation, in Long, A., and Kra, R.S., eds., Proceedings of the 14th International ^{14}C Conference: Radiocarbon, v. 34, book 3, p. 321–329.

McNichol, A.P., Jones, G.A., Hutton, D.L., and Gagnon, A.R., 1994, The rapid preparation of seawater $\sum CO_2$ for radiocarbon analysis at the National Ocean Sciences AMS Facility: Radiocarbon, v. 36, book 2, p. 237–246.

Moran, J.E., Hudson, G.B., Eaton, G.F., and Leif, R., 2002, A contamination vulnerability assessment for the Livermore–Amador and Niles Cone Groundwater Basins: Lawrence Livermore National Laboratory internal report UCRL-AR-148831, 25 p.

Mueller, D.K., and Titus, C.J., 2005, Quality of nutrient data from streams and ground water sampled during water years 1992–2001: U.S. Geological Survey Scientific Investigations Report 2005-5106, 27 p.

Okamoto, H.S., Steeber, W.R., Remoy, R., Hill, P., and Perera, S.K., eds., 2002, Determination of 1,2,3-trichloropropane in drinking water by purge and trap gas chromatography/mass spectrometry (February 2002): California Department of Health Services, Division of Drinking Water and Environmental Management, Sanitation and Radiation Laboratories Branch, accessed November 4, 2011, at http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Drinkingwaterlabs/TCPbyPT-GCMS.pdf.

Olsen, L.D., Fram, M.S., and Belitz, Kenneth, 2010, Review of trace-element field-blank data collected for the California Groundwater Ambient Monitoring and Assessment (GAMA) Program, May 2004–January 2008: U.S. Geological Survey Scientific Investigations Report 2009-5220, 47 p.

Parr, J.G., and Porterfield, D.R., 1997, Evaluation of radiochemical data usability: U.S. Department of Energy, Office of Environmental Management, es/er/ms-5, 30 p.

Patton, C.J., and Kryskalla, J.R., 2003, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Evaluation of alkaline persulfate digestion as an alternative to Kjeldahl digestion for determination of total and dissolved nitrogen and phosphorous in water: U.S. Geological Survey Water-Resources Investigations Report 03-4174, 33 p.

Pirkey, K.D., and Glodt, S.R., 1998, Quality control at the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Fact Sheet 026-98, 4 p., accessed February 3, 2011, at http://pubs.er.usgs.gov/usgspubs/fs/fs02698.

Plomley, J.B., Koester, C.J., and March, R.E., 1994, Determination of NDMA in complex environmental matrices by quadrupole ion storage tandem mass spectrometry enhanced by unidirectional ion ejection: Analytical Chemistry, v. 66, no. 24, p. 4437–4443.

PRISM Climate Group, Oregon State University, 2011, United States average annual precipitation, maximum and minimum temperature, 1971–2010, accessed November 14, 2011, at http://prism.oregonstate.edu/.

Radtke, D.B., Davis, J.V., and Wilde, F.D., 2005, Specific electrical conductance (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.3, accessed October 17, 2011, at http://pubs.water.usgs.gov/twri9A6.3/.

Révész, K.M., and Casciotti, K., 2007, Determination of the $\delta(^{15}N/^{14}N)$ and $\delta(^{18}O/^{16}O)$ of nitrate in water: RSIL Lab Code 2900, chap. C17, *in* Révész, Kinga, and Coplen, T.B., eds., Methods of the Reston Stable Isotope Laboratory: Reston, Virginia, U.S. Geological Survey Techniques and Methods, book 10, sec. C, chap. 17, 24 p.

Sandstrom, M.W., Stroppel, M.E., Foreman, W.T., and Schroeder, M.P., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of moderate-use pesticides and selected degradates in water by C-18 solid-phase extraction and gas chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01-4098, 70 p.

Saucedo, G.J., Bedford, D.R., Raines, G.L., Miller, R.J., and Wentworth, C.M., 2000, GIS data for the geologic map of California (version 2.0): Sacramento, California, California Department of Conservation, Division of Mines and Geology.

Schneider, R.J., Jones, G.A., McNichol, A.P., von Reden, K.F., Elder, K.A., Huang, K., and Kessel, E.D., 1994, Methods for data screening, flagging, and error analysis at the National Ocean Sciences AMS Facility: Nuclear Instruments and Methods in Physics Research, book 92, p. 172–175.

Scott, J.C., 1990, Computerized stratified random site-selection approaches for design of a ground-water-quality sampling network: U.S. Geological Survey Water-Resources Investigations Report 90-4101, 109 p.

Shelton, J.L., Fram, M.S., and Belitz, Kenneth, 2013, Groundwater-quality data in the Cascade Range and Modoc Plateau study unit, 2010—Results from the California GAMA Program: U.S. Geological Survey Data Series 688, 124 p.

Soddy, F., 1913, Radioactivity: Annual Reports on the Progress of Chemistry, v. 10, p. 262–288.

State of California, 2001a, Assembly Bill No. 599, Chapter 522, accessed November 16, 2011, at http://www.swrcb.ca.gov/gama/docs/ab_599_bill_20011005_chaptered.pdf.

State of California, 2001b, Groundwater Monitoring Act of 2001: California Water Code, part 2.76, Sections 10780–10782.3, accessed November 16, 2011, at http://www.leginfo.ca.gov/cgi-bin/displaycode?section=wat&group=10001-11000&file=10780-10782.3.

Stookey, L.L., 1970, FerroZine—A new spectrophotometric reagent for iron: Analytical Chemistry, v. 42, p. 779–781.

Thatcher, L.L., Janzer, V.J., and Edwards, K.W., 1977, Methods for the determination of radioactive substances in water: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A5, 95 p.

Timme, P.J., 1995, National Water Quality Laboratory 1995 services catalog: U.S. Geological Survey Open-File Report 95-352, 120 p.

To, T.B., Nordstrom, D.K., Cunningham, K.M., Ball, J.W., and McCleskey, R.B., 1998, New method for the direct determination of dissolved Fe(III) concentration in acid mine waters: Environmental Science & Technology, v. 33, p. 807–813.

U.S. Department of Agriculture–Natural Resources Conservation Service, U.S. Geological Survey, and U.S. Environmental Protection Agency, 2013, Watershed Boundary Dataset: HUC12-180902080201, HUC12-180902080202, HUC12-180902080103, HUC12-180902080102, and HUC12-180902080101, accessed January 14, 2013, at http://datagateway.nrcs.usda.gov.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, 2011, Annual climatological summary—Big Bear Lake (2005–2010), accessed December 2, 2011, at http://cdo.ncdc.noaa.gov/ancsum/ACS?coban=04074199999.

U.S. Environmental Protection Agency, 1989, Semivolatile organic compounds by isotope dilution GSMS (July 1989): Washington, D.C., U.S. Environmental Protection Agency, 68 p.

U.S. Environmental Protection Agency, 1999, National primary drinking water regulations, Radon-222: Federal Register, v. 64, no. 211, p. 59, 245–59, and 294.

U.S. Environmental Protection Agency, 2002, Guidelines for establishing procedures for the analysis of pollutants: U.S. Code of Federal Regulations, Title 40, 136 p.

U.S. Environmental Protection Agency, 2005, Method 331.0—Determination of perchlorate in drinking water by liquid chromatography electrospray ionization mass spectrometry (Revision 1.0, January 2005): Office of Groundwater and Drinking Water, U.S. Environmental Protection Agency Document # 815-R-05-007, 34 p., accessed October 11, 2011, at http://www.epa.gov/safewater/methods/pdfs/methods/met331_0.pdf.

U.S. Environmental Protection Agency, 2008a, Ground Water Rule—Source assessment guidance manual: U.S. Environmental Protection Agency Document # 815-R-07-023, 34 p., accessed March 6, 2013, at http://www.epa.gov/ogwdw/disinfection/gwr/pdfs/guide_gwr_sourcewaterassessments.pdf.

U.S. Environmental Protection Agency, 2008b, Drinking water contaminants, accessed November 11, 2011, at http://www.epa.gov/safewater/contaminants/index.html.

U.S. Environmental Protection Agency, 2008c, Drinking water health advisories—2006 Drinking water standards and health advisory tables, accessed November 11, 2011, at http://www.epa.gov/waterscience/criteria/drinking/.

U.S. Geological Survey, [variously dated], National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A1–A9, accessed November 17, 2011, at http://water.usgs.gov/owq/FieldManual/.

U.S. Geological Survey, 2004, Resources on isotopes: Periodic table—Boron: U.S. Geological Survey Isotopic Tracers Project, accessed May 2, 2012, at http://wwwrcamnl.wr.usgs.gov/isoig/period/b_iig.html.

U.S. Geological Survey, 2011a, What is the Priority Basin Project?: U.S. Geological Survey California Water Science Center website, accessed November 23, 2011, at http://ca.water.usgs.gov/gama/.

U.S. Geological Survey, 2011b, Publications: U.S. Geological Survey California Water Science Center website, accessed November 23, 2011, at http://ca.water.usgs.gov/gama/includes/GAMA_publications.html.

U.S. Geological Survey, 2011c, Inorganic blind sample project: U.S. Geological Survey Branch of Quality Systems, accessed December 14, 2011, at http://bqs.usgs.gov/ibsp/qadata.shtml.

Vengosh, A., Chivas, A.R., and McCulloch, M.T., 1989, Direct determination of boron and chlorine isotopes in geological materials by negative thermal ionization mass spectrometry: Chemical Geology, v. 79, p. 333–343.

Vogel, J.S., Nelson, D.E., and Southon, J.R., 1987, ^{14}C background levels in an accelerator mass spectrometry system: Radiocarbon, v. 29, book 3, p. 323–333.

Weiss, R.F., 1968, Piggyback sampler for dissolved gas studies on sealed water samples: Deep Sea Research, v. 15, p. 721–735.

Western Regional Climate Center, 2011, Western Regional Climate Center, summary climate data for Southern California, average monthly climate summary, accessed December 2, 2011, at http://www.wrcc.dri.edu/summary/Climsmsca.html.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A3/.

Wilde, F.D., 2006, Temperature (ver. 2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.1, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A6.1/.

Wilde, F.D., Busenberg, E., and Radtke, D.B., 2006, pH (ver. 1.3): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.4, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A6.4/.

Wilde, F.D., and Radtke, D.B., 2005, General information and guidelines (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.0, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A6.0/.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1999, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A4/.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 2004, Processing of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, accessed December 8, 2011, at http://pubs.water.usgs.gov/twri9A5/.

Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 95-181, 60 p.

Zaugg, S.D., Smith, S.G., Schroeder, M.P., Barber, L.B., and Burkhardt, M.R., 2002, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of wastewater compounds by polystyrene-divinylbenzene solid-phase extraction and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01-4186, 37 p.

Zogorski, J.S., Carter, J.M., Ivahnenko, T., Lapham, W.W., Moran, M.J., Rowe, B.L., Squillace, P.J., and Toccalino, P.L., 2006, Volatile organic compounds in the Nation's ground water and drinking-water supply wells: U.S. Geological Survey Circular 1292, 101 p.

Table 1.   Identification, sampling, and construction information for sites sampled for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Land-surface datum (LSD) is a datum plane that is approximately at land surface at each site. The altitude of the LSD is described in feet above the North American Vertical Datum of 1988 (NAVD 88). **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. **Other abbreviations**: ft, feet; na, not available]

GAMA site identification number	Sampling information		Site type	Construction information		
	Date sampled (m/dd/ yyyy)	Altitude of LSD (ft above NAVD 88)		Well depth (ft below LSD)	Depth to top perforation (ft below LSD)	Depth to bottom perforation (ft below LSD)
BEAR grid sites (27 sites sampled)						
Bear Valley study area (14 grid sites sampled)						
BEAR-S01	4/26/2010	6,795	Production	370	150	210
BEAR-S02	4/26/2010	6,904	Production	365	154	211
BEAR-S03	4/27/2010	6,757	Production	48	28	48
BEAR-S04	4/27/2010	6,770	Production	290	55	290
BEAR-S05	4/28/2010	6,917	Production	710	210	690
BEAR-S06	4/29/2010	7,223	Production	586	292	576
BEAR-S07	4/29/2010	7,057	Production	330	50	325
BEAR-S08	5/3/2010	7,024	Production	760	230	750
BEAR-S09	5/3/2010	6,794	Production	400	50	400
BEAR-S10	5/4/2010	7,274	Production	268	160	238
BEAR-S11	5/5/2010	6,749	Production	536	200	516
BEAR-S12	5/5/2010	6,719	Production	174	91	166
BEAR-S13	5/6/2010	6,764	Production	236	40	218
BEAR-S14	5/6/2010	7,264	Spring	at LSD	at LSD	at LSD
Selected Hard Rock Areas study area (13 grid sites sampled)						
BEAR-G01	4/19/2010	6,403	Production	230	na	na
BEAR-G02	4/19/2010	5,403	Spring	at LSD	at LSD	at LSD
BEAR-G03	4/20/2010	4,753	Production	300	na	na
BEAR-G04	4/21/2010	5,343	Spring	at LSD	at LSD	at LSD
BEAR-G05	4/21/2010	5,443	Spring	at LSD	at LSD	at LSD
BEAR-G06	4/22/2010	3,843	Spring	at LSD	at LSD	at LSD
BEAR-G07	5/10/2010	5,143	Production	500	120	500
BEAR-G08	5/10/2010	5,205	Production	703	223	703
BEAR-G09	8/19/2010	4,723	Production	500	na	na
BEAR-G10	5/12/2010	6,944	Production	220	na	na
BEAR-G11	5/13/2010	4,763	Spring	at LSD	at LSD	at LSD
BEAR-G12	5/19/2010	6,113	Spring	at LSD	at LSD	at LSD
BEAR-G13	6/30/2010	5,288	Production	375	na	na
BEAR understanding sites (11 sites sampled)						
BEAR-U01 [1]	4/20/2010	6,203	Production	380	200	380
BEAR-U02	4/28/2010	6,751	Production	300	na	na
BEAR-U03 [1]	5/4/2010	7,254	Production	106	66	106
BEAR-U04 [1]	5/4/2010	7,344	Production	215	na	na
BEAR-U05	5/12/2010	7,104	Spring	at LSD	at LSD	at LSD

Table 1.   Identification, sampling, and construction information for sites sampled for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[Land-surface datum (LSD) is a datum plane that is approximately at land surface at each site. The altitude of the LSD is described in feet above the North American Vertical Datum of 1988 (NAVD 88). **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. **Other abbreviations**: ft, feet; na, not available]

GAMA site identification number	Sampling information		Site type	Construction information		
	Date sampled (m/dd/ yyyy)	Altitude of LSD (ft above NAVD 88)		Well depth (ft below LSD)	Depth to top perforation (ft below LSD)	Depth to bottom perforation (ft below LSD)
BEAR understanding sites (11 sites sampled)—Continued						
BEAR-U06 [1]	6/14/2010	7,654	Spring	at LSD	at LSD	at LSD
BEAR-U07 [1]	6/14/2010	7,114	Spring	at LSD	at LSD	at LSD
BEAR-U08 [1]	6/15/2010	7,144	Spring	at LSD	at LSD	at LSD
BEAR-U09 [1]	6/15/2010	7,279	Production	168	54	162
BEAR-U10 [1]	6/16/2010	6,724	Spring	at LSD	at LSD	at LSD
BEAR-U11 [1]	8/19/2010	4,723	Production	500	na	na

[1] Wastewater indicator compounds were collected at this site in addition to the standard set of constituents.

Table 2.   Classes of chemical constituents and field water-quality indicators collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

Constituent classes	Constituent class table	Results table
Field water-quality indicators		
Dissolved oxygen, temperature, pH, and specific conductance	—	4
Turbidity	—	4
Field alkalinity, bicarbonate, and carbonate [1]	—	4
Organic constituents		
Volatile organic compounds (VOCs)	3A	5
Pesticides and pesticide degradates	3B	6
Pharmaceutical compounds	3C	none [2]
Wastewater indicator compounds (WICs) [3]	3D	7
Constituents of special interest		
Perchlorate	3E	8
1,2,3-Trichloropropane (1,2,3-TCP)	3E	none [4]
N-Nitrosodimethylamine (NDMA)	3E	none [4]
Inorganic constituents		
Trace elements	3F	9
Nutrients	3G	10
Dissolved organic carbon (DOC)	3G	10
Major and minor ions, silica, and total dissolved solids (TDS)	3H	11
Laboratory alkalinity, bicarbonate, and carbonate	3H	4
Arsenic and iron species	3I	12
Stable isotopes		
Stable isotopes of hydrogen and oxygen in water	3J	13
Stable isotopes of nitrogen and oxygen in dissolved nitrate	3J	13
Stable isotopes of boron in water	3J	none [5]
Isotopic ratios of strontium in water	3J	13
Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance	3J	13
Radioactivity and dissolved noble gases		
Uranium	3F	14
Tritium	3J	14
Radon-222	3J	14
Dissolved noble gases, tritium, and helium isotope ratios	3J	none [6]

[1] Constituents were sampled for eight understanding sites.

[2] Constituent(s) not detected at concentration(s) greater than the study reporting level(s) in groundwater samples; therefore, a results table is not presented in this report.

[3] Constituent was sampled for nine understanding sites.

[4] Constituent was not detected in groundwater samples.

[5] Results for stable isotopes of boron in water analyzed by U.S. Geological Survey National Research Program, Metals Isotope Research Laboratory, Menlo Park, California, were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

[6] Results for dissolved noble gases, tritium, and helium isotope ratios analyzed by Lawrence Livermore National Laboratory (LLNL), Livermore, California, were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Table 3A. Volatile organic compounds (VOCs), primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2020.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; MCL–US, USEPA maximum contaminant level; NL–CA, CDPH notification level; RSD5–US, USEPA risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL; study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN [1]	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	3.4	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.8	RSD5-US	0.6	—
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.026	MCL-CA	1	—
Bromobenzene	Solvent	81555	108-86-1	0.022	na	na	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	D
Bromodichloromethane	Disinfection byproduct (THM)	32101	75-27-4	0.034	MCL-US	[3] 80	D
Bromoform (Tribromomethane)	Disinfection byproduct (THM)	32104	75-25-2	0.1	MCL-US	[3] 80	D
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.2	HAL-US	10	—
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.08	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.034	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	—
Carbon disulfide	Organic synthesis	77041	75-15-0	0.1	HAL-US	160	—
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.052	MCL-CA	0.5	D
Chlorobenzene	Solvent	34301	108-90-7	0.016	MCL-CA	70	—
Chloroethane	Solvent	34311	75-00-3	0.06	na	na	—
Chloroform (Trichloromethane)	Disinfection byproduct (THM)	32106	67-66-3	0.03	MCL-US	[3] 80	D
Chloromethane	Solvent	34418	74-87-3	0.14	HAL-US	30	—
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	—
2-Chlorotoluene	Solvent	77275	95-49-8	0.028	NL-CA	140	—
4-Chlorotoluene	Solvent	77277	106-43-4	0.042	NL-CA	140	—
Dibromochloromethane	Disinfection byproduct (THM)	32105	124-48-1	0.12	MCL-US	[3] 80	D
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.34	MCL-US	0.2	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.05	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.05	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.028	MCL-CA	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.024	HAL-US	600	—
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.026	MCL-CA	5	—
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.36	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.1	NL-CA	1,000	—

Table 3A. Volatile organic compounds (VOCs), primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2020.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark level, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; MCL–US, USEPA maximum contaminant level; NL–CA, CDPH notification level; RSD5–US, USEPA risk-specific dose at a risk factor of 10⁻⁵ (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN [1]	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.044	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.08	MCL-CA	0.5	—
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.022	MCL-CA	6	D
cis-1,2-Dichloroethene (cis-1,2-DCE)	Solvent	77093	156-59-2	0.022	MCL-CA	6	—
trans-1,2-Dichloroethene (trans-1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.026	MCL-US	5	—
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.03	na	na	—
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	[4] 4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.14	RSD5-US	[4] 4	—
Diethyl ether	Solvent	81576	60-29-7	0.08	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.1	MCL-CA	300	—
Ethyl tert-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.032	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.032	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.06	RSD5-US	9	—
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	—
2-Hexanone (n-Butyl methyl ketone)	Solvent	77103	591-78-6	0.46	na	na	—
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	0.26	na	na	—
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.042	NL-CA	770	—
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	0.06	na	na	—
Methyl acrylate	Organic synthesis	49991	96-33-3	0.56	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.26	na	na	—
Methyl tert-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.1	MCL-CA	13	D
Methyl iso-butyl ketone (MIBK)	Solvent	78133	108-10-1	0.32	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.038	MCL-US	5	D
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.22	na	na	—

Table 3A.   Volatile organic compounds (VOCs), primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2020.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark level, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk-specific dose at a risk factor of 10⁻⁵. **Other abbreviations:** CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL; study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN[1]	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.18	NL-CA	17	—
Perchloroethene (PCE, Tetrachloroethene)	Solvent	34475	127-18-4	0.026	MCL-US	5	D
n-Propylbenzene	Solvent	77224	103-65-1	0.036	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.03	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.14	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.08	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.08	na	na	—
Toluene	Gasoline hydrocarbon	34010	108-88-3	[2]0.69	MCL-CA	150	D[2]
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.06	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	0.08	MCL-CA	5	—
1,1,1-Trichloroethane (1,1,1-TCA)	Solvent	34506	71-55-6	0.03	MCL-CA	200	D
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.046	MCL-CA	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.022	MCL-US	5	D
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	D
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent, organic synthesis	77443	96-18-4	0.12	HAL-US	40	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.034	MCL-CA	1,200	—
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.06	na	na	—
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	[2]0.56	NL-CA	330	D[2]
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.032	NL-CA	330	—
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.06	MCL-CA	0.5	—
m- plus p-Xylene	Gasoline hydrocarbon	85795	108-38-3 / 106-42-3	0.4	MCL-CA	[5]1,750	—
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.1	MCL-CA	[5]1,750	—

[1] This report contains CAS Registry Numbers® (CASRNs), which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client Services℠.

[2] The SRL was defined by Fram and others (2012).

[3] The MCL-US benchmark for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

[4] The RSD5 benchmark for 1,3-dichloropropene is the sum of its isomers (*cis* and *trans*).

[5] The MCL-CA benchmarks for *m*- plus *p*-xylene and *o*-xylene is the sum all three xylene compounds.

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2033.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.010	na	na	—
Alachlor	Herbicide	46342	15972-60-8	0.008	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	—
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	—
Azinphos-methyl oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	—[1]
Benfluralin	Herbicide	82673	1861-40-1	0.014	na	na	—[1]
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	—
Carbofuran	Insecticide	82674	1563-66-2	0.060	MCL-CA	18	—
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.010	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.0032	na	na	—
Chlorpyrifos	Insecticide	38933	2921-88-2	0.010	HAL-US	2	—
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.05	na	na	—[1]
Cyanazine	Herbicide	04041	21725-46-2	0.022	HAL-US	1	—
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	—[1]
λ-Cyhalothrin	Insecticide	61595	91465-08-6	0.010	na	na	—[1]
Cypermethrin	Insecticide	61586	52315-07-8	0.020	na	na	—[1]
DCPA (Dacthal)	Herbicide	82682	1861-32-1	0.0076	HAL-US	70	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	—
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	—
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
Diazinon oxon	Insecticide degradate	61638	962-58-3	0.0060	na	na	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.0042	na	na	—
3,5-Dichloroaniline	Herbicide degradate	61627	626-43-7	0.0030	na	na	—
Dichlorvos	Insecticide	38775	62-73-7	0.02	na	na	—[1]
Dicrotophos	Insecticide	38454	141-66-2	0.08	na	na	—[1]
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	—
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	—[1]
Disulfoton	Insecticide	82677	298-04-4	0.04	HAL-US	0.7	—
Disulfoton sulfone	Insecticide degradate	61640	2497-06-5	0.0136	na	na	—
α-Endosulfan	Insecticide	34362	959-98-8	0.006	na	na	—
Endosulfan sulfate	Insecticide degradate	61590	1031-07-8	0.014	na	na	—
Ethion	Insecticide	82346	563-12-2	0.008	na	na	—
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	—
Ethoprophos	Herbicide	82672	13194-48-4	0.016	na	na	—
S-Ethyl-dipropylthiocarbamate (EPTC)	Herbicide	82668	759-94-4	0.0020	na	na	—
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.0098	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.030	HAL-US	0.7	—

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2033.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.08	na	na	—[1]
Fipronil	Insecticide	62166	120068-37-3	0.018	na	na	—
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013	na	na	—
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	—[1]
Fonofos	Insecticide	04095	944-22-9	0.0044	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	—[1]
Iprodione	Fungicide	61593	36734-19-7	0.014	na	na	—
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaoxon	Insecticide degradate	61652	1634-78-2	0.08	na	na	—
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.007	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.006	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.014	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	—
Molinate	Herbicide	82671	2212-67-1	0.002	MCL-CA	20	—
Myclobutanil	Fungicide	61599	88671-89-0	0.010	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.036	na	na	—[1]
Oxyfluorfen	Herbicide	61600	42874-03-3	0.010	na	na	—[1]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.010	na	na	—
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.014	na	na	—[1]
Phorate	Insecticide	82664	298-02-2	0.02	na	na	—
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.034	na	na	—[1]
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	—[1]
Prometon	Herbicide	04037	1610-18-0	0.012	HAL-US	100	D
Prometryn	Herbicide	04036	7287-19-6	0.006	na	na	—
Pronamide	Herbicide	82676	23950-58-5	0.0036	RSD5-US	20	—
Propanil	Herbicide	82679	709-98-8	0.010	na	na	—
Propargite	Insecticide	82685	2312-35-8	0.020	na	na	—
cis-Propiconazole	Fungicide	79846	60207-90-1	0.006	na	na	—[2]
trans-Propiconazole	Fungicide	79847	60207-90-1	0.02	na	na	—
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuconazole	Fungicide	62852	107534-96-3	0.020	na	na	—[1]
Tebuthiuron	Herbicide	82670	34014-18-1	0.028	HAL-US	500	—[2]
Tefluthrin	Insecticide	61606	79538-32-2	0.010	na	na	—[1]
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	—
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2033.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Terbuthylazine	Herbicide	04022	5915-41-3	0.006	na	na	—
Thiobencarb	Herbicide	82681	28249-77-6	0.016	MCL-CA	70	—
Tribufos	Defoliant	61610	78-48-8	0.018	na	na	—[1]
Trifluralin	Herbicide	82661	1582-09-8	0.018	HAL-US	10	—

[1] The median matrix-spike recovery was less than 70 percent. Low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.

[2] The median matrix-spike recovery was greater than 130 percent. High recoveries may indicate that reported values could be greater than the true concentration in the sample.

Table 3C.   Pharmaceutical compounds, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2080.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Abbreviations**: CASRN, Chemical Abstract Service Registry Number; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CASRN	SRL[1] (µg/L)	Benchmark type	Benchmark level	Detection
Acetaminophen	Analgesic	62000	103-90-2	0.06	na	na	—
Albuterol	Bronchodilator	62020	18559-94-9	0.04	na	na	—
Caffeine	Stimulant	50305	58-08-2	0.10	na	na	—
Carbamazapine	Anticonvulsant, mood stabilizer	62793	298-46-4	0.03	na	na	—
Codeine	Opiod narcotic	62003	76-57-3	0.023	na	na	—
Cotinine	Nicotine metabolite	62005	486-56-6	0.019	na	na	—
Dehydronifedipine	Antianginal metabolite	62004	67035-22-7	0.04	na	na	—
Diltiazem	Antianginal, antihypertensive	62008	42399-41-7	0.04	na	na	—
1,7-Dimethylxanthine	Caffeine metabolite	62030	611-59-6	0.06	na	na	—
Diphenydramine	Antihistime	62796	147-25-0	0.02	na	na	—
Sulfamethoxazole	Antibacterial	62021	723-46-6	0.08	na	na	—
Thiabendazole	Anthelmintic	62801	148-79-8	0.03	na	na	—
Trimethoprim	Antibacterial	62023	738-70-5	0.017	na	na	—
Warfarin	Anticoagulant	62024	81-81-2	0.05	na	na	—

[1] The SRLs were defined by Fram and Belitz (2011).

Table 3D. Wastewater indicator compounds, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1433.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark level, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; MCL–US, USEPA maximum contaminant level; NL–CA, CDPH notification level; RSD5–US, USEPA risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 7); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetophenone	Fragrance, flavor additive	62064	98-86-2	0.4	na	na	—
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	Musk fragrance	62065	21145-77-7	0.028	na	na	—
Anthracene	Wood preservative, combustion product	34221	120-12-7	0.028	na	na	—
Anthraquinone	Textile dye, seed treatment	62066	84-65-1	0.16	na	na	—
Benzo[a]pyrene	Combustion product	34248	50-32-8	0.050	MCL-US	0.2	—
Benzophenone	Fixative for perfumes and soaps	62067	119-61-9	0.08	na	na	—
Bromacil	Herbicide	04029	314-40-9	0.36	HAL-US	70	—
Bromoform (tribromomethane)	Disinfection byproduct (THM)	34288	75-25-2	0.10	MCL-US	80	—[1]
3-tert-Butyl-4-hydroxy anisole (BHA)	Antioxidant, general preservative	62059	25013-16-5	8	na	na	—[1]
Caffeine	Beverages	50305	58-08-2	0.06	na	na	—
Camphor	Flavor, odorant, ointments	62070	76-22-2	0.044	na	na	—
Carbaryl	Insecticide	82680	63-25-2	0.38	RSD5-US	400	—
Carbazole	Insecticide	62071	86-74-8	0.030	na	na	—
Chlorpyrifos	Insecticide	38933	2921-88-2	0.16	HAL-US	2	—[1]
Cholesterol	Fecal indicator, plant sterol	62072	57-88-5	2	na	na	—
3-β-Coprostanol	Carnivore fecal indicator	62057	360-68-9	1.8	na	na	—
Cotinine	Primary nicotine metabolite	62005	486-56-6	0.6	na	na	—
p-Cresol	Wood preservative	62084	106-44-5	0.08	na	na	—
4-Cumylphenol	Nonionic detergent metabolite	62060	599-64-4	0.06	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.16	HAL-US	1	—
1,4-Dichlorobenzene	Moth repellant, fumigant, deodorant	34572	106-46-7	0.040	MCL-CA	5	—
N,N-Diethyl-meta-toluamide (DEET)	Insecticide	62082	134-62-3	0.06	na	na	—
2,6-Dimethylnaphthalene	Diesel fuel, kerosene	62055	581-42-0	0.06	na	na	—[1]
4-Nonylphenol diethoxylates	Nonionic detergent metabolite	62083	na	5.0	na	na	—[1]
4-Octylphenol diethoxylates	Nonionic detergent metabolite	61705	na	1.0	na	na	—[1]
4-Octylphenol monoethoxylates	Nonionic detergent metabolite	61706	na	1.0	na	na	—[1]
Fluoranthene	Component of coal tar and asphalt	34377	206-44-0	0.024	na	na	—
Hexahydrohexamethylcyclopentabenzopyran (HHCB)	Musk fragrance	62075	1222-05-5	0.052	na	na	—

Table 3D. Wastewater indicator compounds, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1433.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark level as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; MCL–US, USEPA maximum contaminant level; NL–CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10⁻⁵. **Other abbreviations:** CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 7); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Indole	Pesticide ingredient	62076	120-72-9	0.08	na	na	—[1]
Isoborneol	Fragrance in perfume	62077	124-76-5	0.18	na	na	—
Isophorone	Solvent	34409	78-59-1	0.08	HAL-US	100	—
Isopropylbenzene	Fuels, paint thinner	62078	98-82-8	0.30	NL-CA	770	—[1]
Isoquinoline	Flavors, fragrances	62079	119-65-3	0.046	na	na	—
d-Limonene	Fungicide	62073	5989-27-5	0.08	na	na	—[1]
Menthol	Cigarettes, cough drops, liniment	62080	89-78-1	0.32	na	na	—
Metalaxyl	Herbicide, fungicide	50359	57837-19-1	0.12	na	na	—
3-Methyl-1(H)-indole (Skatole)	Fragrance, stench in feces	62058	83-34-1	0.036	na	na	—
5-Methyl-1H-benzotriazole	Antioxidant in antifreeze and deicers	62063	136-85-6	1.2	na	na	—[1]
1-Methylnaphthalene	Gasoline, diesel fuel, crude oil	62054	90-12-0	0.022	na	na	—
2-Methylnaphthalene	Gasoline, diesel fuel, crude oil	62056	91-57-6	0.036	na	na	—
Methyl salicylate	Liniment, UV-absorbing lotion	62081	119-36-8	0.044	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.08	HAL-US	700	—[1]
Naphthalene	Fumigant, moth repellent, gasoline	34443	91-20-3	0.040	NL-CA	17	—
para-Nonylphenol (total)	Nonionic detergent metabolite	62085	84852-15-3	2	na	na	—
4-n-Octylphenol	Nonionic detergent metabolite	62061	1806-26-4	0.16	na	na	—
4-tert-Octylphenol	Nonionic detergent metabolite	62062	140-66-9	0.14	na	na	—
Perchloroethene (PCE, Tetrachloroethene)	Solvent	34476	127-18-4	0.12	MCL-US	5	—[1]
Phenanthrene	Manufactured explosives	34462	85-01-8	0.032	na	na	—
Phenol	Disinfectant, organic synthesis	34466	108-95-2	0.16	HAL-US	2,000	D
Prometon	Herbicide	04037	1610-18-0	0.12	HAL-US	100	—
Pyrene	Component of coal tar and asphalt	34470	129-00-0	0.042	na	na	—
β-Sitosterol	Plant sterol	62068	83-46-5	4	na	na	—[1]
β-Stigmastanol	Plant sterol	62086	19466-47-8	2.6	na	na	—[1]
Tributyl phosphate	Antifoaming agent, flame retardant	62089	126-73-8	0.16	na	na	—
Triclosan	Disinfectant, antimicrobial	62090	3380-34-5	0.20	na	na	—
Triethyl citrate (ethyl citrate)	Cosmetics, pharmaceuticals	62091	77-93-0	0.38	na	na	—
Triphenyl phosphate	Plasticizer	62092	115-86-6	0.12	na	na	—

Table 3D. Wastewater indicator compounds, primary uses or sources, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1433.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark level, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; MCL–US, USEPA maximum contaminant level; NL–CA, CDPH notification level; RSD5–US, USEPA risk specific dose at a risk factor of 10⁻⁵. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 7); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Tris(2-butoxyethyl)phosphate	Flame retardant	62093	78-51-3	[2] 0.30	na	na	D
Tris(2-chloroethyl)phosphate	Plasticizer, flame retardant	62087	115-96-8	0.10	na	na	—
Tris(dichlorisopropyl)phosphate	Flame retardant	62088	13674-87-8	0.16	na	na	—

[1] The median matrix-spike recovery was less than 70 percent. Low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.

[2] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

Table 3E. Constituents of special interest, primary uses or sources, comparison benchmarks, and reporting information for Weck Laboratories, Inc., City of Industry, California, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. MRL, benchmark level, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL–US if the MCL–US and MCL–CA are identical, and as MCL–CA when the MCL–CA is lower than the MCL–US or no MCL–US exists. HAL–US, U.S. Environmental Protection Agency lifetime health advisory; MCL–CA, California Department of Public Health (CDPH) maximum contaminant level; NL–CA, CDPH notification level. **Other abbreviations**: USGS, U.S. Geological Survey; CASRN, Chemical Abstract Service Registry Number; MRL, minimum reporting level; D, detected in groundwater samples (table 8); µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CASRN	MRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	63790	14797-73-0	0.10	MCL-CA	6	D
1,2,3-Trichloropropane (1,2,3-TCP)	Fumigant, solvent	77443	96-18-4	0.005	HAL-US	40	—
N-Nitrosodimethylamine (NDMA)	Disinfection byproduct	34438	62-75-9	0.002	NL-CA	0.010	—

Table 3F. Trace elements, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 9); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CASRN	LRL or SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Aluminum	01106	7429-90-5	3.4	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.054	MCL-US	6	D
Arsenic	01000	7440-38-2	0.04	MCL-US	10	D
Barium	01005	7440-39-3	0.14	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.012	MCL-US	4	D
Boron	01020	7440-42-8	2.8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.02	MCL-US	5	D
Chromium	01030	7440-47-3	[1] 0.42	MCL-CA	50	D
Cobalt	01035	7440-48-4	[2] 0.42	na	na	—
Copper	01040	7440-50-8	[1] 1.7	AL-US	1,300	D
Iron	01046	7439-89-6	[1] 6	SMCL-CA	300	D
Lead	01049	7439-92-1	[1] 0.65	AL-US	15	D
Lithium	01130	7439-93-2	0.44	na	na	D
Manganese	01056	7439-96-5	0.79	SMCL-CA	50	D
Molybdenum	01060	7439-98-7	0.014	HAL-US	40	D
Nickel	01065	7440-02-0	[1] 0.36	MCL-CA	100	D
Selenium	01145	7782-49-2	0.040	MCL-US	50	D
Silver	01075	7440-22-4	0.010	SMCL-CA	100	D
Strontium	01080	7440-24-6	0.40	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.020	MCL-US	2	D
Tungsten	01155	7440-33-7	[1] 0.11	na	na	D
Vanadium	01085	7440-62-2	0.16	NL-CA	50	D
Zinc	01090	7440-66-6	[1] 4.8	SMCL-CA [3]	5,000	D

[1] The SRL was defined by Olsen and others (2010).

[2] The SRL was defined based on the highest concentration detected in the Bear Valley and Selected Hard Rock Areas (BEAR) blank samples.

[3] Zinc also has a HAL-US benchmark of 2,000 µg/L.

Table 3G.   Nutrients and dissolved organic carbon (DOC), comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2755 and Laboratory Code 2613.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 10); na, not available; mg/L, milligrams per liter; BEAR, Bear Valley and Selected Hard Rock Areas study unit]

Constituent	USGS parameter code	CASRN	LRL or SRL (mg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.02	HAL-US	[1] 24.7	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.04	MCL-US	10	D
Nitrite (as nitrogen)	00613	14797-65-0	0.001	MCL-US	1	D
Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen)	62854	17778-88-0	0.10	na	na	D
Phosphate, orthophosphate (as phosphorus)	00671	14265-44-2	0.008	na	na	D
Dissolved organic carbon (DOC)	00681	na	[2] 0.8	na	na	D

[1] The HAL-US is 30 mg/L "as ammonia." To facilitate comparison to the analytical results, we have converted and reported this HAL-US as 24.7 mg/L "as nitrogen."

[2] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

Table 3H.   Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. LRL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: CASRN, Chemical Abstract Service Registry Number; LRL, laboratory reporting level; SRL, Study Reporting Level; D, detected in groundwater samples (table 11); na, not available; mg/L, milligrams per liter; SiO$_2$, Silica; CaCO$_3$, calcium carbonate; BEAR, Bear Valley and Selected Hard Rock Areas study unit]

Constituent (synonym or abbreviation)	USGS parameter code	CASRN	LRL or SRL (mg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	0.044	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	[1] 250 (500)	D
Fluoride	00950	16984-48-8	[2] 0.055	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.016	na	na	D
Potassium	00935	7440-09-7	0.064	na	na	D
Sodium	00930	7440-23-5	0.10	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	[1] 250 (500)	D
Silica (as SiO$_2$)	00955	7631-86-9	0.058	na	na	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	10	SMCL-CA	[1] 500 (1,000)	D
Laboratory alkalinity (as CaCO$_3$) [3]	29801	na	1	na	na	D

[1] The SMCL-CAs for chloride, sulfate, and TDS have recommended and upper benchmark values. The upper benchmark value is shown in parentheses.

[2] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

[3] Laboratory alkalinity results are presented in table 4.

Table 3I.   Arsenic and iron species, comparison benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Research Laboratory (NRP) Trace Metal Laboratory (TML), Boulder, Colorado, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. MDL, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; SMCL-US, USEPA secondary maximum contaminant level. **Other abbreviations**: MDL, method detection limit; CASRN, Chemical Abstract Service Registry Number; na, not available; µg/L, micrograms per liter; D, detected in groundwater samples (table 12)]

Constituent	USGS parameter code	CASRN	MDL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Arsenic (total)	99033	7440-38-2	0.5	MCL-US	10	D
Arsenic-III	99034	22569-72-8	1	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-CA	300	D
Iron-II	01047	7439-89-6	2	na	na	D

Table 3J. Dissolved noble gases, isotopic tracers, and uranium and other radioactive constituents, comparison benchmarks, and reporting information for laboratory analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. Benchmark type and benchmark value as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Elements**: H, hydrogen; O, oxygen; N, nitrogen; B, boron; Sr, strontium; C, carbon. **Reporting units**: µg/L, micrograms per liter; pmc, percent modern carbon; pCi/L, picocuries per liter; cm³ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water. **Other abbreviations**: USGS, U.S. Geological Survey; CASRN, Chemical Abstract Service Registry Number; %, percent; na, not available; D, detected in groundwater samples (tables 13 and 14); ssL$_C$, sample-specific critical level; NRP, USGS National Research Program]

Constituent	USGS parameter code	CASRN	Method uncertainty	Reporting units	Benchmark type	Benchmark level	Detection
Dissolved noble gases [1]							
Argon	85563	7440-37-1	2%	cm³ STP/g	na	na	na
Helium-4	85561	7440-59-7	2%	cm³ STP/g	na	na	na
Krypton	85565	7439-90-9	2%	cm³ STP/g	na	na	na
Neon	61046	7440-01-09	2%	cm³ STP/g	na	na	na
Xenon	85567	7440-63-3	2%	cm³ STP/g	na	na	na
Isotopic tracers							
Helium-3 / Helium-4 [1]	61040	na / 7440-59-7	0.8%	atom ratio	na	na	na
δ^2H in water [2]	82082	na	2	per mil	na	na	D
$\delta^{18}O$ in water [2]	82085	na	0.2	per mil	na	na	D
$\delta^{15}N$ in dissolved nitrate [2]	82690	na	0.5	per mil	na	na	D
$\delta^{18}O$ in dissolved nitrate [2]	63041	na	1.0	per mil	na	na	D
$\delta^{11}B$ in water [3]	62648	na	na	per mil	na	na	na [4]
Strontium isotope ratio in water ($^{87}Sr/^{86}Sr$) [3]	75978	na	0.0	atom ratio	na	na	D
$\delta^{13}C$ in dissolved inorganic carbon [5]	82081	na	0.1	per mil	na	na	D
Uranium and other radioactive constituents							
Uranium [6]	22703	7440-61-1	0.008	µg/L	MCL-US	30	D
C-14 [5]	49933	14762-75-5	0.0	pmc	na	na	D
Radon-222 [6]	82303	14859-67-7	ssL$_C$	pCi/L	MCL-US (Proposed)	4,000	D
Tritium [1]	07000	10028-17-8	1	pCi/L	MCL-CA	20,000	na
Tritium [7]	07000	10028-17-8	0.32–0.41	pCi/L	MCL-CA	20,000	D

[1] Lawrence Livermore National Laboratory, Livermore, California (CA-LLNL). Results for dissolved noble gases, tritium, and helium isotope ratios were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

[2] USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA).

[3] USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA).

[4] Results for stable isotopes of boron in water analyzed by USGS NRP Metals Isotope Research Laboratory were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

[5] Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility [NOMAS], Woods Hole, Massachusetts (MA-WHAMS).

[6] USGS NWQL, Denver, Colorado.

[7] USGS Stable Isotope and Tritium Laboratory [SITL], Menlo Park, California (USGSH3CA).

Table 4. Water-quality indicators in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and RL as of April 1, 2010. **Benchmark type**: SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; NTRU, nephelometric turbidity unit; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO₃, calcium carbonate; *, concentration is greater than the benchmark level; —, not detected; E, estimated or having a higher degree of uncertainty]

GAMA site identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, laboratory (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO₃) (29802)	Alkalinity, laboratory (mg/L as CaCO₃) (29801)	Bicarbonate, field (mg/L) (63786)	Bicarbonate, laboratory [2] (mg/L)	Carbonate, field (mg/L) (63788)	Carbonate, laboratory [2] (mg/L)
Benchmark type	na	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na	na	na
Benchmark level	na	na	na	<6.5 or >8.5	<6.5 or >8.5	[1]900 (1,600)	[1]900 (1,600)	na	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[1]	[1]	[1]
BEAR grid sites (27 sites sampled)													
Bear Valley study area (14 grid sites sampled)													
BEAR-S01	0.1	1.7	12.5	7.5	7.5	559	565	nc	235	nc	286	nc	0.4
BEAR-S02	0.1	6.8	11.0	7.6	7.6	277	278	nc	136	nc	165	nc	0.3
BEAR-S03	0.1	4.4	11.0	6.5	6.8	332	328	nc	130	nc	159	nc	—
BEAR-S04	0.6	0.2	13.5	*9.1	*9.0	367	373	nc	176	nc	196	nc	9.0
BEAR-S05	0.2	1.8	14.0	8.2	8.2	250	256	nc	122	nc	147	nc	1.1
BEAR-S06	0.2	7.0	12.0	nc	7.5	437	452	nc	251	nc	305	nc	0.4
BEAR-S07	0.2	5.1	9.0	nc	7.4	666	688	nc	328	nc	399	nc	0.5
BEAR-S08	0.1	6.6	13.0	7.5	7.7	380	387	nc	204	nc	248	nc	0.6
BEAR-S09	0.1	6.8	12.0	6.8	7.5	333	341	nc	161	nc	196	nc	0.3
BEAR-S10	0.1	6.1	13.0	6.8	6.8	365	379	nc	126	nc	154	nc	—
BEAR-S11	0.2	4.1	13.0	7.5	7.5	438	446	nc	214	nc	260	nc	0.4
BEAR-S12	0.9	3.4	16.0	7.4	7.1	387	398	nc	175	nc	213	nc	0.1
BEAR-S13	0.3	6.2	13.0	7.2	7.4	397	400	nc	196	nc	239	nc	0.3
BEAR-S14	0.7	7.8	11.0	7.5	7.7	443	449	nc	223	nc	271	nc	0.6

Table 4. Water-quality indicators in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and RL as of April 1, 2010. **Benchmark type**: SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; NTRU, nephelometric turbidity unit; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO₃, calcium carbonate; *, concentration is greater than the benchmark level; —, not detected; E, estimated or having a higher degree of uncertainty]

GAMA site identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, laboratory (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO₃) (29802)	Alkalinity, laboratory (mg/L as CaCO₃) (29801)	Bicarbonate, field (mg/L) (63786)	Bicarbonate, laboratory[2] (mg/L)	Carbonate, field (mg/L) (63788)	Carbonate, laboratory[2] (mg/L)
Benchmark type	na	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na	na	na
Benchmark level	na	na	na	<6.5 or >8.5	<6.5 or >8.5	¹900 (1,600)	¹900 (1,600)	na	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[1]	[1]	[1]

BEAR grid sites (27 sites sampled)—Continued

Selected Hard Rock Areas study area (13 grid sites sampled)

GAMA site identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, laboratory (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO₃) (29802)	Alkalinity, laboratory (mg/L as CaCO₃) (29801)	Bicarbonate, field (mg/L) (63786)	Bicarbonate, laboratory[2] (mg/L)	Carbonate, field (mg/L) (63788)	Carbonate, laboratory[2] (mg/L)
BEAR-G01	0.8	3.3	12.0	7.2	7.1	230	234	nc	115	nc	140	nc	0.1
BEAR-G02	nc	6.8	10.0	*6.1	*6.3	194	197	nc	44.0	nc	53.7	nc	—
BEAR-G03	nc	3.6	9.5	*6.1	6.9	124	122	nc	52.0	nc	63.4	nc	—
BEAR-G04	nc	4.1	8.0	6.5	7.2	195	194	nc	97.0	nc	118	nc	0.1
BEAR-G05	nc	1.2	7.0	7.2	7.6	199	202	nc	99.0	nc	120	nc	0.2
BEAR-G06	nc	2.9	12.5	7.1	7.3	392	398	nc	194	nc	236	nc	0.2
BEAR-G07	nc	2.5	11.5	7.3	7.5	325	329	nc	158	nc	192	nc	0.3
BEAR-G08	1.4	2.6	12.5	7.7	8.0	278	286	nc	145	nc	175	nc	0.8
BEAR-G09	3.0	0.7	14.5	7.0	7.7	332	340	nc	167	nc	203	nc	0.5
BEAR-G10	nc	3.7	10.5	7.3	7.4	360	371	nc	185	nc	225	nc	0.3
BEAR-G11	nc	7.8	14.0	*6.4	7.2	207	211	nc	73.0	nc	88.9	nc	0.1
BEAR-G12	6.0	5.2	9.5	*6.3	6.8	191	190	nc	98.0	nc	119	nc	—
BEAR-G13	nc	5.6	16.5	6.8	6.8	368	368	nc	175	nc	213	nc	0.1

Table 4. Water-quality indicators in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and RL as of April 1, 2010. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; NTRU, nephelometric turbidity unit; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO3, calcium carbonate; *, concentration is greater than the benchmark level; —, not detected; E, estimated or having a higher degree of uncertainty]

GAMA site identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, laboratory (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO3) (29802)	Alkalinity, laboratory (mg/L as CaCO3) (29801)	Bicarbonate, field (mg/L) (63786)	Bicarbonate, laboratory[2] (mg/L)	Carbonate, field (mg/L) (63788)	Carbonate, laboratory[2] (mg/L)
Benchmark type	na	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na	na	na
Benchmark level	na	na	na	<6.5 or >8.5	<6.5 or >8.5	1 900 (1,600)	1 900 (1,600)	na	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[1]	[1]	[1]
BEAR understanding sites (11 sites sampled)													
BEAR-U01	nc	4.0	9.5	7.1	7.3	344	342	152	152	185	185	0.2	0.2
BEAR-U02	0.7	5.5	13.0	7.5	7.6	563	581	nc	253	nc	307	nc	0.6
BEAR-U03	0.1	6.2	14.0	6.8	7.4	405	410	128	131	156	159	—	0.2
BEAR-U04	1.9	4.4	13.0	7.3	7.9	358	331	119	123	145	149	0.1	0.5
BEAR-U05	nc	2.2	7.0	*6.2	6.5	82.0	88.0	nc	39.0	nc	47.6	nc	—
BEAR-U06	nc	4.8	8.0	*6.0	7.0	171	184	60.5	65.0	73.7	79.2	—	—
BEAR-U07	nc	5.0	9.0	6.5	6.7	346	357	126	139	154	170	—	—
BEAR-U08	nc	5.1	13.0	7.7	7.9	360	369	116	126	141	153	—	0.6
BEAR-U09	nc	2.2	11.5	7.1	7.5	608	628	289	304	352	370	—	0.5
BEAR-U10	0.8	6.3	7.0	*5.6	E7.2	89.0	E97.0	nc	45.0	nc	54.8	nc	—
BEAR-U11	1.0	1.2	16.5	6.8	7.5	301	303	143	154	174	187	0.3	0.3

[1] The SMCL–CA for specific conductance has recommended and upper benchmark values. The upper value is shown in parentheses.

[2] Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with pK1 = 6.35, pK2 = 10.33, and pKw = 14.

Table 5.   Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations**: USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

Primary use or source	Trihalomethanes			
GAMA site identification number	**Chloroform (Trichloromethane)** (µg/L) (32106)	**Bromodichloromethane** (µg/L) (32101)	**Dibromochloromethane** (µg/L) (32105)	**Bromoform (Tribromomethane)** (µg/L) (32104)
Benchmark type	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**
Benchmark level	[1]80	[1]80	[1]80	[1]80
[LRL]	[0.03]	[0.034]	[0.12]	[0.1]
BEAR grid sites (27 sites sampled)				
Number of sites with detections	11	4	1	1
Detection frequency (percent)	40.7	14.8	3.7	3.7
Total detections (number)				
Bear Valley study area (14 grid sites sampled)				
BEAR-S01	0.05	—	—	—
BEAR-S02	—	—	—	—
BEAR-S03	E0.01	—	—	—
BEAR-S04	—	—	—	—
BEAR-S05	—	—	—	—
BEAR-S07	0.12	0.17	0.30	0.32
BEAR-S09	0.15	E0.03	—	—
BEAR-S10	E0.02	—	—	—
BEAR-S11	—	—	—	—
BEAR-S12	—	—	—	—
BEAR-S13	0.07	0.08	—	—
Number of sites with detections	6	3	1	1
Detection frequency (percent)	42.9	21.4	7.1	7.1
Total detections (number)				

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; μg/L, micrograms per liter; na, not available; —, not detected]

Primary use or source	Trihalomethanes			
GAMA site identification number	Chloroform (Trichloromethane) (µg/L) (32106)	Bromodichloromethane (µg/L) (32101)	Dibromochloromethane (µg/L) (32105)	Bromoform (Tribromomethane) (µg/L) (32104)
Benchmark type	MCL-US	MCL-US	MCL-US	MCL-US
Benchmark level	¹80	¹80	¹80	¹80
[LRL]	[0.03]	[0.034]	[0.12]	[0.1]
BEAR grid sites (27 sites sampled)—Continued				
Selected Hard Rock Areas study area (13 grid sites sampled)				
BEAR-G03	E0.02	—	—	—
BEAR-G08	E0.01	—	—	—
BEAR-G09	0.06	—	—	—
BEAR-G10	—	—	—	—
BEAR-G11	0.16	0.10	—	—
BEAR-G13	E0.03	—	—	—
Number of sites with detections	5	1	0	0
Detection frequency (percent)	38.5	7.7	0	0
Total detections (number)				
BEAR understanding sites (11 sites sampled)³				
BEAR-U01	0.94	0.58	E0.1	—
BEAR-U03	—	—	—	—
BEAR-U04	E0.02	—	—	—
BEAR-U08	—	—	—	—
BEAR-U09	—	—	—	—
BEAR-U11	E0.02	—	—	—

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

			Solvents			
Primary use or source						
GAMA site identification number	Perchloroethene (PCE, Tetrachloroethene) (µg/L) (34475)	1,1,1-Trichloroethane (1,1,1-TCA) (µg/L) (34506)	Methylene chloride (Dichloromethane) (µg/L) (34423)	1,1-Dichloroethane (1,1-DCA) (µg/L) (34496)	Carbon tetrachloride (Tetrachloromethane) (µg/L) (32102)	Trichloroethene (TCE) (µg/L) (39180)
Benchmark type	MCL-US	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-US
Benchmark level	5	200	5	5	0.5	5
[LRL]	[0.026]	[0.03]	[0.038]	[0.044]	[0.052]	[0.022]
BEAR grid sites (27 sites sampled)						
Number of sites with detections	5	3	1	1	1	1
Detection frequency (percent)	18.5	11.1	3.7	3.7	3.7	3.7
Total detections (number)						
Bear Valley study area (14 grid sites sampled)						
BEAR-S01	E0.02	E0.02	—	E0.02	—	—
BEAR-S02	—	—	E0.021	—	—	—
BEAR-S03	0.04	—	—	—	—	—
BEAR-S04	—	—	—	—	—	—
BEAR-S05	—	—	—	—	—	—
BEAR-S07	—	—	—	—	—	—
BEAR-S09	0.03	—	—	—	—	—
BEAR-S10	0.04	E0.02	—	—	—	—
BEAR-S11	0.04	—	—	—	—	—
BEAR-S12	—	E0.02	—	—	0.18	0.28
BEAR-S13	—	—	—	—	—	—
Number of sites with detections	5	3	1	1	1	1
Detection frequency (percent)	35.7	21.4	7.1	7.1	7.1	7.1
Total detections (number)						

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

GAMA site identification number	Perchloroethene (PCE, Tetrachloroethene) (µg/L) (34475)	1,1,1-Trichloroethane (1,1,1-TCA) (µg/L) (34506)	Solvents Methylene chloride (Dichloromethane) (µg/L) (34423)	1,1-Dichloroethane (1,1-DCA) (µg/L) (34496)	Carbon tetrachloride (Tetrachloromethane) (µg/L) (32102)	Trichloroethene (TCE) (µg/L) (39180)
Benchmark type	MCL-US	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-US
Benchmark level	5	200	5	5	0.5	5
[LRL]	[0.026]	[0.03]	[0.038]	[0.044]	[0.052]	[0.022]
BEAR grid sites (27 sites sampled)—Continued						
Selected Hard Rock Areas study area (13 grid sites sampled)						
BEAR-G03	—	—	—	—	—	—
BEAR-G08	—	—	—	—	—	—
BEAR-G09	—	—	—	—	—	—
BEAR-G10	—	—	—	—	—	—
BEAR-G11	—	—	—	—	—	—
BEAR-G13	—	—	—	—	—	—
Number of sites with detections	0	0	0	0	0	0
Detection frequency (percent)	0	0	0	0	0	0
Total detections (number)						
BEAR understanding sites (11 sites sampled) [3]						
BEAR-U01	—	E0.02	E0.029	—	—	—
BEAR-U03	E0.01	—	—	—	—	—
BEAR-U04	—	—	—	—	—	—
BEAR-U08	—	—	—	—	—	—
BEAR-U09	—	—	—	—	—	—
BEAR-U11	—	—	—	—	—	—

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations**: USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

Primary use or source	Hydrocarbons		Gasoline oxygenate	Organic synthesis	Fire retardant	Refrigerant	VOC detection summary
GAMA site identification number	1,2,4-Trimethylbenzene (µg/L) (77222)	Toluene (µg/L) (34010)	Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	Bromochloromethane (µg/L) (77297)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	Detections per site
Benchmark type	NL-CA	MCL-CA	MCL-CA	MCL-CA	HAL-US	MCL-CA	
Benchmark level	330	150	13	6	90	150	
[LRL]	[2][0.56]	[2][0.69]	[0.1]	[0.022]	[0.06]	[0.08]	
BEAR grid sites (27 sites sampled)							
Number of sites with detections	3	1	8	2	0	0	17
Detection frequency (percent)	11.1	3.7	29.6	7.4	0	0	63
Total detections (number)							43
Bear Valley study area (14 grid sites sampled)							
BEAR-S01	0.77	—	E0.08	—	—	—	6
BEAR-S02	—	—	E0.09	—	—	—	2
BEAR-S03	—	—	0.10	—	—	—	3
BEAR-S04	—	—	0.14	—	—	—	1
BEAR-S05	—	—	E0.06	—	—	—	1
BEAR-S07	—	—	E0.07	—	—	—	5
BEAR-S09	—	—	—	—	—	—	3
BEAR-S10	—	—	E0.08	—	—	—	4
BEAR-S11	—	—	E0.03	—	—	—	2
BEAR-S12	0.71	—	—	E0.01	—	—	5
BEAR-S13	—	—	—	—	—	—	2
Number of sites with detections	2	—	8	1	0	0	11
Detection frequency (percent)	14.3	—	57.1	7.1	0	0	79
Total detections (number)							34

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Detected constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3A. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-US is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

Primary use or source	Hydrocarbons		Gasoline oxygenate	Organic synthesis	Fire retardant	Refrigerant	VOC detection summary
	1,2,4-Trimethylbenzene (µg/L) (77722)	Toluene (µg/L) (34010)	Methyl tert-butyl ether (MTBE) (µg/L) (78032)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	Bromochloromethane (µg/L) (77297)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	
GAMA site identification number							Detections per site
Benchmark type	**NL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**HAL-US**	**MCL-CA**	
Benchmark level	**330**	**150**	**13**	**6**	**90**	**150**	
[LRL]	²**[0.56]**	²**[0.69]**	**[0.1]**	**[0.022]**	**[0.06]**	**[0.08]**	
BEAR grid sites (27 sites sampled)—Continued							
Selected Hard Rock Areas study area (13 grid sites sampled)							
BEAR-G03	—	—	—	—	—	—	1
BEAR-G08	—	—	—	—	—	—	1
BEAR-G09	—	1.39	—	—	—	—	2
BEAR-G10	—	—	—	1.39	—	—	1
BEAR-G11	0.67	—	—	—	—	—	3
BEAR-G13	—	—	—	—	—	—	1
Number of sites with detections	1	1	0	1	0	0	6
Detection frequency (percent)	7.7	7.7	0	7.7	0	0	46
Total detections (number)							9
BEAR understanding sites (11 sites sampled) ³							
BEAR-U01	—	—	0.24	—	E0.03	—	7
BEAR-U03	—	—	—	—	—	—	1
BEAR-U04	—	—	—	—	—	—	1
BEAR-U08	—	—	0.64	—	—	—	1
BEAR-U09	—	—	—	—	—	0.11	1
BEAR-U11	—	—	—	—	—	—	1

¹ The MCL-US benchmark for trihalomethanes is for the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

² The SRLs for toluene (0.69 µg/L) and 1,2,4-trimethylbenzene (0.56 µg/L) were defined by Fram and others (2012). Detections of toluene (BEAR-U11: E0.05 µg/L) and 1,2,4-trimethylbenzene (BEAR-S06: E0.01 µg/L; BEAR-S14: 0.25 µg/L; BEAR-G03: E0.02 µg/L; BEAR-G07: 0.14 µg/L; BEAR-G09: 0.26 µg/L; BEAR-G12: E0.02 µg/L; BEAR-U04: 0.16 µg/L; BEAR-U06: E0.05 µg/L; BEAR-U07: E0.05 µg/L; BEAR-U08: E0.06 µg/L; BEAR-U09: E0.07 µg/L; BEAR-U10: 0.20 µg/L; and BEAR-U11: 0.20 µg/L) have been reclassified as non-detections and are not presented in this report.

³ Understanding sites were not included in statistical calculations.

Table 6.   Pesticides and pesticide degradates detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed, but only samples with detections are listed. Constituents are listed in order of decreasing detection frequency in the 27 grid sites. All constituents are listed in table 3B. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations**: USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; —, not detected]

Primary use or source	Herbicides		Pesticide detections per site	Pesticide detection summary
GAMA site identification number	**Simazine (µg/L) (04035)**	**Prometon (µg/L) (04037)**		
Benchmark type	**MCL-US**	**HAL-US**		
Benchmark level	**4**	**400**		
[LRL]	**[0.006]**	**[0.012]**		
BEAR grid sites (27 sites sampled)				
Number of sites with detections	4	1		4
Detection frequency (percent)	14.8	3.7		15
Total detections (number)				5
Bear Valley study area (14 grid sites sampled)				
BEAR-S01	E0.007	—	1	
BEAR-S03	0.01	E0.01	2	
BEAR-S10	0.01	—	1	
Number of sites with detections	3	1		3
Detection frequency (percent)	21.4	7.1		21
Total detections (number)				4
Selected Hard Rock Areas study area (13 grid sites sampled)				
BEAR-G01	0.01	—	1	
Number of sites with detections	1	0		1
Detection frequency (percent)	7.7	0		8
Total detections (number)				1
BEAR understanding sites (11 sites sampled) [1]				
BEAR-U03	0.03	—	1	

[1] Understanding sites were not included in statistical calculations.

Table 7.   Wastewater indicator compounds (WICs) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from nine understanding sites were analyzed, but only samples with detections are listed. All constituents are listed in table 3D. **GAMA site identification number**: BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: HAL-US, USEPA lifetime health advisory level. **Other abbreviations**: USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; WIC, wastewater indicator compound; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; ≤, less than or equal to; —, not detected]

Primary use or source	Flame retardant	Disinfectant	
GAMA site identification number	Tris(2-butoxyethyl) phosphate (µg/L) (62093)	Phenol (µg/L) (34466)	WIC detections per site
Benchmark type	na	HAL-US	
Benchmark level	na	2,000	
[LRL or SRL]	[0.30] [1]	[0.16]	
BEAR understanding sites (9 sites sampled)			
BEAR-U06	≤0.10	E0.10	1
BEAR-U08	0.95	—	1

[1] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

Table 8.   Perchlorate detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the constituent given in table 3E. Samples from all 38 sites were analyzed, but only samples with detections are listed. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and MRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; MRL, method reporting level; µg/L, micrograms per liter; —, not detected; na, not available]

GAMA site identification number	Perchlorate (µg/L) (63790)	GAMA site identification number	Perchlorate (µg/L) (63790)
Benchmark type	MCL-CA	**Benchmark type**	MCL-CA
Benchmark level	6	**Benchmark level**	6
[MRL]	[0.10]	**[MRL]**	[0.10]
BEAR grid sites (27 sites sampled)		**BEAR grid sites (27 sites sampled)—Continued**	
Number of sites with detections	21	Selected Hard Rock Areas study area (13 grid sites sampled)	
Detection frequency (percent)	78	BEAR-G02	0.47
Bear Valley study area (14 grid sites sampled)		BEAR-G03	0.28
BEAR-S01	0.23	BEAR-G04	0.20
BEAR-S02	0.11	BEAR-G05	0.14
BEAR-S03	0.27	BEAR-G06	0.15
BEAR-S05	0.17		
BEAR-S06	0.22	BEAR-G11	0.15
		BEAR-G12	0.10
BEAR-S07	0.20	BEAR-G13	0.13
BEAR-S08	0.14	Number of sites with detections	8
BEAR-S09	0.26	Detection frequency (percent)	62
BEAR-S10	0.96	**BEAR understanding sites (11 sites sampled) [1]**	
BEAR-S11	0.26	BEAR-U01	0.20
		BEAR-U02	0.40
BEAR-S12	0.20	BEAR-U03	0.47
BEAR-S13	0.24	BEAR-U04	0.49
BEAR-S14	0.13	BEAR-U06	0.28
Number of sites with detections	13		
Detection frequency (percent)	93	BEAR-U07	0.50
		BEAR-U09	0.20
		BEAR-U11	na [2]

[1] Understanding sites were not included in statistical calculations.

[2] Sample was broken during shipment to the laboratory.

Table 9.   Trace elements detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents is given in table 3F. **GAMA site identification number:** BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL or SRL]	[3.4]	[0.054]	[0.04]	[0.14]	[0.012]	[2.8]	[0.02]	[0.42] [1]	[0.42] [2]	[1.7] [1]	[6] [1]	[0.65] [1]
BEAR grid sites (27 sites sampled)												
Bear Valley study area (14 grid sites sampled)												
BEAR-S01	—	—	1.1	134	—	30	—	0.79	≤0.05	≤0.65	—	≤0.17
BEAR-S02	—	—	1.4	63.9	—	6	—	0.60	≤0.03	≤1.1	—	≤0.39
BEAR-S03	—	—	0.13	41.0	—	26	—	≤0.12	≤0.05	5.4	≤3	≤0.29
BEAR-S04	E3.3	0.08	*35.2	13.2	—	150	0.04	—	≤0.02	—	7	≤0.08
BEAR-S05	—	—	1.5	35.7	—	9	—	2.7	≤0.03	—	—	≤0.22
BEAR-S06	—	—	0.36	73.2	—	8	—	0.43	≤0.05	3.2	—	≤0.45
BEAR-S07	—	—	0.38	89.9	—	11	—	≤0.10	≤0.05	5.0	—	≤0.40
BEAR-S08	—	—	0.20	30.1	—	8	—	0.64	≤0.05	—	—	≤0.12
BEAR-S09	—	—	0.09	28.0	—	6	—	0.43	≤0.05	1.9	—	1.1
BEAR-S10	—	—	0.05	22.0	—	16	E0.02	≤0.24	≤0.05	3.4	21	≤0.50
BEAR-S11	—	—	0.43	37.6	—	14	E0.02	0.88	≤0.10	≤0.98	—	≤0.29
BEAR-S12	—	—	0.21	21.6	—	32	0.03	1.7	≤0.05	—	—	≤0.26
BEAR-S13	—	—	0.16	29.4	—	5	—	2.0	≤0.09	≤1.1	—	≤0.20
BEAR-S14	E2.5	—	0.12	19.5	—	11	E0.02	≤0.10	≤0.08	2.0	—	≤0.37
Selected Hard Rock Areas study area (13 grid sites sampled)												
BEAR-G01	17.3	—	0.30	3.08	E0.01	5	E0.02	—	≤0.02	≤0.97	12	≤0.09
BEAR-G02	17.0	E0.03	E0.03	6.01	0.02	5	E0.02	—	≤0.28	3.2	10	≤0.26
BEAR-G03	5.8	—	E0.03	8.20	—	4	—	—	≤0.06	2.1	≤5	4.1
BEAR-G04	—	—	0.14	20.7	—	E2	0.06	—	≤0.11	≤0.81	*356	2.8
BEAR-G05	—	E0.03	0.06	5.13	—	5	0.10	—	≤0.31	—	*435	≤0.19

Table 9. Trace elements detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents is given in table 3F. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; μg/L, micrograms per liter; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Aluminum (μg/L) (01106)	Antimony (μg/L) (01095)	Arsenic (μg/L) (01000)	Barium (μg/L) (01005)	Beryllium (μg/L) (01010)	Boron (μg/L) (01020)	Cadmium (μg/L) (01025)	Chromium (μg/L) (01030)	Cobalt (μg/L) (01035)	Copper (μg/L) (01040)	Iron (μg/L) (01046)	Lead (μg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL or SRL]	[3.4]	[0.054]	[0.04]	[0.14]	[0.012]	[2.8]	[0.02]	[0.42]¹	[0.42]²	[1.7]¹	[6]¹	[0.65]¹
BEAR grid sites (27 sites sampled)—Continued												
Selected Hard Rock Areas study area (13 grid sites sampled)—Continued												
BEAR-G06	—	E0.03	0.05	12.8	—	31	—	—	≤0.01	≤1.1	—	≤0.14
BEAR-G07	—	—	0.09	6.64	—	6	0.05	—	≤0.09	5.6	—	3.5
BEAR-G08	—	E0.04	0.44	1.77	—	4	0.03	≤0.11	≤0.10	2.8	≤4	1.5
BEAR-G09	—	—	0.06	8.75	—	5	—	—	≤0.05	—	119	0.83
BEAR-G10	—	—	0.77	5.08	E0.01	8	E0.02	—	≤0.10	≤0.74	—	≤0.22
BEAR-G11	4.2	—	0.06	3.38	—	7	—	≤0.10	≤0.04	3.2	—	0.73
BEAR-G12	3.7	—	0.25	1.36	0.03	3	0.07	—	≤0.13	≤0.70	12	≤0.24
BEAR-G13	—	—	0.05	7.58	E0.01	4	—	≤0.08	≤0.07	≤0.59	—	≤0.47
BEAR understanding sites (11 sites sampled)												
BEAR-U01	—	—	0.05	10.4	—	6	—	—	≤0.08	≤1.1	—	1.2
BEAR-U02	—	E0.03	0.50	57.5	—	24	0.02	≤0.14	≤0.17	1.8	—	≤0.44
BEAR-U03	—	—	0.14	26.3	—	34	0.02	≤0.13	≤0.06	3.5	7	≤0.46
BEAR-U04	—	—	0.16	7.40	0.01	8	E0.01	≤0.13	≤0.03	3.1	10	≤0.09
BEAR-U05	94.6	—	E0.03	2.99	0.05	4	—	—	≤0.04	27.4	72	10.3
BEAR-U06	9.3	—	0.08	5.89	E0.01	10	—	≤0.08	≤0.07	2.8	22	0.65
BEAR-U07	—	—	0.32	54.8	—	9	—	≤0.09	≤0.16	≤1.3	—	≤0.21
BEAR-U08	—	—	4.2	8.71	E0.01	39	E0.01	—	≤0.10	—	102	≤0.09
BEAR-U09	—	—	0.44	72.4	—	15	0.02	≤0.07	≤0.17	≤1.4	—	≤0.26
BEAR-U10	12.3	E0.04	0.08	3.97	0.05	E2	E0.02	—	≤0.19	5.0	40	≤0.58
BEAR-U11	10.3	0.14	0.07	4.23	—	4	—	—	≤0.11	—	*487	1.7

Table 9. Trace elements detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents is given in table 3F. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	na	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	MCL-US	na	NL-CA	SMCL-CA
Benchmark level	na	na	40	100	50	100	4,000	2	na	50	5,000
[LRL or SRL]	[0.44]	[0.79]²	[0.014]	[0.36]¹	[0.040]	[0.010]	[0.40]	[0.020]	[0.11]¹	[0.16]	[4.8]¹
BEAR grid sites (27 sites sampled)											
Bear Valley study area (14 grid sites sampled)											
BEAR-S01	5.0	≤0.20	0.526	≤0.27	0.45	—	536	—	0.31	7.8	≤2.5
BEAR-S02	3.2	≤0.25	0.235	≤0.13	0.41	—	678	—	0.11	9.6	≤2.1
BEAR-S03	2.9	—	0.157	≤0.23	0.05	—	210	—	—	2.1	≤3.5
BEAR-S04	3.6	≤0.70	6.24	—	0.89	—	82.8	—	8.3	16.1	—
BEAR-S05	2.0	≤0.40	0.591	≤0.09	0.09	—	216	—	1.1	10.4	≤2.6
BEAR-S06	1.3	—	E0.014	≤0.27	0.07	—	182	—	≤0.01	2.0	—
BEAR-S07	0.8	≤0.16	0.669	0.36	0.06	—	302	—	≤0.01	1.7	6.8
BEAR-S08	1.5	—	0.273	≤0.30	0.17	—	191	—	≤0.03	1.3	—
BEAR-S09	—	—	0.399	≤0.24	0.27	—	167	—	≤0.03	1.1	≤1.4
BEAR-S10	2.3	≤0.28	2.36	0.56	0.85	—	164	—	0.21	1.2	≤3.9
BEAR-S11	1.9	1.9	0.870	0.50	0.33	—	218	—	0.87	9.7	—
BEAR-S12	E0.30	—	2.88	≤0.32	0.14	—	127	—	7.0	3.9	≤4.1
BEAR-S13	—	≤0.40	0.262	0.55	0.12	—	201	—	≤0.06	2.1	7.1
BEAR-S14	1.3	≤0.17	0.886	0.45	0.33	—	99.3	—	0.13	0.39	24.0
Selected Hard Rock Areas study area (13 grid sites sampled)											
BEAR-G01	108	≤0.42	2.40	≤0.11	0.04	—	457	—	≤0.02	0.78	18.7
BEAR-G02	11.0	1.0	E0.025	≤0.17	0.17	0.02	289	—	—	0.83	22.9
BEAR-G03	6.1	≤0.73	0.156	≤0.13	0.08	—	117	—	≤0.01	1.4	12.1
BEAR-G04	14.3	10.4	0.047	≤0.33	E0.03	—	153	—	—	2.1	63.4
BEAR-G05	12.1	22.3	0.260	≤0.20	0.06	—	184	—	—	1.2	80.3

Table 9. Trace elements detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents is given in table 3F. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	MCL-US	na	NL-CA	SMCL-CA
Benchmark level	na	50	40	100	50	100	4,000	2	na	50	5,000
[LRL or SRL]	[0.44]	[0.79]2	[0.014]	[0.36]1	[0.040]	[0.010]	[0.40]	[0.020]	[0.11]1	[0.16]	[4.8]1
BEAR grid sites (27 sites sampled)—Continued											
Selected Hard Rock Areas study area (13 grid sites sampled)—Continued											
BEAR-G06	23.1	≤0.20	2.25	≤0.28	0.19	—	292	—	≤0.01	2.5	≤4.3
BEAR-G07	37.3	2.8	1.84	0.56	0.15	—	444	—	≤0.05	0.92	92.8
BEAR-G08	16.1	≤0.15	2.22	0.53	0.71	—	138	E0.02	0.12	2.4	109
BEAR-G09	38.4	*50.1	2.00	≤0.10	0.09	—	447	—	≤0.02	0.70	425
BEAR-G10	48.6	6.0	2.73	0.71	E0.03	—	642	—	—	0.72	147
BEAR-G11	16.4	≤0.74	0.651	≤0.25	0.26	—	125	—	≤0.08	2.5	63.9
BEAR-G12	65.1	2.0	0.028	≤0.32	E0.03	—	151	—	—	0.54	33.0
BEAR-G13	33.3	≤0.40	0.885	0.47	0.11	—	250	—	—	4.8	—
BEAR understanding sites (11 sites sampled)											
BEAR-U01	32.3	—	0.08	≤0.16	0.09	—	221	—	—	2.1	—
BEAR-U02	5.7	≤0.33	2.57	≤0.26	0.30	—	118	—	1.8	2.0	≤3.4
BEAR-U03	2.7	≤0.18	5.07	0.51	1.3	—	192	—	0.13	1.5	≤1.8
BEAR-U04	5.9	5.1	1.55	≤0.26	0.56	—	92.3	—	0.64	1.5	5.2
BEAR-U05	22.9	1.5	E0.025	≤0.23	E0.03	—	65.7	—	—	0.33	≤2.0
BEAR-U06	1.6	≤0.50	E0.026	≤0.30	—	—	203	—	≤0.03	0.52	22.8
BEAR-U07	1.9	≤0.30	0.286	0.51	E0.03	—	397	—	≤0.03	1.6	7.4
BEAR-U08	2.3	*108	2.75	0.72	E0.02	—	581	—	0.89	0.19	12.7
BEAR-U09	0.90	≤0.22	1.48	1.0	0.46	—	306	—	≤0.03	1.3	≤4.7
BEAR-U10	18.2	1.4	—	≤0.28	—	—	136	—	—	0.53	13.4
BEAR-U11	44.9	*155	1.26	≤0.12	—	—	540	—	≤0.05	0.34	256

1 The SRL was defined by Olsen and others (2010).

2 The SRL was defined based on the highest concentration detected in the BEAR blank samples.

Table 10.   Nutrients and dissolved organic carbon (DOC) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed for nutrients and DOC. Information about the constituents given in table 3G. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; SRL, study reporting level; mg/L, milligrams per liter; na, not available; —, not detected; ≤, less than or equal to; NWQL, USGS National Water Quality Laboratory]

GAMA site identification number	Ammonia (as nitrogen) (mg/L) (00608)	Nitrite (as nitrogen) (mg/L) (00613)	Nitrite plus nitrate (as nitrogen) (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen) (mg/L) (62854)	Phosphate, orthophosphate (as phosphorus) (mg/L) (00671)	DOC (mg/L) (00681)
Benchmark type	HAL-US	MCL-US	MCL-US	na	na	na
Benchmark level	[1] 24.7	1	10	na	na	na
[LRL or SRL]	[0.02]	[0.001]	[0.04]	[0.10]	[0.006]	[0.8] [2]
BEAR grid sites (27 sites sampled)						
Bear Valley study area (14 grid sites sampled)						
BEAR-S01	—	—	1.42	1.49	0.021	≤0.6
BEAR-S02	—	—	0.15	0.14	0.045	≤0.5
BEAR-S03	—	—	1.51	1.55	0.103	0.9
BEAR-S04	—	—	0.50	0.52	0.025	—
BEAR-S05	—	—	0.22	0.21	0.013	—
BEAR-S06	—	—	0.47	0.50	0.022	—
BEAR-S07	—	—	1.33	1.38	0.055	≤0.8
BEAR-S08	—	—	0.12	0.12	0.042	—
BEAR-S09	—	—	0.49	0.51	0.074	—
BEAR-S10	—	—	4.03	4.16	0.028	≤0.4
BEAR-S11	—	—	0.92	0.94	0.018	—
BEAR-S12	—	—	0.31	0.32	0.060	—
BEAR-S13	—	—	1.09	1.06	0.092	≤0.4
BEAR-S14	—	—	0.36	0.36	0.015	≤0.6
Selected Hard Rock Areas study area (13 grid sites sampled)						
BEAR-G01	—	—	0.22	0.22	0.018	≤0.5
BEAR-G02	—	—	0.40	0.41	0.058	≤0.5
BEAR-G03	—	—	0.11	0.12	0.026	≤0.7
BEAR-G04	—	0.004	0.99	1.00	0.021	—
BEAR-G05	E0.014	0.005	0.40	0.43	0.010	—
BEAR-G06	—	—	0.22	0.25	0.019	≤0.4
BEAR-G07	—	—	E0.04	E0.10	0.016	≤0.7
BEAR-G08	—	—	0.07	E0.07	0.032	—
BEAR-G09	—	0.007	0.17	0.19	0.012	≤0.6
BEAR-G10	—	—	0.10	0.12	0.009	≤0.6

Table 10.   Nutrients and dissolved organic carbon (DOC) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed for nutrients and DOC. Information about the constituents given in table 3G. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; SRL, study reporting level; mg/L, milligrams per liter; na, not available; —, not detected; ≤, less than or equal to; NWQL, USGS National Water Quality Laboratory]

GAMA site identification number	Ammonia (as nitrogen) (mg/L) (00608)	Nitrite (as nitrogen) (mg/L) (00613)	Nitrite plus nitrate (as nitrogen) (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen) (mg/L) (62854)	Phosphate, orthophosphate (as phosphorus) (mg/L) (00671)	DOC (mg/L) (00681)
Benchmark type	HAL-US	MCL-US	MCL-US	na	na	na
Benchmark level	[1] 24.7	1	10	na	na	na
[LRL or SRL]	[0.02]	[0.001]	[0.04]	[0.10]	[0.006]	[0.8] [2]
BEAR grid sites (27 sites sampled)—Continued						
Selected Hard Rock Areas study area (13 grid sites sampled)—Continued						
BEAR-G11	—	—	3.83	3.76	0.030	—
BEAR-G12	—	—	0.25	0.25	0.072	≤0.6
BEAR-G13	—	—	0.33	0.30	0.049	≤0.4
BEAR understanding sites (11 sites sampled)						
BEAR-U01	—	—	1.24	1.26	0.018	—
BEAR-U02	—	—	0.97	1.00	0.019	≤0.4
BEAR-U03	—	—	6.81	7.19	0.069	≤0.6
BEAR-U04	—	—	0.52	0.54	0.120	≤0.4
BEAR-U05	—	—	0.65	0.72	0.028	1.7
BEAR-U06	—	—	0.71	0.78	0.034	3.2
BEAR-U07	—	—	1.85	1.95	0.029	1.1
BEAR-U08	—	—	E0.02	[3] —	0.009	≤0.5
BEAR-U09	—	—	1.74	1.85	0.028	2.8
BEAR-U10	—	—	0.47	0.47	0.103	≤0.4
BEAR-U11	—	0.006	0.07	E0.06	0.010	≤0.4

[1] The HAL-US is 30 mg/L "as ammonia." To facilitate comparison to the analytical results, we have converted and reported this HAL-US as 24.7 mg/L "as nitrogen."

[2] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

[3] Total nitrogen concentration in this sample is less than the sum of the filtered nitrogen analytes and falls outside the USGS NWQL acceptance criterion of a 10 percent relative percent difference. However, the absolute difference is ≤0.02 mg/L, thus, the difference is unlikely to affect interpretation of the data.

Table 11.   Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents given in table 3H. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LRL, laboratory reporting level; SRL, study reporting level; mg/L, milligrams per liter; SiO_2, silicon dioxide; E, estimated or having a higher degree of uncertainty; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Silica (as SiO_2) (mg/L) (00955)	TDS (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	SMCL-CA	na	SMCL-CA
Benchmark level	na	na	[1] 250 (500)	2	na	na	na	na	[1] 250 (500)	na	[1] 500 (1,000)
[LRL or SRL]	[0.02]	[0.044]	[0.12]	[0.06] [2]	[0.002]	[0.016]	[0.064]	[0.10]	[0.18]	[0.058]	[10]
BEAR grid sites (27 sites sampled)											
Bear Valley study area (14 grid sites sampled)											
BEAR-S01	0.06	50.4	16.4	0.53	0.002	34.1	2.15	19.8	47.2	25.4	345
BEAR-S02	E0.02	32.8	4.5	0.14	—	10.1	1.56	12.7	9.9	23.7	172
BEAR-S03	0.04	39.8	21.3	≤0.05	E0.001	6.9	2.18	13.1	6.8	23.5	209
BEAR-S04	0.03	2.0	4.3	1.0	0.019	1.4	1.13	81.3	14.4	9.7	220
BEAR-S05	0.03	18.3	5.0	0.37	—	8.0	1.44	21.0	6.0	13.8	149
BEAR-S06	E0.01	67.0	2.8	≤0.04	—	15.3	1.06	6.3	1.9	21.1	248
BEAR-S07	0.05	82.6	14.1	0.22	E0.001	35.5	3.57	7.3	42.8	19.0	398
BEAR-S08	E0.02	45.5	2.9	0.10	—	18.8	1.88	10.7	8.5	28.5	220
BEAR-S09	0.03	37.2	5.6	0.12	—	17.3	1.58	8.7	15.8	26.8	197
BEAR-S10	0.14	36.8	20.4	2.0	E0.002	7.5	1.98	28.4	17.0	25.8	247
BEAR-S11	0.04	48.0	8.7	0.40	E0.001	18.4	1.58	20.0	12.8	20.6	253
BEAR-S12	0.03	29.7	5.6	*2.8	E0.001	10.9	1.12	41.7	20.6	22.2	239
BEAR-S13	0.05	46.8	8.8	≤0.06	—	17.6	1.93	11.2	5.3	29.7	224
BEAR-S14	E0.01	37.8	1.54	0.17	—	34.9	2.94	2.8	22.8	15.0	246
Selected Hard Rock Areas study area (13 grid sites sampled)											
BEAR-G01	—	32.6	5.3	E0.08	—	1.9	0.54	14.4	2.6	20.0	159
BEAR-G02	0.02	19.8	28.8	≤0.05	—	2.9	1.21	11.9	4.3	32.8	153
BEAR-G03	E0.01	12.7	6.2	—	0.002	2.8	1.62	7.8	4.3	24.3	98.0
BEAR-G04	E0.01	19.9	3.6	0.10	—	5.6	2.04	10.8	0.85	31.1	150
BEAR-G05	—	23.8	2.8	≤0.06	—	5.1	2.99	9.1	1.8	18.2	119
BEAR-G06	0.03	49.8	7.3	0.29	E0.001	12.3	2.63	17.9	15.5	30.6	258
BEAR-G07	0.05	42.1	12.3	0.20	0.013	3.3	1.74	24.2	3.0	20.8	209
BEAR-G08	—	46.5	3.9	0.24	—	4.8	1.36	8.1	4.6	32.7	202
BEAR-G09	0.03	38.0	8.1	0.15	0.004	8.4	2.72	19.4	2.1	19.0	187
BEAR-G10	E0.02	55.8	5.8	0.14	E0.001	3.3	0.28	16.5	7.9	16.2	225
BEAR-G11	0.04	19.0	6.5	0.09	—	4.9	2.11	12.2	7.5	32.0	153
BEAR-G12	E0.02	27.4	2.7	0.13	E0.001	2.1	0.91	9.7	2.6	42.7	151
BEAR-G13	0.04	40.2	11.9	0.10	E0.002	14.2	4.23	16.5	3.8	30.3	229

Table 11. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents given in table 3H. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type, benchmark level, and LRL as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LRL, laboratory reporting level; SRL, study reporting level; mg/L, milligrams per liter; SiO_2, silicon dioxide; E, estimated or having a higher degree of uncertainty; na, not available; —, not detected; ≤, less than or equal to; *, concentration is greater than the benchmark level]

GAMA site identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Silica (as SiO_2) (mg/L) (00955)	TDS (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	SMCL-CA	na	SMCL-CA
Benchmark level	na	na	[1] 250 (500)	2	na	na	na	na	[1] 250 (500)	na	[1] 500 (1,000)
[LRL or SRL]	[0.02]	[0.044]	[0.12]	[0.06] [2]	[0.002]	[0.016]	[0.064]	[0.10]	[0.18]	[0.058]	[10]
BEAR understanding sites (11 sites sampled)											
BEAR-U01	E0.02	40.4	14.5	0.04	—	12.3	3.25	13.2	3.3	18.3	215
BEAR-U02	0.04	50.5	14.3	0.81	E0.001	33.2	2.17	19.1	40.8	25.0	343
BEAR-U03	0.10	41.4	22.1	0.99	E0.002	12.2	2.02	20.8	15.8	27.7	262
BEAR-U04	0.16	30.1	20.4	0.20	E0.002	11.3	5.04	18.0	15.6	19.6	203
BEAR-U05	—	10.2	1.4	0.05	E0.001	0.78	0.36	5.4	1.34	25.2	73.0
BEAR-U06	0.03	15.6	9.4	0.14	0.003	5.3	1.87	11.0	5.7	25.3	123
BEAR-U07	0.06	39.8	15.8	0.13	0.004	12.5	3.46	13.5	12.9	34.3	241
BEAR-U08	0.03	34.3	5.4	1.3	0.008	9.0	2.48	32.0	52.9	14.3	230
BEAR-U09	0.05	71.0	9.8	0.24	0.003	38.7	4.35	8.5	23.9	23.5	374
BEAR-U10	—	8.4	1.7	E0.07	—	0.60	0.73	9.3	0.48	39.9	90.0
BEAR-U11	E0.02	31.6	7.0	0.14	0.004	7.0	2.53	19.9	1.5	16.7	172

[1] The SMCL-CA for chloride, sulfate, and TDS have recommended and upper benchmark values. The upper benchmark value is shown in parentheses.

[2] The SRL was defined based on the highest concentration detected in the BEAR blank samples.

Table 12.   Arsenic and iron species detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Data in this table was generated at the USGS NRP-TML, Boulder, Colorado, using research methods. Information about the constituents given in table 3I. Samples were collected at all 38 sites, but only samples with detections are listed. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Method detection limit, benchmark type, and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; NRP, USGS National Research Program; TML, Trace Metal Laboratory; MDL, method detection limit; na, not available; µg/L, micrograms per liter; *, concentration is greater than the benchmark level; —, not detected]

GAMA site identification number	Arsenic (total) (99033) (µg/L)	Arsenic-III (99034) (µg/L)	Iron (total) (01046) (µg/L)	Iron-II (01047) (µg/L)
Benchmark type	MCL-US	na	SMCL-CA	na
Benchmark level	10	na	300	na
[MDL]	[0.5]	[1]	[2]	[2]
BEAR grid sites (27 sites sampled)				
Bear Valley study area (14 grid sites sampled)				
BEAR-S01	0.9	—	—	—
BEAR-S02	1.0	—	—	—
BEAR-S03	—	—	2.4	—
BEAR-S04	*29.5	—	5.6	2.0
BEAR-S05	1.3	—	—	—
BEAR-S07	—	—	2.1	—
BEAR-S10	—	—	4.7	2.9
Selected Hard Rock Areas study area (13 grid sites sampled)				
BEAR-G01	—	—	6.6	4.2
BEAR-G02	—	—	11.8	8.3
BEAR-G03	—	—	2.0	—
BEAR-G04	—	—	*384	330
BEAR-G05	—	—	*445	308
BEAR-G09	—	—	2.5	—
BEAR-G10	—	—	2.6	—
BEAR-G12	—	—	11.4	8.3
BEAR understanding sites (11 sites sampled)				
BEAR-U04	—	—	7.8	4.4
BEAR-U05	—	—	23.0	16.8
BEAR-U06	—	—	21.3	12.9
BEAR-U08	4.4	3.7	105	87.3
BEAR-U10	—	—	43.7	35.5
BEAR-U11	—	—	*516	203

Table 13.   Isotopic tracers detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the constituents given in table 3J. Samples from all 38 sites were analyzed, with the exception of the stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance (30 sites). Stable isotope ratios of hydrogen, oxygen, nitrogen, and carbon are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Isotopic ratios of strontium are reported as the abundance of atoms of the heavier isotope to the lighter isotope of the element. Results for stable isotopes of boron in water analyzed by USGS NRP Metals Isotope Research Laboratory, Menlo Park, California, were not completed in time for inclusion in this report; results will be presented in a subsequent publication. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type and benchmark level as of April 1, 2010. **Other abbreviations**: USGS, U.S. Geological Survey; H, hydrogen; O, oxygen; N, nitrogen; Sr, strontium; C, carbon; na, not available; NRP, USGS National Research Program]

GAMA site identification number	δ^2H in water (per mil) (82082)	δ^{18}O in water (per mil) (82085)	δ^{15}N in nitrate (per mil) (82690)	δ^{18}O in nitrate (per mil) (63041)	Strontium isotope ratio (δ^{87}Sr/δ^{86}Sr) (atom ratio) (75978)	δ^{13}C (per mil) (82081)	Carbon-14 (percent modern) (49933)
Benchmark type	na	na	na	na	na	na	na
Benchmark level	na	na	na	na	na	na	na
BEAR grid sites (27 sites sampled)							
Bear Valley study area (14 grid sites sampled)							
BEAR-S01	−80.9	−11.20	10.23	2.31	0.71761	−13.61	78.58
BEAR-S02	−80.8	−11.54	7.99	−3.03	0.71437	−14.14	76.35
BEAR-S03	−75.8	−10.83	8.00	1.48	0.71250	−15.90	102.2
BEAR-S04	−83.4	−11.52	13.49	0.80	0.71096	−8.08	5.540
BEAR-S05	−83.9	−11.84	11.4	−2.87	0.71992	−12.16	37.13
BEAR-S06	−84.5	−11.90	5.08	−2.87	0.71292	−11.56	74.96
BEAR-S07	−73.9	−10.27	7.57	0.19	0.71256	−13.31	94.87
BEAR-S08	−88.3	−12.32	4.23	−5.60	0.71979	−11.89	69.58
BEAR-S09	−89.5	−12.44	6.65	−2.38	0.72045	−12.67	82.24
BEAR-S10	−93.3	−12.54	7.11	−3.27	0.74468	na [1]	na [1]
BEAR-S11	−85.6	−11.95	8.54	0.08	0.72429	na [1]	na [1]
BEAR-S12	−87.6	−12.19	6.92	−4.90	0.72179	−12.33	68.37
BEAR-S13	−85.5	−12.05	8.72	0.07	0.72063	−12.83	73.97
BEAR-S14	−87.1	−12.37	1.43	1.83	0.71863	na [1]	na [1]
Selected Hard Rock Areas study area (13 grid sites sampled)							
BEAR-G01	−68.6	−10.16	3.35	1.77	0.71085	−18.07	76.82
BEAR-G02	−58.7	−9.05	4.49	9.94	0.71088	−20.36	108.1
BEAR-G03	−57.3	−8.90	2.33	3.16	0.71101	−20.39	105.8
BEAR-G04	−68.1	−10.0	0.02	0.06	0.71083	−18.30	98.42
BEAR-G05	−64.7	−9.86	1.20	4.26	0.71096	−17.35	86.96
BEAR-G06	−62.6	−9.31	1.63	4.95	0.71046	−16.42	88.34
BEAR-G07	−59.0	−9.04	10.71	3.27	0.71040	−17.45	78.03
BEAR-G08	−60.9	−9.46	2.72	3.77	0.71067	na [1]	na [1]
BEAR-G09	−66.0	−9.97	5.25	6.43	0.71007	−17.35	71.66
BEAR-G10	−71.2	−10.7	6.91	2.29	0.71080	−15.91	80.07
BEAR-G11	−54.2	−8.73	−0.39	10.42	0.71416	−18.92	99.33
BEAR-G12	−71.5	−10.60	3.76	2.62	0.71093	na [1]	na [1]
BEAR-G13	−66.4	−9.97	7.01	4.42	0.71045	−18.18	95.12

Table 13.   Isotopic tracers detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the constituents given in table 3J. Samples from all 38 sites were analyzed, with the exception of the stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance (30 sites). Stable isotope ratios of hydrogen, oxygen, nitrogen, and carbon are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Isotopic ratios of strontium are reported as the abundance of atoms of the heavier isotope to the lighter isotope of the element. Results for stable isotopes of boron in water analyzed by USGS NRP Metals Isotope Research Laboratory, Menlo Park, California, were not completed in time for inclusion in this report; results will be presented in a subsequent publication. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type and benchmark level as of April 1, 2010. **Other abbreviations**: USGS, U.S. Geological Survey; H, hydrogen; O, oxygen; N, nitrogen; Sr, strontium; C, carbon; na, not available; NRP, USGS National Research Program]

GAMA site identification number	δ^2H in water (per mil) (82082)	δ^{18}O in water (per mil) (82085)	δ^{15}N in nitrate (per mil) (82690)	δ^{18}O in nitrate (per mil) (63041)	Strontium isotope ratio (δ^{87}Sr/δ^{86}Sr) (atom ratio) (75978)	δ^{13}C (per mil) (82081)	Carbon-14 (percent modern) (49933)
Benchmark type	na	na	na	na	na	na	na
Benchmark level	na	na	na	na	na	na	na
BEAR understanding sites (11 sites sampled)							
BEAR-U01	–65.4	–9.72	7.23	3.69	0.71124	na [1]	na [1]
BEAR-U02	–83.0	–11.22	6.36	0.72	0.71337	–10.64	82.87
BEAR-U03	–87.7	–11.49	7.60	–2.40	0.73860	–14.56	97.06
BEAR-U04	–99.3	–13.55	6.21	–1.58	0.77499	na [1]	na [1]
BEAR-U05	–68.5	–10.31	5.52	2.74	0.71069	na [1]	na [1]
BEAR-U06	–60.3	–8.07	4.47	2.22	0.72344	–17.31	106.8
BEAR-U07	–49.6	–5.72	1.56	1.84	0.71187	–16.13	102.5
BEAR-U08	–81.0	–11.57	18.67	19.66	0.71553	–11.11	51.92
BEAR-U09	–55.3	–6.72	4.78	3.63	0.71235	–12.44	89.50
BEAR-U10	–69.8	–10.58	4.68	6.65	0.71022	–19.66	108.5
BEAR-U11	–65.1	–10.02	11.71	7.14	0.70994	–17.77	67.48

[1] Sample was broken during shipment to the laboratory.

Table 14. Uranium and other radioactive constituents detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[The five-digit number in parentheses below the constituent name is the USGS parameter code used to uniquely identify a specific constituent or property. Samples from all 38 sites were analyzed. Information about the constituents given in table 3J. Tritium activities less than the sample-specific critical level (ssL_C) are reported as non-detections (—). The reporting level (RL) for uranium is an LRL. **GAMA site identification number**: BEAR-S, Bear Valley study area grid site; BEAR-G, Selected Hard Rock Areas study area grid site; BEAR-U, Bear Valley and Selected Hard Rock Areas study unit understanding site. Benchmark type and benchmark level as of April 1, 2010. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US if the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; RL, reporting level; CSU, combined standard uncertainty; pCi/L, picocurie per liter; µg/L, micrograms per liter; ±, plus or minus; *, concentration is greater than the benchmark level]

GAMA site identification number	Radon-222 (pCi/L) (82303)		Tritium (pCi/L) (07000)		Uranium (µg/L) (22703)
Benchmark type	MCL-US (Proposed)		MCL-CA		MCL-US
Benchmark level	4,000		20,000		30
[RL]	Result ± CSU	ssL_C	Result ± CSU	ssL_C	[0.008]
BEAR grid sites (27 sites sampled)					
Bear Valley study area (14 grid sites sampled)					
BEAR-S01	320 ± 22	14	5.5 ± 0.35	0.32	2.7
BEAR-S02	280 ± 21	14	2.1 ± 0.32	0.32	1.7
BEAR-S03	1,580 ± 89	16	8.9 ± 0.41	0.32	0.93
BEAR-S04	330 ± 24	16	1.1 ± 0.32	0.32	3.1
BEAR-S05	300 ± 25	22	—	0.32	1.2
BEAR-S06	232 ± 17	12	0.7 ± 0.32	0.32	0.24
BEAR-S07	151 ± 13	12	7.4 ± 0.38	0.32	0.80
BEAR-S08	490 ± 33	18	—	0.32	0.86
BEAR-S09	2,080 ± 120	17	1.7 ± 0.32	0.32	0.86
BEAR-S10	3,900 ± 210	14	3.0 ± 0.32	0.32	7.7
BEAR-S11	400 ± 26	13	3.6 ± 0.32	0.32	3.8
BEAR-S12	1,600 ± 90	13	—	0.32	2.2
BEAR-S13	2,250 ± 120	12	1.5 ± 0.32	0.32	1.8
BEAR-S14	206 ± 16	11	9.0 ± 0.41	0.32	0.57
Selected Hard Rock Areas study area (13 grid sites sampled)					
BEAR-G01	*10,300 ± 550	15	5.5 ± 0.41	0.32	*87.2
BEAR-G02	*7,800 ± 420	15	9.8 ± 0.48	0.32	1.5
BEAR-G03	3,260 ± 180	16	14.0 ± 0.57	0.32	0.47
BEAR-G04	*22,200 ± 1,200	14	6.1 ± 0.41	0.32	13.8
BEAR-G05	*6,900 ± 370	14	6.2 ± 0.35	0.32	19.8
BEAR grid sites (27 sites sampled)—Continued					
Selected Hard Rock Areas study area (13 grid sites sampled)—Continued					
BEAR-G06	2,660 ± 150	12	3.1 ± 0.32	0.32	16.7
BEAR-G07	*19,300 ± 1,000	12	4.0 ± 0.32	0.32	*57.0
BEAR-G08	*16,300 ± 870	12	3.4 ± 0.32	0.32	*61.8
BEAR-G09	*4,300 ± 230	12	2.8 ± 0.34	0.32	17.5
BEAR-G10	*7,100 ± 380	13	6.5 ± 0.54	0.48	25.4
BEAR-G11	3,040 ± 170	11	8.4 ± 0.48	0.38	5.5
BEAR-G12	*10,600 ± 570	11	8.0 ± 0.51	0.41	18.6
BEAR-G13	2,510 ± 140	11	4.6 ± 0.48	0.41	18.2
BEAR understanding sites (11 sites sampled)					
BEAR-U01	*7,400 ± 400	16	6.2 ± 0.41	0.32	*43.7
BEAR-U02	290 ± 25	22	3.2 ± 0.32	0.32	2.7
BEAR-U03	2,460 ± 140	14	7.3 ± 0.38	0.32	7.0
BEAR-U04	*4,600 ± 250	14	0.6 ± 0.32	0.32	11.0
BEAR-U05	*7,000 ± 380	13	11.6 ± 0.57	0.41	1.9
BEAR-U06	2,920 ± 160	13	13.8 ± 0.64	0.41	0.20
BEAR-U07	570 ± 35	13	10.6 ± 0.57	0.41	0.58
BEAR-U08	1,670 ± 92	11	—	0.38	0.14
BEAR-U09	950 ± 54	11	10.4 ± 0.57	0.41	1.8
BEAR-U10	*8,000 ± 430	13	9.2 ± 0.54	0.41	1.4
BEAR-U11	*4,600 ± 250	12	1.0 ± 0.32	0.32	26.7

Appendix

This appendix includes discussions of the methods used to collect and analyze groundwater samples and report the resulting water-quality data. These methods were selected to obtain representative samples of the groundwater from each site and to minimize the potential for contamination of the samples or bias in the data. Procedures used to collect and assess QC data, and the results of the QC assessments also are discussed.

In the BEAR study unit, groundwater samples were collected and QA/QC procedures were implemented by using standard and modified USGS protocols from the NFM (U.S. Geological Survey, variously dated; Wilde and others, 1999, 2004) and the NAWQA Program (Koterba and others, 1995). The QA plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described in Maloney (2005) and Pirkey and Glodt (1998).

Sample Collection and Analysis

Samples were collected from two types of sites: production wells and springs ("springs" in this study unit include horizontal wells). Sites classified as production wells are vertically drilled into the ground and have pumps that bring the groundwater from the aquifer system to land surface and into a distribution system. Sites were classified as springs if groundwater discharged naturally at land surface from the aquifer without a drilled hole or if the well was drilled horizontally. A few springs had pumps to transport groundwater from the spring to a storage tank at a higher elevation.

Prior to sampling, each well was pumped continuously to purge at least three casing volumes of water from the well (Wilde and others, 1999). Wells were sampled by using Teflon® tubing with brass and stainless-steel fittings attached to a sampling point (usually a hose-bib fitting) on the well discharge pipe as close to the wellhead as possible. The sampling point was located upstream from water-storage tanks or wellhead treatment systems (if present). If a chlorinating system was attached to the well, the chlorinator was shut off, when possible, before the well was purged and sampled, in order to clear all chlorine out of the system. The absence of free chlorine was verified by using a Hach® field test kit. Samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the wellhead by a 10–50 ft length of the Teflon® tubing (Lane and others, 2003). All fittings and lengths of Teflon® tubing were cleaned between samples (Wilde, 2004). All of the springs had sampling points on discharge pipes similar to the sampling points found on wells. Field water-quality indicators were measured and samples were collected by using the same protocols as used for wells.

For the field measurements, groundwater was pumped through a flow-through chamber (attached to the sampling point) fitted with a multi-probe meter that simultaneously measures the field water-quality indicators—dissolved oxygen, temperature, pH, and specific conductance. Turbidity was measured in the field with a calibrated turbidity meter. Field measurements were made in accordance with protocols in the USGS NFM (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured turbidity, dissolved oxygen, temperature, pH, and specific conductance values were recorded at 5-minute (min) intervals, and when these values remained stable for a minimum of 30 min, samples for laboratory analyses then were collected.

Field measurements and instrument calibrations were recorded on field record sheets and electronically in the Personal Computer Field Form (PCFF) program on field laptop computers. Analytical service requests for the NWQL were generated by PCFF, whereas analytical service requests for non-NWQL analysis were entered into laboratory-specific spreadsheets. Information from PCFF was uploaded directly into the USGS NWIS database at the end of the week of sample collection.

Prior to sample collection, polyethylene sample bottles were pre-rinsed three times with deionized water and then once with native sample water before sample collection. Samples requiring acidification were acidified to a pH of between 2 and 1 with the appropriate acids by using ampoules of certified, traceable concentrated acids obtained from the NWQL.

Samples for the analysis of VOCs were collected in three 40-milliliter (mL) sample vials that were purged with three vial volumes of unfiltered groundwater before bottom-filling to eliminate atmospheric contamination. One to one (1:1) hydrochloric acid to water (HCl/H_2O) solution was added as a preservative to the VOC samples. Samples for analysis of 1,2,3-TCP were collected by top-filling two 40-mL sample vials that were pre-treated with 0.5 mL 6-Normal (N) HCl acid (as a preservative), at Weck Laboratories, Inc. (Weck), City of Industry, California. Each sample to be analyzed for perchlorate was collected in a 125-mL polystyrene bottle and then filtered in two or three 20-mL aliquots of unfiltered groundwater through a 0.20-micrometer (µm) pore-size Corning® syringe-tip disk filter into a sterilized 125-mL bottle. Samples for the analysis of tritium were collected by bottom-filling one 1-L polyethylene bottle and one 1-L glass bottle with unfiltered groundwater, after first overfilling the bottles with three volumes of unfiltered groundwater. Samples for analysis of stable isotopes of hydrogen and oxygen in water were collected in a 60-mL clear glass bottle filled with unfiltered groundwater, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Samples were collected in 1-L baked amber glass bottles for the analyses of pesticides and pesticide degradates, pharmaceutical compounds, WICs, and NDMA. Samples for analyses of pesticides and pesticide degradates, pharmaceutical compounds, and WICs were filtered through a 0.7-µm nominal pore-size glass fiber filter during collection, whereas the samples for NDMA analysis were filtered at Weck prior to analysis. NDMA sample bottles, treated with 0.05 grams (g) of sodium thiosulfate ($Na_2S_2O_3$) (as a preservative), were provided by Weck.

Groundwater samples for trace element, major and minor ion, silica, and TDS analyses required filling one 250-mL polyethylene bottle with unfiltered groundwater and one 500-mL and one 250-mL polyethylene bottle with filtered groundwater (Wilde and others, 2004). Filtration was done by using a 0.45-µm pore-size PALL® unvented capsule filter that was pre-rinsed with 2 L of deionized water and then rinsed with 1 L of groundwater prior to sampling. The 250-mL filtered sample then was preserved with 7.5-N nitric acid. Samples to be analyzed for nutrients and stable isotopes of nitrogen and oxygen in dissolved nitrate each were filtered into 125-mL brown polyethylene bottles. Samples for analyses of arsenic and iron species were filtered into a 250-mL polyethylene bottle that was covered with tape to prevent light exposure and preserved with 6-N hydrochloric acid. Samples for analyses of stable isotopes of boron in water and isotopic ratios of strontium in water were filtered into one 250-mL polyethylene bottle and secured with electrical tape to prevent leakage and evaporation. Samples for analyses of stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance were bottom-filled into 500-mL glass bottles that first were overfilled with three bottle volumes of filtered groundwater. These samples had no headspace and were sealed with conical caps to avoid atmospheric contamination. Samples for field alkalinity titrations were collected by filtering groundwater into a 500-mL polyethylene bottle.

Samples for analysis of DOC were collected from the hose bib at the wellhead by using a Teflon® filtration apparatus attached to a foot-long length of Teflon® tubing. For each sample, 100 mL of groundwater and (or) certified inorganic-free blank water was first filtered to waste through the baked 0.7-µm nominal pore-size glass-fiber filter, then 100 mL of groundwater was filtered into a 125-mL baked amber glass bottle (Wilde and others, 2004). Each sample then was preserved immediately by lowering the pH to between 2 and 1 with 4.5-N sulfuric acid.

For the collection of groundwater for analysis of radon-222, a stainless-steel and Teflon® valve assembly was attached to the sampling port at the wellhead (Wilde and others, 2004). The valve was closed partially to create back pressure, and a 10-mL groundwater sample was taken through a Teflon® septum on the valve assembly by using a glass syringe affixed with a stainless-steel needle. The sample was then injected into a 25-mL vial partially filled with a scintillation mixture (mineral oil) and shaken. The vial then was placed in an insulated cardboard tube to protect the sample during shipping.

Dissolved noble gases were collected in ⅜-inch-diameter copper tubes by using reinforced nylon tubing connected to the hose bib at the wellhead. Groundwater was flushed through the tubing to dislodge any bubbles before the flow was restricted with a back-pressure valve. Clamps on either side of the copper tube then were tightened, trapping a sample of groundwater for analyses of dissolved noble gases (Weiss, 1968).

Field alkalinity was measured in the mobile laboratory at the field site. Alkalinity was measured on filtered groundwater samples by Gran's titration method (Gran, 1952). Titration data were entered directly into PCFF, and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were automatically calculated from the titration data by using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$. Concentrations of HCO_3^- and CO_3^{2-} also were calculated from the laboratory alkalinity and laboratory pH measurements.

Temperature-sensitive samples were stored on ice prior to and during daily shipping to the various laboratories. The non-temperature- or non-time-sensitive samples for tritium, stable isotopes of hydrogen and oxygen in water, stable isotopes of boron in water, isotopic ratios of strontium in water, and dissolved noble gases were shipped monthly. Temperature- or time-sensitive samples for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, WICs, perchlorate, NDMA, 1,2,3-TCP, trace elements, nutrients, DOC, major and minor ions, silica, and TDS were shipped daily. The temperature-sensitive samples for arsenic and iron species were stored on ice and shipped weekly. Samples for stable isotopes of nitrogen and oxygen in dissolved nitrate and stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance were stored on ice, archived in a laboratory refrigerator and (or) freezer, and shipped after results for nitrate and alkalinity were received from the NWQL.

Eight laboratories performed chemical analyses for this study (table A1), although most of the analyses were performed at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous QA program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory QC samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are tested continuously, and laboratory reporting levels are updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://nwql.usgs.gov/Public/Performance/publiclabcertcoverpage.html). In addition, the USGS Branch of Quality Systems (BQS) maintains independent oversight of QA at the NWQL and laboratories contracted by the NWQL. The BQS also runs the National Field Quality Assurance Program (NFQA) that includes

annual testing of all USGS field personnel for proficiency in making field water-quality measurements (http://qadata. cr.usgs.gov/nfqa/). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded directly into the USGS NWIS database. Results of analyses made at other laboratories are compiled in a project database and uploaded from there into the USGS NWIS database. Some laboratory QC data are stored in the USGS NWIS database also.

Data Reporting

Laboratory Reporting Conventions

The USGS NWQL uses different conventions for reporting results for organic, inorganic, and radioactive constituents. The USGS NWQL used the LRL and long-term method detection level (LT-MDL) for reporting analytical results for organic and inorganic constituents (note that the reporting convention for inorganic constituents was changed in October 2010, after samples from the BEAR study unit were analyzed, to a reporting convention that only uses the LT-MDL). The LRL is set to minimize the reporting of false negatives (not detecting a compound when it actually is present in a sample) to less than 1 percent (Childress and others, 1999). The USGS NWQL updates LRL values regularly, and the values listed in this report were in effect during the period that groundwater samples from the BEAR study unit were analyzed (April to August 2010). The LRL usually is set at two times the LT-MDL. The LT-MDL is derived from the standard deviation of at least 24 method detection level (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero (at the MDL there is less than a 1-percent chance of a false positive). LT-MDLs continually are monitored and updated (Childress and others, 1999; U.S. Environmental Protection Agency, 2002).

Concentrations between the LRL and the LT-MDL are reported as having a higher degree of uncertainty (coded by the letter "E" preceding the values in the tables and text). For inorganic constituents, concentrations less than the LT-MDL are reported as non-detections with a dash (–) in the data tables. For organic constituents analyzed with information-rich methods, detections less than the LT-MDL have high certainty of presence, but the precise concentration is uncertain. These values are also E-coded. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection, such as those methods used to analyze VOCs, pesticides and pesticide degradates, and WICs. Compounds are identified by presence of characteristic fragmentation patterns in their mass spectra in addition to being quantified by measurement of peak areas at their associated chromatographic retention

times. E-coded values also may result from detections outside the range of calibration standards, from detections that did not meet all laboratory QC criteria, and from samples that were diluted prior to analysis (Childress and others, 1999).

Some constituents in this study are reported by using minimum reporting levels (MRLs) or method uncertainties (MU). The MRL is the smallest measurable concentration of a constituent that may be reliably reported by using a given analytical method (Timme, 1995). The MU generally indicates the precision of a particular analytical measurement; it gives a range of values wherein the true value will be found.

Results for most constituents are given by using the LRL, MDL, or MRL values provided by the analyzing laboratories. Results for some organic and inorganic constituents are presented with raised SRLs derived from assessing results from QC samples associated with groundwater samples collected as part of the GAMA-PBP (see the appendix section titled "Detections in Blank Samples and Application of SRLs").

The methods used for analysis of the radioactive constituents (radon-222 and tritium) measure activities by counting techniques (table A1). Activity often is used instead of concentration for reporting the presence of radioactive constituents. Activity of these constituents in groundwater is measured in units of picocuries per liter, where 1 pCi/L is approximately equal to two atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

The reporting limits for radon-222 and tritium are based on sample-specific critical levels (ssL_C) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and non-radioactive inorganic constituents. Here, the critical level is defined as the minimum measured activity that indicates a positive detection of the radionuclide in the sample with less than a 5-percent probability of a false positive detection. Sample-specific critical levels are used for radioactive measurements because the critical level is sensitive to sample size and sample yield during analytical processing and is dependent on instrument background, on counting times for the sample and background, and on the characteristics of the instrument being used and the nuclide being measured. An ssL_C is calculated for each sample, and the measured activity in the sample is compared to the ssL_C associated with that sample. Measured activities less than the ssL_C are reported as non-detections with a dash (–) in the data tables.

The analytical uncertainties associated with measurement of activities also are sensitive to sample-specific parameters, including sample size, sample yield during analytical processing, and time elapsed between sample collection and various steps in the analytical procedure, as well as parameters associated with the instrumentation. Therefore, measured activities of radioactive constituents are reported with sample-specific combined standard uncertainties (CSU). The CSU is reported at the 68-percent confidence level (1-sigma).

Stable isotopic compositions of hydrogen, oxygen, nitrogen, boron, and carbon are reported as relative isotope ratios in units of per mil by using the standard delta notation (Coplen and others, 2002):

$$\delta^i E = \left[\frac{R_{sample}}{R_{reference}} - 1 \right] \text{x } 1,000 \text{ per mil} , \quad \text{(A1)}$$

where

i is the atomic mass of the heavier isotope of the element;

E is the element (H for hydrogen, O for oxygen, N for nitrogen, B for boron, C for carbon);

R_{sample} is the ratio of the abundance of the heavier isotope of the element (^{2}H, ^{18}O, ^{15}N, ^{11}B, ^{13}C) to the lighter isotope of the element (^{1}H, ^{16}O, ^{14}N, ^{10}B, ^{12}C) in the sample; and

$R_{reference}$ is the ratio of the abundance of the heavier isotope of the element to the lighter isotope of the element in the reference material.

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned δ^{18}O and δ^2H values of 0 per mil (note that δ^2H is sometimes written as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium). The reference material for nitrogen is atmospheric nitrogen gas, which is assigned a δ^{15}N value of 0 per mil. The reference material for boron is the National Institute of Standards and Technology (NIST) reference material SRM 951 boric acid, which is assigned a δ^{11}B value of 0 per mil (Coplen and others, 2002). The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a δ^{13}C value of 0 per mil. Positive values indicate enrichment of the heavier isotope, and negative values indicate depletion of the heavier isotope, compared to the ratios observed in the standard reference material. Isotopic ratios of strontium in water are presented as the abundance of atoms of the heavier isotope (^{87}Sr) to the lighter isotope (^{86}Sr) of the element.

Constituents Determined by Multiple Methods or Laboratories

Twenty-one constituents targeted in this study were measured by more than one analytical method or by more than one laboratory (table A2). The preferred methods for these constituents were selected on the basis of the procedure recommended by the NWQL (http://wwwnwql.cr.usgs.gov/dyn.shtml?Preferred_method_selection_procedure).

The water-quality indicators—alkalinity, pH, and specific conductance—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both measurements are reported (table 4). Field values are generally preferred because field

conditions are considered more representative of groundwater conditions (Hem, 1985).

1,4-Dichlorobenzene, isopropylbenzene, naphthalene, PCE, and bromoform (tribromomethane) each appear on the following NWQL analytical schedules: VOCs (Schedule 2020; table 3A) and WICs (Schedule 1433; table 3D). For constituents collected on Schedules 2020 and 1433, the preferred method was Schedule 2020.

Carbaryl, chlorpyrifos, diazinon, metalaxyl, metolachlor, and prometon each appear on the following NWQL analytical schedules: pesticides and pesticide degradates (Schedule 2033; table 3B) and WICs (Schedule 1433; table 3D). For constituents collected on Schedules 2033 and 1433, the preferred method was Schedule 2033.

Caffeine and cotinine each appear on the following NWQL analytical schedules: pharmaceutical compounds (Schedule 2080; table 3C) and WICs (Schedule 1433; table 3D). For constituents collected on both Schedules 2080 and 1433, the preferred method was Schedule 2080.

1,2,3-TCP was measured at the NWQL (reporting level was an LRL of 0.12 µg/L) and Weck (reporting level was an MRL of 0.005 µg/L) (tables 3A, E). 1,2,3-TCP was not detected in any samples analyzed by either method, so this compound is not listed in tables 5 and 8.

For total arsenic and total iron concentrations, the approved method, Schedule 1948 (table 3F), used by the NWQL is preferred over the research methods used by the USGS NRP-TML (table 3I); however, results from both measurements are reported (tables 9 and 12). The concentrations of arsenic and iron measured by the USGS NRP-TML only are used to calculate ratios of redox species.

For example,

$$Fe(III) = Fe(T) - Fe(II) , \quad \text{(A2)}$$

where

Fe(T)   is the total iron concentration (measured),

Fe(II)   is the concentration of ferrous iron (measured), and

Fe(III)   is the concentration of ferric iron (calculated).

Tritium also was measured at two laboratories: LLNL and USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (SITL) (table 3J). Only tritium data from the SITL were available for reporting at the time of this publication (table 14).

Quality-Assurance and Quality-Control Methods and Results

The purpose of QA/QC is to identify which data best represent groundwater conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, and (or) laboratory analysis. Four types of QC measurements were evaluated in this study: (1) blank samples were collected to assess positive

bias as a result of contamination during sample handling or analysis, (2) replicate samples were collected to assess variability, (3) matrix-spike tests were done to assess positive or negative bias for organic constituents, and (4) surrogate compounds were added to samples analyzed for organic constituents to assess potential bias from laboratory analytical methods.

Blank Samples

The primary purposes of collecting blank samples are to evaluate the magnitude of potential contamination of samples with compounds of interest during sample handling or analysis, and to identify and mitigate the sources of sample contamination.

Methods of Blank Sample Collection and Analysis

Blank samples were collected by using blank water certified by the NWQL to contain less than the reporting levels for selected constituents investigated in the study (http://wwwnwql.cr.usgs.gov/USGS/OBW/obw.html). Nitrogen-purged, organic-free blank water was used for blanks of organic constituents, and inorganic-free water was used for blanks of inorganic constituents. Three types of blanks were collected: field blank samples, source-solution blank samples, and equipment blank samples.

Field blank samples were collected to assess whether contamination of samples was introduced during collection, processing, transport, and analysis. To collect field blanks, blank water either was pumped or poured through the sampling equipment (fittings and tubing) used to collect groundwater samples, then processed and transported by using the same protocols used for the groundwater samples. Typically, 12 L of blank water were pumped through the sampling equipment before each field blank was collected. Field blanks were analyzed for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, WICs, perchlorate, 1,2,3-TCP, NDMA, trace elements, nutrients, DOC, major and minor ions, silica, TDS, and arsenic and iron species.

A source-solution blank sample was collected at the beginning of a study or when using a new lot of blank water to assess potential contamination of samples during transport and analysis and potential contamination of the certified blank water obtained from the NWQL. Source-solution blanks were collected by pouring blank water directly into sample containers that were preserved, stored, shipped, and analyzed in the same manner as the groundwater samples. The source-solution blank sample was analyzed for VOCs, pharmaceutical compounds, WICs, perchlorate, NDMA, 1,2,3-TCP, trace elements, major and minor ions, silica, and TDS.

An equipment blank sample was collected at the USGS San Diego Projects Office before the start of the sampling period to assess whether the sampling equipment was sufficiently clean (after a long period of storage) to be used for collection of groundwater samples in the BEAR

study unit. The equipment blank sample was analyzed for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, WICs, perchlorate, 1,2,3-TCP, NDMA, trace elements, nutrients, DOC, major and minor ions, silica, and TDS.

Blank samples were not collected for radon because the laboratory determines an ssL_C value for each sample. The ssL_C is the minimum measured value that indicates a non-zero amount of the radionuclide in the sample. Stated another way, it is the amount of the radionuclide that is statistically significantly greater than the amount in a blank. In addition, blank samples were not collected for tritium or dissolved noble gases. Tritium and dissolved noble gases are in the atmosphere and would dissolve into any solution used in collecting a blank, making it impractical to collect a blank for these constituents. Isotopic ratios of hydrogen, oxygen, nitrogen, boron, strontium, and carbon are an intrinsic property of any of these elements; therefore, the concept of a blank does not apply to these ratios.

Methods of Determining Study Reporting Levels (SRLs)

The SRLs for selected VOCs were defined by Fram and others (2012) on the basis of the assessment of results from field blank samples, source-solution blank samples, laboratory instrument blank samples, and groundwater samples from the first 32 GAMA-PBP study units (May 2004 through September 2010). SRLs were established for those VOCs that had evidence of potential contamination due to field or laboratory processes. Detections of VOCs having concentrations less than or equal to the SRLs were reclassified as non-detections.

The SRLs for pharmaceutical compounds were defined by Fram and Belitz (2011) and correspond to the highest LT-MDL or interim method detection limit (I-MDL) used by the NWQL during the first 31 GAMA PBP study units (May 2004 through June 2010). Detections of pharmaceutical compounds having concentrations less than or equal to the SRLs were reclassified as non-detections.

The SRLs for trace elements were defined by Olsen and others (2010) on the basis of statistical assessment of results from the field blanks from the first 20 GAMA PBP study units (May 2004 through January 2008). The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents possibly introduced while groundwater samples were collected, transported, and analyzed. Detections of trace elements having concentrations less than or equal to the SRLs were reported with a ≤ symbol preceding the value to indicate that the true value may be less than or equal to the reported value (including the possibility of being a non-detection).

The SRLs for three other constituents collected for the BEAR study unit [tris(2-butoxyethyl) phosphate, fluoride, and DOC] were defined as equal to the highest concentration measured in the blank samples. Detections of constituents in

groundwater samples at concentrations less than or equal to the SRLs defined by the blank samples were reclassified as non-detections (for organic constituents) or reported with a ≤ symbol preceding the value (for inorganic constituents) as described by Fram and others (2012), Fram and Belitz (2011), and Olsen and others (2010).

In the USGS NWIS database, data affected by SRLs (if any) are accompanied with the following comment: "Result is < or = reported value, based on QC data."

Detections in Blank Samples and Application of SRLs

Table A3 presents a summary of detections in the blank samples and the SRLs applied for the BEAR study unit. Blank samples were collected at 13 percent of the sites sampled in the BEAR study unit.

VOCs were not detected in the five blank samples (three field blanks, one source-solution blank, and one equipment blank) collected for the BEAR study unit. Two VOCs (toluene and 1,2,4-trimethylbenzene) have SRLs defined by Fram and others (2012) and were detected in groundwater samples.

Toluene has an SRL of 0.69 µg/L as defined by Fram and others (2012) and was detected in two groundwater samples at concentrations of E0.05 µg/L and 1.39 µg/L (table 5). The measured concentration of E0.05 µg/L was reclassified as a non-detection and not included in the calculation of detection frequency (table 5, footnote #2).

1,2,4-Trimethylbenzene has an SRL of 0.56 µg/L as defined by Fram and others (2012) and was detected in 16 groundwater samples at concentrations ranging from E0.01 µg/L to 0.77 µg/L (median 0.15 µg/L). Thirteen of the detections were at concentrations less than the SRL and were reclassified as non-detections and not presented in table 5 (footnote #2). The three remaining detections were considered to be representative of groundwater quality and are presented in table 5.

Pharmaceutical compounds were not detected in the five blank samples collected for the BEAR study unit, but they have SRLs defined by Fram and Belitz (2011). Five pharmaceutical compounds (acetaminophen, caffeine, carbamazepine, 1,7-dimethylxanthine, and sulfamethoxazole) were detected in groundwater samples at concentrations less than the SRLs. These results were reclassified as non-detections and not presented in this report.

Three blank samples (one field blank, one source-solution blank, and one equipment blank) were collected in the BEAR study unit for the analysis of WICs. Tris(2-butoxyethyl) phosphate was detected in the equipment blank at a concentration of E0.30 µg/L. An SRL was defined on the basis of the blank detection and was applied to the result from one groundwater site. This detection of tris(2-butoxyethyl) phosphate (E0.10 µg/L) was reclassified as a non-detection in table 7.

Five blank samples were collected in the BEAR study unit for the analysis of trace elements. Seven trace elements (arsenic, cobalt, copper, lead, manganese, nickel, and zinc)

were detected in one or more of the blanks collected. Three trace elements (chromium, iron, and tungsten) were detected in groundwater samples at concentrations less than or equal to the SRLs defined by Olsen and others (2010).

A summary of inorganic blank sample detections and (or) concentration ranges and SRL applications is listed here:

- Arsenic was detected in one field blank at a concentration of 0.05 µg/L. Arsenic does not have an SRL defined by Olsen and others (2010). It has been determined that one field blank detection out of five blank samples in the BEAR study unit is not enough evidence to indicate that there has been a change in patterns of arsenic detections in blanks from what was observed by Olsen and others (2010); therefore, application of an SRL was not necessary.

- Chromium has an SRL of 0.42 µg/L as defined by Olsen and others (2010). This SRL was applied to the results from 13 groundwater sites (table 9).

- Cobalt was detected in three field blanks and in the equipment blank at concentrations ranging from 0.11 µg/L to 0.42 µg/L. An SRL of 0.42 µg/L was established on the basis of the field blank results and was applied to the results from all 38 groundwater sites (table 9).

- Copper was detected in one field blank at a concentration of E0.99 µg/L. Copper has an SRL of 1.7 µg/L as defined by Olsen and others (2010). An SRL of 1.7 µg/L was applied to the results from 13 groundwater sites (table 9).

- Iron has an SRL of 6 µg/L as defined by Olsen and others (2010). This SRL was applied to the results from three groundwater sites (table 9).

- Lead was detected in two field blanks at concentrations of 0.13 µg/L and 0.60 µg/L. Lead has an SRL of 0.65 µg/L as defined by Olsen and others (2010). An SRL of 0.65 µg/L was applied to the results from 27 groundwater sites (table 9).

- Manganese was detected in three field blanks and in the equipment blank at concentrations ranging from E0.16 µg/L to 0.79 µg/L. Manganese has an SRL of 0.20 µg/L as defined by Olsen and others (2010). An SRL of 0.79 µg/L was established on the basis of the field blank results and was applied to the results from 19 groundwater sites (table 9).

- Nickel was detected in one field blank at a concentration of 0.14 µg/L. Nickel has an SRL of 0.36 µg/L as defined by Olsen and others (2010). An SRL of 0.36 µg/L was applied to the results from 24 groundwater sites (table 9).

- Tungsten has an SRL of 0.11 µg/L as defined by Olsen and others (2010). This SRL was applied to the results from 15 groundwater sites (table 9).

- Zinc was detected in one field blank at a concentration of 3.0 µg/L. Zinc has an SRL of 4.8 µg/L as defined by Olsen and others (2010). An SRL of 4.8 µg/L was applied to the results from 12 groundwater sites (table 9).

Five blanks were collected in the BEAR study unit for the analysis of nutrients and DOC. Nutrients were not detected in any of the blank samples, but DOC was detected in the equipment blank at a concentration of 0.8 milligram per liter (mg/L). An SRL was defined on the basis of the blank detection and was applied to the results from 21 groundwater sites (table 10).

Five blanks were collected in the BEAR study unit for the analysis of the major and minor ions, silica, and TDS. Major and minor ions, silica, and TDS were not detected in any of the blank samples with the exception of fluoride, which was detected in one field blank at a concentration of 0.06 mg/L. An SRL was defined on the basis of the blank detection and was applied to the results from five groundwater sites (table 11).

Three field blanks were collected in the BEAR study unit for the analysis of arsenic and iron species at the USGS NRP-TML. Arsenic and iron species were not detected in any blank samples with the exception of iron (total), which was detected in one field blank at a concentration of 0.003 µg/L. Iron (total) was not detected at concentrations less than 0.003 µg/L; therefore, application of an SRL was not necessary.

Detections in blank samples did not occur in the BEAR study unit for these constituent groups: pesticides and pesticide degradates and the constituents of special interest.

Replicate Pairs

Sequential replicate pairs were collected to assess the precision of the water-quality data. Estimates of data precision are needed to assess whether differences between concentrations in samples are because of differences in groundwater quality or because of variability that may result from collecting, processing, and analyzing the samples.

Methods of Assessment of Replicate Pairs

Three methods for measuring replicate pair variability were used to assess precision over the range of measured concentrations in groundwater samples. The variability between results in the replicate pairs was represented by the absolute standard deviation (SD) for low concentrations and by relative standard deviation (RSD) for high concentrations (Anderson, 1987; Mueller and Titus, 2005). The RSD is defined as the SD divided by the mean concentration for each replicate pair expressed as a percentage. The boundary between concentrations for each metric was defined as 5 times (x) the selected reporting level (RL) for each constituent. The

RL may be an LRL, SRL, MDL, or MRL for each constituent; therefore the SD was used for pairs with mean concentrations $< 5 \times RL$, and the RSD was used for pairs with mean concentrations $> 5 \times RL$.

Replicate pairs for all constituents except for radioactive constituents were evaluated as follows.

- If both values were reported as detections, the SD or RSD was calculated. Acceptable variability is defined as an SD of $< \frac{1}{2}$ RL or an RSD of < 10 percent. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.

- If both values were reported as non-detections, the variability was set to zero by definition.

- If one value was reported as a non-detection, and the other value was reported as a detection $< RL$, then a value of zero was substituted for the non-detection, and the SD was calculated. Substituting zero for the non-detection would yield the maximum estimate of variability for the replicate pair.

- If one value was reported as a non-detection and the other value was flagged with a $\leq$ symbol, or if both values were flagged with a $\leq$ symbol, the SD was not calculated because the values may be analytically identical. The $\leq$ symbol indicates that the value is a maximum potential concentration and the true concentration could be $< RL$ for the other sample in the pair.

- If one value was reported as a non-detection and the other value was reported as a detection $> RL$, the variability for the pair was considered unacceptable.

Replicate pairs for radioactive constituents were evaluated by using the following equation (Parr and Porterfield, 1997; McCurdy and others, 2008) to calculate the normalized absolute difference (NAD):

$$NAD \leq \frac{|x - y|}{\sqrt{CSU_X^2 + CSU_Y^2}} \qquad (A3)$$

where

$x =$ activities of a radioactive constituent in the groundwater sample,

$y =$ activities of the same radioactive constituent in the replicate sample,

$CSU_x =$ combined standard uncertainty of x at the 1σ confidence level, and

$CSU_y =$ combined standard uncertainty of y at the 1σ confidence level.

Values < 1.65 for the NAD correspond to a significance level (α) of 5 percent (α = 0.05), indicating differences that are acceptably small and not statistically significant.

If results from replicate pairs indicate that variability is unacceptable for a constituent, then this greater variability must be considered when interpreting the data. If measured concentrations are slightly greater than a water-quality benchmark, then actual concentrations could be less than that benchmark. Similarly, if measured concentrations are less than a water-quality benchmark, then actual concentrations could be greater than a benchmark. If a constituent has high variability in replicate pairs, then a larger difference between concentrations measured in two samples is required to conclude that the two samples have significantly different concentrations.

Variability in Replicate Pairs

Tables A4A–C summarize the results of the replicate pair analyses for constituents detected in groundwater samples collected in the BEAR study unit. Replicate pairs were collected for 11 percent of the samples collected.

Three replicate pairs were analyzed for the VOCs. Nine of the 16 VOCs detected in groundwater samples had replicate pairs that were composed of two values reported as non-detections. The seven remaining VOCs yielded replicate pairs reported either as two non-detections, one value as a detection and one as a non-detection, or two detections. The replicate pair analyses of these VOCs resulted in SDs and RSDs within acceptable variability (table A4A).

Four replicate pairs were analyzed for the pesticide and pesticide degradate compounds. Three of the four replicate pairs for both simazine and prometon were composed of two values reported as non-detections. The remaining replicate pair for simazine resulted in one value reported as a detection and one as a non-detection. The replicate pair for prometon yielded two values reported as detections. The replicate pair analyses for simazine and prometon resulted in SDs within acceptable variability (table A4A).

One replicate pair was analyzed for the WICs. Both replicate pairs for tris(2-butoxyethel) phosphate and phenol were composed of two values reported as non-detections. As a result, these constituents are not presented on table A4A.

Four replicate pairs for perchlorate, 1,2,3-TCP, and NDMA were analyzed at Weck for variability. One of the replicate pairs for perchlorate and all of the replicate pairs for 1,2,3-TCP and NDMA were composed of two values reported as non-detections. The three remaining replicate pairs for perchlorate yielded two values reported as detections, and each replicate pair analysis resulted in an SD within acceptable variability (table A4A).

Four replicate pairs were analyzed for DOC, and one of these pairs was composed of two values reported as non-detections. The three remaining replicate pairs yielded two values reported as detections, and all replicate pair analyses resulted in SDs within acceptable variability (table A4A).

Four replicate pairs were analyzed for trace elements, nutrients, major and minor ions, silica, TDS, and arsenic and iron species. All replicate pairs were either composed of

two values reported as non-detections or two values reported as detections. The analyses for all replicate pairs reported as detections resulted in SDs and RSDs within acceptable variability (table A4B).

Four replicate pairs were analyzed for tritium and radon-222. All replicate pairs yielded statistically similar results ($\alpha \leq 0.05$) and were, therefore, considered acceptable (table A4C).

Groundwater detections were not modified on the basis of the replicate pair analyses.

Matrix Spikes

Addition of a known concentration of a constituent (spike) to a replicate groundwater sample enables the laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. The known compounds added in matrix spikes are the same as those analyzed in the groundwater samples. This enables an analysis of matrix interferences on a compound-by-compound basis. For this study, matrix spikes were added by the laboratories performing the analysis rather than in the field. Low and high matrix-spike recoveries may be a potential concern if the concentration of a compound in a groundwater sample is close to the benchmark; a low recovery could result in a falsely measured concentration less than the benchmark, whereas a high recovery could result in a falsely measured concentration greater than the benchmark.

The GAMA-PBP defined the data-quality objective range for acceptable median matrix-spike recoveries as 70 to 130 percent. Only constituents with median matrix-spike recoveries outside of this range were flagged as having unacceptable recoveries. Matrix-spike tests were performed for VOCs, pesticides and pesticide degradates, WICs, 1,2,3-TCP, and NDMA because the analytical methods for these constituents may be susceptible to matrix interferences.

Matrix-Spike Recoveries

Tables A5A–D presents a summary of matrix-spike recoveries for the BEAR study unit. Spiked samples were collected at 13 percent of the sites sampled.

Five groundwater samples were spiked with VOCs to calculate matrix-spike recoveries. Median matrix-spike recoveries for all 85 spike compounds were between 70 and 130 percent (table A5A).

Four groundwater samples were spiked with pesticide and pesticide degradate compounds to calculate matrix-spike recoveries. Median matrix-spike recoveries for 61 of the 83 spike compounds were between 70 and 130 percent. Twenty of the spike compounds had median matrix-spike recoveries < 70 percent, and two had median matrix-spike recoveries > 130 percent. Both of the spike compounds detected in groundwater samples (simazine and prometon) had median matrix-spike recoveries within the acceptable range (table A5B).

One groundwater sample was spiked with WICs to calculate matrix-spike recoveries. Matrix-spike recoveries for 45 of the 60 spike compounds were between 70 and 130 percent. Fifteen of the spike compounds had median matrix-spike recoveries < 70 percent. Both of the compounds detected in groundwater samples [phenol and tris(2-butoxyethyl) phosphate] had median matrix-spike recoveries within the acceptable range (table A5C).

Four groundwater samples were spiked with NDMA and 1,2,3-TCP to calculate matrix-spike recoveries at Weck. All median matrix-spike recoveries were between 70 and 130 percent (table A5D).

Groundwater detections were not modified on the basis of the matrix-spike recovery analyses.

Surrogate Compounds

Surrogate compounds are added to groundwater samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added in the laboratory to all groundwater and QC samples that were analyzed by the NWQL for VOCs, pesticides and pesticide degradates, and WICs. Surrogates are used to identify general problems that may arise during laboratory sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of DOC) that produce a positive bias or incomplete laboratory recovery (possibly because of improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70 to 130 percent recovery of surrogates, in general, is considered acceptable; values outside this range indicate possible problems with the processing and analysis of samples (Connor and others, 1998; Sandstrom and others, 2001).

Surrogate Compound Recoveries

Table A6 presents a summary of the surrogate compound recoveries for the BEAR study unit. The table lists the surrogate compound, the analytical schedule on which it was applied, the number of analyses for blank and groundwater samples, the number of surrogate recoveries < 70 percent, and the number of recoveries > 130 percent for the blank and groundwater samples. Blank and groundwater samples were considered separately to assess whether or not the matrixes present in groundwater samples affect surrogate compound recoveries.

Most surrogate compound recoveries for the blank and groundwater samples were within the acceptable range of 70 to 130 percent. In total, 87 percent of the blank and 88 percent of the groundwater sample surrogate recoveries for VOC analyses were within the acceptable range. In addition, 100 percent of the blank and 97 percent of the groundwater sample surrogate recoveries for pesticide and pesticide degradate analyses were within the acceptable range. Finally, 67 percent of the blank and groundwater sample surrogate

recoveries for WICs analyses were within the acceptable range (table A6). There were no significant differences between VOC, pesticide and pesticide degradate, and WIC surrogate recoveries in blank and groundwater samples (Wilcoxon rank sum test, p < 0.05).

Groundwater detections were not modified on the basis of the surrogate compound recovery analyses.

Laboratory Bias in Trace Element Analyses

Laboratory bias as indicated from internal laboratory QC tests was investigated to determine whether or not the BEAR study unit data were affected by laboratory procedures. The BQS operates the Inorganic Blind Sample Project (IBSP) to monitor and evaluate the quality of results for analyses of trace elements, nutrients, major and minor ions, silica, and TDS by the NWQL. The IBSP submits standard reference samples consisting of natural matrix water samples spiked with reagent chemicals that contain known concentrations of the inorganic constituents (Farrar and Long, 1997). The IBSP data are readily available on the BQS website, and the BQS issues monthly summaries of the results, reporting the amount of bias (if any) observed in the results (U.S. Geological Survey, 2011c).

The BQS monthly summaries were examined for April through August 2010, the period of time during which samples were analyzed for the BEAR study unit. During this time period, the BQS reported that three inorganic constituents showed evidence of bias: a positive bias for barium and cadmium and a negative bias for magnesium. Examination of the results for the IBSP samples for these three constituents indicated that the analytical biases reported by the BQS were not significant for the data collected for the BEAR study unit.

The IBSP samples for barium had concentrations ranging from 26.0 µg/L to 63.0 µg/L. The average difference between the measured and expected concentrations was 1.0 µg/L (standard deviation = 2.0 µg/L), and the average RPD between the measured and expected concentrations was 2 percent (standard deviation = 5 percent). The MCL-CA for barium is 1,000 µg/L, thus the estimate of bias from the ISBP samples would be relevant for assessment of whether groundwater samples have barium concentrations greater than or less than the MCL-CA concentration or greater than or less than ½ of the MCL-CA concentration. However, the maximum concentration of barium in samples from the BEAR study unit was 134 µg/L (table 9); thus, a potential positive bias of 1.0 µg/L, or 2 percent, would not result in a measured concentration greater than either threshold when the true concentration would have been below the threshold.

The IBSP samples for cadmium had concentrations ranging from 0.18 µg/L to 1.7 µg/L. The average difference between the measured and expected concentrations was 0.12 µg/L (standard deviation = 0.09 µg/L), and the average RPD between the measured and expected concentrations was

19 percent (standard deviation = 30 percent). The MCL-US for cadmium is 5 µg/L; thus, the estimate of bias from the ISBP samples would be relevant for assessment of whether groundwater samples have cadmium concentrations greater than or less than the MCL-US concentration or greater than or less than ½ of the MCL-US concentration. However, the maximum concentration of cadmium in samples from the BEAR study unit was 0.10 µg/L (table 9); thus, a potential positive bias of 0.12 µg/L, or 19 percent, would not result in a measured concentration above either threshold when the true concentration would have been below the threshold.

The IBSP samples for magnesium had concentrations ranging from 0.05 mg/L to 7.3 mg/L. The average difference between the measured and expected concentrations was –0.18 mg/L (standard deviation = 0.21 mg/L), and the average RPD between the measured and expected concentrations was –5 percent (standard deviation = 3 percent). A negative bias of 0.18 mg/L, or 5 percent, can only potentially affect measured concentrations of less than 7.3 mg/L in BEAR study unit groundwater samples (table 11). Magnesium does not currently have an established regulatory or non-regulatory health-based benchmark or a non-regulatory benchmark established for aesthetic concerns; therefore, this negative bias will not affect the assessments of groundwater quality being made by the GAMA-PBP.

Table A1.   Analytical methods used by the U.S. Geological Survey (USGS) National Water Quality Laboratory and contract laboratories.

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. **Abbreviations**: UV, ultraviolet; USEPA, U.S. Environmental Protection Agency; VOC, volatile organic compound; WIC, wastewater indicator compound; TDS, total dissolved solids; DOC, dissolved organic carbon; NRP, USGS National Research Program]

Constituent classes	Analytical method	Laboratory and analytical schedule	Citation(s)
		Water-quality indicators	
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
		Organic constituents	
VOCs	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Pesticides and pesticide degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2033	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001; Madsen and others, 2003
Pharmaceutical compounds	Solid-phase extraction and HPLC/mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002; Furlong and others, 2008
WICs	Polystyrene-divinylbenzene solid-phase extraction and capillary-column gas chromatography/mass spectrometry	NWQL, Schedule 1433	Zaugg and others, 2002
		Constituents of special interest	
Perchlorate	Liquid chromatography with mass spectrometry/mass spectrometry (USEPA Method 331.0)	Weck Laboratories, Inc. [Weck], City of Industry, California (CA-WECK), standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
1,2,3-Trichloropropane (1,2,3-TCP)	Isotopic dilution purge and trap/gas chromatography/mass spectrometry	Weck Laboratories, Inc. [Weck], City of Industry, California (CA-WECK), standard operating procedure ORG083	Okamoto and others, 2002
N-Nitrosodimethylamine (NDMA)	Isotopic dilution with gas chromatography and chemical-ionization mass spectrometry (USEPA Method 1625 modified)	Weck Laboratories, Inc. [Weck], City of Industry, California (CA-WECK), standard operating procedure ORG065.R10	U.S. Environmental Protection Agency, 1989; Plomley and others, 1994
		Inorganic constituents and DOC	
Trace elements, major and minor ions, and TDS	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma with atomic emission spectrometry, and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; American Public Health Association, 1998; Garbarino and others, 2006
Nutrients	Alkaline persulfate digestion, Kjeldahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
DOC	UV-promoted persulfate oxidation and infrared spectrometry	NWQL, Laboratory Code 2613	Brenton and Arnett, 1993
Arsenic and iron species	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy	USGS NRP Trace Metal Laboratory [TML], Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; McCleskey and others, 2003

Table A1.   Analytical methods used by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and contract laboratories.

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. **Abbreviations:** UV, ultraviolet; USEPA, U.S. Environmental Protection Agency; VOC, volatile organic compound; WIC, wastewater indicator compound; TDS, total dissolved solids; DOC, dissolved organic carbon; NRP, USGS National Research Program]

Constituent classes	Analytical method	Laboratory and analytical schedule	Citation(s)
Isotopic tracers			
Stable isotopes of hydrogen and oxygen in water	Gaseous hydrogen and carbon dioxide–water equilibration and stable-isotope mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Schedule 1142	Epstein and Mayeda, 1953; Coplen and others, 1991; Coplen, 1994
Stable isotopes of nitrogen and oxygen in dissolved nitrate	Denitrifier method and mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Laboratory Code 2900	Révész and Casciotti, 2007
Stable isotopes of boron in water	Negative thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA)	Vengosh and others, 1989; Dwyer and Vengosh, 2008
Isotopic ratio of strontium in water	Chemical separations and thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA)	Bullen and others, 1996
Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance	Accelerator mass spectrometry	Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility [NOSAMS], Woods Hole, Massachusetts (MA-WHAMS), NWQL Schedule 2255	Vogel and others, 1987; Donahue and others, 1990; McNichol and others, 1992; Gagnon and Jones, 1993; McNichol and others, 1994; Schneider and others, 1994
Uranium and other radioactive constituents and dissolved noble gases			
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory [SITL], Menlo Park, California (USGSH3CA), NWQL Schedule 1565	Thatcher and others, 1977
Radon–222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Dissolved noble gases, tritium, and helium isotope ratios	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory [LLNL], Livermore, California (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004

Table A2.   Preferred analytical methods or laboratories for selected constituents collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Preferred analytical methods or laboratories were selected on the basis of the procedure recommended by the NWQL (http://wwwnwql.cr.usgs.gov/dyn. shtml?Preferred_method_selection_procedure). **Abbreviations**: USGS, U.S. Geological Survey; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; NRP, USGS National Research Project; VOC, volatile organic compound; WIC, wastewater indicator compound; Weck, Weck Laboratories Inc., City of Industry, California; TML, USGS NRP Trace Metal Laboratory, Boulder, Colorado; LLNL, Lawrence Livermore National Laboratory, Livermore, California; SITL, USGS Stable Isotope and Tritium Laboratory, Menlo Park, California; np, no preference]

Constituent (synonym or abbreviation)	Primary constituent classification	Analytical methods or laboratory	Preferred analytical method or laboratory
Results from the preferred method reported			
1,4-Dichlorobenzene	VOC	Schedule 2020 (NWQL), Schedule 1433 (NWQL)	Schedule 2020
Isopropylbenzene	VOC	Schedule 2020 (NWQL), Schedule 1433 (NWQL)	Schedule 2020
Naphthalene	VOC	Schedule 2020 (NWQL), Schedule 1433 (NWQL)	Schedule 2020
Perchloroethene (PCE, Tetrachloroethene)	VOC	Schedule 2020 (NWQL), Schedule 1433 (NWQL)	Schedule 2020
Bromoform (Tribromomethane)	VOC	Schedule 2020 (NWQL), Schedule 1433 (NWQL)	Schedule 2020
Carbaryl	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Chlorpyrifos	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Diazinon	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Dichlorvos	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Metalaxyl	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Metolachlor	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Prometon	Pesticide	Schedule 2033 (NWQL), Schedule 1433 (NWQL)	Schedule 2033
Caffeine	WIC	Schedule 2080 (NWQL), Schedule 1433 (NWQL)	Schedule 2080
Cotinine	WIC	Schedule 2080 (NWQL), Schedule 1433 (NWQL)	Schedule 2080
Results from both methods or laboratories reported			
pH	Water-quality indicator	field, Schedule 1948 (NWQL)	field
Specific conductance	Water-quality indicator	field, Schedule 1948 (NWQL)	field
Alkalinity	Water-quality indicator	field, Schedule 1948 (NWQL)	field
1,2,3-Trichloropropane (1,2,3-TCP)	VOC	Schedule 2020 (NWQL), Weck	Weck
Arsenic (total)	Trace element	Schedule 1948 (NWQL), TML	Schedule 1948
Iron (total)	Trace element	Schedule 1948 (NWQL), TML	Schedule 1948
Tritium	Isotopic tracer	SITL, LLNL	np

Table A3. Constituents detected in blank samples and the study reporting level (SRL) analysis for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[**Abbreviations**: RL, reporting level; ≤, less than or equal to; VOC, volatile organic compound; WIC, wastewater indicator compound; E, estimated or having a higher degree of uncertainty; µg/L, micrograms per liter; mg/L, milligrams per liter; —, not detected; nv, no value in category]

Constituent	Number of blank detections / total number of blank samples			RL	Concentration(s) detected in the blank sample(s)	SRL[1]	Number of groundwater samples ≤-coded / total number of detections
	Field blank	Source-solution blank	Equipment blank				
VOCs (µg/L)							
Toluene	0/3	0/1	0/1	0.018	—	0.69 [B]	1/2
1,2,4-Trimethylbenzene	0/3	0/1	0/1	0.032	—	0.56 [B]	13/16
Pharmaceutical compounds (µg/L)							
Acetaminophen	0/3	0/1	0/1	0.01	—	0.06 [C]	1/1
Caffeine	0/3	0/1	0/1	0.007	—	0.10 [C]	1/1
Carbamazepine	0/3	0/1	0/1	0.015	—	0.03 [C]	1/1
1,7-Dimethylxanthine	0/3	0/1	0/1	0.01	—	0.06 [C]	1/1
Sulfamethoxazole	0/3	0/1	0/1	0.05	—	0.08 [C]	1/1
WICs (µg/L)							
Tris(2-butoxyethyl) phosphate	0/1	0/1	1/1	0.8	E0.30	0.30 [A]	1/2
Trace elements (µg/L)							
Arsenic	1/3	0/1	0/1	0.044	0.05	nv [2]	0/38
Chromium	0/3	0/1	0/1	0.12	—	0.42 [D]	13/22
Cobalt	3/3	0/1	1/1	0.010	0.09, 0.11, 0.11, 0.42	0.42 [A]	38/38
Copper	1/3	0/1	0/1	1.0	E0.99	1.7 [D]	13/30
Iron	0/3	0/1	0/1	6	—	6 [D]	3/18
Lead	2/3	0/1	0/1	0.030	0.13, 0.60	0.65 [D]	27/38
Manganese	3/3	0/1	1/1	0.26	E0.16, E0.19, E0.21, 0.79	0.79 [A]	19/32
Nickel	1/3	0/1	0/1	0.12	0.14	0.36 [D]	24/37
Tungsten	0/3	0/1	0/1	0.02	—	0.11 [D]	15/28
Zinc	1/3	0/1	0/1	2.8	3.0	4.8 [D]	12/32
Major and minor ions (mg/L)							
Fluoride	1/3	0/1	0/1	0.08	E0.06	0.06 [A]	5/38
Dissolved organic carbon (DOC) (mg/L)							
DOC	0/3	0/1	1/1	0.66	0.8	0.8 [A]	21/26
Arsenic and iron species (µg/L)							
Iron (total)	1/3	nv	nv	0.002	0.003	nv [3]	0/18

[1] SRLs were defined: A, by the highest concentration in blank samples collected for the BEAR study unit; B, by Fram and others (2012); C, by Fram and Belitz (2011); and D, by Olsen and others (2010).

[2] It has been determined that the field blank detection is not enough evidence to indicate that there has been a change in patterns of arsenic detections in blanks from what was observed by Olsen and others (2010); therefore, application of an SRL was not necessary.

[3] Constituent was not detected in groundwater samples at concentrations less than the SRL; therefore, application of an SRL was not necessary.

Table A4A.   Replicate pair analysis for organic constituents, constituents of special interest, and dissolved organic carbon (DOC) detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Constituents for which all replicate pairs were non-detections are not listed. **Abbreviations**: SD, standard deviation; RSD, relative standard deviation; >, greater than; <, less than; RL, reporting level; nv, no value in category]

Constituent (synonym or abbreviation)	Number of replicate pairs with non-detections in both samples / number of replicate pairs	Number of SDs > ½ RL / number of replicate pairs with concentrations < 5 times the RL	Number of RSDs > 10 percent / number of replicate pairs with concentrations > 5 times the RL
Volatile organic compounds (VOC)			
Chloroform (Trichloromethane)	1/3	0/1	0/1
Methyl *tert*-butyl ether (MTBE)	2/3	0/1	nv
Perchloroethene (PCE, Tetrachloroethene)	1/3	0/2	nv
Bromodichloromethane	1/3	0/2	nv
1,2,4-Trimethylbenzene	2/3	nv	0/1
1,1-Dichloroethene (1,1-DCE)	2/3	0/1	nv
Bromochloromethane	2/3	0/1	nv
Pesticides and pesticide degradates			
Simazine	3/4	0/1	nv
Prometon	3/4	0/1	nv
Constituent of special interest			
Perchlorate	1/4	0/3	nv
Dissolved organic carbon (DOC)			
DOC	1/4	0/3	nv

Table A4B. Replicate pair analysis for inorganic constituents detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Constituents for which all replicate pairs were non-detections are not listed. **Abbreviations**: SD, standard deviation; RSD, relative standard deviation; RL, reporting level; >, greater than; <, less than; SiO_2, silicon dioxide; ≤, less than or equal to; nv, no value in category]

Constituent	Number of replicate pairs with non-detections or ≤ symbols in both samples / number of replicate pairs	Number of SDs > ½ RL / number of replicate pairs with concentrations < 5 times the RL	Number of RSDs > 10 percent / number of replicate pairs with concentrations > 5 times the RL
Trace Elements			
Antimony	2/4	0/2	nv
Arsenic	0/4	0/3	0/1
Barium	0/4	nv	0/4
Boron	0/4	0/2	0/2
Cadmium	2/4	0/2	nv
Chromium	2/4	0/2	nv
Cobalt	0/4	0/3	0/1
Copper	0/4	0/3	0/1
Iron	2/4	0/2	nv
Lead	0/4	0/4	nv
Lithium	1/4	nv	0/3
Manganese	2/4	0/1	0/1
Molybdenum	0/4	nv	0/4
Nickel	0/4	0/3	0/1
Selenium	0/4	0/2	0/2
Strontium	0/4	nv	0/4
Tungsten	1/4	0/3	nv
Uranium	0/4	nv	0/4
Vanadium	0/4	nv	0/4
Zinc	0/4	0/3	0/1
Nutrients			
Nitrate plus nitrite (as nitrogen)	1/4	0/1	0/2
Nitrite (as nitrogen)	3/4	0/1	nv
Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen)	1/4	0/1	0/2
Phosphate, orthophosphate (as phosphorus)	0/4	0/2	0/2
Major and minor ions, silica, and total dissolved solids (TDS)			
Bromide	0/4	0/4	nv
Calcium	0/4	nv	0/4
Chloride	0/4	nv	0/4
Fluoride	0/4	0/3	0/1
Iodide	1/4	0/3	nv
Magnesium	0/4	nv	0/4
Potassium	0/4	nv	0/4
Sodium	0/4	nv	0/4
Sulfate	0/4	nv	0/4
Silica (as SiO_2)	0/4	nv	0/4
TDS	0/4	nv	0/4
Arsenic and iron species			
Iron (total)	2/4	0/2	nv
Iron-II	2/4	0/2	nv

Table A4C.   Replicate pair analysis for radioactive constituents detected in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[For activities of radioactive constituents, a replicate pair analysis is defined as acceptable if the p-value for the normalized absolute difference is less than the significance level, α = 0.05. **Abbreviations**: α, significance level; >, greater than]

Constituent	Number of replicate pairs with p > 0.05 / number of replicate pairs
Radon-222	0/4
Tritium	0/4

Table A5A. Matrix-spike recoveries for volatile organic compounds (VOCs) in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Acceptable recovery range is between 70 and 130 percent]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	5	95	131	113
Acrylonitrile	5	98	117	111
tert-Amyl methyl ether (TAME)	5	86	103	97
Benzene	5	99	141	103
Bromobenzene	5	90	100	99
Bromochloromethane [1]	5	97	111	103
Bromodichloromethane [1]	5	93	102	97
Bromoform (Tribromomethane) [1]	5	83	105	88
Bromomethane (Methyl bromide)	5	104	110	109
n-Butylbenzene	5	75	99	89
sec-Butylbenzene	5	81	105	102
tert-Butylbenzene	5	85	114	106
Carbon disulfide	5	66	80	75
Carbon tetrachloride (Tetrachloromethane) [1]	5	95	106	100
Chlorobenzene	5	93	98	97
Chloroethane	5	91	109	103
Chloroform (Trichloromethane) [1]	5	99	127	110
Chloromethane	5	91	113	100
3-Chloropropene	5	110	118	113
2-Chlorotoluene	5	95	110	101
4-Chlorotoluene	5	87	109	95
Dibromochloromethane [1]	5	88	106	94
1,2-Dibromo-3-chloropropane (DBCP)	5	81	108	88
1,2-Dibromoethane (EDB)	5	92	104	100
Dibromomethane	5	94	107	101
1,2-Dichlorobenzene	5	94	114	104
1,3-Dichlorobenzene	5	87	104	94
1,4-Dichlorobenzene	5	90	112	93
trans-1,4-Dichloro-2-butene	5	91	100	98
Dichlorodifluoromethane (CFC-12)	5	70	89	74
1,1-Dichloroethane (1,1-DCA) [1]	5	104	110	108
1,2-Dichloroethane (1,2-DCA)	5	105	115	109
1,1-Dichloroethene (1,1-DCE) [1]	5	90	101	96
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	5	99	106	101
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	5	93	107	101
1,2-Dichloropropane	5	95	104	97
1,3-Dichloropropane	5	99	106	103
2,2-Dichloropropane	5	77	91	89
1,1-Dichloropropene	5	90	100	93
cis-1,3-Dichloropropene	5	81	87	86
trans-1,3-Dichloropropene	5	72	90	78
Diethyl ether	5	107	119	109
Diisopropyl ether (DIPE)	5	96	109	102

Table A5A.   Matrix-spike recoveries for volatile organic compounds (VOC) in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Ethylbenzene	5	87	229	94
Ethyl *tert*-butyl ether (ETBE)	5	91	99	93
Ethyl methacrylate	5	91	96	92
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	5	78	102	98
Hexachlorobutadiene	5	71	90	78
Hexachloroethane	5	80	109	87
2-Hexanone (*n*-Butyl methyl ketone)	5	92	105	100
Iodomethane (Methyl iodide)	5	107	119	111
Isopropylbenzene	5	83	116	109
4-Isopropyl-1-methyl benzene	5	73	103	98
Methyl acrylate	5	105	117	111
Methyl acrylonitrile	5	103	124	114
Methyl *tert*-butyl ether (MTBE) [1]	5	102	115	104
Methyl *iso*-butyl ketone (MIBK)	5	99	107	101
Methylene chloride (Dichloromethane) [1]	5	92	107	100
Methyl ethyl ketone (2-butanone, MEK)	5	101	120	110
Methyl methacrylate	5	83	95	92
Naphthalene	5	77	106	99
Perchloroethene (PCE, Tetrachloroethene) [1]	5	88	100	93
n-Propylbenzene	5	78	106	96
Styrene	4	79	165	94.2
1,1,1,2-Tetrachloroethane	5	88	102	99
1,1,2,2-Tetrachloroethane	5	95	110	105
Tetrahydrofuran	5	90	121	102
1,2,3,4-Tetramethylbenzene	5	72	104	97
1,2,3,5-Tetramethylbenzene	5	80	114	107
Toluene [1]	5	96	300	103
1,2,3-Trichlorobenzene	5	85	105	94
1,2,4-Trichlorobenzene	5	71	96	83
1,1,1-Trichloroethane (1,1,1-TCA) [1]	5	98	103	101
1,1,2-Trichloroethane (1,1,2-TCA)	5	96	105	100
Trichloroethene (TCE) [1]	5	91	102	95
Trichlorofluoromethane (CFC-11) [1]	5	91	113	106
1,2,3-Trichloropropane (1,2,3-TCP)	5	95	109	107
Trichlorotrifluoroethane (CFC-113)	5	70	102	92
1,2,3-Trimethylbenzene	5	80	114	107
1,2,4-Trimethylbenzene [1]	5	87	318	106
1,3,5-Trimethylbenzene	5	84	109	104
Vinyl bromide (Bromoethene)	5	96	107	98
Vinyl chloride (Chloroethene)	5	96	119	107
m- and *p*-Xylene	5	86	119	104
o-Xylene	5	85	117	93

[1] Constituents detected in groundwater samples.

Table A5B.   Matrix-spike recoveries for pesticides and pesticide degradates in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Acceptable recovery range is between 70 and 130 percent]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	4	96	136	103.4
Alachlor	4	98	120	105.8
Atrazine	4	9	109	101.5
Azinphos-methyl	4	77	140	95.2
Azinphos-methyl oxon	4	51	136	68.6
Benfluralin	4	57	70	59.5
Carbaryl	4	100	169	125.0
Carbofuran	4	95	152	122.6
2-Chloro-2,6-diethylacetanilide	4	94	132	104.3
4-Chloro-2-methylphenol	4	69	85	76.1
Chlorpyrifos	4	67	86	82.9
Chlorpyrifos oxon	4	19	78	35.7
Cyanazine	4	62	114	109.6
Cyfluthrin	4	49	75	63.7
λ-Cyhalothrin	4	46	59	48.5
Cypermethrin	4	53	75	62.0
DCPA (Dacthal)	4	103	110	107.2
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	4	24	99	79.3
Desulfinylfipronil	4	90	127	94.7
Desulfinylfipronil amide	4	56	115	87.0
Diazinon	4	88	108	92.8
Diazinon oxon	4	100	119	105.9
3,4-Dichloroaniline	4	84	95	87.5
3,5-Dichloroaniline	4	92	97	94.7
Dichlorvos	4	17	48	32.5
Dicrotophos	4	35	49	44.5
Dieldrin	4	76	94	83.2
2,6-Diethylaniline	4	92	103	96.1
Dimethoate	4	48	77	61.8
Disulfoton	4	63	128	71.6
Disulfoton sulfone	4	81	131	99.2
α-Endosulfan	4	76	89	78.4
Endosulfan sulfate	4	70	91	75.5
Ethion	4	71	89	76.3
Ethion monoxon	4	82	98	89.8
Ethoprophos	4	100	129	107.2
S-Ethyl-dipropylthiocarbamate (EPTC)	4	92	104	95.1
2-Ethyl-6-methylaniline	4	83	102	93.1
Fenamiphos	4	89	132	93.9
Fenamiphos sulfone	4	76	139	92.0
Fenamiphos sulfoxide	4	28	74	32.9
Fipronil	4	81	113	96.3

Table A5B.   Matrix-spike recoveries for pesticides and pesticide degradates in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Fipronil sulfide	4	76	128	81.0
Fipronil sulfone	4	58	71	63.0
Fonofos	4	90	95	92.4
Hexazinone	4	34	75	64.7
Iprodione	4	66	102	75.5
Isofenphos	4	94	134	96.4
Malaoxon	4	73	132	99.6
Malathion	4	96	140	103.5
Metalaxyl	4	100	120	111.2
Methidathion	4	80	103	97.7
Metolachlor	4	91	131	99.4
Metribuzin	4	89	126	98.1
Molinate	4	96	115	99.2
Myclobutanil	4	35	108	88.2
1-Naphthol	4	36	61	46.8
Oxyfluorfen	4	58	70	66.2
Paraoxon-methyl	4	49	95	71.5
Parathion-methyl	4	79	89	84.3
Pendimethalin	4	70	86	81.7
cis-Permethrin	4	59	82	65.8
Phorate	4	73	80	74.4
Phorate oxon	4	118	132	124.4
Phosmet	4	26	74	32.5
Phosmet oxon	4	23	93	28.6
Prometon [1]	4	11	115	98.3
Prometryn	4	6	109	103.4
Pronamide	4	84	98	90.4
Propanil	4	87	203	100.5
Propargite	4	68	112	71.4
cis-Propiconazole	4	22	162	151.9
trans-Propiconazole	4	6	101	87.2
Simazine [1]	4	10	99	88.6
Tebuconazole	4	19	84	65.3
Tebuthiuron	4	141	178	157.3
Tefluthrin	4	33	68	43.9
Terbufos	4	75	86	81.1
Terbufos oxon sulfone	4	59	139	93.4
Terbuthylazine	4	17	109	104.5
Thiobencarb	4	95	127	97.9
Tribufos	4	44	80	51.8
Trifluralin	4	69	97	75.4

[1] Constituents detected in groundwater samples.

Table A5C.   Matrix-spike recoveries for wastewater indicator compounds (WICs) in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Acceptable recovery range is between 70 and 130 percent.]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Recovery (percent)	Constituent (synonym or abbreviation)	Number of spiked samples collected	Recovery (percent)
Acetophenone	1	101	Isophorone	1	91
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	1	88	Isopropylbenzene	1	64
Anthracene	1	83	Isoquinoline	1	64
Anthraquinone	1	96	*d*-Limonene	1	44
Benzo[a]pyrene	1	88	Menthol	1	95
Benzophenone	1	92	Metalaxyl	1	104
Bromacil	1	98	3-Methyl-1(H)-indole (Skatole)	1	79
Bromoform (tribromomethane)	1	61	5-Methyl-1H-benzotriazole	1	64
3-*tert*-Butyl-4-hydroxy anisole (BHA)	1	45	1-Methylnaphthalene	1	74
Caffeine	1	95	2-Methylnaphthalene	1	74
Camphor	1	96	Methyl salicylate	1	92
Carbaryl	1	72	Metolachlor	1	93
Carbazole	1	93	Naphthalene	1	83
Chlorpyrifos	1	80	*para*-Nonylphenol (total)	1	77
Cholesterol	1	61	4-*n*-Octylphenol	1	74
3-β-Coprostanol	1	71	4-*tert*-Octylphenol	1	79
Cotinine	1	74	Perchloroethene (PCE, Tetrachloroethene)	1	25
p-Cresol	1	85	Phenanthrene	1	93
4-Cumylphenol	1	83	Phenol [1]	1	92
Diazinon	1	107	Prometon	1	98
1,4-Dichlorobenzene	1	71	Pyrene	1	93
N,*N*-Diethyl-meta-toluamide (DEET)	1	106	β-Sitosterol	1	64
2,6-Dimethylnaphthalene	1	64	β-Stigmastanol	1	69
4-Nonylphenol diethoxylates	1	63	Tributyl phosphate	1	88
4-Octylphenol diethoxylates	1	47	Triclosan	1	83
4-Octylphenol monoethoxylates	1	61	Triethyl citrate (ethyl citrate)	1	93
Fluoranthene	1	98	Triphenyl phosphate	1	92
Hexahydrohexamethylcyclopentabenzopyran (HHCB)	1	86	Tris(2-butoxyethyl) phosphate [1]	1	86
Indole	1	57	Tris(2-chloroethyl) phosphate	1	98
Isoborneol	1	86	Tris(dichlorisopropyl) phosphate	1	92

[1] Constituent detected in groundwater samples.

Table A5D.   Matrix-spike recoveries for constituents of special interest in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[Acceptable recovery range is between 70 and 130 percent]

Constituent (synonym or abbreviation)	Number of spiked samples collected	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
N-Nitrosodimethylamine (NDMA)	4	96	127	111.2
1,2,3-Trichloropropane (1,2,3-TCP)	4	92	119	111.1

Table A6. Surrogate compound recoveries for volatile organic compounds (VOCs), pesticides and pesticide degradates, and wastewater indicator compounds (WICs) in samples collected for the Bear Valley and Selected Hard Rock Areas (BEAR) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, April to August 2010.

[**Abbreviations**: NWQL, U.S. Geological Survey National Water Quality Laboratory; <, less than; >, greater than]

Surrogate compound	NWQL analytical schedule	Constituent class analyzed	Number of blank samples analyzed	Median recovery in blank samples (percent)	Number of surrogate recoveries <70 percent in blank samples	Number of surrogate recoveries >130 percent in blank samples	Number of groundwater samples analyzed	Median recovery in groundwater samples (percent)	Number of surrogate recoveries <70 percent in groundwater samples	Number of surrogate recoveries >130 percent in groundwater samples
1-Bromo-4-fluorobenzene	2020	VOC	5	95	0	0	38	91	0	0
1,2-Dichloroethane-$d4$	2020	VOC	5	120	0	2	38	125	0	14
Toluene-$d8$	2020	VOC	5	94	0	0	38	94	0	0
Diazinon-$d10$	2033	Pesticide	4	77	0	0	38	78	2	0
α-HCH-$d6$	2033	Pesticide	4	87	0	0	38	87	0	0
Caffeine-13C	1433	WIC	3	90	0	0	9	93	0	0
Decafluorobiphenyl	1433	WIC	3	36	3	0	9	47	9	0
Fluoranthene-$d10$	1433	WIC	3	89	0	0	9	94	0	0