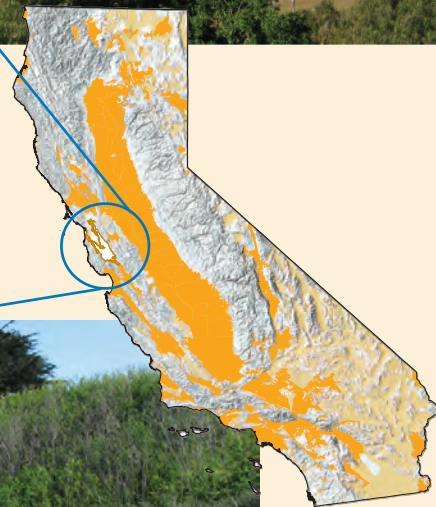


Prepared in cooperation with the California State Water Resources Control Board
A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Ground-Water Quality Data in the San Francisco Bay Study Unit, 2007: Results from the California GAMA Program



Data Series 396

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



Cover Photographs:

Top: Santa Clara Valley, California, April 2007. (Photograph taken by Michael Wright, U.S. Geological Survey.)

Bottom: Monitoring well in San Francisco County, California, May 2007. (Photograph taken by Michael Solt, U.S. Geological Survey.)

Ground-Water Quality Data in the San Francisco Bay Study Unit, 2007: Results from the California GAMA Program

By Mary C. Ray, Justin T. Kulongoski, and Kenneth Belitz

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

U.S. Department of the Interior

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U.S. Geological Survey

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U.S. Geological Survey, Reston, Virginia: 2009

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Abbreviations and Acronyms

(Additional information or clarification given in parentheses)

| | |
|-----------|--|
| AB | Assembly Bill (through the California State Assembly) |
| AL-US | Action Level (USEPA) |
| CAS | Chemical Abstract Service (American Chemical Society) |
| 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-US | Lifetime Health Advisory (USEPA) |
| HCl | hydrochloric acid |
| HPLC | high-performance liquid chromatography |
| LRL | laboratory reporting level |
| LSD | land-surface datum |
| LT-MDL | long-term method detection level |
| MCL-CA | maximum contaminant level (CDPH) |
| MCL-US | maximum contaminant level (USEPA) |
| MDL | method detection limit |
| MIMS | Membrane Inlet Mass Spectrometry |
| MRL | minimum reporting level |
| MU | method uncertainty |
| N | Normal (1-gram equivalent per liter of solution) |
| na | not available |
| nc | sample not collected |
| nd | no data |
| NL-CA | California notification level (CDPH) |
| NWIS | National Water Information System (USGS) |
| PCFF-GAMA | personal computer field forms program designed for GAMA sampling |
| QC | quality control |
| RPD | relative percent difference |
| RSD | relative standard deviation |
| RSD5-US | risk-specific dose at 10^{-5} (USEPA) |
| SF | San Francisco Bay study unit grid well |
| SFU | San Francisco Bay study unit understanding well |
| SFM | San Francisco Bay study unit monitoring well |
| SFBAY | San Francisco Bay GAMA study unit |
| SMCL-CA | secondary maximum contaminant level (CDPH) |
| SMCL-US | secondary maximum contaminant level (USEPA) |
| SSMDC | sample-specific minimum detectable concentration |
| TDS | total dissolved solids |

| | |
|-------|--|
| TT-US | Treatment Technique (USEPA) |
| US | United States |
| V | analyte detected in sample and an associated blank thus data are not included in ground-water-quality assessment |

Organizations

| | |
|-------|---|
| CDPH | California Department of Public Health |
| CDWR | California Department of Water Resources |
| USEPA | U.S. Environmental Protection Agency |
| LLNL | Lawrence Livermore National Laboratory |
| MWH | Montgomery Watson Harza Laboratory |
| NAWQA | National Water Quality Assessment (USGS) |
| NRP | National Research Program (USGS) |
| TML | National Research Program Trace Metal Laboratory (USGS) |
| NWQL | National Water Quality Laboratory (USGS) |
| SWRCB | State Water Resources Control Board |
| USEPA | U.S. Environmental Protection Agency |
| USGS | U. S. Geological Survey |

Selected chemical names

| | |
|-------------------|--------------------------------|
| CaCO ₃ | calcium carbonate |
| DBCP | 1,2-dibromo-3-chloropropane |
| DOC | dissolved organic carbon |
| EDB | 1,2-dibromomethane |
| HCl | hydrochloric acid |
| NDMA | <i>N</i> -nitrosodimethylamine |
| PCE | tetrachloroethene |
| 1,2,3-TCP | 1,2,3-trichloropropane |
| TDS | total dissolved solids |
| THM | trihalomethane |
| VOC | volatile organic compound |

Units of Measure

| | |
|-------------------------|--|
| cm ³ STP/g | cubic centimeters at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water |
| δ ⁱ <i>E</i> | standard delta notation, the ratio of a heavier isotope of an element (^{<i>i</i>} <i>E</i>) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil |
| ft | foot (feet) |
| in. | inch |
| kg | kilogram |
| L | liter |

| | |
|---------|--|
| mg | milligram |
| mg/L | milligrams per liter (parts per million) |
| mi | mile |
| mL | milliliter |
| µg/L | micrograms per liter (parts per billion) |
| µL | microliter |
| µm | micrometer |
| µS/cm | microsiemens per centimeter |
| pCi/L | picocurie per liter |
| per mil | parts per thousand |
| pmc | percent modern carbon |
| TU | tritium unit |
| > | greater than |
| < | less than |
| — | not detected |
| °C | degrees Celsius |
| °F | degrees Fahrenheit |

Notes

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

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

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).

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Ground-Water Quality Data in the San Francisco Bay Study Unit, 2007: Results from the California GAMA Program

By Mary C. Ray, Justin T. Kulongoski, and Kenneth Belitz

Abstract

Ground-water quality in the approximately 620-square-mile San Francisco Bay study unit (SFBAY) was investigated from April through June 2007 as part of the Priority Basin project of the Ground-Water Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin project was developed in response to the Groundwater Quality Monitoring Act of 2001, and is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB).

The study was designed to provide a spatially unbiased assessment of raw ground-water quality, as well as a statistically consistent basis for comparing water quality throughout California. Samples in SFBAY were collected from 79 wells in San Francisco, San Mateo, Santa Clara, Alameda, and Contra Costa Counties. Forty-three of the wells sampled were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study unit (grid wells). Thirty-six wells were sampled to aid in evaluation of specific water-quality issues (understanding wells).

The ground-water samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, pharmaceutical compounds, and potential wastewater-indicator compounds), constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]), naturally occurring inorganic constituents (nutrients, major and minor ions, trace elements, chloride and bromide isotopes, and uranium and strontium isotopes), radioactive constituents, and microbial indicators. Naturally occurring isotopes (tritium, carbon-14 isotopes, and stable isotopes of hydrogen, oxygen, nitrogen, boron, and carbon), and dissolved noble gases (noble gases were analyzed in collaboration with Lawrence Livermore National Laboratory) also were measured to help identify the source and age of the sampled ground water.

Quality-control samples (blank samples, replicate samples, matrix spike samples) were collected for approximately one-third of the wells, and the results for these samples were used to evaluate the quality of the data for the ground-water samples. Assessment of the quality-control information from the field blanks resulted in applying “V” codes to approximately 0.1 percent of the data collected for ground-water

samples (meaning a constituent was detected in blanks as well as the corresponding environmental data). See the *Appendix* section “Quality-Control-Sample Results.”

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, and (or) blended with other waters to maintain acceptable water quality. Regulatory thresholds apply to treated water that is delivered to the consumer, not to raw ground water. However, to provide some context for the results, concentrations of constituents measured in the raw ground water were compared with regulatory and non-regulatory health-based thresholds established by the U.S. Environmental Protection Agency (USEPA) and California Department of Public Health (CDPH) and thresholds established for aesthetic concerns (secondary maximum contaminant levels, SMCL-CA) by CDPH.

VOCs were detected in about one-half of the grid wells, while pesticides were detected in about one-fifth of the grid wells. Concentrations of all VOCs and pesticides detected in samples from all SFBAY wells were below health-based thresholds. No pharmaceutical compounds were detected in any SFBAY well. One potential wastewater-indicator compound, caffeine, was detected in one grid well in SFBAY. Concentrations of most trace elements and nutrients detected in samples from all SFBAY wells were below health-based thresholds. Exceptions include nitrate, detected above the USEPA maximum contaminant level (MCL-US) in 3 samples; arsenic, above the USEPA maximum contaminant level (MCL-US) in 3 samples; cadmium, above the MCL-US in 1 sample; boron, above the CDPH notification level (NL-CA) in 2 samples; and strontium, above the USEPA lifetime health advisory level (HAL-US) in 2 samples. The radioactive constituent radon-222 was detected above the proposed MCL-US in two grid wells, but no wells had detections above the proposed alternative MCL-US. Most of the samples from all SFBAY wells had concentrations of major ions, total dissolved solids, and trace elements below the non-enforceable thresholds set for aesthetic concerns. Six or fewer samples contained chloride, sulfate, or iron at concentrations above the SMCL-CA thresholds. No microbial indicators were detected in SFBAY grid wells.

Introduction

Ground water comprises nearly half of the water used for public supply in California (Hutson and others, 2004). To assess the quality of ground water in aquifers used for drinking-water supply and establish a program for monitoring trends in ground-water quality, the State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (<http://www.waterboards.ca.gov/gama>). The GAMA program consists of three projects: Priority Basin Assessment, conducted by the USGS (<http://ca.water.usgs.gov/gama/>); Voluntary Domestic Well Assessment, conducted by the SWRCB; and Special Studies, conducted by LLNL.

The SWRCB initiated the GAMA Priority Basin project in response to the Ground-Water Quality Monitoring Act of 2001 (Sections 10780-10782.3 of the California Water Code, Assembly Bill 599). AB 599 is a public mandate to assess and monitor the quality of ground water used as public supply for municipalities in California. The project is a comprehensive assessment of statewide ground-water quality designed to help better understand and identify risks to ground-water resources and to increase the availability of information about ground-water quality to the public. As part of the AB 599 process, the USGS, in collaboration with the SWRCB, developed the monitoring plan for the project (Belitz and others, 2003; State Water Resources Control Board, 2003). Key aspects of the project are inter-agency collaboration and cooperation with local water agencies and well owners. Local participation in the project is entirely voluntary.

The GAMA Priority Basin project is unique because the data collected during the study include the results from analyses of an extensive number of chemical constituents at very low concentrations, analyses that are not normally available. A broader understanding of ground-water composition will be especially useful for providing an early indication of changes in water quality, and for identifying the natural and human factors affecting water quality. Additionally, the GAMA Priority Basin project will analyze a suite of constituents broader than that required by the California Department of Public Health (CDPH). An understanding of the occurrence and distribution of these constituents is important for the long-term management and protection of ground-water resources.

The range of hydrologic, geologic, and climatic conditions that exists in California must be considered in an assessment of ground-water quality. Belitz and others (2003) partitioned the state conceptually into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics, and representative regions in all 10 provinces were included in the project design (*fig. 1*). Eighty percent of California's approximately 16,000 public-supply wells are located in ground-water basins within these hydrologic provinces. These ground-water basins, defined by the California Department of Water Resources (CDWR), generally

consist of fairly permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Ground-water basins were prioritized for sampling on the basis of the number of public-supply wells in the basin, with secondary consideration given to municipal ground-water use, agricultural pumping, the number of leaking underground fuel tanks, and pesticide applications within the basins (Belitz, and others, 2003). In addition, some ground-water basins or groups of adjacent similar basins with relatively few public-supply wells were assigned high priority so that all hydrogeologic provinces would be represented in the subset of basins sampled. The 116 priority basins were grouped into 35 study units. Some areas not in the defined ground-water basins were included in several of the study units to represent the 20 percent of public-supply wells not located in the ground-water basins. The San Francisco Bay GAMA study unit, hereinafter referred to as SFBAY, contains 8 of the 116 CDWR ground-water basins; all 8 basins are in the Southern Coast Ranges hydrogeologic province. SFBAY was considered high priority for sampling, to provide adequate representation of the Southern Coast Ranges hydrogeologic province (Belitz and others, 2003).

This report is one of a series of reports presenting water-quality data collected in each study unit (Wright and others, 2005; Kulongoski and others, 2006; Bennett and others, 2006; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Dawson and others, 2008; Landon and Belitz, 2008). Subsequent reports will present three types of water-quality assessments using the data collected in each study unit: (1) Status: assessment of the current quality of the ground-water resource, (2) Trends: detection of changes in ground-water quality and (3) Understanding: identification of the natural and human factors affecting ground-water quality (Kulongoski and Belitz, 2004).

Purpose and Scope

The purposes of this report are (1) to describe the study design and study methods, (2) to present the results of quality-control tests, and (3) to present the analytical results for ground-water samples collected in SFBAY. Ground-water samples were analyzed for organic, inorganic, and microbial constituents, field parameters, radioactive isotopes, noble gases, and chemical tracers. The chemical and microbial data presented in this report were evaluated by comparing them to State and federal drinking water regulatory and other health-based standards that are applied to treated drinking water. Regulatory thresholds considered for this report are those established by the United States Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH). The data presented in this report are intended to characterize the quality of untreated ground-water resources within the study unit, not the treated drinking water delivered to consumers by water purveyors. Discussion of the factors that influence the distribution and occurrence of the constituents detected in ground-water samples will be the subject of subsequent publications.



Figure 1. Map showing the hydrogeologic provinces of California and the location of the San Francisco Bay Ground-water Ambient Monitoring and Assessment (GAMA) study unit, California.

Hydrogeologic Setting

Knowledge of the hydrogeologic setting is important in the design of a ground-water-quality investigation. The San Francisco Bay study unit (SFBAY) lies within the Southern Coast Ranges Hydrogeologic Province (*fig. 1*) described by Belitz and others (2003), and includes eight of the CDWR-defined ground-water basins in the San Francisco Bay Hydrologic Region: Marina, Lobos, Downtown, Islais Valley, South San Francisco, Visitacion Valley, Westside, and Santa Clara Valley (*fig. 2*) (California Department of Water Resources, 2003). Combined, these basins define the extent of SFBAY and cover an area of approximately 620 square miles (mi²), primarily in San Francisco, San Mateo, Santa Clara, Alameda, and Contra Costa Counties. The study unit is bounded on the west by the Santa Cruz Mountains and the San Andreas fault, on the east by the Diablo Range and Franciscan Basement, on the north by the Golden Gate strait, and on the south by the Santa Clara Valley ground-water divide. This ground-water divide at Cochrane Road in Morgan Hill separates the northerly flow of water toward San Francisco Bay from the southerly flow of water towards Monterey Bay (Moran and others, 2002b).

The climate in the SFBAY area is characterized by warm, dry summers, and winters that are cool and moist (Hanson and others, 2004). Average rainfall across the study unit ranges from 14 in/yr in the southern and southwestern parts of the study unit to 28 in/yr in the northern parts of the study unit; rainfall can be more than 50 in/yr in the surrounding mountains (California Department of Water Resources, 2004a,b).

The main water-bearing units within the Visitacion Valley, Islais Valley, Westside, and South San Francisco basins (*fig. 2*) consist, in part, of unconsolidated sediments of dune sand; Pleistocene age deposits consisting of fine-grained sand, silty sand, and discontinuous beds of clay; marine estuarine deposits (locally referred to as the “Bay Mud”); and artificial fill (California Department of Water Resources, 2004a,b). Impermeable bedrock is composed of consolidated sediments of the Franciscan Complex (Schlocker, 1974) and interbedded strata of marine mudstone, sandstone, and conglomerate of late Jurassic and Cretaceous age (Bailey and others, 1964; California Department of Water Resources, 2004a,b). The water-bearing units within the Lobos, Marina, and Downtown basins include Pleistocene age deposits consisting of fine-grained sand, silty sand, and discontinuous beds of clay, and alluvial fan deposits (California Department of Water Resources, 2004a,b). In the Santa Clara Valley, the aquifers are composed of Recent, Holocene-age, and Pleistocene-age fluvial deposits and the “Bay Mud.” The alluvial deposits that form the regional aquifer systems are underlain by Pliocene deposits composed of gravel, sand, silt, and clay, and Tertiary-age sediments (California Department of Water Resources, 2004a,b; Hanson and others, 2004).

The San Francisco Bay rests in the core of a broad Franciscan (basement) synform (downward-arched fold). The Hayward Fault and the San Andreas Fault (*fig. 2*) form the current eastern and western boundaries of the synform. Both faults are major tectonic features; the Hayward Fault separates Franciscan units (on the west) from Cenozoic units (on the east) and impedes the westward flow of ground water (California Environmental Protection Agency, San Francisco Bay Regional Water Quality Control Board, 2003). Differences in water levels between the east and the west sides of the Hayward fault show the impermeable nature of this geologic structure.

Natural recharge to the ground-water flow system in the Santa Clara Valley occurs along the mountain fronts, and flows toward the center of the basin and toward the southern San Francisco Bay. However, the predominant recharge mechanisms for the ground-water flow system are artificial recharge from the infiltration of imported water and leakage from transmission pipelines that transport the imported water, as well as return flow from landscape irrigation (Hanson and others, 2004). The Coyote Creek (*fig. 2*) is the main drainage feature of the Santa Clara Valley Ground-Water Basin. It originates in the Diablo Range and flows northwesterly through the valley before entering the San Francisco Bay (California Environmental Protection Agency and S.F. Bay Regional Board Groundwater Committee, 2003). The predominant source of recharge in the San Francisco Peninsula region is infiltration of precipitation and streamflow (California Department of Water Resources, 2004a,b).

Methods

Methods used for the GAMA program were selected to achieve the following objectives: (1) design a sampling plan suitable for statistical analysis, (2) collect samples in a consistent manner, (3) analyze samples using proven and reliable laboratory methods, (4) assure the quality of the ground-water data, and (5) maintain data securely and with relevant documentation.

Study Design

The wells selected for sampling in this study reflect the combination of two well selection strategies. Forty-three wells were selected using a randomized grid-based method (Scott, 1990) in order to provide a statistically unbiased, spatially distributed assessment of the quality of ground-water resources used for public drinking water supply. Thirty-six additional wells were selected to aid in the understanding of specific ground-water quality issues in the SFBAY study unit.

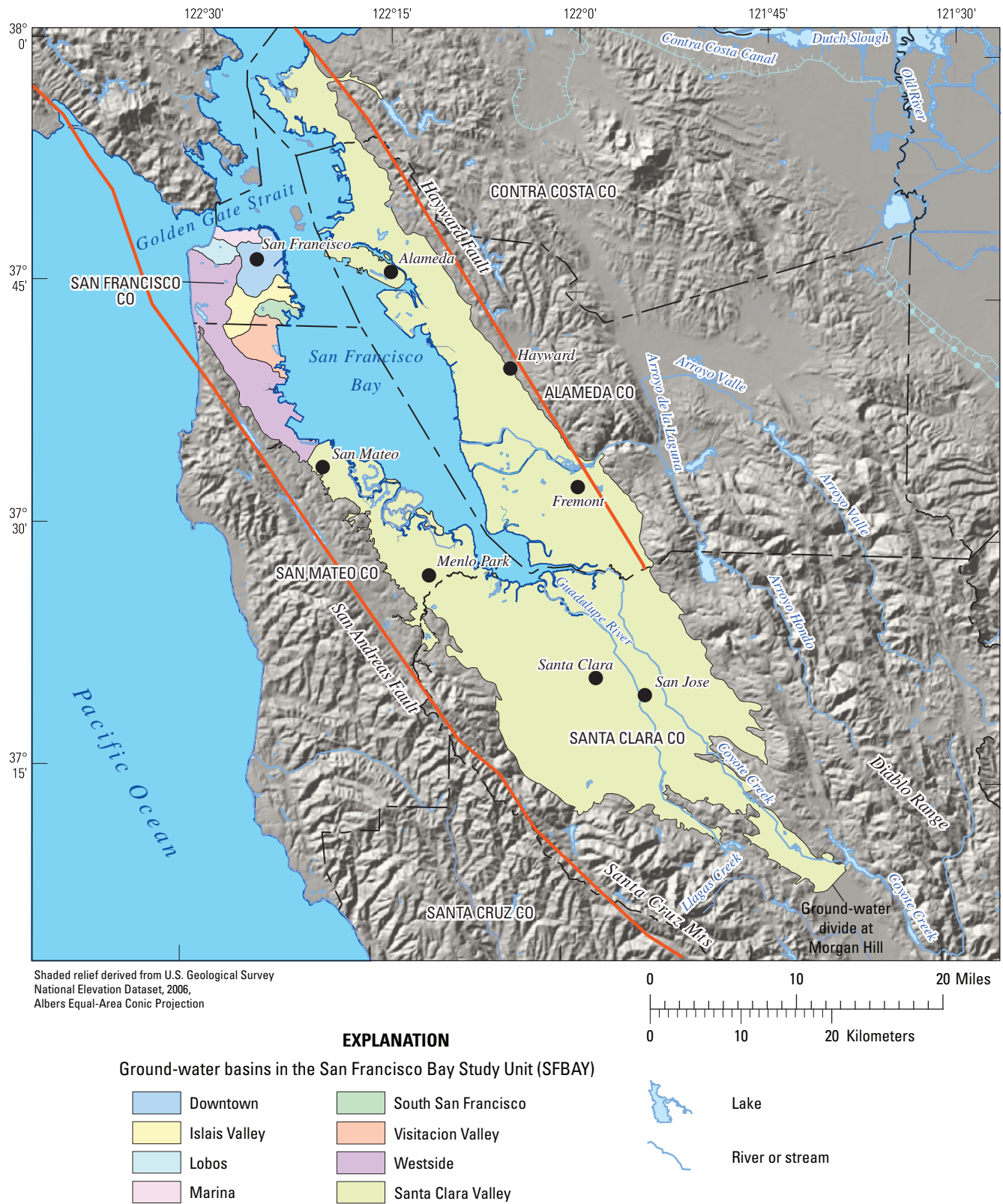


Figure 2. Map showing the California Department of Water Resources defined ground-water basins and the major hydrologic features in the San Francisco Bay Ground-water Ambient Monitoring and Assessment (GAMA) study unit, California.

To select an unbiased, spatially distributed network of wells, the locations of wells listed in the statewide databases maintained by the CDPH and USGS were plotted on a regional map. A grid of 68 equal-area cells (10 mi²) was then drawn over SFBAY, with the objective of selecting one public-supply well per grid cell to sample (*fig. 3*). Forty-three of the 68 grid cells were sampled (*table 1*; all tables shown in back of report). Twenty-five grid cells were not sampled because some had no wells, or because permission to sample was not granted for any qualifying wells in those cells. If a grid cell contained more than one public-supply well, each well was randomly assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located upstream from treatment, capability to pump for several hours, and available well-construction information), and for which permission to sample could be obtained, was then sampled. If a grid cell did not contain accessible public-supply wells, domestic and irrigation wells were considered for sampling. In this fashion, one well was selected in 43 of the 68 qualifying grid cells to provide a spatially distributed, randomized monitoring network for the study unit (*fig. 3*). Wells sampled as part of the randomized grid-cell network are hereinafter referred to as “grid wells.” Grid wells in SFBAY were numbered spatially, beginning in the northwest corner of the study unit and progressing counter-clockwise around the Bay, and the prefix “SF” was appended to each number.

Thirty-six additional wells were sampled to evaluate changes in water chemistry along selected ground-water flow paths or between shallow and deeper aquifers. Wells sampled as part of these studies were not included in the statistical characterization of water quality in SFBAY because they were not randomly selected. These additional (nonrandomized) wells are collectively referred to as “understanding wells” in the text of this report. There were two types of understanding wells: clustered monitoring wells (SFM prefix) and production wells (SFU prefix) (*fig. 4*).

The GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, and well-construction information, are given in *table 1*. The 43 grid wells sampled included 32 public-supply, 1 industrial, 1 institutional, 1 desalination, and 8 irrigation wells. The 36 understanding wells included 24 monitoring and 12 public-supply wells. Ground-water samples were collected from the wells in April through June 2007.

Well locations and identifications were verified using GPS, 1:24,000-scale USGS topographic maps, comparison with existing well information in USGS and CDPH databases, and information provided by well owners. Drillers’ logs for wells were obtained when available. Well information was recorded manually on field sheets, and electronically using specialized software on field laptop computers. All information was verified and then uploaded into the USGS National Water Information System (NWIS).

The wells in SFBAY were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents (termed the “fast” schedule) (*table 2*): pH, dissolved oxygen, temperature, specific conductance, alkalinity, VOCs, pesticides and pesticide degradates, perchlorate, stable isotopes of hydrogen and oxygen in water and of nitrogen and oxygen in nitrate, tritium and dissolved noble gases, arsenic and iron species, hexavalent and total chromium, nutrients, carbon isotopes, and uranium and strontium isotopes. Some wells were also sampled on the “slow” schedule (*table 2*), which includes all the constituents on the “fast” schedule plus: turbidity; pharmaceuticals; potential wastewater-indicators; *N*-nitrosodimethylamine (NDMA); major and minor ions; trace elements; radon-222; boron isotopes; low-level halogenated VOCs (for concentrations typically below the method detection limit); chloride and bromide isotopes (at selected wells only); and, microbial constituents. Fast and slow refer to the relative amount of time required to sample the well for all the analytes on the schedule. In SFBAY, 48 of the ground-water wells were sampled on the fast schedule and 31 on the slow schedule.

Sample-Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of ground water is collected at each site, and that the samples are collected and handled in a way that minimizes the potential for contamination of samples. The methods used to collect samples are described in the Appendix section “Sample Collection and Analysis”.

Tables 3A-L list the compounds analyzed in each constituent class. Ground-water samples were analyzed for 85 VOCs (*table 3A*); 117 pesticides and pesticide degradates (*table 3B,C*); 14 pharmaceutical compounds (*table 3D*); 62 potential wastewater-indicator compounds (*table 3E*); 2 constituents of special interest (*table 3F*); 5 nutrients (*table 3G*); 10 major and minor ions, total dissolved solids, and 24 trace elements (*table 3H*); arsenic, chromium, and iron species (*table 3I*); stable isotopes of oxygen and hydrogen in water, nitrogen and oxygen in nitrate, boron, carbon, and chlorine and bromine, uranium and strontium isotopes, and three radioactive constituents, tritium, radon-222, and carbon-14 (*table 3J*); 5 dissolved noble gases, and helium stable isotope ratios (*table 3K*); and 2 microbial constituents (*table 3L*). The methods used to analyze samples are described in Appendix *table A1* and the Appendix section “Sample Collection and Analysis.”

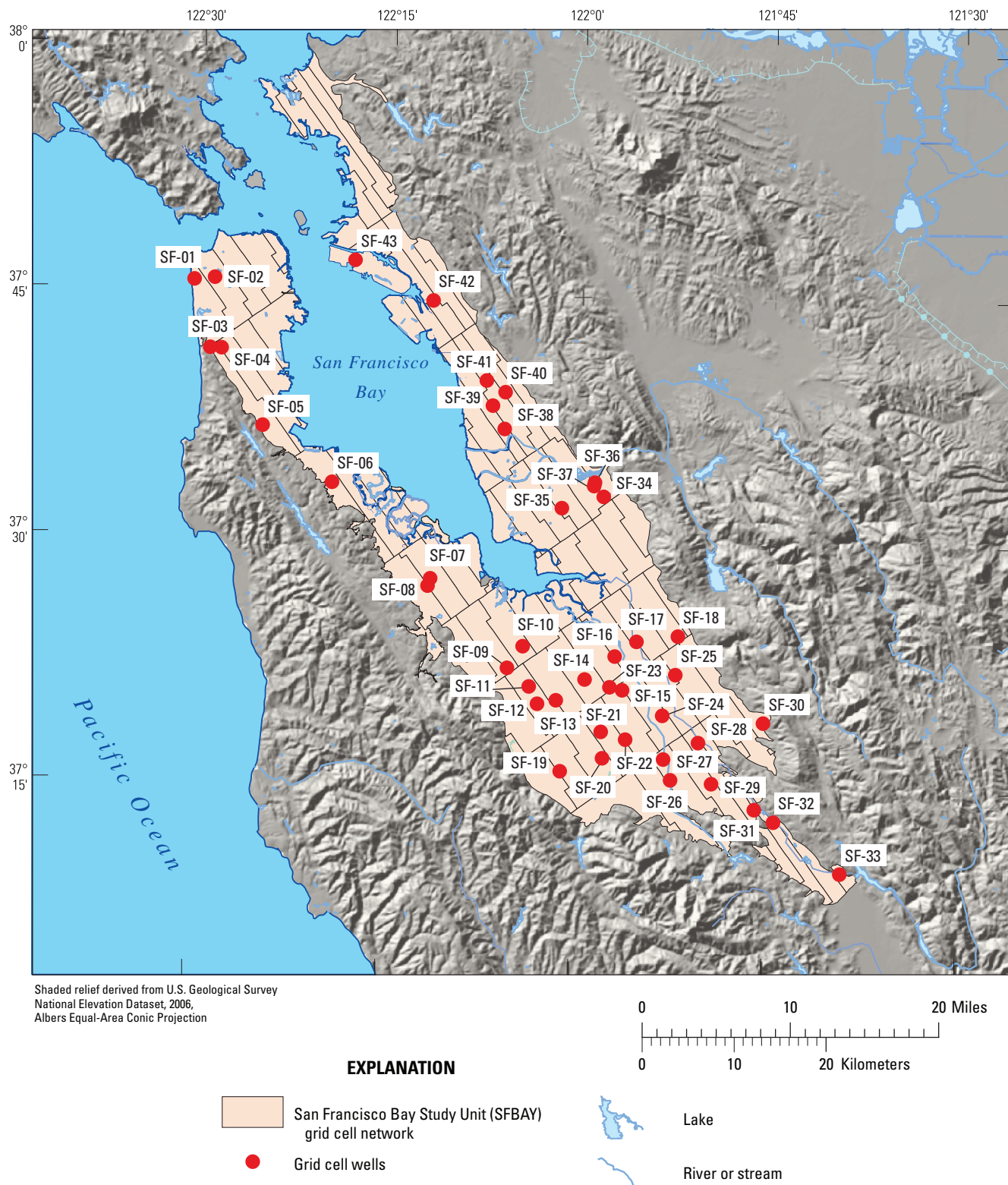


Figure 3. Map showing the distribution of study unit grid cells and the locations of sampled grid cell wells in the San Francisco Bay Ground-water Ambient Monitoring and Assessment (GAMA) study unit, California.

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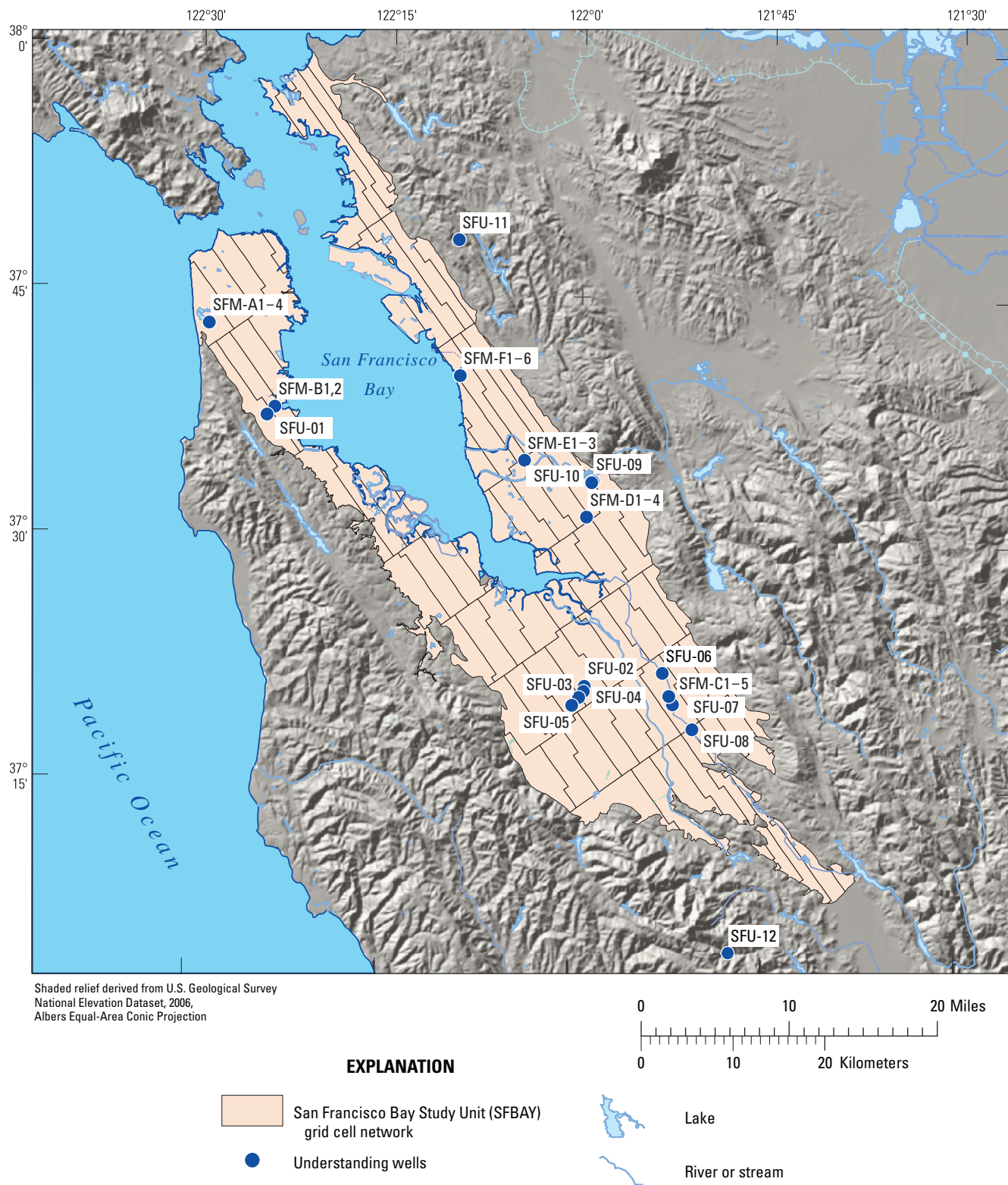


Figure 4. Map showing the distribution of study unit grid cells and the locations of understanding wells in the San Francisco Bay Ground-water Ambient Monitoring and Assessment (GAMA) study unit, California.

Data Reporting

The methods and conventions used for reporting the data are described in the *Appendix* section “Data Reporting”. Seventeen constituents analyzed in this study were measured by more than one method at the USGS National Water Quality Laboratory (NWQL) (*table A2*). For these constituents, only the results from the preferred method are reported. Four other constituents—arsenic, iron, and chromium concentrations, and tritium activities—were measured by more than one laboratory, and both sets of these results are reported.

Quality-Assurance

The quality-assurance methods used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and are described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality assurance 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). Quality-control (QC) samples collected in the SFBAY study include source-solution blanks, field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate any contamination of the samples, and any bias and variability of the data that may have resulted from collecting, processing, storing, transporting, and laboratory analysis of the samples. The quality-assurance methods are described in the Quality Assurance section of the *Appendix*.

Water-Quality Results

Quality-Control-Sample Results

Results of quality-control analyses (blank samples, replicate samples, matrix spikes, and surrogates) were used to evaluate the quality of the data for the ground-water samples (see *Appendix*). Assessment of the quality-control information from the field blanks resulted in applying “V” codes to approximately 0.1 percent of the data collected for ground-water samples (meaning a constituent was detected in blanks as well as the corresponding environmental data); the affected data are preceded by a “V” in *tables 4–16*. Matrix-spike recoveries for several organic constituents were lower than the lower end of the acceptable limits, which may indicate that these constituents might not have been detected in some samples if they were present at very low concentrations. The quality-control results are described in the *Appendix* section “Quality-Control-Sample Results”.

Comparison Thresholds

Concentrations of constituents detected in ground-water samples were compared with CDPH and USEPA drinking-water health-based thresholds and thresholds established for aesthetic purposes (California Department of Health Services, 2007a; U.S. Environmental Protection Agency, 2006). CDPH replaced California Department of Health Services (CDHS) on July 1, 2007. The chemical and microbial data presented in this report are meant to characterize the quality of the untreated ground-water resources within SFBAY, and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical and microbial composition of treated drinking water may differ from untreated ground water because treated drinking water may be disinfected, filtered, mixed with other waters, and exposed to the atmosphere before being delivered to consumers.

The following thresholds 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. CDPH has established MCLs for constituents not regulated by the USEPA and has lowered the threshold concentration for a number of constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA and adopted by CDPH is labeled “MCL-US,” and one set by CDPH that is more stringent than the MCL-US is labeled “MCL-CA.” CDPH is notified when constituents are detected at concentrations exceeding MCL-US or MCL-CA thresholds in samples collected for the GAMA Priority Basin project.
- **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 above the action-level thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH are the same, thus the thresholds are labeled “AL-US” in this report.
- **TT – Treatment Technique.** Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of microbial constituents in drinking water. Detections of microbial constituents above the treatment-technique thresholds trigger requirements for additional mandatory disinfection during water treatment. The action levels established by the USEPA and CDPH are the same, thus the thresholds are labeled “TT-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 technical qualities of drinking water, such as scaling and staining. Both the USEPA and CDPH define SMCLs, but unlike MCLs, SMCLs established by CDPH are not required to be at least as stringent as those established by USEPA. SMCLs established by CDPH (SMCL-CA) are used in this report 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 CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected above 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 (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 10^{-5} . RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by ten (RSD5-US).

For constituents having MCLs, detections in ground-water samples were compared to the MCL-US or MCL-CA. If a constituent had an SMCL, its concentration was compared to the SMCL-CA. For chloride, sulfate, specific conductance, and total dissolved solids, CDPH defines a “recommended” and an “upper” SMCL-CA; detections of these constituents in ground-water samples were compared with both levels. The SMCL-US for these constituents corresponds to the recommended SMCL-CA. Detected concentrations of constituents that lack an MCL or SMCL were compared to the NL-CA. Detected concentrations of constituents that lack an MCL, SMCL, or NL-CA were compared with the HAL-US. Detected concentrations of constituents that lack an MCL, SMCL, NL-CA, or HAL-US were compared with the RSD5-US. Note that the result of using this hierarchy to select comparison thresholds for constituents that have multiple types of established thresholds is that the selected threshold may not be the threshold that has the lowest concentration. The comparison thresholds used in this report are listed in *tables 3A–L* for all constituents and in *tables 4–16* for constituents detected in

ground-water samples from SFBAY. Not all constituents analyzed for this study have established thresholds.

Constituents detected at concentrations above thresholds set for health-based and aesthetic purposes are marked with asterisks in *tables 4–16*. In this study, only two constituents (nitrate [*table 9*] and radon-222 [*table 15*]) were detected at concentrations higher than health-based thresholds in grid wells. These constituents were detected in 3 of the 43 grid wells. Six additional constituents (specific conductance and pH [*table 4*], chloride and total dissolved solids [*table 10*], and iron and manganese [*table 11*]) were detected in 9 of the 43 grid wells at concentrations above thresholds set for aesthetic concerns.

Ground-Water-Quality Data

Results from analyses of raw (untreated) ground water from SFBAY are presented in *tables 4–16*. Ground-water samples collected in SFBAY were analyzed for up to 339 constituents, and 248 of those constituents were not detected in any of the samples (*table 3A–L*). The results tables present only the constituents that were detected and list only samples in which at least one constituent was detected. For constituent classes that were analyzed at all of the grid wells, the tables include the number of wells at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells), and the total number of constituents detected at each well. Results for the understanding wells also are presented in the tables, but these results were excluded from the detection frequency calculations to avoid statistically over-representing the areas near these wells.

Table 4 presents data for water-quality indicators measured in the field and at the NWQL, while *tables 5* through *16* present the results of laboratory ground-water analyses organized by compound classes:

- Organic Constituents
 - VOCs (*table 5*)
 - Pesticides and pesticide degradates (*table 6*)
 - Pharmaceuticals (none detected, no table)
 - Potential wastewater-indicator compounds (*table 7*)
 - Constituents of special interest (*table 8*)
- Inorganic constituents
 - Nutrients (*table 9*)
 - Major and minor ions (*table 10*)
 - Trace elements (*table 11*)
 - Arsenic, iron, and chromium species (*table 12*)

- Isotopic tracers and noble gases
 - Stable isotopes and tritium and carbon-14 activities (*table 13*, results not available for the stable isotopes of chlorine and bromine at the publishing date of this report)
 - Uranium and strontium isotopes (results not available at the publishing date of this report)
 - Noble gases and helium isotopes (*table 14*)
 - Radioactive constituents (*table 15*)
 - Microbial indicators (*table 16*)

Field Parameters

Field and laboratory measurements of dissolved oxygen, pH, specific conductance, alkalinity, and associated parameters (turbidity and water temperature) are presented in *table 4*. Dissolved oxygen and alkalinity are used as indicators of natural processes that control water chemistry. Specific conductance is the unit electrical conductivity of the water and is proportional to the amount of total dissolved solids (TDS) in the water. The pH value indicates the acidity or basicity of the water. Six grid wells had specific conductance values above the recommended SMCL-CA, although only two wells were also above the upper threshold and these wells were not public-supply wells. One grid well had a pH value outside of the SMCL-US range for pH. Laboratory pH values may be higher than field pH values because the pH of ground water may increase when exposed to the atmosphere (see *Appendix*).

Organic Constituents

Volatile organic compounds (VOC) are in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water, and are characterized by their tendency to evaporate. VOCs usually persist longer in ground water than in surface water because ground water is isolated from the atmosphere. Of the 85 VOCs analyzed (*table 3A*), 22 were detected in ground-water samples (not including constituents that had V-coded detections, meaning a constituent was detected in blanks as well as in the corresponding environmental samples), 14 of which were from grid wells; all detections were below health-based thresholds, and most ranged from less than half to one-hundredth of the threshold values (*table 5*). Three VOCs were detected in more than 10 percent of the grid wells sampled: chloroform, often a byproduct of disinfecting drinking water, 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), a refrigerant, and 1,1,1-trichloroethane (1,1,1-TCA), a solvent used for dry cleaning and other purposes. These compounds are among the most commonly detected VOCs in ground water nationally (Zogorski and others, 2006). One or more VOCs were detected in 21 of the 43 grid wells sampled. Six samples had toluene detections that were V-coded, and

these data were not used for summary statistical calculations. Affected values are preceded by a V in *table 5*.

Pesticides include herbicides, insecticides, and fungicides and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. Although the preferred analytical method for caffeine is schedule 2060, its primary use is not as a pesticide. It is more useful as a potential wastewater-indicator compound. Caffeine data is not used for summary statistical calculations of pesticides. Of the 117 pesticides and pesticide degradates analyzed (*tables 3B,C*), 6 were detected in SFBAY grid well samples; all detections were below health-based thresholds, and all were one-tenth to less than one one-hundredth of the threshold values (*table 6*). Deethylatrazine, a degradate of atrazine, was detected in more than 10 percent of the grid well samples. This compound is among the most commonly detected pesticide compounds in ground water nationally (Gilliom and others, 2006). One or more pesticide compounds were detected in 8 of the 43 grid wells (approximately 19 percent).

Ground-water samples were analyzed for pharmaceutical compounds at the 31 slow wells in SFBAY. No pharmaceutical compounds were detected (*table 3D*) in any well in SFBAY.

Potential wastewater-indicator organic compounds include detergents, fragrances, flame-retardants, and other man-made compounds. Although these compounds may indicate the presence of wastewater, they have other sources also. Of the 62 potential wastewater-indicator compounds analyzed (*table 3E*) at the 31 slow wells (*table 1*), 2 were detected in SFBAY ground-water samples from understanding wells (*table 7*). None were detected in the three grid wells where potential wastewater-indicator compounds were analyzed. Caffeine, although analyzed with pesticides, is a potential wastewater-indicator compound. It was detected in one SFBAY grid well and in 5 understanding wells (*table 6*).

Constituents of Special Interest

Perchlorate and NDMA are constituents of special interest in California because they recently have been found to be widely distributed in water supplies (California Department of Health Services, 2007b). Perchlorate was detected in approximately 46 percent of the grid wells; concentrations measured in all SFBAY wells were less than the MCL-CA (*table 8*). NDMA was analyzed for in samples from three grid wells, but was detected in none of them. NDMA was detected in nine understanding wells, but three of the detections were V-coded due to detections in field blanks. Affected values are preceded by a V in *table 8*.

Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, most of the inorganic constituents are naturally in ground water, although their concentrations may be influenced by human activities.

The nutrients, nitrogen and phosphorus, in ground water can affect biological activity in aquifers and in surface-water bodies that receive ground-water discharge. Nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the ground water. High concentrations of nitrate can adversely affect human health, particularly the health of infants. All of the concentrations of nitrate, nitrite, and ammonia measured in samples from the SFBAY wells were below health-based thresholds except those in one grid well and two understanding wells, which were above the MCL-US for nitrate (*table 9*); however, these three wells are not public supply wells.

The major-ion composition, total dissolved solids (TDS) content, and levels of certain trace elements in ground water affect the aesthetic properties of water, such as taste, color, and odor, and the technical properties, such as scaling and staining. Although there are no adverse health effects associated with these properties, they may reduce consumer satisfaction with the water or may have economic effects. CDPH has established non-enforceable thresholds (SMCL-CAs) that are based on aesthetic or technical properties rather than health-based concerns for the major ions chloride and sulfate, TDS, and several trace elements (*tables 3H, 10, 11*).

Samples collected to be analyzed for major and minor ions and total dissolved solids (TDS) were collected at the 31 slow wells (3 grid wells and 28 understanding wells) in SFBAY (*table 10*). The concentrations of sulfate measured in the three SFBAY grid wells were below the recommended SMCL-CA. The concentrations of chloride measured in 2 of the 3 grid wells were below the recommended SMCL-CAs. One well was above the upper threshold, but it was not a public-supply well. Concentrations of chloride in four understanding wells and concentrations of sulfate in two of these wells were above the upper threshold. Samples from three grid wells contained TDS above the recommended SMCL-CA, and one had TDS above the upper SMCL-CA. Fifteen of the understanding wells contained TDS above the recommended SMCL-CA, and five had TDS above the upper SMCL-CA.

Samples to be analyzed for trace elements were collected at the 31 slow wells in SFBAY (*table 11*). Iron and manganese are trace elements whose concentrations are affected by the oxidation-reduction state of the ground water. Precipitation of minerals containing iron or manganese may stain surfaces orange, brown, or black. Concentrations of iron in the three SFBAY grid wells in which it was analyzed were not detected above the SMCL-CA (*table 11*). One understanding well had a concentration of iron above the SMCL-CA. One of the three grid wells had a concentration of manganese above the SMCL-CA, and it was not a public-supply well (*table 11*). Concentrations of manganese in 15 understanding wells were above the SMCL-CA.

Seventeen of the 24 trace elements analyzed in this study have health-based thresholds. Of the 21 trace elements detected, 15 have health-based thresholds (three trace elements were not detected: beryllium, silver, and thallium). No detections of these 14 trace elements in the three SFBAY grid wells sampled for this constituent were above health-based thresholds (*table 11*). Arsenic was detected in three understanding wells at concentrations above the MCL-US. Cadmium was detected in one understanding well at a concentration above the MCL-US. Boron and strontium were detected in the same two understanding wells at concentrations above the NL-CA and the HAL-US, respectively. None of the understanding wells which had detections of arsenic, cadmium, boron or strontium above health-based thresholds were public supply wells.

Arsenic, chromium, and iron occur as different species depending on the oxidation-reduction state of the ground water. The oxidized and reduced species have different solubilities in ground water and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can also be used to aid in interpretation of the oxidation-reduction state of the aquifer. Concentrations of total arsenic, iron, and chromium, and the concentrations of either the reduced or the oxidized species of each element are reported on *table 12*. The concentration of the other species can be calculated by using the difference. The concentrations of arsenic, chromium, and iron reported in *table 12* may be different than those reported in *table 11* because different analytical methods were used (see *Appendix*). The concentrations reported in *table 11* are considered to be more accurate.

Isotopic Tracers and Noble Gases

The isotopic ratios of oxygen isotopes and hydrogen isotopes in water, of nitrogen isotopes in nitrogen gas, and of nitrogen isotopes and oxygen isotopes in dissolved nitrate, and tritium and carbon-14 activities, and the concentrations of dissolved noble gases in ground water may be used as tracers of hydrologic processes. The isotopic ratios of oxygen and hydrogen in water (*table 13*) aid in interpretation of the location of ground-water recharge. These stable isotopic ratios reflect the altitude, latitude, and temperature of precipitation, and also the extent of evaporation of the water sample. Additionally, the ratios of nitrogen isotopes and oxygen isotopes in dissolved nitrate (*table 13*) aid in interpretation of the sources and processes affecting these solutes in ground-water. Concentrations of dissolved noble gases (*table 14*) provide a means of estimating ground-water recharge conditions that are due to the solubility characteristics of these gases.

Tritium activities (*table 13*), carbon-14 activities (*table 13*), and helium isotope ratios (*table 14*) provide information about the age (time since recharge) of the ground-water. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Tritium is produced in the atmosphere by cosmic-ray produced neutrons interacting with nitrogen-14 (Craig and Lal, 1961), by atmospheric nuclear explosions, and by the operation of nuclear reactors. Carbon-14 (*table 13*) is a radioactive isotope of carbon that is also produced in the atmosphere by cosmic-ray neutrons interacting with the stable isotopes of nitrogen, oxygen, and carbon (Faure, 1986). Carbon-14 is incorporated into carbon dioxide and mixed throughout the atmosphere before dissolving in water and entering the hydrologic cycle.

Tritium is the only isotopic tracer that has a health-based threshold. All measured tritium activities in samples from SFBAY wells were less than one-hundredth of the MCL-CA (*table 13*).

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most of the radioactivity in ground water comes from decay of naturally-occurring isotopes of uranium and thorium in minerals in the sediments or fractured rocks that comprise the aquifer. Uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead. Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium and thorium decay series. In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha particle (two protons and two neutrons) or a beta particle (electron or positron) from its nucleus. For example, radium-226 emits an alpha particle and therefore transforms into radon-222. Radium-228 emits a beta particle to form actinium-228. 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 increases the risk of getting cancer.

Activity is often cited instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in ground water is measured in units of picocuries per liter (pCi/L); one picocurie approximately equals two atoms decaying per minute. The number of atoms decaying equals the number of alpha or beta particles emitted.

SFBAY samples from the 31 slow wells were analyzed for the radioactive constituent radon-222. Radon-222 was detected in 30 of the 31 samples (*table 15*). Two grid wells and 14 understanding wells had activities of radon-222 above the proposed MCL-US of 300 pCi/L; however, no samples had an activity above the proposed alternative MCL-US of 4,000 pCi/L. The alternative MCL-US is applied if the State or local water agency has an approved multimedia mitigation program to address radon in indoor air (U.S. Environmental Protection Agency, 1999a).

Microbial Indicators

Water is disinfected during drinking-water treatment to prevent diseases that may be spread by water-borne microbial constituents derived from human or animal wastes. The specific viruses and bacteria responsible for diseases are not usually measured because routine analytical methods are not available. Measurements are made of microbial constituents that are more easily analyzed and serve as indicators of human or animal waste in water. Drinking water purveyors respond to detections of microbial indicators by applying additional disinfectants to the water.

Samples from 3 SFBAY grid wells and 28 understanding wells were analyzed for microbial indicators. No microbial indicators were detected in any SFBAY grid wells or production wells (*table 16*). F-specific coliphage was detected in one monitoring well and somatic coliphage was detected in a different monitoring well.

Future Work

Subsequent reports will be focused on assessment of the data presented in this report using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting ground-water quality. Water-quality data contained in the CDPH and USGS NWIS databases, and water-quality data available from other State and local water agencies will be compiled, evaluated, and used in combination with the data that is presented in this report; the results of these future efforts will appear in one or more subsequent reports.

Summary

Ground-water quality in the approximately 620-square-mile San Francisco Bay study unit (SFBAY) was investigated from April to June 2007 as part of the Priority Basin Assessment Project of Ground-Water Ambient Monitoring and Assessment (GAMA) Program. The project is a comprehensive assessment of statewide ground-water quality designed to identify and characterize risks to ground-water resources and to increase the availability of information about ground-water quality to the public. SFBAY was the eighteenth study unit sampled as part of the project.

Ground-water samples were analyzed for a large number of organic constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, pharmaceutical compounds, and potential wastewater-indicator compounds); constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]); naturally occurring inorganic constituents (nutrients, major and minor ions, trace elements, chloride and bromide isotopes, and uranium and strontium isotopes); radioactive constituents; and microbial indicators. Naturally occurring isotopes (tritium, carbon-14 isotopes, and stable isotopes of hydrogen, oxygen, nitrogen, boron, and carbon) and dissolved noble gases (analyzed in collaboration with Lawrence Livermore National Laboratory) also were measured to help identify the sources and ages of the sampled ground water.

This study did not attempt to 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. Regulatory thresholds apply to treated water that is served to the consumer, not to raw ground water. However, to provide some context for the results, concentrations of constituents measured in the raw ground water were compared with regulatory and non-regulatory health-based thresholds established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH), and thresholds established for aesthetic concerns by CDPH.

Fourteen VOCs and six pesticides were detected in grid wells sampled for this study; however, all detections of VOCs and pesticides in SFBAY grid wells were below health-based thresholds, and most were less than one-tenth of the threshold values. Pharmaceutical compounds were not detected in any SFBAY wells. One potential wastewater-indicator compound, caffeine, was detected in one SFBAY grid well. All detections of perchlorate, NDMA, and trace elements in SFBAY grid wells were below established thresholds, although the concentration of nitrate was above the MCL-US in one grid well. Radon-222 was above the proposed MCL-US in two grid wells, but no wells had detections above the proposed alternative MCL-US. Specific conductance, pH, chloride, and iron were detected at concentrations above secondary maximum contaminant levels (SMCL-CAs), non-enforceable thresholds set for aesthetic concerns, in samples from six or fewer wells. No microbial indicators were detected in SFBAY grid wells.

Subsequent reports will present analyses of the data from this report using a variety of statistical, qualitative, and quantitative approaches to assess the natural and human factors affecting ground-water quality.

Acknowledgments

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References Cited

- American Public Health Association, 1998, Standard methods for the examination of water and (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, 2002, ASTM D 3972, Standard Test Method for Isotopic Uranium in Water by Radiochemistry: Philadelphia, Pennsylvania, American Society for Testing and Materials International. Also available at <http://www.astm.org/Standards/D3972.htm>.
- Bailey, E.H., Irwin, W.P., and Jones, D.L., 1964, Franciscan and related rocks, and their significance in the geology of Western California: California Division of Mines and Geology Bulletin 183, 177 p.
- Ball, J.W., and McCleskey, R.B., 2003a, A new cation-exchange method for accurate field speciation of hexavalent chromium: U.S. Geological Survey Water-Resources Investigations Report 03-4018, 17 p.
- Ball, J.W., and McCleskey, R.B., 2003b, A new cation-exchange method for accurate field speciation of hexavalent chromium: *Talanta*, v. 61, p. 305-313.
- Belitz, Kenneth, Dubrovsky, N.M., Burow, K.R., Jurgens, B.C., and Johnson, T., 2003, Framework for a ground-water quality monitoring and assessment program for California: U.S. Geological Survey Water-Resources Investigations Report 03-4166, 78 p.

- Bennett, G.L., V. Belitz, Kenneth, and Milby Dawson, B.J., 2006, California GAMA Program: Ground-water quality data in the northern San Joaquin basin study unit, 2005: U.S. Geological Survey Data Series 196, 122 p.
- Böhlke, J.K., Mroczkowski, S. J., and Coplen, T. B., 2003, Oxygen isotopes in nitrate: New reference materials for ^{18}O : ^{17}O : ^{16}O measurements and observations on nitrate-water equilibration: *Rapid Communications in Mass Spectrometry*, v. 17, p. 1835–1846.
- Bushon, R.N., 2003, Fecal indicator viruses: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.2. Accessed June 28, 2007 at <http://pubs.water.usgs.gov/twri9A7.2/>
- California Department of Health Services [California Department of Public Health as of July 1, 2007], 2007b, Public drinking systems, Monitoring, Chemicals and contaminants in drinking water. Accessed March 31, 2007 at <http://www.dhs.ca.gov/ps/ddwem/chemicals/default.htm>.
- California Department of Water Resources, 2003, California's groundwater: California Department of Water Resources Bulletin 118, 246 p. Accessed June 20, 2007, at <http://www.groundwater.water.ca.gov/bulletin118/>
- California Environmental Protection Agency, San Francisco Bay Regional Water Quality Control Board, 2003, A Comprehensive groundwater protection evaluation for South San Francisco Bay basins. Accessed June 20, 2007, at <http://www.swrcb.ca.gov/rwqcb2/pdfsobaygdwtr/SouthBayReport.pdf> Accessible as of August 8, 2008 at <http://www.waterboards.ca.gov/sanfranciscobay/sobayground.shtml>
- 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.
- 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., 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.
- Coplen, T.B., Hopple, J.A., Böhlke, J.K., Peiser, H.S., Rieder, S.E., Krouse, H.R., Rosman, K.J.R., Ding, T., Vocke, R.D., Jr., Revesz, 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.
- Craig, H., and Lal, D., 1961, The production rate of natural tritium: *Tellus*, v. 13, p. 85–105.
- Dawson, B.J., Bennett, G.L., V. and Belitz, Kenneth, 2008, Ground-water quality data in the southern Sacramento Valley, California, 2005—Results from the California GAMA Program: U.S. Geological Survey Data Series 285, 93 p.
- Donahue, D.J., Linick, T.W., and Jull, A.J.T., 1990, Ratio and background corrections for accelerator mass spectrometry radiocarbon measurements: *Radiocarbon*, v. 32, p. 135–142.
- 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, S., 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.
- Faure, G., 1986, Principles of isotope geology (2nd ed.): New York, John Wiley and Sons, 589 p.
- Firestone, R.B., Shirley, V.S., Baglin, C.M., Chu, S.Y.F., and Zipkin, J., 1996, Table of isotopes (8th ed.): New York, John Wiley & Sons, 3168 p. Also available at <http://ie.lbl.gov/toipdf/toi20.pdf>
- 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.
- 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.

- Furlong, E.T., Anderson, B.D., Werner, S.L., Soliven, P.P., Coffey, L.J., and Burkhardt, M.R., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by graphitized carbon-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01-4134, 73 p. Also available at <http://nwql.usgs.gov/Public/pubs/WRIR01-4134.html>
- Furlong, E.T., Werner, S.L., Anderson, B.D., and Cahill, J.D., 2008, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—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, chap. A9, 56 p. Also available at <http://pubs.usgs.gov/tm/tm5b5/>
- 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. Also available at <http://nwql.usgs.gov/Public/pubs/OFR99-093/OFR99-093.html>
- Garbarino, J.R., and Damrau, D.L., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of organic plus inorganic mercury in filtered and unfiltered natural water with cold vapor - atomic fluorescence spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01-4132, 16 p. Also available at <http://nwql.usgs.gov/Public/pubs/WRIR01-4132.html>
- 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, sec B, chap. 1, 88 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 ground water, 1992–2001: U.S. Geological Survey Circular 1291, 172 p.
- Gran, G., 1952, Determination of the equivalence point in potentiometric titration, Part II: Analyst, p. 77–661.
- Grob, R.L., ed., 1995, Modern practice of gas chromatography (3rd ed.): New York, John Wiley & Sons, 888 p.
- Hamlin, S.N., Belitz, K., Kraja, S., and Dawson, B.J., 2002, Ground-water quality in the Santa Ana watershed, California: Overview and data summary: U.S. Geological Survey Water-Resources Investigations Report 02-4243, 137 p.
- Hanson, R.T., Li, Zhen, and Faunt, C.C., 2004, Documentation of the Santa Clara Valley regional ground-water/surface-water flow model, Santa Clara County, California: U.S. Geological Survey Scientific Investigations Report 2004-5231, 75 p.
- Hautman, D.P., Munch, D.J., Eaton, A.D., and Haghani, A.W., 1999, Method 314.0 Determination of perchlorate in drinking water using ion chromatography, revision 1.0: U.S. Environmental Protection Agency. Accessed June 22, 2004, at http://www.epa.gov/safewater/methods/analyticalmethods_ogwdw.html
- Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.
- Jull, A.J.T., Burr, G.S., McHargue, L.R., Lange, T.E., Lifton, N.A., Beck, J.W., Donahue, D.J., and Lal, D., 2004, New frontiers in dating of geological, paleoclimatic, and anthropological applications using accelerator mass spectrometric measurements of ¹⁴C and ¹⁰Be in diverse samples: Global and Planetary Change, v. 41, p. 309–323.
- Kendall, C., 1998, Tracing nitrogen sources and cycling in catchments, in Kendall, C., and McDonnell, J.J., eds., Isotope tracers in catchment hydrology: Amsterdam, Elsevier Science, chap. 16, p. 519–576.
- 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, Ground-water 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., and Belitz, K., 2004, Ground-water ambient monitoring and assessment program: U.S. Geological Survey Fact Sheet 2004-3088, 2 p.
- Kulongoski, J.T., Belitz, K., and Dawson, B.J., 2006, Ground-water quality data in the North San Francisco Bay Hydrogeologic provinces, California, 2004: Results from the California Ground-Water Ambient Monitoring and Assessment (GAMA) Program: U.S. Geological Survey Data Series 167, 100 p.

- Kulongoski, J.T., and Belitz, K., 2007, Ground-water quality data in the Monterey Bay and Salinas Valley Basins, California, 2005—Results from the California GAMA Program: U.S. Geological Survey Data Series DS-258, 84 p.
- Landon, M.K., and Belitz, Kenneth, 2008, Ground-water quality data in the Central Eastside San Joaquin Basin 2006—Results from the California GAMA Program: U.S. Geological Survey Data Series 325, 88 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 June 28, 2007, 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 June 28, 2007, 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. Also available at <http://pubs.usgs.gov/of/2005/1263/pdf/OFR2005-1263.pdf>
- 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.
- Moran, J.E., Hudson, G.B., Eaton, G.F., and Leif, R., 2002a, A contamination vulnerability assessment for the Livermore-Amador and Niles Cone Groundwater Basins, Lawrence Livermore Laboratory internal report UCRL-AR-148831, 25 p.
- Moran, J.E., Hudson, G.B., Eaton, G.F., and Leif, R., 2002b, A contamination vulnerability assessment for the Santa Clara and San Mateo Groundwater Basins, Lawrence Livermore Laboratory internal report UCRL-TR-201929, 49 p.
- Myers, D.N., 2004, Fecal indicator bacteria (ver. 2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.1. Accessed June 28, 2007, at <http://pubs.water.usgs.gov/twri9A7.1/>
- 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 FS-026-98, 4 p. Available at <http://pubs.er.usgs.gov/usgspubs/fs/fs02698>
- 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 June 28, 2007, at <http://pubs.water.usgs.gov/twri9A6.3/>
- Rose, D.L., and Sandstrom, M.W., 2003, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of gasoline oxygenates, selected degradates, and BTEX in water by heated purge and trap/gas chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 03-4079, 31 p.
- Rounds, S.A., 2006, Alkalinity and acid neutralizing capacity (ver. 3): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.6. Accessed June 28, 2007 at <http://pubs.water.usgs.gov/twri9A6.6/>
- Sandstrom, M.W., Stoppel, 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.
- Schlocker, Julius, 1974, Geology of the San Francisco North Quadrangle, California: US Geological Survey Professional Paper 782.
- 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., Burow, K.R., Belitz, K., Dubrovsky, N.M., Land, M.T., and Gronberg, J.M., 2001, Low-level volatile organic compounds in active public supply wells as ground-water tracers in the Los Angeles physiographic basin, California, 2000: U.S. Geological Survey Water-Resources Investigations Report 01-4188. 29 p.
- Shouakar-Stash, O., Drimmie, R.J., and Frape, S.K., 2005a, Determination of inorganic chlorine stable isotopes by continuous isotope ratio mass spectrometry: Rapid Communication in Mass Spectrometry, v. 19, p. 121–127.
- Shouakar-Stash, O., Frape, S.K., and Drimmie, R.J., 2005b, Determination of bromine stable isotopes using continuous-flow isotope ratio mass spectrometry: Analytical Chemistry, v. 77, no. 13, p. 4027–4033.
- Singleton, M.J., Woods, K.N., Conrad, M.E., Depaolo, D.J., and Dresel, P.E., 2005, Tracking sources of unsaturated zone and groundwater nitrate contamination using nitrogen and oxygen stable isotopes at the Hanford Site, Washington: Environmental Science and Technology, v. 39, p. 3563–3570.
- Singleton, M.J., Esser, B.K., Moran, J.E., Hudson, G.B., McNab, W.W., and Harter, T., 2007, Saturated zone denitrification: Potential for natural attenuation of nitrate contamination in shallow groundwater under dairy operations: Environmental Science and Technology, v. 41, p. 759–765.
- State Water Resources Control Board, 2003, A comprehensive groundwater quality monitoring program for California: Assembly Bill 599. Report to the Governor and Legislature, March 2003, 100 p. Available at http://www.waterboards.ca.gov/gama/docs/final_ab_599_rpt_to_legis_7_31_03.pdf
- Stookey, L.L., 1970, FerroZine - a new spectrophotometric reagent for iron: Analytical Chemistry, v. 42, p. 779–781.
- Stumm, W., and Morgan, J.J., 1996, Aquatic chemistry: Chemical equilibria and rates in natural waters (3d ed.): New York, John Wiley & Sons, 1022 p.
- 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 and Technology, v. 33, p. 807–813.
- U.S. Environmental Protection Agency, 1980, Prescribed procedures for measurement of radioactivity in drinking water: U.S. Environmental Protection Agency EPA-600-4-80-032.
- U.S. Environmental Protection Agency, 1995, Method 524.2, Measurement of purgeable organic compounds in water by capillary column gas chromatography/mass spectrometry: U.S. Environmental Protection Agency EPA/600/R-95-131.
- U.S. Environmental Protection Agency, 1996, Method 8270C—Semivolatile organic compounds by gas chromatography/mass spectrometry, revision 3: U.S. Environmental Protection Agency, 54 p.
- U.S. Environmental Protection Agency, 1999a, National Primary Drinking Water Regulations, Radon-222: Federal Register, v. 64, no. 211, p. 59245–59294.
- U.S. Environmental Protection Agency, 1999b, Method 1625 revision B—Semivolatile organic compounds by isotope dilution GC/MS, 40 CFR Part 136, Appendix A.
- U.S. Environmental Protection Agency, 2001, Method 1601—Male-specific (F+) and somatic coliphage in water by two-step enrichment procedure—April 2000 Draft: U.S. Environmental Protection Agency EPA 821-R-00-009.
- U.S. Environmental Protection Agency, 2002a, Guidelines for establishing procedures for the analysis of pollutants: U.S. Code of Federal Regulations, Title 40, 136 p.
- U.S. Environmental Protection Agency, 2002b, Method 1604—Total coliforms and Escherichia coli in water by membrane filtration using a simultaneous detection technique (MI medium): U.S. Environmental Protection Agency EPA 821-R-02-024.
- U.S. Environmental Protection Agency, 2004, National primary drinking water regulations - analytical method for uranium: U.S. Code of Federal Regulations, Title 40, part 141, p. 31008–31013.
- U.S. Environmental Protection Agency, 2006, 2006 Edition of the drinking water standards and health advisories: U.S. Environmental Protection Agency, Office of Water EPA 822-R-06-013. Accessed June 21, 2007, at <http://www.epa.gov/waterscience/criteria/drinking/dwstandards.pdf>.
- 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. Available at <http://water.usgs.gov/owq/FieldManual/>
- Weiss, R.F., 1968, Piggyback sampler for dissolved gas studies on sealed water samples: Deep Sea Research, v. 15, p. 721–735.

- 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 June 28, 2007, 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 June 28, 2007, 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 June 28, 2007 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 June 28, 2007, at <http://pubs.water.usgs.gov/twri9A6.0/>
- Wilde, F.D., Radtke, D.B., Gibbs, J., and Iwatsubo, R.T., 2006, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4. Accessed June 28, 2007, at <http://pubs.water.usgs.gov/twri9A4/>
- Wilde, F.D., Radtke, D.B., Gibbs, Jacob, and Iwatsubo, R.T., eds., 2004, Processing of water samples (ver. 2.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5. Accessed June 28, 2007, at <http://pubs.water.usgs.gov/twri9A5/>
- Wright, M.T., Belitz, K., and Burton, C.A., 2005, California GAMA program: Ground-water quality in the San Diego drainages hydrologic province, California, 2004: U.S. Geological Survey Data Series 129, 91 p. Also available at <http://pubs.usgs.gov/ds/2005/129/>
- 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. Also available at <http://nwql.usgs.gov/OFR-95-181.shtml>
- 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. Also available at <http://pubs.usgs.gov/wri/wri014186/>
- 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.

Tables

Table 1. Identification, sampling and construction information for wells sampled for the San Francisco Bay Ground-Water Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[GAMA Identification number: SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Other Abbreviations: ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

| GAMA identification number | Sampling information | | Elevation of LSD (ft above NAVD 88) ² | Construction information | | |
|----------------------------------|-------------------------|-----------------------------------|--|------------------------------|--------------------------------------|---|
| | Date (mm/dd/yyyy) | Sampling schedule ¹ | | Well depth (ft below LSD) | Top perforation (ft below LSD) | Bottom perforation (ft below LSD) |
| Grid wells | | | | | | |
| SF-01 | 06/20/2007 | Fast | 25 | na | na | na |
| SF-02 | 06/20/2007 | Fast | 158 | 360 | 170 | 350 |
| SF-03 | 05/24/2007 | Fast | 131 | 410 | 170 | 375 |
| SF-04 | 05/24/2007 | Fast | 221 | na | na | na |
| SF-05 | 05/23/2007 | Fast | 53 | 480 | na | na |
| SF-06 | 05/23/2007 | Fast | 28 | 180 | na | na |
| SF-07 | 05/21/2007 | Fast | 68 | 220 | na | na |
| SF-08 | 05/21/2007 | Fast | 50 | 275 | 240 | 275 |
| SF-09 | 05/03/2007 | Fast | 145 | 1,120 | 289 | 1,120 |
| SF-10 | 05/03/2007 | Fast | 73 | 680 | 290 | 660 |
| SF-11 | 05/22/2007 | Fast | 203 | 596 | 348 | 526 |
| SF-12 | 05/22/2007 | Fast | 253 | na | na | na |
| SF-13 | 04/23/2007 ³ | Fast | 177 | 760 | 340 | 750 |
| SF-14 | 04/25/2007 | Fast | 63 | 528 | 165 | 363 |
| SF-15 | 04/26/2007 | Fast | 70 | 810 | 540 | 790 |
| SF-16 | 04/30/2007 | Fast | 44 | 665 | 295 | 665 |
| SF-17 | 06/05/2007 | Fast | 29 | na | na | na |
| SF-18 | 05/02/2007 | Fast | 120 | 816 | 300 | 816 |
| SF-19 | 06/18/2007 | Fast | 372 | 540 | 200 | 520 |
| SF-20 | 05/02/2007 | Fast | 203 | 840 | 358 | 798 |
| SF-21 | 05/02/2007 | Fast | 160 | 815 | 350 | 795 |
| SF-22 | 05/03/2007 | Fast | 175 | 827 | 378 | 818 |
| SF-23 | 04/25/2007 | Fast | 73 | 890 | 300 | 870 |
| SF-24 | 04/24/2007 | Slow | 101 | 780 | 165 | 774 |
| SF-25 | 05/01/2007 | Fast | 98 | 612 | 267 | 603 |
| SF-26 | 05/01/2007 | Fast | 172 | 427 | 107 | 376 |
| SF-27 | 05/01/2007 | Fast | 160 | 437 | 186 | 400 |
| SF-28 | 04/23/2007 | Slow | 123 | 517 | 386 | 454 |
| SF-29 | 04/23/2007 | Fast | 178 | 275 | 102 | 266 |
| SF-30 | 06/06/2007 | Fast | 955 | 80 | 41 | 80 |
| SF-31 | 04/23/2007 | Fast | 232 | 286 | na | na |
| SF-32 | 04/24/2007 | Fast | 248 | na | na | na |
| SF-33 | 04/30/2007 | Fast | 381 | 366 | 161 | 346 |
| SF-34 | 06/05/2007 | Fast | 53 | 153 | 60 | 153 |
| SF-35 | 06/12/2007 | Slow | 33 | 248 | 216 | 240 |

Table 1. Identification, sampling and construction information for wells sampled for the San Francisco Bay Ground-Water Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[**GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. **Other Abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

| GAMA identification number | Sampling information | | Elevation of LSD (ft above NAVD 88)² | Construction information | | |
|---|------------------------------|--|--|--------------------------------------|---|--|
| | Date (mm/dd/yyyy) | Sampling schedule¹ | | Well depth (ft below LSD) | Top perforation (ft below LSD) | Bottom perforation (ft below LSD) |
| SF-36 | 06/04/2007 | Fast | 65 | 190 | 100 | 180 |
| SF-37 | 06/05/2007 | Fast | 76 | 200 | 80 | 177 |
| SF-38 | 06/21/2007 | Fast | 12 | 535 | na | na |
| SF-39 | 06/19/2007 | Fast | 43 | 600 | 480 | 580 |
| SF-40 | 06/21/2007 | Fast | 70 | 550 | 245 | 530 |
| | | | | | | |
| SF-41 | 06/21/2007 | Fast | 40 | 155 | 35 | 155 |
| SF-42 | 06/19/2007 | Fast | 13 | 495 | 324 | 479 |
| SF-43 | 06/20/2007 | Fast | 13 | 353 | 269 | 345 |
| | | | | | | |
| Understanding wells | | | | | | |
| SFU-01 | 06/13/2007 | Slow | 28 | 630 | na | na |
| SFU-02 | 04/30/2007 | Fast | 85 | 570 | 309 | 557 |
| SFU-03 | 04/26/2007 | Fast | 98 | 594 | 310 | 563 |
| SFU-04 | 04/26/2007 | Fast | 118 | 800 | 445 | 780 |
| SFU-05 | 04/25/2007 | Fast | 144 | 604 | 302 | 507 |
| SFU-06 | 04/26/2007 | Slow | 68 | 800 | 315 | 745 |
| | | | | | | |
| SFU-07 | 06/14/2007 | Slow | 123 | 560 | 295 | 467 |
| SFU-08 | 04/25/2007 | Slow | 120 | 749 | 314 | 737 |
| SFU-09 | 06/04/2007 | Fast | 68 | 320 | 220 | 300 |
| SFU-10 | 06/04/2007 | Fast | 56 | 465 | 189 | 455 |
| SFU-11 | 06/07/2007 | Fast | 967 | na | na | na |
| SFU-12 | 06/18/2007 | Fast | 1,073 | na | na | na |
| | | | | | | |
| SFM-A1 | 05/21/2007 | Slow | 65 | 575 | 555 | 565 |
| SFM-A2 | 05/22/2007 | Slow | 65 | 440 | 410 | 430 |
| SFM-A3 | 05/22/2007 | Slow | 65 | 270 | 240 | 260 |
| SFM-A4 | 05/23/2007 | Slow | 65 | 155 | 140 | 150 |
| | | | | | | |
| SFM-B1 | 05/24/2007 | Slow | 15 | 146 | 126 | 136 |
| SFM-B2 | 05/24/2007 | Slow | 15 | 74 | 54 | 64 |
| | | | | | | |
| SFM-C1 | 05/08/2007 | Slow | 96 | 1,000 | 820 | 840 |
| SFM-C2 | 05/09/2007 | Slow | 96 | 640 | 620 | 640 |
| SFM-C3 | 05/09/2007 | Slow | 96 | 540 | 520 | 540 |
| SFM-C4 | 05/10/2007 | Slow | 96 | 425 | 405 | 425 |
| SFM-C5 | 05/07/2007 | Slow | 96 | 72 | 62 | 72 |
| | | | | | | |
| SFM-D1 | 05/15/2007 | Slow | 38 | 480 | 450 | 480 |
| SFM-D2 | 05/15/2007 | Slow | 38 | 340 | 330 | 340 |
| SFM-D3 | 05/14/2007 | Slow | 38 | 260 | 230 | 260 |
| SFM-D4 | 05/14/2007 | Slow | 38 | 80 | 50 | 80 |

Table 1. Identification, sampling and construction information for wells sampled for the San Francisco Bay Ground-Water Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[GAMA Identification number: SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Other Abbreviations: ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

| GAMA identification number | Sampling information | | Elevation of LSD (ft above NAVD 88) ² | Construction information | | |
|----------------------------------|----------------------|-----------------------------------|--|------------------------------|--------------------------------------|---|
| | Date (mm/dd/yyyy) | Sampling schedule ¹ | | Well depth (ft below LSD) | Top perforation (ft below LSD) | Bottom perforation (ft below LSD) |
| SFM-E1 | 05/17/2007 | Slow | 10 | 470 | 430 | 470 |
| SFM-E2 | 05/17/2007 | Slow | 10 | 200 | 180 | 200 |
| SFM-E3 | 05/16/2007 | Slow | 10 | 100 | 50 | 100 |
| SFM-F1 | 06/21/2007 | Slow | 7 | 1,010 | 990 | 1,010 |
| SFM-F2 | 06/19/2007 | Slow | 7 | 860 | 830 | 860 |
| SFM-F3 | 06/18/2007 | Slow | 7 | 640 | 530 | 640 |
| SFM-F4 | 06/18/2007 | Slow | 7 | 318 | 298 | 318 |
| SFM-F5 | 06/20/2007 | Slow | 7 | 138 | 128 | 138 |
| SFM-F6 | 6/20/2007 | Slow | 7 | 45 | 35 | 45 |

¹Sampling schedules: fast, used for a standard set of constituents; slow, used for these plus another set of constituents, causing sampling to require more time. Sampling schedules are described in *table 2*.

²Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The elevation of the LSD is described in feet above the North American Vertical Datum 1988.

³Also sampled for uranium and strontium isotopes on 5/22/2007.

Table 2. Classes of chemical and microbial constituents and water-quality indicators collected for the slow and fast well sampling schedules in the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.[NWQL, U.S. Geological Survey National Water-Quality Laboratory; NDMA, *N*-nitrosodimethylamine; sampling schedules are defined in *table 1*]

| Analyte classes | Slow schedule | Fast schedule | Analyte list table | Results table |
|---|----------------|---------------|--------------------|-----------------|
| Water-quality indicators | | | | |
| Dissolved oxygen, pH, specific conductance, temperature | X | X | | 4 |
| Alkalinity and turbidity | X | | | 4 |
| Alkalinity (NWQL) | | X | | 4 |
| Organic constituents | | | | |
| Volatile organic compounds | X | X | 3A | 5 |
| Pesticides and pesticide degradation products | X | X | 3B, 3C | 6 |
| Pharmaceutical compounds | X | | 3D | na ¹ |
| Potential wastewater-indicator compounds | X | | 3E | 7 |
| Constituents of special interest | | | | |
| Perchlorate | X | X | 3F | 8 |
| <i>N</i> -nitrosodimethylamine (NDMA) | X | | 3F | 8 |
| Inorganic constituents | | | | |
| Nutrients | X | X | 3G | 9 |
| Major and minor ions and trace elements | X | | 3H | 10, 11 |
| Chromium abundance and speciation | X | X | 3I | 12 |
| Arsenic and iron abundances and speciation | X | X | 3I | 12 |
| Radioactivity and gases | | | | |
| Radon-222 | X | | 3J | 15 |
| Tritium | X | X | 3J | 13 |
| Tritium and noble gases | X | X | 3K | 14 |
| Stable isotopes | | | | |
| Stable isotopes of carbon and carbon-14 abundance | X | X | 3J | 13 |
| Stable isotopes of hydrogen and oxygen in water | X | X | 3J | 13 |
| Stable isotopes of nitrogen and oxygen in nitrate | X | X | 3J | 13 |
| Stable isotopes of boron | X | | 3J | 13 |
| Chloride and bromide isotopes | X ² | | 3J | ns ³ |
| Uranium and strontium isotopes | X | X | 3J | ns ³ |
| Microbial constituents | | | | |
| Male-specific (F+) and somatic coliphage | X | | 3L | 16 |

¹ No detections of pharmaceutical compounds in SFBay study unit wells.² Only at selected wells.³ Results for these constituents are not available as of the publishing date of this report.

Table 3A. Volatile organic compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2020.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected; na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

| Constituent | Primary use or source | USGS parameter code | CAS number ¹ | LRL ($\mu\text{g/L}$) | Threshold type ² | Threshold value ($\mu\text{g/L}$) | Detection |
|---|-------------------------------|---------------------|-------------------------|-------------------------|-----------------------------|-------------------------------------|-----------|
| Acetone | Solvent | 81552 | 67-64-1 | 6 | na | na | D |
| Acrylonitrile | Organic synthesis | 34215 | 107-13-1 | 0.4 | RSD5-US | 0.6 | — |
| Benzene | Gasoline hydrocarbon | 34030 | 71-43-2 | 0.016 | MCL-CA | 1 | D |
| Bromobenzene | Solvent | 81555 | 108-86-1 | 0.02 | na | na | — |
| Bromochloromethane | Fire retardant | 77297 | 74-97-5 | 0.06 | HAL-US | 90 | — |
| Bromodichloromethane | Disinfection by-product (THM) | 32101 | 75-27-4 | 0.04 | MCL-US | ³ 80 | D |
| Bromoform (Tribromomethane) | Disinfection by-product (THM) | 32104 | 75-25-2 | 0.08 | MCL-US | ³ 80 | — |
| <i>n</i> -Butylbenzene | Gasoline hydrocarbon | 77342 | 104-51-8 | 0.14 | NL-CA | 260 | — |
| <i>sec</i> -Butylbenzene | Gasoline hydrocarbon | 77350 | 135-98-8 | 0.04 | NL-CA | 260 | — |
| <i>tert</i> -Butylbenzene | Gasoline hydrocarbon | 77353 | 98-06-6 | 0.08 | NL-CA | 260 | — |
| Carbon disulfide | Organic synthesis | 77041 | 75-15-0 | 0.06 | NL-CA | 160 | D |
| Carbon tetrachloride (Tetrachloromethane) | Solvent | 32102 | 56-23-5 | 0.08 | MCL-CA | 0.5 | D |
| Chlorobenzene | Solvent | 34301 | 108-90-7 | 0.02 | MCL-CA | 70 | — |
| Chloroethane | Solvent | 34311 | 75-00-3 | 0.1 | na | na | D |
| Chloroform (Trichloromethane) | Disinfection by-product (THM) | 32106 | 67-66-3 | 0.04 | MCL-US | ³ 80 | D |
| Chloromethane | Refrigerant/organic synthesis | 34418 | 74-87-3 | 0.1 | HAL-US | 30 | D |
| 3-Chloro-1-propene | Organic synthesis | 78109 | 107-05-1 | 0.08 | na | na | — |
| 2-Chlorotoluene | Solvent | 77275 | 95-49-8 | 0.04 | NL-CA | 140 | — |
| 4-Chlorotoluene | Solvent | 77277 | 106-43-4 | 0.04 | NL-CA | 140 | — |
| Dibromochloromethane | Disinfection by-product (THM) | 32105 | 124-48-1 | 0.12 | MCL-US | ³ 80 | — |
| 1,2-Dibromo-3-chloropropane (DBCP) | Fumigant | 82625 | 96-12-8 | 0.5 | MCL-US | 0.2 | — |
| 1,2-Dibromoethane (EDB) | Fumigant | 77651 | 106-93-4 | 0.04 | MCL-US | 0.05 | — |
| Dibromomethane | Solvent | 30217 | 74-95-3 | 0.04 | na | na | — |
| 1,2-Dichlorobenzene | Solvent | 34536 | 95-50-1 | 0.04 | MCL-CA | 600 | — |
| 1,3-Dichlorobenzene | Solvent | 34566 | 541-73-1 | 0.04 | HAL-US | 600 | — |
| 1,4-Dichlorobenzene | Fumigant | 34571 | 106-46-7 | 0.04 | MCL-CA | 5 | — |
| <i>trans</i> -1,4-Dichloro-2-butene | Organic synthesis | 73547 | 110-57-6 | 0.6 | na | na | — |
| Dichlorodifluoromethane (CFC-12) | Refrigerant | 34668 | 75-71-8 | 0.14 | NL-CA | 1,000 | D |
| 1,1-Dichloroethane | Solvent | 34496 | 75-34-3 | 0.06 | MCL-CA | 5 | D |
| 1,2-Dichloroethane | Solvent | 32103 | 107-06-2 | 0.1 | MCL-CA | 0.5 | — |
| 1,1-Dichloroethene | Organic synthesis | 34501 | 75-35-4 | 0.02 | MCL-CA | 6 | D |
| <i>cis</i> -1,2-Dichloroethene | Solvent | 77093 | 156-59-2 | 0.02 | MCL-CA | 6 | D |
| <i>trans</i> -1,2-Dichloroethene | Solvent | 34546 | 156-60-5 | 0.018 | MCL-CA | 10 | — |
| Dichloromethane (Methylene chloride) | Solvent | 34423 | 75-09-2 | 0.04 | MCL-US | 5 | D |
| 1,2-Dichloropropane | Fumigant | 34541 | 78-87-5 | 0.02 | MCL-US | 5 | — |
| 1,3-Dichloropropane | Fumigant | 77173 | 142-28-9 | 0.06 | na | na | — |

Table 3A. Volatile organic compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2020.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected; na, not available; µg/L, micrograms per liter; —, not detected]

| Constituent | Primary use or source | USGS parameter code | CAS number ¹ | LRL (µg/L) | Threshold type ² | Threshold value (µg/L) | Detection |
|--|-----------------------|---------------------|-------------------------|------------|-----------------------------|------------------------|----------------|
| 2,2-Dichloropropane | Fumigant | 77170 | 594-20-7 | 0.06 | na | na | — |
| 1,1-Dichloropropene | Organic synthesis | 77168 | 563-58-6 | 0.04 | na | na | — |
| <i>cis</i> -1,3-Dichloropropene | Fumigant | 34704 | 10061-01-5 | 0.06 | RSD5-US | ⁴ 4 | — |
| <i>trans</i> -1,3-Dichloropropene | Fumigant | 34699 | 10061-02-6 | 0.1 | 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 | 0.02 | MCL-CA | 300 | — |
| Ethyl <i>tert</i> -butyl ether (ETBE) | Gasoline oxygenate | 50004 | 637-92-3 | 0.04 | na | na | — |
| Ethyl methacrylate | Organic synthesis | 73570 | 97-63-2 | 0.14 | na | na | — |
| 1-Ethyl-2-methylbenzene (<i>o</i> -Ethyl toluene) | Gasoline hydrocarbon | 77220 | 611-14-3 | 0.04 | na | na | — |
| Hexachlorobutadiene | Organic synthesis | 39702 | 87-68-3 | 0.1 | RSD5-US | 9 | — |
| Hexachloroethane | Solvent | 34396 | 67-72-1 | 0.14 | HAL-US | 1 | — |
| 2-Hexanone (<i>n</i> -Butyl methyl ketone) | Solvent | 77103 | 591-78-6 | 0.4 | na | na | — |
| Isopropylbenzene (Cumene) | Gasoline hydrocarbon | 77223 | 98-82-8 | 0.04 | NL-CA | 770 | — |
| 4-Isopropyl-1-methylbenzene | Gasoline hydrocarbon | 77356 | 99-87-6 | 0.08 | na | na | — |
| Methyl acrylate | Organic synthesis | 49991 | 96-33-3 | 0.4 | na | na | — |
| Methyl acrylonitrile | Organic synthesis | 81593 | 126-98-7 | 0.4 | na | na | — |
| Methyl bromide (Bromomethane) | Fumigant | 34413 | 74-83-9 | 0.4 | HAL-US | 10 | — |
| Methyl <i>tert</i> -butyl ether (MTBE) | Gasoline oxygenate | 78032 | 1634-04-4 | 0.1 | MCL-CA | 13 | D |
| Methyl ethyl ketone (2-Butanone, MEK) | Solvent | 81595 | 78-93-3 | 1.6 | HAL-US | 4,000 | D |
| Methyl iodide (Iodomethane) | Organic synthesis | 77424 | 74-88-4 | 0.4 | na | na | — |
| Methyl isobutyl ketone (MIBK) | Solvent | 78133 | 108-10-1 | 0.2 | NL-CA | 120 | — |
| Methyl methacrylate | Organic synthesis | 81597 | 80-62-6 | 0.2 | na | na | — |
| Methyl <i>tert</i> -pentyl ether (<i>tert</i> -Amyl methyl ether, TAME) | Gasoline oxygenate | 50005 | 994-05-8 | 0.04 | na | na | — |
| Naphthalene | Gasoline hydrocarbon | 34696 | 91-20-3 | 0.4 | NL-CA | 17 | — |
| <i>n</i> -Propylbenzene | Solvent | 77224 | 103-65-1 | 0.04 | NL-CA | 260 | — |
| Styrene | Gasoline hydrocarbon | 77128 | 100-42-5 | 0.04 | 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 | 0.1 | MCL-CA | 1 | — |
| Tetrachloroethene (PCE) | Solvent | 34475 | 127-18-4 | 0.04 | MCL-US | 5 | D |
| Tetrahydrofuran | Solvent | 81607 | 109-99-9 | 1 | na | na | D |
| 1,2,3,4-Tetramethylbenzene | Gasoline hydrocarbon | 49999 | 488-23-3 | 0.14 | na | na | D |
| 1,2,3,5-Tetramethylbenzene | Gasoline hydrocarbon | 50000 | 527-53-7 | 0.12 | na | na | — |
| Toluene | Gasoline hydrocarbon | 34010 | 108-88-3 | 0.018 | MCL-CA | 150 | ⁵ D |
| 1,2,3-Trichlorobenzene | Organic synthesis | 77613 | 87-61-6 | 0.12 | na | na | — |
| 1,2,4-Trichlorobenzene | Solvent | 34551 | 120-82-1 | 0.12 | MCL-CA | 5 | — |
| 1,1,1-Trichloroethane | Solvent | 34506 | 71-55-6 | 0.04 | MCL-CA | 200 | D |

Table 3A. Volatile organic compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2020.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected; na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

| Constituent | Primary use or source | USGS parameter code | CAS number ¹ | LRL ($\mu\text{g/L}$) | Threshold type ² | Threshold value ($\mu\text{g/L}$) | Detection |
|---|---------------------------|---------------------|-------------------------|-------------------------|-----------------------------|-------------------------------------|-----------|
| 1,1,2-Trichloroethane | Solvent | 34511 | 79-00-5 | 0.04 | MCL-CA | 5 | — |
| Trichloroethene (TCE) | Solvent | 39180 | 79-01-6 | 0.02 | 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 | NL-CA | 0.005 | — |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113) | Refrigerant | 77652 | 76-13-1 | 0.04 | MCL-CA | 1,200 | D |
| 1,2,3-Trimethylbenzene | Gasoline hydrocarbon | 77221 | 526-73-8 | 0.08 | na | na | — |
| 1,2,4-Trimethylbenzene | Gasoline hydrocarbon | 77222 | 95-63-6 | 0.04 | NL-CA | 330 | — |
| 1,3,5-Trimethylbenzene | Organic synthesis | 77226 | 108-67-8 | 0.04 | 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 | 0.08 | MCL-CA | 0.5 | — |
| <i>m</i> - and <i>p</i> -Xylene | Gasoline hydrocarbon | 85795 | 108-38-3/ 106-42-3 | 0.08 | MCL-CA | ⁶ 1,750 | — |
| <i>o</i> -Xylene | Gasoline hydrocarbon | 77135 | 95-47-6 | 0.04 | MCL-CA | ⁶ 1,750 | — |

¹This report contains CAS Registry Numbers®, which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM.

²Maximum contaminant level thresholds are listed as MCL-US when 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.

³The MCL-US thresholds for trihalomethanes are the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

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

⁵All detections of toluene were V-coded due to detections in field blanks, and are therefore not included in groundwater quality assessment.

⁶The MCL-CA thresholds for *m*- and *p*-Xylene and *o*-Xylene is the sum all three xylene compounds.

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2003.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; µg/L, micrograms per liter; —, not detected]

| Constituent | Primary use or source | USGS parameter code | CAS number | LRL (µg/L) | Threshold type ¹ | Threshold value (µg/L) | Detection |
|---|-----------------------|---------------------|-------------|------------|-----------------------------|------------------------|----------------|
| Acetochlor | Herbicide | 49260 | 34256-82-1 | 0.006 | na | na | — |
| Alachlor | Herbicide | 46342 | 15972-60-8 | 0.005 | MCL-US | 2 | — |
| Atrazine | Herbicide | 39632 | 1912-24-9 | 0.007 | MCL-CA | 1 | D |
| Azinphos-methyl | Insecticide | 82686 | 86-50-0 | 0.080 | na | na | — |
| Azinphos-methyl-oxon | Insecticide degradate | 61635 | 961-22-8 | 0.042 | na | na | — ² |
| Benfluralin | Herbicide | 82673 | 1861-40-1 | 0.010 | na | na | — |
| Carbaryl | Insecticide | 82680 | 63-25-2 | 0.060 | RSD5-US | 400 | — |
| 2-Chloro-2,6-diethylacet-anilide | Herbicide degradate | 61618 | 6967-29-9 | 0.0065 | na | na | — |
| 4-Chloro-2-methylphenol | Herbicide degradate | 61633 | 1570-64-5 | 0.005 | na | na | — |
| Chlorpyrifos | Insecticide | 38933 | 2921-88-2 | 0.005 | HAL-US | 2 | — |
| Chlorpyrifos, oxygen analog | Insecticide degradate | 61636 | 5598-15-2 | 0.0562 | na | na | — ² |
| Cyfluthrin | Insecticide | 61585 | 68359-37-5 | 0.053 | na | na | — ² |
| Cypermethrin | Insecticide | 61586 | 52315-07-8 | 0.046 | na | na | — ² |
| Dacthal (DCPA) | Herbicide | 82682 | 1861-32-1 | 0.003 | HAL-US | 70 | — |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine) | Herbicide degradate | 04040 | 6190-65-4 | 0.014 | na | na | D ² |
| 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 | — |
| 3,4-Dichloroaniline | Herbicide degradate | 61625 | 95-76-1 | 0.0045 | na | na | — |
| Dichlorvos | Insecticide | 38775 | 62-73-7 | 0.013 | na | na | — ² |
| Dicrotophos | Insecticide | 38454 | 141-66-2 | 0.0843 | na | na | — ² |
| 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 | 0.0061 | na | na | — ² |
| Ethion | Insecticide | 82346 | 563-12-2 | 0.016 | na | na | — |
| Ethion monoxon | Insecticide degradate | 61644 | 17356-42-2 | 0.021 | na | na | — |
| 2-Ethyl-6-methylaniline | Herbicide degradate | 61620 | 24549-06-2 | 0.010 | na | na | — |
| Fenamiphos | Insecticide | 61591 | 22224-92-6 | 0.029 | HAL-US | 0.7 | — |
| Fenamiphos sulfone | Insecticide degradate | 61645 | 31972-44-8 | 0.053 | na | na | — |
| Fenamiphos sulfoxide | Insecticide degradate | 61646 | 31972-43-7 | 0.040 | na | na | — ² |
| Fipronil | Insecticide | 62166 | 120068-37-3 | 0.016 | 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 | — |
| Fonofos | Insecticide | 04095 | 944-22-9 | 0.006 | HAL-US | 10 | — |
| Hexazinone | Herbicide | 04025 | 51235-04-2 | 0.026 | HAL-US | 400 | — ² |
| Iprodione | Fungicide | 61593 | 36734-19-7 | 0.026 | na | na | — |
| Isofenphos | Insecticide | 61594 | 25311-71-1 | 0.011 | na | na | — |

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2003.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

| Constituent | Primary use or source | USGS parameter code | CAS number | LRL ($\mu\text{g/L}$) | Threshold type ¹ | Threshold value ($\mu\text{g/L}$) | Detection |
|-------------------------|-----------------------|---------------------|------------|-------------------------|-----------------------------|-------------------------------------|----------------|
| Malaoxon | Insecticide degradate | 61652 | 1634-78-2 | 0.039 | na | na | — |
| Malathion | Insecticide | 39532 | 121-75-5 | 0.016 | HAL-US | 100 | — |
| Metalaxyl | Fungicide | 61596 | 57837-19-1 | 0.0069 | na | na | — |
| Methidathion | Insecticide | 61598 | 950-37-8 | 0.0087 | na | na | — |
| Metolachlor | Herbicide | 39415 | 51218-45-2 | 0.010 | HAL-US | 700 | D |
| Metribuzin | Herbicide | 82630 | 21087-64-9 | 0.012 | HAL-US | 70 | — |
| Myclobutanil | Fungicide | 61599 | 88671-89-0 | 0.033 | na | na | — |
| 1-Naphthol | Insecticide degradate | 49295 | 90-15-3 | 0.0882 | na | na | — ² |
| Paraoxon-methyl | Insecticide degradate | 61664 | 950-35-6 | 0.019 | na | na | — ² |
| Parathion-methyl | Insecticide | 82667 | 298-00-0 | 0.008 | HAL-US | 1 | — |
| Pendimethalin | Herbicide | 82683 | 40487-42-1 | 0.020 | na | na | — |
| <i>cis</i> -Permethrin | Insecticide | 82687 | 54774-45-7 | 0.010 | na | na | — ² |
| Phorate | Insecticide | 82664 | 298-02-2 | 0.020 | na | na | — |
| Phorate oxon | Insecticide degradate | 61666 | 2600-69-3 | 0.027 | na | na | — |
| Phosmet | Insecticide | 61601 | 732-11-6 | 0.0079 | na | na | — ² |
| Phosmet oxon | Insecticide degradate | 61668 | 3735-33-9 | 0.0511 | na | na | — ² |
| Prometon | Herbicide | 04037 | 1610-18-0 | 0.010 | HAL-US | 100 | D |
| Prometryn | Herbicide | 04036 | 7287-19-6 | 0.0059 | na | na | — |
| Pronamide (Propyzamide) | Herbicide | 82676 | 23950-58-5 | 0.004 | RSD5-US | 20 | — |
| Simazine | Herbicide | 04035 | 122-34-9 | 0.006 | MCL-US | 4 | D |
| Tebuthiuron | Herbicide | 82670 | 34014-18-1 | 0.016 | HAL-US | 500 | — |
| Terbufos | Insecticide | 82675 | 13071-79-9 | 0.012 | HAL-US | 0.4 | — |
| Terbufos oxon sulfone | Insecticide degradate | 61674 | 56070-15-6 | 0.045 | na | na | — |
| Terbuthylazine | Herbicide | 04022 | 5915-41-3 | 0.0083 | na | na | — |
| Tribufos | Herbicide | 61610 | 78-48-8 | 0.035 | na | na | — |
| Trifluralin | Herbicide | 82661 | 1582-09-8 | 0.009 | HAL-US | 10 | — |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The 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.

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2060.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property; Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL, Lifetime Health Advisory; MCL-CA, California Department of Health Services Maximum Contaminant Level; MCL-US, U.S. Environmental Protection Agency Maximum Contaminant Level; RSD5, risk specific dose at 10^{-5} µg/L. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; na, not available; D, detected; —, not detected; µg/L, micrograms per liter]

| Constituent | Primary use or source | USGS parameter code | CAS number | LRL (µg/L) | Threshold type ¹ | Threshold value (µg/L) | Detection |
|---|---------------------------|---------------------|-------------|------------|-----------------------------|------------------------|----------------|
| Acifluorfen | Herbicide | 49315 | 50594-66-6 | 0.060 | na | na | — ² |
| Aldicarb ³ | Insecticide | 49312 | 116-06-3 | 0.04 | MCL-US | 3 | — ² |
| Aldicarb sulfone | Insecticide/ degradate | 49313 | 1646-88-4 | 0.080 | MCL-US | 3 | — |
| Aldicarb sulfoxide | Degradate | 49314 | 1646-87-3 | 0.040 | MCL-US | 4 | — |
| Atrazine | Herbicide | 39632 | 1912-24-9 | 0.007 | MCL-CA | 1 | D |
| Bendiocarb | Insecticide | 50299 | 22781-23-3 | 0.040 | na | na | — |
| Benomyl | Fungicide | 50300 | 17804-35-2 | 0.020 | na | na | D ² |
| Bensulfuron-methyl | Herbicide | 61693 | 83055-99-6 | 0.018 | na | na | — |
| Bentazon | Herbicide | 38711 | 25057-89-0 | 0.020 | MCL-CA | 18 | D |
| Bromacil | Herbicide | 04029 | 314-40-9 | 0.040 | HAL-US | 70 | — |
| Bromoxynil | Herbicide | 49311 | 1689-84-5 | 0.120 | na | na | D ² |
| Caffeine | Beverages | 50305 | 58-08-2 | 0.040 | na | na | D |
| Carbaryl | Herbicide | 49310 | 63-25-2 | 0.020 | RSD5-US | 400 | — |
| Carbofuran | Herbicide | 49309 | 1563-66-2 | 0.060 | MCL-CA | 18 | — |
| Chloramben, methyl ester | Herbicide | 61188 | 7286-84-2 | 0.100 | na | na | — |
| Chlorimuron-ethyl | Herbicide | 50306 | 90982-32-4 | 0.080 | na | na | — |
| 3-(4-Chlorophenyl)-1-methyl urea | Degradate | 61692 | 5352-88-5 | 0.060 | na | na | — |
| Clopyralid | Herbicide | 49305 | 1702-17-6 | 0.060 | na | na | — ² |
| Cycloate | Herbicide | 04031 | 1134-23-2 | 0.060 | na | na | — |
| 2,4-D plus 2,4-D methyl ester | Herbicide | 66496 | na | 0.020 | MCL-US | 70 | — |
| 2,4-DB (4-(2,4-Dichlorophenoxy)butyric acid) | Herbicide | 38746 | 94-82-6 | 0.020 | na | na | — ² |
| DCPA (Dacthal) monoacid | Degradate | 49304 | 887-54-7 | 0.020 | na | na | — |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine) | Degradate | 04040 | 6190-65-4 | 0.014 | na | na | D |
| Deisopropyl atrazine (2-chloro-6-ethylamino-4-amino-s-triazine) | Degradate | 04038 | 1007-28-9 | 0.08 | na | na | — |
| Dicamba | Herbicide | 38442 | 1918-00-9 | 0.080 | HAL | 4,000 | — ² |
| Dichlorprop | Herbicide | 49302 | 120-36-5 | 0.040 | na | na | — |
| Dinoseb | Herbicide | 49301 | 88-85-7 | 0.040 | MCL-US | 7 | — ² |
| Diphenamid | Herbicide | 04033 | 957-51-7 | 0.040 | HAL-US | 200 | D |
| Diuron | Herbicide | 49300 | 330-54-1 | 0.040 | RSD5-US | 20 | — |
| Fenuron | Herbicide | 49297 | 101-42-8 | 0.040 | na | na | — |
| Flumetsulam | Herbicide | 61694 | 98967-40-9 | 0.060 | na | na | — |
| Fluometuron | Herbicide | 38811 | 2164-17-2 | 0.040 | HAL-US | 90 | — |
| Hydroxyatrazine (2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine) | Degradate | 50355 | 2163-68-0 | 0.080 | na | na | — |
| 3-Hydroxycarbofuran | Degradate | 49308 | 16655-82-6 | 0.020 | na | na | — |
| Imazaquin | Herbicide | 50356 | 81335-37-7 | 0.040 | na | na | — |
| Imazethapyr | Herbicide | 50407 | 81335-77-5 | 0.040 | na | na | — |
| Imidacloprid | Insecticide | 61695 | 138261-41-3 | 0.060 | na | na | — |
| Linuron | Herbicide | 38478 | 330-55-2 | 0.040 | na | na | — |

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2060.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property; Thresholds and threshold values as of December 1, 2007. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when 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, Lifetime Health Advisory; MCL-CA, California Department of Health Services Maximum Contaminant Level; MCL-US, U.S. Environmental Protection Agency Maximum Contaminant Level; RSD5, risk specific dose at 10^{-5} µg/L. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; na, not available; D, detected; —, not detected; µg/L, micrograms per liter]

| Constituent | Primary use or source | USGS parameter code | CAS number | LRL (µg/L) | Threshold type ¹ | Threshold value (µg/L) | Detection |
|--|-----------------------|---------------------|-------------|------------|-----------------------------|------------------------|----------------|
| MCPA (2-Methyl-4-chlorophenoxyacetic acid) | Herbicide | 38482 | 94-74-6 | 0.060 | HAL-US | 30 | — |
| MCPB (4-(2-Methyl-4-chlorophenoxy) butyric acid) | Herbicide | 38487 | 94-81-5 | 0.200 | na | na | — ² |
| Metalaxyl | Fungicide | 50359 | 57837-19-1 | 0.040 | na | na | — |
| Methiocarb | Insecticide | 38501 | 2032-65-7 | 0.040 | na | na | — |
| Methomyl | Insecticide | 49296 | 16752-77-5 | 0.060 | HAL-US | 200 | — |
| Metsulfuron methyl ³ | Herbicide | 61697 | 74223-64-6 | 0.140 | na | na | — |
| Neburon | Herbicide | 49294 | 555-37-3 | 0.020 | na | na | — |
| Nicosulfuron | Herbicide | 50364 | 111991-09-4 | 0.10 | na | na | — |
| Norflurazon | Herbicide | 49293 | 27314-13-2 | 0.040 | na | na | — |
| Oryzalin | Herbicide | 49292 | 19044-88-3 | 0.040 | na | na | — |
| Oxamyl | Insecticide | 38866 | 23135-22-0 | 0.040 | MCL-CA | 50 | — |
| Picloram | Herbicide | 49291 | 1918-02-01 | 0.120 | MCL-US | 500 | — ² |
| Propham | Herbicide | 49236 | 122-42-9 | 0.060 | HAL-US | 100 | — |
| Propiconazole | Fungicide | 50471 | 60207-90-1 | 0.060 | na | na | — |
| Propoxur | Insecticide | 38538 | 114-26-1 | 0.040 | HAL-US | 3 | — |
| Siduron | Herbicide | 38548 | 1982-49-6 | 0.040 | na | na | — |
| Sulfometuron-methyl | Herbicide | 50337 | 74222-97-2 | 0.060 | na | na | D |
| Tebuthiuron | Herbicide | 82670 | 34014-18-1 | 0.016 | HAL-US | 500 | — |
| Terbacil | Herbicide | 04032 | 5902-51-2 | 0.040 | HAL-US | 90 | — |
| Triclopyr | Herbicide | 49235 | 55335-06-3 | 0.040 | na | na | — |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The 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.

³Although listed as LRLs, these constituents are reported using method reporting levels (MRL).

Table 3D. Pharmaceutical compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2080.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of February 27, 2008.
Other abbreviations: CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter; —, not detected]

| Constituent (common name) | Primary use or source | USGS parameter code | CAS number | LRL ¹ (µg/L) | Threshold type | Threshold value (µg/L) | Detection |
|------------------------------|---|---------------------------|---------------|----------------------------|-------------------|------------------------------|----------------|
| Acetaminophen | Analgesic | 62000 | 103-90-2 | 0.08 | na | na | — |
| Albuterol | Anti-inflammatory; bronchodilator | 62020 | 18559-94-9 | 0.04 | na | na | — |
| Caffeine | Stimulant | 50305 | 58-08-2 | 0.06 | na | na | — |
| Carbamazepine | Anticonvulsant; analgesic; mood stabilizer | 62793 | 298-46-4 | 0.04 | na | na | — |
| Codeine | Opioid narcotic | 62003 | 76-57-3 | 0.04 | na | na | — |
| Cotinine | Nicotine metabolite | 62005 | 486-56-6 | 0.03 | na | na | — |
| Dehydronifedipine | Antianginal metabolite | 62004 | 67035-22-7 | 0.06 | na | na | — |
| Diltiazem | Antianginal; antihypertensive | 62008 | 42399-41-7 | 0.04 | na | na | — ² |
| Diphenhydramine | Antihistamine | 62796 | 58-73-1 | 0.05 | na | na | — |
| Paraxanthine | Caffeine metabolite | 62030 | 611-59-6 | 0.10 | na | na | — |
| Sulfamethoxazole | Antibacterial, antiprotozoal | 62021 | 723-46-6 | 0.10 | na | na | — |
| Thiabendazole | Anthelmintic | 62801 | 148-79-8 | 0.10 | na | na | — |
| Trimethoprim | Antibacterial | 62023 | 738-70-5 | 0.04 | na | na | — |
| Warfarin | Anticoagulant | 62024 | 81-81-2 | 0.06 | na | na | — |

¹ As a result of the assessment of the quality-control information, the LRLs used for this study are more conservative than those reported by the USGS National Water Quality Laboratory for the time period during which these samples were analyzed.

²The 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.

Table 3E. Potential wastewater-indicator compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 1433.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Health Services notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

| Constituent (common name) | Primary use or source | USGS parameter code | CAS number | LRL ($\mu\text{g/L}$) | Threshold type ¹ | Threshold value ($\mu\text{g/L}$) | Detection |
|---|---------------------------------------|---------------------------|---------------|----------------------------|--------------------------------|---|----------------|
| Acetophenone | Fragrance, flavor additive | 62064 | 98-86-2 | 0.10 | na | na | — |
| Acetyl hexamethyl tetrahydro naphthalene (AHTN) | Musk fragrance | 62065 | 21145-77-7 | 0.50 | na | na | — |
| Anthracene | Wood preservative, combustion product | 34221 | 120-12-7 | 0.08 | na | na | — |
| 9,10-Anthraquinone | Dye/textiles, seed treatment | 62066 | 84-65-1 | 0.16 | na | na | — |
| Benzo[a]pyrene | Combustion product | 34248 | 50-32-8 | 0.12 | MCL-US | 0.2 | — |
| Benzophenone | Fixative for perfumes and soaps | 62067 | 119-61-9 | 0.18 | na | na | — |
| Bisphenol A | Polycarbonate resins, flame retardant | 62069 | 80-05-7 | 0.40 | na | na | — ² |
| Bromacil | Herbicide | 04029 | 314-40-9 | 0.04 | HAL-US | 70 | — |
| Bromoform (tribromomethane) | Disinfection by-product | 34288 | 75-25-2 | 0.08 | MCL-US | 80 | — ² |
| 3- <i>tert</i> -Butyl-4-hydroxy anisole (BHA) | Antioxidant, general preservative | 32059 | 25013-16-5 | 0.60 | na | na | — ² |
| Caffeine | Beverages | 50305 | 58-08-2 | 0.10 | na | na | — |
| Camphor | Flavor, odorant, ointments | 62070 | 76-22-2 | 0.10 | na | na | — |
| Carbaryl | Insecticide | 82680 | 63-25-2 | 1.00 | RSD5-US | 400 | — |
| Carbazole | Insecticide | 62071 | 86-74-8 | 0.08 | na | na | — |
| Chlorpyrifos | Insecticide | 38933 | 2921-88-2 | 0.12 | HAL-US | 2 | — |
| Cholesterol | Fecal indicator, plant sterol | 62072 | 57-88-5 | 1.40 | na | na | — ² |
| 3- β -Coprostanol | Carnivore fecal indicator | 62057 | 360-68-9 | 1.60 | na | na | — ² |
| Cotinine | Primary nicotine metabolite | 62005 | 486-56-6 | 0.40 | na | na | — |
| <i>p</i> -Cresol | Wood preservative | 62084 | 106-44-5 | 0.18 | na | na | — |
| 4-Cumylphenol | Nonionic detergent metabolite | 62060 | 599-64-4 | 0.14 | na | na | — |
| Diazinon | Insecticide | 39572 | 333-41-5 | 0.08 | HAL-US | 1 | — |
| <i>N,N</i> -diethyl- <i>m</i> -toluamide (DEET) | Insecticide | 62082 | 134-62-3 | 0.20 | na | na | — |
| 1,4-Dichlorobenzene | Moth repellant, fumigant, deodorant | 34572 | 106-46-7 | 0.08 | MCL-CA | 5 | — ² |
| 2,6-Dimethylnaphthalene | Diesel/kerosene | 62055 | 581-42-0 | 0.20 | na | na | — ² |
| Fluoranthene | Component of coal tar and asphalt | 34377 | 206-44-0 | 0.08 | na | na | — |
| Hexahydrohexamethylcyclopentabenzopyran (HHCB) | Musk fragrance | 62075 | 1222-05-5 | 0.50 | na | na | — |
| Indole | Pesticide ingredient | 62076 | 120-72-9 | 0.14 | na | na | — |
| Isoborneol | Fragrance in perfumery | 62077 | 124-76-5 | 0.06 | na | na | — |
| Isophorone | Solvent | 34409 | 78-59-1 | 0.14 | HAL-US | 100 | — |
| Isopropylbenzene | Fuels, paint thinner | 62078 | 98-82-8 | 0.10 | NL-CA | 770 | — ² |
| Isoquinoline | Flavors and fragrances | 62079 | 119-65-3 | 0.40 | na | na | — |
| <i>d</i> -Limonene | Fungicide | 62073 | 5989-27-5 | 0.14 | na | na | — ² |
| Menthol | Cigarettes, cough drops, liniment | 62080 | 89-78-1 | 0.20 | na | na | — |
| Metalaxyl | Herbicide, fungicide | 50359 | 57837-19-1 | 0.08 | na | na | — |

Table 3E. Potential wastewater-indicator compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 1433.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Health Services notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

| Constituent (common name) | Primary use or source | USGS parameter code | CAS number | LRL ($\mu\text{g/L}$) | Threshold type ¹ | Threshold value ($\mu\text{g/L}$) | Detection |
|--|--|---------------------------|---------------|----------------------------|--------------------------------|---|----------------|
| 3-Methyl-1(H)-indole (Skatole) | Fragrance, stench in feces | 62058 | 83-34-1 | 0.08 | na | na | — |
| 5-Methyl-1H-benzotriazole | Antioxidant in antifreeze and deicers | 62063 | 136-85-6 | 1.80 | na | na | — ² |
| 1-Methylnaphthalene | Gasoline, diesel fuel, or crude oil | 62054 | 90-12-0 | 0.10 | na | na | — |
| 2-Methylnaphthalene | Gasoline, diesel fuel, or crude oil | 62056 | 91-57-6 | 0.08 | na | na | — ² |
| Methyl salicylate | Liniment, UV-absorbing lotion | 62081 | 119-36-8 | 0.18 | na | na | — |
| Metolachlor | Herbicide | 39415 | 51218-45-2 | 0.08 | HAL-US | 700 | — |
| Naphthalene | Fumigant, moth repellent, gasoline | 34443 | 91-20-3 | 0.10 | NL-CA | 17 | — |
| 4-Nonylphenol (total) | Nonionic detergent metabolite | 62085 | 84852-15-3 | 1.80 | na | na | — |
| 4- <i>n</i> -Octylphenol | Nonionic detergent metabolite | 62061 | 1806-26-4 | 0.16 | na | na | — |
| 4- <i>tert</i> -Octylphenol | Nonionic detergent metabolite | 62062 | 140-66-9 | 0.10 | na | na | — |
| 4-Nonylphenol diethoxylates (Diethoxynonylphenol) | Nonionic detergent metabolite | 62083 | n/a | 5.00 | na | na | — ³ |
| 4-Octylphenol diethoxylates (Diethoxyoctylphenol) | Nonionic detergent metabolite | 61705 | n/a | 1.00 | na | na | — |
| 4-Octylphenol monoethoxyl- ates (Ethoxyoctylphenol) | Nonionic detergent metabolite | 61706 | n/a | 1.00 | na | na | — ³ |
| Pentachlorophenol | Herbicide, wood preservative | 34459 | 87-86-5 | 2.00 | MCL-US | 1 | — ² |
| Phenanthrene | Explosives, oil, combustion product | 34462 | 85-01-8 | 0.08 | na | na | — |
| Phenol | Disinfectant, organic synthesis | 34466 | 108-95-2 | 0.20 | HAL-US | 2000 | — |
| Prometon | Herbicide | 04037 | 1610-18-0 | 0.18 | HAL-US | 100 | — |
| Pyrene | Component of coal tar and asphalt | 34470 | 129-00-0 | 0.08 | na | na | — |
| β -Sitosterol | Plant sterol | 62068 | 83-46-5 | 2.00 | na | na | — ² |
| β -Stigmastanol | Plant sterol | 62086 | 19466-47-8 | 2.00 | na | na | — ² |
| Tetrachloroethylene (PCE) | Solvent, degreaser | 34476 | 127-18-4 | 0.18 | MCL-US | 5 | — ² |
| Tributyl phosphate | Antifoaming agent, flame retar- dant | 62089 | 126-73-8 | 0.20 | na | na | — |
| Triclosan | Disinfectant, antimicrobial | 62090 | 3380-34-5 | 0.20 | na | na | — |
| Triethyl citrate (ethyl citrate) | Cosmetics, pharmaceuticals | 62091 | 77-93-0 | 0.40 | na | na | — |
| Triphenyl phosphate | Plasticizer, resin, flame retardant | 62092 | 115-86-6 | 0.16 | na | na | — |
| Tris(2-butoxyethyl)phos- phate | Flame retardant | 62093 | 78-51-3 | 0.50 | na | na | D |
| Tris(2-chloroethyl)phosphate | Plasticizer, flame retardant | 62087 | 115-96-8 | 0.18 | na | na | D |
| Tris(dichlorisopropyl) phosphate | Flame retardant | 62088 | 13674-87-8 | 0.18 | na | na | — |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The 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.

³The median matrix-spike recovery was greater than 130 percent.

Table 3F. Constituents of special interest, primary uses or sources, comparative thresholds, and reporting information for the Montgomery Watson Harza Laboratory.

[Thresholds and threshold values as of December 1, 2007. **Threshold type:** NL-CA, California notification level; MCL-CA, California Department of Health Services maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected; µg/L, micrograms per liter]

| Constituent | Primary use or source | CAS number | MRL (µg/L) | Threshold type ¹ | Threshold value (µg/L) | Detection |
|---------------------------------------|--------------------------------|------------|------------|-----------------------------|------------------------|-----------|
| <i>N</i> -Nitrosodimethylamine (NDMA) | Rocket fuel, plasticizer | 62-75-9 | 0.002 | NL-CA | 0.01 | D |
| Perchlorate | Rocket fuel, fireworks, flares | 14797-73-0 | 0.5 | MCL-CA | 6 | D |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 3G. Nutrients, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2755.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; mg/L, milligrams per liter]

| Constituent | USGS parameter code | CAS number | LRL (mg/L) | Threshold type ¹ | Threshold value (mg/L) | Detection |
|--|---------------------|------------|------------|-----------------------------|------------------------|-----------|
| Ammonia, as nitrogen | 00608 | 7664-41-7 | 0.02 | HAL-US | ² 30 | D |
| Nitrite (as nitrogen) | 00613 | 14797-65-0 | 0.002 | MCL-US | 1 | D |
| Nitrite plus nitrate (as nitrogen) | 00631 | na | 0.06 | MCL-US | 10 | D |
| Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen) | 62854 | 17778-88-0 | 0.06 | na | na | D |
| Orthophosphate (as phosphorus) | 00671 | 14265-44-2 | 0.006 | na | na | D |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The HAL-US for ammonia is as ammonia, based on the inhalation of ammonia vapors.

Table 3H. Major and minor ions and trace elements, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Health Services notification level; SMCL-CA, California Department of Health Services secondary maximum contaminant level; AL-US, U.S. Environmental Protection Agency action level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected; na, not available; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

| Constituent | USGS parameter code | CAS number | LRL | Threshold type ¹ | Threshold value | Detection |
|--|---------------------------|---------------|-------|--------------------------------|--------------------------|-----------|
| Major and minor ions (mg/L) | | | | | | |
| Bromide | 71870 | 24959-67-9 | 0.02 | na | na | D |
| Calcium | 00915 | 7440-70-2 | 0.02 | na | na | D |
| Chloride | 00940 | 16887-00-6 | 0.12 | SMCL-CA | 250 ² (500) | D |
| Fluoride | 00950 | 16984-48-8 | 0.10 | MCL-CA | 2 | D |
| Iodide | 78165 | 7553-56-2 | 0.002 | na | na | D |
| Magnesium | 00925 | 7439-95-4 | 0.014 | na | na | D |
| Potassium | 00935 | 7440-09-7 | 0.04 | na | na | D |
| Silica | 00955 | 7631-86-9 | 0.018 | na | na | D |
| Sodium | 00930 | 7440-23-5 | 0.20 | na | na | D |
| Sulfate | 00945 | 14808-79-8 | 0.18 | SMCL-CA | 250 ² (500) | D |
| Residue on evaporation (total dissolved solids, TDS) | 70300 | na | 10 | SMCL-US | 500 ² (1,000) | D |
| Trace elements (µg/L) | | | | | | |
| Aluminum | 01106 | 7429-90-5 | 1.6 | MCL-CA | 1,000 | D |
| Antimony | 01095 | 7440-36-0 | 0.06 | MCL-US | 6 | D |
| Arsenic | 01000 | 7440-38-2 | 0.12 | MCL-US | 10 | D |
| Barium | 01005 | 7440-39-3 | 0.08 | MCL-CA | 1,000 | D |
| Beryllium | 01010 | 7440-41-7 | 0.06 | MCL-US | 4 | — |
| Boron | 01020 | 7440-42-8 | 8 | NL-CA | 1,000 | D |
| Cadmium | 01025 | 7440-43-9 | 0.04 | MCL-US | 5 | D |
| Chromium | 01030 | 7440-47-3 | 0.12 | MCL-CA | 50 | D |
| Cobalt | 01035 | 7440-48-4 | 0.04 | na | na | D |
| Copper | 01040 | 7440-50-8 | 0.4 | AL-US | 1,300 | D |
| Iron | 01046 | 7439-89-6 | 6 | SMCL-CA | 300 | D |
| Lead | 01049 | 7439-92-1 | 0.12 | AL-US | 15 | D |
| Lithium | 01130 | 7439-93-2 | 0.6 | na | na | D |
| Manganese | 01056 | 7439-96-5 | 0.2 | SMCL-CA | 50 | D |
| Molybdenum | 01060 | 7439-98-7 | 0.12 | HAL-US | 40 | D |
| Nickel | 01065 | 7440-02-0 | 0.06 | MCL-CA | 100 | D |
| Selenium | 01145 | 7782-49-2 | 0.08 | MCL-US | 50 | D |
| Silver | 01075 | 7440-22-4 | 0.10 | SMCL-CA | 100 | — |
| Strontium | 01080 | 7440-24-6 | 0.4 | HAL-US | 4,000 | D |
| Thallium | 01057 | 7440-28-0 | 0.04 | MCL-US | 2 | — |
| Tungsten | 01155 | 7440-33-7 | 0.06 | na | na | D |
| Uranium | 22703 | 7440-61-1 | 0.04 | MCL-US | 30 | D |
| Vanadium | 01085 | 7440-62-2 | 0.04 | NL-CA | 50 | D |
| Zinc | 01090 | 7440-66-6 | 0.6 | SMCL-CA | 5,000 | D |

¹ Maximum contaminant level thresholds are listed as MCL-US when 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.

²The recommended SMCL-CA thresholds for chloride, sulfate, and TDS are listed with the upper SMCL-CA thresholds in parentheses.

Table 3I. Arsenic, chromium, and iron species, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) Trace Metal Laboratory, Boulder, Colorado.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Health Services secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter; D, detected]

| Constituent (valence state) | USGS parameter code | CAS number | MDL (µg/L) | Threshold type ¹ | Threshold level (µg/L) | Detection |
|--------------------------------|---------------------------|---------------|---------------|--------------------------------|------------------------------|-----------|
| Arsenic(III) | 99034 | 22569-72-8 | 1 | na | na | D |
| Arsenic(total) | 01000 | 7440-38-2 | 0.5 | MCL-US | 10 | D |
| Chromium(VI) | 01032 | 18540-29-9 | 1 | na | na | D |
| Chromium(total) | 01030 | 7440-47-3 | 1 | MCL-CA | 50 | D |
| Iron(II) | 01047 | 7439-89-6 | 2 | na | na | D |
| Iron(total) | 01046 | 7439-89-6 | 2 | SMCL-CA | 300 | D |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 3J. Isotopic and radioactive constituents, comparative thresholds, and reporting information for laboratories.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Stable isotope ratios 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. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Health Services maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; SSMDC, sample specific minimum detectable concentration; D, detected]

| Constituent | USGS parameter code | CAS number | Reporting level type | Reporting level or uncertainty | Threshold type ¹ | Threshold value | Detection |
|--|---------------------------|---------------|-------------------------|--------------------------------------|--------------------------------|--------------------|-----------|
| Stable isotope ratios (per mil) | | | | | | | |
| δ ² H of water ² | 82082 | na | MU | 2 | na | na | D |
| δ ¹⁸ O of water ² | 82085 | na | MU | 0.20 | na | na | D |
| δ ¹³ C of dissolved carbonates ³ | 82081 | na | 1 sigma | 0.05 | na | na | D |
| δ ¹⁵ N of nitrate ² | 82690 | na | MU | 0.30 | na | na | D |
| δ ¹⁸ O of nitrate ² | 63041 | na | MU | 0.50 | na | na | D |
| δ ¹¹ B ⁴ | 62648 | na | MU | na | na | na | D |
| δ ³⁷ Cl ³ | na | na | na | na | na | na | na |
| δ ⁸¹ Br ³ | na | na | na | na | na | na | na |
| Inorganic Tracers | | | | | | | |
| Uranium isotopes | na | na | na | na | na | na | na |
| Strontium isotopes | na | na | na | na | na | na | na |
| Radioactive constituents (percent modern) | | | | | | | |
| Carbon-14 ⁵ | 49933 | 14762-75-5 | 1 sigma | 0.0015 | na | na | D |
| Radioactive constituents (pCi/L) | | | | | | | |
| Radon-222 ^{6,7} | 82303 | 14859-67-7 | SSMDC | see Table 16 | Prop. MCL-US | 300, 4,000 | D |
| Tritium ⁸ | 07000 | 10028-17-8 | MRL | 1 | MCL-CA | 20,000 | D |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²USGS Stable Isotope Laboratory, Reston, Virginia.

³University of Waterloo (contract laboratory).

⁴USGS National Research Program, Menlo Park, California

⁵University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory).

⁶USGS National Water Quality Laboratory.

⁷Two MCL-US thresholds have been proposed, 300 pCi/L and 4,000 pCi/L.

⁸USGS Stable Isotope and Tritium Laboratory, Menlo Park, California.

Table 3K. Noble gases and tritium, comparison thresholds and reporting information for the Lawrence Livermore National Laboratory

[Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Health Services maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; cm³ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter; D, detected in ground-water samples]

| Constituent | CAS number | MU (percent) | Reporting units | Threshold type ¹ | Threshold value (pCi/L) | Detection |
|-------------------|--------------|--------------|-----------------------|-----------------------------|-------------------------|-----------|
| Helium-3/Helium-4 | na/7440-59-7 | 0.75 | atom ratio | na | na | D |
| Argon | 7440-37-1 | 2 | cm ³ STP/g | na | na | D |
| Helium-4 | 7440-59-7 | 2 | cm ³ STP/g | na | na | D |
| Krypton | 7439-90-9 | 2 | cm ³ STP/g | na | na | D |
| Neon | 7440-01-09 | 2 | cm ³ STP/g | na | na | D |
| Xenon | 7440-63-3 | 2 | cm ³ STP/g | na | na | D |
| Tritium | 10028-17-8 | 1 | pCi/L | MCL-CA | 20,000 | na |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 3L. Microbial constituents, comparison thresholds, and reporting information for the U.S. Geological Survey (USGS) Ohio Microbiology Laboratory parameter codes 99335 and 99332.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of December 1, 2007. **Threshold type:** TT-US, U.S. Environmental Protection Agency treatment technique - a required process intended to reduce the level of contamination in drinking water. **Other abbreviations:** MDL, method detection limit; na, not available; D, detected]

| Constituent | USGS parameter code | Primary source | MDL | Threshold type | Threshold value | Detection |
|----------------------|---------------------|-----------------------------------|-----|----------------|----------------------------------|-----------|
| F-specific coliphage | 99335 | Sewage and animal waste indicator | na | TT-US | 99.99 percent killed/inactivated | D |
| Somatic coliphage | 99332 | Sewage and animal waste indicator | na | TT-US | 99.99 percent killed/inactivated | D |

Table 4. Water-quality indicators in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold 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:** A, average value of two replicate measurements; C, Celsius; E, estimated value; mg/L, milligrams per liter; na, not available; nc, sample not collected; NTU, nephelometric turbidity unit; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; CaCO_3 , calcium carbonate; <, less than; *, value exceeds threshold]

| GAMA identification number | Turbidity, field (NTU) (63676) | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field ($^{\circ}\text{C}$) (00010) | pH, lab ¹ (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab ¹ ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (90095) | Specific conductance, field ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (00095) | Alkalinity, lab ¹ (mg/L as CaCO_3) (29801) | Alkalinity, field (mg/L as CaCO_3) (29802) |
|----------------------------|--------------------------------|--|---|---|------------------------------------|--|---|---|--|
| Threshold type | na | na | na | SMCL-US | SMCL-US | SMCL-CA | SMCL-CA | na | na |
| Threshold level | na | na | na | 6.5–8.5 | 6.5–8.5 | ² 900 (1,600) | ² 900 (1,600) | na | na |
| Grid wells | | | | | | | | | |
| SF-01 | nc | 9.4 | 18.0 | nc | 7.5 | nc | 521 | 148 | nc |
| SF-02 | nc | 6.3 | 18.0 | nc | 7.3 | nc | 648 | 161 | nc |
| SF-03 | nc | 2.6 | 20.0 | nc | 7.5 | nc | 841 | 194 | nc |
| SF-04 | nc | 1.7 | 24.5 | nc | 8.1 | nc | 421 | 113 | nc |
| SF-05 | nc | 4.8 | 20.5 | nc | 7.1 | nc | 514 | 135 | nc |
| SF-06 | nc | 4.7 | 18.5 | nc | 6.5 | nc | 514 | 155 | nc |
| SF-07 | nc | 1.9 | 19.0 | nc | 6.9 | nc | *1,180 | 444 | nc |
| SF-08 | nc | 6.5 | 20.5 | nc | 7.6 | nc | 885 | 222 | nc |
| SF-09 | nc | 4.8 | 19.0 | nc | 7.3 | nc | 803 | 313 | nc |
| SF-10 | nc | 1.1 | 19.5 | nc | 7.6 | nc | 571 | 234 | nc |
| SF-11 | nc | 11.9 | 16.0 | nc | 7.3 | nc | 592 | 229 | nc |
| SF-12 | nc | 7.9 | 16.5 | nc | 7.3 | nc | 647 | 259 | nc |
| SF-13 | nc | 5.8 | 20.5 | nc | 7.1 | nc | 670 | 249 | nc |
| SF-14 | nc | 4.1 | 20.0 | nc | 7.4 | nc | 691 | 259 | nc |
| SF-15 | nc | <0.2 | 23.5 | nc | 7.7 | nc | 462 | 181 | nc |
| SF-16 | nc | <0.2 | 23.5 | nc | 7.9 | nc | 439 | 177 | nc |
| SF-17 | nc | 0.6 | 19.5 | nc | 7.4 | nc | 863 | 316 | nc |
| SF-18 | nc | 5.1 | 20.0 | nc | 7.4 | nc | 958 | 319 | nc |
| SF-19 | nc | 0.2 | 19.5 | nc | 7.7 | nc | 478 | 224 | nc |
| SF-20 | nc | 5.9 | 18.0 | nc | 7.3 | nc | 490 | 168 | nc |
| SF-21 | nc | 4.9 | 18.0 | nc | 7.2 | nc | 520 | 185 | nc |
| SF-22 | nc | 3.1 | 17.5 | nc | 7.5 | nc | 443 | 139 | nc |
| SF-23 | nc | 3.8 | 19.0 | nc | 7.6 | nc | 534 | 195 | nc |
| SF-24 | 0.3 | 1.1 | 19.5 | 7.5 | 7.4 | 913 | 688 | 336 | A329 |
| SF-25 | nc | 7.3 | 20.0 | nc | 7.4 | nc | 709 | 276 | nc |
| SF-26 | nc | 0.8 | 19.0 | nc | 7.3 | nc | 531 | 184 | nc |
| SF-27 | nc | 1.1 | 19.0 | nc | 7.4 | nc | 568 | 204 | nc |
| SF-28 | nc | 1.1 | 19.0 | 7.6 | 7.5 | 965 | 823 | 363 | A350 |
| SF-29 | nc | 1.8 | 18.5 | nc | 7.4 | nc | 740 | 292 | nc |
| SF-30 | nc | 5.7 | 18.0 | nc | 7.1 | nc | *1,430 | 415 | nc |

Table 4. Water-quality indicators in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold 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:** A, average value of two replicate measurements; C, Celsius; E, estimated value; mg/L, milligrams per liter; na, not available; nc, sample not collected; NTU, nephelometric turbidity unit; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; CaCO_3 , calcium carbonate; <, less than; *, value exceeds threshold]

| GAMA identification number | Turbidity, field (NTU) (63676) | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field ($^{\circ}\text{C}$) (00010) | pH, lab ¹ (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab ¹ ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (90095) | Specific conductance, field ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (00095) | Alkalinity, lab ¹ (mg/L as CaCO_3) (29801) | Alkalinity, field (mg/L as CaCO_3) (29802) |
|----------------------------|--------------------------------|--|---|---|------------------------------------|--|---|---|--|
| Threshold type | na | na | na | SMCL-US | SMCL-US | SMCL-CA | SMCL-CA | na | na |
| Threshold level | na | na | na | 6.5–8.5 | 6.5–8.5 | ² 900 (1,600) | ² 900 (1,600) | na | na |
| SF-31 | nc | 2.1 | 18.0 | nc | 7.5 | nc | 601 | 248 | nc |
| SF-32 | nc | 1.1 | 20.0 | nc | 7.7 | nc | 609 | 278 | nc |
| SF-33 | nc | 3.3 | 19.5 | nc | 7.3 | nc | 578 | 280 | nc |
| SF-34 | nc | 0.2 | 18.5 | nc | 7.3 | nc | *1,380 | 433 | nc |
| SF-35 | 0.2 | 0.5 | 18.5 | 7.4 | 7.2 | *2,970 | *2,910 | 228 | A219 |
| SF-36 | nc | 2.7 | 18.0 | nc | 7.1 | nc | 870 | 270 | nc |
| SF-37 | nc | 0.3 | 18.5 | nc | 7.2 | nc | 797 | 234 | nc |
| SF-38 | nc | <0.2 | 22.0 | nc | 7.5 | nc | 865 | 231 | nc |
| SF-39 | nc | <0.2 | 23.5 | nc | 7.3 | nc | 795 | 230 | nc |
| SF-40 | nc | 0.4 | 20.5 | nc | 7.4 | nc | 817 | 308 | nc |
| SF-41 | nc | 10.5 | 18.0 | nc | *9.4 | nc | 52 | 17 | nc |
| SF-42 | nc | 0.7 | 19.5 | nc | 7.2 | nc | *2,090 | 178 | nc |
| SF-43 | nc | 1.0 | 19.7 | nc | 7.3 | nc | *1,130 | 206 | nc |
| Understanding wells | | | | | | | | | |
| SFU-01 | 0.4 | 0.2 | 22.5 | 7.6 | 7.5 | 769 | 763 | 214 | A205 |
| SFU-02 | nc | 3.0 | 20.0 | nc | 7.5 | nc | 526 | 217 | nc |
| SFU-03 | nc | 6.3 | 19.0 | nc | 7.5 | nc | 428 | 200 | nc |
| SFU-04 | nc | 7.9 | 19.0 | nc | 7.8 | nc | 575 | 214 | nc |
| SFU-05 | nc | 8.8 | 19.0 | nc | 7.3 | nc | 652 | 226 | nc |
| SFU-06 | 0.2 | 0.4 | 21.5 | 7.7 | 7.5 | 820 | 682 | 300 | A270 |
| SFU-07 | 0.2 | 2.4 | 19.0 | 7.6 | 7.4 | 890 | 860 | 322 | A310 |
| SFU-08 | 0.1 | 1.0 | 18.5 | 7.7 | 7.5 | *1,000 | 740 | 378 | A371 |
| SFU-09 | nc | 1.9 | 17.5 | nc | 7.2 | nc | *1,080 | 288 | nc |
| SFU-10 | nc | 0.2 | 17.5 | nc | 7.4 | nc | *974 | 217 | nc |
| SFU-11 | nc | 2.5 | 15.0 | nc | 7.0 | nc | 603 | 201 | nc |
| SFU-12 | nc | 5.0 | 14.5 | nc | 6.8 | nc | 278 | 121 | nc |
| SFM-A1 | 0.2 | 0.2 | 23.5 | 7.8 | 7.6 | 880 | 823 | 211 | A202 |
| SFM-A2 | 0.2 | 0.2 | 20.0 | 8.1 | 8.0 | 435 | 427 | 115 | A112 |
| SFM-A3 | 0.3 | 0.6 | 20.0 | 7.6 | 7.4 | 491 | 454 | 118 | A114 |
| SFM-A4 | 0.1 | 3.0 | 19.5 | 7.7 | 7.5 | 524 | 484 | 113 | A108 |

Table 4. Water-quality indicators in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold 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:** A, average value of two replicate measurements; C, Celsius; E, estimated value; mg/L, milligrams per liter; na, not available; nc, sample not collected; NTU, nephelometric turbidity unit; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; CaCO_3 , calcium carbonate; <, less than; *, value exceeds threshold]

| GAMA identification number | Turbidity, field (NTU) (63676) | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field ($^{\circ}\text{C}$) (00010) | pH, lab ¹ (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab ¹ ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (90095) | Specific conductance, field ($\mu\text{S}/\text{cm}$ @ 25 $^{\circ}\text{C}$) (00095) | Alkalinity, lab ¹ (mg/L as CaCO_3) (29801) | Alkalinity, field (mg/L as CaCO_3) (29802) |
|----------------------------|--------------------------------|--|---|---|------------------------------------|--|---|---|--|
| Threshold type | na | na | na | SMCL-US | SMCL-US | SMCL-CA | SMCL-CA | na | na |
| Threshold level | na | na | na | 6.5–8.5 | 6.5–8.5 | ² 900 (1,600) | ² 900 (1,600) | na | na |
| SFM-B1 | 2.2 | 1.2 | 19.0 | 7.8 | 7.7 | *920 | *915 | 208 | A196 |
| SFM-B2 | 130 | 0.2 | 19.0 | 7.0 | 6.9 | E*28,600 | *28,100 | 712 | A666 |
| SFM-C1 | 0.2 | 0.2 | 22.5 | 8.0 | 8.0 | 598 | 541 | 172 | A166 |
| SFM-C2 | 0.2 | 0.3 | 22.0 | 7.9 | 7.9 | 675 | 634 | 207 | A184 |
| SFM-C3 | 0.1 | 0.2 | 22.0 | 7.6 | 7.5 | 792 | 732 | 290 | A280 |
| SFM-C4 | 0.1 | 0.3 | 20.0 | 7.8 | 7.6 | 849 | 810 | 319 | A314 |
| SFM-C5 | 0.1 | 0.6 | 21.0 | 7.5 | 7.3 | *1,030 | *1,010 | 382 | A352 |
| SFM-D1 | 4.7 | 0.2 | 22.5 | 8.1 | 8.0 | 583 | 570 | 219 | A209 |
| SFM-D2 | 2.1 | 0.2 | 20.0 | 7.9 | 7.7 | 711 | 680 | 249 | A238 |
| SFM-D3 | 0.5 | <0.2 | 21.0 | 7.3 | 7.2 | *3,420 | *3,300 | 319 | A296 |
| SFM-D4 | 1.6 | <0.2 | 20.0 | 7.4 | 7.2 | *1,880 | *1,830 | 642 | A627 |
| SFM-E1 | 2.4 | 0.2 | 20.5 | 7.9 | 7.8 | *1,250 | *1,400 | 206 | A195 |
| SFM-E2 | 0.7 | 0.3 | 19.0 | 7.5 | 7.4 | *1,170 | *1,110 | 308 | A300 |
| SFM-E3 | 0.3 | 0.7 | 18.5 | 7.3 | 7.2 | *2630 | *2,500 | 321 | A308 |
| SFM-F1 | 9.5 | 5.5 | 19.0 | 8.0 | 7.8 | *1,420 | *1,390 | 456 | A416 |
| SFM-F2 | 0.2 | <0.2 | 20.0 | 8.2 | 8.2 | *1,000 | *985 | 261 | A249 |
| SFM-F3 | 0.1 | <0.2 | 20.5 | 7.8 | 7.6 | 518 | 517 | 156 | A148 |
| SFM-F4 | 0.1 | 0.2 | 19.5 | 7.9 | 7.7 | 796 | 789 | 260 | A249 |
| SFM-F5 | 0.3 | 0.2 | 18.5 | 8.0 | 7.8 | 803 | 771 | 289 | A284 |
| SFM-F6 | 17 | 0.5 | 19.0 | 6.7 | 6.5 | E*101,000 | *98,900 | 402 | A389 |

¹USGS National Water Quality Laboratory, Denver, Colorado (NWQL).

²The SMCL-CA for specific conductance has recommended and upper threshold values. The upper value is shown in parentheses.

Table 5. Volatile organic compounds (VOC) detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency, within each constituent class, in the 43 grid wells. All analytes are listed in *table 3.A. GAMA Identification number*: SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type**: MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Health Services maximum contaminant level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; NL-CA, California Department of Public Health notification level. **Other abbreviations**: E, estimated value; V, analyte was detected in a sample and an associated blank, thus data are not included in ground-water quality assessment; LRL, laboratory reporting level; µg/L, microgram per liter; —, not detected]

| GAMA identifica- tion number | Trihalomethane | | | Refrigerant | | | Solvent | | | | | |
|--|---|--|--|--|---|---|---|---|--|---|---|---|
| | Chloroform (trichloro- methane), (µg/L) (32106) | Bromo- dichloro- methane, (µg/L) (32101) | 1,1,2-Tri- chloro- 1,2,2-triflu- oroethane (CFC-113), (µg/L) (77652) | Trichloro- fluoro- methane (CFC-11), (µg/L) (34488) | Dichloro- difluoro- methane (CFC-12), (µg/L) (34668) | Chloro- meth- ane, (µg/L) (34418) | 1,1,1- Trichloro- ethane (TCA), (µg/L) (34506) | Tetrachlo- roethene (PCE), (µg/L) (34475) | 1,1-Di- chloro- ethane, (µg/L) (34496) | cis-1,2- Dichloro- ethene, (µg/L) (77093) | Carbon tetra- chloride (Tetrachlo- rometh- ane), (µg/L) (32102) | Trichloro- ethene (TCE), (µg/L) (39180) |
| Threshold type ¹ | MCL-US | MCL-US | MCL-CA | MCL-CA | NL-CA | HAL-US | MCL-US | MCL-US | MCL-CA | MCL-CA | MCL-CA | MCL-US |
| Threshold level | 80 | 80 | 1200 | 150 | 1000 | 30 | 200 | 5 | 5 | 6 | 0.5 | 5 |
| [LRL] | [0.04] | [0.04] | [0.04] | [0.08] | [0.14] | [0.1] | [0.04] | [0.04] | [0.06] | [0.02] | [0.08] | [0.02] |
| SF-37 | E0.05 | — | — | — | — | — | — | — | — | — | — | — |
| SF-38 | E0.03 | — | — | — | — | — | — | — | — | — | — | — |
| SF-40 | E0.14 | — | — | — | — | — | — | — | — | — | — | — |
| SF-41 | 38.8 | 1.19 | — | — | — | — | — | — | — | — | — | — |
| SF-42 | — | — | — | — | — | — | — | 0.21 | — | 0.19 | — | 1.46 |
| SF-43 | E0.03 | — | — | — | — | — | — | — | — | — | — | — |
| Number of detection frequency (percent) | 13 | 1 | 7 | 1 | 0 | 0 | 7 | 4 | 2 | 1 | 1 | 1 |
| Detection frequency (percent) | 30 | 2.3 | 16 | 2.3 | 0 | 0 | 16 | 9.0 | 4.7 | 2.3 | 2.3 | 2.3 |

Table 5. Volatile organic compounds (VOC) detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency, within each constituent class, in the 43 grid wells. All analytes are listed in *table 3A*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Health Services maximum contaminant level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; NL-CA, California Department of Public Health notification level. **Other abbreviations:** E, estimated value; V, analyte was detected in a sample and an associated blank, thus data are not included in ground-water quality assessment; LRL, laboratory reporting level; µg/L, microgram per liter; —, not detected]

| GAMA identi- fication number | Solvent | | | Organic synthesis | | Gasoline oxygenate | | Gasoline | | Degra- date/ Solvent | | VOC detections per well |
|---|---|--|---|--|---|---|--|-------------------------------|-------------------------------|-------------------------------|--|-------------------------------|
| | Chloro- ethane, (µg/L) (34311) | Dichloro- methane, (µg/L) (34423) | Ethyl methyl ketone, (µg/L) (81595) | Tetra- hydrofu- ran, (µg/L) (81607) | 1,1- Dichloro- ethene, (µg/L) (34501) | Carbon disulfide, (µg/L) (77041) | Methyl tert- butyl ether (MTBE), (µg/L) (78032) | Toluene, (µg/L) (34010) | Benzene, (µg/L) (34030) | Acetone, (µg/L) (81552) | 1,2,3,4- Tetra-methyl- benzene, (µg/L) (49999) | |
| Threshold type ¹ | na | MCL-US | HAL-US | na | MCL-CA | NL-CA | MCL-CA | MCL-CA | MCL-CA | na | na | |
| Threshold level | na | 5 | 4000 | na | 6 | 160 | 13 | 150 | 1 | na | na | |
| [LRL] | [0.1] | [0.04] | [1.6] | [1] | [0.02] | [0.06] | [0.1] | [0.018] | [0.016] | [6] | [0.14] | |
| SF-37 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| SF-38 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| SF-40 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| SF-41 | — | — | — | — | — | E0.02 | — | V0.02 | — | 8 | — | 4 |
| SF-42 | — | — | — | — | — | — | — | — | — | — | — | 3 |
| SF-43 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| Number of detc- tions | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 0 | 0 | 1 | 0 | |
| Detc- tion fre- quency (per- cent) | 0 | 0 | 0 | 0 | 9.0 | 2.3 | 4.7 | 0 | 0 | 2.3 | 0 | 349 |

Table 5. Volatile organic compounds (VOC) detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency, within each constituent class, in the 43 grid wells. All analytes are listed in *table 3A*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Health Services maximum contaminant level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; NL-CA, California Department of Public Health notification level. **Other abbreviations:** E, estimated value; V, analyte was detected in a sample and an associated blank, thus data are not included in ground-water quality assessment; LRL, laboratory reporting level; µg/L, microgram per liter; —, not detected]

| GAMA identi- fication number | Solvent | | | Organic synthesis | | Gasoline oxygenate | Gasoline | | Degra- date/ Solvent | | VOC detections per well |
|---------------------------------------|---|--|---|--|---|---|--|-------------------------------|-------------------------------|-------------------------------|--|
| | Chloro- ethane, (µg/L) (34311) | Dichloro- methane, (µg/L) (34423) | Ethyl methyl ketone, (µg/L) (81595) | Tetra- hydrofu- ran, (µg/L) (81607) | 1,1- Dichloro- ethene, (µg/L) (34501) | Carbon disulfide, (µg/L) (77041) | Methyl <i>tert</i> - butyl ether (MTBE), (µg/L) (78032) | Toluene, (µg/L) (34010) | Benzene, (µg/L) (34030) | Acetone, (µg/L) (81552) | 1,2,3,4- Tetra-methyl- benzene, (µg/L) (49999) |
| Threshold type ¹ | na | MCL-US | HAL-US | na | MCL-CA | NL-CA | MCL-CA | MCL-CA | MCL-CA | na | na |
| Threshold level | na | 5 | 4000 | na | na | 160 | 13 | 150 | 1 | na | na |
| [LRL] | [0.1] | [0.04] | [1.6] | [1] | [0.02] | [0.06] | [0.1] | [0.018] | [0.016] | [6] | [0.14] |
| Understanding wells | | | | | | | | | | | |
| SFU-02 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFU-03 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFU-04 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFU-05 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFU-08 | — | — | — | — | E0.04 | — | — | — | — | — | 4 |
| SFU-09 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFM-A3 | — | — | — | — | — | — | — | — | — | — | 2 |
| SFM-A4 | — | — | — | — | — | — | — | — | — | — | 2 |
| SFM-B1 | — | — | — | 3 | — | — | — | V0.04 | — | 6 | 3 |
| SFM-B2 | — | E0.1 | — | E.1 | — | E0.04 | — | V0.02 | — | — | 4 |
| SFM-D1 | — | — | — | — | — | — | — | V0.03 | — | — | 0 |
| SFM-F1 | E0.1 | — | — | — | — | 0.55 | — | — | — | — | 4 |
| SFM-F2 | — | — | — | — | — | E0.03 | — | — | — | — | 1 |
| SFM-F3 | — | — | — | — | — | — | — | — | — | — | 1 |
| SFM-F5 | — | — | — | — | — | — | — | V0.01 | — | — | 0 |
| SFM-F6 | — | — | 4.5 | 144 | — | — | — | — | E0.02 | — | 4 |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The MCL-US threshold for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

³Frequency of detection of at least one VOC in the grid wells. Detections with V remark codes are not included.

Table 6. Pesticides and pesticide degradates detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 43 grid wells. All analytes are listed in *tables 3B* and *3C*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Health Services maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; µg/L, microgram per liter; na, not available; —, not detected]

| GAMA identification number | 2-Chloro-4-isopropylamino-6-amino-s-triazine (deethyl-atrazine), (µg/L) (04040) | Atrazine, (µg/L) (39632) | Simazine, (µg/L) (04035) | Prometon, (µg/L) (04037) | Benomyl, (µg/L) (50300) | Caffeine ¹ , (µg/L) (50305) | Sulfo-meturon, (µg/L) (50337) | Bentazon, (µg/L) (38711) | Metolachlor, (µg/L) (39415) | Pesticide detections per well |
|-------------------------------|---|--------------------------|--------------------------|--------------------------|-------------------------|--|-------------------------------|--------------------------|-----------------------------|-------------------------------|
| Threshold type ² | na | MCL-CA | MCL-US | HAL-US | na | na | na | MCL-CA | HAL-US | |
| Threshold level | na | 1 | 4 | 100 | na | na | na | 18 | 700 | |
| [LRL] | [0.014] | [0.007] | [0.006] | [0.01] | [0.02] | [0.04] | [0.06] | [0.02] | [0.01] | |
| Grid wells | | | | | | | | | | |
| SF-01 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-02 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-11 | — | — | — | — | E 0.003 | — | — | — | — | 1 |
| SF-19 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-26 | E 0.005 | — | 0.011 | — | — | — | — | — | — | 2 |
| SF-27 | — | E 0.006 | E 0.007 | — | — | — | — | — | — | 2 |
| SF-28 | E 0.096 | 0.107 | — | — | — | — | — | — | — | 2 |
| SF-31 | E 0.006 | — | — | — | — | E 0.006 | — | — | — | 1 |
| SF-34 | — | — | — | E 0.01 | — | — | — | — | — | 1 |
| SF-36 | E 0.006 | E 0.005 | 0.011 | — | — | — | — | — | — | 3 |
| SF-37 | E 0.004 | 0.008 | — | E 0.01 | — | — | E 0.003 | — | — | 4 |
| SF-38 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-39 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-40 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-41 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-42 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SF-43 | — | — | — | — | — | na ³ | — | — | — | 0 |
| Number of detections | 5 | 4 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | |
| Detection frequency (percent) | 12 | 9.0 | 7.0 | 4.6 | 2.3 | 2.3 | 2.3 | 0 | 0 | ⁴ 19 |
| Understanding wells | | | | | | | | | | |
| SFU-12 | — | — | — | — | — | na ³ | — | — | — | 0 |
| SFM-C1 | — | — | — | — | — | E 0.003 | — | — | — | 1 |
| SFM-E1 | — | — | — | — | — | E 0.011 | — | — | — | 1 |
| SFM-E3 | — | — | — | — | — | — | — | E 0.01 | E 0.007 | 2 |
| SFM-F1 | — | — | — | — | — | E 0.04 | — | — | — | 1 |
| SFM-F3 | — | — | — | — | — | E 0.02 | — | — | — | 1 |
| SFM-F5 | — | — | — | — | — | E 0.05 | — | — | — | 1 |

¹Although the preferred analytical method is schedule 2060, caffeine's primary use is not as a pesticide. It is more representative of a potential wastewater indicator compound. Caffeine data is not used for summary statistical calculations of pesticides.

²Maximum contaminant level thresholds are listed as MCL-US when 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.

³Samples for this analyte ruined in preparation at the lab.

⁴Frequency of detection of at least one pesticide or pesticide degradate in the grid wells.

Table 7. Potential wastewater indicator compounds detected in samples collected for the San Francisco Bay Ground-Water Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes are listed in *table 3E*. **GAMA Identification number:** SFM, San Francisco Bay study unit monitoring well. **Other abbreviations:** LRL, laboratory reporting level; µg/L, microgram per liter; E, estimated value; —, not detected]

| GAMA identification number | Tris(2-chloroethyl) phosphate (µg/L) (62087) | Tris(2-butoxyethyl) phosphate (µg/L) (62093) |
|---|---|---|
| Threshold type | na | na |
| Threshold | na | na |
| [LRL] | [0.18] | [0.5] |
| Grid wells | | |
| Number of detections | 0 | 0 |
| Detection frequency (percent) | 0 | 0 |
| Understanding wells | | |
| SFM-D1 | — | E 0.1 |
| SFM-F1 | E 0.1 | — |

Table 8. Constituents of special interest [Perchlorate and *N*-Nitrosodimethylamine (NDMA)] detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Information about the analytes given in *table 3F*. Samples from all 79 wells were analyzed for perchlorate, samples from the 31 slow wells (3 grid wells and 28 understanding wells) were sampled for NDMA; only wells with at least one detection are listed. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** MRL, method reporting level; µg/L, microgram per liter; nc, not collected; —, not detected; V, analyte detected in sample and an associated blank; thus, data are not included in ground-water quality assessment]

| GAMA identification number | Perchlorate (µg/L) (61209) | <i>N</i> -Nitroso-dimethylamine (NDMA) (µg/L) (64176) | GAMA identification number | Perchlorate (µg/L) (61209) | <i>N</i> -Nitroso-dimethylamine (NDMA) (µg/L) (64176) |
|-------------------------------|----------------------------|---|-----------------------------|----------------------------|---|
| Threshold type ¹ | MCL-CA | NL-CA | Threshold type ¹ | MCL-CA | NL-CA |
| Threshold level | 6 | 0.01 | Threshold level | 6 | 0.01 |
| [MRL] | [0.5] | [0.002] | [MRL] | [0.5] | [0.002] |
| Grid wells | | | Understanding wells | | |
| SF-01 | 0.80 | nc | SFU-02 | 0.96 | nc |
| SF-02 | 3.8 | nc | SFU-03 | 1.1 | nc |
| SF-03 | 1.3 | nc | SFU-04 | 1.3 | nc |
| SF-06 | 0.51 | nc | SFU-05 | 1.4 | nc |
| SF-07 | 0.90 | nc | | | |
| | | | SFU-06 | 0.58 | — |
| SF-09 | 0.80 | nc | SFU-07 | 0.80 | — |
| SF-10 | 0.76 | nc | SFU-08 | 1.4 | — |
| SF-11 | 0.58 | nc | SFU-10 | 0.72 | nc |
| SF-13 | 1.6 | nc | | | |
| SF-14 | 1.0 | nc | SFM-A1 | — | V0.009 |
| | | | SFM-A2 | — | V0.003 |
| SF-17 | 0.76 | nc | SFM-A3 | 0.68 | V0.002 |
| SF-18 | 1.0 | nc | SFM-A4 | 0.80 | — |
| SF-21 | 0.68 | nc | | | |
| SF-24 | 1.2 | — | SFM-B1 | — | 0.002 |
| SF-25 | 0.62 | nc | SFM-C2 | 1.0 | — |
| | | | SFM-C3 | 1.5 | — |
| SF-28 | 1.8 | — | | | |
| SF-29 | 2.1 | nc | SFM-D4 | — | 0.003 |
| SF-31 | 1.3 | nc | SFM-E2 | 5.2 | — |
| SF-33 | 1.5 | nc | | | |
| SF-40 | 1.1 | nc | SFM-F1 | — | 0.010 |
| Number of detections | 20 | 0 | SFM-F3 | — | 0.004 |
| Detection frequency (percent) | 46 | 0 | SFM-F5 | — | 0.002 |
| | | | SFM-F6 | — | 0.004 |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 9. Nutrients detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed. Information about the analytes given in *table 3G*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; mg/L, milligram per liter; LRL, laboratory reporting level; na, not available; *, value above regulatory threshold; —, not detected]

| GAMA identification number | Ammonia, as nitrogen (mg/L) (00608) | Nitrite, as nitrogen (mg/L) (00613) | Nitrite plus nitrate, as nitrogen (mg/L) (00631) | Total nitrogen (nitrate + nitrite + ammonia + organic- nitrogen), as nitrogen (mg/L) (62854) | Orthophosphate, as phosphorus (mg/L) (00671) |
|----------------------------------|--|--|---|--|---|
| Threshold type ¹ | HAL-US | MCL-US | MCL-US | na | na |
| Threshold | ² 30 | 1 | 10 | na | na |
| [LRL] | [0.02] | [0.002] | [0.06] | [0.06] | [0.006] |
| Grid wells | | | | | |
| SF-01 | — | — | 7.47 | 8.07 | 0.105 |
| SF-02 | — | 0.004 | *12.7 | 13.9 | 0.060 |
| SF-03 | — | — | 5.66 | 5.73 | 0.086 |
| SF-04 | 0.061 | 0.004 | 2.02 | 2.08 | 0.075 |
| SF-05 | 0.047 | 0.007 | 1.29 | 0.35 | 0.103 |
| SF-06 | — | E0.001 | 5.28 | 5.33 | 0.042 |
| SF-07 | — | 0.012 | 6.58 | *6.30 | 0.054 |
| SF-08 | 0.060 | 0.006 | 0.30 | 0.36 | 0.109 |
| SF-09 | — | — | 7.66 | 8.41 | 0.053 |
| SF-10 | — | — | 3.80 | 3.79 | 0.050 |
| SF-11 | — | — | 2.96 | 2.93 | 0.031 |
| SF-12 | — | — | 2.15 | 2.09 | 0.032 |
| SF-13 | — | — | 6.20 | 6.40 | 0.068 |
| SF-14 | — | — | 4.44 | 4.44 | 0.052 |
| SF-15 | — | 0.002 | 1.36 | 1.39 | 0.034 |
| SF-16 | — | E0.001 | 0.52 | 0.54 | 0.059 |
| SF-17 | — | 0.003 | 3.51 | 3.54 | 0.063 |
| SF-18 | — | — | 5.33 | 5.36 | 0.042 |
| SF-19 | 0.023 | 0.004 | 0.20 | 0.25 | 0.066 |
| SF-20 | — | — | 3.06 | 3.07 | 0.026 |
| SF-21 | — | — | 4.85 | *4.61 | 0.025 |
| SF-22 | — | — | 0.69 | 0.71 | 0.024 |
| SF-23 | — | — | 1.93 | 1.96 | 0.045 |
| SF-24 | — | — | 3.81 | 3.82 | 0.030 |
| SF-25 | — | 0.002 | 6.14 | 6.15 | 0.040 |
| SF-26 | — | — | 0.61 | 0.62 | 0.024 |
| SF-27 | — | — | 0.98 | 0.99 | 0.023 |
| SF-28 | — | — | 3.99 | 4.05 | 0.045 |
| SF-29 | — | — | 2.91 | 2.94 | 0.033 |
| SF-30 | — | — | 5.60 | 5.93 | 0.021 |
| SF-31 | — | — | 1.20 | 1.24 | 0.039 |

Table 9. Nutrients detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed. Information about the analytes given in *table 3G*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; mg/L, milligram per liter; LRL, laboratory reporting level; na, not available; *, value above regulatory threshold; —, not detected]

| GAMA identification number | Ammonia, as nitrogen (mg/L) (00608) | Nitrite, as nitrogen (mg/L) (00613) | Nitrite plus nitrate, as nitrogen (mg/L) (00631) | Total nitrogen (nitrate + nitrite + ammonia + organic- nitrogen), as nitrogen (mg/L) (62854) | Orthophosphate, as phosphorus (mg/L) (00671) |
|---|--|--|---|---|---|
| Threshold type¹ | HAL-US | MCL-US | MCL-US | na | na |
| Threshold | ²30 | 1 | 10 | na | na |
| [LRL] | [0.02] | [0.002] | [0.06] | [0.06] | [0.006] |
| SF-32 | — | — | 0.89 | 0.92 | 0.070 |
| SF-33 | — | — | 3.43 | 3.46 | 0.116 |
| SF-34 | — | 0.035 | 2.67 | 2.76 | 0.030 |
| SF-35 | 0.022 | — | 0.49 | 0.54 | 0.095 |
| SF-36 | — | — | 1.61 | 1.60 | 0.022 |
| SF-37 | — | — | 0.69 | 0.76 | 0.022 |
| SF-38 | 0.093 | — | — | 0.20 | 0.117 |
| SF-39 | — | E0.001 | 0.15 | 0.18 | 0.094 |
| SF-40 | — | — | 2.64 | 2.90 | 0.022 |
| SF-41 | 0.424 | 0.004 | E0.05 | 0.54 | E0.006 |
| SF-42 | — | 0.203 | 2.04 | 2.20 | 0.027 |
| SF-43 | — | E0.002 | 0.19 | 0.27 | 0.092 |
| Understanding Wells | | | | | |
| SFU-01 | 0.040 | 0.004 | 0.33 | 0.36 | 0.068 |
| SFU-02 | — | — | 3.78 | 3.76 | 0.048 |
| SFU-03 | — | — | 4.07 | 4.09 | 0.053 |
| SFU-04 | — | — | 5.34 | 5.35 | 0.052 |
| SFU-05 | — | — | 5.89 | ³ 5.77 | 0.061 |
| SFU-06 | — | — | 1.14 | 1.13 | 0.041 |
| SFU-07 | — | — | 3.30 | 3.45 | 0.052 |
| SFU-08 | — | — | 3.93 | 4.00 | 0.039 |
| SFU-09 | — | — | 2.73 | 2.87 | 0.027 |
| SFU-10 | — | — | 2.02 | 2.00 | 0.037 |
| SFU-11 | — | — | E0.06 | — | 0.037 |
| SFU-12 | — | — | 0.11 | 0.11 | 0.008 |
| SFM-A1 | 0.679 | — | — | 0.70 | 0.079 |
| SFM-A2 | E0.017 | 0.037 | 4.82 | ³ 4.55 | 0.078 |
| SFM-A3 | 0.064 | 0.092 | 8.54 | 9.04 | 0.043 |
| SFM-A4 | — | E0.002 | *11.2 | 11.9 | 0.091 |
| SFM-B1 | 0.710 | — | — | 0.80 | 0.235 |
| SFM-B2 | 3.88 | — | — | 3.40 | 0.266 |

Table 9. Nutrients detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed. Information about the analytes given in *table 3G*. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; thresholds and threshold values as of December 1, 2007. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; mg/L, milligram per liter; LRL, laboratory reporting level; na, not available; *, value above regulatory threshold; —, not detected]

| GAMA identification number | Ammonia, as nitrogen (mg/L) (00608) | Nitrite, as nitrogen (mg/L) (00613) | Nitrite plus nitrate, as nitrogen (mg/L) (00631) | Total nitrogen (nitrate + nitrite + ammonia + organic- nitrogen), as nitrogen (mg/L) (62854) | Orthophosphate, as phosphorus (mg/L) (00671) |
|-----------------------------------|--|--|---|--|---|
| Threshold type¹ | HAL-US | MCL-US | MCL-US | na | na |
| Threshold | ²30 | 1 | 10 | na | na |
| [LRL] | [0.02] | [0.002] | [0.06] | [0.06] | [0.006] |
| SFM-C1 | — | — | — | — | 0.041 |
| SFM-C2 | — | 0.009 | 6.57 | 6.71 | 0.035 |
| SFM-C3 | — | E0.002 | 3.73 | 3.75 | 0.032 |
| SFM-C4 | — | E0.001 | 3.85 | 3.98 | 0.047 |
| SFM-C5 | — | — | 2.56 | 2.63 | 0.045 |
| SFM-D1 | 0.151 | — | — | 0.17 | 0.232 |
| SFM-D2 | 0.026 | — | — | E0.03 | 0.081 |
| SFM-D3 | 0.770 | — | — | 0.77 | 0.116 |
| SFM-D4 | — | — | 3.63 | 3.71 | 0.032 |
| SFM-E1 | E0.017 | 0.005 | 0.28 | 0.33 | 0.056 |
| SFM-E2 | — | 0.008 | *11.0 | 11.1 | 0.051 |
| SFM-E3 | — | E0.001 | 3.56 | 3.65 | 0.026 |
| SFM-F1 | 0.105 | 0.002 | — | 0.15 | 0.607 |
| SFM-F2 | 0.167 | — | — | 0.19 | 0.239 |
| SFM-F3 | — | — | 0.36 | 0.40 | 0.146 |
| SFM-F4 | 0.183 | — | — | 0.23 | 0.428 |
| SFM-F5 | 0.728 | — | — | 0.68 | 0.990 |
| SFM-F6 | 2.46 | — | — | 2.17 | 1.27 |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²The HAL-US for ammonia is as ammonia, based on the inhalation of ammonia vapors.

³Total nitrogen in these samples is less than the sum of the filtered nitrogen analytes, but falls within the U.S. Geological Survey National Water Quality Laboratory acceptance criteria of a 10 percent relative percent difference.

Table 10. Major and minor ions, and total dissolved solids, detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parenthesis below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes listed in *table 3H, GAMA Identification number*: SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay monitoring well; thresholds and threshold values as of December 1, 2007. **Threshold type**: MCL-CA, California Department of Health Services maximum contaminant level; SMCL-CA, California Department of Health Services Secondary Maximum Contaminant Level. **Other abbreviations**: LRL, laboratory reporting level; E, estimated value; na, not available; mg/L, milligrams per liter. —, not detected; *, value above recommended threshold; **, value above upper threshold]

| GAMA identification number | Calcium (mg/L) (00915) | Magnesium (mg/L) (00925) | Potassium (mg/L) (00935) | Sodium (mg/L) (00930) | Bicarbonate ¹ (mg/L) | Carbonate ¹ (mg/L) | Bromide (mg/L) (71870) | Chloride (mg/L) (00940) | Fluoride (mg/L) (00950) | Iodide (mg/L) (71865) | Silica (mg/L) (00955) | Sulfate (mg/L) (00945) | Total dissolved solids (TDS) (mg/L) (70300) |
|----------------------------------|------------------------------|--------------------------------|--------------------------------|-----------------------------|------------------------------------|----------------------------------|------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|------------------------------|--|
| Threshold type ² | na | na | na | na | na | na | na | SMCL-CA (00940) | MCL-CA (00950) | na | na | SMCL-CA (00945) | SMCL-CA (70300) |
| Threshold level | na | na | na | na | na | na | na | 250 (500) | 2 | na | na | 250 (500) | 3500 (1,000) |
| [LRL] | [0.02] | [0.014] | [0.04] | [0.2] | [1] | [1] | [0.02] | [0.12] | [0.1] | [0.002] | [0.018] | [0.18] | [10] |
| Grid wells | | | | | | | | | | | | | |
| SF-24 | 88.7 | 46.0 | 1.50 | 37.1 | 408 | — | 0.20 | 53.4 | E0.09 | E0.001 | 29.2 | 64.9 | *529 |
| SF-28 | 66.2 | 65.8 | 1.31 | 42.6 | 442 | — | 0.20 | 52.4 | 0.17 | E0.001 | 30.2 | 81.3 | *578 |
| SF-35 | 204 | 69.2 | 3.79 | 259 | 277 | — | 2.78 | **736 | E0.07 | 0.033 | 21.8 | 142 | **1,860 |
| Understanding wells | | | | | | | | | | | | | |
| SFU-01 | 43.1 | 32.6 | 3.87 | 68.7 | 260 | — | 0.24 | 85.7 | 0.14 | 0.027 | 30.4 | 55.3 | 454 |
| SFU-06 | 69.2 | 39.0 | 1.31 | 46.8 | 364 | — | 0.18 | 49.8 | 0.16 | 0.022 | 27.0 | 72.9 | *545 |
| SFU-07 | 73.8 | 55.4 | 1.40 | 36.0 | 392 | — | 0.17 | 48.8 | 0.18 | — | 28.3 | 77.1 | *527 |
| SFU-08 | 71.4 | 64.4 | 1.37 | 40.6 | 459 | — | 0.21 | 57.1 | 0.19 | 0.002 | 29.7 | 78.0 | *871 |
| SFM-A1 | 50.7 | 29.5 | 3.97 | 90.4 | 256 | — | 0.32 | 105 | 0.19 | 0.023 | 30.0 | 81.5 | *517 |
| SFM-A2 | 20.1 | 22.1 | 1.67 | 31.3 | 138 | — | 0.18 | 48.9 | — | 0.003 | 34.9 | 7.97 | 232 |
| SFM-A3 | 27.2 | 20.3 | 1.87 | 42.1 | 143 | — | 0.21 | 39.5 | 0.13 | 0.006 | 31.1 | 34.1 | 293 |
| SFM-A4 | 27.6 | 26.0 | 1.78 | 37.3 | 137 | — | 0.26 | 37.9 | E0.06 | 0.003 | 29.0 | 43.4 | 309 |
| SFM-B1 | 41.1 | 27.5 | 6.68 | 96.3 | 252 | — | 0.47 | 144 | 0.23 | 0.022 | 32.1 | 33.6 | *511 |
| SFM-B2 | 456 | 579 | 59.7 | 4820 | 867 | — | 35.9 | **9,690 | 0.18 | 1.31 | 25.9 | **717 | **18,200 |
| SFM-C1 | 22.0 | 9.00 | 1.07 | 89.3 | 208 | 1 | 0.24 | 74.1 | 0.13 | 0.136 | 24.3 | 18.0 | 330 |
| SFM-C2 | 58.5 | 18.3 | 1.28 | 56.5 | 251 | — | 0.15 | 42.2 | E0.10 | 0.003 | 23.7 | 58.0 | 408 |
| SFM-C3 | 82.7 | 32.5 | 1.42 | 40.0 | 353 | — | 0.16 | 52.2 | E0.07 | 0.006 | 29.6 | 55.0 | 488 |
| SFM-C4 | 84.8 | 39.4 | 1.58 | 37.0 | 387 | 1 | 0.17 | 42.9 | 0.11 | 0.002 | 26.8 | 62.5 | *501 |
| SFM-C5 | 86.7 | 61.2 | 1.52 | 39.6 | 465 | — | 0.21 | 59.7 | 0.23 | E0.001 | 24.9 | 87.4 | *614 |

Table 10. Major and minor ions, and total dissolved solids, detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parenthesis below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes listed in *table 3H. GAMA Identification number*: SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay monitoring well; thresholds and threshold values as of December 1, 2007. **Threshold type**: MCL-CA, California Department of Health Services maximum contaminant level; SMCL-CA, California Department of Health Services Secondary Maximum Contaminant Level. **Other abbreviations**: LRL, laboratory reporting level; E, estimated value; na, not available; mg/L, milligrams per liter. —, not detected; *, value above recommended threshold; **, value above upper threshold]

| GAMA identification number | Calcium (mg/L) (00915) | Magnesium (mg/L) (00925) | Potassium (mg/L) (00935) | Sodium (mg/L) (00930) | Bicarbonate ¹ (mg/L) | Carbonate ¹ (mg/L) | Bromide (mg/L) (71870) | Chloride (mg/L) (00940) | Fluoride (mg/L) (00950) | Iodide (mg/L) (71865) | Silica (mg/L) (00955) | Sulfate (mg/L) (00945) | Total dissolved solids (TDS) (mg/L) (70300) |
|----------------------------------|------------------------------|--------------------------------|--------------------------------|-----------------------------|------------------------------------|----------------------------------|------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|------------------------------|--|
| Threshold type ² | na | na | na | na | na | na | na | na | MCL-CA | na | na | SMCL-CA | SMCL-CA |
| Threshold level | na | na | na | na | na | na | na | na | 2 | na | na | 250 (500) | 3500 (1,000) |
| [LRL] | [0.02] | [0.014] | [0.04] | [0.2] | [1] | [1] | [0.02] | [0.12] | [0.1] | [0.002] | [0.018] | [0.18] | [10] |
| SFM-D1 | 18.3 | 3.46 | 1.03 | 111 | 263 | 2 | 0.14 | 35.2 | 0.12 | 0.192 | 21.0 | 35.0 | 359 |
| SFM-D2 | 46.1 | 12.3 | 1.58 | 90.1 | 301 | 1 | 0.20 | 52.3 | 0.17 | 0.147 | 22.4 | 45.3 | 426 |
| SFM-D3 | 264 | 88.7 | 6.03 | 245 | 389 | — | 3.11 | **878 | E0.10 | 0.027 | 25.4 | 114 | **1,920 |
| SFM-D4 | 110 | 50.9 | 2.72 | 234 | 702 | — | 0.69 | 188 | 0.29 | 0.005 | 18.9 | 101 | **1,120 |
| SFM-E1 | 56.8 | 14.3 | 2.31 | 170 | 249 | — | 0.84 | 226 | 0.24 | 0.325 | 21.1 | 60.6 | *680 |
| SFM-E2 | 133 | 36.9 | 3.22 | 47.8 | 375 | — | 0.89 | 130 | 0.15 | 0.003 | 23.0 | 73.7 | *679 |
| SFM-E3 | 178 | 82.3 | 3.03 | 216 | 390 | — | 2.29 | **593 | 0.17 | 0.009 | 18.3 | 129 | **1,580 |
| SFM-F1 | 21.6 | 11.1 | 3.77 | 280 | 551 | — | 0.70 | 146 | 0.79 | 1.97 | 22.1 | 61.5 | na |
| SFM-F2 | 15.7 | 6.08 | 1.53 | 190 | 313 | 2 | 0.64 | 138 | 0.33 | 1.75 | 21.2 | 37.2 | *568 |
| SFM-F3 | 15.6 | 4.56 | 1.16 | 92.1 | 189 | — | 0.14 | 47.1 | 0.28 | 0.357 | 22.7 | 33.1 | 302 |
| SFM-F4 | 32.9 | 11.4 | 1.53 | 127 | 314 | 1 | 0.20 | 68.1 | 0.20 | 0.31 | 31.3 | 50.7 | 487 |
| SFM-F5 | 34.0 | 17.5 | 5.22 | 121 | 350 | 2 | 0.22 | 62.3 | 0.27 | 0.258 | 35.1 | 37.5 | 488 |
| SFM-F6 | 1,350 | 2,910 | 376 | 22,700 | 490 | — | 140 | **44,200 | 0.13 | 1.29 | 22.5 | **5,540 | **77,800 |

¹Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values (*table 4*) using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_w = 14$.

²Maximum contaminant level thresholds are listed as MCL-US when 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.

³The SMCL-CA for chloride, sulfate, and total dissolved solids have recommended and upper threshold values. The upper value is shown in parentheses.

Table 11. Trace elements detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes are listed in *table 3H*. **GAMA Identification number:** SF, San Francisco Bay study unit grid-well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA well identification number | Aluminum (µg/L) (01106) | Antimony (µg/L) (01095) | Arsenic (µg/L) (01000) | Barium (µg/L) (01005) | Boron (µg/L) (01020) | Cadmium (µg/L) (01025) | Chromium (µg/L) (01030) | Cobalt (µg/L) (01035) | Copper (µg/L) (01040) | Iron (µg/L) (01046) |
|---------------------------------|-------------------------------|-------------------------------|------------------------------|-----------------------------|----------------------------|------------------------------|-------------------------------|-----------------------------|-----------------------------|---------------------------|
| Threshold type ¹ | MCL-CA 1,000 | MCL-US 6 | MCL-US 10 | MCL-CA 1,000 | NL-CA 1,000 | MCL-US 5 | MCL-CA 50 | na | AL-US 1,300 | SMCL-CA 300 |
| Threshold level | [1.6] | [0.06] | [0.12] | [0.08] | [8] | [0.04] | [0.12] | [0.04] | [0.4] | [6] |
| Grid Wells | | | | | | | | | | |
| SF-24 | — | E0.04 | 0.40 | 242 | 129 | — | 4.9 | — | 2.5 | 11 |
| SF-28 | — | E0.05 | 0.83 | 302 | 179 | — | 5.0 | — | 1.9 | — |
| SF-35 | — | — | 1.1 | 83 | 417 | — | — | E0.04 | E0.73 | 24 |
| Understanding Wells | | | | | | | | | | |
| SFU-01 | E1.2 | — | 0.91 | 104 | 87 | — | E0.11 | E0.02 | — | 16 |
| SFU-06 | — | E0.05 | 0.74 | 141 | 128 | — | 0.62 | — | E0.21 | — |
| SFU-07 | — | E0.03 | 0.48 | 186 | 122 | — | 4.8 | — | 2.6 | — |
| SFU-08 | — | E0.05 | 0.67 | 272 | 150 | — | 5.7 | — | 1.1 | 7 |
| SFM-A1 | E1.2 | — | 1.4 | 125 | 97 | — | E0.08 | E0.02 | — | 202 |
| SFM-A2 | E1.5 | 0.09 | 1.8 | 24 | 19 | — | 2.6 | 0.10 | E0.29 | 6 |
| SFM-A3 | E1.1 | 0.29 | 3.3 | 46 | 26 | — | 0.32 | 0.41 | — | 56 |
| SFM-A4 | — | E0.04 | 1.7 | 16 | 28 | — | 5.5 | — | — | E4 |
| SFM-B1 | 2.3 | — | 3.8 | 35 | 103 | — | 0.28 | — | — | 106 |
| SFM-B2 | E19.4 | — | *13.3 | 148 | *1,230 | — | — | 1.8 | — | *1,370 |
| SFM-C1 | E1.5 | E0.03 | 1.4 | 204 | 175 | E0.02 | E0.08 | E0.03 | — | E4 |
| SFM-C2 | E0.9 | 0.11 | 0.91 | 235 | 122 | E0.02 | E0.09 | 0.08 | E0.28 | E4 |
| SFM-C3 | — | 0.06 | 0.61 | 319 | 117 | — | 0.94 | 0.04 | E0.27 | 7 |
| SFM-C4 | E0.9 | 0.08 | 0.74 | 226 | 97 | E0.02 | 1.4 | 0.07 | E0.29 | 10 |
| SFM-C5 | E0.9 | E0.03 | 0.54 | 64 | 123 | — | 0.77 | — | 0.42 | E6 |

Table 11. Trace elements detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes are listed in *table 3H*. **GAMA Identification number:** SF, San Francisco Bay study unit grid-well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA well identification number | Aluminum (µg/L) (01106) | Antimony (µg/L) (01095) | Arsenic (µg/L) (01000) | Barium (µg/L) (01005) | Boron (µg/L) (01020) | Cadmium (µg/L) (01025) | Chromium (µg/L) (01030) | Cobalt (µg/L) (01035) | Copper (µg/L) (01040) | Iron (µg/L) (01046) |
|---------------------------------|-------------------------------|-------------------------------|------------------------------|-----------------------------|----------------------------|------------------------------|-------------------------------|-----------------------------|-----------------------------|---------------------------|
| Threshold type ¹ | MCL-CA | MCL-US | MCL-US | MCL-CA | NL-CA | MCL-US | MCL-CA | na | AL-US | SMCL-CA |
| Threshold level | 1,000 | 6 | 10 | 1,000 | 1,000 | 5 | 50 | na | 1,300 | 300 |
| [LRL] | [1.6] | [0.06] | [0.12] | [0.08] | [8] | [0.04] | [0.12] | [0.04] | [0.4] | [6] |
| SFM-D1 | 2.4 | 0.10 | 6.1 | 91 | 260 | E0.02 | E0.11 | 0.06 | — | 114 |
| SFM-D2 | E1.3 | 0.07 | 1.9 | 131 | 391 | 0.04 | 0.34 | 0.06 | — | 9 |
| SFM-D3 | 12.4 | E0.06 | 1.0 | 180 | 336 | 0.20 | 0.34 | 0.18 | E0.44 | E12 |
| SFM-D4 | E1.1 | 0.09 | 0.59 | 69 | 871 | 0.04 | 1.6 | 0.04 | 0.51 | 14 |
| SFM-E1 | 7.1 | 0.09 | 1.7 | 140 | 461 | 0.05 | 0.30 | 0.04 | — | E4 |
| SFM-E2 | — | 0.07 | 0.79 | 96 | 388 | E0.03 | 0.24 | 0.05 | E0.25 | E4 |
| SFM-E3 | — | — | 0.42 | 62 | 394 | E0.04 | 1.1 | E0.06 | — | 19 |
| SFM-F1 | — | 0.16 | *15.0 | 91 | 744 | 0.20 | 0.89 | E0.03 | 5.5 | 10 |
| SFM-F2 | 2.6 | 0.13 | 6.4 | 69 | 549 | 0.04 | E0.07 | — | — | E 5 |
| SFM-F3 | E1.4 | E0.05 | 0.71 | 31 | 344 | E0.02 | 0.12 | 0.08 | — | — |
| SFM-F4 | E1.5 | 0.08 | 6.3 | 49 | 449 | E0.02 | 0.31 | E0.02 | — | E5 |
| SFM-F5 | — | 0.09 | *13.5 | 36 | 451 | — | 0.15 | 0.04 | 0.47 | — |
| SFM-F6 | — | — | 8.5 | 98 | *5,720 | *10.0 | 6.5 | 43.0 | E16.0 | — |

Table 11. Trace elements detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes are listed in *table 3H. GAMA Identification number*: SF, San Francisco Bay study unit grid-well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA identification number | Lead (µg/L) (01049) | Lithium (µg/L) (01130) | Manganese (µg/L) (01056) | Molyb- denum (µg/L) (01060) | Nickel (µg/L) (01065) | Selenium (µg/L) (01145) | Strontium (µg/L) (01080) | Tungsten (µg/L) (01155) | Uranium (µg/L) (22703) | Vanadium (µg/L) (01085) | Zinc (µg/L) (01090) |
|----------------------------------|---------------------------|------------------------------|--------------------------------|--------------------------------------|-----------------------------|-------------------------------|--------------------------------|-------------------------------|------------------------------|-------------------------------|---------------------------|
| Threshold type¹ | AL-US | na | SMCL-CA | HAL-US | MCL-CA | MCL-US | HAL-US | na | MCL-US | NL-CA | SMCL-CA |
| Threshold level | 15 | na | 50 | 40 | 100 | 50 | 4000 | na | 30 | 50 | 5,000 |
| [LRL] | [0.12] | [0.6] | [0.2] | [0.12] | [0.06] | [0.08] | [0.4] | [0.06] | [0.04] | [0.04] | [0.6] |
| Grid Wells | | | | | | | | | | | |
| SF-24 | 0.61 | 9.3 | 0.7 | 0.6 | 0.20 | 6.0 | 604 | — | 1.42 | 3.4 | 6.0 |
| SF-28 | 1.21 | 11.1 | — | 0.7 | 0.21 | 4.6 | 653 | — | 1.34 | 4.6 | 4.9 |
| SF-35 | 1.18 | 18.6 | *408 | 0.7 | 0.40 | 0.29 | 2140 | — | 1.62 | 1.5 | 2.6 |
| Understanding Wells | | | | | | | | | | | |
| SFU-01 | 0.91 | 33.9 | *84.8 | 0.7 | 0.35 | 0.68 | 487 | E0.03 | 0.36 | 2.9 | 1.4 |
| SFU-06 | 0.22 | 7.7 | — | 1.1 | 0.07 | 3.3 | 475 | — | 1.27 | 3.6 | 1.3 |
| SFU-07 | 0.91 | 6.2 | — | 0.9 | 0.10 | 5.4 | 516 | — | 1.19 | 3.1 | 2.5 |
| SFU-08 | 0.68 | 9.3 | — | 0.7 | 0.19 | 5.0 | 614 | — | 1.30 | 4.3 | 2.1 |
| SFM-A1 | — | 42.4 | *239 | 1.3 | 0.26 | — | 517 | 0.18 | E0.02 | 0.07 | 3.2 |
| SFM-A2 | — | 2.7 | *63.6 | 0.5 | 0.67 | 0.47 | 133 | 0.10 | 0.22 | 7.2 | 0.65 |
| SFM-A3 | — | 1.5 | *590 | 4.2 | 1.3 | 0.46 | 179 | 0.29 | 0.53 | 4.1 | 1.0 |
| SFM-A4 | — | 4.0 | 0.6 | 0.3 | 0.31 | 1.0 | 182 | E0.05 | 0.57 | 8.1 | E0.59 |
| SFM-B1 | — | 16.6 | *264 | 2.2 | 0.23 | E0.07 | 375 | 0.18 | 0.21 | 0.30 | — |
| SFM-B2 | — | 107 | *8,560 | 10.9 | 3.9 | 1.2 | *5,210 | — | 7.95 | 4.5 | 15.0 |
| SFM-C1 | — | 5.6 | 22.5 | 9.3 | 0.14 | — | 184 | 0.08 | 0.23 | 8.3 | 0.63 |
| SFM-C2 | — | 7.0 | 21.3 | 2.7 | 0.14 | 3.1 | 422 | 0.06 | 0.98 | 5.7 | 0.70 |
| SFM-C3 | — | 9.0 | 8.7 | 0.4 | 0.30 | 3.9 | 567 | E0.04 | 1.52 | 5.0 | 1.0 |
| SFM-C4 | — | 7.8 | 10.4 | 1.5 | 0.85 | 5.2 | 491 | 0.40 | 2.01 | 3.5 | 1.8 |
| SFM-C5 | — | 11.4 | 0.6 | 0.7 | 0.59 | 6.5 | 852 | 0.06 | 1.92 | 1.9 | 1.5 |

Table 11. Trace elements detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the 31 slow wells (3 grid wells and 28 understanding wells) were analyzed, but only samples with detections are listed. All analytes are listed in *table 3H. GAMA Identification number*: SF, San Francisco Bay study unit grid-well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA identification number | Lead (µg/L) (01049) | Lithium (µg/L) (01130) | Manganese (µg/L) (01056) | Molybdenum (µg/L) (01060) | Nickel (µg/L) (01065) | Selenium (µg/L) (01145) | Strontium (µg/L) (01080) | Tungsten (µg/L) (01155) | Uranium (µg/L) (22703) | Vanadium (µg/L) (01085) | Zinc (µg/L) (01090) |
|-----------------------------|---------------------|------------------------|--------------------------|---------------------------|-----------------------|-------------------------|--------------------------|-------------------------|------------------------|-------------------------|---------------------|
| Threshold type ¹ | AL-US | na | SMCL-CA | HAL-US | MCL-CA | MCL-US | HAL-US | na | MCL-US | NL-CA | SMCL-CA |
| Threshold level | 15 | na | 50 | 40 | 100 | 50 | 4000 | na | 30 | 50 | 5,000 |
| [LRL] | [0.12] | [0.6] | [0.2] | [0.12] | [0.06] | [0.08] | [0.4] | [0.06] | [0.04] | [0.04] | [0.6] |
| SFM-D1 | — | 5.1 | *165 | 14.4 | 0.26 | E0.05 | 246 | 0.23 | 0.40 | 0.42 | — |
| SFM-D2 | — | 8.9 | *128 | 22.8 | 0.46 | 1.8 | 651 | 0.21 | 1.22 | 2.3 | — |
| SFM-D3 | — | 21.5 | *2,030 | 2.2 | 0.50 | E0.12 | 2,890 | 0.14 | 2.92 | 1.6 | E 0.92 |
| SFM-D4 | — | 22.0 | 3.4 | 1.8 | 0.53 | 2.9 | 968 | 0.17 | 5.83 | 1.6 | 1.4 |
| SFM-E1 | — | 14.6 | *99.9 | 25.8 | 0.36 | — | 853 | 0.30 | 1.13 | 3.9 | — |
| SFM-E2 | — | 14.1 | 29.6 | 1.5 | 0.25 | 13.4 | 1,570 | 0.61 | 4.38 | 1.4 | 0.90 |
| SFM-E3 | — | 17.1 | 8.9 | 1.0 | 1.4 | E 0.1 | 1,760 | E0.07 | 3.44 | 1.0 | 1.2 |
| SFM-F1 | — | 17.7 | *92.4 | 30.8 | 1.5 | 0.09 | 342 | 2.9 | 2.98 | 2.7 | 9.7 |
| SFM-F2 | — | 11.6 | 25.4 | 33.8 | 0.13 | E0.04 | 260 | 0.49 | 0.73 | 5.4 | — |
| SFM-F3 | — | 10.5 | *55.1 | 10.6 | 0.17 | — | 187 | 0.18 | 0.34 | 1.8 | — |
| SFM-F4 | — | 11.2 | *152 | 9.5 | 0.38 | — | 544 | 0.31 | 1.36 | 1.1 | — |
| SFM-F5 | — | 15.2 | *90.3 | 5.9 | 0.31 | — | 401 | 0.32 | 0.77 | 1.3 | — |
| SFM-F6 | — | 412 | *37,000 | 20.0 | 46.5 | 7.5 | *23,600 | — | 9.50 | 9.5 | — |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 12. Species of inorganic arsenic, iron, and chromium detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Data in this table were analyzed at the U.S. Geological Survey Trace Metals Laboratory (laboratory entity code USGSTMCO) using research methods and are not stored in the USGS' NWIS database. Information about analytes given in *table 31*. Samples from all 79 wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA identification number | Iron (total) (µg/L) | Iron (II) (µg/L) | Arsenic (total) (µg/L) | Arsenic (III) (µg/L) | Chromium (total) (µg/L) | Chromium (VI) (µg/L) |
|---|------------------------------------|-----------------------------|---------------------------------------|---------------------------------|--|---------------------------------|
| Threshold type¹ | SMCL-CA | na | MCL-US | na | MCL-CA | na |
| Threshold level | 300 | na | 10 | na | 50 | na |
| [MDL] | [2] | [2] | [0.5] | [1] | [1] | [1] |
| Grid wells | | | | | | |
| SF-01 | — | — | 1.7 | — | 18 | 17 |
| SF-02 | 6 | 2 | — | — | 27 | 25 |
| SF-03 | 12 | 2 | — | — | 7 | 7 |
| SF-04 | 10 | 2 | — | — | 10 | 10 |
| SF-05 | 3 | 2 | — | — | 3 | 3 |
| SF-06 | 2 | — | — | — | — | — |
| SF-07 | *469 | 249 | — | — | — | — |
| SF-08 | 4 | — | 0.9 | — | — | — |
| SF-09 | 9 | 3 | — | — | 3 | 2 |
| SF-10 | 6 | 2 | — | — | — | — |
| SF-11 | — | — | — | — | 2 | 2 |
| SF-12 | — | — | — | — | 1 | 1 |
| SF-13 | 3 | — | — | — | — | — |
| SF-14 | 2 | — | — | — | — | — |
| SF-15 | 3 | — | 1.8 | — | — | — |
| SF-16 | 3 | — | 0.7 | — | — | — |
| SF-17 | 11 | 5 | 0.6 | — | — | — |
| SF-18 | 23 | 3 | — | — | — | — |
| SF-19 | 6 | — | 0.9 | — | — | — |
| SF-20 | 10 | 3 | — | — | — | — |
| SF-21 | 49 | 17 | — | — | 1 | — |
| SF-22 | 81 | 51 | — | — | — | — |
| SF-23 | 4 | — | — | — | — | — |
| SF-24 | 12 | 3 | — | — | 4 | 4 |
| SF-25 | 3 | 2 | — | — | — | — |
| SF-26 | 57 | 32 | — | — | 2 | 2 |
| SF-27 | 7 | 7 | — | — | 2 | 2 |
| SF-28 | — | — | — | — | 4 | 4 |
| SF-29 | 3 | — | — | — | 4 | 3 |
| SF-31 | 3 | — | — | — | 8 | 9 |

Table 12. Species of inorganic arsenic, iron, and chromium detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[Data in this table was analyzed at the U.S. Geological Survey Trace Metals Laboratory (laboratory entity code USGSTMCO) using research methods and are not stored in the USGS' NWIS database. Information about analytes given in *table 31*. Samples from all 79 wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA identification number | Iron (total) (µg/L) | Iron (II) (µg/L) | Arsenic (total) (µg/L) | Arsenic (III) (µg/L) | Chromium (total) (µg/L) | Chromium (VI) (µg/L) |
|---|------------------------------------|-----------------------------|---------------------------------------|---------------------------------|--|---------------------------------|
| Threshold type¹ | SMCL-CA | na | MCL-US | na | MCL-CA | na |
| Threshold level | 300 | na | 10 | na | 50 | na |
| [MDL] | [2] | [2] | [0.5] | [1] | [1] | [1] |
| SF-32 | 3 | — | 1.8 | — | — | — |
| SF-33 | — | — | 0.6 | — | 3 | 3 |
| SF-34 | 2 | — | 0.5 | — | — | — |
| SF-35 | 24 | 22 | 0.9 | — | — | — |
| SF-36 | — | — | 0.5 | — | 1 | — |
| SF-38 | 59 | 7 | 0.9 | — | — | — |
| SF-39 | 6 | — | — | — | — | — |
| SF-40 | 6 | — | 0.8 | — | — | — |
| SF-41 | 55 | — | — | — | — | — |
| SF-42 | 156 | — | — | — | — | — |
| SF-43 | 36 | 30 | 1.8 | — | — | — |
| Number of detections | 36 | 19 | 14 | 0 | 17 | 15 |
| Detection frequency (percent) | 80 | 42 | 31 | 0 | 38 | 33 |
| Understanding wells | | | | | | |
| SFU-01 | 14 | 8 | 1.1 | — | — | — |
| SFU-02 | — | — | — | — | 2 | 2 |
| SFU-04 | 2 | — | — | — | — | — |
| SFU-06 | 4 | 3 | — | — | — | — |
| SFU-07 | — | — | — | — | 5 | 5 |
| SFU-08 | — | — | — | — | 6 | 6 |
| SFU-09 | 5 | — | 0.6 | — | 1 | — |
| SFU-10 | 3 | — | 0.8 | — | — | — |
| SFU-11 | 3 | — | — | — | — | — |
| SFM-A1 | 188 | 159 | 1.3 | — | — | — |
| SFM-A2 | 5 | 2 | 1.7 | — | 3 | 3 |
| SFM-A3 | 53 | 10 | 1.3 | 1 | — | — |
| SFM-A4 | 4 | 2 | — | — | 5 | 5 |
| SFM-B1 | 100 | 100 | 1.6 | 2 | — | — |
| SFM-B2 | — | — | 8.5 | 9 | — | — |

Table 12. Species of inorganic arsenic, iron, and chromium detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[Data in this table was analyzed at the U.S. Geological Survey Trace Metals Laboratory (laboratory entity code USGSTMCO) using research methods and are not stored in the USGS' NWIS database. Information about analytes given in *table 31*. Samples from all 79 wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, microgram per liter; —, not detected; *, value exceeds threshold]

| GAMA identification number | Iron (total) (µg/L) | Iron (II) (µg/L) | Arsenic (total) (µg/L) | Arsenic (III) (µg/L) | Chromium (total) (µg/L) | Chromium (VI) (µg/L) |
|---|------------------------------------|-----------------------------|---------------------------------------|---------------------------------|--|---------------------------------|
| Threshold type¹ | SMCL-CA | na | MCL-US | na | MCL-CA | na |
| Threshold level | 300 | na | 10 | na | 50 | na |
| [MDL] | [2] | [2] | [0.5] | [1] | [1] | [1] |
| SFM-C2 | 4 | — | — | — | — | — |
| SFM-C3 | 6 | — | — | — | — | — |
| SFM-C4 | 10 | 5 | — | — | — | — |
| SFM-C5 | 7 | 4 | — | — | — | — |
| SFM-D1 | 112 | 53 | 2.3 | 2 | — | — |
| SFM-D2 | 10 | 6 | — | — | — | — |
| SFM-D3 | 17 | 12 | 1.3 | — | — | — |
| SFM-D4 | 13 | 4 | — | — | 2 | 2 |
| SFM-E1 | 4 | 3 | — | — | — | — |
| SFM-E2 | 6 | 2 | — | — | — | — |
| SFM-E3 | 8 | 4 | — | — | — | — |
| SFM-F1 | 6 | 6 | 10 | — | — | — |
| SFM-F2 | 4 | — | 5.2 | 3 | — | — |
| SFM-F3 | 5 | — | — | — | — | — |
| SFM-F4 | 5 | — | 5.8 | — | — | — |
| SFM-F5 | 5 | — | 15 | 7 | — | — |
| SFM-F6 | 35 | 29 | 6.5 | 2 | 2 | 4 |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

Table 13. Results for analyses of stable isotope ratios and tritium and carbon-14 activities in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Information about analytes given in *table 3J*. Samples from all 79 wells were analyzed for stable isotopes of water and nitrate, tritium and carbon. Thirty-one slow wells were analyzed for stable isotopes of boron. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; N, nitrogen; B, boron; na, not available; nc, sample not collected; pCi/L, picocuries per liter; —, not detected]

| GAMA identification number | $\delta^2\text{H}$ of water (per mil) (82082) ¹ | $\delta^{18}\text{O}$ of water (per mil) (82085) ¹ | Tritium (pCi/L) (07000) ² | Tritium 2-sigma combined uncertainty (pCi/L) (75985) ² | $\delta^{13}\text{C}$ of dissolved carbonates (per mil) (82081) ³ | Carbon-14 (percent modern) (49933) ⁴ | $\delta^{15}\text{N}$ of dissolved nitrate (per mil) (82690) ¹ | $\delta^{18}\text{O}$ of dissolved nitrate (per mil) (63041) ¹ | $\delta^{11}\text{B}$ (per mil) (62648) ⁵ |
|----------------------------------|---|--|--|--|--|--|---|---|--|
| Threshold type ⁶ | na | na | MCL-CA | na | na | na | na | na | na |
| Threshold level | na | na | 20,000 | na | na | na | na | na | na |
| Grid wells | | | | | | | | | |
| SF-01 | -45.6 | -6.70 | 17.0 | 1.3 | -20.23 | 86.97 | 7.28 | 3.30 | nc |
| SF-02 | -42.8 | -6.50 | 10.2 | 1.0 | -19.42 | 84.25 | 6.89 | 2.51 | nc |
| SF-03 | -33.6 | -5.25 | 6.7 | 1.0 | na | na | 8.16 | 2.31 | nc |
| SF-04 | -37.6 | -5.94 | 1.0 | 0.6 | -18.99 | 65.16 | 6.90 | 2.77 | nc |
| SF-05 | -35.4 | -5.66 | 0.6 | 0.6 | -17.92 | 50.16 | 6.73 | 4.27 | nc |
| SF-06 | -58.4 | -8.45 | 7.0 | 1.0 | -19.14 | 105.5 | 8.90 | 1.78 | nc |
| SF-07 | -50.5 | -7.30 | 17.3 | 1.3 | -19.71 | 93.74 | 7.91 | 3.84 | nc |
| SF-08 | -42.8 | -6.27 | 4.5 | 0.6 | -15.57 | 44.44 | 23.29 | 11.48 | nc |
| SF-09 | -42.6 | -6.15 | 3.8 | 1.3 | -14.55 | 80.15 | 7.68 | 2.75 | nc |
| SF-10 | -41.0 | -6.29 | 1.6 | 0.6 | -14.09 | 54.44 | 7.94 | 3.56 | nc |
| SF-11 | -40.9 | -6.30 | 7.7 | 1.0 | -12.01 | 88.62 | 6.22 | 1.94 | nc |
| SF-12 | -40.6 | -6.20 | 9.3 | 1.0 | -13.08 | 97.76 | 7.50 | 2.37 | nc |
| SF-13 | -43.8 | -6.36 | 4.5 | 0.6 | -15.27 | 79.52 | 6.85 | 3.72 | nc |
| SF-14 | -42.0 | -6.50 | 3.8 | 0.6 | -15.02 | 75.88 | 6.83 | 4.46 | nc |
| SF-15 | -40.5 | -6.64 | 0.6 | 0.6 | -14.46 | 49.77 | 8.01 | 4.69 | nc |
| SF-16 | -42.2 | -6.51 | 1.3 | 0.6 | -14.50 | 42.12 | 11.58 | 7.60 | nc |
| SF-17 | -42.5 | -6.29 | 6.7 | 1.0 | -14.37 | 80.06 | 8.05 | 5.96 | nc |
| SF-18 | -46.8 | -6.79 | 5.8 | 1.0 | -14.21 | 51.94 | 10.31 | 5.76 | nc |
| SF-19 | -42.9 | -6.50 | — | 1.0 | -17.44 | 36.73 | 24.39 | 19.36 | nc |
| SF-20 | -46.8 | -6.67 | 10.2 | 1.0 | -14.52 | 99.74 | 7.17 | 2.50 | nc |
| SF-21 | -48.3 | -6.96 | 9.9 | 1.0 | -15.35 | 95.89 | 6.80 | 2.60 | nc |
| SF-22 | -52.0 | -7.40 | 8.6 | 1.0 | -14.10 | 105.6 | 7.99 | 0.27 | nc |
| SF-23 | -44.6 | -6.76 | 9.6 | 1.0 | -14.45 | 77.69 | 7.76 | 3.11 | nc |
| SF-24 | -43.3 | -6.18 | 9.9 | 1.0 | -16.15 | 83.63 | 9.23 | 6.39 | 16.4 |
| SF-25 | -52.8 | -7.35 | 11.2 | 1.0 | -13.43 | 73.32 | 6.68 | 4.67 | nc |
| SF-26 | -43.2 | -5.82 | 4.8 | 0.6 | -13.67 | 99.84 | 9.42 | 3.54 | nc |
| SF-27 | -43.4 | -6.19 | 6.4 | 1.0 | -14.41 | 89.86 | 8.44 | 4.20 | nc |
| SF-28 | -43.2 | -6.08 | 10.6 | 1.0 | -15.31 | 95.57 | 11.23 | 8.65 | 9.0 |
| SF-29 | -43.8 | -6.05 | 8.3 | 1.0 | -15.60 | 98.48 | 9.47 | 7.89 | nc |
| SF-30 | -46.2 | -6.67 | 7.0 | 1.0 | -13.47 | 85.23 | 9.92 | 4.24 | nc |

Table 13. Results for analyses of stable isotope ratios and tritium and carbon-14 activities in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Information about analytes given in *table 3J*. Samples from all 79 wells were analyzed for stable isotopes of water and nitrate, tritium and carbon. Thirty-one slow wells were analyzed for stable isotopes of boron. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; N, nitrogen; B, boron; na, not available; nc, sample not collected; pCi/L, picocuries per liter; —, not detected]

| GAMA identification number | $\delta^2\text{H}$ of water (per mil) (82082) ¹ | $\delta^{18}\text{O}$ of water (per mil) (82085) ¹ | Tritium (pCi/L) (07000) ² | Tritium 2-sigma combined uncertainty (pCi/L) (75985) ² | $\delta^{13}\text{C}$ of dissolved carbonates (per mil) (82081) ³ | Carbon-14 (percent modern) (49933) ⁴ | $\delta^{15}\text{N}$ of dissolved nitrate (per mil) (82690) ¹ | $\delta^{18}\text{O}$ of dissolved nitrate (per mil) (63041) ¹ | $\delta^{11}\text{B}$ (per mil) (62648) ⁵ |
|-----------------------------|--|---|--------------------------------------|---|--|---|---|---|--|
| Threshold type ⁶ | na | na | MCL-CA | na | na | na | na | na | na |
| Threshold level | na | na | 20,000 | na | na | na | na | na | na |
| SF-31 | -41.2 | -5.75 | 10.2 | 1.0 | -13.87 | 96.45 | 7.09 | 4.97 | nc |
| SF-32 | -43.6 | -6.02 | 8.6 | 1.0 | -14.94 | 92.52 | 6.96 | 4.43 | nc |
| SF-33 | -42.9 | -6.17 | 6.1 | 0.6 | -14.98 | 77.81 | 6.14 | 3.58 | nc |
| SF-34 | -33.8 | -4.15 | 12.8 | 1.3 | -14.74 | 87.59 | 30.87 | 18.46 | nc |
| SF-35 | -46.6 | -6.28 | 20.2 | 1.6 | -15.98 | 35.28 | 18.68 | 11.64 | 17.0 |
| SF-36 | -47.7 | -6.54 | 12.5 | 1.3 | -15.35 | 99.87 | 8.54 | 3.99 | nc |
| SF-37 | -48.7 | -6.68 | 12.2 | 1.3 | -14.96 | 92.35 | 13.26 | 9.21 | nc |
| SF-38 | -49.6 | -7.26 | — | 0.6 | -14.36 | 23.28 | na ⁷ | na ⁷ | nc |
| SF-39 | -49.6 | -7.27 | 0.0 | 1.0 | -14.40 | 23.74 | 16.59 | 12.16 | nc |
| SF-40 | -39.9 | -6.06 | 1.3 | 1.0 | -15.41 | 55.97 | 13.09 | 8.96 | nc |
| SF-41 | -98.1 | -13.38 | 9.3 | 1.0 | -12.69 | na | -2.12 | -8.65 | nc |
| SF-42 | -42.9 | -6.33 | — | 1.0 | -16.64 | 2.240 | 17.47 | 8.30 | nc |
| SF-43 | -48.1 | -6.95 | 0.3 | 0.6 | -15.93 | 11.83 | 20.98 | 12.16 | nc |
| Understanding Wells | | | | | | | | | |
| SFU-01 | -36.2 | -5.75 | — | 1.0 | -17.58 | 43.87 | 16.22 | 11.89 | 16.2 |
| SFU-02 | -43.8 | -6.70 | 5.1 | 0.6 | -14.35 | 76.67 | 6.06 | 3.21 | nc |
| SFU-03 | -45.2 | -6.84 | 5.8 | 0.6 | -13.83 | 79.36 | 5.87 | 3.48 | nc |
| SFU-04 | -45.8 | -6.80 | 6.1 | 0.6 | -14.51 | 82.98 | 6.45 | 3.27 | nc |
| SFU-05 | -46.2 | -6.73 | 7.4 | 1.0 | -15.10 | 85.11 | 6.95 | 3.31 | nc |
| SFU-06 | -43.5 | -6.32 | 6.4 | 0.6 | -14.21 | 67.69 | 13.25 | 8.15 | 11.0 |
| SFU-07 | -42.4 | -6.14 | 10.9 | 1.3 | -16.07 | 88.17 | 8.73 | 5.33 | 13.2 |
| SFU-08 | -43.7 | -6.18 | 10.2 | 1.0 | -15.04 | 93.54 | 10.91 | 8.67 | 15.0 |
| SFU-09 | -48.8 | -6.53 | 19.8 | 1.6 | -14.86 | 96.44 | 8.50 | 4.29 | nc |
| SFU-10 | -50.2 | -6.85 | 45.1 | 3.0 | -13.52 | 85.93 | 10.66 | 5.14 | nc |
| SFU-11 | -39.9 | -6.48 | 1.3 | 1.0 | -15.20 | 90.74 | 11.75 | 5.81 | nc |
| SFU-12 | -40.2 | -6.70 | na | na | -17.22 | 90.64 | 4.78 | -0.92 | nc |
| SFM-A1 | -39.6 | -6.25 | 0.3 | 0.6 | -18.22 | 15.73 | na ⁷ | na ⁷ | 9.0 |
| SFM-A2 | -38.1 | -6.04 | — | 0.6 | -18.48 | 71.28 | 6.30 | 4.08 | 24.6 |
| SFM-A3 | -40.2 | -6.20 | 4.8 | 0.6 | -20.81 | 65.82 | 7.83 | 2.74 | 31.0 |
| SFM-A4 | -42.1 | -6.54 | 13.8 | 1.3 | -20.67 | 86.57 | 10.14 | 3.61 | 44.7 |

Table 13. Results for analyses of stable isotope ratios and tritium and carbon-14 activities in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Information about analytes given in *table 3J*. Samples from all 79 wells were analyzed for stable isotopes of water and nitrate, tritium and carbon. Thirty-one slow wells were analyzed for stable isotopes of boron. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; N, nitrogen; B, boron; na, not available; nc, sample not collected; pCi/L, picocuries per liter; —, not detected]

| GAMA identification number | $\delta^2\text{H}$ of water (per mil) (82082) ¹ | $\delta^{18}\text{O}$ of water (per mil) (82085) ¹ | Tritium (pCi/L) (07000) ² | Tritium 2-sigma combined uncertainty (pCi/L) (75985) ² | $\delta^{13}\text{C}$ of dissolved carbonates (per mil) (82081) ³ | Carbon-14 (percent modern) (49933) ⁴ | $\delta^{15}\text{N}$ of dissolved nitrate (per mil) (82690) ¹ | $\delta^{18}\text{O}$ of dissolved nitrate (per mil) (63041) ¹ | $\delta^{11}\text{B}$ (per mil) (62648) ⁵ |
|-----------------------------------|--|---|--------------------------------------|---|--|---|---|---|--|
| Threshold type⁶ | na | na | MCL-CA | na | na | na | na | na | na |
| Threshold level | na | na | 20,000 | na | na | na | na | na | na |
| SFM-B1 | -36.9 | -5.82 | — | 0.6 | -20.58 | 40.32 | na ⁷ | na ⁷ | 17.4 |
| SFM-B2 | -31.6 | -4.69 | 0.6 | 0.6 | -14.21 | 50.07 | na ⁷ | na ⁷ | 59.4 |
| SFM-C1 | -47.1 | -7.18 | — | 1.0 | -17.00 | 7.770 | na ⁷ | na ⁷ | 22.6 |
| SFM-C2 | -43.9 | -6.56 | 9.0 | 1.3 | -15.46 | 80.16 | 6.70 | 3.64 | 22.0 |
| SFM-C3 | -41.8 | -6.11 | 8.0 | 1.0 | -14.92 | 79.52 | 8.35 | 5.86 | 13.7 |
| SFM-C4 | -42.7 | -6.22 | 8.0 | 1.0 | -15.57 | 83.68 | 9.17 | 6.81 | 15.0 |
| SFM-C5 | -44.2 | -6.40 | 9.6 | 1.0 | -16.50 | 84.65 | 13.31 | 8.27 | 8.2 |
| SFM-D1 | -49.4 | -7.25 | 2.9 | 0.6 | -15.56 | 8.750 | na ⁷ | na ⁷ | 0.4 |
| SFM-D2 | na | na | 0.3 | 0.6 | -13.97 | 49.48 | na ⁷ | na ⁷ | 8.7 |
| SFM-D3 | -44.5 | -6.52 | 10.9 | 1.0 | -14.73 | 75.95 | na ⁷ | na ⁷ | 15.9 |
| SFM-D4 | -47.0 | -6.67 | 13.4 | 1.0 | -16.79 | 90.12 | 11.57 | 7.60 | 10.5 |
| SFM-E1 | -48.2 | -7.28 | 0.3 | 0.6 | -14.11 | 37.18 | 13.74 | 12.58 | 10.7 |
| SFM-E2 | -42.6 | -6.31 | 10.9 | 1.0 | -15.38 | 85.31 | 8.15 | 6.24 | 18.0 |
| SFM-E3 | na | na | 99.8 | 5.8 | -15.74 | 95.46 | 12.58 | 12.44 | 17.1 |
| SFM-F1 | -49.3 | -7.24 | 0.3 | 1.0 | -16.24 | 4.750 | na ⁷ | na ⁷ | 32.6 |
| SFM-F2 | -50.4 | -7.46 | — | 1.0 | -11.46 | 2.250 | na ⁷ | na ⁷ | 18.5 |
| SFM-F3 | -67.8 | -9.66 | 4.2 | 1.0 | -14.33 | 14.93 | 24.69 | 10.80 | 14.7 |
| SFM-F4 | -43.3 | -6.37 | — | 1.0 | -15.49 | 16.93 | na ⁷ | na ⁷ | 9.5 |
| SFM-F5 | -40.8 | -6.01 | 0.3 | 1.0 | -14.65 | 31.14 | na ⁷ | na ⁷ | 8.5 |
| SFM-F6 | -20.5 | -2.38 | 0.6 | 0.6 | -14.95 | 73.75 | na ⁷ | na ⁷ | 42.6 |

¹USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA).

²USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA).

³University of Waterloo (contract laboratory) (CAN-UWIL).

⁴University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory) (AZ-UAMSL).

⁵USGS National Research Program, Menlo Park, California.

⁶Maximum contaminant level thresholds are listed as MCL-US when 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.

⁷Sample not analyzed for nitrate isotopes due to a non-detectable concentration of nitrate.

Table 14. Results for analyses of noble gases and helium isotopes in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed at Lawrence Livermore National Laboratory. Information on analytes given in *table 3K*. **GAMA identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. **Other abbreviations:** cm³ STP/g H₂O, cubic centimeters at standard temperature and pressure per gram of water; na, not available; pCi/L, picocuries per liter]

| GAMA well identification number | Collection date (mm/dd/yy) | Dissolved gas analysis date (mm/dd/yy) | Helium-3/ helium-4 (61040) | Noble gas | | | | |
|---------------------------------------|-------------------------------|--|----------------------------------|--|--------------------|--------------------|--------------------|--------------------|
| | | | | Helium-4 (85561) | Neon (61046) | Argon (85563) | Krypton (85565) | Xenon (85567) |
| | | | (atom ratio) | cm ³ STP/g H ₂ O | | | | |
| | | | × 10 ⁻⁶ | × 10 ⁻⁷ | × 10 ⁻⁷ | × 10 ⁻⁴ | × 10 ⁻⁸ | × 10 ⁻⁸ |
| Threshold type | na | na | na | na | na | na | na | na |
| Threshold level | na | na | na | na | na | na | na | na |
| Grid wells | | | | | | | | |
| SF-01 | 06/20/07 | 02/08/08 | 1.77 | 1.80 | 7.13 | 6.29 | 11.13 | 1.32 |
| SF-02 | 06/20/07 | 01/19/08 | 1.81 | 0.63 | 2.45 | 3.53 | 7.60 | 1.02 |
| SF-03 | 05/24/07 | 11/14/07 | 1.60 | 0.44 | 2.14 | 3.48 | 7.47 | 1.07 |
| SF-04 | 05/24/07 | 01/12/08 | 1.33 | 0.60 | 2.37 | 3.57 | 7.90 | 1.04 |
| SF-05 | 05/23/07 | 11/14/07 | 1.04 | 0.70 | 2.14 | 3.38 | 7.47 | 1.06 |
| SF-06 | 05/23/07 | 11/09/07 | 1.41 | 0.55 | 2.89 | 3.55 | 7.69 | 1.05 |
| SF-07 | 05/21/07 | 03/27/08 | 1.60 | 1.67 | 8.11 | 5.43 | 9.50 | 1.15 |
| SF-08 | 05/21/07 | 11/08/07 | 1.16 | 8.30 | 4.04 | 4.53 | 9.20 | 1.23 |
| SF-09 | 05/03/07 | 01/23/08 | 0.91 | 3.47 | 5.78 | 5.55 | 10.20 | 1.19 |
| SF-10 | 05/03/07 | 01/23/08 | 1.39 | 0.90 | 3.73 | 4.60 | 9.22 | 1.17 |
| SF-11 | 05/22/07 | 11/08/07 | 1.60 | 1.74 | 8.11 | 6.28 | 11.16 | 1.36 |
| SF-12 | 05/22/07 | 11/08/07 | 1.54 | 1.22 | 4.41 | 4.89 | 9.73 | 1.23 |
| SF-13 | 04/23/07 | 01/19/08 | 1.43 | 1.53 | 5.89 | 5.68 | 10.35 | 1.22 |
| SF-14 | 04/25/07 | 01/21/08 | 1.44 | 1.35 | 5.48 | 5.56 | 10.44 | 1.24 |
| SF-15 | 04/26/07 | 01/22/08 | 1.07 | 1.67 | 4.21 | 4.84 | 9.56 | 1.20 |
| SF-16 | 04/30/07 | 04/21/08 | 1.01 | 1.93 | 4.13 | 4.68 | 9.68 | 1.22 |
| SF-17 | 06/05/07 | 01/10/08 | 1.79 | 1.02 | 4.12 | 4.80 | 9.42 | 1.13 |
| SF-18 | 05/02/07 | 01/18/08 | 1.52 | 5.30 | 26.34 | 8.83 | 19.12 | 1.86 |
| SF-19 | 06/18/07 | 01/18/08 | 0.75 | 1.37 | 2.73 | 3.87 | 8.32 | 1.12 |
| SF-20 | 05/02/07 | 01/20/08 | 1.60 | 2.17 | 8.61 | 6.73 | 11.34 | 1.35 |
| SF-21 | 05/02/07 | 01/18/08 | 1.47 | 0.59 | 5.89 | 5.39 | 9.70 | 1.18 |
| SF-22 | 05/03/07 | 01/19/08 | 1.40 | 1.28 | 4.70 | 4.72 | 8.92 | 1.11 |
| SF-23 | 04/25/07 | 01/20/08 | 1.52 | 1.35 | 4.89 | 5.18 | 9.82 | 1.22 |
| SF-24 | 04/24/07 | 01/19/08 | 1.64 | 2.98 | 10.86 | 7.23 | 12.02 | 1.33 |
| SF-25 | 05/01/07 | 01/23/08 | 1.57 | 2.01 | 9.67 | 8.36 | 15.35 | 1.58 |
| SF-26 | 05/01/07 | 01/18/08 | 1.53 | 0.52 | 2.21 | 3.26 | 7.13 | 0.92 |
| SF-27 | 05/01/07 | 04/21/08 | 0.90 | 1.48 | 2.55 | 3.45 | 7.58 | 1.02 |
| SF-28 | 04/23/07 | 01/19/08 | 1.56 | 0.80 | 3.09 | 3.87 | 8.17 | 1.03 |
| SF-29 | 04/23/07 | 01/19/08 | 1.60 | 0.71 | 2.73 | 3.63 | 7.92 | 1.02 |
| SF-30 | 06/06/07 | 01/10/08 | 1.38 | 0.51 | 2.15 | 3.24 | 7.05 | 0.98 |
| SF-31 | 04/23/07 | 01/19/08 | 1.68 | 0.60 | 2.45 | 3.51 | 7.66 | 1.01 |
| SF-32 | 04/24/07 | 01/19/08 | 1.64 | 0.54 | 2.23 | 3.35 | 7.46 | 1.01 |

Table 14. Results for analyses of noble gases and helium isotopes in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed at Lawrence Livermore National Laboratory. Information on analytes given in *table 3K*. **GAMA identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. **Other abbreviations:** cm³ STP/g H₂O, cubic centimeters at standard temperature and pressure per gram of water; na, not available; pCi/L, picocuries per liter]

| GAMA well identification number | Collection date (mm/dd/yy) | Dissolved gas analysis date (mm/dd/yy) | Helium-3/ helium-4 (61040) | Noble gas | | | | |
|---------------------------------------|-------------------------------|--|----------------------------------|--|--------------------|--------------------|--------------------|--------------------|
| | | | (atom ratio) | Helium-4 (85561) | Neon (61046) | Argon (85563) | Krypton (85565) | Xenon (85567) |
| | | | | cm ³ STP/g H ₂ O | | | | |
| | | | | × 10 ⁻⁷ | × 10 ⁻⁷ | × 10 ⁻⁴ | × 10 ⁻⁸ | × 10 ⁻⁸ |
| Threshold type | na | na | na | na | na | na | na | na |
| Threshold level | na | na | na | na | na | na | na | na |
| SF-33 | 04/30/07 | 01/22/08 | 3.63 | 1.47 | 3.42 | 4.08 | 8.47 | 1.06 |
| SF-34 | 06/05/07 | 01/10/08 | 1.47 | 0.90 | 3.15 | 4.05 | 8.37 | 1.05 |
| SF-35 | 06/12/07 | 01/10/08 | 2.21 | 0.76 | 2.85 | 3.74 | 7.82 | 1.03 |
| SF-36 | 06/04/07 | 01/12/08 | 1.43 | 0.60 | 2.50 | 3.50 | 7.59 | 1.00 |
| SF-37 | 06/05/07 | 01/10/08 | 1.40 | 0.59 | 2.33 | 3.56 | 7.78 | 1.04 |
| SF-38 | 06/21/07 | 02/06/08 | 5.58 | 14.44 | 2.60 | 3.85 | 8.06 | 1.15 |
| SF-39 | 06/19/07 | 04/28/08 | 5.37 | 12.80 | 2.39 | 3.76 | 7.92 | 1.13 |
| SF-40 | 06/21/07 | 02/06/08 | 1.17 | 0.97 | 2.77 | 3.94 | 8.39 | 1.12 |
| SF-41 | 06/21/07 | 02/06/08 | 0.40 | 2.31 | 2.06 | 3.59 | 8.06 | 1.20 |
| SF-42 | 06/19/07 | 01/18/08 | 1.27 | 3.09 | 2.46 | 3.74 | 8.09 | 1.11 |
| SF-43 | 06/20/07 | 01/19/08 | 1.57 | 5.44 | 2.39 | 3.78 | 8.33 | 1.16 |
| Understanding wells | | | | | | | | |
| SFU-01 | 06/13/07 | 01/17/08 | 1.63 | 1.12 | 4.46 | 4.68 | 9.00 | 1.13 |
| SFU-02 | 04/30/07 | 01/22/08 | 1.47 | 1.66 | 6.55 | 5.90 | 70.71 | 1.28 |
| SFU-03 | 04/26/07 | 01/22/08 | 1.54 | 2.03 | 8.60 | 6.82 | 11.60 | 1.33 |
| SFU-04 | 04/26/07 | 01/21/08 | 1.44 | 2.30 | 9.44 | 6.96 | 11.87 | 1.31 |
| SFU-05 | 04/25/07 | 01/21/08 | 1.46 | 1.63 | 6.33 | 5.98 | 10.62 | 1.26 |
| SFU-06 | 04/26/07 | 01/21/08 | 2.59 | 4.80 | 13.67 | 8.60 | 14.58 | 1.52 |
| SFU-07 | 06/14/07 | 01/17/08 | 1.63 | 1.12 | 4.46 | 4.68 | 9.00 | 1.13 |
| SFU-08 | 04/25/07 | 01/20/08 | 1.58 | 0.89 | 3.38 | 4.01 | 8.22 | 1.04 |
| SFU-09 | 06/04/07 | 01/13/08 | 1.98 | 0.75 | 2.99 | 3.79 | 7.91 | 1.02 |
| SFU-10 | 06/04/07 | 01/13/08 | 4.37 | 0.81 | 2.93 | 3.81 | 8.13 | 1.06 |
| SFU-11 | 06/07/07 | 01/10/08 | 1.24 | 0.57 | 2.25 | 3.75 | 8.40 | 1.17 |
| SFU-12 | 06/18/07 | 01/17/08 | 1.25 | 0.55 | 2.07 | 3.48 | 7.99 | 1.10 |
| SFM-A1 | 05/21/07 | 03/27/08 | 0.09 | 1.14 | 2.72 | 4.64 | 8.70 | 1.27 |
| SFM-A2 | 05/22/07 | 03/27/08 | 1.28 | 0.59 | 2.32 | 3.78 | 7.58 | 1.05 |
| SFM-A3 | 05/22/07 | 11/08/07 | 1.70 | 0.57 | 2.47 | 3.55 | 7.65 | 1.10 |
| SFM-A4 | 05/23/07 | 11/14/07 | 1.79 | 0.48 | 2.16 | 3.36 | 7.43 | 1.06 |
| SFM-B1 | 05/24/07 | 01/12/08 | 0.08 | 0.87 | 2.13 | 3.53 | 7.98 | 1.09 |
| SFM-B2 | 05/24/07 | 03/27/08 | 1.00 | 0.61 | 2.71 | 3.13 | 6.85 | 0.93 |
| SFM-C1 | 05/08/07 | 02/05/08 | 1.04 | 6.34 | 3.33 | 4.25 | 9.29 | 1.24 |
| SFM-C2 | 05/09/07 | 02/05/08 | 1.51 | 1.22 | 4.52 | 5.01 | 9.34 | 1.15 |
| SFM-C3 | 05/09/07 | 02/05/08 | 2.84 | 1.43 | 4.22 | 4.74 | 8.97 | 1.13 |

Table 14. Results for analyses of noble gases and helium isotopes in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 79 wells were analyzed at Lawrence Livermore National Laboratory. Information on analytes given in *table 3K*. **GAMA identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. **Other abbreviations:** cm³ STP/g H₂O, cubic centimeters at standard temperature and pressure per gram of water; na, not available; pCi/L, picocuries per liter]

| GAMA well identification number | Collection date (mm/dd/yy) | Dissolved gas analysis date (mm/dd/yy) | Helium-3/ helium-4 (61040) | Noble gas | | | | |
|---------------------------------------|-------------------------------|--|----------------------------------|--|--------------------|--------------------|--------------------|--------------------|
| | | | | Helium-4 (85561) | Neon (61046) | Argon (85563) | Krypton (85565) | Xenon (85567) |
| | | | (atom ratio) | cm ³ STP/g H ₂ O | | | | |
| | | | × 10 ⁻⁶ | × 10 ⁻⁷ | × 10 ⁻⁷ | × 10 ⁻⁴ | × 10 ⁻⁸ | × 10 ⁻⁸ |
| Threshold type | na | na | na | na | na | na | na | na |
| Threshold level | na | na | na | na | na | na | na | na |
| SFM-C4 | 05/10/07 | 02/05/08 | 1.52 | 0.97 | 3.98 | 4.79 | 9.07 | 1.15 |
| SFM-C5 | 05/07/07 | 02/05/08 | 1.39 | 0.54 | 2.89 | 4.78 | 9.32 | 1.22 |
| SFM-D1 | 05/15/07 | 11/07/07 | 6.03 | 5.40 | 3.20 | 4.29 | 8.93 | 1.23 |
| SFM-D2 | 05/15/07 | 11/07/07 | 4.74 | 1.94 | 2.98 | 4.10 | 8.63 | 1.17 |
| SFM-D3 | 05/14/07 | 11/07/07 | 1.47 | 0.47 | 2.03 | 3.37 | 7.39 | 1.00 |
| SFM-D4 | 05/14/07 | 11/07/07 | 1.52 | 0.84 | 3.64 | 4.51 | 8.78 | 1.15 |
| SFM-E1 | 05/17/07 | 11/08/07 | 6.14 | 16.50 | 2.72 | 3.93 | 8.40 | 1.18 |
| SFM-E2 | 05/17/07 | 11/08/07 | 2.00 | 0.81 | 4.52 | 4.35 | 8.80 | 1.14 |
| SFM-E3 | 05/16/07 | 11/07/07 | 3.48 | 0.67 | 2.93 | 3.93 | 8.21 | 1.08 |
| SFM-F1 | 06/21/07 | 02/06/08 | 2.75 | 1.62 | 2.82 | 5.91 | 14.21 | 1.97 |
| SFM-F2 | 06/19/07 | 01/18/08 | 2.57 | 21.30 | 2.30 | 3.66 | 8.18 | 1.15 |
| SFM-F3 | 06/18/07 | 01/18/08 | 5.25 | 7.15 | 2.23 | 3.59 | 8.15 | 1.15 |
| SFM-F4 | 06/18/07 | 01/18/08 | 3.83 | 2.20 | 2.66 | 3.95 | 8.62 | 1.19 |
| SFM-F5 | 06/20/07 | 01/19/08 | 1.59 | 0.81 | 2.63 | 3.91 | 8.52 | 1.16 |
| SFM-F6 | 06/20/07 | 02/05/08 | 4.32 | 0.06 | 4.16 | 0.05 | 9.16 | 1.03 |

Table 15. Radioactive constituents detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Information about analytes given in *table 3J*. Samples from the 31 slow wells were analyzed, but only samples with a detection are listed. **GAMA Identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well; Thresholds and threshold values as of December 1, 2007. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** pCi/L, picocuries per liter. *, value above lower threshold level]

| GAMA identification number | Radon-222 (pCi/L) (82303) |
|-----------------------------|---------------------------|
| Threshold type ¹ | Proposed MCL-US |
| Threshold value | ² 300 (4,000) |
| Grid Wells | |
| SF-24 | *350 |
| SF-28 | *380 |
| SF-35 | 290 |
| Understanding Wells | |
| SFU-01 | 270 |
| SFU-06 | *350 |
| SFU-07 | *320 |
| SFU-08 | *370 |
| SFM-A1 | 180 |
| SFM-A2 | 230 |
| SFM-A3 | 160 |
| SFM-A4 | 250 |
| SFM-B1 | 260 |
| SFM-B2 | 270 |
| SFM-C1 | *440 |
| SFM-C2 | *360 |
| SFM-C3 | *320 |
| SFM-C4 | 290 |
| SFM-C5 | 210 |
| SFM-D1 | 270 |
| SFM-D2 | 290 |
| SFM-D3 | 220 |
| SFM-D4 | *330 |
| SFM-E1 | *420 |
| SFM-E2 | *370 |
| SFM-E3 | 280 |
| SFM-F2 | *460 |
| SFM-F3 | *910 |
| SFM-F4 | *370 |
| SFM-F5 | *380 |
| SFM-F6 | *340 |

¹Maximum contaminant level thresholds are listed as MCL-US when 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.

²Two MCLs have been proposed for radon-222. The proposed Alternative MCL is in parentheses.

Table 16. Microbial indicators detected in ground-water samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from 31 slow wells (3 grid wells and 28 understanding wells) were analyzed. **GAMA identification number:** SF, San Francisco Bay study unit grid well; SFU, San Francisco Bay study unit understanding well; SFM, San Francisco Bay study unit monitoring well. **Threshold type:** TT-US, U.S. Environmental Protection Agency treatment technique. **Other abbreviations:** —, not detected; M, presence verified but not quantified]

| GAMA identification number | F-specific coliphage (99335) | Somatic coliphage (99332) |
|----------------------------|------------------------------|---------------------------|
| Threshold type | TT-US | TT-US |
| Threshold level | 99.9% Killed/Inactive | 99.9% Killed/Inactive |
| Understanding wells | | |
| SFM-D1 | — | M |
| SFM-E3 | M | — |

Appendix

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

Sample Collection and Analysis

Ground-water samples were collected using standard and modified USGS protocols from the USGS NAWQA program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated), and protocols described by Weiss (1968), Shelton and others (2001), Ball and McClesky (2003a,b), and Wright and others (2005).

Before sampling, each well was pumped continuously in order to purge at least three casing-volumes of water from the well (Wilde and others, 1999). Samples were collected using Teflon tubing with brass and stainless-steel fittings attached to a sampling point on the well discharge pipe as close to the well as possible. The sampling point was always located upstream of any well-head treatment system or water storage tank. If a chlorinating system was attached to the well, the chlorinator was shut off at least 24 hours before purging and sampling the well in order to clear all chlorine out of the system. Samples on the fast schedule were collected at the well head through a foot-long length of Teflon tubing. Samples on the slow schedule were collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10- to 50- foot length of the Teflon tubing (Lane and others, 2003). Submersible sampling pumps were used to collect water from the monitoring wells, following USGS protocols (U.S. Geological Survey, variously dated). All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004).

For the field measurements, ground water was pumped through a flow-through chamber fitted with a multi-probe meter that simultaneously measured the water-quality indicators—dissolved oxygen, temperature, pH, and specific conductance. Field measurements were made in accordance with protocols in the USGS National Field Manual (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 temperature, dissolved oxygen, pH, and specific conductance values were recorded at 5-minute intervals for at least 30 minutes, and after these values remained stable for 20 minutes, samples to be analyzed in the laboratory were collected. Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF-GAMA, a software package designed by the USGS with support from the GAMA program.

Analytical service requests and chain of custody documentation were also managed by PCFF-GAMA. Information from PCFF-GAMA was uploaded directly into NWIS at the end of each week during which samples were collected.

For analyses requiring filtered water, ground-water was diverted through a 0.45- μ m pore size vented capsule filter, a disk filter, or a baked glass-fiber filter depending on the protocol for the analysis (Wilde and others, 1999; Wilde and others, 2004). Before samples were collected, polyethylene sample bottles were pre-rinsed three times using deionized water, and then once with native water. Samples requiring acidification were acidified to a pH of 2 or less with the appropriate acids using ampoules of certified, traceable concentrated acids obtained from the USGS National Water Quality Laboratory (NWQL).

Temperature-sensitive samples collected to be analyzed for volatile organic compounds, pesticides, pharmaceutical compounds, potential wastewater-indicator compounds, compounds of special interest, nutrients, major, minor, and trace elements, uranium and strontium isotopes, and coliphage were stored on ice before and during daily shipping to the various laboratories. Non-temperature sensitive samples collected to be analyzed for radon-222 were also shipped daily. Temperature-sensitive samples collected to be analyzed for carbon isotopes, arsenic and iron speciation, boron isotopes, and nitrogen and oxygen isotopes in nitrate were kept refrigerated and shipped after all samples were collected from SFBAY. The non-temperature sensitive samples collected to be analyzed for tritium, noble gases, chromium speciation, and stable isotopes were shipped monthly.

Detailed sampling protocols for individual analyses and groups of analytes are described by Koterba and others (1995) and in the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004) and the references for analytical methods listed in *table A1*; only brief descriptions are given here. Volatile organic compounds (VOC) were collected in three 40-mL sample vials that were purged with three vial volumes of sample water before bottom filling to eliminate atmospheric contamination. Six normal (6 N) hydrochloric acid (HCl) was added as a preservative to the VOC samples. The perchlorate sample was collected in a 125-mL polyethylene bottle. Tritium samples were collected by bottom filling two 1-L polyethylene bottles with unfiltered ground water after first overfilling the bottle with three volumes of water. Samples collected to be analyzed for stable isotopes of hydrogen and oxygen in water were collected in 60-mL, clear glass bottles filled with unfiltered water, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Samples to be analyzed for pesticides and pesticide degradation products, pharmaceuticals, potential wastewater indicators, and *N*-nitrosodimethylamine (NDMA) were collected in 1-L baked amber bottles. Pesticide, pharmaceutical, and wastewater-indicator samples were filtered with a glass fiber filter, whereas the NDMA samples were filtered at the Montgomery Watson Harza (MWH) laboratory before analysis.

Ground-water samples collected to be analyzed for major and minor ions, trace elements, alkalinity, and total dissolved solids required filling one 250-mL polyethylene bottle with raw groundwater, and one 500-mL and one 250-mL polyethylene bottles with filtered ground water (Wilde and others, 2004). The filter used was a Whatman capsule filter. The 250-mL filtered sample was then preserved with 7.5 N nitric acid. Arsenic and iron speciation samples were filtered into a 250-mL polyethylene bottle that was covered with tape to prevent light exposure, and preserved with 6 N HCl. The nutrient sample was filtered into a 125-mL brown polyethylene bottle. Nitrate isotope samples were filtered into a 125-mL brown polyethylene bottle until it was three-fourths full. Boron isotope samples were filtered into a 250-mL polyethylene bottle, and uranium and strontium isotope samples were filtered into a separate 250-mL polyethylene bottle. Carbon isotope samples were filtered and bottom filled into two 500-mL glass bottles that were first overfilled with three bottle volumes of ground water. These samples had no headspace and were sealed with a conical cap to avoid atmospheric contamination. Samples for performing field alkalinity titrations were collected by filtering ground water into a 500-mL polyethylene bottle, and samples for laboratory alkalinity titrations were filtered into a 250-mL polyethylene bottle. The samples collected to be analyzed for chlorine stable isotope and bromine stable isotope analysis were collected by filtering ground water into a 5-gallon polyethylene carboy container and securing the cap with electrical tape to prevent leakage and evaporation.

Chromium, radon-222, noble gases, and microbial constituents were collected from the hose bib at the well head, regardless of the sampling schedule (fast or slow). Chromium speciation samples were collected using a 10-mL syringe with an attached 0.45- μm disk filter. After the syringe was thoroughly rinsed and filled with ground water, 4 mL of the ground water was forced through the disk filter; the next 2 mL of the ground water was slowly filtered into a small centrifuge vial to be analyzed for total chromium. Hexavalent chromium, Cr (VI) was then collected by attaching a small cation-exchange column to the syringe filter, and after conditioning the column with 2 mL of sample water, 2 mL was collected in a second centrifuge vial. Both vials were preserved with 10 μL of 7.5 N nitric acid (Ball and McClesky, 2003a,b).

To collect radon-222, a stainless steel and Teflon valve assembly was attached to the sampling port at the well head (Wilde and others, 2004). The valve was partially closed to create back pressure, and a 10-mL sample was collected through a Teflon septum on the valve assembly using a glass syringe affixed with a stainless steel needle. The sample was then injected into a 25-mL vial partially filled with scintillation mixture (mineral oil) and shaken. The vial was then placed in a cardboard tube in order to shield it from light during shipping.

Noble gases were collected in 3/8-in copper tubes using reinforced nylon tubing connected to the hose bib at the well-head. Ground water was flushed through the tubing to dislodge bubbles before flow was restricted with a back pressure valve.

Clamps on either side of the copper tube were then tightened, trapping a sample of ground water for analyses of noble gases (Weiss, 1968).

Samples collected for analysis of microbial constituents were collected at the well head also (Myers, 2004; Bushon, 2003). Before the samples were collected, the sampling port was sterilized using isopropyl alcohol, and ground water was run through the sampling port for at least three minutes to remove any traces of the sterilizing agent. One sterilized 3-liter carboy was filled for the analysis of coliphage (F-specific coliphage and somatic coliphage determinations).

Turbidity and alkalinity were measured in the mobile laboratory at the well site. Turbidity was measured in the field with a calibrated turbidity meter. Alkalinity in filtered samples was measured by Gran's titration method (Gran, 1952; Stumm and Morgan, 1996; Rounds, 2006). Titration data were entered directly into PCFF-GAMA and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were automatically calculated from the titration data using the advanced speciation method. Concentrations of HCO_3^- and CO_3^{2-} also were calculated from the laboratory alkalinity and pH measurements. Calculations were made in a spreadsheet using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with pK_1 ($-\log_{10}$ of the first acid dissociation constant for H_2CO_3) = 6.35, pK_2 ($-\log_{10}$ of the second acid dissociation constant for H_2CO_3) = 10.33, and pK_w ($-\log_{10}$ of the acid dissociation constant for water) = 14.

Eleven laboratories performed chemical and microbial analyses for this study (see *table A1*), although most of the samples were analyzed at the NWQL or by labs contracted by the NWQL. The NWQL maintains a rigorous quality assurance program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory quality control 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 (MDL) are continuously tested and laboratory reporting levels updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://nwql.usgs.gov/lab_cert.shtml). In addition, the Branch of Quality Systems within the USGS Office of Water Quality independently oversees quality assurance at the NWQL and laboratories contracted by the NWQL. The Branch of Quality Systems also runs the National Field Quality Assurance program that annually tests the proficiency of all USGS field personnel who measure water-quality in the field (<http://nfqa.cr.usgs.gov/>). Results of analyses made at the NWQL or laboratories contracted by the NWQL are uploaded directly into NWIS by the NWQL. Some laboratory quality-control data are stored in NWIS also.

Data Reporting

Laboratory Reporting Conventions

The USGS NWQL uses the laboratory reporting level (LRL) as a threshold for reporting analytical results. The LRL is set to minimize the reporting of false negatives (not detecting a compound when it is actually in a sample) to less than 1 percent (Childress, and others, 1999). The LRL is usually set at two-times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation of at least 24 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 MDL, there is less than 1 percent chance of a false positive) (U.S. Environmental Protection Agency, 2002a). The USGS NWQL monitors and updates LT-MDL and LRL values regularly, and the values listed in this report were in effect when ground-water samples from the SFBAY study unit were analyzed.

Detections between the LRL and the LT-MDL are reported as estimated concentrations (designated with an “E” before the values in the tables). For information-rich methods, detections below the LRL have a high certainty of detection, but the precise concentration is uncertain. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection (VOCs, pesticides, pharmaceuticals, and wastewater-indicators). Compounds are identified by characteristic fragmentation patterns in their mass spectra in addition to being quantified by measurements of peak areas at their associated chromatographic retention times. E-values also may result from detections outside the range of calibration standards, detections that did not meet all laboratory quality-control criteria, and from samples that were diluted prior to analysis (Childress and others, 1999).

Some compound concentrations in this study are reported using minimum reporting levels (MRL) or method uncertainties (MU). The MRL is the smallest measurable concentration of a constituent that may be reliably reported 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.

Detections that may have resulted from inadvertent sample contamination are reported with a “V” before the values in the tables. The potential for sample contamination was assessed using results from field, source-solution, and laboratory blanks.

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

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

where

- E is the element (O for oxygen, N for nitrogen, C for carbon, or H for hydrogen) and i is the atomic mass of the heavier isotope of the element
- R_{sample} is the ratio of the abundance of the heavier isotope (^{18}O , ^{15}N , ^{13}C , or ^2H) to the lighter isotope (^{16}O , ^{14}N , ^{12}C , or ^1H) in the sample and,
- $R_{\text{reference}}$ is the ratio of the abundance of the heavier isotope to the lighter isotope in the reference material

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values of 0 per mil (note that $\delta^2\text{H}$ is also written as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium). The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a $\delta^{13}\text{C}$ value of 0 per mil. The reference material for nitrogen is nitrogen gas in atmospheric air, which is assigned a $\delta^{15}\text{N}$ value of 0 per mil (Kendall, 1998; Singleton and others, 2005). 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.

Constituents on Multiple Analytical Schedules

Twenty-four constituents targeted in this study are determined by more than one analytical schedule or 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://www.nwql.cr.usgs.gov/USGS/Preferred_method_selection_procedure.html). Methods having full approval are preferred over those having provisional approval and approved methods are favored over research methods. The most accurate and precise method that has lower LRLs for the overlapping constituents is preferred. A method may be selected as the preferred method to provide consistency with historical data analyzed by the same method.

Seventeen of the constituents appear in *table A2* and in the following NWQL analytical schedules: VOCs (Schedule 2020; *table 3A*), pesticides (Schedule 2003 and 2060; *tables 3B,C*), pharmaceutical compounds (Schedule 2080; *table 3D*), and wastewater-indicator compounds (Schedule 1433; *table 3E*). For constituents on Schedules 2020 and 1433, the preferred method was Schedule 2020 because it is more accurate and precise and the VOCs listed have lower LRLs. For constituents on Schedules 2003, 2060 and 1433, the preferred method was Schedule 2003 because it is more accurate and precise and has lower LRLs for pesticide constituents, and for consistency with other GAMA data (all samples

collected for the GAMA Priority Basin project are analyzed using Schedule 2003 or an equivalent). The only exception to this preferred method rule is caffeine, for which the preferred method is Schedule 2060. For constituents on Schedules 2080 and 1433, the preferred method was Schedule 1433. Although schedule 2080 has a lower LRL for the overlapping constituents, the NWQL considered Schedule 1433 the preferred method during the time of the SFBAY study because Schedule 2080 had provisional approval, whereas Schedule 1433 had full approval. For the constituents that appear on two or more NWQL analytical schedules, only the results from the preferred method are reported.

The water-quality indicators—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both are reported because alkalinity was measured in more samples at NWQL than in the field.

For arsenic, chromium, and iron concentrations, the approved method, Schedule 1948, used by the NWQL is preferred over the research methods used by the USGS Trace Metal Laboratory. The concentrations measured by the Trace Metal Laboratory are only used to calculate ratios of redox

species for each element: for $\frac{\text{As(V)}}{\text{As(III)}}$ arsenic, $\frac{\text{Cr(VI)}}{\text{Cr(III)}}$ for chromium, and $\frac{\text{Fe(III)}}{\text{Fe(II)}}$ for iron. For example:

$$\frac{\text{Fe(III)}}{\text{Fe(II)}} = \frac{\text{Fe(T)} - \text{Fe(II)}}{\text{Fe(II)}}$$

where

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

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

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

Quality Assurance

The quality assurance used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality assurance plan followed by the NWQL, the primary laboratory used to analyze samples for the study, is described by Maloney (2005) and Pirkey and Glodt (1998). Quality-control (QC) samples collected in the SFBAY study unit include source-solution blanks, field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate contamination in the sample and bias and variability of the data that may have resulted from the sample collection, processing, storage, transportation, and laboratory analysis.

Blanks

Blank samples (blanks) were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the analytes investigated in the study. Two types of blanks were collected: source-solution and field blanks. Source-solution blanks were collected to verify that the blank water used for the field blanks was free of the analytes of interest. Source-solution and field blanks were collected for most analyses at 11 percent of the wells sampled to determine if equipment or procedures used in the field or the laboratory introduced contamination. Field blanks were analyzed for VOCs, pesticides and pesticide degradates, perchlorate, NDMA, nutrients, major and minor ions, trace elements, iron, arsenic, and chromium speciation, pharmaceuticals, and potential wastewater indicators. Field blanks were not collected for tritium or noble gases. Tritium and noble gases are in the atmosphere and would dissolve into any solution used in collecting a blank, making it impractical to collect a field blank for these analytes. An indirect indicator of the quality of environmental data is tritium, whose activities are expected to be less than 3 pCi/L in water recharged before the 1950s. Tritium activities below the MRL of 1 pCi/L in several samples implies that the sampling methods did not bias the results for tritium. Stable-isotopic ratios of oxygen, hydrogen, carbon, nitrogen, boron, chloride, bromide, uranium, and strontium are an intrinsic property of any of these elements; therefore, the concept of a blank does not apply to these ratios.

Source-solution blanks were collected at the sampling site by pouring blank water directly into sample containers that were preserved, stored, shipped, and analyzed in the same manner as the ground-water samples. For field blanks, blank water was either pumped or poured through the sampling equipment (fittings and tubing) used to collect ground water, then processed and transported using the same protocols as those used for the ground-water samples. Source-solution blanks were analyzed for only a subset of the sites for which they were collected; if an analyte was detected in a field blank, the corresponding source-solution blank was analyzed.

Contamination in field blanks may originate from several different types of sources, including contamination of the source-solution water, carry-over from the previous sample, contamination from known sources specific to a field site, and systematic or random contamination from field or laboratory equipment or processes. These different sources of contamination require different strategies for V-coding detections in environmental samples on the basis of detections in field blanks.

Detections in source-solution blanks were used to evaluate potential contamination of the source-solution water. If a constituent was detected in a source-solution blank at a concentration similar to or greater than the lowest concentration detected in any field blank collected using the same lot of source-solution water, the source-solution water was interpreted as the origin of the contamination in the blanks, and detections of that constituent in field blanks collected using

the same lot of source-solution water were disregarded as an indicator of bias that could have affected the environmental samples.

Another source of contamination evaluated was carry-over from the previous sample collected with the same equipment. The equipment used to collect samples from wells on the slow schedule was different from the equipment used to collect samples from wells on the fast schedule; therefore, detections of constituents in field blanks collected at slow wells were compared with detections in ground water samples from slow wells, and detections in field blanks collected at fast wells were compared with detections in ground water samples from fast wells. Carry-over between samples is very rare because the procedures used to clean the equipment after a sample is collected have been developed and extensively tested to assure that carry-over does not occur. Potential carry-over was evaluated using time-series analysis to look for patterns suggesting constituents were carried-over from a sample containing high concentrations to the next ground-water sample or field blank collected with the same equipment. If no detections were reported in field blanks or ground-water samples collected after ground-water samples containing high concentrations of the constituent, carry-over was ruled out as a source of contamination.

Contamination from known sources may produce distinctive patterns of detections, particularly of VOCs, in field blanks and ground-water samples. Substances that may be encountered at the field site, such as lubricants (for example, WD-40), cements used on PVC-piping, exhaust fumes from pump engines, and the methanol used to clean sample lines, contain recognizable associations of VOC constituents. If a recognizable association of VOC constituents was detected in a field blank and the field notes indicated that a known source was present that may have affected the collection of the field blank but not the associated ground-water samples, the field blank was not used to V-code detections of individual VOCs in ground-water samples. If a recognizable association of VOC constituents was detected in a ground-water sample and the field notes indicated that a known source was present and may have affected sample collection, the detections in the ground-water sample were examined for potential V-coding. However, detecting these co-occurring VOC constituents in ground-water samples does not necessarily indicate contamination during sample collection, because these VOC constituents also may occur together in ground water.

If an analyte detected in a field blank could not be attributed to the source-solution, carry-over, or a specific problem recorded in the field notes, that field blank was used to V-code detections in all ground water samples collected with the same equipment. If the concentration of an analyte detected in a field blank was greater than the concentration measured in a ground-water sample collected before or after the blank sample, the ground-water value was V-coded (*table A3*). Affected values are indicated by a 'V' preceding the value in the tables, and are excluded from the summary statistics. If a compound was detected in multiple field blanks and the

detections could not be attributed to the source-solution water, any ground-water sample in which the compound was detected was evaluated for possible contamination.

Replicates

Sequential replicate samples were collected to assess variability that may result from processing and analyzing inorganic and organic constituents. Relative standard deviation (RSD) of the measured values was used in determining the variability between replicate pairs for each compound (*table A4*). The RSD is defined as the standard deviation divided by the mean concentration for each replicate pair of samples, multiplied by 100 percent. If one value for a sample pair was reported as a non-detection and the other value was reported as an estimate below or equal to the LRL or MRL, the RSD was set to zero because the values are analytically identical. If one value in a sample pair was reported as a non-detection and the other value was greater than the LRL or MRL, the non-detection value was set equal to one-quarter of the LRL and the RSD was calculated (Hamlin and others, 2002). Values of RSD less than 20 percent are considered acceptable in this study. An RSD value of 20 percent corresponds to a relative percent difference (RPD) value of 29 percent. High RSD values for a compound at low concentrations may indicate analytical uncertainty, particularly for concentrations within an order of magnitude of LT-MDL or MDL. Sequential replicate samples were collected at 9 percent of the wells sampled.

Matrix Spikes

Adding a known concentration of a constituent ("spike") to a replicate environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. The known compounds added in matrix spikes are the same as those being analyzed using the method. This enables matrix interferences to be analyzed on a compound by compound basis. Matrix spikes were added at the laboratory that analyzed the samples. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it was present at very low concentrations. Low and high matrix-spike recoveries may be a concern if the concentration of a compound in a ground-water sample is close to the MCL: a low recovery could falsely result in a measured concentration below the MCL, whereas a high recovery could falsely result in a measured concentration above the MCL.

Acceptable ranges for matrix-spike recoveries are based on the acceptable ranges established for laboratory "set" spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution as that used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable ranges for set spike recoveries are 70 to 130 percent for NWQL schedules 2020 and 1433 (Connor and others, 1998; Zaug and others, 2002;

Rose and Sandstrom, 2003), 60 to 120 percent for NWQL schedules 2003 and 2060 (Furlong and others, 2001; Sandstrom and others, 2001), and 60 to 130 percent for Schedule 2080 (Kolpin and others, 2002). On the basis of these ranges, 70 to 130 percent was defined as the acceptable range for matrix-spike recoveries for organic compounds in this study.

Matrix spikes were added to samples collected for the analysis of VOCs, NDMA, pesticide compounds, pharmaceuticals, and potential wastewater-indicators because the analytical methods for these constituents are chromatographic methods which may be susceptible to matrix interferences. Replicate samples for the addition of matrix spikes were collected at 9 percent of the wells sampled, although not all analyte classes were tested at every well (*table A5*).

Surrogates

Surrogate compounds are added to environmental samples in the laboratory before analysis in order to monitor the performance of the analytical method for each sample. Surrogate compounds were added to all ground-water and quality-control samples that were analyzed for VOCs, pesticide and pesticide degradates, NDMA, pharmaceuticals, and potential wastewater indicators (*table A6*). Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d8* used for the VOC analytical method has the same chemical structure as toluene, except that the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (hydrogen-2). Toluene-*d8* and toluene behave very similarly during the analytical procedure, but the small mass difference between the two causes slightly different chromatographic retention times; thus using a toluene-*d8* surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996); thus deuterated compounds like toluene-*d8* do not occur naturally and are not found in environmental samples. Surrogates are used to identify general problems that may arise during sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of dissolved organic carbon) that produce a positive bias, or incomplete laboratory recovery (possibly from improperly maintaining and calibrating analytical equipment) that produces a negative bias. A 70 to 130 percent recovery of surrogates is generally considered acceptable; values outside this range indicate possible problems with processing and analyzing samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Sample Results

Detections of Constituents in Field and Source-Solution Blanks

Field blanks were collected at approximately 11 percent of the sites sampled in SFBAY. *Table A3* gives a summary of detections in field blanks. Four VOCs were detected in 1 to 4 of the 9 field blanks analyzed for VOCs. The environmental samples collected before and after these field blanks were free of all of these VOCs except toluene; hence no ground-water sample detections were V-coded as a result of these blank detections. Toluene was detected in 4 of the 9 field blanks analyzed. As a result of this high detection frequency, all 6 environmental toluene detections were V-coded and will not be considered in the statistical results (*table 5*). Low levels of toluene were detected in source-solution and field blanks in many of the earlier study units (Wright and others, 2005; Kulongoski and others, 2006; Bennett and others, 2006; Kulongoski and Belitz, 2007; Dawson and others, 2008).

Two pharmaceutical compounds (acetaminophen and diphenhydramine) were detected once in the five field blanks analyzed for pharmaceutical compounds. Acetaminophen or diphenhydramine were not detected in ground-water samples.

One potential wastewater-indicator compound, benzophenone, was detected in one of the five field blanks. It was not detected in the ground-water samples.

N-Nitrosodimethylamine (NDMA) was detected in one of five field blanks. There were detected concentrations of NDMA in three environmental samples following this field blank that were less than the blank detection. These three ground-water sample detections were V-coded in *table 8*.

One major or minor ion, silica, was detected in the five field blanks. Environmental samples had detections of silica greater than 400 times the detected concentrations in blanks; hence, no ground-water detections were V-coded. Total nitrogen was detected in one field blank. Environmental samples collected before and after these field blanks had detected concentrations that were four times higher than the blank concentration; hence, no ground-water sample detections were V-coded as a result of these blank detections.

Field blanks were collected at 5 of the 31 sites sampled for analysis of trace elements by the NWQL. Three trace elements were detected in field blanks: lead was detected in 1 of the field blanks, nickel was detected in 1 field blank, and vanadium was detected in 2 of the 5 field blanks. For each of these three constituents, the minimum concentration detected in the ground-water samples collected before and after these field blanks was at least 8 times greater than the maximum concentration detected in the field blanks. As a result, no ground-water detections were V-coded (*table 11*).

There were no detections of iron(II), arsenic(III), arsenic (total), chromium(VI), or chromium (total) in 9 field blanks in samples analyzed at the USGS Trace Metal Laboratory (TML). Iron (total) was detected in two field blanks. The minimum concentration detected in ground-water samples

collected before and after these field blanks was greater than the maximum concentration detected in the field blanks. Thus, no ground-water detections were V-coded (*table 12*). Furthermore, measurements of iron (total) from the NWQL (*table 11*) were preferred over measurements at the TML (*tables A2, 12*), so these blank detections did not affect interpretations of environmental concentrations.

No compounds were detected in field blanks for the following analyte groups: pesticides (9 field blanks), perchlorate (9 field blanks), and nutrients (5 field blanks).

Variability in Replicate Samples

Table A4 summarizes the results of replicate analyses for constituents detected in ground-water samples collected in the SFBAY study. Concentrations or activities in the environmental and replicate samples are reported for all replicate analyses yielding RSD values greater than 20 percent. Most of the replicate sample pairs collected during the San Francisco Bay study had RSDs less than 20 percent. Thirteen replicate sample pairs representing trace elements had RSDs greater than 20 percent. The magnitudes of the concentrations of the replicate sample pairs with RSD values greater than 20 percent were within a factor of about three of the LRLs for cobalt, iron, arsenic, and zinc. At these low concentrations, small deviations in measured values result in large RSDs. No data were V-coded as a result of variability in replicate analyses.

Matrix-Spike Recoveries

Table A5 summarizes matrix-spike recoveries for the SFBAY study. Adding a spike or known concentration of a constituent to an environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. Seven environmental samples were spiked with VOCs and pesticides and pesticide degradates, and two with pharmaceuticals, potential wastewater- indicators, and NDMA to calculate matrix-spike recoveries (*table A5*). Seventy-nine of the 85 VOCs had spike recoveries within the acceptable range of 70 through 130 percent. Four VOCs (chloromethane, methyl bromide, vinyl bromide, and vinyl chloride) had at least one matrix spike recovery greater than 130 percent. Of these compounds, only chloromethane was detected in ground-water samples (in 1 of 79 samples). Dichlorodifluoromethane (CFC-12) and hexachlorobutadiene were the only VOCs that had at least one spike recovery below 70 percent. Recoveries of CFC-12 were 61 and 64 percent in 2 of 7 spiked samples and CFC-12 was detected in 1 ground-water understanding sample. Hexachlorobutadiene had 2 of 7 spike recoveries below 70 percent and was not detected in ground-water samples. (Note that low recoveries may indicate that this compound might not have been detected in some samples if it was present at very low concentrations.)

Seven ground-water samples were spiked with pesticide and pesticide degradate compounds in schedule 2003 (*table 3B*) in order to calculate matrix spike recoveries. Thirty-five of the 63 spike compounds had recoveries within the acceptable range of 70 through 130 percent (*table A5B*). Eight spike compounds had at least 1 recovery greater than 130 percent. Twenty-one spike compounds had at least one recovery (minimum recovery) below 70 percent. Of these 21 spike compounds, one (deethylatrazine) was detected in ground-water samples. (Note that low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.)

Seven environmental samples were spiked with polar pesticide or pesticide degradate compounds found in schedule 2060 (*table 3C*) in order to calculate matrix-spike recoveries. Spike recoveries are only reported for the preferred NWQL analyses. Twenty-seven of the 53 spike compounds had recoveries for all spikes within the acceptable range of 70 through 130 percent (*table A5C*). Twenty-six spike compounds had at least one recovery below 70 percent. Of these 26 compounds, 3 (benomyl, bentazon, and caffeine) were detected in ground-water samples. (Note that low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.)

Two ground-water samples were spiked with pharmaceutical compounds. Twelve of the fourteen pharmaceutical compounds had recoveries within the acceptable range of 70 to 130 percent. Two compounds had recoveries less than 70 percent for at least one of the two tests (*table A5D*). (Note that low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.)

Two ground-water samples were spiked with wastewater-indicator compounds. Twenty of the sixty-two compounds had recoveries less than 70 percent and three had recoveries greater than 130 percent (*table A5E*). The two compounds detected in ground-water samples had recoveries within the acceptable range of 70 through 130 percent.

Two ground-water samples were spiked with NDMA. Both spike recoveries were within the acceptable range of 70 to 130 percent (*table A5F*).

Surrogate Compound Recoveries

Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recovery of similar constituents. *Table A6* lists in columns the surrogate, the analytical schedule on which it was applied, the number of analyses for blank and non-blank samples, the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blank and non-blank samples. Blank and non-blank samples were considered separately to assess whether the matrices in non-blank samples affect surrogate recoveries. No systematic differences between surrogate recoveries in blank and environmental samples were observed.

Surrogate recoveries were in the acceptable range of 70 to 130 percent for 99 percent of pesticide (schedule 2003) surrogate recoveries, 95 percent of pesticide and pesticide degradate (schedule 2060) recoveries, 92 percent of NDMA recoveries (MWH laboratory), and 94 percent of pharmaceutical compound (schedule 2080) recoveries.

Eighty percent of VOC surrogate recoveries (188 out of 237 analyses) were in the acceptable range of 70 to 130 percent. Nine environmental samples with detections of VOCs had recoveries of the surrogate 1,2-dichloroethane-*d*4 greater than 130 percent. Two VOCs detected in two of these samples elute near 1,2-dichloroethane-*d*4 in the chromatographic sequence. A high recovery for a surrogate suggests that the measured concentrations of analytes eluting near the surrogate may be biased to higher concentrations. Both detections already had “E” codes (*table 5*); thus no additional flagging was needed.

Surrogate recoveries were in the acceptable range for 60 percent of potential wastewater-indicator compounds. All recoveries of bisphenol A-*d*3 were 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. There were no detections of bisphenol A in environmental samples.

Table A1. Analytical methods used for the determination of organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional 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. HPLC, high performance liquid chromatography; VOC, volatile organic compound]

| Analyte | 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 degradates | Solid-phase extraction and gas chromatography/mass spectrometry | NWQL, Schedule 2003 | Zaugg and others, 1995; Lindley and others, 1996; Madsen and others, 2003; Sandstrom and others, 2001 |
| Pesticides and degradates | Solid-phase extraction and HPLC/mass spectrometry | NWQL, Schedule 2060 | Furlong and others, 2001 |
| Pharmaceuticals | Solid-phase extraction and HPLC/mass spectrometry | NWQL, Schedule 2080 | Kolpin and others, 2002; Furlong and others, 2008 |
| Wastewater-indicators | Solid-phase extraction and gas chromatography/mass spectrometry | NWQL, Schedule 1433 | Zaugg and others, 2002 |
| Constituents of special interest | | | |
| Perchlorate | Chromatography and mass spectrometry | Montgomery Watson Harza Laboratory (CA-MHWL) | Hautman and others, 1999 |
| <i>N</i> -nitrosodimethylamine (NDMA) | Chromatography and mass spectrometry | Montgomery Watson Harza Laboratory (CA-MHWL) | U.S. Environmental Protection Agency, 1996; U.S. Environmental Protection Agency, 1999b |
| Inorganic constituents | | | |
| Nutrients | Alkaline persulfate digestion, Kjeldahl digestion | NWQL, Schedule 2755 | Fishman, 1993; Patton and Kryskalla, 2003 |
| Major and minor ions, trace elements and nutrients | Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry | NWQL, Schedule 1948 | Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; Garbarino and Damrau, 2001; American Public Health Association, 1998; Garbarino and others, 2006 |
| Chromium, arsenic and iron speciation | Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy | USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO) | Stookey, 1970; To and others, 1998; Ball and McCleskey, 2003a,b; McCleskey and others, 2003 |
| Stable isotopes | | | |
| 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 |
| Nitrogen and oxygen isotopes of nitrate | Denitrifier method and mass spectrometry | Lawrence Livermore National Laboratory (CA-LLNL) | Singleton and others, 2005; Böhlke and others, 2003 |

Table A1. Analytical methods used for the determination of organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.—Continued

[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. HPLC, high performance liquid chromatography; VOC, volatile organic compound]

| Analyte | Analytical method | Laboratory and analytical schedule | Citation(s) |
|----------------------------------|---|--|---|
| Carbon isotopes | Accelerator mass spectrometry | University of Waterloo, Environmental Isotope Lab (CAN-UWIL); University of Arizona Accelerator Mass Spectrometry Lab (AZ-UAMSL), NWQL Schedule 2015 | Donahue and others, 1990; Jull and others, 2004 |
| Bromine isotopes | Continuous-flow isotope ratio mass spectrometry | University of Waterloo, Environmental Isotope Lab (CAN-UWIL) | Shouakar-Stash and others, 2005b |
| Chlorine isotopes | Continuous-flow isotope ratio mass spectrometry | University of Waterloo, Environmental Isotope Lab (CAN-UWIL) | Shouakar-Stash and others, 2005a |
| Radioactivity and gases | | | |
| Tritium | Electrolytic enrichment-liquid scintillation | USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA) | Thatcher and others, 1977 |
| Tritium and noble gases | Helium-3 in-growth and mass spectrometry | Lawrence Livermore National Laboratory (CA-LLNL) | Moran and others, 2002a; Eaton and others, 2004 |
| Radon-222 | Liquid scintillation counting | NWQL, Schedule 1369 | American Society for Testing and Materials, 1998 |
| Uranium isotopes | Chemical separations and alpha-particle spectrometry | Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130 | American Society for Testing and Materials, 2000, D3972 |
| Microbial constituents | | | |
| F-specific and somatic coliphage | Single-agar layer (SAL) and two-step enrichment methods | USGS Ohio Water Microbiology Laboratory (USGSOHML) | U.S. Environmental Protection Agency, 2001 |

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Preferred analytical schedules are generally the methods of analysis with the greatest accuracy and precision out of the ones used for the compound in question except in cases where consistency with historic data analyzed using the same method is preferred. LLNL, Lawrence Livermore National Laboratory; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory; VOC, volatile organic compound]

| Constituent | Primary constituent classification | Analytical schedules | Preferred analytical schedule |
|---|------------------------------------|----------------------|-------------------------------|
| Results from preferred method reported | | | |
| Atrazine | Pesticide | 2003, 2060 | 2003 |
| Bromacil | Pesticide | 2060, 1433 | 2060 |
| Bromoform (Tribromomethane) | VOC | 2020, 1433 | 2020 |
| Caffeine | Wastewater indicator | 2060, 1433, 2080 | 2060 |
| Carbaryl | Pesticide | 2060, 2003, 1433 | 2003 |
| Chlorpyrifos | Pesticide | 2003, 1433 | 2003 |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine) | Pesticide degradate | 2003, 2060 | 2003 |
| Cotinine | Wastewater indicator | 1433, 2080 | 1433 |
| Diazinon | Pesticide | 2003, 1433 | 2003 |
| 1,4-Dichlorobenzene | VOC, pesticide | 2020, 1433 | 2020 |
| Isopropylbenzene | VOC | 2020, 1433 | 2020 |
| Metalaxyl | Pesticide | 2060, 2003, 1433 | 2003 |
| Metolachlor | Pesticide | 2003, 1433 | 2003 |
| Naphthalene | VOC | 2020, 1433 | 2020 |
| Prometon | Pesticide | 2003, 1433 | 2003 |
| Tetrachloroethene (PCE) | VOC | 2020, 1433 | 2020 |
| Tebuthiuron | Herbicide | 2060, 2003 | 2003 |
| Results from both methods reported (different USGS parameter codes) | | | |
| Alkalinity | Water-quality indicator | 1948, field | field |
| Arsenic, total | Trace element | 1948, TML | 1948 |
| Chromium, total | Trace element | 1948, TML | 1948 |
| Iron, total | Trace element | 1948, TML | 1948 |
| pH | Water-quality indicator | 1948, field | field |
| Specific conductance | Water-quality indicator | 1948, field | field |
| Tritium | Radioactive | LLNL, SITL | both |

Table A3. Constituents detected in field blanks collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[V-coded data are reported but not used in summary statistics; E, estimated value; µg/L, micrograms per liter; mg/L, milligrams per liter; — not detected]

| Constituent | Slow schedule | | | Fast schedule | | |
|--|---|--|---|---|--|---|
| | Number of field blank detections/analyses | Maximum concentration detected in field blanks | Number of ground-water samples censored | Number of field blank detections/analyses | Maximum concentration detected in field blanks | Number of ground-water samples censored |
| Organic constituents (µg/L) | | | | | | |
| Carbon disulfide | 1/5 | E 0.04 | 0 | 0/4 | — | 0 |
| Methyl ethyl ketone (2-Butanone, MEK) | 1/5 | 8.6 | 0 | 0/4 | — | 0 |
| <i>m</i> -Xylene plus <i>p</i> -xylene | 2/5 | E 0.05 | 0 | 0/4 | — | 0 |
| Toluene | 4/5 | E 0.018 | 5 | 0/4 | — | 1 |
| Acetaminophen | 1/5 | E 0.001 | 0 | 0/0 | — | 0 |
| Diphenhydramine | 1/5 | E 0.003 | 0 | 0/0 | — | 0 |
| Benzophenone | 1/5 | E 0.028 | 0 | 0/0 | — | 0 |
| Constituents of special interest ¹ (µg/L) | | | | | | |
| <i>N</i> -Nitrosodimethylamine (NDMA) | 1/5 | 0.01 | 3 | 0/0 | — | 0 |
| Inorganic constituents (mg/L) | | | | | | |
| Silica | 1/5 | 0.044 | 0 | 0/0 | — | 0 |
| Total Nitrogen | 1/5 | 0.10 | 0 | 0/0 | — | 0 |
| Trace elements (µg/L) | | | | | | |
| Iron (TML) ² | 1/5 | 2 | 0 | 1/4 | 3 | 0 |
| Lead | 1/5 | 0.13 | 0 | 0/0 | — | 0 |
| Nickel | 1/5 | E 0.03 | 0 | 0/0 | — | 0 |
| Vanadium | 2/5 | 0.04 | 0 | 0/0 | — | 0 |

¹Analyses performed at Montgomery Watson Harza Laboratories, Monrovia, California.²Iron analyses made by U.S. Geological Survey Trace Metal Laboratory (80093).

Table A4. Quality-control summary for replicate analyses of constituents detected in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[RSD, relative standard deviation in percent; E, estimated value; na, not available; TU, tritium unit; <, less than; >, greater than; µg/L, microgram per liter; pCi/L, picocurie per liter]

| Constituent | Number of relative standard deviations > 20%/number of replicate pairs | Maximum relative standard deviation (percent) | Measured values for pairs with RSD > 20 (environmental, replicate) |
|---|--|---|--|
| Volatile organic compounds from schedule 2020 | | | |
| All VOCs from schedule 2020 | 0/7 | <20 | na |
| Pesticides and pesticide degradates from schedules 2003 and 2060 | | | |
| All additional pesticides and pesticide degradates from schedule 2003 | 0/7 | 0 | na |
| All additional pesticides and pesticide degradates from schedule 2060 | 0/7 | 0 | na |
| Wastewater Compounds from schedule 1433 | | | |
| All potential wastewater-indicator compounds | 0/2 | 0 | na |
| Pharmaceuticals from schedule 2080 | | | |
| All pharmaceuticals | 0/2 | 0 | na |
| Constituents of special interest ¹ | | | |
| Perchlorate | 0/7 | 0 | na |
| N-Nitrosodimethylamine (NDMA) | 0/2 | 0 | na |
| Major ions, minor ions, trace elements, nutrients, arsenic, chromium, and iron speciation | | | |
| Cobalt (µg/L) | 1/2 | 39 | (E0.04, 0.07) |
| Zinc (µg/L) | 1/2 | 85 | (1.8, 0.4) |
| All additional major ions, minor ions, trace elements from schedule 1948 | 0/2 | <20 | na |
| Iron (total) (µg/L) ² | 7/7 | 61 | (<2, 5), (10, 15), (49, 50), (<2, 3), (24, 23), (3, <2), (6, 5) |
| Arsenic (total) (µg/L) ² | 4/7 | 53 | (<0.5, 1.1), (0.93, 0.81), (0.84, 0.85), (0.91, 0.90) |
| Chromium (total), chromium(VI), arsenic(III), iron(III), (µg/L) ² | 0/7 | <20 | na |
| Nutrients from schedule 2755 | 0/7 | <20 | na |
| Isotopes, radioactivity, and noble gases | | | |
| Tritium (TU) and noble gases ³ | na | na | na |
| Tritium ⁴ (TU) | 0/7 | <20 | na |
| Oxygen and hydrogen isotopes | 0/7 | <20 | na |
| Carbon isotopes | na | na | na |
| Radon (pCi/L) | 0/2 | <20 | na |
| Nitrogen and oxygen isotopes of nitrate | na | na | na |
| Boron isotopes | 0/2 | <20 | na |
| Uranium and Strontium isotopes | na | na | na |

¹Analyses performed at Montgomery Watson Harza Laboratories, Monrovia, California.

²Analyses performed at U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado.

³Analyses performed at Lawrence Livermore National Laboratory, Livermore, California.

⁴Analyses performed at U.S. Geological Survey, Menlo Park, California.

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|--|-------------------------------|----------------------------------|----------------------------------|---------------------------------|
| Acetone ¹ | 7 | 95 | 122 | 107 |
| Acrylonitrile | 7 | 92 | 112 | 108 |
| Benzene ¹ | 7 | 93 | 112 | 104 |
| Bromobenzene | 7 | 90 | 109 | 101 |
| Bromochloromethane | 7 | 95 | 120 | 110 |
| Bromodichloromethane ¹ | 7 | 92 | 115 | 102 |
| Bromoform (Tribromomethane) | 7 | 78 | 114 | 92 |
| <i>n</i> -Butylbenzene | 7 | 74 | 106 | 90 |
| <i>sec</i> -Butylbenzene | 7 | 89 | 112 | 102 |
| <i>tert</i> -Butylbenzene | 7 | 90 | 120 | 111 |
| Carbon disulfide ¹ | 7 | 70 | 92 | 76 |
| Carbon tetrachloride (Tetrachloromethane) ¹ | 7 | 91 | 117 | 107 |
| Chlorobenzene | 7 | 88 | 107 | 96 |
| Chloroethane ¹ | 7 | 91 | 126 | 107 |
| Chloroform (Trichloromethane) ¹ | 7 | 100 | 122 | 111 |
| Chloromethane ¹ | 7 | 92 | 138 | 111 |
| 3-Chloro-1-propene | 7 | 109 | 128 | 114 |
| 2-Chlorotoluene | 7 | 91 | 108 | 102 |
| 4-Chlorotoluene | 7 | 87 | 111 | 102 |
| Dibromochloromethane | 7 | 79 | 115 | 94 |
| 1,2-Dibromo-3-chloropropane (DBCP) | 7 | 79 | 123 | 97 |
| 1,2-Dibromoethane (EDB) | 7 | 88 | 113 | 104 |
| Dibromomethane | 7 | 95 | 114 | 108 |
| 1,2-Dichlorobenzene | 7 | 84 | 115 | 101 |
| 1,3-Dichlorobenzene | 7 | 85 | 119 | 103 |
| 1,4-Dichlorobenzene | 7 | 85 | 118 | 106 |
| <i>trans</i> -1,4-Dichloro-2-butene | 7 | 85 | 111 | 100 |
| Dichlorodifluoromethane (CFC-12) ¹ | 7 | 61 | 119 | 81 |
| 1,1-Dichloroethane ¹ | 7 | 95 | 118 | 109 |
| 1,2-Dichloroethane | 7 | 90 | 122 | 107 |
| 1,1-Dichloroethene ¹ | 7 | 85 | 116 | 95 |
| <i>cis</i> -1,2-Dichloroethene ¹ | 7 | 99 | 107 | 104 |
| <i>trans</i> -1,2-Dichloroethene | 7 | 97 | 121 | 110 |
| Dichloromethane (Methylene chloride) ¹ | 7 | 95 | 113 | 103 |
| 1,2-Dichloropropane | 7 | 94 | 105 | 102 |
| 1,3-Dichloropropane | 7 | 90 | 117 | 106 |
| 2,2-Dichloropropane | 7 | 82 | 95 | 85 |
| 1,1-Dichloropropene | 7 | 91 | 111 | 94 |
| <i>cis</i> -1,3-Dichloropropene | 7 | 79 | 93 | 87 |
| <i>trans</i> -1,3-Dichloropropene | 7 | 78 | 100 | 89 |
| Diethyl ether | 7 | 87 | 104 | 96 |
| Diisopropyl ether (DIPE) | 7 | 90 | 102 | 92 |

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|--|-------------------------------|----------------------------------|----------------------------------|---------------------------------|
| Ethylbenzene | 7 | 90 | 113 | 97 |
| Ethyl tert-butyl ether (ETBE) | 7 | 78 | 93 | 89 |
| Ethyl methacrylate | 7 | 83 | 100 | 92 |
| 1-Ethyl-2-methylbenzene (<i>o</i> -Ethyl toluene) | 7 | 84 | 105 | 99 |
| Hexachlorobutadiene | 7 | 63 | 86 | 80 |
| Hexachloroethane | 7 | 79 | 115 | 100 |
| 2-Hexanone (n-Butyl methyl ketone) | 7 | 85 | 123 | 102 |
| Isopropylbenzene (Cumene) | 7 | 90 | 112 | 96 |
| 4-Isopropyl-1-methylbenzene | 7 | 85 | 110 | 99 |
| Methyl acrylate | 7 | 88 | 115 | 106 |
| Methyl acrylonitrile | 7 | 95 | 130 | 114 |
| Methyl bromide (Bromomethane) | 7 | 104 | 149 | 110 |
| Methyl <i>tert</i> -butyl ether (MTBE) ¹ | 7 | 87 | 98 | 93 |
| Methyl ethyl ketone (2-Butanone, MEK) ¹ | 7 | 91 | 113 | 108 |
| Methyl iodide (Iodomethane) | 7 | 98 | 118 | 107 |
| Methyl isobutyl ketone (MIBK) | 7 | 82 | 107 | 96 |
| Methyl methacrylate | 7 | 82 | 94 | 88 |
| Methyl <i>tert</i> -pentyl ether (<i>tert</i> -Amyl methyl ether, TAME) | 7 | 84 | 101 | 98 |
| Naphthalene | 7 | 80 | 102 | 87 |
| <i>n</i> -Propylbenzene | 7 | 85 | 110 | 99 |
| Styrene | 7 | 84 | 116 | 98 |
| 1,1,1,2-Tetrachloroethane | 7 | 87 | 117 | 106 |
| 1,1,2,2-Tetrachloroethane | 7 | 88 | 128 | 104 |
| Tetrachloroethene (PCE) ¹ | 7 | 93 | 128 | 103 |
| Tetrahydrofuran ¹ | 7 | 91 | 128 | 112 |
| 1,2,3,4-Tetramethylbenzene ¹ | 7 | 76 | 107 | 94 |
| 1,2,3,5-Tetramethylbenzene | 7 | 84 | 124 | 102 |
| Toluene ¹ | 7 | 91 | 115 | 99 |
| 1,2,3-Trichlorobenzene | 7 | 85 | 114 | 97 |
| 1,2,4-Trichlorobenzene | 7 | 78 | 100 | 86 |
| 1,1,1-Trichloroethane ¹ | 7 | 92 | 118 | 108 |
| 1,1,2-Trichloroethane | 7 | 87 | 112 | 103 |
| Trichloroethene (TCE) ¹ | 7 | 89 | 105 | 95 |
| Trichlorofluoromethane (CFC-11) ¹ | 7 | 90 | 120 | 108 |
| 1,2,3-Trichloropropane (1,2,3-TCP) | 7 | 84 | 124 | 106 |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113) ¹ | 7 | 71 | 107 | 84 |
| 1,2,3-Trimethylbenzene | 7 | 89 | 122 | 107 |
| 1,2,4-Trimethylbenzene | 7 | 86 | 121 | 109 |
| 1,3,5-Trimethylbenzene | 7 | 86 | 115 | 103 |
| Vinyl bromide (Bromoethene) | 7 | 104 | 132 | 118 |
| Vinyl chloride (Chloroethene) | 7 | 95 | 134 | 109 |
| <i>m</i> - and <i>p</i> -Xylene | 7 | 91 | 128 | 105 |
| <i>o</i> -Xylene | 7 | 89 | 104 | 97 |

¹ Constituents detected in ground-water samples.

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|----------------------------|----------------------------------|----------------------------------|---------------------------------|
| Acetochlor | 7 | 102 | 124 | 114 |
| Alachlor | 7 | 103 | 124 | 111 |
| Atrazine ¹ | 7 | 101 | 111 | 107 |
| Azinphos-methyl | 7 | 88 | 121 | 101 |
| Azinphos-methyl-oxon | 7 | 25 | 74 | 44 |
| Benfluralin | 7 | 70 | 89 | 74 |
| Carbaryl | 7 | 99 | 157 | 122 |
| 2-Chloro-2,6-diethylacetanilide | 7 | 91 | 111 | 103 |
| 4-Chloro-2-methylphenol | 7 | 57 | 95 | 71 |
| Chlorpyrifos | 7 | 100 | 111 | 105 |
| Chlorpyrifos, oxygen analog | 7 | 9 | 49 | 23 |
| Cyfluthrin | 7 | 48 | 106 | 60 |
| Cypermethrin | 7 | 51 | 104 | 60 |
| Dacthal (DCPA) | 7 | 103 | 128 | 115 |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine) ¹ | 7 | 44 | 74 | 56 |
| Desulfinylfipronil | 7 | 86 | 117 | 104 |
| Desulfinylfipronil amide | 7 | 73 | 134 | 110 |
| Diazinon | 7 | 94 | 109 | 99 |
| 3,4-Dichloroaniline | 7 | 87 | 105 | 92 |
| Dichlorvos | 7 | 16 | 47 | 25 |
| Dicrotophos | 7 | 22 | 76 | 41 |
| Dieldrin | 7 | 77 | 137 | 94 |
| 2,6-Diethylaniline | 7 | 87 | 107 | 97 |
| Dimethoate | 7 | 29 | 57 | 38 |
| Ethion | 7 | 87 | 112 | 95 |
| Ethion monoxon | 7 | 83 | 124 | 102 |
| 2-Ethyl-6-methylaniline | 7 | 89 | 104 | 100 |
| Fenamiphos | 7 | 77 | 175 | 110 |
| Fenamiphos sulfone | 7 | 32 | 115 | 72 |
| Fenamiphos sulfoxide | 6 | 29 | 51 | 46 |
| Fipronil | 7 | 87 | 150 | 120 |
| Fipronil sulfide | 7 | 76 | 120 | 98 |
| Fipronil sulfone | 7 | 65 | 100 | 80 |
| Fonofos | 7 | 93 | 107 | 95 |
| Hexazinone | 7 | 59 | 89 | 66 |
| Iprodione | 7 | 54 | 87 | 79 |
| Isofenphos | 7 | 100 | 131 | 124 |
| Malaoxon | 7 | 82 | 98 | 95 |
| Malathion | 7 | 92 | 128 | 111 |
| Metalaxyl | 7 | 100 | 120 | 110 |
| Methidathion | 7 | 92 | 111 | 104 |
| Metolachlor ¹ | 7 | 102 | 118 | 111 |
| Metribuzin | 7 | 75 | 114 | 96 |
| Myclobutanil | 7 | 94 | 122 | 107 |
| 1-Naphthol | 7 | 21 | 43 | 29 |
| Paraoxon-methyl | 7 | 46 | 78 | 57 |
| Parathion-methyl | 7 | 82 | 110 | 96 |

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to 2007.—Continued

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|------------------------|----------------------------|----------------------------------|----------------------------------|---------------------------------|
| Pendimethalin | 7 | 84 | 128 | 104 |
| <i>cis</i> -Permethrin | 7 | 55 | 96 | 66 |
| Phorate | 7 | 57 | 93 | 71 |
| Phorate oxon | 7 | 85 | 136 | 106 |
| Phosmet | 7 | 6 | 24 | 16 |
| Phosmet oxon | 6 | 6 | 12 | 8 |
| Prometon ¹ | 7 | 92 | 117 | 105 |
| Prometryn | 7 | 102 | 120 | 112 |
| Propyzamide | 7 | 89 | 114 | 105 |
| Simazine ¹ | 7 | 103 | 116 | 111 |
| Tebuthiuron | 7 | 99 | 165 | 122 |
| Terbufos | 7 | 84 | 124 | 98 |
| Terbufos oxon sulfone | 7 | 73 | 111 | 78 |
| Terbuthylazine | 7 | 100 | 118 | 109 |
| Tribufos | 7 | 62 | 105 | 82 |
| Trifluralin | 7 | 77 | 102 | 83 |

¹Constituents detected in ground-water samples.

Table A5C. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|--|----------------------------|----------------------------------|----------------------------------|---------------------------------|
| Acifluorfen | 7 | 60 | 75 | 64 |
| Aldicarb | 5 | 34 | 109 | 62 |
| Aldicarb sulfone | 7 | 30 | 88 | 80 |
| Aldicarb sulfoxide | 7 | 84 | 110 | 101 |
| Bendiocarb | 7 | 61 | 84 | 74 |
| Benomyl ¹ | 7 | 39 | 95 | 68 |
| Bensulfuron-methyl | 7 | 72 | 97 | 87 |
| Bentazon ¹ | 7 | 63 | 89 | 70 |
| Bromacil | 7 | 87 | 122 | 108 |
| Bromoxynil | 7 | 46 | 81 | 64 |
| Caffeine ¹ | 5 | 42 | 90 | 80 |
| Carbofuran | 7 | 83 | 104 | 93 |
| Chloramben, methyl ester | 7 | 75 | 108 | 98 |
| Chlorimuron-ethyl | 7 | 55 | 75 | 70 |
| 3-(4-Chlorophenyl)-1-methyl urea | 7 | 44 | 100 | 92 |
| Clopyralid | 7 | 39 | 82 | 60 |
| Cycloate | 7 | 69 | 78 | 72 |
| 2,4-D plus 2,4-D methyl ester | 7 | 73 | 92 | 80 |
| 2,4-DB (4-(2,4-Dichlorophenoxy)butyric acid) | 7 | 57 | 74 | 66 |
| DCPA (Dacthal) monoacid | 7 | 65 | 100 | 74 |
| Deisopropyl atrazine (2-chloro-6-ethylamino-4-amino-s-triazine) | 7 | 75 | 100 | 95 |
| Dicamba | 7 | 47 | 82 | 69 |
| Dichlorprop | 7 | 73 | 89 | 78 |
| Dinoseb | 7 | 48 | 73 | 62 |
| Diphenamid | 7 | 86 | 107 | 96 |
| Diuron | 7 | 88 | 107 | 100 |
| Fenuron | 7 | 76 | 100 | 88 |
| Flumetsulam | 7 | 66 | 110 | 83 |
| Fluometuron | 7 | 89 | 104 | 100 |
| Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine) | 7 | 80 | 121 | 95 |
| 3-Hydroxycarbofuran | 7 | 61 | 100 | 90 |
| Imazaquin | 7 | 63 | 97 | 92 |
| Imazethapyr | 7 | 56 | 105 | 95 |
| Imidacloprid | 7 | 66 | 102 | 85 |
| Linuron | 7 | 89 | 106 | 93 |
| MCPA (2-Methyl-4-chlorophenoxyacetic acid) | 7 | 67 | 85 | 74 |
| MCPB (4-(2-Methyl-4-chlorophenoxy) butyric acid) | 7 | 58 | 77 | 68 |
| Methiocarb | 7 | 83 | 100 | 91 |
| Methomyl | 5 | 90 | 111 | 99 |
| Metsulfuron methyl | 7 | 40 | 79 | 73 |
| Neburon | 7 | 78 | 96 | 89 |
| Nicosulfuron | 7 | 81 | 123 | 98 |

Table A5C. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to 2007.—Continued

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|----------------------------------|----------------------------|----------------------------------|----------------------------------|---------------------------------|
| Norflurazon | 7 | 87 | 104 | 94 |
| Oryzalin | 7 | 76 | 85 | 78 |
| Oxamyl | 5 | 75 | 98 | 86 |
| Picloram | 7 | 48 | 86 | 62 |
| Propham | 7 | 81 | 105 | 92 |
| Propiconazole | 7 | 75 | 91 | 84 |
| Propoxur | 7 | 81 | 104 | 95 |
| Siduron | 7 | 90 | 110 | 96 |
| Sulfometuron-methyl ¹ | 7 | 71 | 94 | 83 |
| Terbacil | 7 | 73 | 102 | 91 |
| Triclopyr | 7 | 60 | 94 | 78 |

¹Constituents detected in ground-water samples.

Table A5D. Quality-control summary for matrix-spike recoveries of pharmaceutical compounds in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) |
|-------------------|-------------------------------|----------------------------------|----------------------------------|
| Acetaminophen | 2 | 77 | 98 |
| Albuterol | 2 | 80 | 104 |
| Caffeine | 2 | 100 | 115 |
| Carbamazepine | 2 | 100 | 101 |
| Codeine | 2 | 87 | 87 |
| Cotinine | 2 | 84 | 91 |
| Dehydronifedipine | 2 | 95 | 104 |
| Diltiazem | 2 | 35 | 59 |
| Diphenhydramine | 2 | 58 | 83 |
| Paraxanthine | 2 | 78 | 88 |
| Sulfamethoxazole | 2 | 77 | 95 |
| Thiabendazole | 2 | 86 | 91 |
| Trimethoprim | 2 | 97 | 98 |
| Warfarin | 2 | 74 | 78 |

Table A5E. Quality-control summary for matrix-spike recoveries of potential wastewater-indicator compounds in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) |
|---|----------------------------|----------------------------------|----------------------------------|
| Acetophenone | 2 | 117 | 124 |
| Acetyl hexamethyl tetrahydro naphthalene (AHTN) | 2 | 98 | 111 |
| Anthracene | 2 | 74 | 78 |
| 9,10-Anthraquinone | 2 | 102 | 102 |
| Benzo[a]pyrene | 2 | 68 | 71 |
| Benzophenone | 2 | 104 | 112 |
| Bisphenol A | 2 | 5 | 8 |
| Bromacil | 2 | 97 | 100 |
| Bromoform (tribromomethane) | 2 | 61 | 75 |
| 3- <i>tert</i> -Butyl-4-hydroxy anisole (BHA) | 2 | 28 | 34 |
| Caffeine | 2 | 94 | 98 |
| Camphor | 2 | 96 | 107 |
| Carbaryl | 2 | 82 | 91 |
| Carbazole | 2 | 89 | 91 |
| Chlorpyrifos | 2 | 91 | 99 |
| Cholesterol | 2 | 43 | 58 |
| 3- β -Coprostanol | 2 | 41 | 63 |
| Cotinine | 2 | 73 | 81 |
| <i>p</i> -Cresol | 2 | 114 | 124 |
| 4-Cumylphenol | 2 | 94 | 96 |
| Diazinon | 2 | 86 | 99 |
| <i>N,N</i> -diethyl- <i>m</i> -toluamide (DEET) | 2 | 113 | 114 |
| 1,4-Dichlorobenzene | 2 | 63 | 64 |
| 2,6-Dimethylnaphthalene | 2 | 33 | 69 |
| Fluoranthene | 2 | 87 | 88 |
| Hexahydrohexamethylcyclopentabenzopyran (HHCB) | 2 | 91 | 111 |
| Indole | 2 | 86 | 91 |
| Isoborneol | 2 | 63 | 95 |
| Isophorone | 2 | 103 | 116 |
| Isopropylbenzene | 2 | 35 | 49 |
| Isoquinoline | 2 | 99 | 104 |
| <i>d</i> -Limonene | 2 | 30 | 31 |
| Menthol | 2 | 62 | 99 |
| Metalaxyl | 2 | 117 | 119 |
| 3-Methyl-1(H)-indole (Skatole) | 2 | 84 | 102 |
| 5-Methyl-1H-benzotriazole | 2 | 55 | 70 |
| 1-Methylnaphthalene | 2 | 66 | 76 |
| 2-Methylnaphthalene | 2 | 57 | 66 |
| Methyl salicylate | 2 | 111 | 114 |
| Metolachlor | 2 | 106 | 116 |
| Naphthalene | 2 | 80 | 86 |
| 4-Nonylphenol (total) | 2 | 79 | 93 |
| 4- <i>n</i> -Octylphenol | 2 | 67 | 78 |
| 4- <i>tert</i> -Octylphenol | 2 | 95 | 101 |
| 4-Nonylphenol diethoxylates (Diethoxynonylphenol) | 2 | 164 | 179 |
| 4-Octylphenol diethoxylates (Diethoxyoctylphenol) | 2 | 83 | 131 |

Table A5E. Quality-control summary for matrix-spike recoveries of potential wastewater-indicator compounds in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.—
Continued

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) |
|---|----------------------------|----------------------------------|----------------------------------|
| 4-Octylphenol monoethoxylates (Ethoxyoctylphenol) | 2 | 166 | 173 |
| Pentachlorophenol | 1 | 19 | 19 |
| Phenanthrene | 2 | 78 | 87 |
| Phenol | 2 | 106 | 113 |
| Prometon | 2 | 80 | 96 |
| Pyrene | 2 | 83 | 84 |
| beta-Sitosterol | 2 | 41 | 74 |
| beta-Stigmastanol | 2 | 60 | 73 |
| Tetrachloroethylene (PCE) | 2 | 9 | 11 |
| Tributyl phosphate | 2 | 94 | 104 |
| Triclosan | 2 | 99 | 103 |
| Triethyl citrate (ethyl citrate) | 2 | 87 | 90 |
| Triphenyl phosphate | 2 | 91 | 96 |
| Tris(2-butoxyethyl)phosphate ¹ | 2 | 90 | 97 |
| Tris(2-chloroethyl)phosphate ¹ | 2 | 90 | 98 |
| Tris(dichlorisopropyl)phosphate | 2 | 100 | 100 |

¹Constituents detected in ground-water samples

Table A5F. Quality-control summary for matrix-spike recoveries of *N*-Nitrosodimethylamine (NDMA) in ground-water samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Mini- mum recovery (per- cent) | Maxi- mum recovery (per- cent) |
|---------------------------------------|-------------------------------|--|--|
| <i>N</i> -Nitrosodimethylamine (NDMA) | 2 | 98 | 102 |

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds, pesticides and pesticide degradates, pharmaceutical compounds, potential wastewater-indicator compounds, and constituents of special interest in samples collected for the San Francisco Bay Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April to June 2007.

[VOC, volatile organic compound; MWH, Montgomery Watson Harza Laboratory; NDMA, *N*-nitrosodimethylamine]

| Surrogate | Analytical schedule | Constituent or constituent class analyzed | Number of blank analyses | Median recovery in blanks (percent) | Number of surrogate recoveries below 70 percent in blanks | Number of surrogate recoveries above 130 percent in blanks | Number of sample analyses | Median recovery in samples (percent) | Number of surrogate recoveries below 70 percent in samples | Number of surrogate recoveries above 130 percent in samples |
|--------------------------------|---------------------|---|--------------------------|-------------------------------------|---|--|---------------------------|--------------------------------------|--|---|
| 1-Bromo-4-fluorobenzene | 2020 | VOC, gas oxygenate | 9 | 77 | 1 | 0 | 79 | 72 | 22 | 0 |
| 1,2-Dichloroethane- <i>d</i> 4 | 2020 | VOC, gas oxygenate | 9 | 111 | 0 | 2 | 79 | 125 | 0 | 27 |
| Toluene- <i>d</i> 8 | 2020 | VOC, gas oxygenate | 9 | 97 | 0 | 0 | 79 | 98 | 0 | 0 |
| Diazinon- <i>d</i> 10 | 2003 | Pesticide | 9 | 101 | 0 | 0 | 79 | 104 | 0 | 1 |
| alpha-HCH- <i>d</i> 6 | 2003 | Pesticide | 9 | 89 | 0 | 0 | 79 | 90 | 0 | 0 |
| 2,4,5-T | 2060 | Pesticide | 9 | 82 | 0 | 0 | 79 | 77 | 6 | 0 |
| Barban | 2060 | Pesticide | 9 | 87 | 0 | 0 | 79 | 88 | 0 | 0 |
| Caffeine- ¹³ C | 2060 | Pesticide | 9 | 88 | 0 | 0 | 79 | 85 | 6 | 0 |
| NDMA- <i>d</i> 6 | MWH | NDMA | 5 | 78 | 2 | 0 | 31 | 84 | 1 | 0 |
| Ethyl nicotinate- <i>d</i> 4 | 2080 | Pharmaceutical | 5 | 94 | 1 | 0 | 31 | 90 | 2 | 0 |
| Carbamazepine- <i>d</i> 10 | 2080 | Pharmaceutical | 5 | 101 | 1 | 0 | 31 | 103 | 0 | 0 |
| Caffeine- ¹³ C | 1433 | Wastewater-indicator | 5 | 98 | 0 | 0 | 31 | 98 | 0 | 0 |
| Decafluorobiphenyl | 1433 | Wastewater-indicator | 5 | 61 | 3 | 0 | 31 | 68 | 19 | 0 |
| Fluoranthene- <i>d</i> 10 | 1433 | Wastewater-indicator | 5 | 105 | 0 | 0 | 31 | 102 | 0 | 0 |
| Bisphenol A- <i>d</i> 3 | 1433 | Wastewater-indicator | 5 | 4 | 5 | 0 | 31 | 0 | 31 | 0 |

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