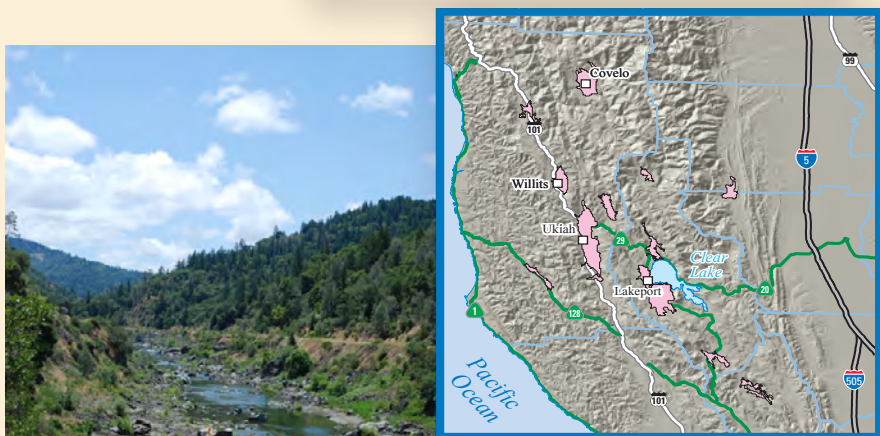
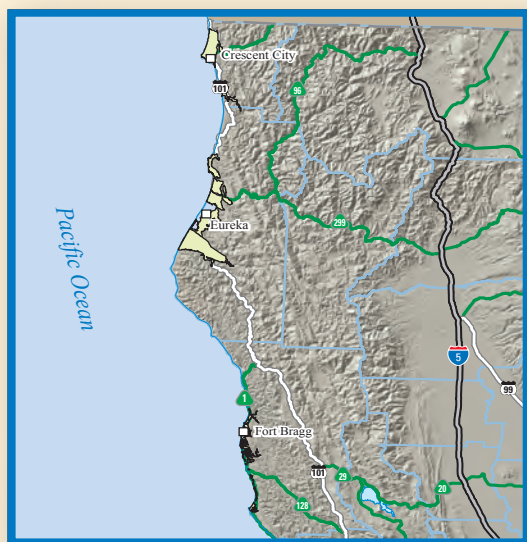


Prepared in cooperation with the California State Water Resources Control Board and the
U.S. Geological Survey National Water-Quality Assessment Program
A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Groundwater-Quality Data in the Northern Coast Ranges Study Unit, 2009: Results from the California GAMA Program



Data Series 609



Cover:

Top right: Public supply well, Mendocino, California. (Photograph taken by Stephen Schmitt, U.S. Geological Survey.)

Bottom left: Eel River from California Highway 162, near Covelo, California. (Photograph taken by Barbara Dawson, U.S. Geological Survey.)

Bottom right: Trinidad Head Memorial, Trinidad, California. (Photograph taken by George Bennett V, U.S. Geological Survey.)

Groundwater-Quality Data in the Northern Coast Ranges Study Unit, 2009: Results from the California GAMA Program

By Timothy M. Mathany, Barbara J. Dawson, Jennifer L. Shelton, and
Kenneth Belitz

Prepared in cooperation with the California State Water Resources Control Board and the U.S. Geological Survey National Water-Quality Assessment Program

Data Series 609

U.S. Department of the Interior
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KEN SALAZAR, Secretary

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Suggested citation:

Mathany, T.M., Dawson, B.J., Shelton, J.L., and Belitz, Kenneth, 2011, Groundwater-quality data in the northern Coast Ranges study unit, 2009: Results from the California GAMA Program: U.S. Geological Survey Data-Series 609, 92 p.

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Conversion Factors, Datums, and Abbreviations and Acronyms

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi ²)	2.590	square kilometer (km ²)
pound, avoirdupois (lb)	0.45359	kilogram (kg)

SI to Inch/Pound

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
micrometer (μm)	3.3×10^{-6}	foot (ft)
kilometer (km)	0.6214	mile (mi)
square kilometer (km ²)	0.3861	square mile (mi ²)
liter (L)	1.0567	quart (qt)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound, avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
 $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$.

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

Turbidity is given in nephelometric turbidity units (NTRU).

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

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

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

Conversion Factors, Datums, and Abbreviations and Acronyms—Continued

Datums

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

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

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

Selected Terms and Symbols

α	confidence level
$\text{cm}^3 \text{ STP/g}$	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
$\delta \text{ } ^i\text{E}$	delta notation, the ratio of a heavier isotope of an element ($i\text{E}$) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil
=	equal to
>	greater than
\geq	greater than or equal to
<	less than
\leq	less than or equal to
N	Normal (1-gram-equivalent per liter of solution)
—	not detected
p	significant level
pH	measure of the acidity of water
$\text{pK}_{1,2}$	acid dissociation constants of carbonic acid
pK_w	acid dissociation constant of water
R	result
z	test statistic
\pm	plus or minus
*	value is greater than benchmark level
**	value is greater than upper benchmark level

Abbreviations and Acronyms

AL	action level
AL-US	action level (USEPA)
APE	Alternate Place Entry Form program designed for USGS sampling
CAS	Chemical Abstract Service (American Chemical Society)
CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
DWP	Domestic Well Project (SWRCB)
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment Program
GPS	Global Positioning System

Conversion Factors, Datums, and Abbreviations and Acronyms—Continued

Abbreviations and Acronyms—Continued

HAL	lifetime health advisory level
HAL-US	lifetime health advisory level (USEPA)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land surface datum
LT-MDL	long-term method detection level
M	presence verified but not quantified
MCL	maximum contaminant level
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
na	not available
nc	not collected
NELAP	National Environmental Laboratory Accreditation Program
NFM	National Field Manual (USGS)
NFQA	National Field Quality Assurance Program (USGS)
NL	notification level
NL-CA	notification level (CDPH)
NOCO	Northern Coast Ranges study unit
NOCO-CO	Coastal Basins study area
NOCO-IN	Interior Basins study area
nv	no measured value or no value in category
np	no preference
NWIS	National Water Information System (USGS)
OBSP	Organic Blind Sample Program (USGS)
PBP	Priority Basin Project
PCFF	Personal Computer Field Form program designed for USGS sampling
QA	quality assurance
QC	quality control
RL	reporting level
RPD	relative percent difference
RSD	relative standard deviation
RSD5	risk-specific dose at 10^{-5} (USEPA)
S	most probable value
SD	standard deviation
SMCL	secondary maximum contaminant level
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)

Conversion Factors, Datums, and Abbreviations and Acronyms—Continued

Abbreviations and Acronyms—Continued

SRL	study reporting level (concentration cutoff for applying the \leq symbol)
ssL _c	sample-specific critical level
TT	Treatment Technique
TT-US	Treatment Technique (USEPA)
U.S.	United States
UV	ultraviolet
VPDB	Vienna Pee Dee Belemnite (the international reference standard for carbon isotopes)
VSMOW	Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency)

Organizations

BQS	Branch of Quality Systems (USGS)
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
LLNL	Lawrence Livermore National Laboratory
NAWQA	National Water-Quality Assessment (USGS)
NWQL	National Water Quality Laboratory (USGS)
SWRCB	California State Water Resources Control Board
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Selected Chemical Names

CaCO ₃	calcium carbonate
CO ₃ ⁻²	carbonate
CFC	chlorofluorocarbon
DOC	dissolved organic carbon
H ₂ O	water
HCl	hydrochloric acid
HCO ₃ ⁻	bicarbonate
MTBE	methyl <i>tert</i> -butyl ether
PCE	perchloroethene (tetrachloroethene)
SiO ₂	silicon dioxide
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

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Groundwater-Quality Data in the Northern Coast Ranges Study Unit, 2009: Results from the California GAMA Program

By Timothy M. Mathany, Barbara J. Dawson, Jennifer L. Shelton, and Kenneth Belitz

Abstract

Groundwater quality in the 633-square-mile Northern Coast Ranges (NOCO) study unit was investigated by the U.S. Geological Survey (USGS) from June to November 2009, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP) and the U.S. Geological Survey National Water-Quality Assessment Program (NAWQA). The GAMA-PBP was developed in response to the California Groundwater Quality Monitoring Act of 2001 and is being conducted in collaboration with the SWRCB and Lawrence Livermore National Laboratory (LLNL). The NOCO study unit was the thirtieth study unit to be sampled as part of the GAMA-PBP.

The GAMA Northern Coast Ranges study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer systems, and to facilitate statistically consistent comparisons of untreated groundwater quality throughout California. The primary aquifer systems (hereinafter referred to as primary aquifers) are defined as that part of the aquifer corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the NOCO study unit. The quality of groundwater in shallow or deep water-bearing zones may differ from the quality of groundwater in the primary aquifers; shallow groundwater may be more vulnerable to surficial contamination.

In the NOCO study unit, groundwater samples were collected from 58 wells in 2 study areas (Interior Basins and Coastal Basins) in Napa, Lake, Mendocino, Glenn, Humboldt, and Del Norte Counties. The 58 wells were selected by using a spatially distributed, randomized grid-based method to provide statistical representation of the study areas. GAMA-PBP wells sampled as part of the spatially-distributed, randomized grid-cell network are referred to as "grid wells."

The groundwater samples were analyzed for organic and special-interest constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, and perchlorate), naturally occurring inorganic constituents (trace elements,

nutrients, dissolved organic carbon [DOC], major and minor ions, silica, total dissolved solids [TDS], and alkalinity), radioactive constituents (radon-222, radium isotopes, gross alpha and gross beta radioactivity, lead-210, and polonium-210), and microbial indicators (F-specific and somatic coliphage, *Escherichia coli* [*E. coli*] and total coliform). Naturally occurring isotopes (stable isotopes of hydrogen and oxygen in water, stable isotopes of carbon in dissolved inorganic carbon, activities of tritium, and carbon-14 abundance), and dissolved noble gases also were measured to identify the sources and ages of the sampled groundwater. In total, 239 constituents and 12 field water-quality indicators were measured.

Three types of quality-control samples (blanks, replicates, and matrix-spikes) were collected at up to 12 percent of the wells in the NOCO study unit, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Blanks rarely contained detectable concentrations of any constituent, suggesting that contamination from sample collection procedures was not a significant source of bias in the data for the groundwater samples. Replicate samples generally were within the limits of acceptable analytical reproducibility. Matrix-spike recoveries were within the acceptable range (70 to 130 percent) for approximately 89 percent of the compounds.

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

Most inorganic constituents that were detected in groundwater samples from the 58 grid wells in the NOCO study unit were detected at concentrations less than drinking-water benchmarks. In addition, all detections of organic and special-interest constituents from NOCO study-unit well samples were less than health-based benchmarks.

In total, VOCs were detected in 22 of the 58 wells sampled (approximately 38 percent), and pesticides and pesticide degradates were detected in 6 wells (approximately 10 percent) in the NOCO study unit. In the Interior Basins (NOCO-IN) study area, VOCs were detected in 13 of the 28 wells sampled (approximately 46 percent), and pesticides and pesticide degradates were detected in 5 wells (approximately 18 percent). In the Coastal Basins (NOCO-CO) study area, VOCs were detected in 9 of the 30 wells sampled (approximately 30 percent), and pesticide degradates were detected in 1 well.

Trace elements were sampled at all 58 wells in the NOCO study unit, and most detections in groundwater samples were less than health-based benchmarks. Exceptions in the NOCO-IN study area include two detections of arsenic greater than the USEPA maximum contaminant level (MCL-US) of 10 micrograms per liter ($\mu\text{g/L}$), one detection of barium greater than California maximum contaminant level (MCL-CA) of 1,000 $\mu\text{g/L}$, and five detections of boron greater than the CDPH notification level (NL-CA) of 1,000 $\mu\text{g/L}$. All detections of trace elements from wells in the NOCO-CO study area were less than health-based benchmarks. In addition, all detections of nutrients, major and minor ions, and radioactive constituents from all of the NOCO study-unit wells were less than health-based benchmarks.

Results for trace elements, major ions, and TDS with non-regulatory benchmarks set for aesthetic concerns from the 28 NOCO-IN study-area wells showed that iron concentrations greater than the CDPH secondary maximum contaminant level (SMCL-CA) of 300 $\mu\text{g/L}$ were detected in 7 wells. Manganese concentrations greater than the SMCL-CA of 50 $\mu\text{g/L}$ were detected in 12 wells. TDS concentrations greater than the SMCL-CA recommended benchmark of 500 mg/L were measured in 4 of the 28 NOCO-IN study-area wells.

In the 30 NOCO-CO study-area wells, iron concentrations greater than the SMCL-CA were detected in 8 wells, and manganese concentrations greater than the SMCL-CA were detected in 11 wells.

Microbial indicators (viral and bacterial) were sampled for at 57 wells in the NOCO study unit. One or more microbial indicator was detected in 22 wells (11 of 28 NOCO-IN study-area wells and 11 of 29 NOCO-CO study-area wells).

Introduction

About one-half of the water used for public and domestic drinking-water supply in California is groundwater (Hutson and others, 2004). To assess the quality of ambient groundwater in aquifers used for public drinking-water supply and to establish a baseline groundwater-quality monitoring program, the California State Water Resources Control Board (SWRCB) in cooperation with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL) implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (California Environmental Protection Agency, 2011, website at http://www.waterboards.ca.gov/water_issues/programs/gama/). The main goals of the GAMA Program are to improve groundwater monitoring and to increase the availability of groundwater-quality data to the public. The GAMA Program currently consists of three Projects: the (1) GAMA Priority Basin Project (PBP) conducted by the USGS (U.S. Geological Survey, 2011a, California Water Science Center website at <http://ca.water.usgs.gov/gama/>); (2) the GAMA Domestic Well Project (DWP) conducted by the SWRCB; and (3) GAMA Special Studies conducted by LLNL. The GAMA-PBP primarily focuses on the deep part of the groundwater resource, which is typically used for public drinking-water supply. The GAMA-DWP generally focuses on the shallow aquifer systems, which may be particularly at risk as a result of surficial contamination. GAMA Special Studies Project focuses on using research methods to help explain the source, fate, transport, and occurrence of chemicals that can affect groundwater quality.

All published and quality-assurance/quality-control (QA/QC) approved analytical data collected for the GAMA Program are stored in the web-based Geotracker Database (California State Water Resources Control Board, 2009, website at <https://geotracker.waterboards.ca.gov/gama/>). The Geotracker Database also stores groundwater-quality data and related reports collected by other State agencies, such as the California Department of Public Health (CDPH), California Department of Water Resources (CDWR), California Department of Pesticide Regulation (CDPR), and data collected by the SWRCB and Regional Boards from environmental monitoring wells at contaminated and (or) remediated sites.

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

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

The range of hydrologic, geologic, and climatic conditions in California must be considered in an assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics: Cascades and Modoc Plateau, Klamath Mountains, Northern Coast Ranges, Central Valley, Sierra Nevada, Basin and Range, Southern Coast Ranges, Transverse Ranges and selected Peninsular Ranges, Desert, and San Diego Drainages (fig. 1). These 10 hydrogeologic provinces include groundwater basins and subbasins designated by the CDWR (California Department of Water Resources, 2003). Groundwater basins and subbasins generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin. Eighty percent of California's approximately 16,000 active and standby drinking-water wells listed in the statewide database maintained by the CDPH (hereinafter referred to as CDPH wells) are located in groundwater

basins and subbasins within the 10 hydrogeologic provinces. Groundwater basins and subbasins were prioritized for sampling on the basis of the number of CDPH wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and registered pesticide applications (Belitz and others, 2003). Of the 472 basins and subbasins designated by the CDWR, 116 priority basins were selected and grouped into 35 study units, representing approximately 95 percent of the CDPH wells in California. In addition, some areas outside of the defined groundwater basins were included in the nearest respective study unit to achieve representation of the 20 percent of the CDPH wells not located in the groundwater basins.

The data collected in each study unit are used for three types of water-quality assessments: (1) *Status*—assessment of the current quality of the groundwater resource; (2) *Understanding*—identification of the natural and human factors affecting groundwater quality; and (3) *Trends*—detection of changes in groundwater quality (Kulongoski and Belitz, 2004). The assessments are intended to characterize the quality of groundwater in the primary aquifer systems of the study units, not the treated drinking water delivered to consumers by water purveyors. The primary aquifer systems (hereinafter referred to as primary aquifers) are defined as that part of the aquifer corresponding to the perforation intervals of wells listed in the CDPH databases for the study units. The CDPH database lists wells used for municipal and community drinking-water supplies, and includes wells from systems classified as non-transient (such as those in cities, towns, and mobile-home parks) and transient (such as those in schools, campgrounds, and restaurants). Collectively, the CDPH refers to these wells as “public-supply” wells. Groundwater quality in shallow or deep parts of the aquifer systems may differ from that in the primary aquifers. In particular, shallow groundwater may be more vulnerable to surface contamination. As a result, samples from shallow wells (such as many private domestic wells and environmental monitoring wells) can have higher concentrations of constituents from anthropogenic sources (such as VOCs and nitrate) than samples from wells screened in the underlying primary aquifers (Landon and others, 2010).

This USGS Data Series Report is the first in a series of reports presenting the water-quality data collected in the Northern Coast Ranges study unit (hereinafter referred to as the NOCO study unit) and is similar to USGS Data Series Reports written for the GAMA-PBP study units sampled to date. Data Series Reports and additional reports addressing the status, understanding, and trends aspects of the water-quality assessments of each study unit are available from the U.S. Geological Survey (2011b) at http://ca.water.usgs.gov/projects/gama/includes/GAMA_publications.html.



Figure 1. Hydrogeologic provinces of California and the location of the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study unit and study areas.

Purpose and Scope

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

The NOCO study unit lies in the central, western, and northern part of the Northern Coast Ranges hydrogeologic province as described by Belitz and others (2003). Groundwater is a major source of public drinking-water supply for many of the cities located in the NOCO study unit (Water Education Foundation, 2006). Therefore, the NOCO study unit was considered high priority for sampling to provide adequate representation of the Northern Coast Ranges hydrogeologic province. In addition, the NOCO study unit was considered a high priority for sampling to complete assessment of groundwater quality in the California Coastal Basins Principal Aquifer of the United States (U.S. Geological Survey, 2003) by the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program (Lapham and others, 2005). As a result, the NAWQA groundwater status and trends study collaborated with the GAMA-PBP to assess groundwater quality in the NOCO study unit.

Hydrogeologic Setting

The NOCO study unit is located in Northern California within the CDWR-defined Sacramento River and North Coast hydrogeologic regions and includes a total of 34 groundwater basins and subbasins (California Department of Water Resources, 2004a–gg). Combined, these basins and subbasins define the extent of the two study areas (Interior Basins and Coastal Basins) of the NOCO study unit, and cover an area of 633 square miles (mi²) in Napa, Sonoma, Colusa, Lake, Mendocino, Glenn, Humboldt, and Del Norte Counties, California ([figs. 2A–C](#) and [3A–C](#)).

Northern Coast Ranges–Interior Basins Study Area

The Interior Basins study area (hereinafter referred to as the NOCO-IN study area) is 256 mi² in area and contains 23 CDWR-defined basins (California Department of Water Resources, 2004a–w). The NOCO-IN study area is located in a region of Northern California approximately 25 to 60 mi inland of the Pacific Ocean and about 60 to 130 mi north of San Francisco. The study area consists primarily of noncontiguous inland valleys whose boundaries on the west, north, east, and south are the surrounding hills and (or) mountains. In the central part of the study area, some of the inland valleys share Clear Lake as a border ([fig. 2A–C](#)).

Land-surface altitudes in the study area range from about 475 feet above mean sea level (ft above msl) near the town of Hopland, to over 4,200 ft above msl on Mount Konocti, located just east of the town of Kelseyville. The major surface drainage features of the study area are the Eel, Russian, and Navarro Rivers and their tributaries: all of which have their headwaters outside of the study area and terminate in the Pacific Ocean. There are also large creeks (Outlet, Stoney, Scotts, St. Helena, and Pope) and numerous small creeks that drain the valleys of the study area ([fig. 2A–C](#)).

The climate in the study area is classified as Mediterranean, with warm to hot dry summers and cold, wet winters (National Oceanic and Atmospheric Administration, 2010). Practically all precipitation in the study area occurs in the fall and winter months, with average annual precipitation ranging from a low of around 22 inches (in.) near the town of Stonyford, to more than 65 in. near the town of Laytonville (California Department of Water Resources, 2004i, r; U.S. Department of Commerce, 2010).

The primary aquifers in the study area occur in Quaternary-alluvium groundwater basins made up of sand, silt, gravel, and clay eroded from the surrounding hills. These deposits interfinger with and grade into alluvial fan and terrace deposits along the sides of the valleys, and older more consolidated alluvium at depth, and in some valleys, finer-grained lake deposits towards the center of the basins. Groundwater conditions are mostly unconfined, with some confined areas toward the center of valleys and at depth (California Department of Water Resources, 2004e–w). The major rock types surrounding the alluvial valleys are the Jurassic-Cretaceous Franciscan Formation (mudstone, graywacke sandstones, chert) and ophiolitic and metamorphic volcanic rocks (Muir and Webster, 1977; Farrar, 1986; California Department of Water Resources, 2004e–w).

6 Groundwater-Quality Data in the Northern Coast Ranges Study Unit, 2009: Results from the California GAMA Program

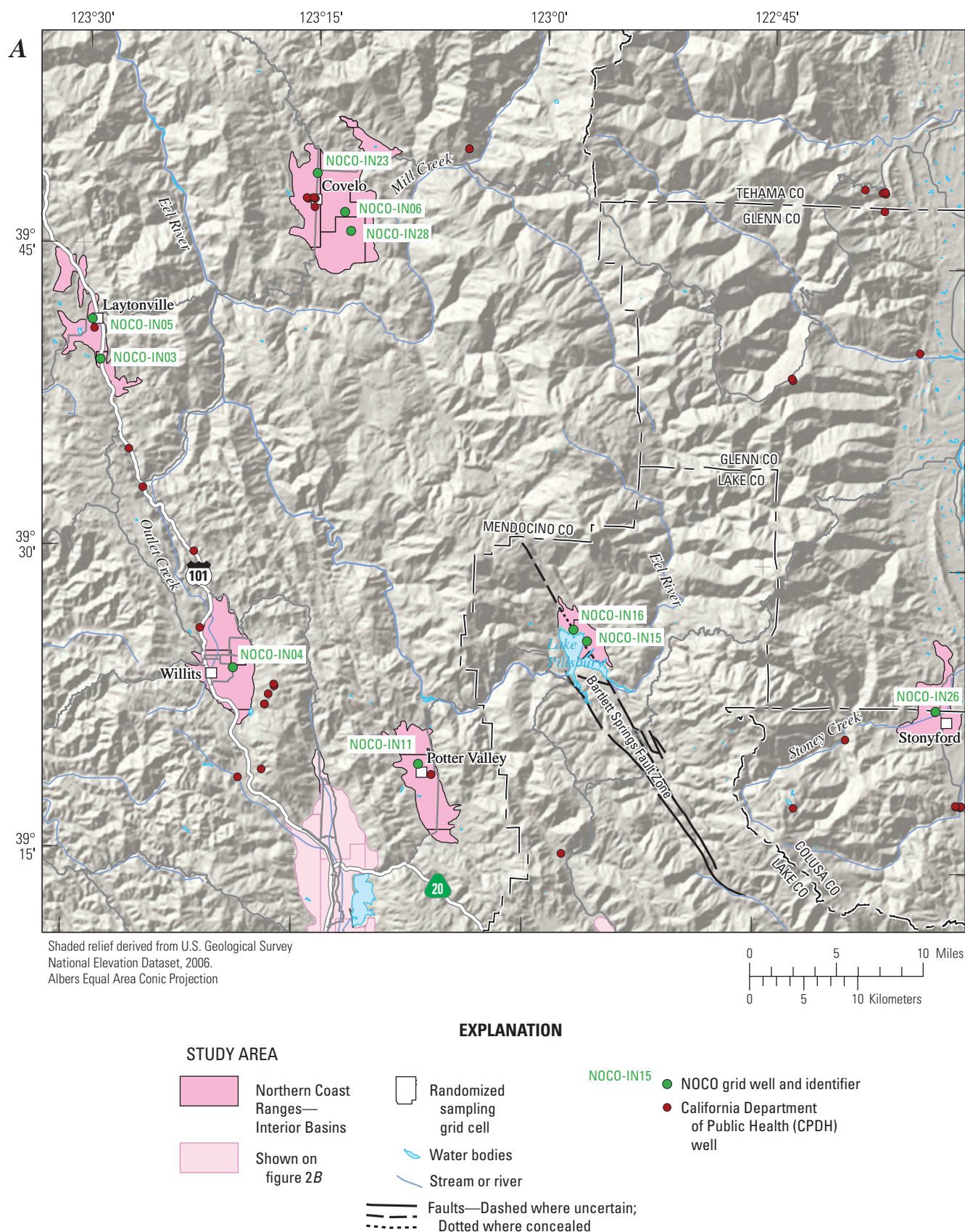


Figure 2. The Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the location of (A) the northern part, (B) the central part, (C) the southern part of the Interior Basins study area (NOCO-IN), the boundaries of the California Department of Water Resources (CDWR) defined groundwater basins, the distribution of the Interior Basins study area grid cells, the location of California Department of Public Health (CDPH) wells, and the location of sampled grid wells, major cities, major roads, topographic features, and hydrologic features.

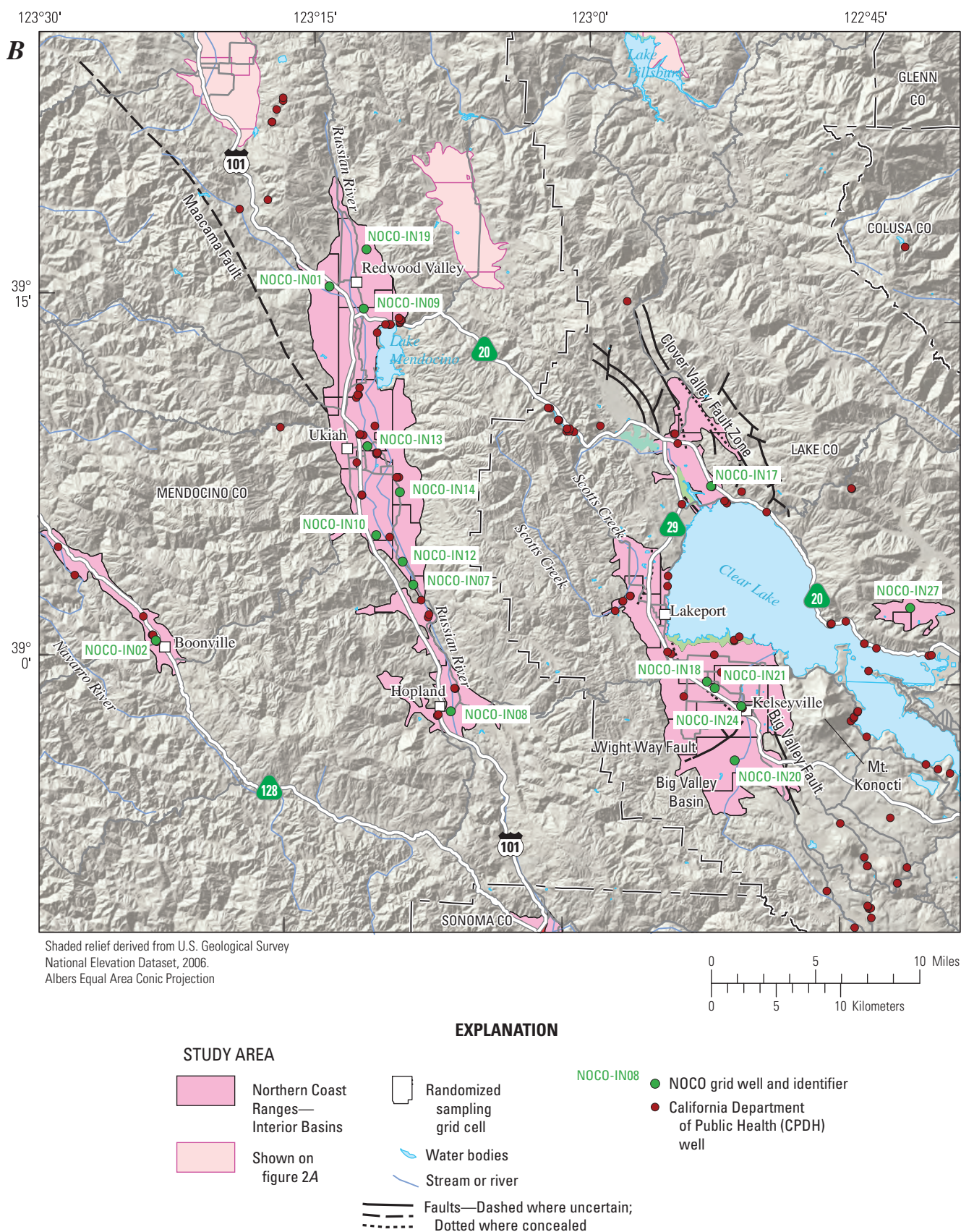


Figure 2.—Continued

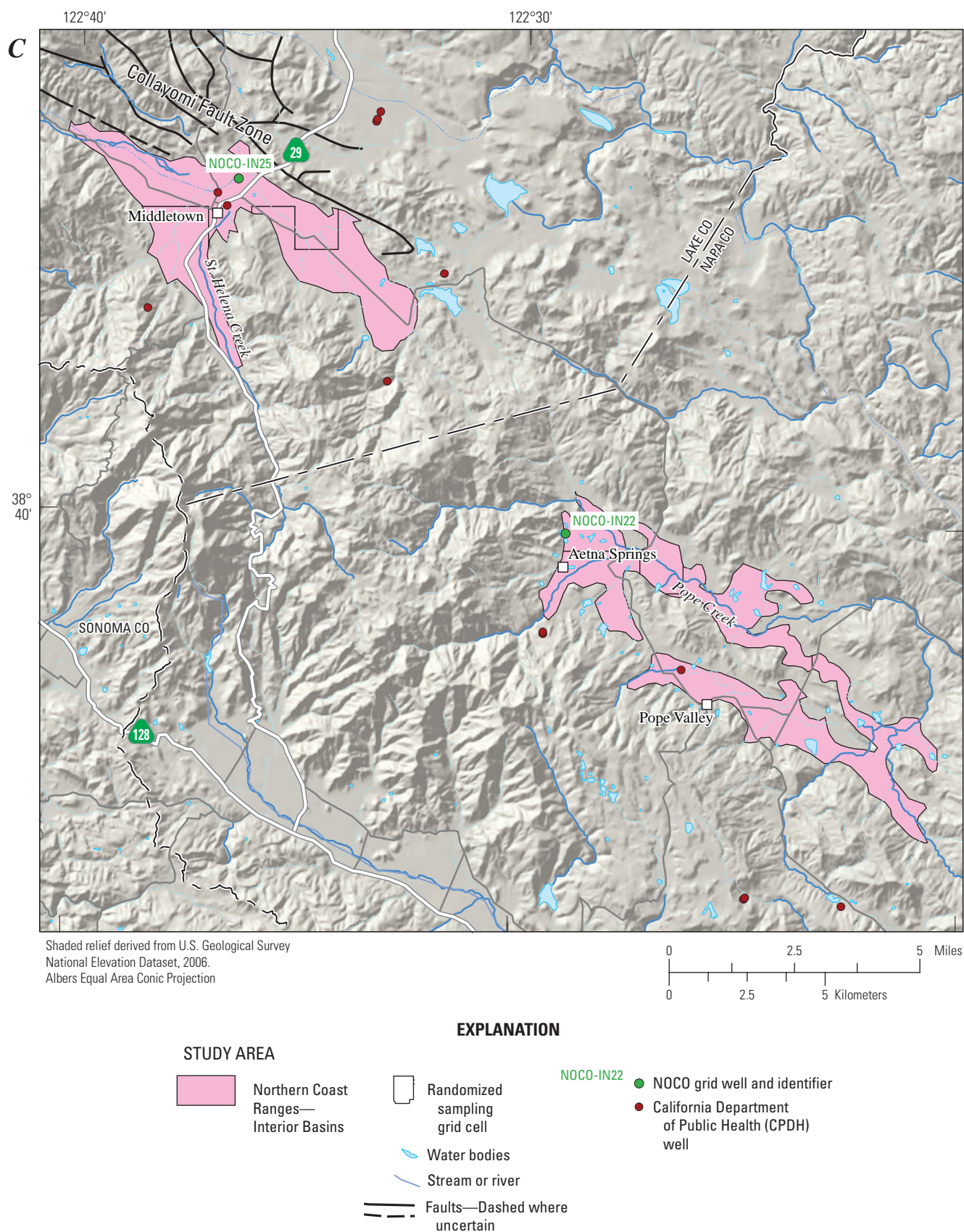


Figure 2.—Continued

In groundwater basins near Clear Lake, the major rock type is Quaternary volcanic rock associated with the Clear Lake or Sonoma Volcanic fields (Soil Mechanics and Foundation Engineers Inc., 1967; Earth Sciences Associates, 1978; California Department of Water Resources, 2004a–d). In the Big Valley basin, groundwater also is supplied by thin volcanic ash layers/lenses interbedded with low permeability sediments (California Department of Water Resources, 2004b).

The general groundwater-flow direction in the study area is from the sides toward the center of the valleys, following the topography and the direction of surface-water flow. The study area has several northwest-trending faults (Maacama, Big Valley, and Wight Way) and fault zones (Bartlett, Clover Valley, and Collayomi) that act as hydrologic barriers to groundwater movement (California Department of Water Resources, 2004a–w) ([fig. 2A–C](#)).

Groundwater recharge in the study area occurs from a mixture of ambient recharge (direct percolation of precipitation and irrigation waters, infiltration of run-off from surrounding hills, and seepage from rivers and creeks) (California Department of Water Resources, 2004a–w).

Northern Coast Ranges–Coastal Basins Study Area

The Coastal Basins study area (hereinafter referred to as the NOCO-CO study area) is 377 mi² in area and contains a total of 11 CDWR-defined basins and subbasins (California Department of Water Resources, 2004x–gg). The study area is located along the Northern California coast beginning just north of Point Arena and extending to the Oregon border. The study area has three distinct sections (northern, central, and southern), each bordered on the west by the Pacific Ocean and on the north, east, and south by the hills surrounding the coastal valleys ([fig. 3A–C](#)).

Land-surface altitudes in the study area range from sea level where the study area boundary touches the Pacific Ocean, to approximately 500 ft above msl in the hills above the city of Fortuna. The major surface drainage features of the study area are the Smith, Klamath, Mad, Eel, Noyo, and Big Rivers and their tributaries: all of which have their headwaters outside of the study area and terminate in the Pacific Ocean.

The climate in the study area is influenced by the Pacific Ocean and is classified as coastal (National Oceanic and Atmospheric Administration, 2010). It is characterized by cool to mild summers and cold wet winters. Coastal fog and low clouds are common throughout the year. Average annual precipitation in the study area ranges from a low of around

38 in. near the town of Trinidad to a high of approximately 79 in. near the town of Klamath (U.S. Department of Commerce, 2010).

The primary aquifers in the northern part of the study area principally occur in the Smith River Plain, a marine terrace made up of Holocene alluvial fan and floodplain deposits; in the Pleistocene terrace deposits; and in the Pleistocene Battery Formation (California Department of Water Resources, 1987, 2004x). In the central part of the study area the primary aquifers occur in groundwater basins consisting of alluvial deposits associated with drowned river mouths of the Klamath, Mad, and Eel Rivers. The alluvial deposits consist of Holocene alluvium, dune sand, the Pleistocene Hookton Formation, and the deeper Pliocene-Pleistocene Carlotta Formation (Johnson, 1978; California Department of Water Resources, 2004y–dd). Primary aquifers in the southern part of the study area are found in the Fort Bragg-area terrace deposits. These deposits are discontinuous, uplifted, and dissected Pleistocene marine terraces along the Pacific Ocean. The terrace deposits consist of semi-consolidated clay, silt, sand, and gravel derived from adjacent formations (largely the Franciscan Formation), that are up to 150-ft thick (California Department of Water Resources, 1982, 2004ff–gg).

The groundwater basins in the northern and central parts of the study area are in hydraulic connection with the Pacific Ocean and sea water extends as a transition wedge underneath fresh groundwater in some of the basins. In the southern part of the study area the uplifted terrace deposits prevent hydraulic connection between groundwater basins and the Pacific Ocean (California Department of Water Resources, 2004x–gg).

The general groundwater-flow direction in the study area is from east to west towards the Pacific Ocean. In the northern part of the study area, dune sand accumulation has created Lake Earl ([fig. 3A](#)), which acts as a restrictive structure to groundwater movement. In the central and southern parts of the study area several northwest trending faults (Freshwater and Table Bluff) and fault zones (Little Salmon and San Andreas) act as hydrologic barriers (California Department of Water Resources, 2004x–gg) ([fig. 3B, C](#)).

Groundwater recharge in the study area occurs from a mixture of ambient recharge (direct percolation of precipitation and irrigation waters, infiltration of run-off from surrounding areas, seepage from the Smith, Klamath, Mad, Eel, Noyo, and Big Rivers and their tributaries, and seepage from small creeks that flow into Humboldt and Arcata Bays) and subsurface inflow (from non-alluvial geologic units that bound the alluvial basins) (California Department of Water Resources, 2004x–gg).

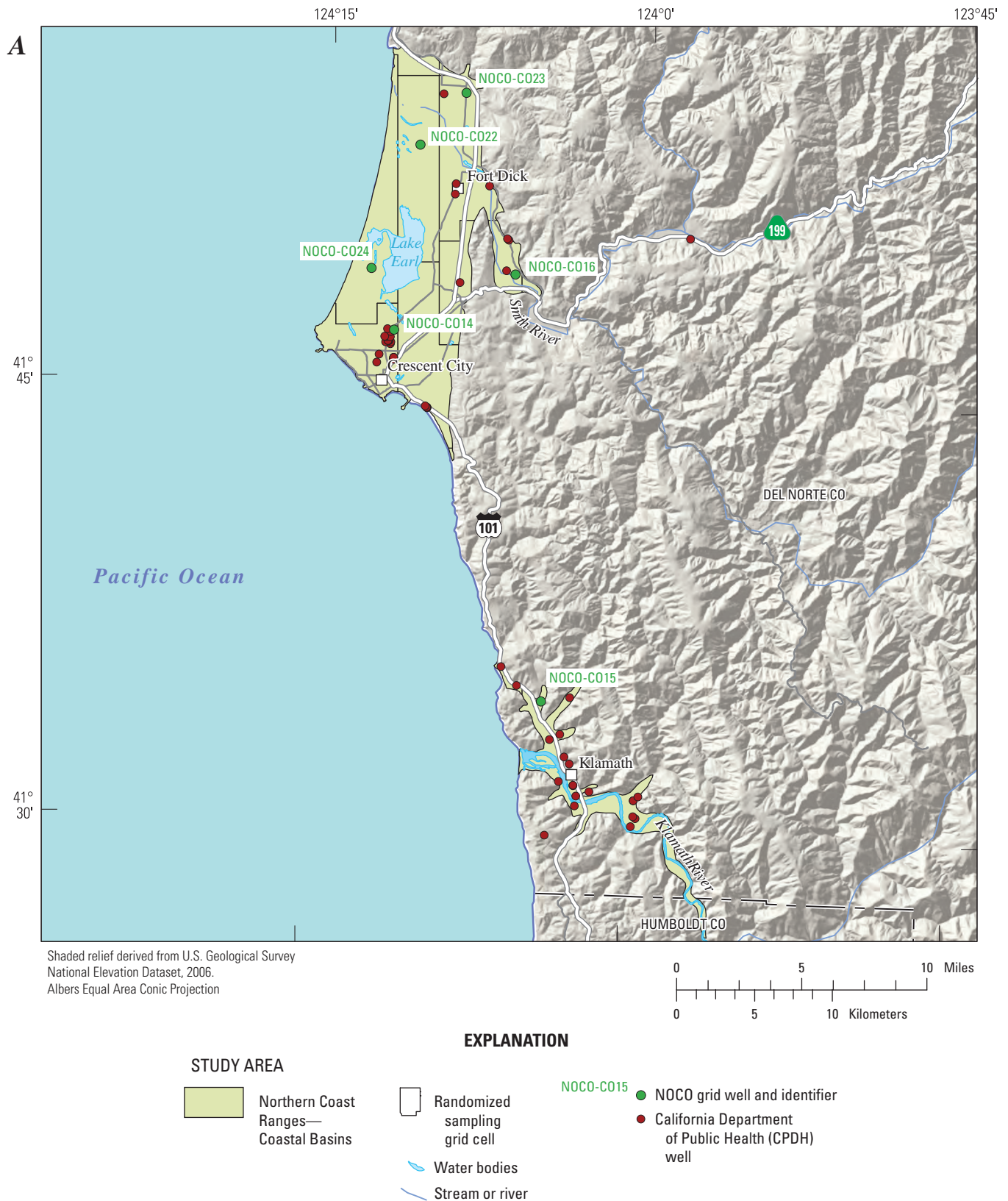


Figure 3. The Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the location of (A) the northern part, (B) the central part, (C) the southern part of the Coastal Basins study area (NOCO-CO), the boundaries of the California Department of Water Resources (CDWR) defined groundwater basins, the distribution of the Coastal Basins study area grid cells, the location of California Department of Public Health (CDPH) wells, and the location of sampled grid wells, major cities, major roads, topographic features, and hydrologic features.

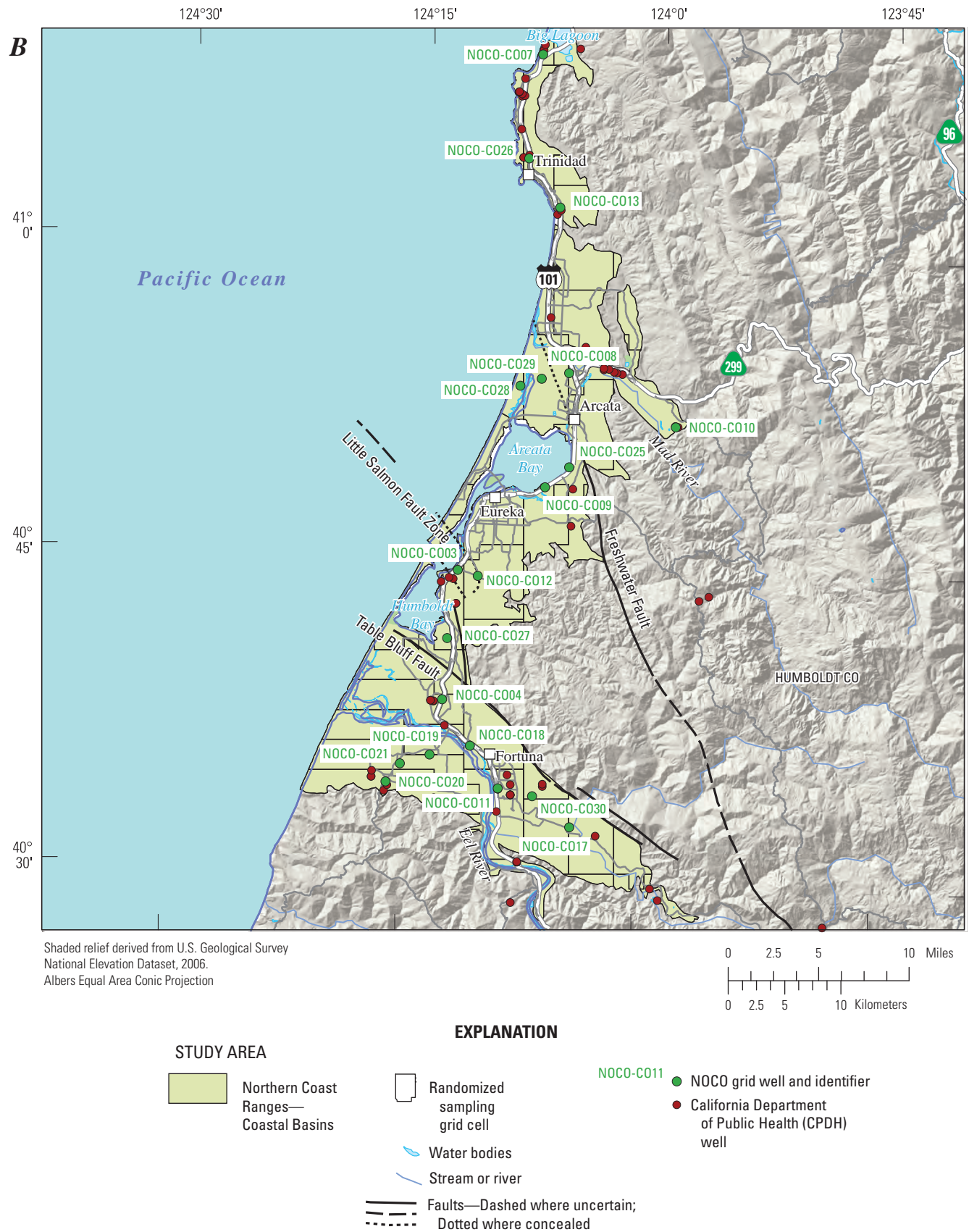


Figure 3.—Continued

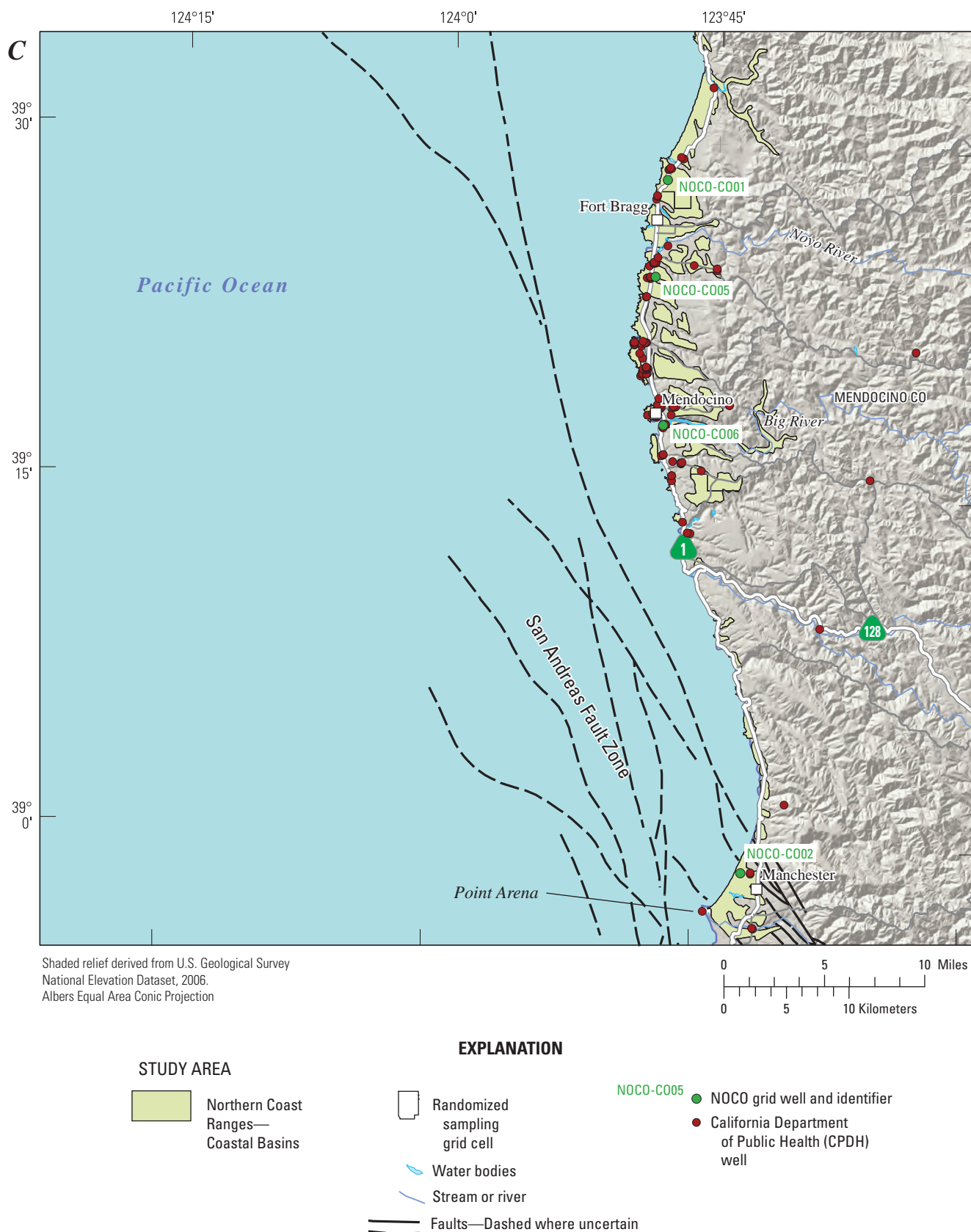


Figure 3.—Continued

Methods

Methods used for the GAMA-PBP were selected to achieve the following objectives: (1) design a sampling plan for suitable statistical representation; (2) collect samples in a consistent manner; (3) analyze samples by using proven and reliable laboratory methods; (4) assure the quality of the groundwater data; and (5) maintain data securely and with relevant documentation. The [appendix](#) contains detailed descriptions of the sample-collection protocols and analytical methods, the QA plan, and the results of analyses of QC samples.

Study Design

The 58 wells in this study are located within surficial alluvium and were selected for sampling to provide a statistically unbiased, spatially-distributed assessment of the quality of groundwater resources used for public drinking-water supply. Wells sampled as part of the spatially-distributed, randomized grid-cell network, hereinafter, are referred to as “grid wells”.

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

In the NOCO study unit, an attempt was made to sample available CDPH wells located within each grid cell. If a grid cell contained more than one CDPH well, each well randomly was assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located prior to treatment, or capability to pump for several hours) was sampled. If a grid cell contained no accessible CDPH wells, then other types of wells, such as domestic, irrigation, and (or) industrial, were considered for sampling. An attempt was made to select these “alternative” wells by choosing ones with depths and screened intervals similar to CDPH wells in the area. In this fashion, one well was selected in each cell to provide a spatially distributed, randomized monitoring network.

The NOCO-IN study area was divided into 30 equal-area grid cells, 8.5 mi² (22 square kilometers [km²]) in area; a total of 28 wells were sampled inside this grid network ([fig. 2A–C](#)). The NOCO-CO study area was divided into 30 equal-area grid cells, 12.5 mi² (approximately 32 km²) in area. In the grid network of the NOCO-CO study area, coverage was complete, with every grid cell represented by a well sampled ([fig. 3A–C](#)).

The 58 grid wells sampled in the NOCO study unit were named for the study area where they were located by using the prefix “NOCO-IN” for the Interior Basins study area and “NOCO-CO” for the Coastal Basins study area, and by using a suffix numbered in the order of sample collection within each study area ([figs. 2A–C](#) and [3A–C](#)). Unlike previous Data Series Reports written for the GAMA-PBP study units, all of the wells sampled in the NOCO study unit were classified as grid wells; therefore, none of the wells in the NOCO study unit were considered “understanding wells.”

The GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, land-surface altitude, well type, and available well-construction information is shown in [table 1](#). Groundwater samples were collected from 29 CDPH wells, 16 domestic wells, 7 irrigation wells, 3 industrial wells, 1 abandoned well, 1 stock-supply well, and 1 spring during the period from June to November 2009.

Well locations were verified by using global positioning system (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 or other sources of construction information were obtained when available. Well information and location were recorded by hand on field sheets, and electronically on field laptop computers using the Alternate Place Entry Form (APE) program designed by the USGS. All information was verified and then uploaded into the USGS National Water Information System (NWIS). Well owner, well category, and well location information is confidential.

The wells in the NOCO study unit were sampled for a standard set of constituents, including: field water-quality indicators, organic and special-interest constituents, naturally occurring inorganic constituents, radioactive constituents, microbial indicators, naturally occurring isotopes, and dissolved noble gases.

Most of the constituents were specified for collection by the NAWQA Program for Major Aquifer Studies assessments. Selected constituents, including perchlorate, stable isotopes of hydrogen and oxygen in water, tritium, stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance, and dissolved noble gases, were specified for collection by the GAMA-PBP and similar data have been collected in other basins in California.

The standard set of constituents was termed the “*slow*” schedule ([table 2](#)). In addition to the *slow* schedule, mercury was added for the NOCO-IN study area and iodide was added for the NOCO-CO study area. *Slow* refers to the time required to sample the well for all the analytes on the schedule. One *slow* well could be sampled in 1 day. In NOCO, all 58 of the wells were sampled on the *slow* schedule ([table 1](#)).

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the NAWQA Program (Koterba and others, 1995) and the USGS National Field Manual (NFM) (U.S. Geological Survey, variously dated). These sampling protocols are followed so that representative samples of groundwater are collected at each site, and so that the samples are collected and handled in ways that minimize the potential for contamination.

[Table 3A–I](#) list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs ([table 3A](#)); 83 pesticides and pesticide degradates ([table 3B](#)); perchlorate ([table 3C](#)); 24 trace elements ([table 3D](#)); 5 nutrients and DOC ([table 3E](#)); 9 major and minor ions, silica, TDS, and laboratory alkalinity ([table 3F](#)); stable isotopes of hydrogen and oxygen in water, stable isotopes of carbon in dissolved inorganic carbon, and 9 radioactive constituents, including tritium and carbon-14 abundance ([table 3G](#)); 5 dissolved noble gases and helium stable isotopic ratios ([table 3H](#)); and 4 microbial indicators ([table 3I](#)). The methods and laboratories used for sample collection and analysis are described in the appendix section titled “[Sample Collection and Analysis](#).”

Data Reporting

The methods and conventions used for reporting the data are described in the appendix section titled “[Data Reporting](#).” Two field water-quality indicators—pH and specific conductance—were measured in the field and at the USGS National Water Quality Laboratory (NWQL), and both results are reported (see appendix section titled “[Field Water-quality Indicators Measured by Multiple Methods](#)”).

Quality-Assurance Methods

The QA/QC procedures used for this study followed the protocols described in the NFM (U.S. Geological Survey, variously dated) and used by the USGS NAWQA Program (Koterba and others, 1995). The QA plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described in Pirkey and Glodt (1998) and Maloney (2005). QC samples collected in the NOCO study are: blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate potential contamination, as well as bias and variability of the data that may have resulted from sample collection, processing, storage, transportation, and laboratory analysis. QA/QC procedures and results are described in the appendix section titled “[Quality-Assurance Methods](#).”

Water-Quality Results

Quality-Control Results

Results of QC analyses (blanks, replicates, and matrix and surrogate spikes) were used to evaluate the quality of the data for the groundwater samples. On the basis of detections in NWQL blanks and blanks collected for this and previous GAMA-PBP study units, some of the detections reported by the laboratory for five VOCs, seven trace elements, and DOC were considered suspect and, therefore, were either removed from the set of groundwater-quality data presented in this report or flagged with a \leq symbol (see [table A2](#) and additional discussion in the appendix section titled “[Detections in Blanks and SRL Analysis](#)”). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Variability for nearly 100 percent of the replicate pairs for constituents detected in samples was within the acceptable limits ([table A3A–C](#)). Median matrix-spike recoveries for 19 of the 169 organic and special-interest constituents analyzed were lower than the acceptable limit of 70 percent ([tables 3B](#) and [A4B](#)). Constituents for which low recoveries occurred might not have been detected in some samples if they were present at concentrations near the laboratory reporting levels (LRLs). These compounds are indicated with a footnote in the “Detection” column of [table 3B](#). The QC results are described in the appendix section titled “[Quality-Control Results](#).”

Comparison Benchmarks

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

- **MCL—Maximum Contaminant Level.** Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which States are required to comply, and individual States may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the benchmark concentration for a number of constituents with MCLs established by the USEPA. In this report, a benchmark 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.” Well owners are notified when constituents are detected at concentrations greater than an MCL-US or an MCL-CA benchmark in samples collected for the GAMA-PBP, but these detections do not constitute violations of CDPH regulations.
 - **AL—Action Level.** Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead greater than the action-level benchmarks trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH are the same; thus, the benchmarks 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. TT requirements are applied when water delivered to consumers exceeds specified action levels. Detections of microbial constituents greater than benchmarks trigger requirements for mandatory additional disinfection during water treatment. The action levels established by the USEPA and CDPH are the same; thus, these benchmarks 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 the 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 are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.
 - **NL—Notification Level.** Health-based notification levels established by CDPH (NL-CA) for some of the constituents in drinking water that lack MCLs. If a constituent is detected at concentrations greater than its NL-CA, California State law requires timely notification of local governing bodies and recommends consumer notification.
 - **HAL—Lifetime Health Advisory Level.** The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (L) (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilograms (kg) (154-lb) 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 10 (RSD5-US).
- For constituents with MCLs, detections in groundwater samples were compared to the MCL-US or MCL-CA. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and TDS, CDPH defines a “recommended” and an “upper” SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US for these constituents corresponds to the recommended SMCL-CA. Detected concentrations of constituents without an MCL or SMCL were compared to the NL-CA. For constituents without an MCL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents without an MCL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. For constituents without an MCL, SMCL, NL-CA, or HAL-US, or RSD5-US, detected concentrations were compared with the AL-US. Note that using this hierarchy to select the comparison benchmark for a constituent with more than one type of established benchmark will not necessarily result in selection of the benchmark with the lowest concentration. For example, for zinc the SMCL-CA is 5,000 µg/L and the HAL-US is 2,000 µg/L, but the comparison benchmark selected by this hierarchy is the SMCL-CA. The comparison benchmarks used in this report are listed in [table 3A–I](#) for all constituents and in [tables 4–13](#) for constituents detected in groundwater samples from the NOCO study unit. Established benchmarks are not available for all constituents analyzed for this study. Detections of constituents at concentrations greater than the selected comparison benchmark are marked with asterisks in [tables 4, 8, and 10](#).

Groundwater-Quality Data

Results from analyses of untreated groundwater samples from the NOCO study unit are presented in [tables 4–13](#). These results are separated into the two study areas that make up the NOCO study unit (NOCO-IN and NOCO-CO). Groundwater samples collected in the NOCO study unit were analyzed for 239 constituents; 157 of those constituents were not detected in any of the samples, and 76 constituents were detected ([table 3A–F](#)). The results from LLNL for five dissolved noble gases and for helium isotope ratios have not been received and are not presented in this report; they will be included in a subsequent publication.

For organic and special-interest (perchlorate) constituent classes, the results tables include the following summary statistics: the number of wells from which each analyte was detected, the frequency at which it was detected (in relation to the number of wells in the study unit and each study area), and the total number of constituents detected at each well. For the inorganic, isotopic, and radioactive constituent classes, the tables include all of the wells, constituents, and samples analyzed. For the microbial indicators, the table includes only those wells where detections occurred.

Water-quality indicators measured in the field and at the NWQL are included in [table 4](#). The results of groundwater analyses organized by compound classes are presented in [tables 5–13](#):

- Organic constituents
 - Volatile organic compounds (VOC) ([table 5](#))
 - Pesticides and pesticide degradates ([table 6](#))
- Perchlorate ([table 7](#))
- Inorganic constituents
 - Trace elements ([table 8](#))
 - Nutrients and dissolved organic carbon (DOC) ([table 9](#))
 - Major and minor ions, silica, and total dissolved solids (TDS) ([table 10](#))
- Isotopic tracers ([table 11](#))
- Radioactive constituents
 - Radon-222 ([table 12A](#))
 - Radium isotopes ([table 12B](#))
 - Gross alpha and gross beta radioactivity ([table 12C](#))
 - Lead-210 and polonium-210 ([table 12D](#))
- Microbial indicators ([table 13](#))

Field Water-Quality Indicators

Field measurements of turbidity, dissolved oxygen, and water temperature, and field and laboratory measurements of pH, specific conductance, alkalinity, and associated parameters (bicarbonate and carbonate concentrations) are presented in [table 4](#). Turbidity, dissolved oxygen, alkalinity, dissolved oxygen, and bicarbonate and carbonate concentrations are used as indicators of natural processes that affect water chemistry. The pH value indicates the acidity of the water. Specific conductance is the measure of electrical conductivity of the water and is proportional to amount of total dissolved solids in the water.

Field pH values for 14 of the 58 grid wells sampled (9 NOCO-IN study-area wells and 5 NOCO-CO study-area wells) in the NOCO study unit were outside of the SMCL-US range for pH (<6.5 or >8.5) ([table 4](#)). Laboratory pH values may be dissimilar to field pH values because the pH of groundwater may change upon removal from the ambient environment and exposure to the atmosphere.

Specific-conductance values (both field and laboratory) for three NOCO-IN study-area wells were greater than the recommended SMCL-CA of 900 microsiemens per centimeter ($\mu\text{S}/\text{cm}$).

Organic Constituents

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

Of the 85 VOCs analyzed, 8 were detected in NOCO study-unit groundwater samples; all detections in grid-well samples were at concentrations less than health-based benchmarks ([table 5](#)). One or more VOCs were detected in 22 of the 58 NOCO study-unit grid wells sampled (about 38 percent detection frequency). In the NOCO-IN study area, VOCs were detected in 13 of the 28 wells (approximately 46 percent). VOCs that were detected in more than 10 percent of the NOCO-IN study-area wells were chloroform (trichloromethane), 1,1,1-trichloroethane (1,1,1-TCA), and methyl tert-butyl ether (MTBE). In the NOCO-CO study area, VOCs were detected in 9 of the 30 wells (approximately 30 percent). Chloroform was the only VOC detected in more than 10 percent of the NOCO-CO study-area wells ([table 5](#)). Chloroform is among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006).

Pesticides include herbicides, insecticides, and fungicides, and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. Of the 83 pesticides and pesticide degradates analyzed at all of the grid wells in the NOCO study unit, 2 pesticides (simazine

and atrazine) and 1 pesticide degradate (deethylatrazine) were detected in groundwater samples; all detections were at concentrations less than health-based benchmarks ([table 6](#)). One or more pesticide compounds were detected in 6 of the 58 NOCO study-unit grid wells (about 10 percent detection frequency). In the NOCO-IN study area, pesticides and pesticide degradates were detected in 5 of the 28 wells (approximately 18 percent). The herbicide simazine was detected in more than 10 percent of the NOCO-IN well samples. Simazine was detected in 1 of the 30 wells sampled in the NOCO-CO study area ([table 6](#)). Simazine is among the nation's most commonly detected pesticide compounds in groundwater (Gilliom and others, 2006).

Constituent of Special Interest

Perchlorate is a constituent of special interest in California because it may adversely affect water quality and recently has been found in water supplies (California Department of Public Health, 2008b). Perchlorate was analyzed for at all 58 grid wells in the NOCO study unit and was detected in 14 of the 58 wells (about 24 percent detection frequency). In the NOCO-IN study area, perchlorate was detected in 9 of 28 wells (approximately 32 percent). In the NOCO-CO study area, perchlorate was detected in 5 of 30 wells (approximately 17 percent). Perchlorate was not measured at concentrations greater than the MCL-CA of 6 micrograms per liter ($\mu\text{g/L}$) in any of the wells in the NOCO study unit ([table 7](#)).

Inorganic Constituents

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

Regulatory health-based or non-regulatory aesthetic benchmarks have been established for 22 of 24 trace elements analyzed in this study ([table 3D](#)). Of the 18 trace elements with health-based benchmarks, concentrations of most detections of the trace elements in the 58 NOCO study-unit grid wells were less than these benchmarks ([table 8](#)). The exceptions were a few detections of arsenic, barium, and boron greater than benchmarks in NOCO-IN study-area wells. Arsenic concentrations greater than the USEPA maximum contaminant level (MCL-US) of $10 \mu\text{g/L}$ were detected in 2 of 28 NOCO-IN study-area wells. A barium concentration greater than the MCL-CA of $1,000 \mu\text{g/L}$ was detected in one NOCO-IN study-area well. Boron concentrations greater than the CDPH notification level (NL-CA) of $1,000 \mu\text{g/L}$ were detected in five NOCO-IN study-area wells. All detections of trace elements in NOCO-CO study-area wells were at concentrations less than regulatory health-based benchmarks ([table 8](#)).

Note that results from the USGS Branch of Quality Systems (BQS) QA program (within the USGS Office of Water Quality) during the time period that NOCO study-unit samples were analyzed at the NWQL indicate negative analytical biases for iron and magnesium (of 25 and 7.8 percent, respectively) and positive analytical bias for uranium (of 13 percent) (U.S. Geological Survey, 2009). The results suggest that iron and magnesium concentrations may be slightly underestimated and uranium concentrations may be slightly overestimated.

Nutrients (nitrogen and phosphorus) and DOC present in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Inorganic nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. High concentrations of nitrate can adversely affect human health, particularly the health of infants.

Nutrients and DOC were sampled for at all 28 grid wells in the NOCO-IN study area and at 29 of 30 grid wells in the NOCO-CO study area. Nutrients were not measured at concentrations greater than health-based benchmarks in any of the 57 wells in the NOCO study unit ([table 9](#)).

The levels of certain trace elements, major-ion composition, and total dissolved solids (TDS) content in groundwater affect the aesthetic properties of water, such as taste, color, and odor, and the technical properties of water, such as scaling and staining. Although there are no adverse health effects directly associated with these properties, they may reduce consumer satisfaction with the water or may have economic effects. The CDPH has established non-enforceable benchmarks (SMCL-CAs) that are based on aesthetic properties rather than on human-health concerns for iron, manganese, silver, zinc, chloride, sulfate, and TDS. Iron and manganese are trace elements whose concentrations are affected by the oxidation-reduction state of the groundwater. Precipitation of minerals containing iron or manganese may cause orange, brown, or black staining of surfaces. Iron, manganese, silver, zinc, chloride, sulfate, and TDS were sampled for at all 58 wells in the NOCO study unit.

Iron concentrations greater than the SMCL-CA of $300 \mu\text{g/L}$ was detected in seven NOCO-IN study-area wells and in eight NOCO-CO study-area wells ([table 8](#)).

Manganese concentrations greater than the SMCL-CA of $50 \mu\text{g/L}$ was detected in 12 NOCO-IN study-area wells and 11 NOCO-CO study-area wells ([table 8](#)).

TDS concentrations greater than the recommended SMCL-CA benchmark of 500 mg/L was detected in four NOCO-IN study-area wells ([table 10](#)).

All silver, zinc, chloride, and sulfate concentrations detected in the 58 NOCO study-unit wells were less than the corresponding SMCL-CA ([tables 8, 10](#)).

Isotopic Tracers and Dissolved Noble Gases

The isotopic ratios, activities, and abundances of many elements and the concentrations of dissolved gases (including noble gases) may be used as tracers of hydrologic processes (Clark and Fritz, 1997).

The isotopic ratios of hydrogen and oxygen in water ([table 11](#)) aid in the interpretation of the sources of groundwater recharge. These stable isotopic ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface-water bodies or soils prior to infiltration into the aquifer or directly from groundwater close to land surface once in the aquifer system.

Tritium activities ([table 11](#)), helium isotope ratios, and carbon-14 abundance ([table 11](#)) provide information about the age (time since recharge) of groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are produced continuously by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium greater than background generally indicate the presence of water recharged since the early 1950s. Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young groundwater.

Carbon-14 ([table 11](#)) is a radioactive isotope of carbon. Low levels of carbon-14 are produced continuously by interaction of cosmic radiation with the Earth's atmosphere, and incorporated into atmospheric carbon dioxide. Carbon dioxide dissolves in precipitation, surface water, and groundwater exposed to the atmosphere, thereby entering the hydrologic cycle. Because carbon-14 decays with a half-life of approximately 5,700 years, low activities of carbon-14, relative to modern values, generally indicate a presence of groundwater that is several thousand years old.

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

Of the isotopic tracer constituents analyzed for this study, tritium is the only one with a health-based benchmark. All measured tritium activities in samples from the NOCO study-unit grid wells were more than three orders of magnitude less than the MCL-CA benchmark ([table 11](#)).

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most radioactivity in groundwater comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of

the aquifer. Uranium and thorium decay in a series of steps eventually forming stable isotopes of lead (Soddy, 1913; Faure and Mensing, 2005). Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium or thorium decay series. In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha or a beta particle from its nucleus. For example, radium-226 emits an alpha particle and therefore turns into radon-222. Radium-228 decays to form actinium-228 by emission of a beta particle. Polonium-210 is a radioactive decay product in the natural uranium-238 decay series; along with lead-210 it is one of two relatively long-lived decay products of radon-222 (U.S. Department of Energy, 2005). The alpha and beta particles emitted during radioactive decay are hazardous to human health because these energetic particles may damage cells. Radiation damage to cell DNA may increase the risk of getting cancer.

Activity often is used instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in groundwater is measured in units of picocuries per liter (pCi/L), and 1 pCi/L is approximately equal to two atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

Radon-222 was sampled for at 57 wells, radium isotopes (radium-226 and radium-228), lead-210, and polonium-210 were sampled for at 54 wells, and gross alpha and gross beta radioactivity were sampled for at all 58 wells in the NOCO study unit.

Radon-222 activities for all NOCO study-unit well samples were less than the proposed MCL-US of 4,000 pCi/L ([table 12A](#)). The proposed MCL-US will apply if the state or local water agency has an approved multimedia mitigation program to address radon levels in indoor air (U.S. Environmental Protection Agency, 1999).

Radium isotopes (radium-226 and radium-228) activities for all NOCO study-unit well samples were less than the MCL-US of 5 pCi/L ([table 12B](#)). The MCL-US benchmark for radium is the sum of radium-226 and radium-228.

Gross alpha and gross beta radioactivity for all NOCO study-unit well samples was less than established health-based benchmarks ([table 12C](#)). One gross alpha radioactivity sample (72-hour count) and one gross beta radioactivity sample (72-hour count) were counted after the 72-hour time period at the laboratory. A delay in the counting by the laboratory may result in lower activities than may have been observed for these analytes if the count had been performed within the 72-hour time period; the results for these two analytes are footnoted in [table 12C](#).

Lead-210 was detected in 2 of 24 NOCO-IN study-area wells and in 3 of 30 NOCO-CO study-area wells. Polonium-210 was detected in 6 NOCO-IN study-area wells and in 11 NOCO-CO study-area wells ([table 12D](#)).

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 generally are not measured because routine analytical methods are not available. Measurements are made of more easily analyzed microbial constituents that serve as indicators of the presence of human or animal waste in water. Drinking water purveyors respond to detections of microbial indicators by applying additional disinfection agents to the water.

Microbial indicators were sampled for at 57 grid wells in the NOCO study unit. F-specific coliphage (a viral indicator) was detected in 2 of 29 NOCO-CO study-area wells. Somatic coliphage (a viral indicator) was detected in 2 of 28 NOCO-IN study-area wells and in 1 NOCO-CO study-area well. *Escherichia coli* (*E. coli*) (a bacterial indicator) was detected in one NOCO-IN study-area well and in three NOCO-CO study-area wells. Total coliform (a bacterial indicator) was detected in 10 NOCO-IN study-area wells and in 9 NOCO-CO study-area wells ([table 13](#)). The health-based benchmarks for microbial indicators are based on recurring detections in treated drinking water, thus, the detections reported here do not constitute an exceedance of the benchmarks.

Future Work

Subsequent reports will be focused on assessment of the data presented in this report by using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting groundwater quality in the NOCO study unit. Water-quality data contained in the CDPH databases will be compiled, evaluated, and used in combination with the data that are presented in this report. Additionally, these subsequent reports will include the LLNL results (dissolved noble gases and helium isotope ratios) for the NOCO study unit.

Summary

Groundwater quality in the 633-square-mile Northern Coast Ranges (NOCO) study unit was investigated by the U.S. Geological Survey (USGS) from June to November 2009, as part of the Priority Basin Project (PBP) of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) PBP. The GAMA Program was created to provide a comprehensive baseline of groundwater quality in the state. The GAMA-PBP was created as a result of the Groundwater Quality Monitoring Act of 2001 (Sections 10780–10782.3 of the California Water Code, Assembly Bill 599) to assess and monitor the quality

of groundwater. The GAMA-PBP is being conducted by the USGS in cooperation with the SWRCB and Lawrence Livermore National Laboratory (LLNL). The NOCO study unit sampling was conducted with support from the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program to assess the California Coastal Basins principal aquifer.

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

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 benchmarks apply to treated water that is served to the consumer, not to untreated groundwater. However, to provide some context for the results, concentrations of constituents measured in the untreated groundwater were compared with regulatory and non-regulatory health-based benchmarks established by the U.S. Environmental Protection Agency (USEPA) and CDPH, and non-regulatory benchmarks established for aesthetic concerns by CDPH.

The NOCO study unit is located in the central, western, and northern parts of the Northern Coast Ranges hydrologic province and includes a total of 34 groundwater basins and subbasins defined by the California Department of Water Resources. The NOCO study included assessment of the groundwater quality from 58 wells in Napa, Lake, Mendocino, Glenn, Humboldt, and Del Norte Counties, California. All 58 wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study areas. GAMA-PBP wells sampled as part of the spatially distributed, randomized grid-cell network are referred to as "grid wells."

Groundwater samples were analyzed for field water-quality indicators, organic and special-interest constituents, naturally occurring inorganic constituents, radioactive constituents, and microbial indicators. Naturally-occurring isotopes and dissolved noble gases also were measured to provide a dataset to interpret the sources and ages of the sampled groundwater. In total, 239 constituents and 12 field water-quality indicators were measured. This report describes the sampling, analytical, and QA methods used in the study, and present the results of the chemical analyses made of the groundwater samples.

All detected concentrations of organic constituents, nutrients, major and minor ions, and radioactive constituents in samples collected from the 58 grid wells in the NOCO study unit were less than health-based benchmarks. Of the 28 wells in the Interior Basins (NOCO-IN) study area, two detections of arsenic were greater than the USEPA maximum contaminant level (MCL-US), one detection of barium was greater than CDPH maximum contaminant level (MCL-CA), and five detections of boron were greater than the CDPH notification level (NL-CA).

Concentrations of most of the samples from NOCO study-unit grid wells collected for trace elements, major ions, and TDS measured less than the non-enforceable benchmarks set for aesthetic concerns. Iron was detected at concentrations greater than the CDPH secondary maximum contaminant level (SMCL-CA) of 300 µg/L in 7 wells in the NOCO-IN study area and 8 wells in the NOCO-CO study area. Manganese was detected at concentrations greater than the SMCL-CA of 50 µg/L in 12 NOCO-IN study-area wells and in 11 NOCO-CO study-area wells. TDS concentrations greater than the SMCL-CA recommended benchmark of 500 mg/L were measured in four NOCO-IN study-area wells.

Microbial indicators (viral and bacterial) were sampled for at 57 wells in the NOCO study unit. One or more microbial indicator was detected in 11 wells in both the NOCO-IN and NOCO-CO study areas.

Acknowledgments

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

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Table 1. Identification, sampling, and construction information for wells sampled for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[GAMA well identification number: NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. Sampling schedule is described in [table 2](#). Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The altitude of the LSD is described in feet above the North American Vertical Datum 1988. **Abbreviations:** ft, feet; NAVD 88, North American Vertical Datum 1988; na, not available]

Sampling information				Construction information			
GAMA well identification number	Date sampled (mm/dd/yyyy)	Sampling schedule	Altitude of LSD (ft above NAVD88)	Well type	Well depth (ft below LSD)	Depth to top perforation (ft below LSD)	Depth to bottom perforation (ft below LSD)
NOCO grid wells							
NOCO-IN01	06/01/2009	Slow	748	Production	165	79	157
NOCO-IN02	06/02/2009	Slow	363	Production	120	60	120
NOCO-IN03	06/03/2009	Slow	1,673	Production	58	33	58
NOCO-IN04	06/04/2009	Slow	1,385	Production	55	na	na
NOCO-IN05	06/08/2009	Slow	1,633	Production	60	na	na
NOCO-IN06	06/10/2009	Slow	1,342	Production	¹ 136	na	na
NOCO-IN07	06/15/2009	Slow	523	Production	40	23	38
NOCO-IN08	06/16/2009	Slow	483	Production	40	25	40
NOCO-IN09	06/17/2009	Slow	713	Production	400	148	385
NOCO-IN10	06/18/2009	Slow	553	Production	101	35	94
NOCO-IN11	06/22/2009	Slow	958	Production	100	60	100
NOCO-IN12	06/23/2009	Slow	558	Production	215	40	215
NOCO-IN13	06/24/2009	Slow	599	Production	36	15	36
NOCO-IN14	06/25/2009	Slow	658	Production	135	75	135
NOCO-IN15	07/06/2009	Slow	1,856	Production	300	80	220
NOCO-IN16	07/07/2009	Slow	1,845	Production	152	39	152
NOCO-IN17	07/08/2009	Slow	1,368	Production	75	na	na
NOCO-IN18	07/09/2009	Slow	1,360	Production	170	50	160
NOCO-IN19	07/13/2009	Slow	823	Production	80	21	80
NOCO-IN20	07/14/2009	Slow	1,470	Production	75	na	na
NOCO-IN21	07/15/2009	Slow	361	Production	52	40	48
NOCO-IN22	07/16/2009	Slow	801	Production	180	na	na
NOCO-IN23	07/20/2009	Slow	1,399	Production	142	40	142
NOCO-IN24	07/21/2009	Slow	1,380	Production	116	70	115
NOCO-IN25	07/22/2009	Slow	1,072	Production	283	56	217
NOCO-IN26	07/23/2009	Slow	1,154	Production	126	30	114
NOCO-IN27	07/27/2009	Slow	1,776	Production	155	40	115
NOCO-IN28	07/28/2009	Slow	1,345	Production	¹ 41	na	na
NOCO-CO01	07/29/2009	Slow	71	Production	25	16	18
NOCO-CO02	07/30/2009	Slow	48	Production	55	35	55
NOCO-CO03	08/03/2009	Slow	38	Production	380	280	370
NOCO-CO04	08/04/2009	Slow	243	Production	325	na	na
NOCO-CO05	08/05/2009	Slow	126	Production	² 15	10	10

Table 1. Identification, sampling, and construction information for wells sampled for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[GAMA well identification number: NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. Sampling schedule is described in [table 2](#). Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The altitude of the LSD is described in feet above the North American Vertical Datum 1988. **Abbreviations:** ft, feet; NAVD 88, North American Vertical Datum 1988; na, not available]

Sampling information				Construction information			
GAMA well identification number	Date sampled (mm/dd/ yyyy)	Sampling schedule	Altitude of LSD (ft above NAVD88)	Well type	Well depth (ft below LSD)	Depth to top perforation (ft below LSD)	Depth to bottom perforation (ft below LSD)
NOCO grid wells—Continued							
NOCO-CO06	08/06/2009	Slow	95	Production	37	20	37
NOCO-CO07	08/10/2009	Slow	124	Production	130	0	130
NOCO-CO08	08/11/2009	Slow	33	Production	215	150	210
NOCO-CO09	08/12/2009	Slow	5	Production	397	356	376
NOCO-CO10	08/13/2009	Slow	115	Production	225	210	220
NOCO-CO11	08/17/2009	Slow	50	Production	115	43	103
NOCO-CO12	08/18/2009	Slow	56	Production	62	na	na
NOCO-CO13	08/19/2009	Slow	318	Production	100	34	100
NOCO-CO14	08/24/2009	Slow	42	Production	32	20	32
NOCO-CO15	08/25/2009	Slow	27	Production	85	30	85
NOCO-CO16	08/26/2009	Slow	56	Production	75	38	58
NOCO-CO17	08/27/2009	Slow	153	Production	50	23	50
NOCO-CO18	08/31/2009	Slow	39	Production	65	55	60
NOCO-CO19	09/01/2009	Slow	37	Production	50	na	na
NOCO-CO20	09/02/2009	Slow	93	Spring	na	na	na
NOCO-CO21	09/03/2009	Slow	24	Production	168	146	166
NOCO-CO22	09/14/2009	Slow	15	Production	35	na	na
NOCO-CO23	09/15/2009	Slow	39	Production	45	35	45
NOCO-CO24	09/16/2009	Slow	24	Production	15	na	na
NOCO-CO25	09/17/2009	Slow	13	Production	193	175	193
NOCO-CO26	10/05/2009	Slow	267	Production	15	15	15
NOCO-CO27	10/06/2009	Slow	8	Production	400	na	na
NOCO-CO28	10/06/2009	Slow	18	Production	120	na	na
NOCO-CO29	10/07/2009	Slow	10	Production	200	na	na
NOCO-CO30	10/0:/2009	Slow	390	Production	196	166	196

¹ Well depth estimated from hole depth.

² Well depth estimated from a variety of well records.

Table 2. Classes of chemical constituents and field water-quality indicators collected for the slow well-sampling schedule in the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

Analyte classes	Slow schedule	Analyte list table	Results table
Field water-quality indicators			
Dissolved oxygen, temperature, pH, and specific conductance	X		4
Turbidity	X		4
Field alkalinity, bicarbonate, and carbonate	X		4
Organic constituents			
Volatile organic compounds (VOC)	X	3A	5
Pesticides and pesticide degradates	X	3B	6
Constituent of special interest			
Perchlorate	X	3C	7
Inorganic constituents			
Trace elements	X	3D	8
Nutrients	X	3E	9
Dissolved organic carbon (DOC)	X	3E	9
Major and minor ions, silica, and total dissolved solids (TDS)	X	3F	10
Stable isotopes			
Stable isotopes of hydrogen and oxygen in water	X	3G	11
Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance	X	3G	11
Radioactivity and dissolved noble gases			
Tritium	X	3G	11
Radon-222	X	3G	12A
Radium isotopes	X	3G	12B
Gross alpha and gross beta radioactivity	X	3G	12C
Lead-210	X	3G	12D
Polonium-210	X	3G	12D
Dissolved noble gases and helium isotope ratios	X	3H	none ¹
Microbial constituents			
F-specific coliphage	X	3I	13
Somatic coliphage	X	3I	13
<i>Escherichia coli</i> (<i>E. coli</i>)	X	3I	13
Total coliform	X	3I	13

¹ Results for dissolved noble gases and helium isotope ratios analyzed by Lawrence Livermore National Laboratory (LLNL) were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

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

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers[®] (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. **LRL, Benchmark type,** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; LRL, laboratory reporting level; SRL, study reporting level; $\mu\text{g/L}$, micrograms per liter; HAL-US, USEPA lifetime health advisory level; MCL-CA, CDPH maximum contaminant level; na, not available; MCL-US, USEPA maximum contaminant level; –, not detected; D, detected in groundwater samples (table 5); GAMA, Groundwater Ambient Monitoring and Assessment Program; NOCO, Northern Coast Ranges study unit; NL-CA, CDPH notification level; THM, trihalomethane; RSD5-US, USEPA risk specific dose at a risk factor of 10^{-5} ; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL/SRL ($\mu\text{g/L}$)	Benchmark type	Benchmark level ($\mu\text{g/L}$)	Detection
Acetone	Solvent	81552	67-64-1	3.4	na	na	–
Acrylonitrile	Organic synthesis	34215	107-13-1	0.8	RSD5-US	0.6	–
<i>tert</i> -Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	–
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.026	MCL-CA	1	–
Bromobenzene	Solvent	81555	108-86-1	0.022	na	na	–
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	–
Bromodichloromethane	Disinfection by-product (THM)	32101	75-27-4	0.034	MCL-US	180	D
Bromoform (Tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	0.1	MCL-US	180	–
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.2	HAL-US	10	–
<i>n</i> -Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.08	NL-CA	260	–
<i>sec</i> -Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.034	NL-CA	260	–
<i>tert</i> -Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	–
Carbon disulfide	Organic synthesis	77041	75-15-0	² 0.06	NL-CA	160	D
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.052	MCL-CA	0.5	–
Chlorobenzene	Solvent	34301	108-90-7	0.016	MCL-CA	70	–
Chloroethane	Solvent	34311	75-00-3	0.06	na	na	–
Chloroform (Trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	² 0.02	MCL-US	180	D
Chloromethane	Solvent	34418	74-87-3	0.14	HAL-US	30	–
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	–
2-Chlorotoluene	Solvent	77275	95-49-8	0.028	NL-CA	140	–
4-Chlorotoluene	Solvent	77277	106-43-4	0.042	NL-CA	140	–
Dibromochloromethane	Disinfection by-product (THM)	32105	124-48-1	0.12	MCL-US	180	–
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.34	MCL-US	0.2	–
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.05	MCL-US	0.05	–
Dibromomethane	Solvent	30217	74-95-3	0.05	na	na	–
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.028	MCL-CA	600	–
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.024	HAL-US	600	–
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.026	MCL-CA	5	–
<i>trans</i> -1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.36	na	na	–
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.1	NL-CA	1,000	–
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.044	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.08	MCL-CA	0.5	–

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

USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServiceSM. **LRL, Benchmark type, and Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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 exists. **Abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; HAL-US, USEPA lifetime health advisory level; MCL-CA, CDPH maximum contaminant level; na, not available; MCL-US, USEPA maximum contaminant level; –, not detected; D, detected in groundwater samples (table 5); GAMA, Groundwater Ambient Monitoring and Assessment Program; NOCO, Northern Coast Ranges study unit; NL-CA, CDPH notification level; THM, trihalomethane; RSD5-US, USEPA risk specific dose at a risk factor of 10⁻⁵; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health

Constituent	Primary use or source	USGS parameter code	CAS number	LRL/SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.022	MCL-CA	6	–
<i>cis</i> -1,2-Dichloroethene (<i>cis</i> -1,2-DCE)	Solvent	77093	156-59-2	0.022	MCL-CA	6	–
<i>trans</i> -1,2-Dichloroethene (<i>trans</i> -1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	–
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.026	MCL-US	5	–
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	–
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	–
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.03	na	na	–
<i>cis</i> -1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	³ 4	–
<i>trans</i> -1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.14	RSD5-US	³ 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	0.036	MCL-CA	300	–
Ethyl <i>tert</i> -butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.032	na	na	–
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	–
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.032	na	na	–
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.06	RSD5-US	9	–
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	–
2-Hexanone (<i>n</i> -Butyl methyl ketone)	Solvent	77103	591-78-6	0.46	na	na	–
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	0.26	na	na	–
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.042	NL-CA	770	–
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	0.06	na	na	–
Methyl acrylate	Organic synthesis	49991	96-33-3	0.56	na	na	–
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.26	na	na	–
Methyl <i>tert</i> -butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.1	MCL-CA	13	D
Methyl <i>iso</i> -butyl ketone (MIBK)	Solvent	78133	108-10-1	0.32	NL-CA	120	–
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.038	MCL-US	5	–
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	–
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.22	na	na	–
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.18	NL-CA	17	–
Perchloroethene (PCE, Tetrachloroethene)	Solvent	34475	127-18-4	0.026	MCL-US	5	D
<i>n</i> -Propylbenzene	Solvent	77224	103-65-1	0.036	NL-CA	260	–
Styrene ⁴	Gasoline hydrocarbon	77128	100-42-5	0.03	MCL-US	100	–

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

USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers® (CASRN)s is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRN through CAS Client ServiceSM. **LRL, Benchmark type, and Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; LRL, laboratory reporting level; µg/L, micrograms per liter; HAL-US, USEPA lifetime health advisory level; MCL-CA, CDPH maximum contaminant level; na, not available; MCL-US, USEPA maximum contaminant level; -, not detected; D, detected in groundwater samples (table 5); GAMA, Groundwater Ambient Monitoring and Assessment Program; NOCO, Northern Coast Ranges study unit; NL-CA, CDPH notification level; THM, trihalomethane; RSD5-US, USEPA risk specific dose at a risk factor of 10⁻⁵; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health

Constituent	Primary use or source	USGS parameter code	CAS number	LRL/SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.14	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.08	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.08	na	na	—
Toluene ¹	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	—
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.06	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	0.08	MCL-CA	5	—
1,1,1-Trichloroethane (1,1,1-TCA)	Solvent	34506	71-55-6	0.03	MCL-CA	200	D
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.046	MCL-CA	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.022	MCL-US	5	—
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	—
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.12	na ⁵	na	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.034	MCL-CA	1,200	—
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.06	na	na	—
1,2,4-Trimethylbenzene ⁴	Gasoline hydrocarbon	77222	95-63-6	0.032	NL-CA	330	—
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.032	NL-CA	330	—
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.06	MCL-CA	0.5	D
<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	0.032	MCL-CA	6 1,750	—

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

² SRL defined based on the highest concentration detected in the NOCO study unit blanks. Values below the SRL are reported as ≤ the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is < or = reported value, based on a detection in a blank.

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

⁴ Constituent excluded from dataset on the basis of the examination of quality-control samples collected for the first 27 GAMA study units (May 2004 through October 2009) and in laboratory instrument and preparation blanks analyzed during the same time period as the samples (Fram and others, 2011).

⁵ In earlier reports in this series, the NL-CA (0.005 µg/L) was used as the comparison benchmark for 1,2,3-TCP.

⁶ The MCL-CA benchmarks 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 benchmarks, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2033.

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. CAS number: CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. LRL, **Benchmark type**, and **Benchmark level**: Data as of October 8, 2009. **Benchmark type**: Maximum contaminant level benchmarks 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. **Abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; RSD5-US, USEPA risk specific dose at a risk factor of 10⁻⁵; HAL-US, USEPA lifetime health advisory level; –, not detected; D, detected in groundwater samples (table 6); USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.010	na	na	–
Alachlor	Herbicide	46342	15972-60-8	0.008	MCL-US	2	–
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	–
Azinphos-methyl oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	– ¹
Benfluralin	Herbicide	82673	1861-40-1	0.014	na	na	–
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	–
Carbofuran	Insecticide	82674	1563-66-2	0.060	MCL-CA	18	–
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.010	na	na	–
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.003	na	na	– ¹
Chlorpyrifos	Insecticide	38933	2921-88-2	0.010	HAL-US	2	–
Chlorpyrifos-oxon	Insecticide degradate	61636	5598-15-2	0.05	na	na	– ¹
Cyanazine	Herbicide	04041	21725-46-2	0.022	HAL-US	1	–
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	–
λ-Cyhalothrin	Insecticide	61595	91465-08-6	0.010	na	na	– ¹
Cypermethrin	Insecticide	61586	52315-07-8	0.020	na	na	–
DCPA (Dacthal)	Herbicide	82682	1861-32-1	0.008	HAL-US	70	–
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	D ¹
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	–
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	–
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	–
Diazinon oxon	Insecticide degradate	61638	962-58-3	0.006	na	na	–
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.004	na	na	–
3,5-Dichloroaniline	Herbicide degradate	61627	626-43-7	0.003	na	na	–
Dichlorvos	Insecticide	38775	62-73-7	0.02	na	na	– ¹
Dicrotophos	Insecticide	38454	141-66-2	0.08	na	na	– ¹
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	–
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	–
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	– ¹
Disulfoton	Insecticide	82677	298-04-4	0.04	HAL-US	0.7	–
Disulfoton sulfone	Insecticide degradate	61640	2497-06-5	0.014	na	na	–
α-Endosulfan	Insecticide	34362	959-98-8	0.006	na	na	–
Endosulfan sulfate	Insecticide degradate	61590	1031-07-8	0.014	na	na	–
Ethion	Insecticide	82346	563-12-2	0.008	na	na	–
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	–
Ethoprophos	Herbicide	82672	13194-48-4	0.016	na	na	–
S-Ethyl-dipropylthiocarbamate (EPTC)	Herbicide	82668	759-94-4	0.002	na	na	–
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.010	na	na	–
Fenamiphos	Insecticide	61591	22224-92-6	0.030	HAL-US	0.7	–
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	–
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.08	na	na	– ¹
Fipronil	Insecticide	62166	120068-37-3	0.018	na	na	–

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

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Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
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	0.004	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	— ¹
Iprodione	Fungicide	61593	36734-19-7	0.014	na	na	— ¹
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaaxon	Insecticide degradate	61652	1634-78-2	0.08	na	na	—
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.007	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.006	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.014	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	—
Molinate	Herbicide	82671	2212-67-1	0.002	MCL-CA	20	—
Myclobutanil	Fungicide	61599	88671-89-0	0.010	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.036	na	na	— ¹
Oxyfluorfen	Herbicide	61600	42874-03-3	0.010	na	na	— ¹
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.010	na	na	— ¹
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.014	na	na	—
Phorate	Insecticide	82664	298-02-2	0.02	na	na	—
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.034	na	na	— ¹
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.051	na	na	— ¹
Prometon	Herbicide	04037	1610-18-0	0.012	HAL-US	100	—
Prometryn	Herbicide	04036	7287-19-6	0.006	na	na	—
Pronamide	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—
Propanil	Herbicide	82679	709-98-8	0.010	na	na	—
Propargite	Insecticide	82685	2312-35-8	0.020	na	na	—
cis-Propiconazole	Fungicide	79846	60207-90-1	0.006	na	na	—
trans-Propiconazole	Fungicide	79847	60207-90-1	0.02	na	na	—
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuconazole	Fungicide	62852	107534-96-3	0.020	na	na	—
Tebuthiuron	Herbicide	82670	34014-18-1	0.028	HAL-US	500	—
Tefluthrin	Insecticide	61606	79538-32-2	0.010	na	na	— ¹
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	— ¹
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—
Terbutylazine	Herbicide	04022	5915-41-3	0.006	na	na	—
Thiobencarb	Herbicide	82681	28249-77-6	0.016	MCL-CA	70	—
Tribufos	Defoliant	61610	78-48-8	0.018	na	na	— ¹
Trifluralin	Herbicide	82661	1582-09-8	0.018	HAL-US	10	—

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

Table 3C. Perchlorate, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc. analyses.

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Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	63790	14797-73-0	0.10	MCL-CA	6	D

Table 3D. Trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedules 2710.

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. CAS number: CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. LRL, Benchmark type, and Benchmark level: Data as of October 8, 2009. Benchmark type: Maximum contaminant level benchmarks 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. Abbreviations: USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; HAL-US, USEPA lifetime health advisory level; na, not available; D, detected in groundwater samples (table 8); GAMA, Groundwater Ambient Monitoring and Assessment Program; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; NOCO, Northern Coast Ranges study unit; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

Constituent	USGS parameter code	CAS number	LRL/SRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Aluminum	01106	7429-90-5	¹ 1.6	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.054	MCL-US	6	D
Arsenic	01000	7440-38-2	0.044	MCL-US	10	D
Barium	01005	7440-39-3	¹ 0.36	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.012	MCL-US	4	D
Boron	01020	7440-42-8	2.8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.02	MCL-US	5	D
Chromium	01030	7440-47-3	¹ 0.42	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.010	na	na	D
Copper	01040	7440-50-8	¹ 1.7	AL-US	1,300	D
Iron	01046	7439-89-6	¹ 6	SMCL-CA	300	D
Lead	01049	7439-92-1	² 1.1	AL-US	15	D
Lithium	01130	7439-93-2	0.44	na	na	D
Manganese	01056	7439-96-5	¹ 0.2	SMCL-CA	50	D
Mercury	71890	7439-97-6	¹ 0.012	MCL-US	2	D
Molybdenum	01060	7439-98-7	0.028	HAL-US	40	D
Nickel	01065	7440-02-0	¹ 0.36	MCL-CA	100	D
Selenium	01145	7782-49-2	0.040	MCL-US	50	D
Silver	01075	7440-22-4	0.010	SMCL-CA	100	D
Strontium	01080	7440-24-6	0.40	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.020	MCL-US	2	D
Uranium	22703	7440-61-1	0.008	MCL-US	30	D
Vanadium	01085	7440-62-2	¹ 0.11	NL-CA	50	D
Zinc	01090	7440-66-6	¹ 4.8	SMCL-CA ³	5,000	D

¹ SRL defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (Olsen and others, 2010). Values less than the SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on QC data (may include: field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and USGS BQS Blind Blank Program data).

² SRL defined based on the highest concentration detected in the NOCO study unit blanks. Values less than the SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on a detection in a blank.

³ The SMCL for zinc is listed as SMCL-CA because SMCLs established by the CDPH are used in this report for all constituents with SMCL-CA values.

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

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. CAS number: CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. LRL, Laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; mg/L, milligrams per liter; na, not available; HAL-US, USEPA lifetime health advisory level; MCL-US, USEPA maximum contaminant level; D, detected in groundwater samples (table 9); NOCO, Northern Coast Ranges study unit; NWIS, National Water Information System; MCL-CA, CDPH maximum contaminant level; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health;]

Constituent	USGS parameter code	CAS number	LRL/SRL (µg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.02	HAL-US	¹ 24.7	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.04	MCL-US	10	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen)	62854	17778-88-0	0.10	na	na	D
Phosphate, orthophosphate (as phosphorus)	00671	14265-44-2	0.006	na	na	D
Dissolved organic carbon (DOC)	00681	na	² 0.7	na	na	D

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

² SRL defined based on the highest concentration detected in the NOCO study unit blanks. Values less than the SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on a detection in a blank.

Table 3F. Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparative benchmarks, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2750.

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. CAS number: CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. LRL, Laboratory reporting level; SRL, study reporting level; mg/L, milligrams per liter; SiO₂, silicon dioxide; CaCO₃, calcium carbonate; na, not available; SMCL-CA, CDPH secondary maximum contaminant level; MCL-CA, CDPH maximum contaminant level; D, detected in groundwater samples (table 10); MCL-US, USEPA maximum contaminant level; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	0.044	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	² 250 (500)	D
Fluoride	00950	16984-48-8	0.08	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.016	na	na	D
Potassium	00935	7440-09-7	0.064	na	na	D
Sodium	00930	7440-23-5	0.10	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	² 250 (500)	D
Silica (as SiO ₂)	00955	7631-86-9	0.058	na	na	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	10	SMCL-CA	² 500 (1,000)	D
Laboratory alkalinity ¹ (as CaCO ₃)	29801	na	1	na	na	D

¹ The recommended SMCL-CA benchmarks for chloride, sulfate, and TDS are listed with the upper SMCL-CA thresholds in parentheses.

² Laboratory alkalinity results for one sample are presented in table 4.

Table 3G. Isotopic and radioactive constituents, comparative benchmarks, and reporting information for laboratory analyses.

[USGS parameter code: The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. **Reporting level, Benchmark type, and Benchmark level:** Data as of October 8, 2009. 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. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; pCi/L, picocuries per liter; na, not available; MU, method uncertainty; ssL_C, sample-specific critical level; CSU, combined standard uncertainty; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; D, detected in groundwater samples (tables 11 and 12A through 12D); USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Benchmark type	Benchmark level	Detection
Stable isotope ratios (per mil)							
$\delta^2\text{H}$ in water ¹	82082	na	MU	2	na	na	D
$\delta^{18}\text{O}$ in water ¹	82085	na	MU	0.20	na	na	D
$\delta^{13}\text{C}$ in dissolved inorganic carbon ²	82081	na	1-sigma	0.05	na	na	D
Radioactive constituents (percent modern)							
Carbon-14 ²	49933	14762-75-5	1-sigma	0.002	na	na	D
Radioactive constituents (pCi/L)							
Radon-222 ³	82303	14859-67-7	ssL _C	CSU	Proposed MCL-US	4,000	D
Tritium ⁴	07000	10028-17-8	ssL _C	CSU	MCL-CA	20,000	D
Radium-226 ⁵	09511	13982-63-3	ssL _C	CSU	MCL-US	⁶ 5	D
Radium-228 ⁵	81366	15262-20-1	ssL _C	CSU	MCL-US	⁶ 5	D
Gross alpha radioactivity, 72-hour and 30-day counts ⁵	62636, 62639	12587-46-1	ssL _C	CSU	MCL-US	15	D
Gross beta radioactivity, 72-hour and 30-day counts ⁵	62642, 62645	12587-47-2	ssL _C	CSU	MCL-CA	50	D
Lead-210 ⁵	17503	14255-04-0	ssL _C	CSU	na	na	D
Polonium-210 ⁵	19503	13981-52-7	ssL _C	CSU	na	na	D

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

² Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility (contract laboratory, NOSAMS).

³ USGS National Water Quality Laboratory (USGSNWQL).

⁴ USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA).

⁵ Eberline Analytical Services (contract laboratory, CA-EBERL).

⁶ The MCL-US benchmark for radium is the sum of radium-226 and radium-228.

Table 3H. Dissolved noble gases, comparative benchmarks, and reporting information for the Lawrence Livermore National Laboratory analyses.

[**USGS parameter code:** The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. **Abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstracts Service; na, not available; cm³ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water]

Constituent	USGS parameter code	CAS number	Method uncertainty (percent)	Reporting units	Benchmark type	Benchmark value	Detection
Dissolved noble gases							
Argon	85563	7440-37-1	2	cm ³ STP/g	na	na	na
Helium-4	85561	7440-59-7	2	cm ³ STP/g	na	na	na
Krypton	85565	7439-90-9	2	cm ³ STP/g	na	na	na
Neon	61046	7440-01-09	2	cm ³ STP/g	na	na	na
Xenon	85567	7440-63-3	2	cm ³ STP/g	na	na	na
Helium-3 / Helium-4	61040	na / 7440-59-7	0.75	atom ratio	na	na	na

Table 3I. Microbial indicators, comparative benchmarks, and reporting information for the U.S. Geological Survey Ohio Microbiology Laboratory and field analyses.

[**USGS parameter code:** The five-digit code is used to uniquely identify a specific constituent or property. **CAS number:** CAS Registry Numbers® (CASRNs) is a registered trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client ServicesSM. **MDL, Benchmark type, and Benchmark value:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** USGS, U.S. Geological Survey; MDL, method detection limit; mL, milliliter; TT-US, USEPA treatment technique (a required process intended to reduce the level of contamination in drinking water); MCL-US, USEPA maximum contaminant level; D, detected in groundwater samples ([table 13](#)); MCL-CA, CDPH maximum contaminant level; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Constituent	USGS parameter code	Primary source	MDL	Benchmark type	Benchmark 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
<i>Escherichia coli</i> (<i>E. coli</i>) ¹	90901	Sewage and animal waste indicator	1 colony / 100 mL	TT-US	Zero	D
Total coliform - (including fecal coliform and <i>E. coli</i>) ¹	90900	Sewage and animal waste indicator	1 colony / 100 mL	MCL-US	5 percent of samples positive per month	D

¹Analyzed in the field.

Table 4. Field water-quality indicators in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parentheses below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type.** Benchmark level, and RL: Data as of October 8, 2009. **Abbreviations:** NTRU, nephelometric turbidity unit; mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; SMCL-CA, CDPH secondary maximum contaminant level; na, not available; SMCL-US, USEPA secondary maximum contaminant level; <, less than; >, greater than; RL, reporting limit or range; *, value greater than benchmark level; E, estimated or having a higher degree of uncertainty; nc, not collected; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Specific conductance, field (µS/cm at 25 °C) (00095)	SMCL-CA 2 900 (1,600) [5]	SMCL-CA 2 900 (1,600) [5]	Alkalinity, lab (mg/L as CaCO ₃) (29801)	Alkalinity, field (mg/L as CaCO ₃) (39086)	Bicarbonate, field (mg/L) (00453)	Bicarbonate ³ (mg/L) (00452)	Carbonate ³ (mg/L) (00452)
Benchmark type	SMCL-CA 15 [0.1]	na [0.2]	na [0.0–38.5]	SMCL-US <6.5 or >8.5 [0–14]	SMCL-US <6.5 or >8.5 [0–14]	SMCL-US <6.5 or >8.5 [0–14]	SMCL-CA 2 900 (1,600) [5]	SMCL-CA 2 900 (1,600) [5]	na [1]	na [1]	na [1]	na [1]	na [0.1]	na [0.1]
NOCO grid wells (58 wells sampled)														
NOCO-IN01	0.5	0.7	20.0	7.7	7.5	246	245		nc	121	147	nc	–	nc
NOCO-IN02	0.6	7.0	17.5	7.3	7.2	280	276		nc	116	141	nc	–	nc
NOCO-IN03	9.8	0.7	12.5	7.1	*6.1	162	160		nc	75.4	91.9	nc	–	nc
NOCO-IN04	100	10.9	14.0	7.1	*6.3	285	273		nc	120	146	nc	–	nc
NOCO-IN05	16.0	0.3	16.0	7.0	6.7	576	580		nc	150	183	nc	–	nc
NOCO-IN06	0.4	0.4	15.0	7.2	7.2	385	373		nc	198	240	nc	0.3	nc
NOCO-IN07	0.3	1.3	14.5	6.7	*6.0	255	247		nc	97.9	119	nc	–	nc
NOCO-IN08	0.2	5.5	14.0	7.0	6.6	390	384		nc	154	188	nc	–	nc
NOCO-IN09	0.2	<1	20.0	7.7	7.5	443	444		nc	222	271	nc	–	nc
NOCO-IN10	0.4	5.0	16.0	7.0	*6.4	222	219		nc	87.9	107	nc	–	nc
NOCO-IN11	1.1	0.3	18.0	7.1	6.8	343	341		nc	4 158	4 192	nc	4 0.1	nc
NOCO-IN12	0.8	2.2	19.0	7.3	6.9	300	289		nc	4 126	4 153	nc	4 0.2	nc
NOCO-IN13	0.1	3.8	16.0	6.7	*6.1	281	275		nc	4 108	4 131	nc	4 –	nc
NOCO-IN14	0.3	<0.2	18.5	7.5	7.3	326	322		nc	4 127	4 154	nc	4 0.4	nc
NOCO-IN15	8.7	<0.2	15.5	8.0	7.1	303	294		nc	153	187	nc	–	nc
NOCO-IN16	4.1	1.9	15.0	6.9	*6.4	163	158		nc	68.3	83.3	nc	–	nc
NOCO-IN17	0.6	6.2	18.5	7.7	6.9	243	243		nc	95.2	116	nc	–	nc
NOCO-IN18	0.1	1.3	19.0	6.9	6.7	587	582		nc	244	298	nc	–	nc
NOCO-IN19	0.3	2.6	18.5	7.1	*6.0	269	267		nc	67.7	82.6	nc	–	nc
NOCO-IN20	4.6	0.3	23.0	7.0	*6.3	*1,320	*1,310		nc	671	818	nc	0.4	nc
NOCO-IN21	1.7	<0.2	18.5	6.9	6.8	*982	*964		nc	420	512	nc	0.4	nc
NOCO-IN22	0.6	0.5	25.0	7.5	7.4	900	893		nc	422	513	nc	1.0	nc
NOCO-IN23	0.3	1.9	15.0	7.6	7.2	266	254		nc	117	142	nc	–	nc
NOCO-IN24	0.2	3.8	18.5	7.6	7.3	339	331		nc	171	208	nc	–	nc
NOCO-IN25	0.4	0.7	19.0	7.7	7.5	413	409		nc	213	260	nc	–	nc

Table 4. Field water-quality indicators in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parentheses below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and RL:** Data as of October 8, 2009. **Abbreviations:** NTRU, nephelometric turbidity unit; mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; SMCL-CA, CDPH secondary maximum contaminant level; na, not available; SMCL-US, USEPA secondary maximum contaminant level; <, less than; >, greater than; RL, reporting limit or range; *, value greater than benchmark level; E, estimated or having a higher degree of uncertainty; nc, not collected; —, not detected; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Specific conductance, field (µS/cm at 25 °C) (00095)	Alkalinity, lab (mg/L as CaCO ₃) (29801)	Alkalinity, field (mg/L as CaCO ₃) (39086)	Bicarbonate, field (mg/L) (00453)	Bicarbonate ³ (mg/L) (00452)	Carbonate ³ (mg/L)
Benchmark type	SMCL-CA	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na	na
Benchmark level	15	na	na	<6.5 or >8.5	<6.5 or >8.5	2 900 (1,600)	2 900 (1,600)	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[0.1]	[0.1]
NOCO grid wells (58 wells sampled)—Continued												
NOCO-IN26	0.2	4.8	18.0	7.3	6.7	424	414	nc	171	208	—	nc
NOCO-IN27	0.2	<0.2	18.0	*6.2	*6.0	*1,040	*1,030	nc	578	705	—	nc
NOCO-IN28	0.2	<0.2	15.5	7.5	7.2	661	618	nc	344	418	0.7	nc
NOCO-CO01	1.2	<0.2	13.0	7.3	7.2	367	358	nc	100	122	0.1	nc
NOCO-CO02	0.2	11.8	13.5	6.7	6.5	247	250	nc	23.9	29.1	—	nc
NOCO-CO03	0.2	1.3	11.0	7.9	7.7	166	160	nc	56.6	69.0	—	nc
NOCO-CO04	0.3	<0.2	12.5	7.6	7.5	701	687	nc	350	427	—	nc
NOCO-CO05	0.6	5.2	12.0	*5.7	*5.6	196	196	nc	11.3	13.8	—	nc
NOCO-CO06	2.4	4.1	12.0	6.6	6.5	453	397	nc	52.0	63.4	—	nc
NOCO-CO07	18.0	10.4	11.5	7.0	6.5	174	160	nc	55.6	67.8	—	nc
NOCO-CO08	0.1	<0.2	14.5	7.2	7.5	328	317	nc	134	164	0.2	nc
NOCO-CO09	0.2	<0.2	18.0	7.5	7.5	715	701	nc	243	295	0.6	nc
NOCO-CO10	0.2	3.3	13.0	7.9	7.8	287	274	nc	130	158	0.4	nc
NOCO-CO11	0.6	1.3	14.5	6.8	6.7	434	420	nc	178	218	—	nc
NOCO-CO12	0.5	1.1	15.5	7.2	6.8	319	312	nc	76.4	93.2	—	nc
NOCO-CO13	0.3	7.1	13.0	7.2	*6.3	206	203	nc	35.0	42.6	—	nc
NOCO-CO14	0.5	9.7	13.0	7.3	7.7	237	227	83.0	nc	nc	—	0.1
NOCO-CO15	0.2	6.9	10.5	7.4	*6.4	E67.0	63.0	nc	16.9	20.6	—	nc
NOCO-CO16	0.3	7.9	13.0	7.5	6.7	180	171	nc	81.1	98.8	—	nc
NOCO-CO17	0.2	3.1	15.0	6.8	6.5	339	331	nc	143	174	—	nc
NOCO-CO18	0.2	0.3	14.5	6.7	6.5	436	435	nc	183	223	0.1	nc
NOCO-CO19	0.2	0.2	13.5	7.0	6.6	474	466	nc	173	211	0.1	nc
NOCO-CO20	0.3	6.1	12.5	7.8	7.5	414	405	nc	165	200	0.6	nc

Table 4. Field water-quality indicators in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parentheses below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and RL:** Data as of October 8, 2009. **Abbreviations:** NTRU, nephelometric turbidity unit; mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; SMCL-CA, CDPH secondary maximum contaminant level; na, not available; SMCL-US, USEPA secondary maximum contaminant level; <, less than; >, greater than; RL, reporting limit or range; *, value greater than benchmark level; E, estimated or having a higher degree of uncertainty; nc, not collected; —, not detected; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Turbidity, field (NTRU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Specific conductance, field (µS/cm at 25 °C) (00095)	Alkalinity, lab (mg/L as CaCO ₃) (29801)	Alkalinity, field (mg/L as CaCO ₃) (39086)	Bicarbonate, field (mg/L) (00453)	Bicarbonate ³ (mg/L)	Carbonate, field (mg/L) (00452)	Carbonate ³ (mg/L)
Benchmark type	SMCL-CA	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na	na	na
Benchmark level ¹	15	na	na	<6.5 or >8.5	<6.5 or >8.5	2 900 (1,600)	2 900 (1,600)	na	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[1]	[0.1]	[0.1]
NOCO grid wells (58 wells sampled)—Continued													
NOCO-CO21	4.6	0.4	14.5	7.2	7.0	705	715	nc	342	416	nc	0.4	nc
NOCO-CO22	1.2	7.5	13.0	7.3	6.7	335	329	nc	108	132	nc	0.1	nc
NOCO-CO23	0.3	6.3	14.5	7.4	*6.2	E96.0	92.0	nc	35.0	42.6	nc	—	nc
NOCO-CO24	2.0	0.8	12.5	7.0	6.8	252	244	nc	85.7	104	nc	—	nc
NOCO-CO25	0.4	0.3	14.0	7.4	6.7	341	332	nc	121	147	nc	0.1	nc
NOCO-CO26	2.2	4.2	12.0	7.3	*5.5	193	186	nc	28.3	34.5	nc	—	nc
NOCO-CO27	E61.0	0.2	15.5	7.1	6.8	693	675	nc	259	316	nc	—	nc
NOCO-CO28	5.2	0.4	14.0	7.2	7.2	693	672	nc	322	392	nc	—	nc
NOCO-CO29	0.3	0.4	13.0	7.5	7.3	420	418	nc	210	256	nc	—	nc
NOCO-CO30	0.2	4.6	15.5	7.7	7.1	227	222	nc	76.4	93.2	nc	—	nc

¹ The SMCL-CA for turbidity pertains only to surface-water site samples.

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

³ Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_w = 14$.

⁴ Alkalinity, bicarbonate, and carbonate values generated by the Gran's titration method (USGS parameter codes: 29802, 63786, and 63788; respectively).

The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 58 grid wells. All analytes are listed in [table 3A](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark level**, and **LRL**: Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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 exists. **Abbreviations:** µg/L, micrograms per liter; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; NL-CA, CDPH notification level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Primary use or source	Trihalomethane	Solvent	Gasoline	Organic synthesis	Solvent	Trihalomethane	Solvent	Organic synthesis
		1,1,1-Trichloro-ethane (1,1,1-TCA) (µg/L) (34506)	Methyl tert-butyl ether (MTBE) (µg/L) (78032)	Carbon disulfide (µg/L) (77041)	1,1-Di-chloro-ethane (1,1-DCA) (µg/L) (34496)	Bromo-dichloro-methane (µg/L) (32101)	Perchloro-ethene (PCE, Tetrachloro-ethene) (µg/L) (34475)	
GAMA well identification number	Chloroform (Trichloro-methane) (µg/L) (32106)							VOC detection summary ¹
Benchmark type	MCL-US	MCL-US	MCL-CA	NL-CA	MCL-CA	MCL-US	MCL-US	
Benchmark level [LRL/SRL]	80 ³[0.02]	200 [0.02]	13 [0.1]	160 ³[0.06]	5 [0.04]	280 [0.04]	5 [0.04]	0.5 [0.08]
NOCO grid wells (58 wells sampled)								
Number of wells with detections	14	4	4	2	2	2	2	1
Detection frequency (percent)	24.1	6.9	6.9	3.4	3.4	3.4	3.4	1.7
Total detections								31
Inland Basins study area (28 grid wells sampled)								
NOCO-IN02	0.11	-	-	-	-	-	-	1
NOCO-IN03	-	1.52	-	-	E0.08	-	-	2
NOCO-IN04	-	E0.03	-	-	-	-	-	1
NOCO-IN05	-	-	0.1	-	-	-	-	1
NOCO-IN07	≤0.01	-	-	-	-	-	-	0
NOCO-IN09	-	-	0.4	-	-	-	-	1
NOCO-IN11	-	E0.02	-	-	E0.03	-	-	2
NOCO-IN13	E0.09	0.14	-	-	-	-	E0.03	3
NOCO-IN16	E0.04	-	-	-	-	-	-	1
NOCO-IN17	0.25	-	-	-	-	-	-	1
NOCO-IN19	13.0	-	-	-	-	0.43	-	3
NOCO-IN20	-	-	-	0.07	-	-	-	1
NOCO-IN21	-	-	0.2	-	-	-	-	1
NOCO-IN22	-	-	-	≤0.04	-	-	-	0
NOCO-IN24	E0.02	-	-	-	-	-	-	1
Number of wells with detections	6	4	3	2	2	1	1	13
Detection frequency (percent)	21.4	14.3	10.7	3.6	7.1	3.6	3.6	46
Total detections								19

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 58 grid wells. All analytes are listed in [table 3A](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** µg/L, micrograms per liter; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; NL-CA, CDPH notification level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

Primary use or source	Trihalomethane	Solvent	Gasoline	Organic synthesis	Solvent	Trihalomethane	Solvent	Organic synthesis	VOC detection summary ¹
GAMA well identification number	Chloroform (Trichloromethane) (µg/L) (32106)	1,1,1-Trichloroethane (1,1,1-TCA) (µg/L) (34506)	Methyl tert-butyl ether (MTBE) (µg/L) (78032)	Carbon disulfide (µg/L) (77041)	1,1-Dichloroethane (1,1-DCA) (µg/L) (34496)	Bromodichloromethane (µg/L) (32101)	Perchloroethene (PCE, Tetrachloroethene) (µg/L) (34475)	Vinyl chloride (Chloroethene) (µg/L) (39175)	
Benchmark type [LRL/SRL]	MCL-US 80 3 [0.02]	MCL-US 200 [0.02]	MCL-CA 13 [0.1]	NL-CA 160 3 [0.06]	MCL-CA 5 [0.04]	MCL-US 2.80 [0.04]	MCL-US 5 [0.04]	MCL-CA 0.5 [0.08]	
Coastal Basins study area (30 grid wells sampled)									
NOCO-CO05	E0.07	–	–	–	–	–	–	–	1
NOCO-CO06	0.14	–	–	–	–	–	–	–	1
NOCO-CO07	E0.06	–	–	–	–	–	–	–	1
NOCO-CO13	0.24	–	–	–	–	E0.07	E0.03	–	3
NOCO-CO14	0.71	–	–	–	–	–	–	–	1
NOCO-CO18	–	–	E0.1	–	–	–	–	–	1
NOCO-CO23	E0.03	–	–	–	–	–	–	–	1
NOCO-CO26	0.12	–	–	–	–	–	–	–	1
NOCO-CO29	E0.02	–	–	0.12	–	–	–	–	2
Number of wells with detections	8	0	1	1	0	1	1	0	9
Detection frequency (percent)	26.7	0	3.3	3.3	0	3.3	3.3	0	30
Total detections									12

¹ SRLs for styrene, toluene, and 1,2,4-trimethylbenzene were defined on the basis of concentrations and detection frequencies in field blanks and source-solution blanks collected for the first 27 GAMA Priority Basin Project (PBP) study units (May 2004 through October 2009) and in laboratory instrument and preparation blanks analyzed during the same time period as the samples. These constituents were detected more frequently in blanks than in groundwater samples and, therefore, all detections of these constituents were removed from the GAMA PBP groundwater-quality datasets. Concentrations detected in the NOCO study unit: styrene (NOCO-CO27: E0.03 µg/L), toluene (NOCO-CO24: E0.06 µg/L), and 1,2,4-trimethylbenzene (NOCO-IN03: E0.02 µg/L; NOCO-IN04: E0.05 µg/L; NOCO-IN05: E0.09 µg/L; NOCO-IN06: E0.07 µg/L; NOCO-IN15: E0.04 µg/L; NOCO-IN16: E0.11 µg/L; NOCO-IN18: E0.09 µg/L; NOCO-IN20: E0.05 µg/L; NOCO-IN23: E0.04 µg/L; NOCO-IN28: E0.07 µg/L; NOCO-CO02: E0.05 µg/L; NOCO-CO11: E0.04 µg/L; NOCO-CO12: E0.03 µg/L; NOCO-CO13: E0.03 µg/L; NOCO-CO14: E0.03 µg/L; NOCO-CO16: E0.08 µg/L; NOCO-CO17: E0.04 µg/L; NOCO-CO27: E0.02 µg/L; NOCO-CO28: E0.04 µg/L).

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

³ SRL defined based on the highest concentration detected in NOCO blanks. Values below the SRL are reported as ≤ the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is < or = reported value, based on a detection in a blank.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 58 grid wells. All analytes are listed in [table 3B](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Laboratory reporting level, benchmark type, and benchmark level as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; –, not detected]

Primary use or source	Herbicide	Herbicide degradate	Herbicide		
GAMA well identification number	Simazine (µg/L) (04035)	Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine) (µg/L) (04040)	Atrazine (µg/L) (39632)	Detections per well	Pesticide detection summary
Benchmark type	MCL-US	na	MCL-CA		
Benchmark level [LRL]	4 [0.01]	na [0.014]	1 [0.007]		
NOCO grid wells (58 wells sampled)					
Number of wells with detections	6	2	2		6
Detection frequency (percent)	10.3	3.4	3.4		10
Total detections					10
Interior Basins study area (28 grid wells sampled)					
NOCO-IN04	E0.009	E0.006	0.011	3	
NOCO-IN07	E0.005	E0.006	E0.005	3	
NOCO-IN08	E0.007	–	–	1	
NOCO-IN13	E0.005	–	–	1	
NOCO-IN24	E0.009	–	–	1	
Number of wells with detections	5	2	2		5
Detection frequency (percent)	17.9	7.1	7.1		18
Total detections					9
Coastal Basins study area (30 grid wells sampled)					
NOCO-CO26	0.030	–	–	1	
Number of wells with detections	1	0	0		1
Detection frequency (percent)	3.3	0	0		3
Total detections					1

Table 7. Perchlorate detected in the samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Information about the analyte is given in [table 3C](#). Samples from all 58 grid wells were analyzed for perchlorate, but only samples with detections are listed. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area.

Benchmark type, Benchmark level, and MRL: Data as of October 8, 2009.

Benchmark type: Maximum contaminant level benchmarks 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.

Abbreviations: µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MRL, method reporting level; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Perchlorate (µg/L) (63790)
Benchmark type	MCL-CA
Benchmark level	6
[MRL]	[0.10]
NOCO grid wells (58 wells sampled)	
Number of wells with detections	14
Detection frequency (percent)	24
NOCO Inland Basins Study Area (28 grid wells sampled)	
NOCO-IN02	0.11
NOCO-IN08	0.13
NOCO-IN11	0.14
NOCO-IN12	0.18
NOCO-IN13	0.17
NOCO-IN17	0.41
NOCO-IN19	0.27
NOCO-IN26	0.27
NOCO-IN28	0.26
Number of wells with detections	9
Detection frequency (percent)	32
NOCO Coastal Basins Study Area (30 grid wells sampled)	
NOCO-CO05	0.26
NOCO-CO11	0.13
NOCO-CO13	0.12
NOCO-CO14	0.12
NOCO-CO17	0.73
Number of wells with detections	5
Detection frequency (percent)	17

Table 8. Trace elements detected in the samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks are listed as 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL/SRL]	[1.6] ¹	[0.054]	[0.044]	[0.36] ¹	[0.012]	[2.8]	[0.02]	[0.42] ¹	[0.010]	[1.7] ¹	[6] ¹	[1.1] ²
NOCO grid wells (58 wells sampled)												
NOCO-IN01	–	E0.03	0.57	55	–	89.0	0.03	–	–	–	–	≤0.43
NOCO-IN02	–	–	0.54	47	–	108	–	≤0.14	–	≤1.5	–	≤0.20
NOCO-IN03	–	–	0.06	37	–	10.0	–	≤0.17	0.08	≤0.85	243	–
NOCO-IN04	–	–	0.08	62	–	68.0	–	≤0.13	0.10	2.7	128	–
NOCO-IN05	–	–	*57.2	158	E0.02	*2,310	–	≤0.08	0.11	–	*3,420	–
NOCO-IN06	–	–	2.7	256	–	85.0	E0.02	–	0.18	–	*409	≤0.11
NOCO-IN07	–	E0.02	0.09	92	–	122	E0.01	≤0.16	0.07	1.9	22	≤0.28
NOCO-IN08	–	E0.04	0.17	173	–	231	E0.01	≤0.25	0.04	7.1	–	≤0.89
NOCO-IN09	–	–	0.62	208	–	112	0.04	–	0.02	–	178	≤0.15
NOCO-IN10	–	–	0.07	45	–	174	–	≤0.13	0.02	2.9	30	≤0.15
NOCO-IN11	–	–	7.9	123	–	*1,020	–	–	0.14	–	*745	–
NOCO-IN12	–	E0.02	0.19	84	–	29.0	–	≤0.10	E0.01	4.9	–	3.05
NOCO-IN13	–	–	0.07	94	–	112	–	≤0.08	0.03	6.3	≤4	≤0.11
NOCO-IN14	15.2	E0.02	0.39	65	–	220	E0.01	–	0.05	–	*305	≤0.08
NOCO-IN15	S2.2	S0.09	S9.4	S10.4	–	*S1,009	S0.05	≤0.03	S0.02	≤0.55	≤5	≤0.01
NOCO-IN16	–	E0.02	0.11	62	–	63.0	–	≤0.14	0.02	≤0.53	48	≤0.07
NOCO-IN17	8.2	–	0.21	24	–	102	–	1.2	E0.01	≤0.86	–	1.43
NOCO-IN18	–	E0.03	0.23	104	–	258	–	≤0.26	0.05	≤0.73	–	≤0.07
NOCO-IN19	–	–	0.13	91	–	20.0	–	≤0.25	0.03	5.9	–	≤0.54
NOCO-IN20	–	E0.03	3.5	*1,230	–	231	–	≤0.28	0.11	–	*1,620	≤0.14
NOCO-IN21	–	–	0.07	270	–	296	–	–	0.13	–	*1,340	≤0.04
NOCO-IN22	–	0.07	1.5	383	E0.02	*8,470	–	–	0.43	–	126	–
NOCO-IN23	–	E0.03	0.16	160	–	54.0	–	≤0.16	0.03	≤0.95	–	≤0.13
NOCO-IN24	–	0.06	1.1	95	–	131	–	0.67	0.02	≤1.2	≤4	≤0.19
NOCO-IN25	–	–	0.34	197	–	789	–	≤0.33	0.03	–	158	–

Table 8. Trace elements detected in the samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; S, most probable value; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL/SRL]	[1.6] ¹	[0.054]	[0.044]	[0.36] ¹	[0.012]	[2.8]	[0.02]	[0.42] ¹	[0.010]	[1.7] ¹	[6] ¹	[1.1] ²
NOCO grid wells (58 wells sampled)—Continued												
NOCO-IN26	—	0.05	0.55	100	—	532	—	0.76	0.04	≤0.70	≤2	≤0.06
NOCO-IN27	—	—	*23.2	254	0.03	*2,380	—	0.52	1.6	—	*20,200	—
NOCO-IN28	—	E0.03	0.46	283	—	161	E0.02	—	0.15	—	38	≤0.42
NOCO-CO01	4.7	—	1.4	40	E0.01	156	—	≤0.11	0.02	—	*1,100	≤0.05
NOCO-CO02	—	—	0.22	12	—	18.0	—	≤0.21	E0.01	≤1.2	9	≤0.14
NOCO-CO03	4.4	E0.04	6.1	7.0	—	11.0	—	2.0	0.02	—	15	≤0.06
NOCO-CO04	—	—	2.8	454	—	156	—	≤0.07	0.10	—	*554	—
NOCO-CO05	17.7	E0.02	0.06	72	0.06	39.0	0.02	≤0.31	0.06	6.9	—	≤0.54
NOCO-CO06	6.8	0.05	0.18	18	0.04	57.0	0.05	≤0.13	2.2	7.3	63	≤0.24
NOCO-CO07	—	—	0.08	3.0	—	11.0	—	7.7	0.12	4.1	≤3	≤0.41
NOCO-CO08	—	E0.03	0.17	129	—	61.0	—	—	0.06	—	34	—
NOCO-CO09	—	—	3.6	48	—	982	—	≤0.07	0.05	—	*526	—
NOCO-CO10	—	0.04	1.8	4.0	—	11.0	—	6.3	0.06	≤0.95	≤4	≤0.07
NOCO-CO11	—	E0.03	0.11	224	—	46.0	—	≤0.12	0.10	≤1.5	≤3	≤0.16
NOCO-CO12	—	—	0.21	6.0	—	16.0	—	0.80	0.03	≤0.52	14	≤0.14
NOCO-CO13	—	0.42	0.53	72	—	39.0	—	3.0	0.05	3.8	≤2	≤0.80
NOCO-CO14	—	E0.03	1.6	2.0	—	11.0	—	21.0	E0.02	—	37	≤0.09
NOCO-CO15	—	—	E0.05	9.0	—	16.0	—	≤0.15	—	—	—	≤0.09
NOCO-CO16	—	—	0.07	10	—	10.0	—	5.1	0.03	2.1	≤2	≤0.71
NOCO-CO17	—	E0.04	0.06	100	—	69.0	—	≤0.07	0.05	6.0	—	≤0.97
NOCO-CO18	—	—	1.7	275	—	47.0	—	≤0.21	0.06	—	*5,090	≤0.03
NOCO-CO19	—	E0.04	0.15	172	—	74.0	0.03	—	0.47	≤1.0	—	≤1.01
NOCO-CO20	—	0.04	0.72	91	—	37.0	—	2.0	0.05	3.8	—	≤0.72

Table 8. Trace elements detected in the samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; S, most probable value; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL/SRL]	[1.6] ¹	[0.054]	[0.044]	[0.36] ¹	[0.012]	[2.8]	[0.02]	[0.42] ¹	[0.010]	[1.7] ¹	[6] ¹	[1.1] ²
NOCO grid wells (58 wells sampled)—Continued												
NOCO-CO21	E2.4	–	9.3	466	–	113	–	≤0.34	0.19	–	*7,330	–
NOCO-CO22	22.7	E0.02	0.33	12	–	11.0	–	0.52	0.42	–	10	≤0.18
NOCO-CO23	14.7	E0.02	0.12	17	–	8.0	–	1.3	E0.01	≤1.2	≤2	≤0.24
NOCO-CO24	11.4	0.06	4.1	4.0	–	10.0	–	2.5	0.70	≤0.67	*4,290	≤0.42
NOCO-CO25	–	–	0.26	16	–	15.0	0.03	≤0.09	0.50	–	6	≤0.32
NOCO-CO26	44.8	–	0.12	62	E0.01	39.0	0.03	0.46	0.12	≤1.6	25	≤0.03
NOCO-CO27	–	–	0.20	271	–	114	–	≤0.31	0.11	–	*3,080	≤0.06
NOCO-CO28	–	–	0.06	252	–	261	–	0.93	0.14	–	*716	≤0.10
NOCO-CO29	E1.9	E0.03	0.88	168	–	61.0	–	–	0.48	–	71	≤0.02
NOCO-CO30	–	–	0.22	40	–	12.0	–	≤0.18	0.02	≤1.2	≤3	≤0.37

Table 8. Trace elements collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmark are listed as 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; S, most probable value; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA 50	MCL-US 2	HAL-US 40	MCL-CA 100	MCL-US 50	SMCL-CA 100	HAL-US 4,000	MCL-US 2	MCL-US 30	NL-CA 50	SMCL-CA 5,000
Benchmark level [LRL/SRL]	na [0.44]	[0.2] ¹	[0.012] ¹	[0.028]	[0.36] ¹	[0.040]	[0.010]	[0.40]	[0.020]	[0.008]	[0.11] ¹	[4.8] ¹
NOCO grid wells (58 wells sampled)—Continued												
NOCO-IN01	2.7	*84.4	—	9.4	≤0.13	—	—	140	—	0.20	1.4	≤2.9
NOCO-IN02	2.2	—	—	1.1	≤0.24	0.07	—	216	—	0.07	2.1	≤2.3
NOCO-IN03	E0.6	6.3	—	E0.04	1.4	E0.04	—	92.6	—	—	0.28	≤1.0
NOCO-IN04	E0.8	*73.2	—	0.2	1.3	0.42	—	194	—	0.04	0.23	8.8
NOCO-IN05	E1.0	*1,590	—	1.5	0.74	—	—	1,050	—	E0.004	E0.14	—
NOCO-IN06	5.1	*1,390	—	4.1	0.55	—	—	270	—	0.06	0.46	—
NOCO-IN07	1.5	0.3	—	0.1	4.2	0.11	—	146	—	0.01	0.25	≤2.8
NOCO-IN08	2.5	0.2	—	0.3	0.88	0.13	—	434	—	0.13	0.52	≤3.1
NOCO-IN09	6.1	*193	—	16.4	≤0.09	—	—	334	—	0.75	0.99	≤1.8
NOCO-IN10	1.2	0.6	—	0.1	0.56	0.07	—	167	—	0.01	0.40	≤3.2
NOCO-IN11	1.4	*263	—	1.0	0.83	—	—	286	—	0.02	0.49	13.0
NOCO-IN12	6.6	0.6	—	0.5	≤0.24	0.07	—	143	—	0.09	1.5	21.8
NOCO-IN13	1.9	—	—	0.1	1.7	0.24	—	196	—	0.01	0.32	≤2.0
NOCO-IN14	4.6	*308	—	2.4	≤0.15	—	0.011	162	—	0.14	0.58	≤3.0
NOCO-IN15	S1.7	S33.8	—	S29.6	≤0.31	S0.03	—	S24.6	—	S0.05	S0.49	≤1.7
NOCO-IN16	1.5	2.4	—	0.5	0.60	0.12	—	162	—	0.09	0.41	≤1.1
NOCO-IN17	4.2	0.4	—	0.4	≤0.20	0.41	E0.007	54.9	—	E0.004	4.9	5.6
NOCO-IN18	3.3	0.6	—	0.2	2.5	0.22	—	386	—	0.16	1.5	—
NOCO-IN19	3.6	1.3	—	0.1	2.0	0.12	—	122	—	—	0.48	≤3.5
NOCO-IN20	87.3	*199	—	0.1	1.1	E0.05	—	645	—	—	0.16	≤1.1
NOCO-IN21	5.3	*197	—	E0.05	1.9	E0.04	—	407	—	0.01	E0.15	—
NOCO-IN22	28.2	*92.7	—	0.4	10.5	—	—	490	—	0.02	0.24	≤4.5
NOCO-IN23	4.1	0.6	—	0.4	≤0.34	0.47	—	333	—	0.13	0.42	≤1.1
NOCO-IN24	3.9	0.4	—	0.3	1.4	0.09	—	163	—	0.07	2.5	≤1.7

Table 8. Trace elements collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks are listed as 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; S, most probable value; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	na	na	na	na	na	na	na	na	na	na	na
Benchmark level [LRL/SRL]	[0.44]	[0.2] ¹	[0.012] ¹	[0.028]	[0.36] ¹	[0.040]	[0.010]	[0.40]	[0.020]	[0.008]	[0.11] ¹	[4.8] ¹
NOCO grid wells (58 wells sampled)—Continued												
NOCO-IN25	19.0	38.0	–	1.5	0.59	–	–	148	–	–	0.18	–
NOCO-IN26	9.0	≤0.1	–	0.5	3.1	0.19	–	499	–	0.04	1.2	≤1.5
NOCO-IN27	131	*1,010	–	0.4	2.5	E0.03	–	1,040	–	–	0.65	≤4.6
NOCO-IN28	8.1	*1,120	–	4.7	0.54	–	–	408	–	0.84	0.78	≤2.1
NOCO-CO01	6.4	*164	nc	0.3	≤0.27	–	–	107	–	0.01	0.91	22.5
NOCO-CO02	E0.9	0.9	nc	0.1	≤0.14	0.10	–	191	–	–	0.92	≤3.2
NOCO-CO03	8.3	9.5	nc	0.2	≤0.32	0.08	–	36.4	–	0.01	4.1	–
NOCO-CO04	7.2	*629	nc	0.7	≤0.31	–	–	503	–	–	E0.16	13.3
NOCO-CO05	E0.8	8.2	nc	E0.01	≤0.30	E0.04	–	81.7	–	–	0.25	8.8
NOCO-CO06	7.1	24.4	nc	0.1	11.0	0.41	–	243	–	0.01	0.65	14.1
NOCO-CO07	1.6	3.2	nc	–	0.91	E0.06	–	54.2	–	0.01	1.4	≤1.4
NOCO-CO08	E0.8	13.8	nc	0.7	≤0.25	–	–	439	–	0.27	0.98	7.7
NOCO-CO09	9.1	*123	nc	0.2	≤0.12	–	–	118	–	–	0.43	≤2.8
NOCO-CO10	7.1	0.3	nc	0.2	0.38	0.18	–	143	–	0.13	4.2	5.7
NOCO-CO11	3.2	32.3	nc	0.2	1.7	0.44	–	261	–	0.09	E0.14	6.0
NOCO-CO12	4.1	3.3	nc	0.3	2.5	0.09	–	73.0	–	E0.01	0.89	≤1.8
NOCO-CO13	1.5	5.3	nc	0.1	0.82	E0.04	–	147	–	0.01	0.23	≤4.5
NOCO-CO14	2.4	1.8	nc	E0.03	0.48	0.08	–	55.4	–	0.02	2.8	≤2.5
NOCO-CO15	–	≤0.1	nc	0.1	≤0.20	E0.05	–	49.7	–	–	0.20	≤1.8
NOCO-CO16	–	–	nc	E0.04	76.4	0.18	E0.004	30.4	–	–	0.25	≤3.7
NOCO-CO17	2.5	≤0.1	nc	0.1	0.51	0.31	–	282	–	0.04	E0.13	≤4.3
NOCO-CO18	3.2	*1,280	nc	0.4	0.60	–	–	334	–	–	0.26	≤4.0
NOCO-CO19	3.3	*532	nc	0.3	3.5	E0.04	–	514	–	0.08	0.35	≤1.8

Table 8. Trace elements collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 wells were analyzed, with the exception of mercury, which was sampled for at the 28 grid wells in NOCO-IN. Information about the analytes given in [table 3D](#). **GAMA well identification number:** NOCO-IN, Inland Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark level**, and **LRL**: Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks are listed as 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. **Abbreviations:** µg/L, micrograms per liter; MCL-CA, CDPH maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; na, not available; AL-US, USEPA action level; SMCL-CA, CDPH secondary maximum contaminant level; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; *, value greater than benchmark level; S, most probable value; ≤, less than or equal to; NWIS, National Water Information System; QC, quality control; NWQL, National Water Quality Laboratory; BQS, Branch of Quality Systems; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA 50	MCL-US 2	HAL-US 40	MCL-CA 100	MCL-US 50	SMCL-CA 100	HAL-US 4,000	MCL-US 2	MCL-US 30	NL-CA 50	SMCL-CA 5,000
Benchmark level [LRL/SRL]	na [0.44]	[0.2] ¹	[0.012] ¹	[0.028]	[0.36] ¹	[0.040]	[0.010]	[0.40]	[0.020]	[0.008]	[0.11] ¹	[4.8] ¹
NOCO grid wells (58 wells sampled)—Continued												
NOCO-CO20	14.0	4.4	nc	0.8	0.67	0.38	–	129	–	0.27	1.3	≤1.6
NOCO-CO21	3.7	*605	nc	0.3	0.74	E0.05	–	403	–	–	0.32	15.2
NOCO-CO22	–	33.3	nc	0.1	35.1	0.20	E0.005	33.2	–	–	0.52	11.2
NOCO-CO23	–	–	nc	E0.05	8.0	E0.03	E0.009	61.5	–	–	0.27	≤3.3
NOCO-CO24	1.2	*53.4	nc	0.1	22.1	E0.05	–	45.6	–	0.01	2.0	≤2.9
NOCO-CO25	2.9	*148	nc	E0.04	4.8	–	–	144	–	0.03	3.8	≤2.0
NOCO-CO26	–	47.0	nc	E0.03	2.4	–	–	88.1	–	–	0.39	7.2
NOCO-CO27	9.2	*156	nc	0.1	0.44	0.05	–	165	–	–	0.26	≤1.6
NOCO-CO28	5.2	*714	nc	0.1	0.87	0.06	–	408	–	–	0.61	–
NOCO-CO29	1.2	*667	nc	1.2	1.1	–	–	518	–	1.17	0.38	6.8
NOCO-CO30	4.6	10.0	nc	0.2	≤0.33	0.57	–	45.9	–	0.02	0.95	8.0

¹ SRL defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (Olsen and others, 2010). Values below SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on QC data (may include: field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and USGS BQS Blind Blank Program data)

² SRL defined based on the highest concentration detected in the NOCO study unit blanks. Values below the SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on a detection in a blank.

Table 9. Nutrients and dissolved organic carbon (DOC) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 57 grid wells were analyzed. Information about the analytes given in [table 3E](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** mg/L, milligrams per liter; DOC, dissolved organic carbon; HAL-US, USEPA lifetime health advisory level; MCL-US, USEPA maximum contaminant level; na, not available; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; ≤, less than or equal to; MCL-CA, CDPH maximum contaminant level; NWIS, National Water Information System; NWQL, National Water Quality Laboratory; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite, as nitrogen (mg/L) (00613)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic-nitrogen) as nitrogen (mg/L) (62854)	Phosphate, orthophosphate (as phosphorus) (mg/L) (00671)	DOC (mg/L) (00681)
Benchmark type	HAL-US	MCL-US	MCL-US	na	na	na
Benchmark level	¹ 24.7	1	10	na	na	na
[LRL/SRL]	[0.02]	[0.002]	[0.04]	[0.10]	[0.006]	[0.7] ²
NOCO grid wells (57 wells sampled) ³						
NOCO-IN01	0.06	E0.001	0.18	0.25	0.096	≤0.3
NOCO-IN02	–	–	1.49	1.52	0.142	≤0.3
NOCO-IN03	–	–	0.20	0.21	0.011	≤0.6
NOCO-IN04	0.03	–	1.77	1.87	0.017	≤0.6
NOCO-IN05	0.58	E0.001	–	0.63	1.33	1.2
NOCO-IN06	0.39	–	–	0.41	0.241	≤0.3
NOCO-IN07	–	–	0.19	0.23	0.014	0.8
NOCO-IN08	–	E0.001	0.44	⁴ 0.44	0.021	≤0.5
NOCO-IN09	0.13	–	–	⁴ 0.12	0.128	≤0.3
NOCO-IN10	–	–	0.36	0.40	0.012	≤0.3
NOCO-IN11	E0.01	0.002	1.03	1.09	0.187	≤0.3
NOCO-IN12	–	–	1.67	1.71	0.036	–
NOCO-IN13	–	–	1.02	1.05	0.017	≤0.2
NOCO-IN14	0.03	–	–	⁵ –	0.042	≤0.2
NOCO-IN15	0.05	–	–	E0.07	2.41	0.8
NOCO-IN16	–	–	0.23	⁴ 0.22	0.016	≤0.3
NOCO-IN17	–	–	3.81	3.96	0.067	≤0.2
NOCO-IN18	–	–	0.61	0.63	0.047	≤0.5
NOCO-IN19	E0.02	E0.002	3.52	⁴ 3.50	0.034	1.0
NOCO-IN20	7.89	–	–	8.62	2.34	4.3
NOCO-IN21	0.35	0.007	0.08	0.48	0.031	1.1
NOCO-IN22	0.34	–	–	0.34	0.045	≤0.5
NOCO-IN23	–	–	0.36	⁵ 0.29	0.011	≤0.3
NOCO-IN24	–	–	0.08	⁵ E0.05	0.033	≤0.5
NOCO-IN25	0.16	–	–	⁴ 0.15	0.346	≤0.3
NOCO-IN26	–	–	0.16	0.16	0.043	≤0.3
NOCO-IN27	2.14	0.004	–	2.27	0.304	2.9
NOCO-IN28	0.48	–	–	⁴ 0.44	0.057	≤0.4
NOCO-CO01	0.03	–	–	E0.08	0.079	1.6
NOCO-CO02	–	–	8.00	8.40	0.074	–
NOCO-CO03	–	–	0.12	0.12	0.056	–
NOCO-CO04	4.31	–	–	4.39	1.60	1.6
NOCO-CO05	E0.02	–	3.84	⁴ 3.71	0.009	≤0.3

Table 9. Nutrients and dissolved organic carbon (DOC) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 57 grid wells were analyzed. Information about the analytes given in [table 3E](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** mg/L, milligrams per liter; DOC, dissolved organic carbon; HAL-US, USEPA lifetime health advisory level; MCL-US, USEPA maximum contaminant level; na, not available; LRL, laboratory reporting level; SRL, study reporting level; –, not detected; E, estimated or having a higher degree of uncertainty; ≤, less than or equal to; MCL-CA, CDPH maximum contaminant level; NWIS, National Water Information System; NWQL, National Water Quality Laboratory; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite, as nitrogen (mg/L) (00613)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic-nitrogen) as nitrogen (mg/L) (62854)	Phosphate, orthophosphate (as phosphorus) (mg/L) (00671)	DOC (mg/L) (00681)
Benchmark type	HAL-US	MCL-US	MCL-US	na	na	na
Benchmark level	¹ 24.7	1	10	na	na	na
[LRL/SRL]	[0.02]	[0.002]	[0.04]	[0.10]	[0.006]	[0.7] ²
NOCO grid wells (57 wells sampled) ³—Continued						
NOCO-CO06	—	—	E0.03	⁵ —	0.011	≤0.3
NOCO-CO07	—	—	0.62	0.66	0.049	—
NOCO-CO08	—	—	—	—	0.027	≤0.2
NOCO-CO09	0.77	—	—	0.83	0.579	1.1
NOCO-CO10	—	—	0.20	0.20	0.192	0.8
NOCO-CO11	—	—	2.86	2.91	0.013	≤0.3
NOCO-CO12	—	—	2.99	⁴ 2.97	0.071	—
NOCO-CO13	—	—	5.48	⁴ 5.44	0.013	—
NOCO-CO15	—	—	0.47	⁴ 0.43	0.012	—
NOCO-CO16	—	—	0.51	⁴ 0.47	0.017	≤0.4
NOCO-CO17	—	—	0.66	⁴ 0.63	E0.006	≤0.4
NOCO-CO18	0.22	—	—	0.24	E0.006	1.5
NOCO-CO19	E0.01	0.006	3.07	3.26	0.008	0.9
NOCO-CO20	—	E0.001	0.60	⁵ 0.60	0.037	≤0.4
NOCO-CO21	1.78	0.002	—	2.04	0.870	4.6
NOCO-CO22	—	0.021	4.70	⁴ 4.53	0.044	≤0.6
NOCO-CO23	—	—	0.15	0.15	0.013	≤0.3
NOCO-CO24	0.37	0.005	0.30	0.86	0.281	4.5
NOCO-CO25	—	—	—	—	0.092	—
NOCO-CO26	—	—	0.22	0.26	E0.007	1.6
NOCO-CO27	1.49	—	—	1.65	0.111	2.5
NOCO-CO28	4.15	—	—	4.58	2.25	4.5
NOCO-CO29	0.18	—	—	0.21	0.051	≤0.5
NOCO-CO30	—	—	0.58	⁴ 0.56	0.016	—

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

² SRL defined based on the highest concentration detected in the NOCO study unit blanks. Values less than the SRL are reported as less than or equal to the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is less than or equal to reported value, based on a detection in a blank.

³ Samples from NOCO-CO14 were not collected.

⁴ Total nitrogen concentrations in these samples are less than the sum of the filtered nitrogen analytes, but fall within the USGS NWQL acceptance criteria of a 10 percent or less relative percent difference.

⁵ Total nitrogen concentrations in these samples are less than the sum of the filtered nitrogen analytes and fall outside the USGS NWQL acceptance criterion of a 10 percent relative percent difference. The absolute difference is ≤ 0.07 mg/L.

Table 10. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, with the exception of iodide, which was sampled for at the 30 grid wells in NOCO-CO. Information about the analytes given in [table 3F](#). **GAMA well identification number:** NOCO-IN; Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmark; 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. **Abbreviations:** mg/L, milligrams per liter; SiO₂, silicon dioxide; na, not available; SMCL-CA, CDPH secondary maximum contaminant level; MCL-CA, CDPH maximum contaminant level; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; –, not detected; nc, not collected; *, value greater than benchmark level; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Silica (as SiO ₂) (mg/L) (00955)	Residue on evaporation (TDS) (mg/L) (70300)
Benchmark type	na	na	SMCL-CA 1 250 (500)	MCL-CA 2	na	na	na	na	SMCL-CA 1 250 (500)	na	SMCL-CA 1 500 (1,000)
Benchmark level	na	na	[0.12]	[0.08]	[0.002]	[0.016]	[0.064]	[0.10]	[0.18]	na	[10]
[LRL]	[0.02]	[0.044]								[0.058]	
NOCO grid wells (58 wells sampled)											
NOCO-IN01	0.03	14.3	3.95	0.42	nc	4.17	0.65	34.9	2.12	21.7	161
NOCO-IN02	0.04	25.8	9.71	0.17	nc	10.1	0.73	18.8	5.90	26.9	181
NOCO-IN03	E0.01	11.5	3.67	E0.08	nc	10.5	0.35	5.45	1.45	17.0	113
NOCO-IN04	E0.01	27.2	8.16	0.11	nc	12.7	0.89	11.3	7.65	17.2	176
NOCO-IN05	0.24	42.9	87.9	0.25	nc	22.0	0.69	35.9	1.72	30.1	343
NOCO-IN06	0.03	26.6	4.45	0.19	nc	22.3	0.53	21.3	1.26	25.0	215
NOCO-IN07	0.03	15.8	11.0	E0.09	nc	15.6	0.72	10.7	12.6	17.6	153
NOCO-IN08	0.08	36.1	10.8	0.10	nc	19.7	1.33	13.8	29.4	15.4	231
NOCO-IN09	0.04	25.5	9.21	0.22	nc	9.24	0.84	60.3	2.43	26.3	280
NOCO-IN10	E0.01	19.8	5.51	E0.08	nc	12.2	0.58	7.73	13.6	17.5	134
NOCO-IN11	0.06	28.1	5.33	E0.08	nc	21.7	0.56	12.0	11.5	22.5	203
NOCO-IN12	0.03	16.2	10.2	0.26	nc	16.1	0.81	24.2	4.01	28.6	184
NOCO-IN13	0.04	20.8	6.63	E0.09	nc	17.0	0.76	10.6	18.2	19.1	159
NOCO-IN14	0.05	31.4	13.7	0.34	nc	7.04	0.74	25.1	14.9	24.1	193
NOCO-IN15	E0.02	1.98	2.26	0.29	nc	1.45	0.23	65.5	2.89	18.8	194
NOCO-IN16	E0.02	12.4	7.68	E0.06	nc	5.46	0.52	13.2	3.71	14.1	99.0
NOCO-IN17	0.05	9.24	11.4	0.22	nc	17.6	0.32	13.9	4.62	37.2	171
NOCO-IN18	E0.02	50.1	6.86	–	nc	43.6	0.84	11.3	61.7	25.9	354
NOCO-IN19	0.10	18.5	17.8	E0.08	nc	13.2	0.38	14.6	24.2	29.3	167
NOCO-IN20	0.08	67.0	50.4	0.13	nc	132	2.92	26.9	1.98	97.6	*766

Table 10. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, with the exception of iodide, which was sampled for at the 30 grid wells in NOCO-CO. Information about the analytes given in [table 3F](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type, Benchmark level, and LRL:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmark; as 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. **Abbreviations:** mg/L, milligrams per liter; SiO₂, silicon dioxide; na, not available; SMCL-CA, CDPH secondary maximum contaminant level; MCL-CA, CDPH maximum contaminant level; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; –, not detected; nc, not collected; *, value greater than benchmark level; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health, USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Silica (as SiO ₂) (mg/L) (00955)	Residue on evaporation (TDS) (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	SMCL-CA	na	SMCL-CA
Benchmark level	na	na	1 250 (500)	2	na	na	na	na	1 250 (500)	na	1 500 (1,000)
[LRL]	[0.02]	[0.044]	[0.12]	[0.08]	[0.002]	[0.016]	[0.064]	[0.10]	[0.18]	[0.058]	[10]
NOCO grid wells (58 wells sampled)											
NOCO-IN21	0.03	56.4	23.6	–	nc	90.3	1.37	20.5	107	37.7	*598
NOCO-IN22	0.17	28.5	40.4	0.36	nc	61.9	1.70	78.1	12.8	73.7	*560
NOCO-IN23	–	34.5	3.42	E0.06	nc	9.37	0.84	6.68	14.2	14.1	155
NOCO-IN24	E0.01	17.9	5.01	–	nc	29.8	1.49	8.09	4.76	31.1	199
NOCO-IN25	0.02	13.4	6.70	E0.07	nc	27.4	1.25	38.9	2.42	68.0	275
NOCO-IN26	0.05	41.5	23.5	–	nc	13.4	0.83	22.2	4.24	16.3	245
NOCO-IN27	–	63.5	15.6	0.23	nc	70.8	4.66	56.4	E0.11	105	*684
NOCO-IN28	0.14	42.3	8.37	0.21	nc	35.8	0.86	53.0	3.88	21.1	393
NOCO-CO01	0.14	6.61	40.7	0.17	0.007	3.70	4.44	59.0	10.6	23.2	223
NOCO-CO02	0.16	7.33	34.9	–	–	3.66	1.28	31.6	8.24	27.5	180
NOCO-CO03	0.05	5.67	13.9	E0.09	0.004	8.82	1.00	11.1	3.99	23.3	104
NOCO-CO04	0.11	51.9	18.8	E0.06	0.013	39.3	6.23	27.8	4.81	37.7	393
NOCO-CO05	0.10	4.48	29.5	–	0.002	4.00	2.02	22.3	11.3	16.0	114
NOCO-CO06	0.26	20.1	92.7	0.34	0.009	10.7	1.57	47.1	20.3	27.0	268
NOCO-CO07	0.16	6.73	15.4	–	E0.001	7.12	0.79	14.3	2.31	28.2	110
NOCO-CO08	0.03	46.8	7.71	E0.07	0.006	8.18	1.02	7.70	7.11	16.1	195
NOCO-CO09	0.37	15.5	78.1	E0.09	0.084	14.5	4.12	113	–	46.5	423
NOCO-CO10	0.02	29.4	6.96	E0.08	–	13.7	0.92	7.79	8.30	27.3	172
NOCO-CO11	0.04	39.2	11.6	0.12	–	24.8	1.29	11.2	17.8	18.3	250
NOCO-CO12	0.16	11.2	33.2	0.11	0.003	16.8	1.05	23.3	9.05	25.9	179
NOCO-CO13	0.07	12.6	18.1	–	–	4.69	1.02	16.8	8.56	13.7	131
NOCO-CO14	0.08	8.34	15.5	–	–	16.4	0.62	12.6	3.98	28.0	133
NOCO-CO15	0.02	4.49	5.38	–	–	1.45	0.47	4.67	2.68	9.63	38.0

Table 10. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed, with the exception of iodide, which was sampled for at the 30 grid wells in NOCO-CO. Information about the analytes given in [table 3E](#), **GAMA well identification number**: NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type**, **Benchmark level**, and **LRL**: Data as of October 8, 2009. **Benchmark type**: Maximum contaminant level benchmark; as 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. **Abbreviations**: mg/L, milligrams per liter; SiO₂, silicon dioxide; na, not available; SMCL-CA, CDPH secondary maximum contaminant level; MCL-CA, CDPH maximum contaminant level; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; –, not detected; nc, not collected; *, value greater than benchmark level; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Silica (as SiO ₂) (mg/L) (00955)	Residue on evaporation (TDS) (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	SMCL-CA	na	SMCL-CA
Benchmark level	na	na	1 250 (500)	2	na	na	na	na	1 250 (500)	na	1 500 (1,000)
[LRL]	[0.02]	[0.044]	[0.12]	[0.08]	[0.002]	[0.016]	[0.064]	[0.10]	[0.18]	[0.058]	[10]
NOCO grid wells (58 wells sampled)—Continued											
NOCO-CO16	E0.01	3.25	4.31	–	–	19.3	0.34	3.21	1.81	26.9	119
NOCO-CO17	0.04	41.1	8.69	E0.08	–	12.0	1.48	11.0	14.8	13.0	190
NOCO-CO18	0.16	41.0	22.3	0.14	0.020	19.2	1.38	15.8	10.3	22.2	242
NOCO-CO19	0.08	55.2	22.2	E0.07	0.009	19.5	1.60	13.8	22.7	17.4	274
NOCO-CO20	0.08	25.2	22.4	0.26	–	27.1	2.33	16.6	17.7	20.9	234
NOCO-CO21	0.33	59.4	45.6	0.34	0.101	36.6	3.52	28.0	–	35.2	415
NOCO-CO22	0.05	6.59	16.3	–	0.003	34.5	1.54	5.33	6.43	33.0	193
NOCO-CO23	E0.01	4.86	5.20	E0.06	0.002	5.41	0.56	4.10	2.98	11.4	61.0
NOCO-CO24	0.05	8.57	18.2	–	0.005	16.2	1.78	7.50	1.49	30.4	158
NOCO-CO25	0.15	17.8	31.1	0.12	0.022	13.8	1.37	26.8	0.40	38.8	212
NOCO-CO26	0.12	5.38	40.8	E0.04	0.003	4.62	0.60	22.2	4.59	9.77	106
NOCO-CO27	0.48	23.7	63.8	0.19	0.139	31.1	4.19	66.6	–	39.5	394
NOCO-CO28	0.27	37.3	30.6	0.39	0.033	25.0	11.8	62.6	–	50.2	405
NOCO-CO29	0.20	62.0	14.4	0.10	0.005	10.7	1.28	8.82	8.68	17.3	246
NOCO-CO30	0.06	7.84	13.6	0.15	–	13.7	0.70	14.9	17.0	19.6	133

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

Table 11. Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in [table 3G](#). Samples from all 58 grid wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 57 grid wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. 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. Tritium values less than the sample-specific critical level (ssL_c) are reported as non-detections (–). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** H, hydrogen; O, oxygen; pCi/L, picocuries per liter; C, carbon; CSU, 1-sigma combined standard uncertainty; na, not available; MCL-CA, CDPH maximum contaminant level; –, not detected; nc, not collected; \pm , plus or minus; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}\text{C}$ (per mil) (82081)	Carbon-14 (percent modern) (49933)
Benchmark type	na	na	MCL-CA	na	na
Benchmark level	na	na	20,000	na	na
			Result \pm CSU	ssL_c	
NOCO grid wells (58 wells sampled) ¹					
NOCO-IN01	-51.15	-7.86	0.30 \pm 3.2	0.30	39.85
NOCO-IN02	-42.08	-6.36	4.5 \pm 0.41	0.35	81.92
NOCO-IN03	-48.97	-7.52	4.2 \pm 0.41	0.35	105.0
NOCO-IN04	-50.42	-7.59	5.8 \pm 0.41	0.32	98.00
NOCO-IN05	-53.95	-8.01	4.7 \pm 0.38	0.35	57.55
NOCO-IN06	-63.01	-9.20	–	0.35	32.19
NOCO-IN07	-50.97	-7.46	9.0 \pm 0.51	0.38	103.4
NOCO-IN08	-46.84	-7.05	6.9 \pm 0.45	0.35	86.51
NOCO-IN09	-52.17	-7.68	0.30 \pm 0.35	0.35	21.92
NOCO-IN10	-49.31	-7.19	6.9 \pm 0.38	0.32	100.8
NOCO-IN11	-54.81	-8.20	4.4 \pm 0.32	0.32	82.25
NOCO-IN12	-46.28	-6.55	3.4 \pm 0.32	0.32	85.25
NOCO-IN13	-48.04	-7.25	11.4 \pm 0.48	0.32	104.1
NOCO-IN14	-50.02	-7.40	2.6 \pm 0.32	0.32	55.91
NOCO-IN15	-67.87	-9.68	1.2 \pm 0.32	0.32	27.39
NOCO-IN16	-64.21	-9.46	5.7 \pm 0.35	0.32	77.94
NOCO-IN17	-55.46	-7.93	1.5 \pm 0.32	0.32	75.29
NOCO-IN18	-49.63	-7.16	4.2 \pm 0.32	0.32	76.82
NOCO-IN19	-47.12	-7.17	6.6 \pm 0.35	0.32	104.5
NOCO-IN20	-48.92	-6.45	4.5 \pm 0.32	0.32	27.95
NOCO-IN21	-49.62	-7.10	5.8 \pm 0.35	0.32	104.0
NOCO-IN22	-45.14	-6.62	3.2 \pm 0.32	0.32	23.98
NOCO-IN23	-60.75	-9.11	6.5 \pm 0.35	0.32	90.74
NOCO-IN24	-50.14	-7.34	6.3 \pm 0.35	0.32	86.43
NOCO-IN25	-49.46	-7.46	5.7 \pm 0.38	0.32	57.90
NOCO-IN26	-70.85	-10.3	8.1 \pm 0.38	0.32	97.49
NOCO-IN27	-60.09	-8.56	3.4 \pm 0.32	0.32	5.000
NOCO-IN28	-63.53	-9.16	0.67 \pm 0.32	0.32	10.52
NOCO-CO01	-37.68	-5.97	3.2 \pm 0.32	0.32	56.74
NOCO-CO02	-34.32	-5.56	4.8 \pm 0.32	0.32	106.1
NOCO-CO03	-47.13	-7.10	0.35 \pm 0.32	0.32	74.12
NOCO-CO04	-47.57	-7.45	–	0.32	14.26
NOCO-CO05	-37.17	-6.03	6.2 \pm 0.32	0.32	107.4

Table 11. Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in [table 3G](#). Samples from all 58 grid wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 57 grid wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. 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. Tritium values less than the sample-specific critical level (ssL_c) are reported as non-detections (–). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** H, hydrogen; O, oxygen; pCi/L, picocuries per liter; C, carbon; CSU, 1-sigma combined standard uncertainty; na, not available; MCL-CA, CDPH maximum contaminant level; –, not detected; nc, not collected; \pm , plus or minus; MCL-US, USEPA maximum contaminant level; USGS, U.S. Geological Survey; CDPH, California Department of Public Health; USEPA, U.S. Environmental Protection Agency]

GAMA well identification number	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)		$\delta^{13}\text{C}$ (per mil) (82081)	Carbon-14 (percent modern) (49933)
Benchmark type	na	na	MCL-CA		na	na
Benchmark level	na	na	20,000		na	na
			Result \pm CSU	ssL_c		
NOCO grid wells (58 wells sampled) ¹—Continued						
NOCO-CO06	-34.47	-5.80	7.2 \pm 0.35	0.32	-22.48	92.00
NOCO-CO07	-45.30	-7.02	12.5 \pm 0.57	0.38	-22.98	103.0
NOCO-CO08	-53.20	-7.91	2.2 \pm 0.41	0.38	-15.62	69.12
NOCO-CO09	-49.50	-7.44	—	0.35	-10.42	8.980
NOCO-CO10	-49.30	-7.53	3.7 \pm 0.41	0.38	-17.21	73.48
NOCO-CO11	-49.60	-7.36	5.4 \pm 0.41	0.35	-20.57	94.01
NOCO-CO12	-45.60	-7.03	1.2 \pm 0.48	0.45	-22.01	78.60
NOCO-CO13	-46.10	-7.04	5.5 \pm 0.45	0.38	-19.76	89.48
NOCO-CO14	-45.60	-7.08	4.7 \pm 0.38	0.38	nc	nc
NOCO-CO15	-43.30	-7.07	6.0 \pm 0.41	0.32	-16.30	99.13
NOCO-CO16	-47.20	-7.39	7.4 \pm 0.45	0.32	-21.63	102.8
NOCO-CO17	-49.50	-7.48	7.6 \pm 0.48	0.38	-19.29	92.23
NOCO-CO18	-46.10	-6.99	5.7 \pm 0.41	0.32	-21.46	85.85
NOCO-CO19	-45.40	-6.80	5.2 \pm 0.41	0.32	-20.13	103.3
NOCO-CO20	-45.50	-7.02	5.3 \pm 0.35	0.32	-19.95	65.91
NOCO-CO21	-48.50	-7.29	2.4 \pm 0.32	0.32	-13.08	56.89
NOCO-CO22	-43.50	-6.77	4.7 \pm 0.32	0.32	-21.16	106.2
NOCO-CO23	-45.60	-7.18	6.0 \pm 0.32	0.32	-17.37	100.0
NOCO-CO24	-41.70	-6.68	4.0 \pm 0.32	0.32	-22.29	102.9
NOCO-CO25	-53.60	-7.82	—	0.32	-20.30	9.820
NOCO-CO26	-40.60	-6.44	6.2 \pm 0.38	0.32	-23.00	106.4
NOCO-CO27	-49.60	-7.55	—	0.32	-16.12	5.200
NOCO-CO28	-48.20	-7.27	—	0.32	-1.43	50.74
NOCO-CO29	-48.00	-7.16	9.2 \pm 0.41	0.32	-18.87	76.53
NOCO-CO30	-49.80	-7.47	10.3 \pm 0.54	0.38	-21.81	59.22

¹ Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance sample from NOCO-CO14 were not collected.

Table 12A. Radon-222 detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parathesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 57 grid wells were analyzed. Information about the analyte given in [table 3G](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Other Abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; ssL_C, sample-specific critical level; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Radon-222 (pCi/L) (82303)	
	Result ± CSU	ssL _c
Benchmark type	Proposed MCL-US	
Benchmark level	4,000	
NOCO grid wells (57 wells sampled) ¹		
NOCO-IN01	1,150 ± 65	11
NOCO-IN02	1,270 ± 71	12
NOCO-IN03	550 ± 33	12
NOCO-IN04	670 ± 40	11
NOCO-IN05	320 ± 22	12
NOCO-IN06	238 ± 17	12
NOCO-IN07	272 ± 19	11
NOCO-IN08	300 ± 20	12
NOCO-IN09	870 ± 50	12
NOCO-IN10	360 ± 23	11
NOCO-IN11	560 ± 34	12
NOCO-IN12	390 ± 26	13
NOCO-IN13	350 ± 23	11
NOCO-IN14	460 ± 29	12
NOCO-IN15	690 ± 41	11
NOCO-IN16	460 ± 29	11
NOCO-IN17	650 ± 38	11
NOCO-IN18	790 ± 46	11
NOCO-IN19	500 ± 31	11
NOCO-IN20	340 ± 23	13
NOCO-IN21	350 ± 23	11
NOCO-IN22	54 ± 9	11
NOCO-IN23	195 ± 15	12
NOCO-IN24	370 ± 24	12
NOCO-IN25	360 ± 24	12
NOCO-IN26	180 ± 14	11
NOCO-IN27	277 ± 19	12
NOCO-IN28	460 ± 29	13

GAMA well identification number	Radon-222 (pCi/L) (82303)	
	Result ± CSU	ssL _c
Benchmark type	Proposed MCL-US	
Benchmark level	4,000	
NOCO grid wells (57 wells sampled) ¹ —Continued		
NOCO-CO01	242 ± 17	11
NOCO-CO02	1,690 ± 94	11
NOCO-CO03	139 ± 13	12
NOCO-CO04	57 ± 9	11
NOCO-CO05	256 ± 19	14
NOCO-CO06	530 ± 32	12
NOCO-CO07	1,250 ± 70	11
NOCO-CO08	930 ± 53	11
NOCO-CO09	69 ± 10	12
NOCO-CO10	290 ± 20	12
NOCO-CO11	265 ± 19	12
NOCO-CO12	330 ± 22	11
NOCO-CO13	530 ± 33	12
NOCO-CO15	520 ± 31	11
NOCO-CO16	117 ± 12	12
NOCO-CO17	440 ± 27	10
NOCO-CO18	77 ± 10	12
NOCO-CO19	176 ± 14	11
NOCO-CO20	256 ± 18	12
NOCO-CO21	78 ± 10	11
NOCO-CO22	98 ± 11	12
NOCO-CO23	228 ± 17	11
NOCO-CO24	46 ± 8	11
NOCO-CO25	490 ± 30	11
NOCO-CO26	155 ± 14	12
NOCO-CO27	280 ± 20	11
NOCO-CO28	75 ± 10	11
NOCO-CO29	560 ± 34	11
NOCO-CO30	300 ± 20	11

¹ Sample from NOCO-CO14 was not collected.

Table 12B. Radium isotopes detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 54 grid wells were analyzed. Information about the analyte given in [table 3G](#). Measured values less than the sample specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; MCL-US, USEPA maximum contaminant level; —, not detected at an activity above the sample-specific critical level; MCL-CA, CDPH maximum contaminant level; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
	Result ± CSU	ssL _c	Result ± CSU	ssL _c
Benchmark type	MCL-US		MCL-US	
Benchmark level	1 5		1 5	
NOCO grid wells (54 wells sampled) ²				
NOCO-IN05	0.062 ± 0.013	0.016	—	0.22
NOCO-IN06	0.023 ± 0.011	0.018	—	0.24
NOCO-IN07	0.0261 ± 0.068	0.012	0.26 ± 0.16	0.23
NOCO-IN08	0.0607 ± 0.0098	0.012	—	0.20
NOCO-IN09	0.0607 ± 0.0094	0.012	—	0.21
NOCO-IN10	0.0146 ± 0.0076	0.014	—	0.19
NOCO-IN11	0.0375 ± 0.0086	0.012	—	0.24
NOCO-IN12	0.04 ± 0.01	0.017	—	0.19
NOCO-IN13	0.0395 ± 0.0086	0.014	—	0.23
NOCO-IN14	0.0247 ± 0.0078	0.012	—	0.22
NOCO-IN15	0.0154 ± 0.0061	0.013	—	0.24
NOCO-IN16	0.0239 ± 0.0058	0.0095	—	0.25
NOCO-IN17	—	0.015	—	0.17
NOCO-IN18	0.04 ± 0.01	0.015	—	0.20
NOCO-IN19	0.032 ± 0.012	0.016	—	0.21
NOCO-IN20	0.523 ± 0.052	0.018	0.7 ± 0.1	0.22
NOCO-IN21	0.139 ± 0.017	0.015	—	0.19
NOCO-IN22	0.075 ± 0.012	0.015	—	0.19
NOCO-IN23	—	0.019	—	0.22
NOCO-IN24	0.034 ± 0.009	0.015	—	0.27
NOCO-IN25	0.065 ± 0.011	0.017	—	0.16
NOCO-IN26	0.0196 ± 0.0077	0.015	—	0.16
NOCO-IN27	0.087 ± 0.011	0.011	—	0.22
NOCO-IN28	0.0341 ± 0.0075	0.012	—	0.19
NOCO-CO01	0.0411 ± 0.0091	0.015	—	0.20
NOCO-CO02	0.04 ± 0.01	0.015	—	0.22
NOCO-CO03	0.032 ± 0.0094	0.014	—	0.23
NOCO-CO04	0.20 ± 0.023	0.013	—	0.22
NOCO-CO05	0.061 ± 0.011	0.016	0.217 ± 0.071	0.17
NOCO-CO06	0.0440 ± 0.0097	0.016	0.172 ± 0.066	0.16
NOCO-CO07	—	0.015	—	0.21
NOCO-CO08	—	0.015	—	0.28
NOCO-CO09	0.0202 ± 0.0077	0.014	—	0.37
NOCO-CO10	0.0131 ± 0.0066	0.012	—	0.22

Table 12B. Radium isotopes detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009. — Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 54 grid wells were analyzed. Information about the analyte given in [table 3G](#). Measured values less than the sample specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; MCL-US, USEPA maximum contaminant level; —, not detected at an activity above the sample-specific critical level; MCL-CA, CDPH maximum contaminant level; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
	Result ± CSU	ssL _c	Result ± CSU	ssL _c
Benchmark type	MCL-US		MCL-US	
Benchmark level	15		15	
NOCO grid wells (54 wells sampled) ² —Continued				
NOCO-CO11	0.055 ± 0.014	0.016	—	0.21
NOCO-CO12	—	0.016	—	0.22
NOCO-CO13	0.053 ± 0.0095	0.012	—	0.23
NOCO-CO14	0.0169 ± 0.0066	0.013	—	0.25
NOCO-CO15	—	0.015	—	0.18
NOCO-CO16	—	0.015	—	0.16
NOCO-CO17	0.045 ± 0.013	0.014	—	0.18
NOCO-CO18	0.074 ± 0.012	0.016	—	0.18
NOCO-CO19	0.0326 ± 0.0094	0.017	—	0.18
NOCO-CO20	0.026 ± 0.011	0.014	—	0.20
NOCO-CO21	0.073 ± 0.014	0.014	0.284 ± 0.076	0.18
NOCO-CO22	0.0243 ± 0.0082	0.014	—	0.18
NOCO-CO23	0.0348 ± 0.0085	0.013	—	0.16
NOCO-CO24	—	0.017	—	0.22
NOCO-CO25	0.037 ± 0.012	0.016	—	0.18
NOCO-CO26	0.0363 ± 0.0095	0.016	—	0.18
NOCO-CO27	0.209 ± 0.022	0.012	—	0.20
NOCO-CO28	0.116 ± 0.015	0.015	—	0.19
NOCO-CO29	0.0161 ± 0.0096	0.015	—	0.18
NOCO-CO30	—	0.017	—	0.17

¹ The MCL-US benchmark for radium is the sum of radium-226 and radium-228.

² Samples from NOCO-IN01 through NOCO-IN04 were not collected.

Table 12C. Gross alpha and gross beta radioactivity detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed. Information about the analytes given in [table 3G](#). The reference nuclide for measurement of gross alpha is thorium-230, and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; –, not detected; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Gross alpha radioactivity, 72-hour count (pCi/L) (62636)		Gross alpha radioactivity, 30-day count (pCi/L) (62639)		Gross beta radioactivity, 72-hour count (pCi/L) (62642)		Gross beta radioactivity, 30-day count (pCi/L) (62645)	
	Result ± CSU	ssL _c	Result ± CSU	ssL _c	Result ± CSU	ssL _c	Result ± CSU	ssL _c
Benchmark type	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
NOCO grid wells (58 wells sampled)								
NOCO-IN01	–	0.59	–	0.44	–	0.45	–	0.49
NOCO-IN02	–	0.62	–	1.0	–	0.46	0.65 ± 0.31	0.48
NOCO-IN03	–	0.57	–	0.29	–	0.59	–	0.46
NOCO-IN04	–	0.81	–	0.53	0.7 ± 0.4	0.63	0.89 ± 0.43	0.71
NOCO-IN05	–	0.87	–	0.66	–	0.79	–	0.77
NOCO-IN06	–	0.59	–	0.44	0.9 ± 0.3	0.46	–	0.45
NOCO-IN07	–	0.44	–	0.48	0.72 ± 0.29	0.44	–	0.77
NOCO-IN08	7.0 ± 1.1	0.57	2.50 ± 0.61	0.57	1.35 ± 0.33	0.49	2.91 ± 0.43	0.59
NOCO-IN09	1.82 ± 0.53	0.60	0.97 ± 0.42	0.48	0.65 ± 0.31	0.50	0.88 ± 0.48	0.75
NOCO-IN10	–	0.43	0.77 ± 0.32	0.39	2.13 ± 0.33	0.44	2.06 ± 0.44	0.69
NOCO-IN11	–	0.42	0.52 ± 0.24	0.25	0.62 ± 0.29	0.44	0.54 ± 0.29	0.44
NOCO-IN12	–	0.38	–	0.41	1.1 ± 0.37	0.56	1.2 ± 0.37	0.56
NOCO-IN13	–	0.94	–	0.40	0.7 ± 0.3	0.46	–	0.45
NOCO-IN14	–	0.50	–	1.1	–	0.73	0.6 ± 0.3	0.47
NOCO-IN15	–	1.4	–	0.48	–	0.55	–	0.49
NOCO-IN16	–	0.33	–	0.26	–	0.69	–	0.53
NOCO-IN17	–	0.41	0.45 ± 0.24	0.29	–	0.44	–	0.42
NOCO-IN18	0.82 ± 0.43	0.52	–	0.80	–	0.71	–	0.60
NOCO-IN19	–	0.41	–	0.49	–	0.56	0.66 ± 0.29	0.46
NOCO-IN20	7.3 ± 1.7	1.5	–	1.4	4.48 ± 0.54	0.65	2.59 ± 0.48	0.67
NOCO-IN21	1.46 ± 0.81	1.0	–	1.1	0.87 ± 0.34	0.52	0.91 ± 0.34	0.52
NOCO-IN22	1.56 ± 0.82	1.0	–	1.1	0.99 ± 0.32	0.49	1.71 ± 0.36	0.52
NOCO-IN23	–	0.38	–	0.57	0.71 ± 0.29	0.44	–	0.62
NOCO-IN24	–	0.49	–	0.49	1.56 ± 0.33	0.48	1.2 ± 0.4	0.6
NOCO-IN25	–	0.55	–	0.61	0.88 ± 0.46	0.72	0.56 ± 0.34	0.53
NOCO-IN26	0.90 ± 0.39	0.39	0.72 ± 0.44	0.56	–	0.70	–	0.86
NOCO-IN27	–	1.2	–	1.1	4.58 ± 0.49	0.58	3.97 ± 0.44	0.51
NOCO-IN28	0.94 ± 0.56	0.65	1.23 ± 0.51	0.65	–	0.82	0.9 ± 0.5	0.80
NOCO-CO01	0.91 ± 0.49	0.51	0.69 ± 0.49	0.57	3.92 ± 0.53	0.63	2.97 ± 0.48	0.62
NOCO-CO02	0.43 ± 0.25	0.32	–	0.55	1.36 ± 0.46	0.7	1.56 ± 0.39	0.57
NOCO-CO03	–	0.29	–	0.38	1.04 ± 0.28	0.41	1.14 ± 0.39	0.58
NOCO-CO04	2.12 ± 0.78	0.86	–	0.71	5.16 ± 0.71	0.96	4.78 ± 0.66	0.88
NOCO-CO05	1.76 ± 0.38	0.26	0.65 ± 0.38	0.47	1.81 ± 0.31	0.41	1.65 ± 0.39	0.55

Table 12C. Gross alpha and gross beta radioactivity detected in samples collected for the Northern Coast Ranges Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 58 grid wells were analyzed. Information about the analytes given in [table 3C](#). The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; MCL-US, USEPA maximum contaminant level; MCL-CA, CDPH maximum contaminant level; —, not detected; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Gross alpha radioactivity, 72-hour count (pCi/L) (62636)		Gross alpha radioactivity, 30-day count (pCi/L) (62639)		Gross beta radioactivity, 72-hour count (pCi/L) (62642)		Gross beta radioactivity, 30-day count (pCi/L) (62645)	
	Result ± CSU	ssL _c	Result ± CSU	ssL _c	Result ± CSU	ssL _c	Result ± CSU	ssL _c
Benchmark type	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
NOCO grid wells (58 wells sampled)—Continued								
NOCO-CO06	0.61 ± 0.37	0.47	—	0.63	1.51 ± 0.32	0.45	0.59 ± 0.33	0.52
NOCO-CO07	—	0.42	—	0.34	—	0.41	—	0.43
NOCO-CO08	—	1.2	—	0.48	—	0.55	1.25 ± 0.33	0.49
NOCO-CO09	—	1.2	—	0.81	4.17 ± 0.64	0.87	2.88 ± 0.82	1.3
NOCO-CO10	—	0.47	—	0.50	0.54 ± 0.32	0.50	0.69 ± 0.41	0.65
NOCO-CO11	1.18 ± 0.44	0.47	—	0.47	1.22 ± 0.37	0.56	0.71 ± 0.35	0.55
NOCO-CO12	—	0.57	—	0.38	—	1.0	0.68 ± 0.35	0.55
NOCO-CO13	—	0.34	1.03 ± 0.56	0.82	0.95 ± 0.28	0.42	0.65 ± 0.29	0.45
NOCO-CO14	— ¹	0.47	—	0.31	— ¹	0.63	—	0.46
NOCO-CO15	—	0.52	—	0.28	—	0.43	—	0.38
NOCO-CO16	1.35 ± 0.36	0.21	—	0.26	—	0.70	—	0.41
NOCO-CO17	1.32 ± 0.46	0.52	—	0.52	1.56 ± 0.32	0.46	0.95 ± 0.28	0.43
NOCO-CO18	2.05 ± 0.59	0.51	—	0.68	2.19 ± 0.45	0.64	1.07 ± 0.45	0.70
NOCO-CO19	1.3 ± 0.5	0.51	0.87 ± 0.45	0.58	1.19 ± 0.35	0.51	1.54 ± 0.34	0.49
NOCO-CO20	0.63 ± 0.46	0.59	—	0.53	1.64 ± 0.43	0.64	2.15 ± 0.49	0.72
NOCO-CO21	—	0.94	—	1.0	3.46 ± 0.47	0.64	2.85 ± 0.37	0.47
NOCO-CO22	—	0.30	—	0.32	1.73 ± 0.31	0.42	1.33 ± 0.29	0.42
NOCO-CO23	—	0.32	—	0.33	0.94 ± 0.35	0.55	—	0.56
NOCO-CO24	0.54 ± 0.24	0.31	0.34 ± 0.22	0.29	1.28 ± 0.35	0.53	1.5 ± 0.36	0.53
NOCO-CO25	1.35 ± 0.41	0.38	0.05 ± 0.33	0.44	1.6 ± 0.3	0.42	0.86 ± 0.29	0.44
NOCO-CO26	0.8 ± 0.33	0.39	—	0.46	1.59 ± 0.45	0.68	1.2 ± 0.4	0.59
NOCO-CO27	1.23 ± 0.66	0.82	—	0.83	3.54 ± 0.63	0.87	2.39 ± 0.61	0.87
NOCO-CO28	1.36 ± 0.71	0.87	—	0.87	9.75 ± 0.92	0.99	9.41 ± 0.91	0.97
NOCO-CO29	2.2 ± 0.5	0.38	—	0.49	0.88 ± 0.37	0.57	1.0 ± 0.3	0.44
NOCO-CO30	—	0.36	—	0.31	—	0.77	—	0.44

¹ Counted 4 days after collection.

Table 12D. Lead-210 and polonium-210 detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 54 grid wells were analyzed. Information about the analytes given in [table 3G](#). Measured values less than the sample-specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; na, not available; –, not detected; USGS, U.S. Geological Survey]

GAMA well identification number	Lead-210 (pCi/L) (17503)		Polonium-210 (pCi/L) (19503)	
	Result \pm CSU	ssL_c	Result \pm CSU	ssL_c
Benchmark type		na		na
Benchmark level		na		na
NOCO grid wells (54 wells sampled) ¹				
NOCO-IN05	–	0.21	–	0.020
NOCO-IN06	–	0.19	–	0.037
NOCO-IN07	–	0.20	–	0.045
NOCO-IN08	–	0.18	–	0.048
NOCO-IN09	–	0.16	0.038 \pm 0.017	0.024
NOCO-IN10	–	0.16	–	0.026
NOCO-IN11	–	0.22	0.023 \pm 0.014	0.019
NOCO-IN12	–	0.17	0.020 \pm 0.014	0.024
NOCO-IN13	–	0.18	–	0.030
NOCO-IN14	–	0.18	0.024 \pm 0.015	0.019
NOCO-IN15	0.2 \pm 0.3	0.23	0.049 \pm 0.018	0.018
NOCO-IN16	–	0.20	–	0.023
NOCO-IN17	–	0.21	–	0.020
NOCO-IN18	–	0.20	–	0.024
NOCO-IN19	–	0.20	–	0.019
NOCO-IN20	–	0.24	–	0.020
NOCO-IN21	–	0.20	–	0.021
NOCO-IN22	–	0.18	–	0.027
NOCO-IN23	–	0.24	–	0.017
NOCO-IN24	–	0.20	–	0.023
NOCO-IN25	0.2 \pm 0.4	0.20	0.023 \pm 0.014	0.015
NOCO-IN26	–	0.19	–	0.022
NOCO-IN27	–	0.21	–	0.024
NOCO-IN28	–	0.20	–	0.029
NOCO-CO01	–	0.21	0.050 \pm 0.029	0.032
NOCO-CO02	–	0.25	–	0.032
NOCO-CO03	–	0.18	–	0.022
NOCO-CO04	–	0.18	–	0.018
NOCO-CO05	–	0.18	–	0.021
NOCO-CO06	–	0.23	0.030 \pm 0.015	0.016
NOCO-CO07	0.3 \pm 0.23	0.18	–	0.014
NOCO-CO08	–	0.19	–	0.017
NOCO-CO09	–	0.17	0.040 \pm 0.022	0.025
NOCO-CO10	–	0.19	–	0.018

Table 12D. Lead-210 and polonium-210 detected in samples collected for the Northern Coast Ranges Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[The five-digit USGS parameter code in parenthesis below the constituent name is used to uniquely identify a specific constituent or property. Samples from 54 grid wells were analyzed. Information about the analytes given in [table 3G](#). Measured values less than the sample-specific critical level (ssL_c) are reported as non-detections. **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Abbreviations:** pCi/L, picocuries per liter; CSU, combined standard uncertainty; na, not available; –, not detected; USGS, U.S. Geological Survey]

GAMA well identification number	Lead-210 (pCi/L) (17503)		Polonium-210 (pCi/L) (19503)	
	Result \pm CSU	ssL_c	Result \pm CSU	ssL_c
Benchmark type		na		na
Benchmark level		na		na
NOCO grid wells (54 wells sampled) ¹—Continued				
NOCO-CO11	—	0.20	0.025 \pm 0.017	0.021
NOCO-CO12	—	0.18	—	0.035
NOCO-CO13	—	0.19	—	0.029
NOCO-CO14	—	0.21	—	0.026
NOCO-CO15	—	0.20	—	0.025
NOCO-CO16	—	0.19	0.52 \pm 0.059	0.028
NOCO-CO17	—	0.39	—	0.020
NOCO-CO18	0.6 \pm 0.7	0.26	—	0.023
NOCO-CO19	—	0.20	—	0.016
NOCO-CO20	—	0.27	—	0.023
NOCO-CO21	—	0.26	0.033 \pm 0.017	0.017
NOCO-CO22	—	0.29	0.037 \pm 0.017	0.023
NOCO-CO23	—	0.26	—	0.020
NOCO-CO24	—	0.24	—	0.043
NOCO-CO25	—	0.21	0.031 \pm 0.016	0.019
NOCO-CO26	—	0.20	0.038 \pm 0.015	0.018
NOCO-CO27	0.7 \pm 1.1	0.28	0.040 \pm 0.025	0.031
NOCO-CO28	—	0.27	—	0.020
NOCO-CO29	—	0.24	0.045 \pm 0.019	0.022
NOCO-CO30	—	0.46	—	0.020

¹ Samples from NOCO-IN01 through NOCO-IN04 were not collected.

Table 13. Microbial indicators detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[The five-digit USGS parameter code in parentheses below the constituent name is used to uniquely identify a specific constituent or property. Samples from 57 grid wells were analyzed, but only samples with detections are listed. Information about the analytes is given in [table 31](#). **GAMA well identification number:** NOCO-IN, Interior Basins study area grid well; NOCO-CO, Coastal Basins study area grid well. Numbered suffix indicates the order of sample collection within each study area. **Benchmark type** and **Benchmark level:** Data as of October 8, 2009. **Benchmark type:** Maximum contaminant level benchmarks 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. **Abbreviations:** mL, milliliter; TT-US, USEPA treatment technique (a required process intended to reduce the level of contamination in drinking water); MCL-US, USEPA maximum contaminant level; –, not detected; M, presence verified but not quantified; E, estimated or having a higher degree of uncertainty; >, greater than; MCL-CA, CDPH maximum contaminant level; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; CDPH, California Department of Public Health]

GAMA well identification number	Coliphage F-specific (99335)	Coliphage somatic (99332)	<i>Escherichia coli</i> (<i>E. coli</i>) colonies/ 100 mL (90901)	Total coliform colonies/ 100 mL (90900)
Benchmark type	TT-US	TT-US	TT-US	MCL-US
Benchmark level	99.9 percent Killed/inactive	99.9 percent Killed/inactive	No fecal coliforms are allowed	5 percent of samples per month
NOCO Grid wells (57 wells sampled) ¹				
NOCO-IN03	–	–	E1	31
NOCO-IN04	–	–	–	E3
NOCO-IN05	–	–	–	31
NOCO-IN07	–	–	–	E1
NOCO-IN08	–	M	–	–
NOCO-IN12	–	–	–	E9
NOCO-IN14	–	–	–	47
NOCO-IN17	–	–	–	E6
NOCO-IN22	–	–	–	>80
NOCO-IN26	–	M	–	E2
NOCO-IN28	–	–	–	E1
NOCO-CO05	–	–	E1	–
NOCO-CO12	–	–	–	32
NOCO-CO17	–	–	–	E1
NOCO-CO19	–	–	–	E14
NOCO-CO20	–	–	E5	E120
NOCO-CO22	–	–	–	E2
NOCO-CO23	M	–	–	E5
NOCO-CO24	–	–	–	E120
NOCO-CO25	M	–	–	–
NOCO-CO27	–	–	–	E12
NOCO-CO29	–	M	36	E150

¹ Samples from NOCO-CO14 were not collected.

Appendix

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

In the NOCO study unit, groundwater samples were collected and QA/QC procedures were implemented by using standard and modified USGS protocols from the NAWQA Program (Koterba and others, 1995), the NFM (U.S. Geological Survey, variously dated), and protocols described by Shelton and others (2001), Bushon (2003), Myers (2004), and Wright and others (2005). The QA plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described in Maloney (2005) and Pirkey and Glodt (1998).

Sample Collection and Analysis

Prior to sampling, each well was pumped continuously to purge at least three casing-volumes of water from the well (Wilde and others, 1999). Groundwater samples were collected through Teflon® tubing attached to a sampling point on the well (or spring) discharge pipe with brass and stainless-steel fittings. The sampling point was located as close as possible to the well-head or point where the spring issued from the ground, upstream from water-storage tanks, and from well-head treatment system (if a system existed). For the *slow* schedule, samples were either collected at the well head using a foot-long length of Teflon® tubing or collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10–50 ft length of the Teflon® tubing (Lane and others, 2003). All fittings and lengths of tubing were cleaned between samples (Wilde, 2004).

For the field measurements, groundwater was run through a flow-through chamber fitted with a multi-probe meter that simultaneously measures the field water-quality indicators—dissolved oxygen, temperature, pH, and specific conductance. Field measurements were made in accordance with protocols in the NFM (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Turbidity was measured in the field with a calibrated turbidity meter. Measured temperature, dissolved oxygen, pH, specific conductance, and turbidity values were recorded at 5-min intervals for at least 30 min, and when these values remained stable for 20 min, samples for laboratory analyses then were collected.

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

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

Temperature-sensitive samples were stored on ice prior to and during daily shipping to the various laboratories. The non-temperature sensitive samples for tritium, dissolved noble gases, and stable isotopes of hydrogen and oxygen in water were shipped monthly. Temperature- or time-sensitive samples for VOCs, pesticides and pesticide degradates, perchlorate, trace elements, nutrients, DOC, major and minor ions, silica, TDS, radon-222, radium isotopes, gross alpha and gross beta radioactivity, lead-210, polonium-210, and F-specific and somatic coliphage were shipped daily. The temperature-sensitive samples for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance, were stored on ice, archived in a laboratory refrigerator, and shipped after all of the alkalinity measurements were collected.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (1995), the NFM (Wilde and others, 1999, 2004), and in the references for analytical methods listed in [table A1](#); only brief descriptions are given here. VOC samples were collected in three 40-mL sample vials that were purged with three vial volumes of groundwater before bottom filling to eliminate atmospheric contamination. One to one (1:1) hydrochloric acid to water (HCl/H₂O) solution was added as a preservative to the VOC samples. Each sample to be analyzed for perchlorate was collected in a 125-mL polystyrene bottle and then filtered in two or three 20-mL aliquots of groundwater through a 0.20-μm pore-size Corning® syringe-tip disk filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling a 1-L polyethylene bottle after first overfilling the bottle with three volumes of unfiltered groundwater. Samples for analysis of stable isotopes of hydrogen and oxygen in water were collected in a 60-mL clear glass bottle filled with unfiltered groundwater, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Pesticides and pesticide degradates samples were collected in a 1-L baked amber glass bottle after first filtering groundwater through a baked 0.7-μm nominal pore-size glass fiber filter.

Groundwater samples for trace elements, major and minor ions, silica, TDS, and field alkalinity analyses required filling one 250-mL polyethylene bottle with unfiltered groundwater, and one 500-mL and one 250-mL polyethylene bottle with filtered groundwater (Wilde and others, 2004). Filtration was done using a 0.45- μm pore-size Whatman® vented capsule filter that was pre-rinsed with 2-L of deionized water, then rinsed with 1-L of groundwater prior to sampling. Each 250-mL filtered sample then was preserved with 7.5-N nitric acid. Mercury samples were collected by filtering groundwater into a 250-mL glass bottle and preserving with 6-N hydrochloric acid. Iodide samples were collected by filling a 250-mL polyethylene bottle with filtered groundwater. Radium isotope, gross alpha and gross beta radioactivity, Lead-210, and Polonium-210 samples were each filtered into individual 1-L polyethylene bottles and then preserved with 7.5-N nitric acid. Nutrient samples were collected by filtering groundwater into a 125-mL brown polyethylene bottle. Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance samples were filtered and bottom filled into 500-mL glass bottles that first were overfilled with three bottle volumes of groundwater. These samples had no headspace and were sealed with conical caps to avoid atmospheric contamination. Samples for field alkalinity titrations were collected by filtering groundwater into a 500-mL polyethylene bottle.

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

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

Dissolved noble gases were collected in $\frac{3}{8}$ -inch-diameter copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead. Groundwater was flushed through the tubing to dislodge bubbles before the flow was restricted with a back pressure valve. Clamps on either side of the copper tube then were tightened, trapping a sample of groundwater for analyses of dissolved noble gases (Weiss, 1968).

Samples for analysis of the microbial indicators also were collected at the well head following protocols described in Bushon (2003) and Myers (2004). Prior to the collection of samples, the sampling port was sterilized using isopropyl alcohol, and then groundwater was run through the sampling port for at least three minutes to remove any traces of the sterilizing agent. Two sterilized 250-mL Teflon® bottles were then filled with groundwater for coliform analyses (*E. coli* and total coliform determinations) and one sterilized 3-L polypropylene carboy was filled for coliphage analyses (F-specific and somatic coliphage determinations).

Field alkalinity, *E. coli*, and total coliforms were measured in the mobile laboratory at the well site. Alkalinity was measured on filtered samples by the incremental titration method (Barnes, 1964; Yurewicz, 1981) or by Gran's titration method (Gran, 1952). Titration data were entered directly into PCFF and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) automatically were calculated from the titration data using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with $\text{pK}_1 = 6.35$, $\text{pK}_2 = 10.33$, and $\text{pK}_w = 14$. Concentrations of HCO_3^- and CO_3^{2-} also were calculated from the laboratory alkalinity and laboratory pH measurements.

E. coli and total coliform plates were prepared using sterilized equipment and reagents (Myers, 2004). Plates were counted under an ultraviolet light, following a 22-24 hour incubation time at 35 degrees Celsius ($^{\circ}\text{C}$), and the results were entered directly into PCFF.

Eight laboratories performed chemical and microbial analyses for this study (table A1), although most of the analyses were performed at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous QA program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory QC samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples are analyzed regularly. Method detection limits are evaluated continuously and laboratory reporting levels updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (<http://www.nelac-institute.org/accred-labs.php>). In addition, the BQS maintains independent oversight of QA at the NWQL and laboratories contracted by the NWQL. The BQS also runs the National Field Quality Assurance Program (NFQA) that includes annual testing of all USGS field personnel for proficiency in making field water-quality measurements (<http://qadata.cr.usgs.gov/nfqa/>). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded directly into NWIS by the NWQL. Results of analyses made at other laboratories are compiled in a project database and uploaded from there into NWIS. Some laboratory QC data are stored in NWIS also.

Data Reporting

The following section gives details for the laboratory reporting conventions and the constituents that are determined by multiple methods or by multiple laboratories.

Reporting Limits

The NWQL uses the LRL as a benchmark for reporting analytical results. The LRL is set to minimize the reporting of false negatives (not detecting a compound when it actually is present in a sample) to less than 1 percent (Childress and others, 1999). The NWQL updates LRL values regularly, and the values listed in this report were in effect during the period that analyses were made for groundwater samples from the NOCO study (June to November 2009).

The LRL usually is 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 method detection level (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero (at the MDL there is less than 1 percent chance of a false positive). LT-MDLs continually are monitored and updated (Childress and others, 1999; U.S. Environmental Protection Agency, 2002b). Concentrations less than the LT-MDL are reported as non-detections and noted with a dash (–) in the data tables..

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

Some constituents in this study are reported using minimum reporting levels (MRLs) 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.

Results for most constituents are presented using the LRL, MDL, MRL, or MU values provided by the analyzing laboratories. Results for some organic and inorganic constituents are presented using study reporting levels (SRL) derived from assessment of data from QC samples associated with groundwater samples collected as part of the GAMA-PBP (see the appendix section titled “[Assessment of Blank Results and SRLs](#)”).

The methods used for analysis of radiochemical constituents (tritium, radon-222, radium isotopes, gross alpha and gross beta radioactivity, lead-210, and polonium-210) measure activities by counting techniques ([table A1](#)). The reporting limits for radiochemical constituents are based on sample-specific critical levels (ssL_C) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and non-radioactive inorganic constituents. Here, the critical level is defined as the minimum measured activity that indicates a positive detection of the radionuclide in the sample with less than a 5 percent probability of a false positive detection. Sample-specific critical levels are used for radiochemical measurements because the critical level is sensitive to sample size and sample yield during analytical processing and is dependent on instrument background, on counting times for the sample and background, and on the characteristics of the instrument being used and the nuclide being measured. An ssL_C is calculated for each sample and the measured activity in the sample is compared to the ssL_C associated with that sample. Measured activities less than the ssL_C are reported as non-detections with a dash (–) in the data tables.

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

Notation

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

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

where

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

E is the element (O for oxygen, C for carbon, H for hydrogen),

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

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

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values of 0 per mil (note that $\delta^2\text{H}$ is sometimes 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. 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.

Field Water-Quality Indicators Measured by Multiple Methods

Some of the field water-quality indicators—pH and specific conductance—were measured in the field and at the NWQL. The field measurements are the preferred method for the two constituents because groundwater samples change once they are removed from the ambient environment; however, both measurements are reported. Field values are generally preferred because field conditions are considered more representative of groundwater conditions (Hem, 1985).

Quality-Assurance Methods

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

(2) replicate samples were collected to assess variability, (3) matrix spike tests were done to assess positive or negative bias, and (4) surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. Results that were found to have significant contamination bias, on the basis of the QC data collected from this study and previous studies, were flagged with an appropriate remark code (described in subsequent sections) and rejected from subsequent use, including calculations of detection frequency.

Blanks

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

Blank Collection and Analysis

Blanks were collected using blank water certified by the NWQL to contain less than the LRL, MDL, or MRL of the analytes investigated in the study (<http://www.nwql.cr.usgs.gov/USGS/OBW/obw.html>). Nitrogen-purged, organic-free blank water was used for blanks for organic constituents and inorganic-free blank water was used for blanks for other constituents.

Field blanks were collected to assess potential contamination of samples during collection, processing, transport, and analysis. Source-solution blanks were collected to assess potential contamination of samples during transport and analysis, and potential contamination of the certified blank water obtained from the NWQL. The equipment blank was collected at the USGS Sacramento Field Office three weeks prior to the start of the NOCO study unit sampling period to assess potential contamination of samples from equipment storage.

Field blanks were analyzed for VOCs, pesticides and pesticide degradates, perchlorate, trace elements, nutrients, DOC, major and minor ions, silica, TDS, radium isotopes, gross alpha and gross beta radioactivity, lead-210, and polonium-210. Source-solution blanks were analyzed for VOCs, perchlorate, trace elements, nutrients, radium isotopes, gross alpha and gross beta radioactivity, lead-210, and polonium-210. The equipment blank was analyzed for VOCs, perchlorate, trace elements, nutrients, DOC, and lead-210.

Blanks were not collected for tritium and dissolved noble gases. Tritium and dissolved noble gases are in the atmosphere and would dissolve into any solution used in collecting a blank, making it impractical to collect a blank for these analytes. Stable-isotopic ratios of carbon, hydrogen, and oxygen are an intrinsic property of any of these elements; therefore, the concept of a blank does not apply to these ratios.

To collect field blanks, blank water either was pumped or poured through the sampling equipment (fittings and tubing) used to collect groundwater samples, then processed and transported using the same protocols as were used for the groundwater samples. 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 groundwater samples. For the equipment blank, blank water was pumped through the sampling equipment (fittings and tubing) used to collect groundwater, then processed and transported using the same protocols used for the groundwater samples. Twelve liters of blank water were pumped or poured through the sampling equipment before each field and (or) equipment blank was collected.

Assessment of Blank Results and SRLs

Contamination in blanks may originate from several different types of sources that require different strategies for assessment of potential contamination of groundwater samples during sample collection, handling, and analysis. Four primary modes of contamination are assessed in the event of detections in blanks or atypical results in groundwater samples: (1) impurities in the water used to collect the blanks, (2) contamination during sample collection and handling from a known source or condition present at the field site, (3) carry-over of material on the sampling equipment from one sample to the next sample, (4) systematic and random contamination from field or laboratory equipment and processes. The fourth source of contamination (systematic and random) is being addressed using a larger set of field blank results from multiple studies, in addition to the results from blanks collected from the NOCO study unit. The development of this approach and its methods are described by Olsen and others (2010) and Fram and others (2011).

The first potential mode evaluated is the presence of impurities in the water used to collect the blank. Because the blanks were collected using blank water certified by the NWQL to contain less than the LRL, MDL, or MRL of the analytes investigated in the study, the blank water is rarely the source of constituents detected in blanks. Blank water used in the NOCO study unit was certified by the NWQL prior to blank collection.

The second potential mode evaluated is contamination from identifiable, known sources present at a specific field site. Contamination from specific sources may produce distinctive patterns of detections in blanks and groundwater samples, particularly for the VOCs. Substances that may be encountered at the field site contain recognizable associations of VOC constituents. For example, cements used on PVC-piping are primarily composed of tetrahydrofuran with lesser amounts of acetone and methyl ethyl ketone (2-butanone). However, detection of these recognizable associations of VOC constituents in groundwater samples does not necessarily indicate contamination during sample collection because these VOC constituents also may occur together in groundwater.

If a recognizable association of VOC constituents was detected in a field blank or in a groundwater sample, the field notes and photographs from the site at which the field blank or groundwater sample was collected were examined for conditions that may have caused the field blank or the groundwater sample to be contaminated. If such conditions were present, the detections of VOC constituents in the field blank or groundwater sample were considered suspect.

The third potential mode of contamination evaluated was carry-over from the previous groundwater sample or blank collected with the same equipment. Carry-over between samples is rare because the procedures used to clean the equipment between samples have been developed and extensively tested to assure that carry-over is mitigated as much as possible. Potential carry-over was evaluated using time-series analysis to look for patterns suggestive of carry-over of constituents from a sample with high concentrations to the next groundwater sample or blank collected with the same equipment. If non-detections were reported in blanks or groundwater samples collected after the collection of groundwater samples containing high concentrations of the constituent, then carry-over as a mode of contamination was ruled out.

The fourth potential mode of contamination evaluated was random or systematic contamination from field or laboratory equipment or processes. All detections in blanks that could not be accounted for by impurities in the source-solution water, by specific known conditions at field sites, or by carry-over between samples were evaluated for random contamination. Random contamination in field and laboratory processes has an equal chance of affecting each groundwater sample; thus, strategies for flagging detections of constituents that are subject to random contamination in field and laboratory processes must be applied to all groundwater samples. Random or systematic contamination in field and laboratory processes generally is the most common of the four modes of contamination and is addressed by applying SRLs.

SRLs for some organic constituents were defined on the basis of concentrations and detection frequencies in field blanks and source-solution blanks collected for the first 27 GAMA-PBP study units (May 2004 through October 2009) and in laboratory instrument and preparation blanks analyzed during the same time period as the samples (Fram and others, 2011). Acetone, 2-butanone, ethylbenzene, styrene, tetrahydrofuran, toluene, 1,2,4-trimethylbenzene, *m*-xylene plus *p*-xylene, and *o*-xylene were detected more frequently in blanks than in groundwater samples and, therefore, all detections of these constituents were removed from the GAMA-PBP groundwater-quality datasets.

For organic constituents detected less frequently in blanks than in groundwater samples, the concentration corresponding to the 95th percentile of the cumulative frequency distribution of the field blanks, source-solution blanks, or laboratory blanks, whichever was highest, was defined as the SRL. For most constituents, the 95th percentiles of the cumulative frequency distributions were non-detections (values below the

LRL), thus, no SRLs were required. Concentrations of those constituents reported by the laboratory that were less than the SRL are marked with a less than or equal to (\leq) symbol preceding the reported value. Organic constituent results with a \leq symbol were not considered detections in the GAMA-PBP study and were not included in the calculations of detection frequencies.

The SRLs for all trace elements except lead were determined by statistical assessment of results from the field blanks collected in the first 20 GAMA-PBP study units (May 2004 through January 2008) (Olsen and others, 2010). The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents possibly introduced while groundwater samples were collected, handled, transported, and analyzed. The resulting SRLs for trace elements were set at concentrations representing a confidence limit of 90 percent for the 90th percentile of the 86 field blanks used in the assessment. Concentrations of those constituents reported by the laboratory that were less than the SRL are marked with a \leq symbol preceding the reported value.

For all other inorganic constituents, the SRL for applying the \leq symbol was determined from assessment of the blanks collected in the NOCO study unit and was defined as equal to the highest concentration measured in the blanks.

Replicates

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

Two methods for measuring variability were needed to adequately assess precision over the broad range of measured concentrations of most constituents. The variability between measured concentrations in the pairs of sequential replicate samples was represented by the standard deviation (SD) for low concentrations and by relative standard deviation (RSD) for high concentrations (Anderson, 1987; Mueller and Titus, 2005). The RSD is defined as the SD divided by the mean concentration for each replicate pair of samples expressed as a percentage. The boundary between concentrations for which variability is assessed with SD and concentrations for which variability is assessed with RSD was defined as five times the LRL, SRL, MDL, MRL or MU for each constituent.

For this study, acceptable precision for replicate sample pairs is defined as follows:

- For concentrations less than ($<$) five times the LRL, SRL, MDL, MRL, or MU, an SD of $< \frac{1}{2}$ LRL, SRL, MDL, MRL, or MU is acceptable.

- For concentrations greater than or equal to (\geq) five times the LRL, SRL, MDL, MRL, or MU, an RSD of < 10 percent is acceptable. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- For activities of radiochemical constituents (except carbon-14), replicate pairs with values that are statistically indistinguishable at a confidence level (α) of $\alpha = 0.05$ are defined as acceptable.

If results from replicate sample pairs indicate that precision is unacceptable for a constituent and no specific reason can be identified, then this greater variability must be considered when interpreting the data. If measured concentrations are slightly greater than a water-quality benchmark, then actual concentrations could be slightly less than that benchmark. Similarly, if measured concentrations are slightly less than a water-quality benchmark, then actual concentrations could be slightly greater than a benchmark. Also, if a constituent has high variability in replicate sample pairs, then a larger difference between concentrations measured in two samples is required to conclude that the two samples have significantly different concentrations.

Replicate pairs of analyses of all constituents except for radiochemical constituents were evaluated as follows:

- If both values were reported as detections, the SD was calculated if the mean concentration was < 5 times the LRL/SRL/MDL/MRL/MU for the constituent or the RSD was calculated if the mean concentration was ≥ 5 times the LRL/SRL/MDL/MRL/MU for the constituent.
- If both values were reported as non-detections, the variability was set to zero by definition.
- If one value was reported as a non-detection, and the other value was reported as a detection less than the LRL, MDL, MRL, or MU, then a value of zero was substituted for the non-detection and the SD calculated. Substituting zero for the non-detection yielded the maximum estimate of variability for the replicate pair.
- If one value for a sample pair was reported as a non-detection and the other value was reported as a \leq -coded value (less than or equal to the SRL), or if both values were reported as \leq -coded values (less than or equal to the SRL), the SD was not calculated because the values may be analytically identical. The \leq -code indicates that the value is a maximum potential concentration and that concentration may be low enough to be reported as a non-detection.
- If one value was reported as a non-detection and the other value was reported as a detection greater than the LRL, SRL, MDL, MRL, or MU, the variability for the pair was considered unacceptable.

- Replicate pairs of analyses of radiochemical constituents were evaluated using the following equation (McCurdy and others, 2008):

$$z = \frac{|R_1 - R_2|}{\sqrt{(CSU_1^2 + CSU_2^2)}}, \quad (2)$$

where

z is the test statistic,
 R_1 and R_2 are the results for the two samples in the replicate pair and,
 CSU_1 and CSU_2 are the combined standard standard uncertainties associated with the results.

Matrix Spikes

Addition of 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 groundwater, on the analytical technique used to measure the constituent. The known compounds added in matrix spikes are the same as those being analyzed in the method. This enables an analysis of matrix interferences on a compound-by-compound basis. For this study, matrix spikes were added by the laboratory performing the analysis. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it were present at very low concentrations. Low and high matrix-spike recoveries may be a potential concern if the concentration of a compound in a groundwater sample is close to the health-based benchmark; a low recovery could result in a falsely measured concentration less than the health-based benchmark, whereas a high recovery could result in a falsely measured concentration greater than the health-based benchmark.

The GAMA-PBP defined the data-quality objective range for acceptable median matrix-spike recoveries as 70 to 130 percent. Only constituents with median matrix spike recoveries outside of this range were flagged (with a footnote in [table 3](#)) as having unacceptable recoveries. For many constituents, an acceptable range of 70 to 130 percent for median matrix-spike recovery was more restrictive than the acceptable control limits for laboratory-set spike recoveries. Laboratory-set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix-spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules acceptable set spike recovery is within ± 3 F-pseudosigma of the median recovery for at least 30 set spikes (Conner and others, 1998). The F-pseudosigma is calculated by dividing the fourth-spread (analogous to

interquartile range) by 1.349; therefore, the smaller the F-pseudosigma the more precise the determinations (Hoaglin, 1983).

Matrix spikes were performed for VOCs, pesticides and pesticide degradates, and perchlorate because the analytical methods for these constituents may be susceptible to matrix interferences. Positive-control matrix spikes were performed for the viral indicators (F-specific coliphage and somatic coliphage) at the USGS Ohio Water Microbiology Laboratory to determine if the groundwater matrix interferes with microbial growth.

Surrogates

Surrogate compounds are added to environmental samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added to all groundwater and QC samples that were analyzed for VOCs and pesticides and pesticides degradates. Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 that is 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-*d*8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two results in slightly different chromatographic retention times; thus, the use of a toluene-*d*8 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-*d*8 do not occur naturally and are not detected in environmental samples. Surrogates are used to identify general problems that may arise during laboratory sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of DOC) that produce a positive bias or incomplete laboratory recovery (possibly because of improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70 to 130 percent recovery of surrogates, in general, is considered acceptable; values outside this range indicate possible problems with the processing and analysis of samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Results

Detections in Blanks and SRL Analysis

[Table A2](#) presents a summary of detections in the blanks (six field blanks, seven source-solution blanks, and the equipment blank) and the SRL analysis for the NOCO study unit. Field and source-solution blanks were collected at 5 to 12 percent of the sites sampled in the NOCO study unit; not all analyte classes were tested at every well.

Of the 14 blanks analyzed for VOCs; chloroform and carbon disulfide each were detected in one blank. The chloroform blank detection was considered to be random contamination, likely from a field process, but whose exact source could not be identified. This blank detection had an equal chance of affecting each groundwater sample. Chloroform was detected in the blank at a concentration of $E0.02 \mu\text{g/L}$, creating a SRL of $0.02 \mu\text{g/L}$. Chloroform was detected at a concentration less than the SRL in one groundwater sample and was flagged with a \leq symbol. The result was considered a non-detection and was not included in the calculations of chloroform detection frequencies ([tables 5](#) and [A2](#)).

The carbon disulfide blank detection in the NOCO study unit also was considered to be random contamination and had an equal chance of affecting each groundwater sample. Carbon disulfide was detected in the blank at a concentration of $E0.06 \mu\text{g/L}$, creating a SRL of $0.06 \mu\text{g/L}$. Carbon disulfide was detected at a concentration less than the SRL in one groundwater sample and was flagged with a \leq symbol. The result was considered a non-detection and was not included in the calculations of carbon disulfide detection frequencies ([tables 5](#) and [A2](#)).

GAMA SRLs from Fram and others (2011) were used for acetone, 2-butanone, ethylbenzene, styrene, tetrahydrofuran, toluene, 1,2,4-trimethylbenzene, *m*-xylene plus *p*-xylene, and *o*-xylene. Three of these VOCs (styrene, toluene, and 1,2,4-trimethylbenzene) were detected in the NOCO study-unit groundwater samples. These detections were not considered to represent groundwater quality and were excluded from the dataset presented in this report ([tables 3A](#), [5](#), and [A2](#)). 1,2,4-trimethylbenzene was detected in 7 of 14 blanks collected in the NOCO study unit ([table A2](#)).

Eight blanks were collected for analysis of trace elements. Three trace elements were detected in at least one blank; copper, lead, and nickel ([table A2](#)). The detections of copper and nickel were at concentrations less than the SRL assigned by Olsen and others (2010). A SRL for lead ($1.1 \mu\text{g/L}$) was established on the basis of the highest detected concentration in the five blanks. Measured concentrations that were less than the SRL were flagged with a \leq symbol ([table 8](#)). There were no other trace elements detected in any of the blanks in the NOCO study unit.

GAMA SRLs from Olsen and others (2010) were used for aluminum, barium, chromium, copper, iron, manganese, mercury, nickel, vanadium, and zinc. Measured concentrations that were less than the SRL were flagged with a \leq symbol in [table 8](#).

Seven blanks were collected for analysis of DOC and it was detected in two of the blanks ([table A2](#)). A SRL for DOC (0.7 mg/L) was established on the basis of the highest detected concentration in the two blanks. Measured concentrations that were less than the SRL were flagged with a \leq symbol ([table 9](#)).

Four blanks were collected for analysis of radioactive constituents. Results from blanks were not used to define SRLs for radiochemical constituents because the low activities of these constituents occasionally reported in GAMA-PBP blanks are thought to be an artifact of the algorithms used to convert instrument response to activities for blank samples, rather than to reflect presence of these constituents in blank samples (Sylvia Stork, U.S. Geological Survey, written commun., 2010). Activities of radiochemical constituents reported in blanks were all lower than most of the activities reported in the NOCO study-unit groundwater samples, indicating that groundwater samples likely were not significantly contaminated by these constituents during collection, handling, or analysis. Radium-226 had measureable activities in the three blanks, gross alpha radioactivity (30-day count) in one blank, and polonium-210 in two blanks ([table A2](#)).

Constituents were not detected in the blanks for the following analyte groups: pesticides and pesticide degradates (3 blanks); perchlorate (14 blanks); mercury (4 blanks); nutrients (5 blanks); major and minor ions, silica, and TDS (4 blanks); iodide (3 blanks); radium-228, gross alpha radioactivity (72-hour), gross beta radioactivity (72-hour and 30-day counts), and lead-210 (4 blanks).

Variability in Replicate Samples

[Table A3A–C](#) summarizes the results of replicate analyses for constituents detected in groundwater samples collected in the NOCO study unit. Replicate analyses were made on approximately 3 to 10 percent of the samples collected.

Of the 930 replicate pairs of constituents analyzed, 65 were for constituents detected in at least one groundwater sample. Of these 65 pairs, 1 pair (nickel) was outside the limits for acceptable precision. Results for replicate analyses for constituents that were not detected in groundwater samples are not reported in [table A3A–C](#).

Four replicate pairs of samples were analyzed for the 85 VOCs and all pairs yielded two values reported as non-detections with the exception of two replicate pairs of MTBE and one replicate pair of chloroform. The replicate pairs for MTBE and chloroform each yielded two values reported as detections and all replicate pair analysis resulted in SDs within acceptable precision ([table A3A](#)).

Four replicate pairs of samples were analyzed for the 83 pesticide and pesticide degradate compounds and all pairs consisted of two values reported as non-detections ([table A3A](#)).

Six replicate pairs for perchlorate were analyzed at Week Laboratories, Inc. for variability. All of the replicate pairs for perchlorate yielded two values reported as non-detections ([table A3A](#)).

Six replicate pairs of samples were analyzed for DOC. One replicate pair yielded two values reported as detections and resulted in a SD within acceptable precision. Four replicate pairs consisted of two values measured at concentrations less than the SRL of 0.7 mg/L; therefore, variability was not calculated ([table A3A](#)).

Replicate pairs of samples were analyzed for trace elements (three to six pairs), nutrients (five pairs), major and minor ions (three to four pairs), silica and TDS (four pairs), and isotope tracers (two to five pairs). With the exception of one replicate pair of nickel, the SD values for all pairs with concentrations < 5 times the LRL/SRL < ½ LRL/SRL and the RSD values for all pairs with concentrations ≥ 5 times the LRL/SRL were < 10 percent ([table A3B](#)).

The SD for one replicate pair for nickel was 0.20 µg/L (½ SRL is 0.18 µg/L). However, the concentration of nickel in the sample was less than 1 µg/L (more than two orders of magnitude lower than the corresponding MCL-CA of 100 µg/L) ([tables 3D](#) and [8](#)). A slight decrease in precision at these low concentrations is unlikely to affect the assessments of groundwater quality being made by the GAMA-PBP because the assessment for nickel is focused on distribution of concentrations greater than 50 µg/L (½ the MCL-CA benchmark).

One replicate pair for radon-222 and four replicate pairs for radium isotopes, gross alpha and gross beta radioactivity, lead-210, and polonium-210 were analyzed for variability. All replicate pairs for the radioactive constituents yielded statistically similar results ($p \leq 0.05$) and were, therefore, considered acceptable ([table A3C](#)).

Environmental detections were not modified on the basis of the replicate analysis.

Matrix-Spike Recoveries

[Table A4A–D](#) presents a summary of matrix-spike recoveries for the NOCO study unit. Replicate samples for spike additions were collected at approximately 3 to 7 percent of the wells sampled, not all analyte classes were tested at every well.

Two groundwater samples were spiked with VOCs to calculate matrix-spike recoveries at the NWQL. Median matrix-spike recoveries for all 85 VOC spike compounds were within the acceptable range ([table A4A](#)).

Four groundwater samples were spiked with pesticide and pesticide degradate compounds, to calculate matrix-spike recoveries at the NWQL. Median matrix-spike recoveries for 64 of the 83 spike compounds were within the acceptable range of 70 to 130 percent ([table A4B](#)). The median matrix-spike recoveries for two of the three compounds detected in groundwater samples (atrazine and simazine) were within the acceptable range ([tables 3B](#) and [6](#)). Note that low matrix-spike recoveries may indicate that the compound might be present at very low concentrations but not detected in some samples.

The median spike-matrix recovery for deethylatrazine was less than the acceptable range (58.8 percent). Deethylatrazine was detected at a concentration (E0.006 µg) less than the LRL of 0.014 µg in two grid wells in the NOCO study unit ([table 6](#)). Because deethylatrazine was detected at concentrations an order of magnitude less than the LRL, it was determined that the less than the acceptable median spike-matrix recovery did not affect the analysis and results from the NWQL.

At least one matrix-spike recovery for 36 pesticide and pesticide degradate spike compounds was less than 70 percent. Of these pesticide and pesticide degradate spike compounds, deethylatrazine was the only one detected in groundwater samples, and the concentrations could be biased low ([tables 3B](#), [6](#), and [A4B](#)). A similar pattern of unusually low matrix-spike recoveries that started in March 2008 was noted in an assessment of method performance by the Organic Blind Sample Program (OBSP) of the BQS (<http://bqs.usgs.gov/OBSP/>).

Two groundwater samples were spiked with perchlorate to calculate matrix-spike recoveries at Weck Laboratories, Inc. All median matrix-spike recoveries were between 70 and 130 percent ([table A4C](#)).

Four groundwater samples were spiked with F-specific and somatic coliphage at the USGS Ohio Water Microbiology Laboratory to determine if the groundwater matrix interferes with growth. All four samples tested positive for F-specific and somatic coliphage, which indicates matrix interferences were not a problem ([table A4D](#)).

Environmental detections were not modified on the basis of the matrix-spike recovery analysis.

Surrogate Compound Recoveries

[Table A5](#) presents a summary of the surrogate recoveries for the NOCO study unit. Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recoveries of similar constituents.

[Table A5](#) lists the surrogate, the analytical schedule on which it was applied, the number of analyses for blank and environmental samples, the number of surrogate recoveries less than 70 percent, and the number of surrogate recoveries greater than 130 percent for the blank and groundwater samples. Blank and environmental samples were considered separately to assess whether the matrixes present in groundwater samples affect surrogate recoveries.

In the NOCO study unit, most surrogate recoveries for the blank and environmental samples were within the acceptable range of 70 to 130 percent. In total, 81 percent of the blank and 78 percent of the environmental sample surrogate recoveries for VOC analyses were within the acceptable range ([table A5](#)). Additionally, 100 percent of the blank and 94 percent of the environmental sample surrogate recoveries for pesticide and pesticide degradate analyses were within the acceptable range ([table A5](#)). There were no significant differences between VOC and pesticide and pesticide degradate surrogate recoveries in blank and environmental samples (Wilcoxon rank sum test, $p < 0.05$).

Environmental detections were not modified on the basis of the surrogate recovery analysis.

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. **Abbreviations:** VOC, volatile organic compounds; DOC, dissolved organic carbon; USEPA, U.S. Environmental Protection Agency; UV, ultraviolet; SAL, single-agar layer; MI agar, supplemented nutrient agar in which coliforms (total and *Escherichia coli*) produce distinctly different fluorescence under ultraviolet lighting; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; LLNL, Lawrence Livermore National Laboratory]

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 pesticide degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2033	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001; Madsen and others, 2003
Constituent of special interest			
Perchlorate	Liquid chromatography with mass spectrometry/mass spectrometry (USEPA Method 331.0)	Week Laboratories, Inc., City of Industry, California (CA-WECK), standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
Inorganic constituents			
Nutrients	Alkaline persulfate digestion, Kjeldahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
DOC	UV-promoted persulfate oxidation and infrared spectrometry	NWQL, Laboratory Code 2613	Brenton and Arnett, 1993
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, Schedules 2710 and 2750	Fishman and Friedman, 1989; Fishman, 1993; McLain, 1993; Garbarino, 1999; Garbarino and Damrau, 2001; Garbarino and others, 2006
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
Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance	Accelerator mass spectrometry	Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility [NOSAMS], Woods Hole, Massachusetts (MA-WHAMS), NWQL Schedule 2255	Vogel and others, 1987; Donahue and others, 1990; McNichol and others, 1992; Gagnon and Jones, 1993; McNichol and others, 1994; Schneider and others, 1994

Table A1. Analytical methods used for the determination of organic and inorganic constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and 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. **Abbreviations:** VOC, volatile organic compounds; DOC, dissolved organic carbon; USEPA, U.S. Environmental Protection Agency; UV, ultraviolet; SAL, single-agar layer; MI agar, supplemented nutrient agar in which coliforms (total and *Escherichia coli*) produce distinctly different fluorescence under ultraviolet lighting; USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; LLNL, Lawrence Livermore National Laboratory]

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
Radioactivity and gases			
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA), NWQL Schedule 1565	Thatcher and others, 1977
Dissolved noble gases and helium isotope ratios	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory [LLNL], Livermore, California (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Radium isotopes	Alpha activity counting	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1262	Kreiger and Whittaker, 1980 (USEPA methods 903 and 904)
Gross alpha and gross beta radioactivity	Alpha and beta activity counting	Eberline Analytical Services, (CA-EBERL), NWQL Schedule 1792	Kreiger and Whittaker, 1980 (USEPA method 900.0)
Lead-210	Beta activity counting	Eberline Analytical Services (CA-EBERL), NWQL Laboratory Code 2170	Eichrom Technologies, Inc., 2009
Polonium-210	Alpha activity counting	Eberline Analytical Services (CA-EBERL), NWQL Laboratory Code 1550	Eichrom Technologies, Inc., 2009
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
<i>Escherichia coli</i> (<i>E. coli</i>) and total coliform	Membrane filter technique with "MI agar"	USGS field measurement	U.S. Environmental Protection Agency, 2002a; U.S. Geological Survey, variously dated

Table A2. Constituents detected in blanks and the study reporting level (SRL) analysis for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Sources of SRL: NOCO field blanks, the SRL was assigned a value equal to the highest concentration in field blanks collected for this study unit; report by Olsen and others (2010); the SRL was defined on the basis of the examination of quality-control samples collected for the first 20 GAMA study units; report by Fram and others (2011); constituent excluded from dataset on the basis of the examination of quality-control samples collected for the first 27 GAMA study units (May 2004 through October 2009) and in laboratory instrument and preparation blanks analyzed during the same time period as the samples. Abbreviations: LRL, laboratory reporting level; SRL, study reporting level; \leq , less than or equal to; VOC, volatile organic compounds; $\mu\text{g/L}$, micrograms per liter; DOC, dissolved organic carbon; E, estimated or having a higher degree of uncertainty; pCi/L, picocuries per liter; \pm , plus or minus; ssL_C , sample-specific critical level; $-$, not detected]

Constituent	Number of blank detections/ analyses	Concentrations detected in blanks	SRL concentration	Source of SRL	Number of groundwater samples \leq -coded	Number of groundwater detections excluded from dataset
Volatile organic compounds (VOC) ($\mu\text{g/L}$)						
Carbon disulfide	1/14	E0.06	0.06	NOCO field blanks	1	1
Chloroform (trichloromethane)	1/14	E0.02	0.02	NOCO field blanks	1	1
Styrene	0/14	–	LRL	Fram and others, 2011	0	1
Toluene	0/14	–	LRL	Fram and others, 2011	0	1
1,2,4-trimethylbenzene	7/14	0.30, 0.09, E0.03, E0.05, E0.04, E0.02, E0.02	LRL	Fram and others, 2011	0	19
Trace elements ($\mu\text{g/L}$)						
Aluminum	0/8	–	1.6	Olsen and others, 2010	0	0
Barium	0/8	–	0.36	Olsen and others, 2010	0	0
Chromium	0/8	–	0.42	Olsen and others, 2010	30	0
Copper	1/8	0.62	1.7	Olsen and others, 2010	18	0
Iron	0/8	–	6	Olsen and others, 2010	11	0
Lead	5/8	1.1, 0.12, 0.07, 0.11, E0.04	1.1	NOCO field blanks	45	0
Manganese	0/8	–	0.2	Olsen and others, 2010	3	0
Nickel	1/8	E0.10	0.36	Olsen and others, 2010	17	0
Vanadium	0/8	–	0.1	Olsen and others, 2010	0	0
Zinc	0/8	–	4.8	Olsen and others, 2010	35	0
Dissolved organic carbon (DOC) (mg/L)						
DOC	2/7	E0.3, 0.7	0.7	NOCO field blanks	29	0
Radioactive constituents (pCi/L)						
Radium-226	3/4	0.0286 \pm 0.0083, ssL_C = 0.014; 0.0153 \pm 0.0081, ssL_C = 0.012; 0.0239 \pm 0.0082, ssL_C = 0.015	–	NOCO field blanks	0	0
Gross alpha radioactivity, 30-day count	1/4	0.114 \pm 0.091, ssL_C = 0.11	–	NOCO field blanks	0	0
Polonium-210	2/4	0.032 \pm 0.014, ssL_C = 0.018; 0.019 \pm 0.012, ssL_C = 0.014	–	NOCO field blanks	0	0

Table A3A. Quality-control summary for replicate analyses of organic constituents, constituent of special interest, and dissolved organic carbon (DOC) detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Abbreviations: \leq , less than or equal to; SD, percent standard deviation; LRL, laboratory reporting level; SRL, study reporting level; RSD, percent relative standard deviation; VOC, volatile organic compound; DOC, dissolved organic carbon; nv, no value in category]

Constituent	Number of non-detects/ number of replicates	Number of \leq -coded replicates	Number of SDs greater than $\frac{1}{2}$ / LRL/SRL number of replicates with concentration less than 5 times the LRL	Concentrations of replicates with SDs greater than $\frac{1}{2}$ / LRL/SRL (environmental, replicate)	Number of RSDs greater than 10 percent/ number of replicates with concentration greater than 5 times the LRL/SRL	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Volatile organic compounds (VOC) (Schedule 2020)						
Chloroform (Trichloromethane)	3/4	nv	0/1	nv	nv	nv
1,1,1-Trichloroethane (1,1,1-TCA)	4/4	nv	nv	nv	nv	nv
Methyl <i>tert</i> -butyl ether (MTBE)	2/4	nv	0/2	nv	nv	nv
Carbon disulfide	4/4	nv	nv	nv	nv	nv
1,1-Dichloroethane (1,1-DCA)	4/4	nv	nv	nv	nv	nv
Bromodichloromethane	4/4	nv	nv	nv	nv	nv
Perchloroethene (PCE, Tetrachloroethene)	4/4	nv	nv	nv	nv	nv
Vinyl chloride (Chloroethene)	4/4	nv	nv	nv	nv	nv
Pesticides and pesticide degradates (Schedule 2033)						
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine)	4/4	nv	nv	nv	nv	nv
Atrazine	4/4	nv	nv	nv	nv	nv
Simazine	4/4	nv	nv	nv	nv	nv
Constituent of special interest						
Perchlorate	6/6	nv	nv	nv	nv	nv
Dissolved organic carbon (DOC)						
DOC	1/6	4	0/1	nv	nv	nv

Table A3B. Quality-control summary for replicate analyses of inorganic constituents, isotope tracers, and tritium detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[**Abbreviations:** ≤, less than or equal to; SD, percent standard deviation; LRL, laboratory reporting level; SRL, study reporting limit; MDL, method detection limit; MRL, minimum reporting level; RSD, percent relative standard deviation; µg/L, micrograms per liter; TDS, total dissolved solids; SiO₂, silicon dioxide; H, hydrogen; O, oxygen; C, carbon; nv, no value in category]

Constituent	Number of non-detect or ≤-coded replicates/ number of replicates	Number of SDs greater than ½ LRL/SRL/MDL/MRL number of replicates with concentration less than 5 times the LRL/SRL/MDL/MRL/MU	Concentrations of replicates with SDs greater than ½ LRL/SRL/MDL/MRL (environmental, replicate)	Number of RSDs greater than 10 percent/ number of replicates with concentration greater than 5 times the LRL/SRL/MDL/MRL/MU	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Trace Elements (µg/L)					
Aluminum	4/6	0/2	nv	nv	nv
Antimony	3/6	0/3	nv	nv	nv
Arsenic	0/6	0/2	nv	0/4	nv
Barium	0/6	nv	nv	0/6	nv
Beryllium	6/6	nv	nv	nv	nv
Boron	0/6	0/1	nv	0/5	nv
Cadmium	4/6	0/2	nv	nv	nv
Chromium	2/6	0/3	nv	0/1	nv
Cobalt	0/6	0/5	nv	0/1	nv
Copper	5/6	0/1	nv	nv	nv
Iron	0/4	0/1	nv	0/3	nv
Lead	1/6	0/5	nv	nv	nv
Lithium	0/6	0/3	nv	0/3	nv
Manganese	0/6	nv	nv	0/6	nv
Molybdenum	0/6	nv	nv	0/6	nv
Nickel	0/6	1/6	(0.60, 0.88)	nv	nv
Selenium	4/6	0/2	nv	nv	nv
Silver	6/6	nv	nv	nv	nv
Strontium	0/6	nv	nv	0/6	nv
Uranium	0/6	0/4	nv	0/2	nv
Vanadium	0/6	0/3	nv	0/3	nv
Zinc	2/6	0/4	nv	nv	nv
Nutrients					
Ammonia (as nitrogen)	2/5	0/1	nv	0/2	nv
Nitrate plus nitrite (as nitrogen)	3/5	0/1	nv	0/1	nv
Nitrite (as nitrogen)	5/5	nv	nv	nv	nv
Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen)	0/5	0/5	nv	nv	nv
Phosphate, orthophosphate (as phosphorus)	0/5	0/2	nv	0/3	nv

Table A3B. Quality-control summary for replicate analyses of inorganic constituents, isotope tracers, and tritium detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[**Abbreviations:** ≤, less than or equal to; SD, percent standard deviation; LRL, laboratory reporting level; MDL, method detection limit; MRL, minimum reporting level; RSD, percent relative standard deviation; µg/L, micrograms per liter; TDS, total dissolved solids; SiO₂, silicon dioxide; H, hydrogen; O, oxygen; C, carbon; nv, no value in category]

Constituent	Number of non-detect or ≤-coded replicates/ number of replicates	Number of SDs greater than ½ LRL/SRL/MDL/MRL number of replicates with concentration less than 5 times the LRL/SRL/MDL/MRL/MU	Concentrations of replicates with SDs greater than ½ LRL/SRL/MDL/MRL (environmental, replicate)	Number of RSDs greater than 10 percent/ number of replicates with concentration greater than 5 times the LRL/SRL/MDL/MRL/MU	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Major and minor ions, silica, and total dissolved solids (TDS)					
Bromide	0/4	0/3	nv	0/1	nv
Calcium	0/4	nv	nv	0/4	nv
Chloride	0/4	nv	nv	0/4	nv
Fluoride	0/4	0/4	nv	nv	nv
Iodide	0/3	0/2	nv	0/1	nv
Magnesium	0/4	nv	nv	0/4	nv
Potassium	0/4	nv	nv	0/4	nv
Sodium	0/4	nv	nv	0/4	nv
Sulfate	0/4	nv	nv	0/4	nv
Silica (as SiO ₂)	0/4	nv	nv	0/4	nv
TDS	0/4	nv	nv	0/4	nv
Isotope tracers and radioactivity					
δ ² H in water	0/2	nv	nv	0/2	nv
δ ¹⁸ O in water	0/2	nv	nv	0/2	nv
δ ¹³ C in dissolved inorganic carbon	0/5	nv	nv	0/5	nv
Carbon-14	0/5	nv	nv	0/5	nv

Table A3C. Quality-control summary for replicate analyses of radioactive constituents detected in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[For activities of radiochemical constituents, a replicate pair of analyses is defined as acceptable if the p-value for the normalized absolute difference is less than (or equal to) the significance level, $\alpha = 0.05$. **Abbreviations:** nv, no value in category; <, less than; >, greater than]

Constituent	Number of pairs with $p > 0.05$ / number of replicates	Activities for replicate pairs with $p > 0.05$ (environmental, replicate)
Tritium	0/0	nv
Radon-222	0/1	nv
Radium-226	0/4	nv
Radium-228	0/4	nv
Gross alpha radioactivity, 72 hour count	0/4	nv
Gross alpha radioactivity, 30 day count	0/4	nv
Gross beta radioactivity, 72 hour count	0/4	nv
Gross beta radioactivity, 30 day count	0/4	nv
Lead-210	0/4	nv
Polonium-210	0/4	nv

Table A4A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	2	112	115	113.5
Acrylonitrile	2	109	114	111.5
<i>tert</i> -Amyl methyl ether (TAME)	2	99	108	103.5
Benzene	2	100	104	102.0
Bromobenzene	2	98	99	98.5
Bromochloromethane	2	111	112	111.5
Bromodichloromethane ¹	2	101	111	106.0
Bromoform (Tribromomethane)	2	98	104	101.0
Bromomethane (Methyl bromide)	2	105	111	108.0
<i>n</i> -Butylbenzene	2	91	92	91.5
<i>sec</i> -Butylbenzene	2	93	96	94.5
<i>tert</i> -Butylbenzene	2	100	106	103.0
Carbon disulfide ¹	2	79	86	82.0
Carbon tetrachloride (Tetrachloromethane)	2	102	103	102.0
Chlorobenzene	2	98	99	98.5
Chloroethane	2	96	109	102.5
Chloroform (Trichloromethane) ¹	2	104	112	108.0
Chloromethane	2	102	109	105.5
3-Chloropropene	2	110	112	111.0
2-Chlorotoluene	2	100	104	102.0
4-Chlorotoluene	2	100	100	100.0
Dibromochloromethane	2	104	106	105.0
1,2-Dibromo-3-chloropropane (DBCP)	2	101	106	103.5
1,2-Dibromoethane (EDB)	2	105	116	110.5
Dibromomethane	2	107	111	109.0
1,2-Dichlorobenzene	2	101	106	103.5
1,3-Dichlorobenzene	2	97	99	98.0
1,4-Dichlorobenzene	2	91	101	96.0
<i>trans</i> -1,4-Dichloro-2-butene	2	98	99	98.5
Dichlorodifluoromethane (CFC-12)	2	78	84	81.0
1,1-Dichloroethane (1,1-DCA) ¹	2	107	111	109.5
1,2-Dichloroethane (1,2-DCA)	2	100	112	106.0
1,1-Dichloroethene (1,1-DCE)	2	102	113	107.5
<i>cis</i> -1,2-Dichloroethene (<i>cis</i> -1,2-DCE)	2	103	109	106.0
<i>trans</i> -1,2-Dichloroethene (<i>trans</i> -1,2-DCE)	2	105	106	106.5
1,2-Dichloropropane	2	93	110	101.5
1,3-Dichloropropane	2	103	113	108.0
2,2-Dichloropropane	2	71	98	84.5
1,1-Dichloropropene	2	92	95	93.5
<i>cis</i> -1,3-Dichloropropene	2	91	104	97.5
<i>trans</i> -1,3-Dichloropropene	2	89	102	95.5
Diethyl ether	2	117	121	119.0
Diisopropyl ether (DIPE)	2	102	110	106.0
Ethylbenzene	2	93	94	93.5
Ethyl <i>tert</i> -butyl ether (ETBE)	2	98	104	101.0
Ethyl methacrylate	2	100	100	100.0
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	2	87	95	91.0
Hexachlorobutadiene	2	78	85	81.5
Hexachloroethane	2	96	106	101.0
2-Hexanone (<i>n</i> -Butyl methyl ketone)	2	107	108	107.5
Iodomethane (Methyl iodide)	2	113	125	119.0

Table A4A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Isopropylbenzene	2	93	97	95.0
4-Isopropyl-1-methyl benzene	2	95	97	96.0
Methyl acrylate	2	111	111	111.0
Methyl acrylonitrile	2	117	120	118.5
Methyl <i>tert</i> -butyl ether (MTBE) ¹	2	105	116	110.5
Methyl <i>iso</i> -butyl ketone (MIBK)	2	104	105	104.5
Methylene chloride (Dichloromethane)	2	103	104	103.5
Methyl ethyl ketone (2-butanone, MEK)	2	110	116	113.0
Methyl methacrylate	2	98	104	101.0
Naphthalene	2	100	100	100.0
Perchloroethene (PCE, Tetrachloroethene) ¹	2	105	105	105.0
<i>n</i> -Propylbenzene	2	92	95	93.5
Styrene	2	95	96	95.5
1,1,1,2-Tetrachloroethane	2	98	112	105.0
1,1,2,2-Tetrachloroethane	2	106	115	110.5
Tetrahydrofuran	2	110	120	115.0
1,2,3,4-Tetramethylbenzene	2	94	101	97.5
1,2,3,5-Tetramethylbenzene	2	104	113	108.5
Toluene	2	99	103	101.0
1,2,3-Trichlorobenzene	2	102	105	103.5
1,2,4-Trichlorobenzene	2	89	95	92.0
1,1,1-Trichloroethane (1,1,1-TCA) ¹	2	101	107	104.0
1,1,2-Trichloroethane (1,1,2-TCA)	2	108	111	109.5
Trichloroethene (TCE)	2	93	101	97.0
Trichlorofluoromethane (CFC-11)	2	97	103	100.0
1,2,3-Trichloropropane (1,2,3-TCP)	2	103	103	103.0
Trichlorotrifluoroethane (CFC-113)	2	81	97	89.0
1,2,3-Trimethylbenzene	2	99	112	105.5
1,2,4-Trimethylbenzene	2	101	107	104.0
1,3,5-Trimethylbenzene	2	92	97	94.5
Vinyl bromide (Bromoethene)	2	102	108	105.0
Vinyl chloride (Chloroethene) ¹	2	93	124	108.5
<i>m</i> - and <i>p</i> -Xylene	2	100	101	100.5
<i>o</i> -Xylene	2	91	93	92.0

¹ Constituents detected in groundwater samples.

Table A4B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	4	80	118	96.8
Alachlor	4	83	117	102.8
Atrazine ¹	4	81	120	105.4
Azinphos-methyl	4	78	108	96.6
Azinphos-methyl oxon	4	41	100	57.4
Benfluralin	4	63	89	70.1
Carbaryl	4	80	124	95.3
Carbofuran	4	81	110	99.1
2-Chloro-2,6-diethylacetanilide	4	91	130	103.1
4-Chloro-2-methylphenol	4	49	69	61.7
Chlorpyrifos	4	80	88	82.5
Chlorpyrifos-oxon	2	16	21	18.7
Cyanazine	4	78	124	130.1
Cyfluthrin	4	75	83	81.7
λ -Cyhalothrin	4	42	51	47.0
Cypermethrin	4	71	79	75.5
DCPA (Dacthal)	4	101	122	109.3
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine) ¹	4	49	75	58.8
Desulfinylfipronil	4	82	116	100.8
Desulfinylfipronil amide	4	72	110	97.3
Diazinon	4	88	100	92.2
Diazinon oxon	4	60	78	71.3
3,4-Dichloroaniline	4	64	84	73.3
3,5-Dichloroaniline	4	73	96	84.4
Dichlorvos	4	14	22	18.1
Dicrotophos	3	31	52	45
Dieldrin	4	95	115	99.3
2,6-Diethylaniline	4	78	98	88.6
Dimethoate	4	35	47	43.6
Disulfoton	4	67	86	79.8
Disulfoton sulfone	4	67	87	78.3
α -Endosulfan	4	81	108	86.8
Endosulfan sulfate	4	75	106	92.9
Ethion	4	52	84	69.9
Ethion monoxon	4	68	84	78.8
Ethoprophos	4	79	108	85.5
<i>S</i> -Ethyl-dipropylthiocarbamate (EPTC)	4	83	102	90.7
2-Ethyl-6-methylaniline	4	75	104	86.4
Fenamiphos	4	75	100	90.7
Fenamiphos sulfone	4	68	115	114.1
Fenamiphos sulfoxide	3	33	47	40
Fipronil	4	89	115	101.4
Fipronil sulfide	4	83	120	106.3
Fipronil sulfone	4	61	107	87.5
Fonofos	4	78	98	86.7
Hexazinone	4	50	77	65.1
Iprodione	4	38	48	46.9
Isofenphos	4	81	111	93.1
Malaoxon	4	68	95	74.7
Malathion	4	76	103	87.8

Table A4B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Metalaxyl	4	84	120	103.0
Methidathion	4	71	90	83.3
Metolachlor	4	80	120	103.3
Metribuzin	4	69	92	85.7
Molinate	4	83	105	91.2
Myclobutanil	4	75	100	81.5
1-Naphthol	4	22	86	50.0
Oxyfluorfen	4	54	82	68.2
Paraoxon-methyl	4	44	65	51.6
Parathion-methyl	4	69	91	77.1
Pendimethalin	4	75	118	95.2
<i>cis</i> -Permethrin	4	76	81	77.5
Phorate	4	62	84	76.6
Phorate oxon	4	73	100	82.8
Phosmet	3	6	9	8
Phosmet oxon	2	1	7	4.1
Prometon	4	40	111	87.5
Prometryn	4	84	118	95.5
Pronamide	4	79	106	91.9
Propanil	4	76	120	93.6
Propargite	4	69	91	74.1
<i>cis</i> -Propiconazole	4	83	135	103.5
<i>trans</i> -Propiconazole	4	79	97	86.4
Simazine ¹	4	76	120	97.1
Tebuconazole	4	54	82	72.1
Tebuthiuron	4	96	186	124.7
Tefluthrin	4	49	73	62.0
Terbufos	4	60	83	69.3
Terbufos oxon sulfone	4	58	98	77.7
Terbuthylazine	4	89	119	104.6
Thiobencarb	4	88	121	103.1
Tribufos	4	48	71	58.9
Trifluralin	4	76	93	79.2

¹ Constituents detected in groundwater samples.

Table A4C. Quality-control summary for matrix-spike recoveries of perchlorate in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Perchlorate ¹	2	103	112	107.5

¹ Constituent detected in groundwater samples.**Table A4D.** Quality-control summary of microbial indicator positive-spike results in samples collected for the Northern Coast Ranges (NOCO) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

Constituent	Number of spike samples	Positive-spike results
F-specific coliphage ¹	4	Detected ²
Somatic coliphage ¹	4	Detected ²

¹ Constituents detected in groundwater samples.² A detection indicates the groundwater matrix does not affect the detection of coliphage.

Table A5. Quality-control summary for surrogate recoveries of volatile organic compounds (VOC) and pesticides and pesticide degradates in samples collected for the Northern Coast Ranges (NOC) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to November 2009.

[Abbreviation: VOC, volatile organic compound]

Surrogate	Analytical schedule	Constituent or constituent class analyzed	Number of blanks analyses	Median recovery in blanks (percent)	Number of surrogate recoveries less than 70 percent in blanks	Number of surrogate recoveries greater than 130 percent in blanks	Number of sample analyses	Median recovery in samples (percent)	Number of surrogate recoveries less than 70 percent in samples	Number of surrogate recoveries greater than 130 percent in samples
1-Bromo-4-fluorobenzene	2020	VOC	14	84	0	0	58	80	0	0
1,2-Dichloroethane- <i>d</i> 4	2020	VOC	14	132	0	8	58	136	0	38
Toluene- <i>d</i> 8	2020	VOC	14	94	0	0	58	93	0	0
Diazinon- <i>d</i> 10	2033	Pesticide	3	101	0	0	58	100	6	0
α -HCH- <i>d</i> 6	2033	Pesticide	3	106	0	0	58	99	0	1

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Publishing support provided by the U.S. Geological Survey
Publishing Network, Sacramento and Tacoma Publishing Service Centers

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