Prepared in cooperation with the
Massachusetts Department of Environmental Protection
and the Massachusetts Department of Public Health

Arsenic and Uranium in Water from Private Wells Completed in Bedrock of East-Central Massachusetts—Concentrations, Correlations with Bedrock Units, and Estimated Probability Maps

Scientific Investigations Report 2011–5013

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

Cover photos:

A quartz-diorite bedrock formation at the road cut northeast of the I-495, I-290 intersection, in Marlborough, Massachusetts. Photos by Marcus Waldron.

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Conversion Factors and Datums

Multiply	By	To obtain
	Area	
square kilometer (km^2)	0.6214	square mile (mi^2)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = (1.8 × °C) + 32
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).
Concentrations of chemical constituents in water are given in micrograms per liter (µg/L).

Acronyms and Additional Abbreviations

ANOVA	analysis of variance
GIS	Geographic Information System
MDEP	Massachusetts Department of Environmental Protection
MDPH	Massachusetts Department of Public Health
MCL	maximum contaminant level
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
mL	milliliter
NWQL	National Water Quality Laboratory
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Acknowledgments

This investigation would not have been possible without the participation of the many well users who sent in water samples for analysis. Discussion and project planning with the late Elaine Krueger was instrumental for development of the project. Support from the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health is greatly appreciated.

Arsenic and Uranium in Water from Private Wells Completed in Bedrock of East-Central Massachusetts—Concentrations, Correlations with Bedrock Units, and Estimated Probability Maps

By John A. Colman

Abstract

Two U.S. Environmental Protection Agency drinking-water standards for public supplies involving groundwater contaminants that may derive from bedrock sources were promulgated between 2003 and 2006. A new arsenic drinking-water standard, a maximum contaminant level (MCL) of 10 micrograms per liter, became effective in January 2006. The non-radon radionuclides final standard took effect in December 2003, with an MCL for uranium of 30 micrograms per liter. This investigation, conducted in cooperation with the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health, assessed the concentration ranges of arsenic and uranium in bedrock wells with reference to the new concentration standards, and associations of arsenic and uranium with bedrock units of the wells of east-central Massachusetts. The investigation focused on east-central Massachusetts, because State public bedrock-well databases indicate that arsenic concentrations in bedrock well water are elevated in that area. The project exploited the wide areal coverage of private wells to give the first detailed look at concentration distributions of arsenic and uranium through the high-arsenic zone of Massachusetts. The results establish statistical probabilities for elevated concentrations by bedrock unit at the scale of the State geologic map (1:250,000), which can guide future well-water testing, treatment, and supply development.

Well sampling was from 478 randomly selected wells by private-well users who were sent sampling-kit bottles with instructions and a water-use questionnaire. Results indicated that 13 percent of the randomly selected wells contained water with concentrations greater than the drinking-water standard established for public wells for arsenic, and 3.5 percent were greater than the standard for uranium. Arsenic and uranium did not in general co-occur in water of a given well. Of the wells with concentrations exceeding the standards, the questionnaire results indicated that 66 percent were being used for drinking water without treatment for arsenic, and 93 percent were being used without treatment for uranium.

Statistical analysis of the results indicated that distributions of arsenic and uranium concentrations grouped by bedrock unit were log normal. Statistically significant differences were found among distributions by bedrock unit for both arsenic and uranium. However, a zone of elevated concentrations of arsenic was found in groundwater west of the Clinton-Newbury fault (a boundary between two geologic terranes), where correlation between arsenic concentrations and the bedrock units was not significant.

Increased sampling in the investigation was directed in the regions of three 1:24,000 (7.5-minute) quadrangles where recent detailed geologic mapping had been conducted. Improved correlations of arsenic and uranium with bedrock unit were measured for two of the three quadrangles compared to the correlations made for the statewide map.

Cumulative distribution frequencies of concentrations grouped by rock unit or area (zone of elevated arsenic concentration) were used to assess the probability of wells having concentrations exceeding the drinking-water standards. The probabilities were mapped and applied to the estimated number of private wells in the study area to determine the likely number of wells in the study area with concentrations exceeding the standards. For arsenic and uranium, respectively, about 5,700 and 3,300 wells were estimated to contain concentrations exceeding the standards. Estimates for arsenic may approach the total number for the State, because the study area covered the principal known area of elevated arsenic concentrations.

Introduction

Two U.S. Environmental Protection Agency (USEPA) drinking-water standards involving groundwater contaminants that may derive from bedrock sources were promulgated between 2003 and 2006. A new maximum contaminant level (MCL) standard of 10 micrograms per liter (µg/L) for arsenic in drinking water became effective in February 2002, with compliance required by January 2006. The non-radon radionuclides final rule took effect in December 2003, with an MCL for uranium of 30 µg/L. The standards apply to public water supplies. In Massachusetts, the Massachusetts Department of Environmental Protection (MDEP) recommends that the standards also be used as guidelines for private supplies (Massachusetts Department of Environmental Protection, 2008).

Private water supply in Massachusetts, exclusive of the sand and gravel aquifers of the southeastern part of the State, is obtained primarily from wells drilled in bedrock (Hansen and Simcox, 1994). Bedrock water sources also are used for small commercial water supplies and, in some locations, for moderate to large municipal and industrial supplies (Hansen and Simcox, 1994; Lyford, and others 2003). Tens of thousands of private and public bedrock wells are used in the State —91,000 private bedrock wells were estimated for the bedrock geologic units investigated in this study.

Arsenic has long been known to be present in water from bedrock wells in east-central Massachusetts (Zuena and Keane, 1985; Ayotte and others, 2003; 2006), and the State straddles an arsenic belt that extends from Connecticut to New Brunswick, Canada. Elevated uranium concentrations in water from bedrock wells have been associated with igneous rock throughout New England, but also are present in water from other crystalline rock aquifers in the region (Ayotte and others, 2007). This investigation, conducted by the U.S. Geological Survey (USGS) in cooperation with the Massachusetts Department of Environmental Protection (MDEP) and the Massachusetts Department of Public Health (MDPH), was designed to assess the concentration ranges and associations of arsenic and uranium with reference to the new concentration standards and to the classifications of the bedrock geologic units (hereafter bedrock units) in which the wells are drilled. The results can be used to establish statistical probabilities for elevated concentrations by bedrock unit, which can guide future well-water testing, treatment, and supply development.

Purpose and Scope

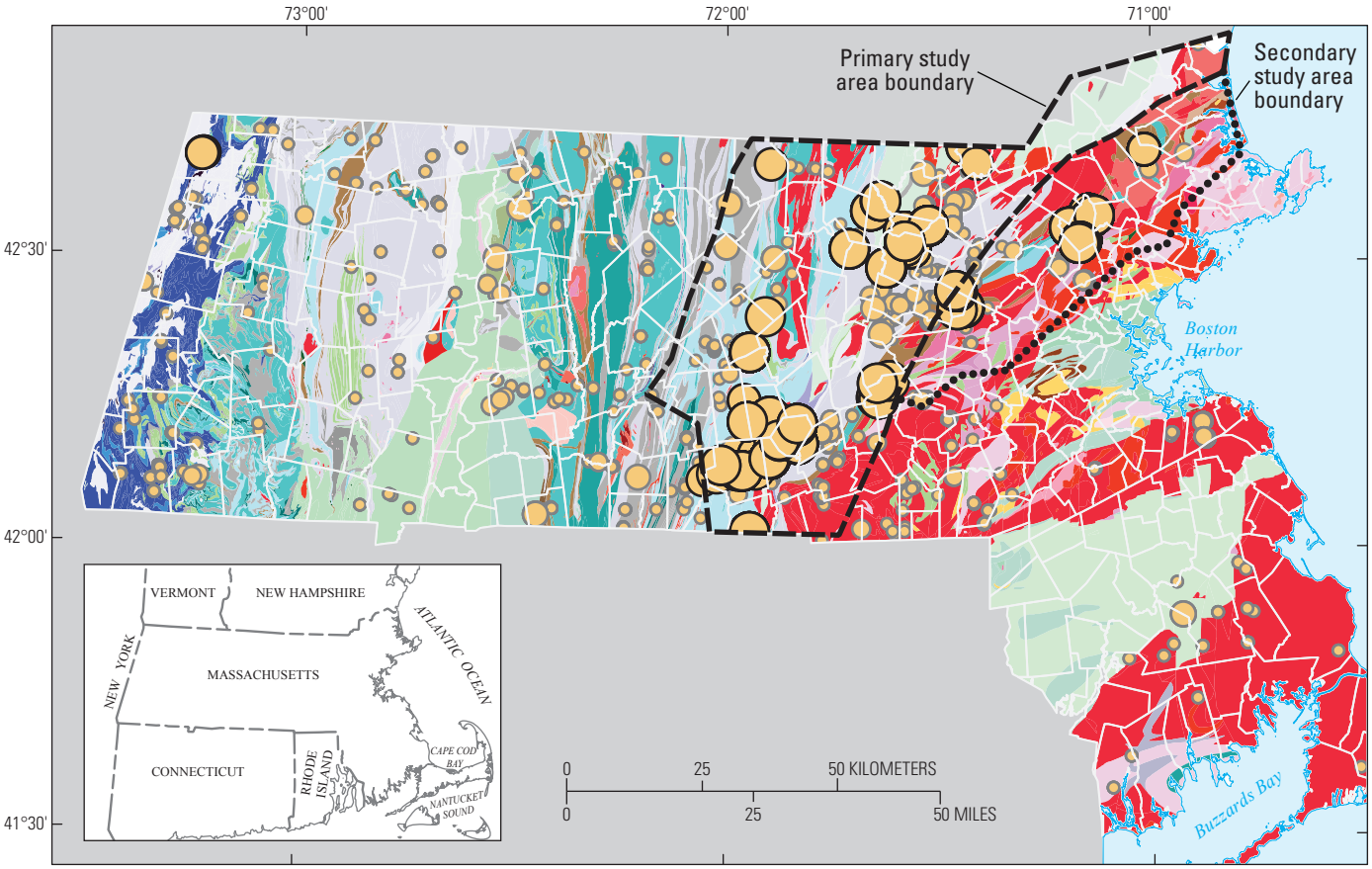
Information about bedrock associations of arsenic and uranium with bedrock well water are needed in Massachusetts to guide future well-water testing, treatment, and supply development. Probability distributions of well-water contaminants by bedrock unit will indicate the likelihood of contamination at a given concentration. Maps of these probabilities can be used to determine the likelihood of the presence of elevated arsenic or uranium concentrations in water of new wells in a given location or for directing testing priorities for existing wells.

The study encompasses the east-central arsenic belt in Massachusetts (fig. 1), the location of nearly all contamination of bedrock wells in the State by arsenic from a natural source. Many but not all wells contaminated by uranium are included in the same area, although igneous rocks, and likely uranium contamination, also occur outside the arsenic belt.

The principal focus of this report is the collection and interpretation of new data from 478 private bedrock wells. The amount of existing unpublished MDEP data from public bedrock wells is large, however, and may substantially supplement the number of observations per bedrock unit. The public bedrock-well data were used for qualitative analysis of the extent of contamination of bedrock units. The newly collected data were used to compute statistics of contaminant distribution. A reporting goal is to produce maps showing the probability statistic that concentrations of arsenic or uranium in well water exceed the drinking-water standards.

Health Effects of Arsenic and Uranium

Health effects from exposure to elevated concentrations of arsenic in drinking water have been established from studies in countries with very elevated levels of arsenic in water supplies, especially Taiwan (Smith and others, 1992; Lamm and others, 2003). Inorganic arsenic is well documented as a human carcinogen of the bladder, lungs, and skin (Centeno and others, 2007). Inorganic arsenic has also been demonstrated to affect many other organ systems, including the gastrointestinal, hepatic, cardiovascular, nervous, renal, and hematopoietic systems. A recent interest in arsenic in drinking water in the northeastern part of the United States relates to possible correlations with increased rates of bladder cancer in the region (Devasa and others, 1999; Ayotte and others, 2006). Epidemiological results demonstrating links between arsenic and health problems involve concentrations greater than the current USEPA drinking-water standard by an order of magnitude or more (National Research Council, 2001). Risk levels at



Base geology from Zen and others (1983), digitized by Nicholson and others (2007), scale 1:250,000, NAD 1983, StatePlane Massachusetts Mainland FIPS 2001, Lambert Conformal Conic projection

EXPLANATION

Town boundary

Arsenic, in micrograms per liter—Black-border symbols indicate concentrations greater than the U.S. Environmental Protection Agency public drinking-water standard

- < 1
- 1 – < 5
- 5 – < 10
- 10 – < 20
- 20 – 1,000

Figure 1. Arsenic concentrations in public bedrock wells in Massachusetts, 2008. Data from the Massachusetts Department of Environmental Protection. See figure 3 and appendix 1 for explanation of bedrock units in the east-central part of Massachusetts. <, less than

the standard are determined by extrapolation from the higher exposure studies. The National Research Council review for the National Academy of Science estimated the bladder cancer risk at about 12 to 23 per 10,000 persons with lifetime consumption of drinking water at 10 µg/L, the current public supply drinking-water standard. Lung cancer risk is estimated at about 14 to 19 per 10,000 persons at 10 µg/L (National Research Council, 2001).

Little is known about the long-term health effects on humans of exposure to low-level environmental uranium. Studies of occupationally exposed persons, such as uranium miners, have shown that the major health effect of uranium in the body is renal (kidney) toxicity (Leggett, 1989; Taylor and Taylor, 1997).

A discussion of the health effects of uranium in New England can also consider the effects of radium and radon, which are associated with uranium in crystalline bedrock aquifers (Ayotte and others, 2007). The association arises from the radioactive decay chain of uranium, which results in radium, through several radioactive decay product precursors. Radium decays directly to short-half-lived radon (3.8 days). Decay of radon results in four short-lived daughters and then longer-lived lead (22 years). Where uranium in drinking water is measured greater than the standard, analyses for radium and radon also could be done. Depending on the analysis technique, differential costs of analyses of the radionuclides means that uranium analysis may be an inexpensive indicator (when compared to gross alpha analysis) for determining the presence or absence of other radionuclides.

Previous Investigations

Several previous water-quality investigations exist for arsenic in New England and areas of Massachusetts. Investigations of uranium are more limited and cover the entire Northeast. The first published investigation to address the concerns of arsenic concentrations in private bedrock wells of New England referred to southeastern New Hampshire (Boudette and others, 1985). Bedrock and anthropogenic sources were analyzed, and the conclusion was drawn that the source was probably anthropogenic. A similar investigation of arsenic wells in Buxton, Maine, concluded that the likely source was bedrock (Marvinney and others, 1994). A three-town investigation in southern New Hampshire, very similar to the present Massachusetts investigation, reported the percentages of arsenic samples with concentrations greater than the 10 µg/L standard by bedrock unit (Montgomery and others, 2003). Several New England-based investigations have evaluated the risk for arsenic occurrence in the region—number of wells affected and probability maps of concentrations greater than or equal to 5 µg/L (for example, Karagas and others, 2002; Ayotte and others, 2003; 2006). Ayotte (2006) used a logistic regression based on many geologic, hydrologic, and anthropologic statistics for the region. A nationwide investigation of contaminants in private wells of selected aquifers included distribution plots of arsenic concentrations for the New England bedrock aquifer (DeSimone, 2009). The New England aquifer was the only aquifer investigated in the eastern United States with elevated concentrations of arsenic in private wells.

One survey of arsenic in private wells from Massachusetts is available from an investigation in Pepperell, Massachusetts (SEA Consultants, 1985). Water was analyzed from 300 wells, and 12 percent of them had concentrations that exceeded the 50-µg/L USEPA standard that was in effect at that time. Attempts to distinguish natural sources of arsenic in bedrock from anthropogenic sources, such as pesticides applied to orchards, were not successful.

Finally, a geologically based review of arsenic presence in the Northeast was published by Peters (2008). The investigation discusses arsenic presence in overburden and bedrock wells from natural and anthropogenic sources. Peters (2008) showed that arsenic concentrations were not correlated with iron concentrations in bedrock well water, and that elevated arsenic concentrations were associated with contacts between metamorphic and intrusive igneous rock.

Uranium was included in the DeSimone (2009) survey of private wells, including several overstandard samples in the New England crystalline-rock aquifers, but the study involved few samples from Massachusetts. In an investigation summarizing uranium and radon data from the northern United States, a correlation was found between uranium, radium, and radon in the New England bedrock aquifer (Ayotte and others 2007). Of the nine northern aquifers investigated, median concentrations of radon and uranium were highest and third highest, respectively, in the New England bedrock aquifer.

Investigative Design

The investigative design followed that of Montgomery and others (2003) in southeastern New Hampshire, addressing the correlations between bedrock units and concentrations of arsenic and uranium. The intent in this study was to cover the known elevated-arsenic areas in Massachusetts so that the assessment of arsenic contamination in the State would be advanced as much as possible. However, future studies may be necessary to characterize other parts of the State with limited areas of elevated arsenic.

Study Area

The primary study area (fig. 1), in east-central Massachusetts, was chosen to include the area of elevated results (greater than or equal to the USEPA drinking-water standard for public supplies, 10 µg/L) of arsenic in public wells (primarily bedrock) published from the MDEP database (Ayotte and others, 2003). Data reviewed after initiation of the project (J.A. Cerutti, Massachusetts Department of Environmental Protection, written commun., 2008; Ayotte,

2006) indicated additional elevated concentrations to the east of the principal study area and one elevated value in the northwest (fig. 1). The primary study area was augmented with a secondary study area (fig. 1) to cover the elevated concentrations in the east. By including the areas of known elevated concentration, the investigation would define arsenic occurrence in the principal areas of Massachusetts where concentrations could be expected to exceed the drinking-water standard.

Although the project study areas were determined on the basis of concentrations of arsenic in bedrock wells, the areas were also appropriate for investigation of uranium (fig. 2). MDEP data show that the arsenic-defined areas include many of the elevated concentrations of uranium in the State. The MDEP uranium coverage is less extensive than that for arsenic, so uranium concentrations are unknown in some areas. Not all of the bedrock units that may have elevated uranium were characterized in the present investigation; however, enough elevated-concentration units were included that correlations between uranium and bedrock unit would be apparent if uranium were controlled by rock type.

The distribution of bedrock units of crystalline igneous and metamorphic rocks in the study area is complex (fig. 3). The study area is crossed by major faults that divide parts of three geologic terranes that include the Merrimack belt, the Nashoba zone and the Milford-Dedham zone (Hatch, 1991, p. v, fig. 2). The primary study area includes most of the Merrimack belt, which extends from the Connecticut Valley belt (indicated by the Merrimack belt western boundary in fig. 3) to the Clinton-Newbury fault (fig. 3), and the western half of the Nashoba zone, which extends from the Clinton-Newbury fault to the Bloody Bluff fault (fig. 3). The secondary study area includes the remainder of the Nashoba zone and the western edge of the Milford-Dedham zone, which begins at the Bloody Bluff fault and extends to the east.

Geologic units are as defined in the digitized version (Nicholson and others, 2007) of the bedrock map of Massachusetts (Zen and others, 1983). The use of these maps to define geologic units for wells is, of course, only as accurate as could be determined from a 1:250,000-scale map. There is the chance that wells near a bedrock boundary may not be correctly assigned to a bedrock unit. Bedrock wells are on the order of 100 m deep and unscreened in their bedrock portions. As such, they may encounter geologic units at depth that are different from units as mapped at the surface. But, due to the scale of the map (1:250,000), only the major rock type is shown at the location of the borehole. For example, a borehole study in a 305-m deep well in Tyngsborough, Mass., is located in the Ayer Granite bedrock unit SOad, but the borehole contains xenoliths of the host metasedimentary Berwick Formation (unit Sb) (Pierce and others, 2007). The level of detail seen in boreholes cannot be displayed on a State-scale map, and detailed studies of individual boreholes are beyond the scope of this regional study.

Sampling Distribution

Well locations were chosen for the study areas by stratified random selection across the bedrock units. Previous arsenic-concentration data (Ayotte and others, 2003; Joseph Cerutti, unpub. data, 2008) indicated that arsenic was more prevalent in the 69 bedrock units of the primary study area, so more sampling was directed at this area. One sampling objective was to collect at least seven samples per bedrock unit so that statistical inference could be made even for small units. So that large units would have coverage throughout their extent, a second objective was applied to supplement the initial seven samples by an additional one sample per 20 km^2 for units 20 km^2 and larger. The largest unit, the Paxton Formation (Sp), is 822 km^2, so the sampling objective for this unit was 48 wells. In the secondary area, the selection objective was 5 wells for each of the 12 bedrock units investigated.

Although a minimum of seven sites per unit in the primary study area was desired, some small units did not have this number of private wells (or even residences) available. Also, areas with public water supplies were necessarily excluded from the investigation, which left gaps in data for some units. These unavoidable exclusions of sampled areas biased the study toward areas where bedrock wells existed.

Wells were selected using randomly generated geo-coordinates and matching closest Google-Earth determined locations of well addresses to well lists provided by the Massachusetts Department of Conservation and Recreation. Locations of the selected sites were moved from the street locations provided by Google Earth to positions of the building at that address using field observations of addresses and buildings, and georeferenced ORTHO photos (Massachusetts Office of Geographic Information (MassGIS), 2005).

Increased sampling in the investigation was directed in the regions of three 1:24,000 (7.5 minute) quadrangles where recent detailed geologic mapping had been conducted. Comparisons of correlations of arsenic and uranium with geologic units based on 1:250,000-scale mapping to those based on more recent 1:24,000-scale mapping could indicate the efficacy of remapping for arsenic and uranium delineation and for correlation with bedrock.

Sample Collection and the Well-User Questionnaire

Samples were collected by private well users during spring and summer of 2009, using bottles included in a sampling kit mailed to the residence at the location of the well. The kit included two labeled 125-mL bottles, a business reply Tyvek® envelope, and a questionnaire to determine water-use practices at the site, as well as to inform the bottle recipients about the program and how to collect the water sample (app. 2). Twice as many sampling kits were mailed out compared to the number required to meet the sampling

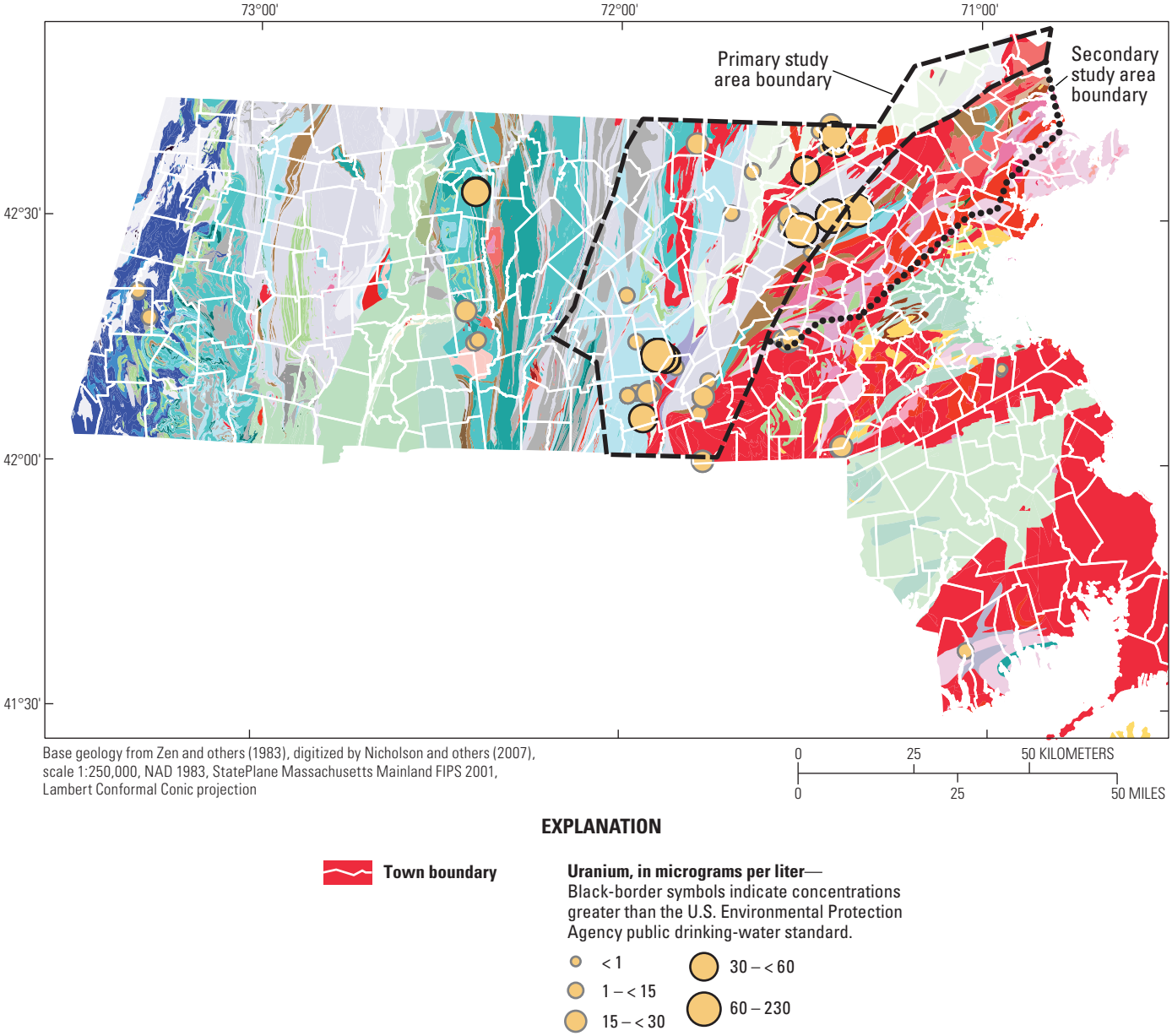


Figure 2. Uranium concentrations in public bedrock wells in Massachusetts, 2008. Data from the Massachusetts Department of Environmental Protection. See figure 3 and appendix 1 for explanation of bedrock units in the east-central part of Massachusetts. <, less than

objective for each rock type. A 50-percent return rate was expected, based on return rates from a similar investigation in New Hampshire (Montgomery and others, 2003). Well users were given 1 month to reply before a followup card was sent. If no reply had been received by 2 months after the followup card, the site was dropped from the study.

Sample Processing and Analytical Methods

All samples were collected by the residents living at the addresses selected for sampling. The samples were returned in a Tyvek® envelope by mail to the USGS office in Northborough, Mass. Samples intended for trace-constituent analysis were acidified to a pH less than 2 in the Northborough laboratory with 0.4-mL analytical-grade concentrated nitric acid (HNO_3). The acidified samples were sent to the USGS National Water Quality Laboratory (NWQL) in Denver, Colo., for analysis as listed in table 1. At the laboratory, samples were subject to an in-bottle acid digestion before analysis so that results represented total constituent values.

Supplemental Data

Additional data (1997 to 2007) on arsenic and uranium in bedrock wells were retrieved from the database of the MDEP (Joseph Cerutti, unpub. data, 2008) (figs. 1 and 2). The data were from analyses of water in public wells and were screened to include only data from bedrock wells. Although the results likely were relevant to the investigation, some differences prevented a simple combination of the data with that collected during this investigation. Different and multiple laboratories (State certified) were used for the analyses for MDEP data than were used for the USGS data. Greater water use may be expected from the public wells in the MDEP database compared to the private wells in the USGS database. The MDEP data were used to help define the areal distribution of arsenic and uranium but were not used in statistical summaries of occurrence of these constituents.

Statistical Comparisons

Parametric statistical tests were used, which are appropriate if normality or any other specific distribution (log normal in this investigation) can be assumed (Iman and Conover, 1983). Analysis of associations of concentration with bedrock unit was determined by one-way analysis of variance (ANOVA) on log-transformed concentration data, using the statistical software package Minitab 16®. Cumulative distribution functions with 95-percent confidence intervals were determined for concentration populations grouped by bedrock unit by fitting data to a log-normal distribution, using the statistical software package Minitab 16® with the options for distribution analysis, and arbitrary data censoring. For bedrock units with fewer than five analyses with concentrations exceeding the analytical reporting limit, the option to assume a common scale was used in the distribution fitting.

The statistical software package SPLUS® was used to compare geologic mapping techniques and the correlation with arsenic and uranium concentrations. The comparisons were made with a multiple linear regression of log-transformed data.

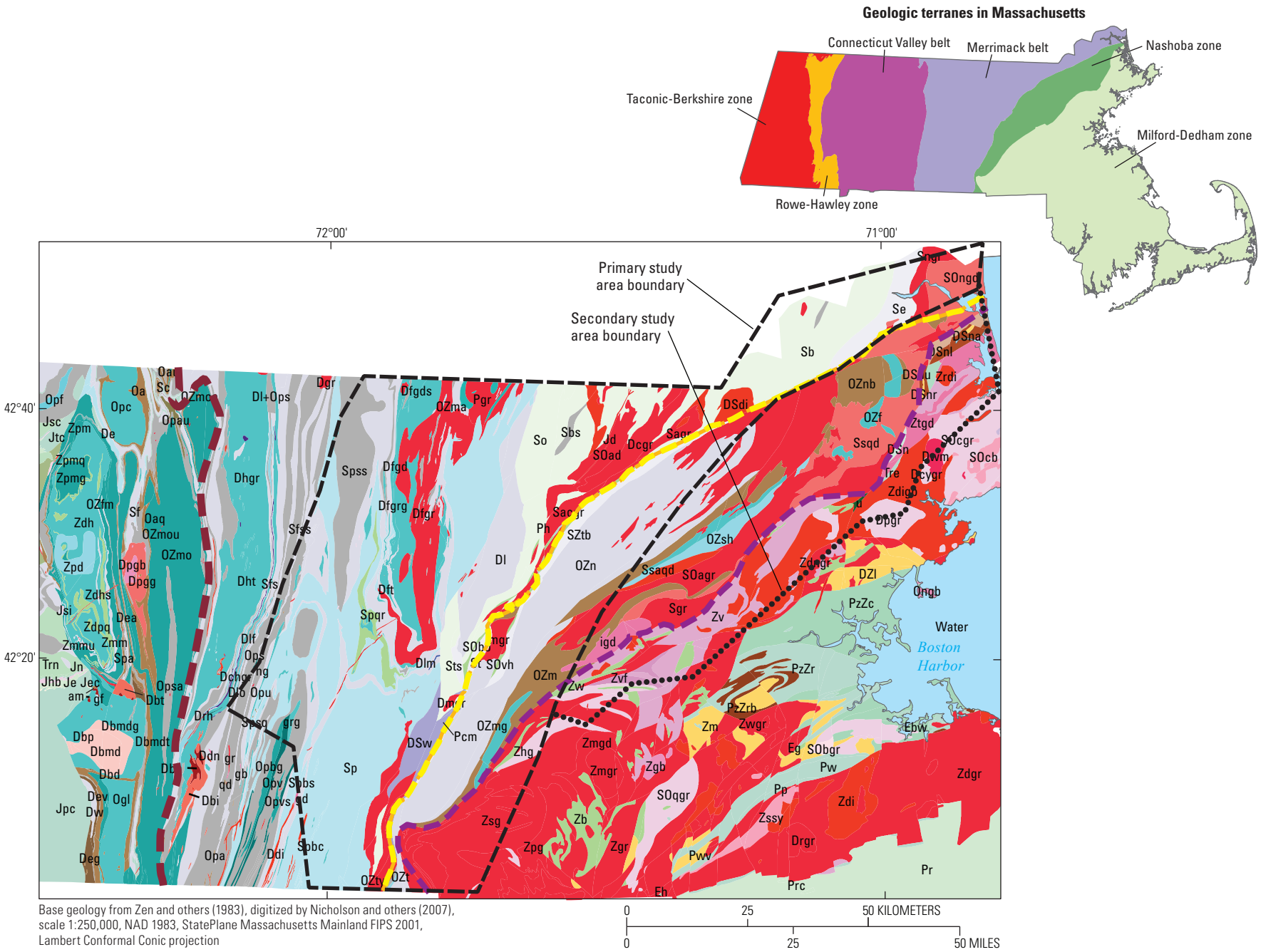
Arsenic and Uranium Concentrations and Correlations with Bedrock Units

The ranges and correlations of arsenic and uranium concentrations among bedrock units are the focus of this project. The project objective is to use the correlations to guide future well-water testing, treatment, and supply development.

Quality Assurance and Other Data Attributes

During the investigation, 60 quality-assurance samples were analyzed for iron, manganese, arsenic, and uranium. The quality-assurance samples included sampling-bottle and preservation-acid blanks, a standard-reference sample, resampling, duplicate sampling, and sample splits (table 2). Quality-assurance results of the blank samples showed that possible contamination did not occur during sampling, during sample handing, or from sampling materials (the bottles and preservation acid). All concentrations measured for the four sampling-bottle blanks during the study were below the reporting limits (table 1) for the respective analytes (table 2). Four samples of standard reference solution (USGS T-195) submitted to the NWQL as blind samples were generally within 5 percent of the known values. Average percent errors (average, in percent, of the absolute difference between replicate pairs divided by the average of the replicates) increased for all elements in the comparison series: split samples, duplicate samples separated by 5 minutes, and duplicate samples separated by months (average interval of 80 days). The error increase reflected variability in samples over time—small, but measureable for samples collected within 5 minutes, and larger for samples collected months apart.

Variability of concentrations over time was investigated by analysis of 48 duplicate samples. USGS personnel visited 12 randomly chosen wells where three samples were collected at each well: duplicate samples within 5 minutes and a third sample to compare with the original sample collected by the well user. Results showed that repeatability for samples collected sequentially at one visit was very good, but that substantial variation can occur for a well sampled over time (fig. 4). Sampling error from additional sources is possible in resampling over time, including the possibility of sampling from different water taps by mistake.



Base geology from Zen and others (1983), digitized by Nicholson and others (2007), scale 1:250,000, NAD 1983, StatePlane Massachusetts Mainland FIPS 2001, Lambert Conformal Conic projection

EXPLANATION

Rock type	Bedrock
alkali-granite (alaskite)	Dcygr Dpgr SOcgr SOqgr Zagr Zhg
amphibolite	am Dea Oa Opa OZm OZmoa OZnb Spa
andesite	DSna
argillite	Ebw Eh PzZc
arkose	Jm Jn Trn
augen gneiss	Opau
basalt	DSnl
biotite gneiss	Opau Opvs OZfm OZmo Zpm Zpmg
calc-silicate rock	Sfs
conglomerate	Jec
dacite	Dbd
diabase	Jd
diorite	Ddi Ddn di DSdi Ssaqd Zdi Zdigb Zrdi
felsic gneiss	Dlf Opf
felsic metavolcanic rock	Zvf
gabbro	Dpgb gb Ongb Zgb
gneiss	Drh OZsh OZtf Zpd
granite	Dcgr Cmgr Drgr gr mgr Pgr Sacgr Sagr Sgr Sngr SOad SOagr Zdgr Zdngr Zgr Zmgd Zmgr Zpg Zsg Zwgr
granitic gneiss	Dbmdg Dchgr Dfgd Dfgds Dfgrg Dhgr Dht grg Ogl Opc OZf OZmg Zdh

Rock type	Bedrock
granodiorite	Dgd gd igd Ztgd
granofels	De gf Sf Sp Spbc Spbs
granulite	Deg
hornblendite	Dbh Oau
mafic gneiss	Dchh Dlo hg Opv
mafic volcanic rock	PzZrb
marble	Dlm
metasedimentary rock	Sb So
metavolcanic rock	Zv
mica schist	Dev Dl+Ops Ops Opsa OZty Sbs Sfss
monzonite	Dwm
mudstone	DSnu
mylonite	Jfg
paragneiss	OZma
pegmatite	Dpe
peridotite	Dbp OZmou Zmmu
phyllite	Dgm Se SObo Sts SZtb
porphyry	SObgr
quartz diorite	Dbi
quartz monzodiorite	Dbmd Dbmdt

Rock type	Bedrock
quartzite	Eg Oaq PZfmg SOvh Soqr St Zb Zdpq Zpmq Zw
rhyolite	DSnr DZl Pwv Zm
sandstone	Je Jsm Jt Pr Prc
schist	Dl Dw OZn OZt Spsq Zdhs Zmm
sedimentary breccia	Jma
sedimentary rock	DSn
serpentinite	u
slate	DSw Pcm
syenite	SOcb Zssy
tonalite	Dbt Dft Dpgg SOngd Ssqd
tuff	Jgb
ultramafic intrusive rock	Opu

Merrimack belt western boundary

Bloody Bluff fault

Clinton-Newbury fault

Figure 3. Bedrock units and principal faults in the project study area of east-central Massachusetts. See appendix 1 for explanation of bedrock units. Map colors from Moyer and others, 2005.

Table 1. Chemical analytical methods used in the arsenic and uranium study, east-central Massachusetts, 2009.

[NWQL, U.S. Geological Survey National Water Quality Laboratory, Denver, Colo.; NA, not applicable; ºC, degrees Celsius]

Constituent	Units	Method	Reporting limit	Method reference
Acid neutralizing capacity	Milligrams per liter as calcium carbonate	Auto titrator at the USGS Northborough lab	NA	Rounds, 2006
Conductance	Microsiemens per centimeter at 25 °C	Orion conductance probe at the USGS Northborough lab	NA	Radtke and others, 2005
pH	pH log units	Initial pH from alkalinity titration at the USGS Northborough lab	NA	Ritz and Collins, 2008
Arsenic	Micrograms per liter	In-bottle acid digestion followed by collision/reaction cell inductively coupled plasma/collider mass spectrometry at NWQL	0.2	Garbarino and others, 2006; Garbarino and Struzeski, 1998
Iron	Micrograms per liter	In-bottle acid digestion followed by inductively coupled plasma-atomic emission spectroscopy at NWQL	14	Garbarino and others, 2006; Garbarino and Struzeski, 1998
Manganese	Micrograms per liter	In-bottle acid digestion followed by inductively coupled plasma/collider mass spectrometry at NWQL	0.4	Garbarino and others, 2006; Garbarino and Struzeski, 1998
Uranium	Micrograms per liter	In-bottle acid digestion followed by inductively coupled plasma/mass spectrometry at NWQL	0.02	Garbarino and others, 2006; Garbarino and Struzeski, 1998

Return Rates for the Water Samples

Of the total 1,580 sample kits sent to well users, samples from 478 wells were returned, a 30-percent return rate. The low return rate resulted in several bedrock units that had too few samples for statistical analysis.

Water Use and Water Quality at Sampled Wells

Results from the returned questionnaires indicate that 91 percent of the respondents use their well water for drinking. Many users treat the water in some way including softening, radon removal, arsenic removal, and reverse osmosis. Of the respondents with wells having arsenic concentrations exceeding the drinking-water standard, however, 66 percent were using water for drinking without treatment. Of the respondents with wells having uranium concentrations exceeding the standard, 93 percent were using water for drinking without treatment. The statistic included one respondent that was not using the water for drinking because it had not been tested. Thus, none of the respondents with wells having uranium concentrations exceeding the standard were treating the water for uranium removal.

Arsenic Concentrations

Arsenic concentrations in the complete dataset ranged from less than 0.2 µg/L (less than the laboratory reporting limit) in 24 percent of all samples tested to 1,540 µg/L. Of the 344 randomly selected samples (excluding intensive quadrangle sampling), 13 percent exceeded the 10 µg/L drinking-water standard. For randomly selected samples from the primary study area, a slightly larger fraction of samples,

Table 2. Quality-assurance results for arsenic, iron, manganese, and uranium.

[USGS, U.S. Geological Survey]

Quality-assurance measure	Details	Number of samples	Result
Bottle blanks	Sample bottles had been sent out in mailers, and were preserved with acid	4	All concentrations were less than the method detection limit
Standard reference samples	USGS standard reference water sample, number T-195	4	Mean relative errors were Arsenic: 4.9 percent Iron: 2.4 percent Manganese: 0.62 percent Uranium: 5.6 percent
Sample splits	One sample split for two analyses	13	Mean relative errors were Arsenic: 3.8 percent Iron: 1.8 percent Manganese: 6.2 percent Uranium: 0.74 percent
Duplicates at one time	Samples collected sequentially on one sampling occasion	13	Mean relative errors were Arsenic: 5.8 percent Iron: 11.3 percent Manganese: 15.1 percent Uranium: 3.3 percent
Duplicates over time	Two samples collected on different sampling days	13	Mean relative errors were Arsenic: 49.5 percent Iron: 80.1 percent Manganese: 61.2 percent Uranium: 74.3 percent

15 percent, exceeded the standard. Concentrations of arsenic were not elevated in the 18 samples west of the primary study area, but some elevated concentrations were measured in the secondary study area, located east of the primary study area (fig. 5). Elevated concentrations can exist near low concentrations in the same bedrock unit, similar to distributions measured in other New England studies (Montgomery and others, 2003).

Arsenic Correlations with Bedrock Units

Arsenic concentrations in well water vary depending on the bedrock unit (fig. 6). Generally, concentrations are not narrowly distributed but rather extend above and below the median concentration for the bedrock unit by an order of magnitude or more. Although there are no bedrock units with elevated concentrations that do not also include low concentrations, there are some units with only low concentrations. One of the lowest-concentration units, Ops, is on the western edge of the study area, confirming the western limit to the elevated-concentration area in east-central Massachusetts. Each of the rock classifications of metamorphic, metamorphic with igneous intrusive, and igneous includes low-concentration and elevated-concentration units.

The variation within a bedrock unit indicates that median concentrations cannot be used for accurate predictions of concentrations in a unit. Concentrations in bedrock units are generally log normally distributed, so parametric statistical tests can be used to determine whether bedrock units and concentrations are related, or if distributions among bedrock units are significantly different. If a relation exists, probabilities of a bedrock well containing a given concentration may be calculated for each bedrock unit from cumulative distribution frequencies.

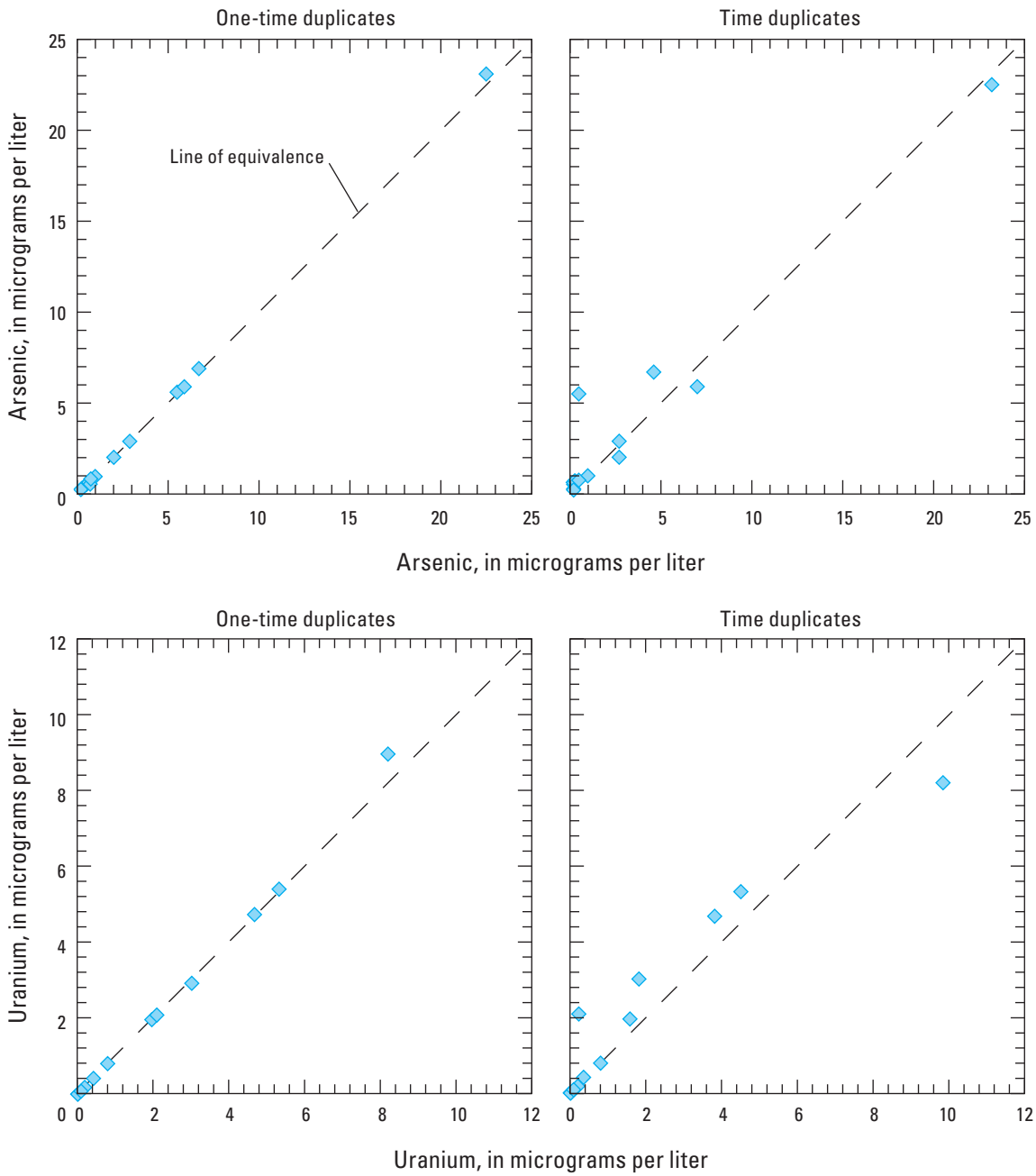
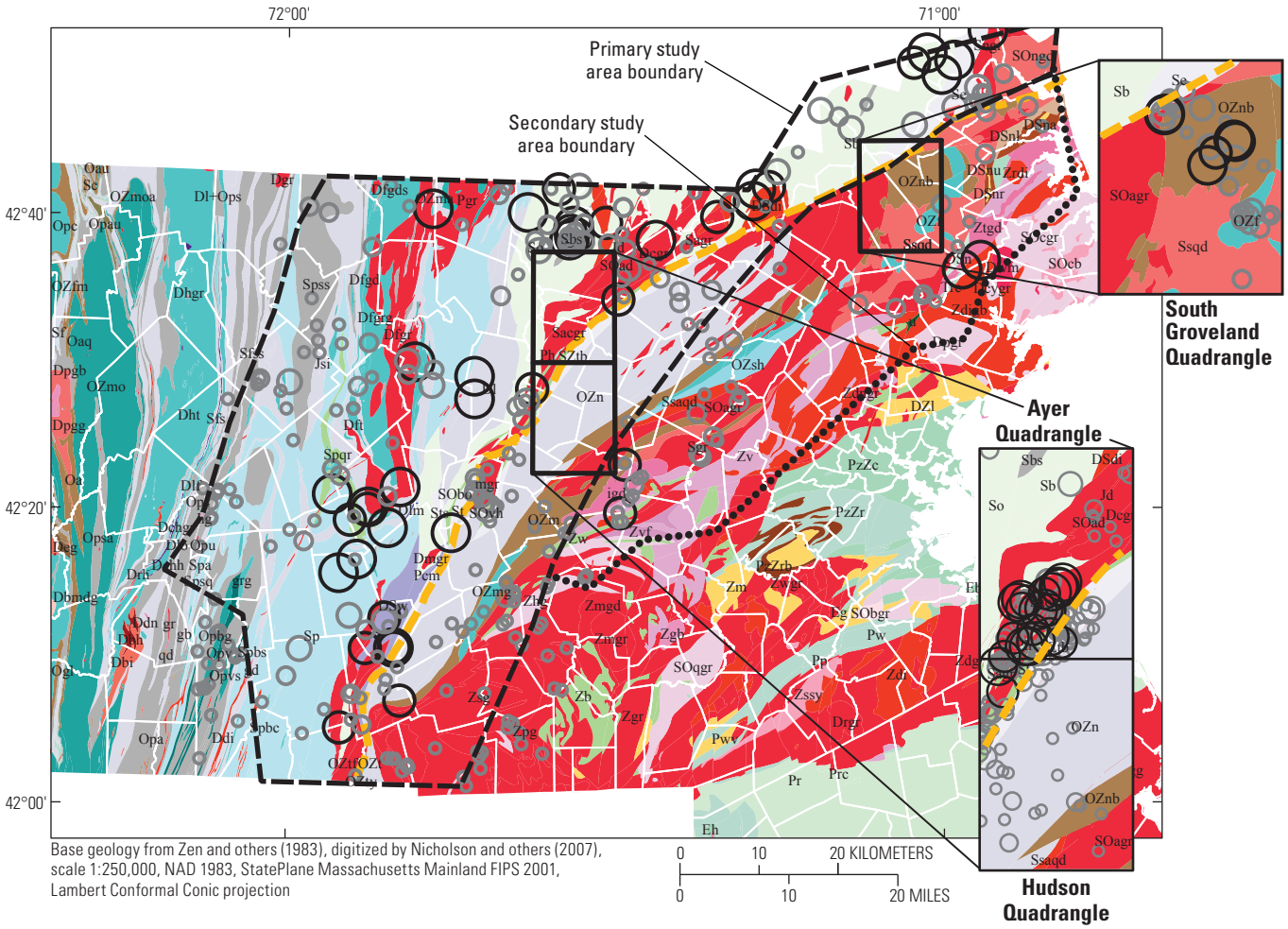


Figure 4. Arsenic and uranium sample duplicates collected on the same day and after about 80 days, east-central Massachusetts, 2009.



EXPLANATION

Town boundary

Clinton-Newbury fault

Arsenic, in micrograms per liter—Black-border symbols indicate concentrations greater than the U.S. Environmental Protection Agency public drinking-water standard.

- < 1
- 1 – < 5
- 5 – < 10
- 10 – < 20
- 20 – 1,540

Figure 5. Arsenic concentrations in east-central Massachusetts, 2009. Sampling coverage was increased in the areas of the insert maps where geology was mapped at the 1:24,000 scale. See figure 3 and appendix 1 for explanation of bedrock units. <, less than

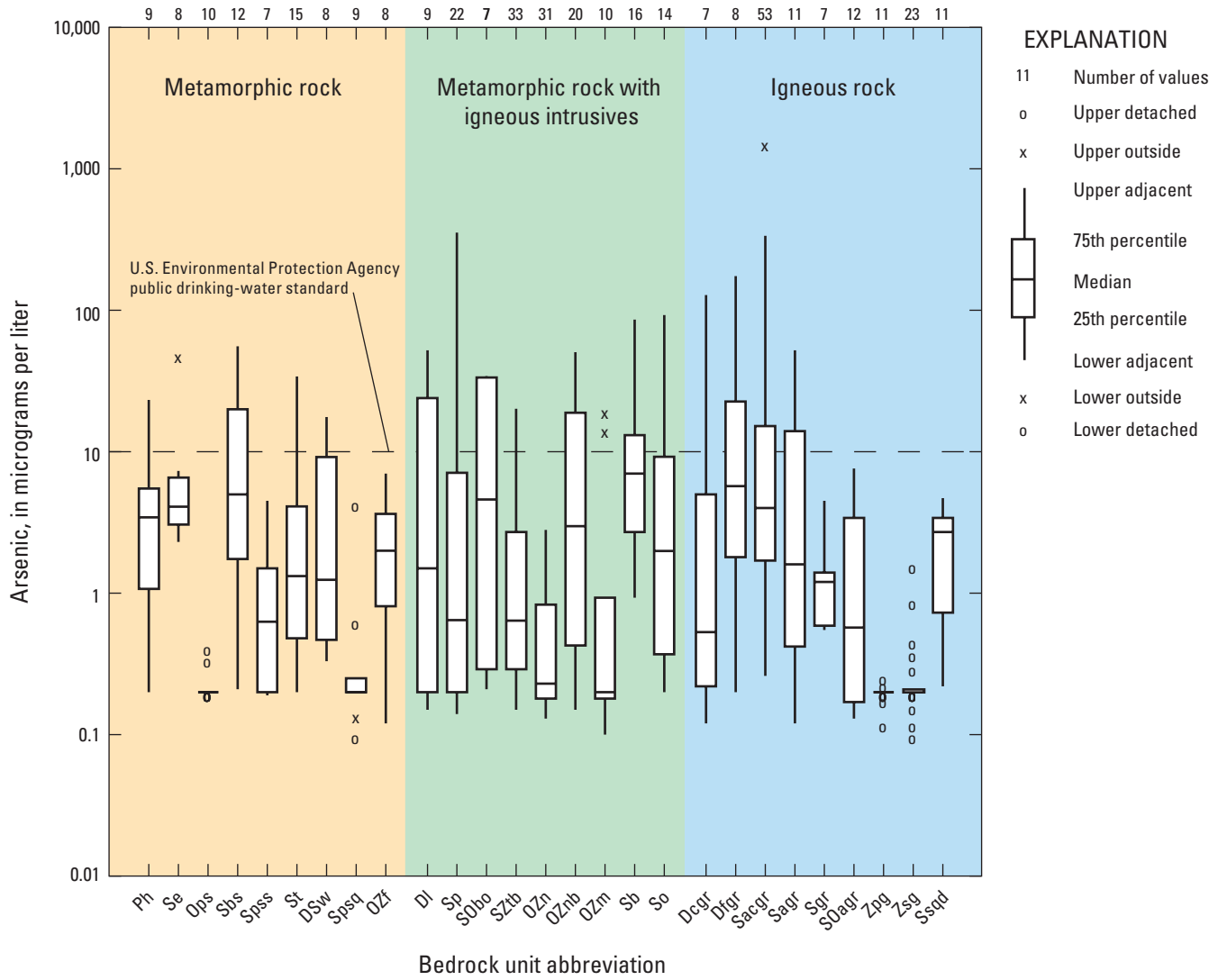
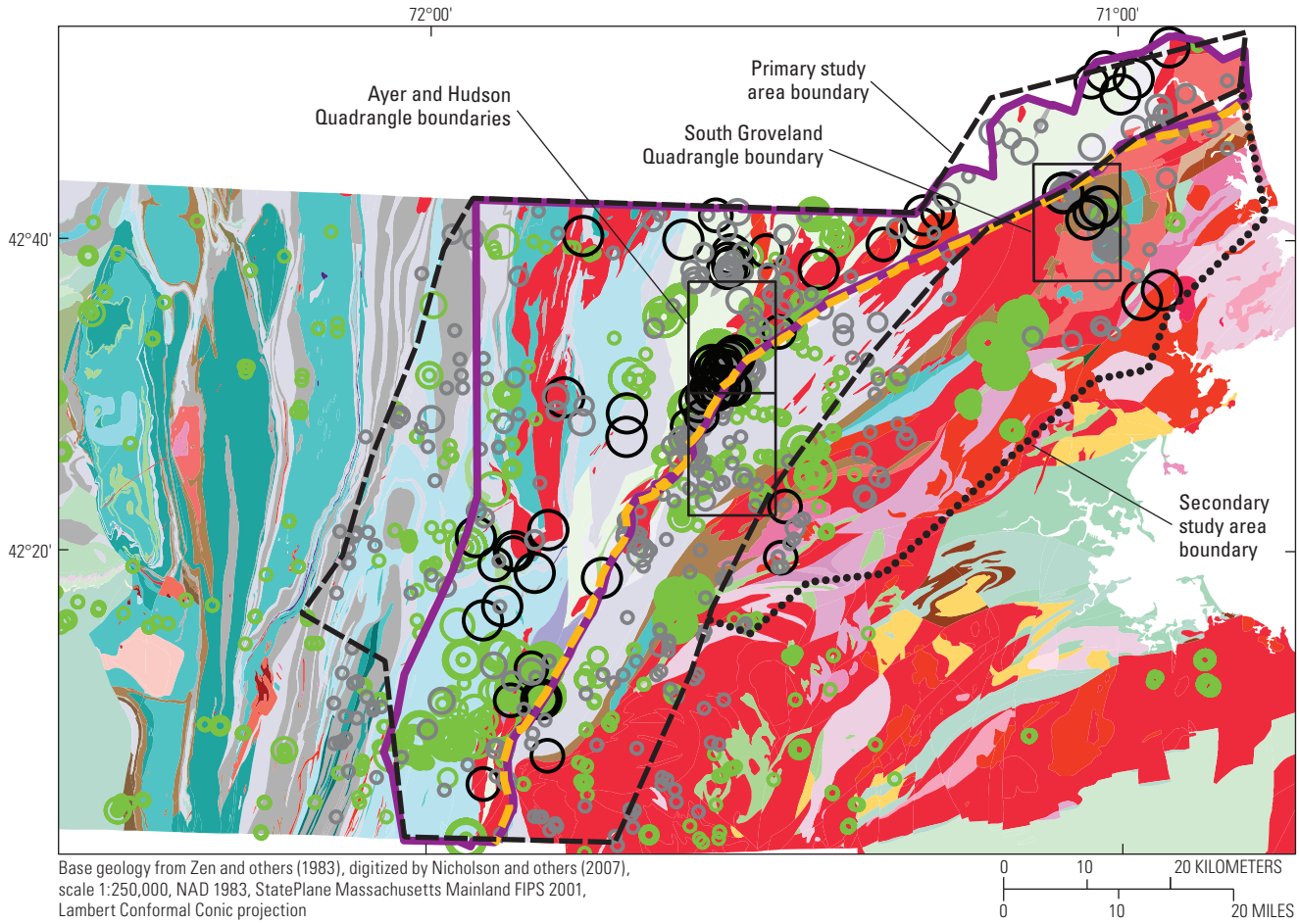


Figure 6. Distribution of arsenic concentrations by bedrock unit, with seven or more samples, in the primary and secondary study areas, east-central Massachusetts, 2009. See figure 3 and appendix 1 for explanation of bedrock units.

Arsenic concentrations north and west of the Clinton-Newbury fault are elevated (fig. 5). The fault marks a boundary between the Merrimack belt and Nashoba zone (fig. 3), and bedrock units do not extend across the fault boundary. The elevated arsenic concentrations extend approximately 20 km west and northwest of the fault. Within the 20-km zone, elevated concentrations were measured across a variety of bedrock unit rock types. Beyond the 20-km distance, sometimes within a rock type that has elevated concentrations near the fault, concentrations decrease. Lower concentrations of arsenic were measured in the large bedrock unit (OZn) east of the Clinton-Newbury fault. However, some elevated arsenic concentrations occur east of the fault, particularly in the OZnb unit.

An elevated-concentration area was defined as being bounded on the east by the Clinton-Newbury fault and extending westward to include all the concentrations measured greater than 10 µg/L (fig. 7). MDEP data were combined with the USGS data to define the western part of the elevated-concentration area. One-way ANOVA analysis was used to assess the relations between concentration and bedrock unit in the elevated-concentration area. Within the elevated-concentration area, there was no statistically significant difference at the 5-percent level between log-transformed concentration distributions, grouped by bedrock unit (fig. 8).



EXPLANATION

Boundary of elevated arsenic concentration area

Clinton-Newbury fault

Arsenic, in micrograms per liter—Black-border symbols indicate concentrations greater than the U.S. Environmental Protection Agency public drinking-water standard.

Massachusetts Department of Environmental Protection sites	U.S. Geological Survey sites
< 1	< 1
1 – < 5	1 – < 5
5 – < 10	5 – < 10
10 – <20	10 – <20
20 – 1,540	20 – 1,540

Figure 7. Arsenic concentrations, including Massachusetts Department of Environmental Protection data, showing elevated concentrations west of the Clinton-Newbury fault, east-central Massachusetts. <, less than

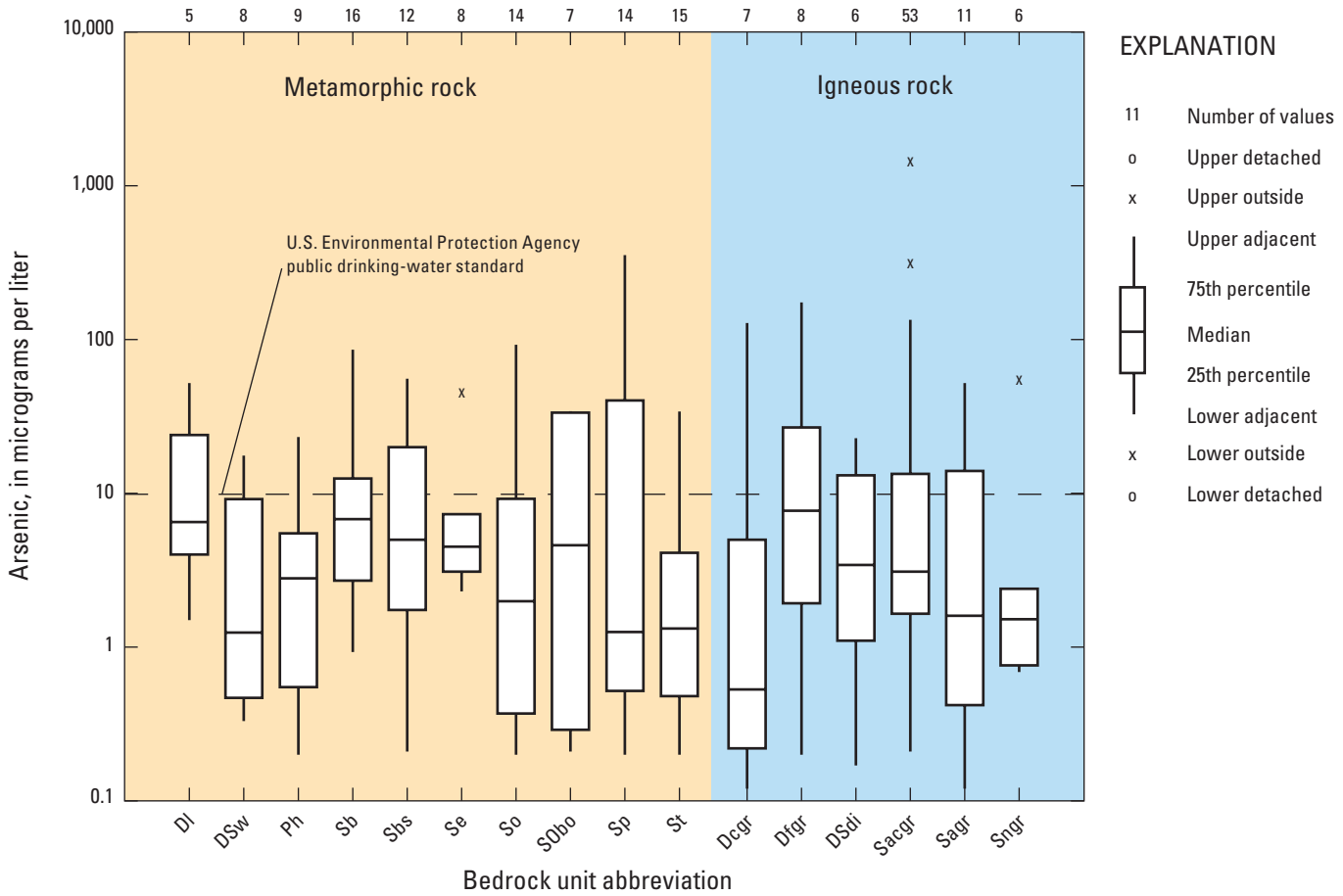
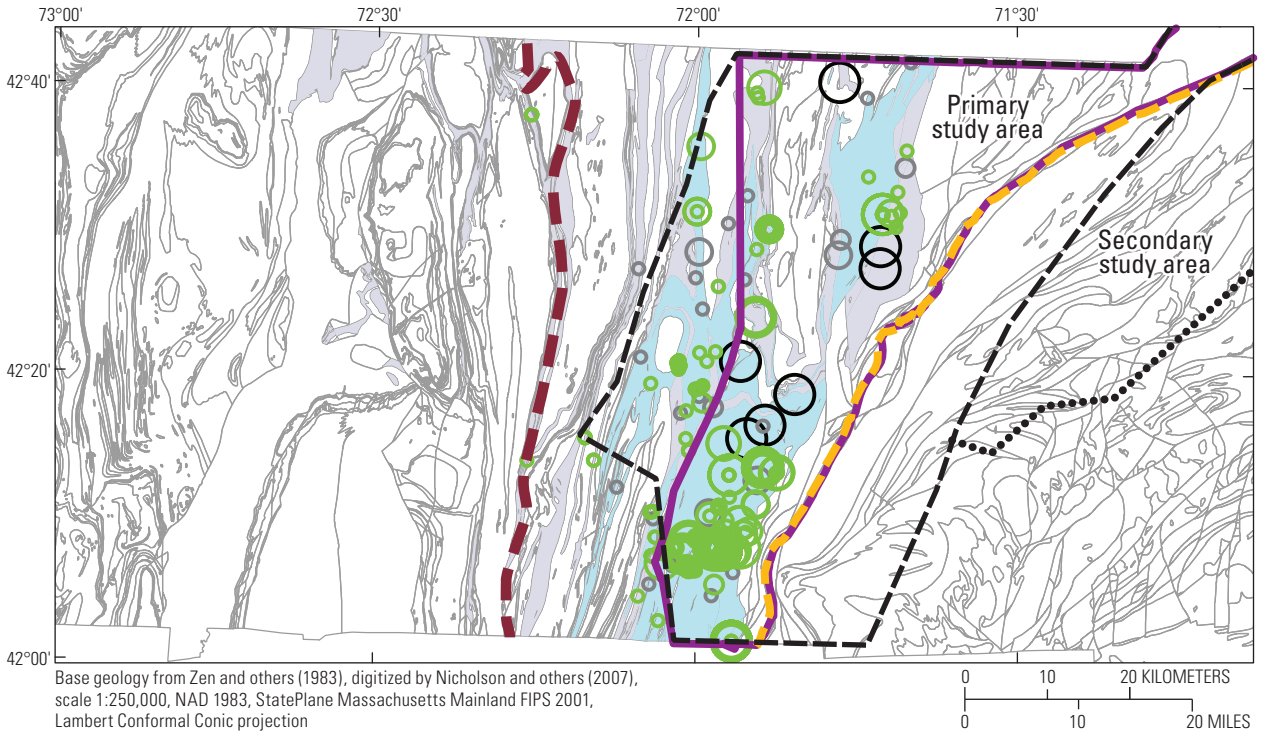


Figure 8. Distribution of arsenic concentrations by rock type in the elevated-concentration area, where differences in concentrations by unit were not significant, east-central Massachusetts. See figure 3 and appendix 1 for explanation of bedrock units.

Two of the bedrock units (Sp and Dl) inside the elevated-concentration area also extend outside the elevated-concentration area, where no concentrations exceeded the standard (fig. 9). Comparison of the data in the two units that cross the area boundary indicated that the difference across the elevated-concentration boundary, but within a bedrock unit, was statistically significant (fig. 10). These statistics indicate that the high-concentration area is within the Merrimack belt, but does not extend to the western boundary of the belt (fig. 9).

Three bedrock units with seven or more samples (Ops, Spss, and Spsq) were west or mostly west of the elevated-arsenic area. Concentrations in these bedrock units were significantly different from the grouped elevated arsenic area adjacent to the west.

A different pattern is observed east of the fault. Most striking is the difference between the bedrock unit SZtb, aligned with the Clinton-Newbury fault, and the bedrock unit OZn, adjacent to the east (fig. 5). Because of extra sampling in the area of the remapped quadrangles, there is an excellent



EXPLANATION

Bedrock unit

- Sp
- Dl
- **Boundary of elevated arsenic concentration area**
- **Clinton-Newbury fault**
- **Merrimack belt western boundary**

Arsenic, in micrograms per liter—Black-border symbols indicate concentrations greater than the U.S. Environmental Protection Agency public drinking-water standard.

Massachusetts Department of Environmental Protection	U.S. Geological Survey sites
< 1	< 1
1 – < 5	1 – < 5
5 – < 10	5 – < 10
10 – <20	10 – <20
20 – 1,540	20 – 354

Figure 9. Arsenic concentrations inside and outside the elevated-arsenic area in bedrock units Dl and Sp. Data from the U.S. Geological Survey and the Massachusetts Department of Environmental Protection. See figure 3 and appendix 1 for explanation of bedrock units. <, less than

visual indication of arsenic concentration association with geology (inset map, fig. 5). One-way ANOVA analysis shows significant concentration differences between lower-concentration (OZn, Zhg, Zpg, Zsg, and Zw) and higher-concentration (SZtb and OZnb) units. The amphibolite-bearing rocks, OZnb, have elevated arsenic. Although not used for statistics, the MDEP dataset includes elevated concentrations in the southern parts of the amphibolite unit (fig. 7), which appears to indicate that the association is rock specific, not region specific as was found in the elevated concentration area in the west.

One-way ANOVA analysis of log-arsenic concentration in the rocks east of the Clinton-Newbury fault indicates that the arsenic concentrations in the OZnb unit are significantly higher than in the OZn unit (fig. 11). In this region east of the Clinton-Newbury fault, the mapped bedrock units indictate the distribution of arsenic concentrations. The OZnb unit extends well outside the primary study area and, as such, extends the area where elevated arsenic concentrations may be expected in Massachusetts from previous estimates (Ayotte and others, 2003).

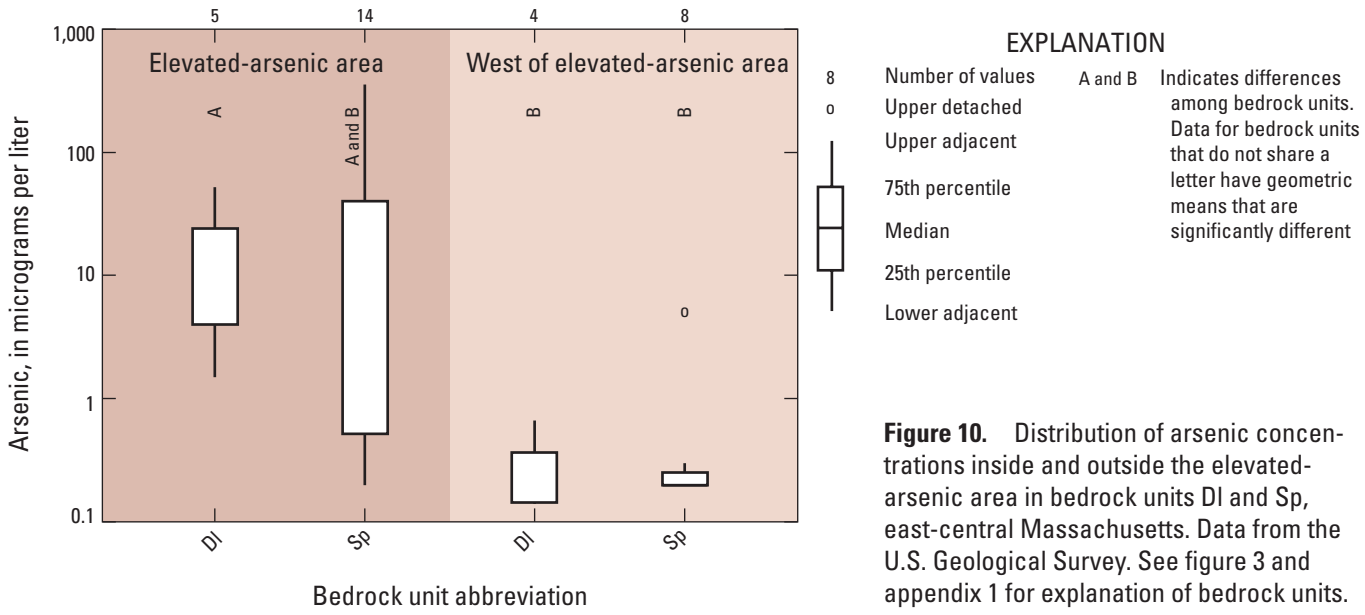


Figure 10. Distribution of arsenic concentrations inside and outside the elevated-arsenic area in bedrock units Dl and Sp, east-central Massachusetts. Data from the U.S. Geological Survey. See figure 3 and appendix 1 for explanation of bedrock units.

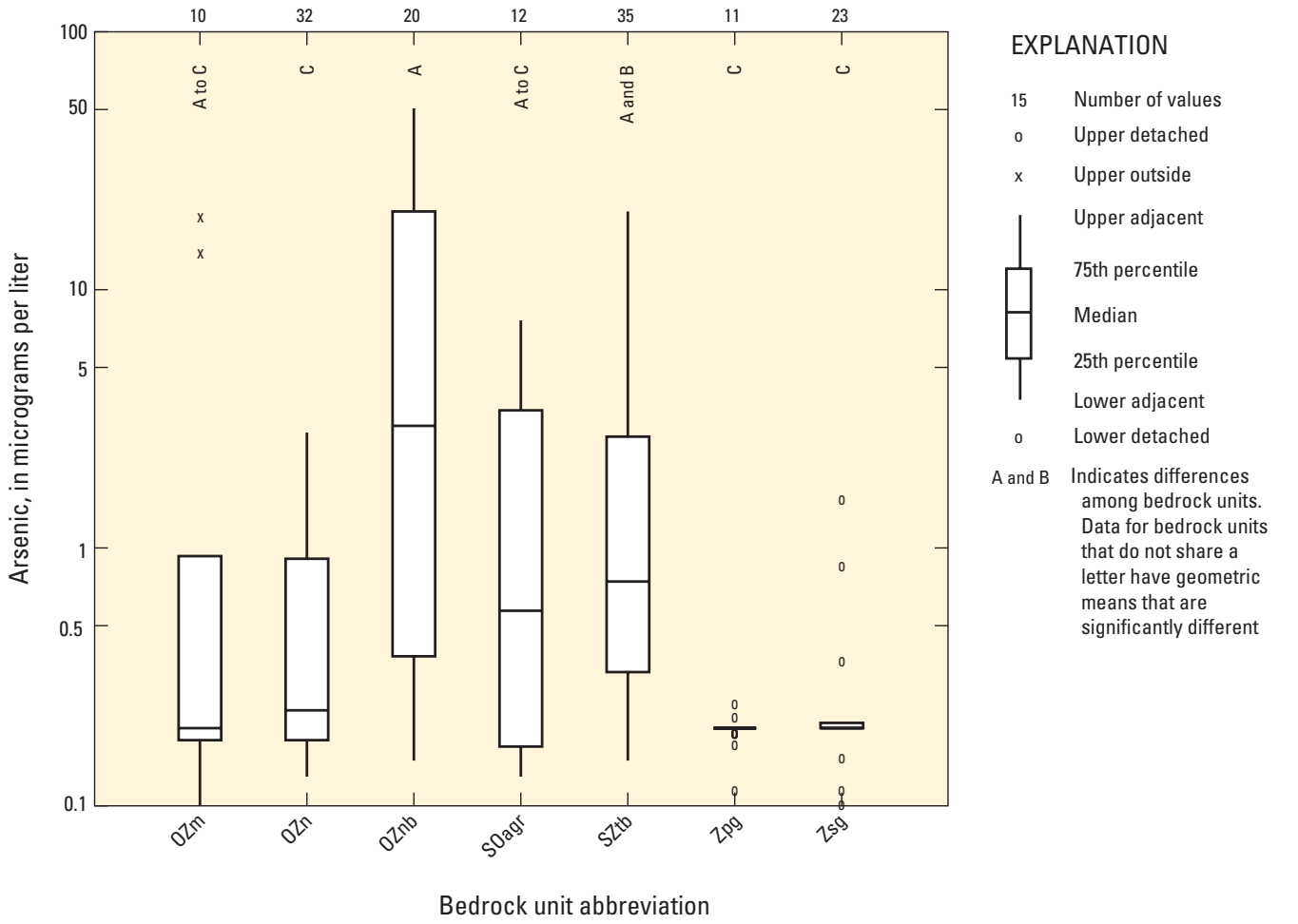


Figure 11. Distribution of arsenic concentrations by bedrock unit east of the Clinton-Newbury fault, east-central Massachusetts. See figure 3 and appendix 1 for explanation of bedrock units.

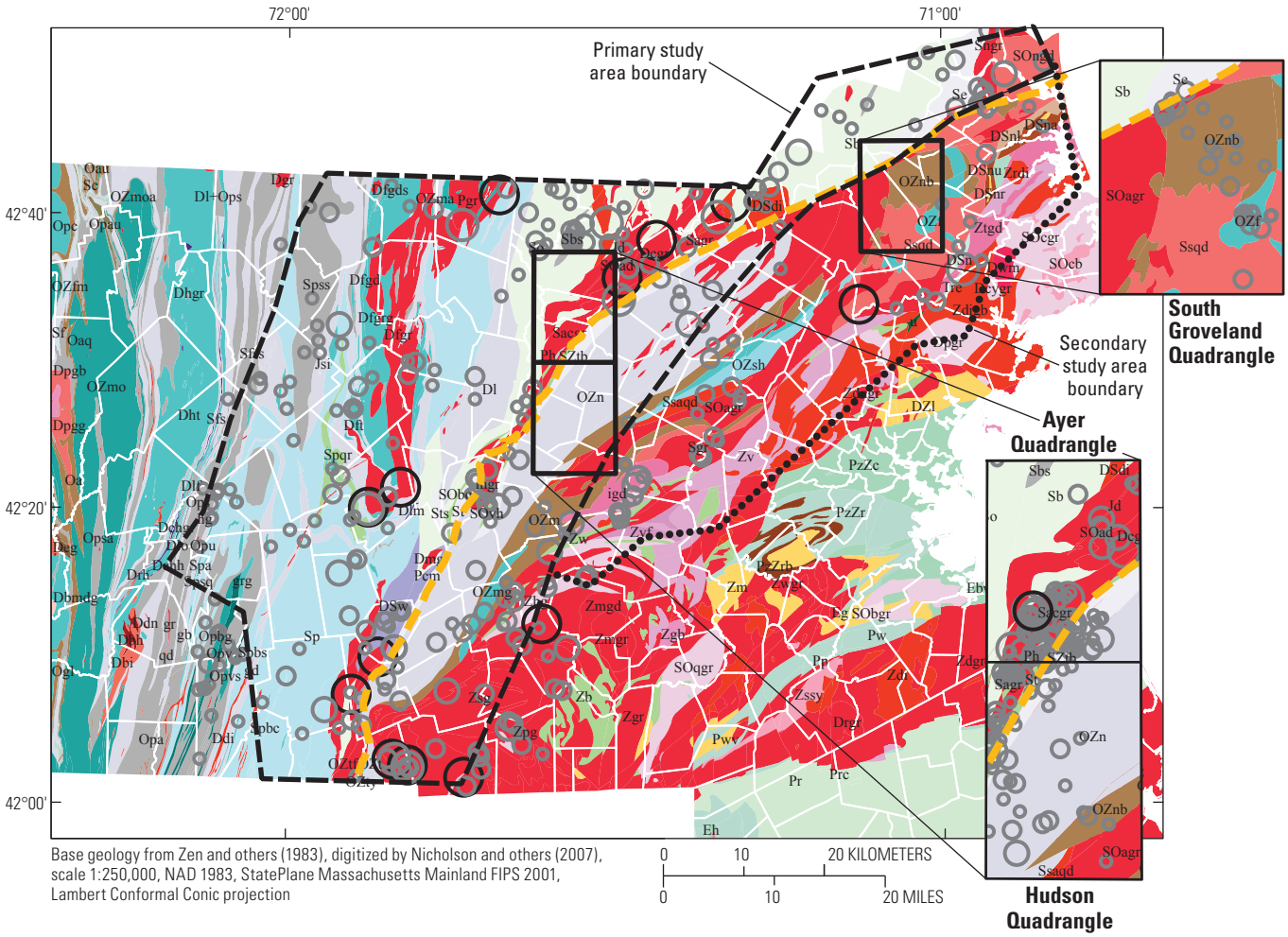


Figure 12. Uranium concentrations in east-central Massachusetts, 2009. Sampling coverage was increased in the areas of the insert maps where geology was mapped at the 1:24,000 scale. See figure 3 and appendix 1 for explanation of bedrock units. <, less than

Uranium Concentrations

Uranium concentrations ranged from less than the analytical reporting limit, 0.02 µg/L, to 817 µg/L. The low reporting limit allows description of uranium concentration variability in virtually all ranges of occurrence. Of 344 samples from the stratified random sampling, 12 samples (3.5 percent) exceeded the drinking-water standard of 30 µg/L. With the samples from the intensive sampling included, concentrations in 13 of the total of 478 samples (2.7 percent) were greater than the drinking-water standard. Elevated concentrations of uranium were widely distributed across the study area (fig. 12). As with arsenic, elevated uranium concentrations can be in close proximity to low concentrations in the same unit. Some units, however, had consistently low concentrations.

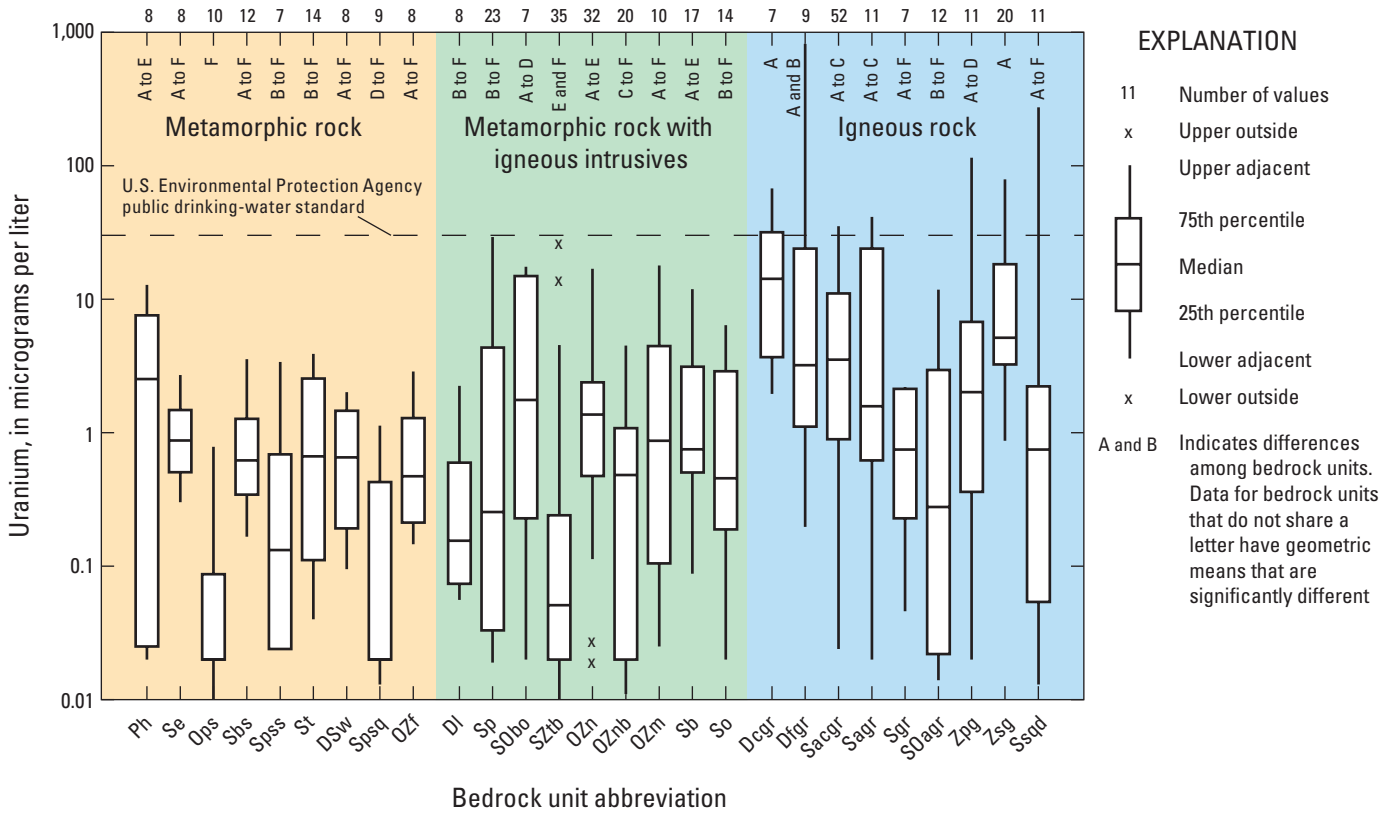


Figure 13. Distribution of uranium concentrations by bedrock unit, with seven or more samples, in the primary and secondary study area, east-central Massachusetts, 2009. See figure 3 and appendix 1 for explanation of bedrock units.

Uranium Correlations with Bedrock Units

Variation of uranium concentration by bedrock unit is apparent in units sampled seven or more times, a threshold used to increase statistical significance (fig. 13). Median concentrations are generally greater in igneous rock than in metamorphic rock (fig. 13). Concentrations in metamorphic rock intruded by igneous rock were intermediate. Concentrations were lowest in the unintruded metamorphic rock. Uranium concentrations exceeded the 30 µg/L drinking-water standard only in the igneous units.

The visual differences (fig. 13) were confirmed by one-way ANOVA analysis applied to the log-transformed uranium concentrations for bedrock units with seven or more samples, using rock type as a discrete independent variable. Significant differences were noted in concentrations among the rock types, indicating the association of rock type with distribution of uranium concentrations. Several bedrock units west of the Clinton-Newbury fault, such as Dcgr and Dl, were significantly different from each other.

Bedrock units classified as metamorphic, but intruded by igneous rocks, occasionally might be expected to reflect the elevated igneous concentrations. Well boreholes might intersect igneous rock even though the unit was classified as metamorphic, although this investigation did not find standard exceedences in metamorphic rock intruded by igneous rock. Intruded rock, however, did include concentrations that were greater than in unintruded rock.

Detailed Geologic Quadrangle Mapping of Bedrock Units

Several of the 1:24,000 quadrangles within the study area were remapped recently (three are shown in fig. 14). Some of the contacts between bedrock units are changed on the new maps compared to the State map (Zen and others, 1983; Nicholson and others, 2007). Bedrock unit identifications of some of the polygons also have changed. Correlations between arsenic and uranium concentration and the remapped units may be stronger than that of the State map if the newly identified units more accurately represent rock boundaries and if the concentrations are controlled by bedrock unit type.

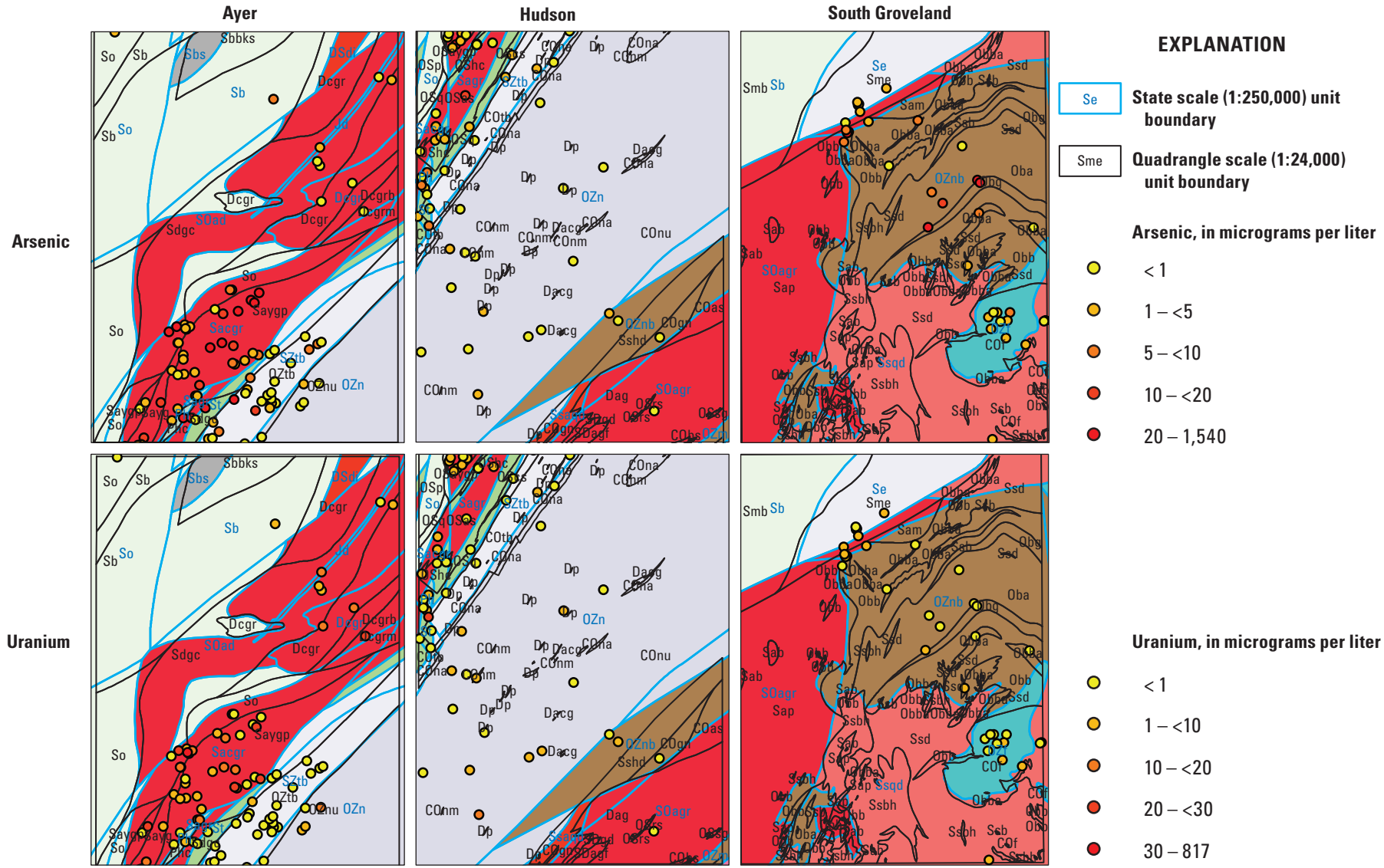


Figure 14. Details of change in geologic remapping of the Ayer, Hudson, and South Groveland 7.5-minute quadrangles compared to the statewide mapping of Zen and others (1983). <, less than

This effort reflects an attempt to test if the analysis of arsenic and uranium concentrations might be scale-dependent, as the 1:250,000 statewide map and 1:24,000 quadrangles differ significantly in scale. In New Hampshire, statewide analysis of well yield found that detailed (1:24,000) geologic maps improved the results of a predictive well-yield probability model over a statewide (1:250,000) model (Moore and others, 2002).

Correlations were compared by considering adjusted R-squared values for multiple linear regression of log concentration on bedrock unit for each pair of maps, that is, the map of Zen and others (1983) published in digital form by Nicholson and others (2007) compared to (1) the Ayer quadrangle (Kopera, 2006), (2) the Hudson quadrangle (Kopera, 2005) and (3) the South Groveland quadrangle (Castle and others, 2005) (table 3). Changes in renaming bedrock units alone would not change the value of the adjusted R-squared. Only a regrouping of well sites could change the R-squared value.

The adjusted R-squared value is a measure of the fraction of variance in the data that is explained by the regression variables. Results of the regressions indicate that no more variance of log-arsenic concentration is explained in the Ayer and Hudson quadrangles by the detailed (1:24,000) geologic mapping than by the statewide (1:250,000) mapping. For uranium, the adjusted R-squared value is about the same for the two mapping scales in the Ayer quadrangle but increases in the Hudson quadrangle with the 1:24,000 mapping. In the South Groveland quadrangle, more variance is explained with the new mapping than the old for both arsenic and uranium. One explanation for these results is the Clinton-Newbury fault that cuts though each quadrangle. In the Ayer and Hudson quadrangles, about half of the wells were in the elevated-arsenic zone where correlation with individual bedrock units was lacking. In the South Groveland quadrangle, only four wells were in the high arsenic zone, and all of these were in the same bedrock unit. Thus, arsenic would not improve with remapping for Ayer and Hudson because of a general lack of correlation by bedrock unit in much of the quadrangles. Uranium, by contrast, improved in two of the quadrangles with remapping and stayed about the same in the third. Overall, these results suggest that detailed mapping improves the ability to explain variance in uranium concentrations by bedrock unit, but that when variability in arsenic concentrations occurs at the terrane-scale, detailed mapping is less useful.

Table 3. Constituent correlation with bedrock units in statewide scale (1:250,000) and quadrangle scale (1:24,000), east-central Massachusetts.

[As, arsenic; U, uranium]

Geologic quadrangle	Regression	Adjusted R-squared	P value
Ayer	Log As, statewide scale	0.31	0.0001
Ayer	Log As, quadrangle scale	0.15	0.0198
Ayer	Log U, statewide scale	0.59	0.0000
Ayer	Log U, quadrangle scale	0.53	0.0000
Hudson	Log As, statewide scale	0.06	0.1952
Hudson	Log As, quadrangle scale	0.04	0.2997
Hudson	Log U, statewide scale	0.16	0.0225
Hudson	Log U, quadrangle scale	0.32	0.0010
South Groveland	Log As, statewide scale	0.03	0.3375
South Groveland	Log As, quadrangle scale	0.22	0.0578
South Groveland	Log U, statewide scale	0.05	0.2673
South Groveland	Log U, quadrangle scale	0.17	0.1006

Water-Quality Correlations with Ancillary Constituents

Analysis of ancillary constituents, acid neutralizing capacity, iron, manganese, and conductance was used to assess geochemical associations of arsenic and uranium occurrences. This was done using two-parameter plots (fig. 15). The plot matrix shows virtually no correlations among constituents. Some constituents appear to be mutually exclusive, particularly arsenic and iron, uranium and iron, and arsenic and uranium (fig. 15). This is in contrast to the relation found in overburden samples, where arsenic and iron are commonly correlated (Stollenwerk and Colman, 2003).

Peters (2008) attributes the difference in iron-arsenic association between overburden and bedrock as reflecting the lack of organic carbon likely present in bedrock units. Iron and arsenic associate in coatings deposited from oxic weathering of arsenic minerals, such as arsenopyrite. These coatings remain in place unless reducing conditions occur, such as associated with the presence of anthropogenic organic carbon (Stollenwerk and Colman, 2003; Peters, 2008). Iron concentrations were elevated in the water of some of the tested wells. The reducing conditions associated with these wells, however, were likely associated with sediments of wetlands or lakes that are providing recharge to the bedrock.

Bedrock Units, Geologic Terranes, and Geologic Sources of Arsenic and Uranium

The MDEP and the USGS data indicate that elevated arsenic in bedrock well water is associated primarily with two terranes in Massachusetts, the Merrimack belt and the Nashoba zone (figs. 1, 3, and 5). Within the terranes of elevated arsenic concentration, arsenic appeared to be correlated with bedrock

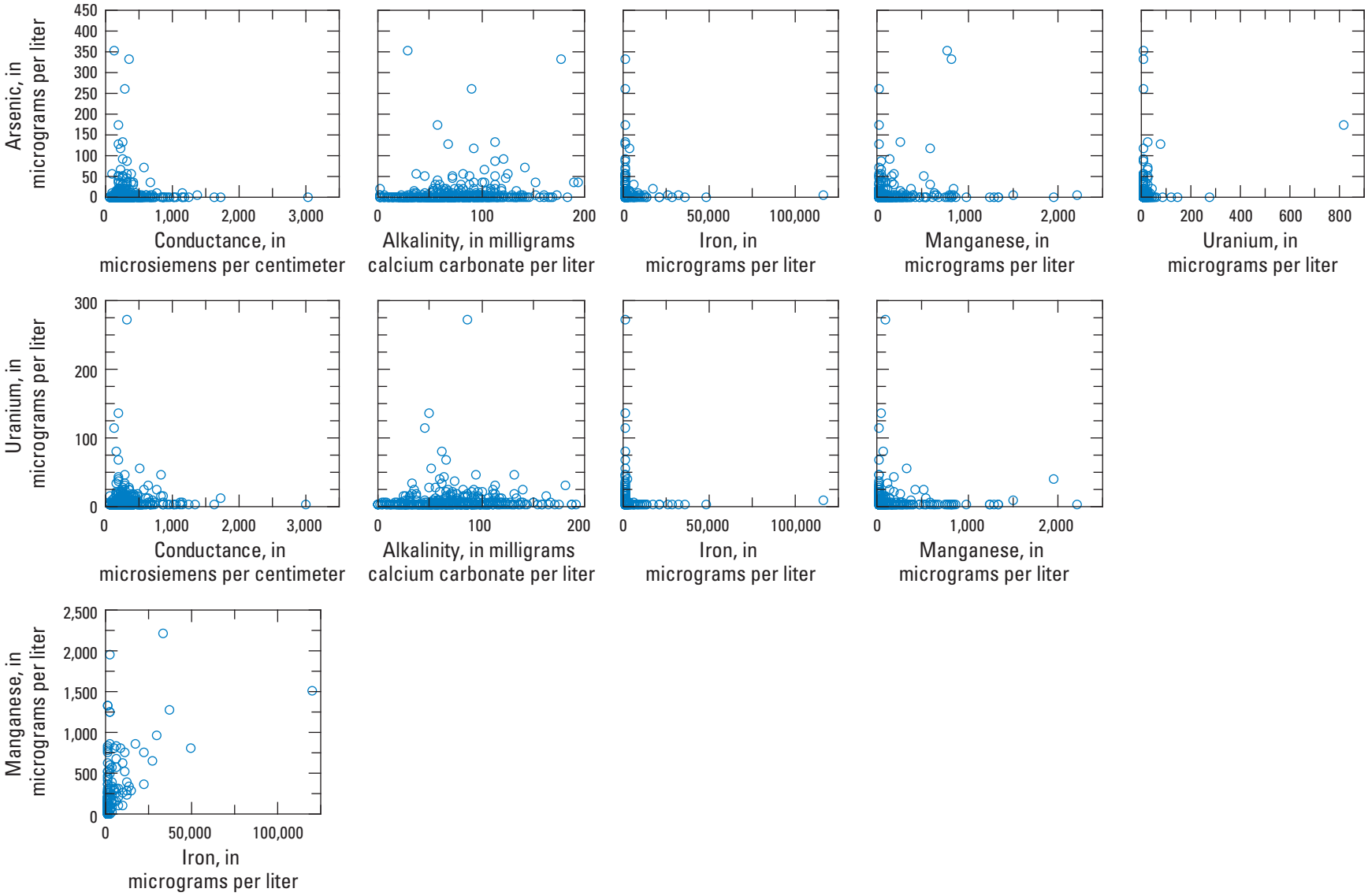


Figure 15. Associations among constituents measured in bedrock wells in east-central Massachusetts, 2009.

units in some parts of the study area and not correlated in other parts (note the elevated-concentration area of fig. 7). Sources of the arsenic in the areas that correlated with bedrock units could be in the rock protolith; however, the arsenic source in areas without bedrock correlation could have resulted from relatively equal redistribution of arsenic by metamorphic and/or metasomatic fluids from an original rock source (Henke, 2009). Although associated with the Merrimack belt, the elevated arsenic did not extend to the western border of the belt (fig. 9). The processes responsible for distributing the arsenic that is present in well water did not operate throughout the terrane.

In the Nashoba zone, where correlation between bedrock unit and arsenic concentrations was more prevalent, bedrock units with elevated arsenic extended to the Bloody Bluff fault, the eastern boundary of the zone. Two elevated arsenic concentrations were measured east of the Bloody Bluff fault in the Milford-Dedham zone, indicating that elevated arsenic concentrations are possible east of the Nashoba zone. Little previous data on arsenic in bedrock wells is available from this area where much of the water supply is public.

In the north, the elevated-arsenic area in Massachusetts abuts New Hampshire towns included in the private bedrock-well study by Montgomery and others (2003). In contrast to Massachusetts where units were grouped for concentration-probability analysis, units were grouped by fraction of samples greater than 10 µg/L in the New Hampshire study. The different statistical approaches prevent exact comparisons of data between the two States. Clearly, however, both States have elevated arsenic concentrations in the border area.

The association of igneous rock with uranium results from its deposition during magma cooling (Keevil and others, 1944). Uranium is one of the last elements to come out of solution, and it associates with rock surfaces from which mobilization into well water can occur. A report on uranium potential in two-mica granites of New England indicates that certain mineralized granites in New Hampshire and Massachusetts contain secondary uranyl-phosphate minerals (Boudette, 1977). Mobilization of uranium can occur in oxic conditions that are common in New England bedrock aquifers.

Maps of Estimated Probability for Elevated Arsenic and Uranium in Groundwater

Arsenic

Determination of probability of wells yielding water with arsenic concentration greater than the USEPA public drinking-water standard (10 µg/L) could help guide development of new supplies—domestic and public—and the testing of existing wells. Because of correlations of arsenic with bedrock unit and with groups of bedrock units described in a previous section on correlations, concentration distributions can be defined by bedrock unit. Cumulative distribution functions can be used to determine overstandard probabilities as well as probabilities of wells yielding water at levels of concentration greater than any given value (fig. 16). The distribution for each unit fits a log-normal distribution, and 95-percent confidence intervals based on the log-normal distribution can be computed (apps. 3 and 4).

The confidence interval of probability estimates depends on the number of samples for the bedrock unit and the concentration for which the probability is of interest. Probability distributions based on randomly selected samples of a population become more accurate as the sample size gets larger. Therefore, confidence intervals are a function of the number of samples. Finally, the probabilities can

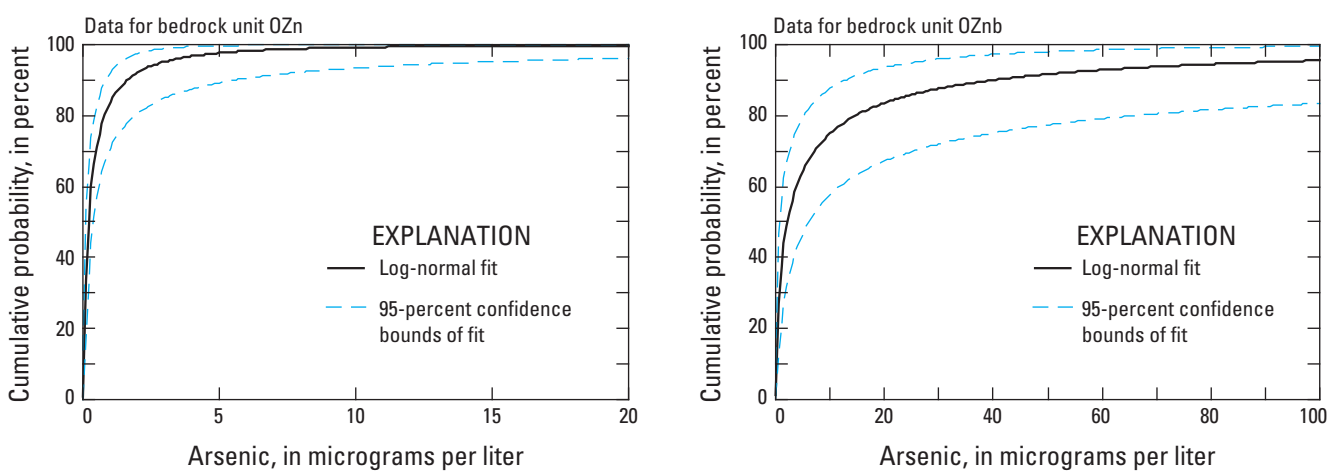


Figure 16. Cumulative probabilities for arsenic for two bedrock units east of the Clinton-Newbury fault.

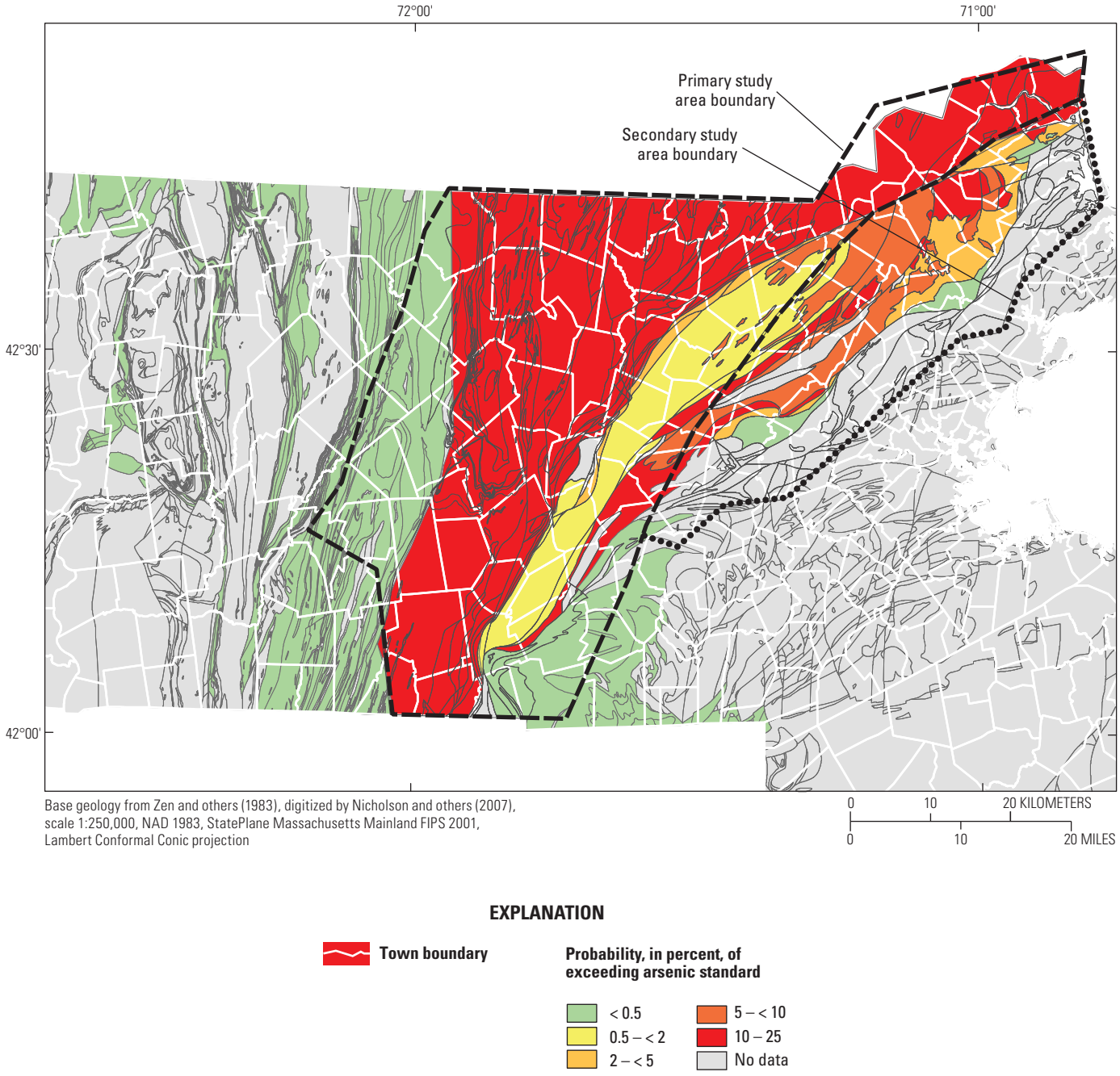


Figure 17. Probabilities of arsenic concentrations in bedrock well water being greater than 10 micrograms per liter, the U.S. Environmental Protection Agency drinking-water standard for public supplies, east-central Massachusetts. <, less than

be mapped so that areas with higher or lower probabilities of concentration than a given level (such as the USEPA drinking-water standard for public water supply) can be known (fig. 17). For example, the probability that a well in the OZn bedrock unit will contain water with an arsenic concentration greater than 10 µg/L (equal to 100 percent minus the cumulative probabililty) is low—0.79 percent with 95-percent confidence interval of 0.05 to 6.6 percent (fig. 16 and app. 3). The probability that a well will contain water with arsenic concentration greater than 10 µg/L for OZnb, an elevated-concentration unit, is 26 percent with a 95-percent confidence interval of 13 to 43 percent.

Bedrock units in the elevated-concentration area (fig. 7) were grouped for computing cumulative probabilities. The probability of well water being greater than 10 µg/L for the elevated-concentration grouping of units was 23 percent, exceeded only by OZnb at 25 percent.

Uranium

In this study, uranium is more generally correlated to bedrock unit than is arsenic, so uranium associations can be mapped exclusively by bedrock unit. Distributions of uranium concentration in a bedrock unit are log normal. Cumulative log-normal distributions indicate the probability of concentrations occurring for the whole range of concentrations, including the probability of exceeding 30 µg/L, the USEPA drinking-water standard for public supplies. The 95-percent confidence intervals of the probability estimates can also be determined from the log-normal fits (fig. 18, apps. 5 and 6). The uncertainty of the predictions—that is, the size of the confidence interval—decreases at high and low ends of the concentration range (fig. 18).

Example probabilities of encountering a concentration greater than 30 µg/L (fig. 18) range from 0.0001 percent (95-percent confidence interval of 0.0 to 0.005 percent) for Ops, to 21 percent (95-percent confidence interval of 5.5 to 50 percent) for Dcgr. Areas with granitic rock have higher probabilities (figs. 5 and 19).

Estimates of the Number of Wells that Exceed USEPA Drinking-Water Standards

Estimates of the number of wells affected can be determined by the product of the probability for well water to exceed the USEPA standard and the estimated number of wells per bedrock unit.

Estimates of private well distributions were made for the MDPH by Weston & Sampson Engineers, Inc., during 2005 (fig. 20). Potential private wells were identified by cross-referencing addresses in property-tax-assessment databases

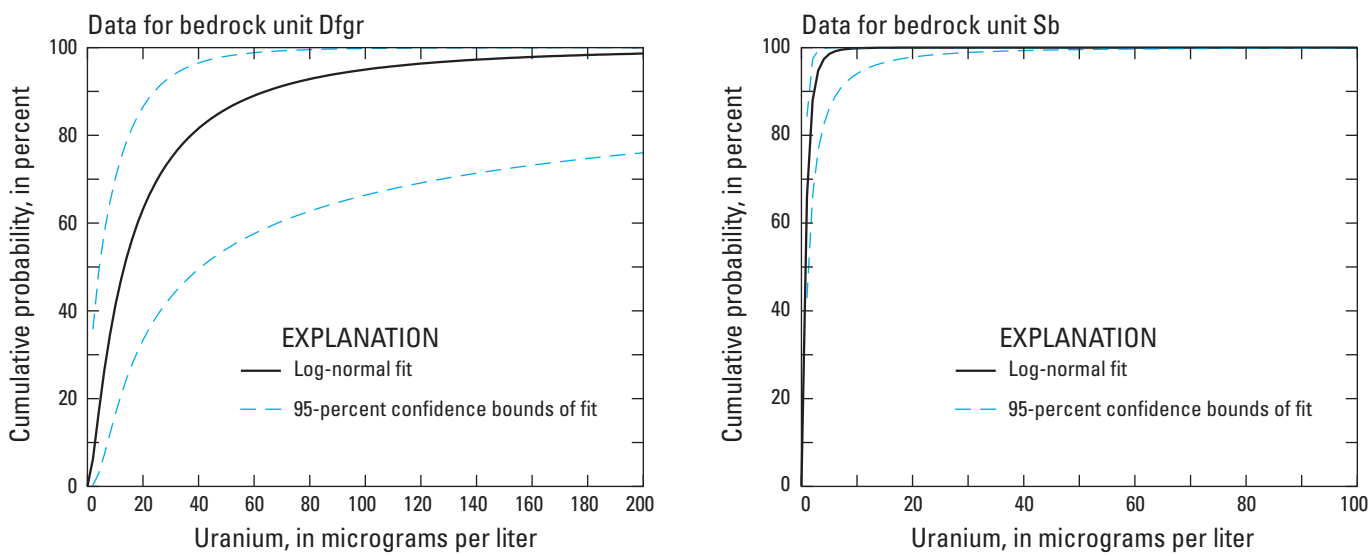


Figure 18. Cumulative log-normal distribution functions for uranium in an elevated-concentration bedrock unit, Dfgr, and a low-concentration bedrock unit, Sb, east-central Massachusetts.

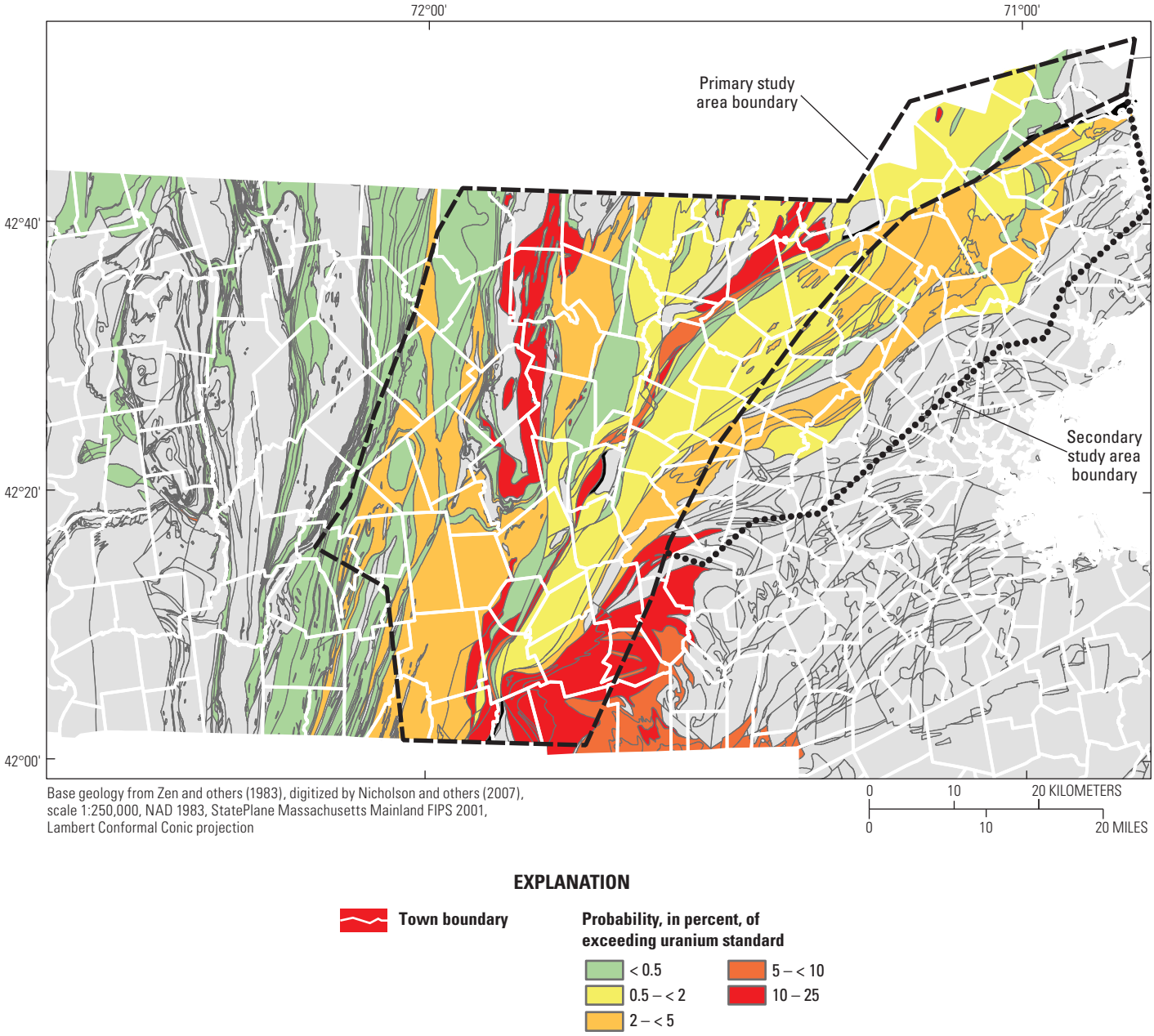


Figure 19. Probabilities of uranium concentrations in bedrock well water being greater than 30 micrograms per liter, the U.S. Environmental Protection Agency drinking water standard for public supplies, east-central Massachusetts. <, less than

with those in water-billing databases. The addresses in the tax-assessment databases that did not have a match in the water-billing databases were classified as potential private wells. In communities not served by a public water supply, all addresses contained in the tax-assessment data were classified as potential private wells. For the purposes of the estimate, all the inferred private wells were assumed to be bedrock wells. All the potential private well addresses were geocoded using the GDT/TeleAtlas Batch Geocoding Service®.

Not all towns in the study area were included in the MDPH inferred private-well investigation (fig. 20). The 1990 census, which provided information about households per census track and percentage of households on public or private water, was used to supplement well estimates in locations not covered by MDPH (U.S. Census, 1992). The census areas in towns not covered by the MDPH study were intersected with the bedrock data using Geographic Information System (GIS) techniques to delineate parts of census tracts that were in each

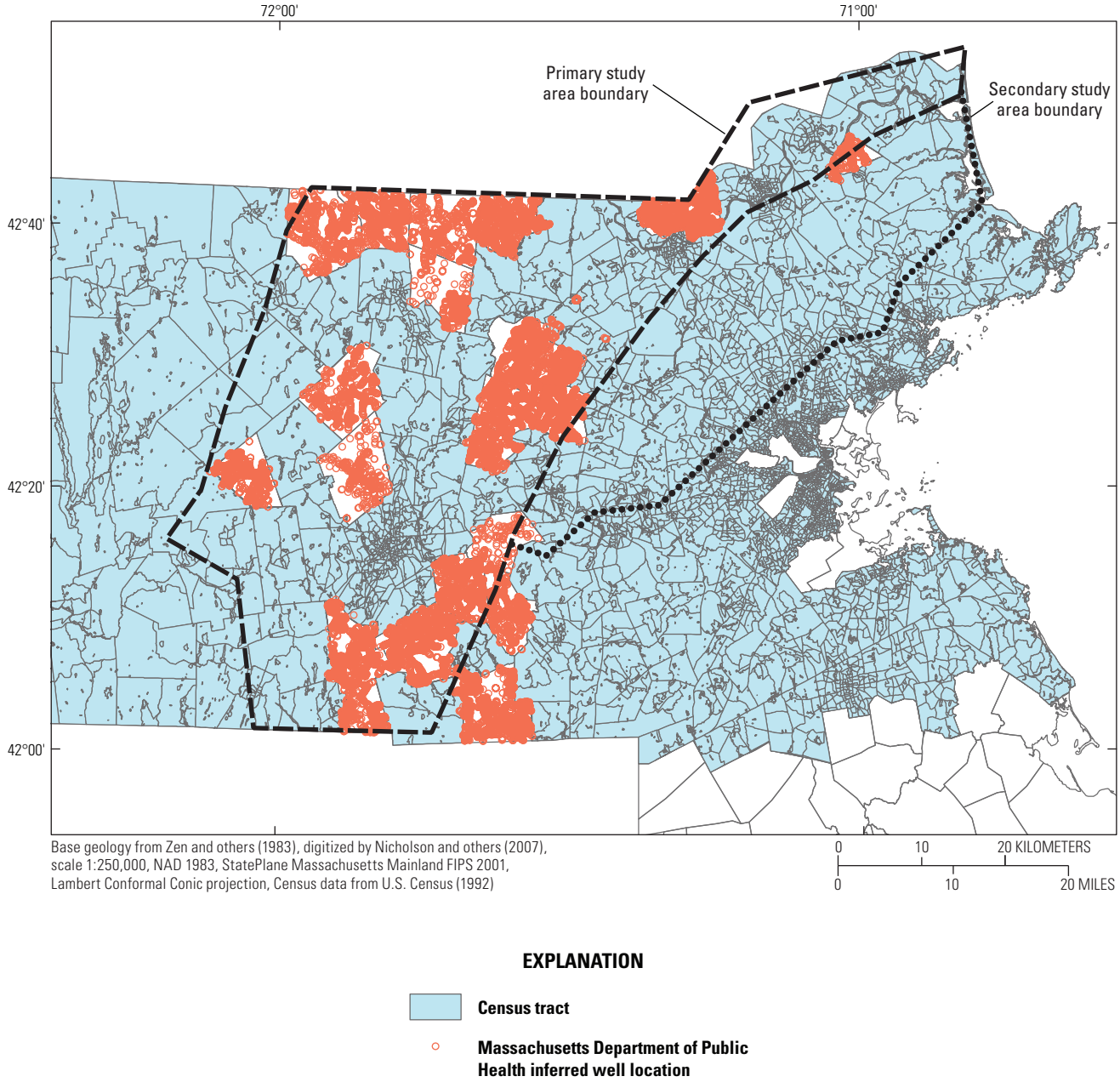


Figure 20. Inferred locations of private wells and census tracts for towns not included in the inferred private-well study, east-central Massachusetts.

Table 4. Number of wells in each bedrock unit and estimates of number of wells exceeding the arsenic and uranium U.S. Environmental Protection Agency drinking-water standards for public supplies, east-central Massachusetts.

[* , bedrock unit within the high-arsenic zone; —, no data; MDPH, Massachusetts Department of Public Health; µg/L, micrograms per liter; standard, U.S.Environmental Protection Agency public drinking-water standard]

Bedrock unit	Total number of MDPH wells	Total number of estimated census wells	Probability of arsenic concentrations greater than 10 µg/L, in percent	Probability of uranium concentrations greater than 30 µg/L, in percent	Estimated number of wells exceeding the 10 µg/L standard for arsenic	Estimated number of wells exceeding the 30 µg/L standard for uranium
Grouped elevated-arsenic units	13,500	5,763	23.08	—	4,445	—
Dcgr*	418	1,275	—	21.01	—	356
Dfgr*	1,522	702	—	13.97	—	311
Dl	2,010	8,024	0.00	0.03	0	3
DSw*	382	629	—	0.13	—	1
Ops	770	7,707	0.10	0.00	8	0
OZf	0	507	7.64	0.01	39	0
OZm	735	679	10.83	4.64	153	66
OZn	7,007	5,621	0.79	0.89	100	113
OZnb	930	1,357	25.50	0.70	583	16
Ph*	60	0	—	11.99	—	7
Sacgr*	884	373	—	8.43	—	106
Sagr*	971	1,013	—	12.54	—	249
Sb*	2,315	4,594	—	0.69	—	47
Sbs*	67	133	—	0.00	—	0
Se*	305	492	—	0.00	—	0
Sgr	0	533	0.00	0.64	0	3
So*	1,374	2,406	—	1.55	—	59
SOagr	569	2,326	6.92	4.11	200	119
SObo*	0	236	—	12.42	—	29
Sp	2,862	10,343	0.00	4.61	0	609
Spsq	85	238	0.14	0.07	0	0
Spss	908	723	0.38	0.18	6	3
Ssqd	224	2,982	4.63	2.53	148	81
St*	245	150	—	0.76	—	3
SZtb	861	464	3.68	0.17	49	2
Zpg	2,197	1,361	0.02	6.94	1	247
Zsg	5,012	2,972	0.10	10.61	8	847
Totals	**32,713**	**57,840**			**5,741**	**3,277**

bedrock unit. The number of wells per census tract was then adjusted by the proportional area of the tract that was in the bedrock unit. Finally, all the wells in the parts of tracts in a bedrock unit were added to determine the number of wells in each unit. The number of wells estimated to exceed a standard was determined by multiplying the probability of exceeding a standard for that bedrock unit by the sum of the number of wells determined from the MDPH assessment and the census assessment (table 4).

Arsenic

For arsenic, no probability was given in table 4 for bedrock units that were within the elevated-arsenic area. Rather, the probabilities for the units in this area are covered by the grouped-units estimate (top of table 4).

The number of wells with arsenic concentrations that exceeded the USEPA drinking-water standard was estimated to be 5,741. Because the study area covered most of the known elevated-concentration areas for the State, this estimate is likely appropriate for the entire State. Several small units within the study area did not have enough data for probability statistics to be computed; however, these would not greatly alter the total.

Uranium

For uranium, correlations were strictly with bedrock units rather than grouped units (table 4). The number of wells with uranium concentrations that exceeded the standard for uranium was estimated to be 3,277. Most of these wells are in igneous rock. Because units west of the Clinton-Newbury fault were not grouped on an areal basis for uranium, several more bedrock units were excluded from the calculation of probability statistics than for arsenic.

Igneous bedrock units in Massachusetts are not confined to the primary and secondary study areas of this investigation. The statewide number of wells affected by uranium is likely larger than the number reported herein, based on the bedrock units in the study areas.

Implications for New Supplies, Testing, and Treatment

Locating Future Bedrock Water Supplies

Few private well owners have options regarding choosing locations that have favorable bedrock. For private supply, the probability maps (figs. 17 and 19) can be used to guide well-water testing.

Although the data collected were from private wells, the data could be used to assess conditions likely in public as well as private bedrock water supplies. Commonly, there are several site options for locating public wells. Consideration of the bedrock unit when selecting sites for public supplies could result in substantially decreased probabilities of concentrations exceeding the drinking-water standard. Towns that straddle the Clinton-Newbury fault, such as Harvard and Westford, could make use of the result that there is a lower probability of elevated arsenic concentration in the rocks east of the fault than those to the west.

Directing Resources for Water Testing

The numbers of overstandard water supplies without treatment can be computed by using the fraction of households currently using water without treatment for arsenic (66 percent of 5,741 = 3,789) and uranium (93 percent of 3,277 = 3,047). If testing could be directed toward the elevated-concentration areas, these numbers of untreated supplies would presumably decrease. By testing all wells that are in bedrock units with probabilities of elevated arsenic concentration greater than 10 percent, 90 percent of the wells exceeding the standard could be identified. Applied to data collected in this investigation, for example, all but two wells exceeding the standard (which are in SZtb with concentrations of 10 and 20 µg/L) would have been tested. This approach is likely to include testing of the highest concentration wells, because the elevated concentrations are associated with bedrock units that have the highest probabilities of overstandard concentrations. For example, of the two wells that were missed by this approach, one had a concentration at the standard and one had a concentration twice the standard; the highest concentration well tested in this study had a concentration 150 times the standard.

Because health risk increases with increasing concentration, a testing routine that likely includes the highest concentrations is beneficial. The 10-percent probability testing algorithm would result in testing 26 percent of all the wells estimated to be in the study areas. As a fraction of wells statewide, the percentage of wells tested would, of course, be much smaller.

For uranium, to determine 90 percent of wells greater than the standard, all units with overstandard probability of 4 percent or greater would need to be analyzed. This would involve testing about 40 percent of the wells in the study area.

Defining Natural Background Concentrations

A problem for site-contamination assessment in areas where arsenic occurs naturally is whether concentrations at a given site are caused by natural conditions or are the result of human-induced activity. In cases where there is a possibility that the bedrock has been contaminated with anthropogenic arsenic, the distribution frequencies of concentration for a given bedrock unit could be used to assess whether or not the distribution frequency of concentration at a site that is suspected of contamination is significantly different from natural conditions.

Summary

This investigation is the first regional-scale study of arsenic concentrations in water from private wells completed in bedrock throughout east-central Massachusetts, the region of elevated-arsenic concentrations in the State. Measurements of uranium concentrations also were included in the investigation, because uranium, similar to arsenic, likely has a bedrock source. Although private water supplies are not subject to new U.S. Environmental Protection Agency (USEPA) drinking-water standards for public-water supplies, such as those established for arsenic and uranium in the last 7 years of 10 and 30 micrograms per liter, respectively, the standards are thresholds whereby private well users can assess the need for water treatment. Concentration data are needed for arsenic and uranium concentrations to (1) assess the geographic distribution of elevated concentrations, (2) guide testing of existing supplies, and (3) develop new supplies. These needs were addressed by correlating concentrations of arsenic and uranium with bedrock units and applying the correlations to the mapped distributions of wells. For arsenic, the number of overstandard wells estimated by these methods in the study area would account for most of the overstandard wells in the State. For uranium, the number of overstandard wells estimated for the study area would be less than the total for the State, because bedrock units with elevated concentrations of uranium are also expected outside of the region of this study.

Samples were collected by private well users that responded to sampling kits that were mailed to randomly selected well addresses. An instruction sheet and water-use questionnaire were included in the sampling kit. Of the wells randomly sampled, 13 percent had concentrations that exceeded the drinking-water standard for arsenic, and 3.5 percent exceeded the drinking-water standard for uranium.

One-way ANOVA analysis of log-transformed concentration data indicated significant differences for arsenic and for uranium concentration populations grouped by bedrock unit in most of the study area. However, an area of elevated arsenic concentrations was identified west of the Clinton-Newbury fault, where there were no significant differences in arsenic concentrations among the bedrock units. Lack of correlation with individual bedrock units in this area could have resulted from relatively equal redistribution of arsenic by metamorphic and/or metasomatic fluids.

Concentrations of arsenic and uranium fit log-normal distributions for populations separated by bedrock unit. For each bedrock unit, log-normal fits of the data were used to determine probabilities of concentrations exceeding the drinking-water standards. Overstandard probabilities were as great as 26 percent for arsenic in a unit containing amphibolite and 21 percent for uranium in a granitic unit.

Water-use data from the well users indicated that most of the overstandard wells were being used for drinking water without treatment—66 percent for arsenic and 93 percent for uranium. This data together with probability and well-distribution data were used to estimate the potential total number of wells in the study area used for drinking water without treatment: approximately 3,800 for arsenic and 3,000 for uranium.

Probability and well-distribution data were also used to determine the sampling effort required to locate 90 percent of the estimated overstandard wells. For arsenic, this could be achieved by sampling wells in those bedrock units with an overstandard probability of 10 percent or greater. This would involve sampling 26 percent of the total number of wells in the study area. For uranium, 90 percent of overstandard wells could be determined by sampling wells in bedrock units with an overstandard probability of 4 percent or greater. This would involve sampling 40 percent of all the wells in the study area.

Increased sampling in the investigation was directed in the regions of three 1:24,000 quadrangles where recent detailed geologic mapping had been conducted. Improved correlations of arsenic and uranium with bedrock unit were measured for two of the three quadrangles compared to the correlations made with the statewide map.

The correlations with bedrock are compatible with a natural bedrock source of the contaminants. By addressing the potential for contamination of bedrock wells in areas of increased contamination probability, well owners and resource managers can better assess risk.

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Appendix 1. Abbreviations and Descriptions for Bedrock Units in and Adjacent to the Study Area

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area.

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
Cbw	Cambrian	Braintree Argillite and Weymouth Fm—argillite, with some rare limestone
Cg	Cambrian	Green Lodge Fm of Rhodes and Graves (1931)—quartzite and slate
Ch	Cambrian	Hoppin Fm—quartzite, argillite, and minor limestone
cu	Unknown age	Cumberlandite—rock containing magnetite, ilmenite, olivine, labradorite, and spinel
Dcgr	Devonian	Chelmsford Granite—muscovite-biotite granite
Dchgr	Devonian	Coys Hill Porphyritic Granite Gneiss—microcline granite gneiss
Dchh	Devonian	Coys Hill Porphyritic Granite Gneiss— hornblende gneiss inclusions
Dcygr	Devonian	Cherry Hill Granite—alaskite granite containing ferro-hornblende
Ddi	Devonian	Hardwick Tonalite: Biotite-hornblende diorite and quartz-bearing diorite
Ddn	Devonian	Hardwick Tonalite: Meladiorite and norite
Dfgd	Devonian	Fitchburg Complex—biotite granodiorite to tonalite gneiss
Dfgds	Devonian	Fitchburg Complex—biotite-muscovite granitic gneiss with mica schist and feldspathic granulite inclusions
Dfgr	Devonian	Fitchburg Complex—muscovite-biotite granite
Dfgrg	Devonian	Fitchburg Complex—biotite-muscovite granite to granodiorite gneiss
Dft	Devonian	Fitchburg Complex—biotite-hornblende tonalite inclusions
Dgd	Devonian	Granodiorite
Dgr	Devonian	Biotite-muscovite granite
Dhgr	Devonian	Hardwick Tonalite—porhyritic microcline-biotite granite gneiss
Dht	Devonian	Hardwick Tonalite—biotite tonalite to granodiorite gneiss
Dl	Devonian	Littleton Fm
Dl+Ops	Devonian	Littleton and Partridge Fms, interfolded
Dl+Ops	Devonian	Partridge Fm—interfolded Littleton and Partridge Fms
Dlf	Devonian	Littleton Fm—quartz-feldspar-garnet gneiss, probably felsic metavolcanic rock
Dlm	Devonian	Littleton Fm—calcitic marble
Dlo	Devonian	Littleton Fm—orthopyroxene-biotite gneiss, probably intermediate metavolcanic rock
Dmgr	Devonian	Muscovite-biotite granite
DOgr	Devonian/Ordovician	Alkalic granite in Franklin
Dpgr	Devonian	Peabody Granite—alkalic granite containing ferro-hornblende
Drgr	Devonian	Granite of Rattlesnake Hill pluton—biotite-granite and fine-grained riebeckite granite
Drh	Devonian	Hardwick Tonalite: Biotite-garnet-feldspar gneiss of Ragged Hill
DSdi	Devonian/Silurian	Diorite and tonalite
DSn	Devonian/Silurian	Newbury Volcanic Complex—undivided sedimentray and volcanic rocks
DSna	Devonian/Silurian	Newbury Volcanic Complex—porphyritic andesite, includes tuffaceous mudstone
DSnl	Devonian/Silurian	Newbury Volcanic Complex—basalt, andesite, rhyolite, and tuff
DSnr	Devonian/Silurian	Newbury Volcanic Complex—micrographic rhyolite
DSnu	Devonian/Silurian	Newbury Volcanic Complex—calcareous mudstone, red mudstone, and siliceous siltstone
DSw	Devonian/Silurian	Worcester Fm—carbonaceous slate and phyllite and minor metagraywacke
Dwm	Devonian	Wenham Monzonite—monzonite containing ferro-hornblende
DZl	Devonian	Lynn Volcanic Complex—rhyolite, agglomerate, and tuff
fgr	Unknown age	Fine-grained granite and granite porphyry

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area. —Continued

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
gb	Precambrian to Paleozoic	Hornblende-olivine gabbro
Cbw	Cambrian	Braintree Argillite and Weymouth Fm—argillite, with some rare limestone
Cg	Cambrian	Green Lodge Fm of Rhodes and Graves (1931)—quartzite and slate
Ch	Cambrian	Hoppin Fm—quartzite, argillite, and minor limestone
cu	Unknown age	Cumberlandite—rock containing magnetite, ilmenite, olivine, labradorite, and spinel
Dcgr	Devonian	Chelmsford Granite—muscovite-biotite granite
Dchgr	Devonian	Coys Hill Porphyritic Granite Gneiss—microcline granite gneiss
Dchh	Devonian	Coys Hill Porphyritic Granite Gneiss— hornblende gneiss inclusions
Dcygr	Devonian	Cherry Hill Granite—alaskite granite containing ferro-hornblende
Ddi	Devonian	Hardwick Tonalite: Biotite-hornblende diorite and quartz-bearing diorite
Ddn	Devonian	Hardwick Tonalite: Meladiorite and norite
Dfgd	Devonian	Fitchburg Complex—biotite granodiorite to tonalite gneiss
Dfgds	Devonian	Fitchburg Complex—biotite-muscovite granitic gneiss with mica schist and feldspathic granulite inclusions
Dfgr	Devonian	Fitchburg Complex—muscovite-biotite granite
Dfgrg	Devonian	Fitchburg Complex—biotite-muscovite granite to granodiorite gneiss
Dft	Devonian	Fitchburg Complex—biotite-hornblende tonalite inclusions
Dgd	Devonian	Granodiorite
Dgr	Devonian	Biotite-muscovite granite
Dhgr	Devonian	Hardwick Tonalite—porhyritic microcline-biotite granite gneiss
Dht	Devonian	Hardwick Tonalite—biotite tonalite to granodiorite gneiss
Dl	Devonian	Littleton Fm
Dl+Ops	Devonian	Littleton and Partridge Fms, interfolded
Dl+Ops	Devonian	Partridge Fm—interfolded Littleton and Partridge Fms
Dlf	Devonian	Littleton Fm—quartz-feldspar-garnet gneiss, probably felsic metavolcanic rock
Dlm	Devonian	Littleton Fm—calcitic marble
Dlo	Devonian	Littleton Fm—orthopyroxene-biotite gneiss, probably intermediate metavolcanic rock
Dmgr	Devonian	Muscovite-biotite granite
DOgr	Devonian/Ordovician	Alkalic granite in Franklin
Dpgr	Devonian	Peabody Granite—alkalic granite containing ferro-hornblende
Drgr	Devonian	Granite of Rattlesnake Hill pluton—biotite-granite and fine-grained riebeckite granite
Drh	Devonian	Hardwick Tonalite: Biotite-garnet-feldspar gneiss of Ragged Hill
DSdi	Devonian/Silurian	Diorite and tonalite
DSn	Devonian/Silurian	Newbury Volcanic Complex—undivided sedimentray and volcanic rocks
DSna	Devonian/Silurian	Newbury Volcanic Complex—porphyritic andesite, includes tuffaceous mudstone
DSnl	Devonian/Silurian	Newbury Volcanic Complex—basalt, andesite, rhyolite, and tuff
DSnr	Devonian/Silurian	Newbury Volcanic Complex—micrographic rhyolite
DSnu	Devonian/Silurian	Newbury Volcanic Complex—calcareous mudstone, red mudstone, and siliceous siltstone
DSw	Devonian/Silurian	Worcester Fm—carbonaceous slate and phyllite and minor metagraywacke
Dwm	Devonian	Wenham Monzonite—monzonite containing ferro-hornblende
DZl	Devonian	Lynn Volcanic Complex—rhyolite, agglomerate, and tuff

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area. —Continued

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
fgr	Unknown age	Fine-grained granite and granite porphyry
gb	Precambrian to Paleozoic	Hornblende-olivine gabbro
gd	Precambrian to Paleozoic	Granodiorite
gr	Precambrian to Paleozoic	Granite
grg	Devonian	Biotite granitic gneiss
hg	Precambrian to Paleozoic	Hornblende-plagioclase gneiss
igd	Precambrian to Paleozoic	Granodiorite of the Indian Head pluton—biotite granodiorite and hornblende-biotite tonalite
Jd	Jurassic	Diabase dikes and sills
Jsi	Jurassic	Silicified fault-breccia or strongly silicified metamorphic rocks
K	Cretaceous	Cretaceous sediments—clay, silt, sand, and gravel, mostly non-marine and near-shore
mgr	Precambrian to Silurian	Muscovite granite
Ogl	Ordovician	Glastonbury Gneiss—granitic gneiss
Ongb	Ordovician	Nahant Gabbro and gabbro at Salem Neck—labradorite-pyroxene gabbro, hornblende gabbro, and hornblende diorite
Opa	Ordovician	Partridge Fm—amphibolite
Opau	Ordovician	Partridge Fm—sillimanite-feldspar augen gneiss
Opbg	Ordovician	Partridge Fm—biotite gneiss
Opc	Ordovician	Pauchaug Gneiss—granitic gneiss
Opf	Ordovician	Partridge Fm—felsic gneiss, metavolcanic, and minor amphibolite
Ops	Ordovician	Partridge Fm—sulfidic mica schist and subordinate amphibolite
Opsa	Ordovician	Partridge Fm—sulfidic mica schist and abundant amphibolite
Opsc	Ordovician	Partridge Fm—sulfidic schist and abundant calc-silicate
Opsg	Ordovician	Partridge Fm—felsic gneiss and schist
Opu	Ordovician	Partridge Fm—ultramafic lenses, commonly hornblendite
Opv	Ordovician	Partridge Fm—mafic and felsic gneisses, metavolcanic, with calc-silicate granofels
Opvs	Ordovician	Partridge Fm—biotite gneiss, metavolcanic; minor amphibolite and sulfidic schist
OZf	Neoproterozoic	Fish Brook Gneiss—biotite-plagioclase quartz gneiss
OZm	Neoproterozoic	Marlboro Fm—amphibolite, biotite schist and gneiss, minor calc-silicate granofels and felsic granofels
OZma	Neoproterozoic	Massabesic Gneiss Complex—biotite feldspar paragneiss intruded by potassium-feldspar-rich gneiss
OZmg	Neoproterozoic	Marlboro Fm—feldspathic gneiss
OZn	Neoproterozoic	Nashoba Fm—sillimanite schist and gneiss, partly sulfidc, amphibolite, biotite gneiss, calc-silicate gneiss, and marble
OZnb	Neoproterozoic	Nashoba Fm: Boxford Mbr—massive amphibolite, minor biotite gneiss
OZq	Neoproterozoic	Quinebaug Fm—amphibolite, biotite, and hornblende gneiss, felsic gneiss, and calc-silicate gneiss
OZsh	Neoproterozoic	Shawsheen Gneiss—sillimanite gneiss, sulfidic at base; minor amphibolite
OZt	Neoproterozoic	Tatnic Hill Fm—sulfidic sillimanite schist, sillimanite schist and gneiss, biotite gneiss; minor amphibolite, calc-silicate gneiss and marble
OZtf	Neoproterozoic	Tatnic Hill Fm: Fly Pond Mbr—calc-silicate gneiss and marble

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area. —Continued

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
OZty	Neoproterozoic	Tatnic Hill Fm: Yantic Mbr—grey mica schist
Pcm	Pennsylvanian	Coal Mine Brook Fm—carbonaceous slate and garnet phyllite; lens of meta-anthracite; conglomerate and arkose
Pd	Pennsylvanian	Dighton Conglomerate—coarse conglomerate having sandy matrix; minor sandstone
Pgr	Pennsylvanian	Biotite granite, with magnetite-bearing pegmatite
Ph	Pennsylvanian	Harvard Conglomerate—conglomerate and chloritoid-hematite phyllite
Pp	Pennsylvanian	Pondville Conglomerate—quartz conglomerate having abundant sandy matrix; boulder conglomerate; arkose
Pr	Pennsylvanian	Rhode Island Fm—sandstone, graywacke, shale, and conglomerate; minor beds of meta-antracite
Prc	Pennsylvanian	Rhode Island Fm—conglomerate, sandstone, and graywacke
Pw	Pennsylvanian	Wamsutta Fm—red to pink conglomerate, graywacke, sandstone, and shale
Pwv	Pennsylvanian	Wamsutta Fm—rhyolite and mafic volcanic rocks
PZb	Unknown age	Bellingham Conglomerate—red and gray metamorphosed conglomerate, sandstone, graywacke, and shale
PzZc	Proterozoic Z to earliest Paleozoic	Cambridge Argillite—gray argillite and minor quartzite; rare sandstone and conglomerate
PzZr	Proterozoic Z to earliest Paleozoic	Roxbury Conglomerate—conglomerate, sandstone, siltstone, argillite, and melaphyre
PzZrb	Proterozoic Z to earliest Paleozoic	Roxbury Conglomerate—melaphyre
q	Unknown age	Massive quartz and silicified rock
qd	Precambrian to Phanerozoic	Quartz diorite
Sacgr	Silurian	Ayer Granite—Clinton facies, porphyritic biotite granite
Sagr	Silurian	Ayer Granite—granite to tonalite
Sb	Silurian	Berwick Fm—metamorphosed calcareous sandstone, silstone, and minor muscovite schist (1 polygon)
Sb	Silurian	Berwick Fm—metamorphosed calcareous sandstone, silstone, and minor muscovite schist
Sbs	Silurian	Berwick Fm—mica schist
Se	Silurian	Eliot Fm—phyllite and calcareous phyllite
Sfs	Silurian	Fitch Fm—sulfidic calc-silicate and minor sulfidic schist
Sfss	Silurian	Fitch Fm—sulfidic mica schist
Sgr	Silurian	Rusty-weathering biotite granite to granodiorite
Sngr	Silurian	Newburyport Complex—porphyritic granite with microcline phenocrysts
So	Silurian	Oakdale Fm—metamorphosed pelitic and calcareous siltsone and muscovite schist
SOad	Silurian	Ayer Granite—Devens-Long Pond facies, porphyritic gneissic biotite granite and granodiorite
SOagr	Silurian	Andover Granite—muscovite-biotite granite
SObgr	Silurian	Blue Hill Granite Porphyry—microperthite-quartz porphyry
SObo	Silurian	Boylston Schist—carbonaceous phyllite and schist, locally sulfidic; quartzite; calc-silicate beds
SOcb	Silurian	Cape Ann Complex: Beverly Syenite
SOcgr	Silurian	Cape Ann Complex—alkalic granite to quartz syenite containing ferro-hornblende
SOcsm	Silurian	Cape Ann Complex: Squam Granite—monzodiorite
SOk	Silurian	Kittery Fm—quartzite, partly calcareous; phyllite, schist

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area. —Continued

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
SOngd	Silurian	Newburyport Complex—tonalite and granodiorite
SOqgr	Silurian	Quincy Granite—alkalic granite containing riebeckite and aegirine
SOrh	Silurian	Reubens Hill Fm—amphibolite, hornblende-chlorite schist, and feldspathic schist; includes metamorphosed diorite
SOvh	Silurian	Vaughn Hills Quartzite—quartzite, phyllite, conglomerate, and chlorite schist
Sp	Silurian	Paxton Fm—biotite granofels, calc-silicate granofels, and sulfidic schist
Spa	Silurian	Paxton Fm—amphibolite
Spbc	Silurian	Paxton Fm—diopside calc-silicate granofels
Spbs	Silurian	Paxton Fm: Bigelow Brook Mbr—biotite granofels, sulfidic schist, and minor calc-silicate granofels
Spqr	Silurian	Paxton Fm—rusty-weathering sulfidic quartzite and sulfidic schist
Spso	Silurian	Paxton Fm: Southbridge Mbr—biotite granofels and calc-silicate granofels
Spsq	Silurian	Paxton Fm—sulfidic magnesian biotite and magnesian cordierite schist and sillimanite quartzite
Spss	Silurian	Paxton Fm—sulfidic mica schist
Ssaqd	Silurian	Straw Hollow Diorite and Assabet Quartz Diorite, undifferentiated—biotite-hornblende diorite and quartz diorite
Ssqd	Silurian	Sharpners Pond Diorite—biotite-hornblende tonalite and diorite
St	Silurian	Tower Hill Quartzite—quartzite and phyllite
Sts	Silurian	Tower Hill Quartzite—gray phyllite
SZtb	Silurian	Tadmuck Brook Schist—andalusite phyllite and sillimanite schist, partly sulfidic; local quartzite
T	Tertiary	Tertiary sediments—unconsolidated sand, silt, and clay in discontinuous patches
TRe	Triassic	Red arkosic conglomerate, sandstone, and siltstone
u	Precambrian to Phanerozoic	Serpentinite
Zagr	Neoproterozoic	Alaskite—mafic-poor gneissic granite, commonly containing muscovite
Zb	Proterozoic Z	Blackstone Group—undivided, quartzite, schist, phyllite, marble, and metavolcanic rocks
Zbq	Proterozoic Z	Blackstone Group: Quinnville Quartzite
Zbs	Proterozoic Z	Blackstone Group—mica schist and phyllite
Zbv	Proterozoic Z	Blackstone Group—greenstone and amphibolite
Zdgr	Proterozoic Z	Dedham Granite—granite; includes dioritic rock
Zdi	Proterozoic Z	Diorite—hornblende diorite metamorhosed in part to amphibolite and hornblende gneiss
Zdigb	Proterozoic Z	Diorite and gabbro—complex of diorite and gabbro, sub. metavolcanic rocks and intrusive granite and granodiorite
Zdngr	Proterozoic Z	Dedham Granite—granite to granodiorite
Zegr	Proterozoic Z	Esmond Granite—biotite granite
Zfgr	Proterozoic Z	Granite of the Fall River pluton—biotite granite, in part mafic poor
Zfm	Proterozoic Z	Felsic and mafic volcanic rocks
Zgb	Proterozoic Z	Gabbro—hornblende gabbro and hornblende-pyroxene gabbro metamorphosed in part to hornblende gneiss and amphibolite
Zgg	Proterozoic Z	Granite, gneiss, and schist, undivided—plutonic and metamorphic rocks
Zgmgd	Proterozoic Z	Grant Mills Granodiorite—porphyritic granodiorite

Appendix 1. Abbreviations and descriptions for bedrock units in and adjacent to the study area. —Continued

[Fm, formation; Mbr, member; bedrock unit abbreviations and descriptions are from Zen and others, 1983]

Bedrock unit abbreviation	Age	Bedrock unit descriptions
Zgn	Proterozoic Z	Biotite gneiss near New Bedford—feldspathic gneiss
Zgr	Proterozoic Z	Biotite granite
Zgs	Proterozoic Z	Gneiss and schist near New Bedford—hornblende and biotite schist and gneiss, amphibolite
Zhg	Proterozoic Z	Hope Valley Alaskite Gneiss—mafic-poor gneissic granite, locally containing muscovite
Zm	Proterozoic Z	Mattapan Volcanic Complex—rhyolite, melaphyre, agglomerate, and tuff
Zmgd	Proterozoic Z	Milford Granite—seriate to subporphyritic granite to granodiorite, locally gneissic
Zmgr	Proterozoic Z	Milford Granite—biotite granite, locally gneissic
Zp	Proterozoic Z	Plainfield Fm—quartzite, pelitic schist, minor calc-silicate rock and amphibolite
Zpg	Proterozoic Z	Ponaganset Gneiss—gneissic biotite granite containing megacrysts of microcline
Zpgr	Proterozoic Z	Porphyritic granite—seriate to porphyritic biotite granite with epidote and sphene and mafic inclusions
Zrdi	Proterozoic Z	Diorite at Rowley—hornblende diorite
Zsg	Proterozoic Z	Scituate Granite Gneiss—gneissic granite containing biotite
Zssy	Proterozoic Z	Sharon Syenite—syenite containing microperthite, oligoclase, and clinopyroxene, mixed with ferro-gabbro
Ztgd	Proterozoic Z	Topsfield Granodiorite—porphyritic granodiorite
Zv	Proterozoic Z	Metamorphosed mafic to felsic flow, and volcaniclastic and hypabyssal intrusive rocks
Zvf	Proterozoic Z	Metamorphosed felsic metavolcanic rocks
Zw	Proterozoic Z	Westboro Fm—quartzite, schist, calc-silicate quartzite, and amphibolite
Zwgr	Proterozoic Z	Westwood Granite

Appendix 2. Letter to Potential Participants in the Study

Appendix 2. Letter to potential participants in the study.

OMB Control Number 1028-0086

USGS Study on Arsenic and Uranium in Bedrock Wells of East Central Massachusetts

Dear Resident Well User:

The U.S. Geological Survey (USGS) and the Massachusetts Department of Environmental Protection (MDEP) are conducting a study of drinking water to assess the extent of possible elevated concentrations of naturally occurring arsenic and uranium in bedrock aquifers that provide drinking water in east central Massachusetts. The well at your address has been chosen by a random selection process to be included in the study.

The study, conducted by John Colman, U.S. Geological Survey (508 490 5027), will indicate relationships between arsenic and uranium concentrations and type of bedrock in which a well is drilled. This information will help guide future water-supply development, well-water testing, and estimates of total numbers of wells affected.

Your participation is completely voluntary, and results from your well will be kept completely confidential (by Exemption 9, well data is not subject to the Freedom of Information Act) and will only be used for the purpose of this study.

We will report results to you with information about health effects of drinking water greater than standards and ways to decrease concentrations. If you have any questions, please do not hesitate to contact the project leader John Colman at: (508) 490 5027.

Questionnaires will be mailed to a small number of the selected well addresses by the Massachusetts Department of Public Health (MDPH). The MDPH questionnaire offers a second program of biomonitoring for some participants concerned about uranium and arsenic effects on health. Participation in the MDPH program is also voluntary and is not required for well testing by USGS.

In Parts 1 and 3 of the survey we want to know a little about your water and where it comes from. In Part 2, there are instructions about how to collect a water sample. When you are done, please use the enclosed business reply envelope to mail your survey and water samples back to the USGS. **Please mail in the bottles and survey soon, if possible within 2 weeks. If it goes longer, however, we are still interested.**

PART 1 - Water Sources and Supplies

The majority of residential water supply wells in east-central Massachusetts are private wells that tap ground water aquifers in fractured bedrock formations. In the first part of this study, we would like to ask you a few questions about your water source and supply.

1. Is your home supplied with water from a private (bedrock) well?

   ☐ Yes (go to question 2)

   ☐ No. My house supply is town water or another source other than bedrock well.

   Please **STOP** here. You do not have to mail back bottles or a water sample.

Appendix 2. Letter to potential participants in the study.—Continued

2. Is your well water treated?

☐ Yes

What is the treatment? _____

☐ No

3. How many people are in your household? *(This question is to determine the amount of water use in your household).*

_____ People live in this household .

4. Do you use your well water for drinking water and/or cooking?

☐ Yes

☐ No, because of water quality issues (Select all that apply):

☐ **Arsenic** ☐ **Uranium**

☐ **Iron** ☐ **Sediment**

☐ **Manganese** ☐ **Taste**

☐ **Other**_____

Part 2 - Water Sampling Instructions

Although collecting a water sample is a relatively simple task, there are several steps that must be taken to ensure accurate results. Please follow the instructions in steps 1-6 below to complete the next section of the survey.

Sampling Objective

The objective is to get a water sample that represents the water in the bedrock aquifer as closely as possible, so please select a tap that does not have treatment. Both bottles should be filled from the same faucet, one that does not have a water treatment system. Sample bottle screw threads and cap should not be contaminated with dirt from hands or the tap.

Once the bottles are filled, please mail the samples and questionnaire in the enclosed, prepaid business reply envelope.

Appendix 2. Letter to potential participants in the study.—Continued

Instructions

1. Collect your water sample **in the sample containers provided by the USGS**. Samples collected in any other container will not meet lab standards and cannot be processed.
2. **Choose a location to sample your water.** If you **do not** have any water treatment devices, such as a water softener or a reverse osmosis filter, take the sample from a cold water tap where you get your drinking water. If you **do** have treatment devices on your water system, (other than a whole-house filter for sediment) please locate a faucet which is attached to the water line before the treatment system.
3. Please avoid contamination of your samples, and do not touch the inside of the bottle or cap.
4. **Turn on the cold water and let it run for 1 minute** to flush the water out of the pipes. Turn the faucet down to a pencil size stream of water and fill the sample container.
5. Place the bottles and your completed survey in the enclosed postage-paid, business-reply envelope.
6. Mail the envelope to the USGS.

PART 3 - Location and Time of Water Sample

Please tell us where and when you collected the water for this sample.

- ☐ Basement Faucet
- ☐ Outside Spigot
- ☐ Bathroom Faucet
- ☐ Kitchen Faucet
- ☐ Other _____

Date and time of sampling_____

We would like to conduct follow-up sampling with a visit to a small number of participants. Would you be willing to participate in the follow-up visit?

☐ Yes, I would like to participate in a follow-up visit.
Please contact me by phone: _____
Or by email: _____

☐ No, I would not like to participate in a follow-up visit.

We would like to thank you for taking the time to participate in this important study.

PAPERWORK REDUCTION ACT STATEMENT: The Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.) requires us to inform you that this information is being collected to inform a study on arsenic and uranium in bedrock wells of east central Massachusetts. The estimated burden for this collection of information is estimated to average 20 minutes per response, including the time for reviewing instructions, answering questions, collecting water samples. The response to this request is voluntary. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB Control Number. Comments regarding the burden estimate or any other aspect of this collection of information should be directed to: John Colman at (508) 490 5027.

Appendix 3. Probability of Arsenic Exceeding a Given Concentration by Bedrock Unit

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micro-grams per liter	Grouped bedrock units with elevated arsenic concentration			Bedrock unit abbreviation					
				Ops*			OZf		
	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.66442	0.60023	0.72414	0.03526	0.00377	0.17241	0.55522	0.27338	0.81066
2	0.52993	0.46620	0.59290	0.01398	0.00108	0.09179	0.36942	0.15070	0.64306
3	0.44855	0.38670	0.51167	0.00764	0.00049	0.06006	0.27105	0.09073	0.54658
4	0.39190	0.33202	0.45446	0.00484	0.00027	0.04334	0.21023	0.05795	0.48441
5	0.34942	0.29143	0.41117	0.00334	0.00017	0.03316	0.16912	0.03875	0.44042
6	0.31604	0.25983	0.37687	0.00244	0.00011	0.02639	0.13965	0.02687	0.40719
7	0.28893	0.23440	0.34879	0.00186	0.00008	0.02161	0.11763	0.01919	0.38091
8	0.26637	0.21342	0.32525	0.00146	0.00006	0.01809	0.10064	0.01406	0.35941
9	0.24723	0.19578	0.30515	0.00117	0.00004	0.01540	0.08721	0.01051	0.34138
10	**0.23076**	**0.18073**	**0.28772**	**0.00096**	**0.00003**	**0.01329**	**0.07637**	**0.00801**	**0.32594**
11	0.21641	0.16771	0.27242	0.00080	0.00003	0.01161	0.06748	0.00619	0.31252
12	0.20376	0.15633	0.25886	0.00068	0.00002	0.01024	0.06008	0.00486	0.30069
13	0.19253	0.14630	0.24673	0.00058	0.00002	0.00910	0.05384	0.00386	0.29017
14	0.18247	0.13739	0.23581	0.00050	0.00001	0.00815	0.04854	0.00310	0.28071
15	0.17341	0.12942	0.22590	0.00043	0.00001	0.00735	0.04399	0.00251	0.27214
16	0.16520	0.12225	0.21687	0.00038	0.00001	0.00666	0.04005	0.00205	0.26434
17	0.15772	0.11576	0.20860	0.00034	0.00001	0.00607	0.03661	0.00169	0.25718
18	0.15088	0.10986	0.20098	0.00030	0.00001	0.00555	0.03360	0.00140	0.25058
19	0.14459	0.10448	0.19395	0.00027	0.00001	0.00510	0.03094	0.00117	0.24447
20	0.13878	0.09954	0.18742	0.00024	0.00001	0.00470	0.02857	0.00099	0.23879
21	0.13341	0.09501	0.18135	0.00022	0.00001	0.00435	0.02647	0.00084	0.23349
22	0.12843	0.09082	0.17568	0.00020	0.00000	0.00403	0.02459	0.00071	0.22853
23	0.12379	0.08694	0.17037	0.00018	0.00000	0.00375	0.02289	0.00061	0.22387
24	0.11945	0.08334	0.16540	0.00016	0.00000	0.00350	0.02136	0.00052	0.21949
25	0.11540	0.08000	0.16072	0.00015	0.00000	0.00327	0.01998	0.00045	0.21535
26	0.11160	0.07687	0.15631	0.00014	0.00000	0.00307	0.01872	0.00039	0.21143
27	0.10802	0.07396	0.15215	0.00013	0.00000	0.00288	0.01758	0.00034	0.20772
28	0.10466	0.07123	0.14821	0.00012	0.00000	0.00271	0.01653	0.00030	0.20419
29	0.10149	0.06866	0.14448	0.00011	0.00000	0.00256	0.01557	0.00026	0.20083
30	0.09849	0.06625	0.14093	0.00010	0.00000	0.00241	0.01469	0.00023	0.19763
31	0.09565	0.06398	0.13756	0.00009	0.00000	0.00228	0.01388	0.00020	0.19458
32	0.09296	0.06184	0.13436	0.00009	0.00000	0.00216	0.01313	0.00018	0.19166
33	0.09040	0.05982	0.13130	0.00008	0.00000	0.00205	0.01244	0.00016	0.18886
34	0.08798	0.05791	0.12839	0.00008	0.00000	0.00195	0.01180	0.00014	0.18618
35	0.08567	0.05609	0.12560	0.00007	0.00000	0.00185	0.01120	0.00012	0.18361

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micro-grams per liter	Grouped bedrock units with elevated arsenic concentration			Bedrock unit abbreviation					
				Ops*			OZf		
	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.08346	0.05438	0.12293	0.00007	0.00000	0.00176	0.01065	0.00011	0.18113
37	0.08136	0.05274	0.12038	0.00006	0.00000	0.00168	0.01014	0.00010	0.17875
38	0.07936	0.05119	0.11793	0.00006	0.00000	0.00160	0.00966	0.00009	0.17646
39	0.07744	0.04972	0.11558	0.00006	0.00000	0.00153	0.00921	0.00008	0.17425
40	0.07561	0.04831	0.11332	0.00005	0.00000	0.00146	0.00879	0.00007	0.17212
41	0.07385	0.04697	0.11115	0.00005	0.00000	0.00140	0.00840	0.00006	0.17006
42	0.07216	0.04569	0.10906	0.00005	0.00000	0.00134	0.00803	0.00006	0.16807
43	0.07055	0.04446	0.10705	0.00004	0.00000	0.00129	0.00768	0.00005	0.16615
44	0.06900	0.04329	0.10512	0.00004	0.00000	0.00123	0.00736	0.00005	0.16428
45	0.06750	0.04217	0.10325	0.00004	0.00000	0.00119	0.00705	0.00004	0.16248
46	0.06607	0.04110	0.10144	0.00004	0.00000	0.00114	0.00676	0.00004	0.16073
47	0.06469	0.04007	0.09970	0.00004	0.00000	0.00110	0.00649	0.00004	0.15903
48	0.06336	0.03908	0.09802	0.00003	0.00000	0.00105	0.00623	0.00003	0.15738
49	0.06208	0.03813	0.09639	0.00003	0.00000	0.00102	0.00599	0.00003	0.15578
50	0.06084	0.03722	0.09481	0.00003	0.00000	0.00098	0.00576	0.00003	0.15423
55	0.05526	0.03316	0.08765	0.00002	0.00000	0.00082	0.00478	0.00002	0.14706
60	0.05054	0.02978	0.08147	0.00002	0.00000	0.00070	0.00402	0.00001	0.14075
65	0.04647	0.02692	0.07609	0.00002	0.00000	0.00060	0.00341	0.00001	0.13514
70	0.04295	0.02447	0.07136	0.00001	0.00000	0.00052	0.00293	0.00001	0.13011
75	0.03987	0.02237	0.06716	0.00001	0.00000	0.00046	0.00253	0.00000	0.12556
80	0.03715	0.02054	0.06341	0.00001	0.00000	0.00040	0.00221	0.00000	0.12143
85	0.03474	0.01894	0.06005	0.00001	0.00000	0.00036	0.00194	0.00000	0.11764
90	0.03258	0.01752	0.05700	0.00001	0.00000	0.00032	0.00171	0.00000	0.11416
95	0.03065	0.01627	0.05424	0.00001	0.00000	0.00029	0.00152	0.00000	0.11094
100	0.02890	0.01515	0.05172	0.00001	0.00000	0.00026	0.00136	0.00000	0.10796
110	0.02587	0.01325	0.04729	0.00000	0.00000	0.00021	0.00109	0.00000	0.10259
120	0.02334	0.01170	0.04351	0.00000	0.00000	0.00018	0.00090	0.00000	0.09788
130	0.02120	0.01041	0.04026	0.00000	0.00000	0.00015	0.00074	0.00000	0.09370
140	0.01937	0.00932	0.03744	0.00000	0.00000	0.00013	0.00062	0.00000	0.08997
150	0.01779	0.00841	0.03495	0.00000	0.00000	0.00011	0.00053	0.00000	0.08660
160	0.01641	0.00762	0.03275	0.00000	0.00000	0.00010	0.00045	0.00000	0.08354
170	0.01520	0.00694	0.03079	0.00000	0.00000	0.00009	0.00039	0.00000	0.08075
180	0.01413	0.00635	0.02904	0.00000	0.00000	0.00008	0.00034	0.00000	0.07819
190	0.01318	0.00583	0.02746	0.00000	0.00000	0.00007	0.00030	0.00000	0.07582
200	0.01233	0.00538	0.02602	0.00000	0.00000	0.00006	0.00026	0.00000	0.07364

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micro-grams per liter	Grouped bedrock units with elevated arsenic concentration			Bedrock unit abbreviation					
				Ops*			OZf		
	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.01157	0.00497	0.02472	0.00000	0.00000	0.00005	0.00023	0.00000	0.07161
220	0.01087	0.00461	0.02352	0.00000	0.00000	0.00005	0.00020	0.00000	0.06971
230	0.01025	0.00429	0.02243	0.00000	0.00000	0.00004	0.00018	0.00000	0.06794
240	0.00968	0.00400	0.02142	0.00000	0.00000	0.00004	0.00016	0.00000	0.06628
250	0.00916	0.00374	0.02050	0.00000	0.00000	0.00004	0.00015	0.00000	0.06472
260	0.00868	0.00350	0.01964	0.00000	0.00000	0.00003	0.00013	0.00000	0.06325
270	0.00824	0.00329	0.01884	0.00000	0.00000	0.00003	0.00012	0.00000	0.06186
280	0.00784	0.00309	0.01810	0.00000	0.00000	0.00003	0.00011	0.00000	0.06055
290	0.00747	0.00291	0.01740	0.00000	0.00000	0.00003	0.00010	0.00000	0.05930
300	0.00712	0.00275	0.01676	0.00000	0.00000	0.00002	0.00009	0.00000	0.05811

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.23792	0.07581	0.50313	0.16282	0.07832	0.29137	0.63210	0.44055	0.79514
2	0.19207	0.05460	0.44482	0.07879	0.02495	0.19331	0.51498	0.33884	0.68819
3	0.16795	0.04320	0.41687	0.04795	0.01088	0.15020	0.44518	0.27992	0.62072
4	0.15207	0.03587	0.39961	0.03262	0.00562	0.12468	0.39654	0.23959	0.57260
5	0.14047	0.03069	0.38756	0.02373	0.00322	0.10742	0.35986	0.20970	0.53578
6	0.13144	0.02681	0.37852	0.01807	0.00199	0.09480	0.33080	0.18642	0.50628
7	0.12413	0.02380	0.37140	0.01422	0.00130	0.08510	0.30699	0.16769	0.48187
8	0.11803	0.02137	0.36559	0.01148	0.00089	0.07737	0.28700	0.15224	0.46118
9	0.11283	0.01938	0.36074	0.00946	0.00063	0.07103	0.26990	0.13926	0.44331
10	**0.10832**	**0.01771**	**0.35659**	**0.00792**	**0.00046**	**0.06573**	**0.25505**	**0.12819**	**0.42764**
11	0.10435	0.01630	0.35299	0.00672	0.00034	0.06122	0.24199	0.11862	0.41375
12	0.10082	0.01508	0.34983	0.00577	0.00026	0.05733	0.23039	0.11026	0.40129
13	0.09765	0.01402	0.34701	0.00501	0.00020	0.05393	0.22000	0.10291	0.39003
14	0.09478	0.01309	0.34449	0.00438	0.00015	0.05093	0.21063	0.09638	0.37979
15	0.09217	0.01227	0.34221	0.00386	0.00012	0.04827	0.20211	0.09055	0.37040
16	0.08977	0.01154	0.34013	0.00342	0.00010	0.04589	0.19434	0.08530	0.36175
17	0.08756	0.01088	0.33823	0.00305	0.00008	0.04374	0.18720	0.08057	0.35374
18	0.08552	0.01029	0.33647	0.00274	0.00007	0.04179	0.18063	0.07627	0.34630
19	0.08361	0.00975	0.33485	0.00247	0.00005	0.04001	0.17454	0.07235	0.33935
20	0.08184	0.00926	0.33335	0.00224	0.00005	0.03839	0.16889	0.06877	0.33285
21	0.08018	0.00882	0.33194	0.00203	0.00004	0.03689	0.16363	0.06547	0.32674
22	0.07862	0.00841	0.33062	0.00185	0.00003	0.03551	0.15871	0.06244	0.32098
23	0.07715	0.00803	0.32939	0.00170	0.00003	0.03423	0.15410	0.05964	0.31555
24	0.07576	0.00768	0.32823	0.00156	0.00002	0.03305	0.14977	0.05704	0.31040
25	0.07445	0.00736	0.32713	0.00143	0.00002	0.03194	0.14569	0.05463	0.30552
26	0.07320	0.00706	0.32609	0.00132	0.00002	0.03091	0.14185	0.05238	0.30088
27	0.07202	0.00679	0.32511	0.00123	0.00001	0.02995	0.13821	0.05028	0.29646
28	0.07089	0.00653	0.32417	0.00114	0.00001	0.02904	0.13477	0.04832	0.29224
29	0.06982	0.00629	0.32328	0.00106	0.00001	0.02819	0.13151	0.04648	0.28821
30	0.06880	0.00606	0.32243	0.00099	0.00001	0.02739	0.12841	0.04476	0.28435
31	0.06782	0.00585	0.32162	0.00092	0.00001	0.02663	0.12545	0.04314	0.28065
32	0.06688	0.00565	0.32084	0.00086	0.00001	0.02591	0.12264	0.04161	0.27711
33	0.06598	0.00546	0.32010	0.00081	0.00001	0.02523	0.11996	0.04017	0.27370
34	0.06511	0.00528	0.31939	0.00076	0.00001	0.02459	0.11740	0.03881	0.27042
35	0.06428	0.00511	0.31870	0.00071	0.00001	0.02398	0.11494	0.03752	0.26726

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.06348	0.00495	0.31804	0.00067	0.00000	0.02339	0.11260	0.03631	0.26422
37	0.06271	0.00480	0.31741	0.00063	0.00000	0.02284	0.11035	0.03515	0.26128
38	0.06197	0.00466	0.31680	0.00060	0.00000	0.02231	0.10819	0.03405	0.25844
39	0.06125	0.00452	0.31621	0.00056	0.00000	0.02181	0.10612	0.03301	0.25570
40	0.06056	0.00439	0.31564	0.00053	0.00000	0.02132	0.10412	0.03202	0.25305
41	0.05989	0.00427	0.31509	0.00050	0.00000	0.02086	0.10220	0.03108	0.25048
42	0.05924	0.00415	0.31455	0.00048	0.00000	0.02042	0.10036	0.03018	0.24799
43	0.05861	0.00404	0.31404	0.00045	0.00000	0.02000	0.09858	0.02932	0.24558
44	0.05801	0.00393	0.31354	0.00043	0.00000	0.01959	0.09686	0.02850	0.24324
45	0.05742	0.00383	0.31305	0.00041	0.00000	0.01920	0.09521	0.02771	0.24097
46	0.05685	0.00374	0.31258	0.00039	0.00000	0.01882	0.09361	0.02696	0.23876
47	0.05629	0.00364	0.31213	0.00037	0.00000	0.01846	0.09206	0.02624	0.23661
48	0.05575	0.00355	0.31168	0.00035	0.00000	0.01811	0.09057	0.02556	0.23452
49	0.05523	0.00347	0.31125	0.00034	0.00000	0.01778	0.08912	0.02490	0.23249
50	0.05472	0.00338	0.31083	0.00032	0.00000	0.01745	0.08772	0.02426	0.23051
55	0.05236	0.00302	0.30889	0.00026	0.00000	0.01600	0.08133	0.02145	0.22133
60	0.05028	0.00271	0.30718	0.00021	0.00000	0.01476	0.07581	0.01912	0.21319
65	0.04843	0.00246	0.30564	0.00018	0.00000	0.01370	0.07099	0.01717	0.20589
70	0.04676	0.00224	0.30426	0.00015	0.00000	0.01277	0.06674	0.01551	0.19930
75	0.04525	0.00205	0.30300	0.00012	0.00000	0.01196	0.06297	0.01409	0.19331
80	0.04387	0.00189	0.30185	0.00011	0.00000	0.01124	0.05959	0.01286	0.18782
85	0.04261	0.00175	0.30079	0.00009	0.00000	0.01060	0.05654	0.01178	0.18277
90	0.04145	0.00162	0.29981	0.00008	0.00000	0.01003	0.05378	0.01084	0.17810
95	0.04037	0.00151	0.29890	0.00007	0.00000	0.00951	0.05128	0.01001	0.17376
100	0.03937	0.00141	0.29805	0.00006	0.00000	0.00905	0.04898	0.00928	0.16972
110	0.03757	0.00124	0.29650	0.00005	0.00000	0.00823	0.04494	0.00803	0.16240
120	0.03598	0.00111	0.29514	0.00004	0.00000	0.00754	0.04149	0.00702	0.15593
130	0.03457	0.00099	0.29391	0.00003	0.00000	0.00696	0.03851	0.00620	0.15015
140	0.03330	0.00089	0.29280	0.00003	0.00000	0.00645	0.03590	0.00551	0.14494
150	0.03215	0.00081	0.29179	0.00002	0.00000	0.00601	0.03361	0.00493	0.14022
160	0.03111	0.00074	0.29086	0.00002	0.00000	0.00562	0.03158	0.00443	0.13591
170	0.03016	0.00068	0.29000	0.00002	0.00000	0.00527	0.02976	0.00401	0.13195
180	0.02928	0.00063	0.28921	0.00001	0.00000	0.00497	0.02813	0.00364	0.12830
190	0.02848	0.00058	0.28847	0.00001	0.00000	0.00469	0.02665	0.00332	0.12492
200	0.02773	0.00054	0.28778	0.00001	0.00000	0.00444	0.02531	0.00304	0.12178

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.02703	0.00050	0.28713	0.00001	0.00000	0.00422	0.02409	0.00280	0.11885
220	0.02638	0.00047	0.28652	0.00001	0.00000	0.00401	0.02297	0.00258	0.11610
230	0.02577	0.00044	0.28595	0.00001	0.00000	0.00382	0.02195	0.00238	0.11353
240	0.02519	0.00041	0.28541	0.00001	0.00000	0.00365	0.02100	0.00221	0.11110
250	0.02465	0.00038	0.28489	0.00001	0.00000	0.00349	0.02012	0.00206	0.10881
260	0.02414	0.00036	0.28440	0.00001	0.00000	0.00335	0.01931	0.00192	0.10665
270	0.02366	0.00034	0.28393	0.00000	0.00000	0.00321	0.01856	0.00179	0.10460
280	0.02320	0.00032	0.28349	0.00000	0.00000	0.00308	0.01786	0.00167	0.10266
290	0.02277	0.00031	0.28307	0.00000	0.00000	0.00297	0.01720	0.00157	0.10080
300	0.02236	0.00029	0.28266	0.00000	0.00000	0.00286	0.01658	0.00147	0.09904

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			SOagr			Spsq		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.43165	0.15898	0.74354	0.32722	0.14632	0.56242	0.06350	0.01045	0.22900
2	0.06143	0.01062	0.21710	0.22397	0.08084	0.45292	0.02471	0.00212	0.14221
3	0.00952	0.00061	0.07257	0.17337	0.05237	0.39760	0.01316	0.00066	0.10868
4	0.00179	0.00004	0.02970	0.14228	0.03691	0.36223	0.00811	0.00026	0.09011
5	0.00040	0.00000	0.01393	0.12094	0.02746	0.33686	0.00546	0.00012	0.07803
6	0.00010	0.00000	0.00719	0.10525	0.02121	0.31738	0.00390	0.00006	0.06940
7	0.00003	0.00000	0.00399	0.09318	0.01686	0.30173	0.00291	0.00003	0.06287
8	0.00001	0.00000	0.00234	0.08358	0.01370	0.28876	0.00224	0.00002	0.05771
9	0.00000	0.00000	0.00143	0.07575	0.01134	0.27773	0.00177	0.00001	0.05351
10	**0.00000**	**0.00000**	**0.00091**	**0.06923**	**0.00952**	**0.26820**	**0.00142**	**0.00001**	**0.05001**
11	0.00000	0.00000	0.00060	0.06371	0.00809	0.25983	0.00117	0.00001	0.04704
12	0.00000	0.00000	0.00040	0.05898	0.00695	0.25239	0.00097	0.00000	0.04447
13	0.00000	0.00000	0.00028	0.05487	0.00602	0.24571	0.00082	0.00000	0.04223
14	0.00000	0.00000	0.00020	0.05127	0.00527	0.23967	0.00069	0.00000	0.04026
15	0.00000	0.00000	0.00014	0.04809	0.00463	0.23416	0.00060	0.00000	0.03850
16	0.00000	0.00000	0.00010	0.04526	0.00410	0.22911	0.00052	0.00000	0.03692
17	0.00000	0.00000	0.00008	0.04273	0.00366	0.22445	0.00045	0.00000	0.03549
18	0.00000	0.00000	0.00006	0.04045	0.00327	0.22013	0.00040	0.00000	0.03420
19	0.00000	0.00000	0.00004	0.03838	0.00294	0.21611	0.00035	0.00000	0.03301
20	0.00000	0.00000	0.00003	0.03650	0.00266	0.21236	0.00031	0.00000	0.03192
21	0.00000	0.00000	0.00003	0.03478	0.00241	0.20884	0.00028	0.00000	0.03092
22	0.00000	0.00000	0.00002	0.03321	0.00219	0.20553	0.00025	0.00000	0.02999
23	0.00000	0.00000	0.00002	0.03176	0.00200	0.20241	0.00022	0.00000	0.02912
24	0.00000	0.00000	0.00001	0.03042	0.00183	0.19946	0.00020	0.00000	0.02832
25	0.00000	0.00000	0.00001	0.02918	0.00168	0.19667	0.00018	0.00000	0.02756
26	0.00000	0.00000	0.00001	0.02803	0.00155	0.19401	0.00017	0.00000	0.02686
27	0.00000	0.00000	0.00001	0.02695	0.00143	0.19149	0.00015	0.00000	0.02620
28	0.00000	0.00000	0.00001	0.02595	0.00132	0.18908	0.00014	0.00000	0.02557
29	0.00000	0.00000	0.00000	0.02502	0.00123	0.18678	0.00013	0.00000	0.02498
30	0.00000	0.00000	0.00000	0.02414	0.00114	0.18458	0.00012	0.00000	0.02443
31	0.00000	0.00000	0.00000	0.02332	0.00106	0.18247	0.00011	0.00000	0.02390
32	0.00000	0.00000	0.00000	0.02254	0.00099	0.18045	0.00010	0.00000	0.02340
33	0.00000	0.00000	0.00000	0.02181	0.00092	0.17851	0.00009	0.00000	0.02292
34	0.00000	0.00000	0.00000	0.02112	0.00086	0.17665	0.00009	0.00000	0.02247
35	0.00000	0.00000	0.00000	0.02047	0.00081	0.17485	0.00008	0.00000	0.02204

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			SOagr			Spsq		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00000	0.00000	0.00000	0.01986	0.00076	0.17312	0.00007	0.00000	0.02162
37	0.00000	0.00000	0.00000	0.01927	0.00071	0.17145	0.00007	0.00000	0.02123
38	0.00000	0.00000	0.00000	0.01872	0.00067	0.16984	0.00006	0.00000	0.02085
39	0.00000	0.00000	0.00000	0.01819	0.00063	0.16828	0.00006	0.00000	0.02049
40	0.00000	0.00000	0.00000	0.01769	0.00060	0.16678	0.00006	0.00000	0.02014
41	0.00000	0.00000	0.00000	0.01721	0.00056	0.16532	0.00005	0.00000	0.01981
42	0.00000	0.00000	0.00000	0.01675	0.00053	0.16390	0.00005	0.00000	0.01949
43	0.00000	0.00000	0.00000	0.01632	0.00050	0.16253	0.00005	0.00000	0.01918
44	0.00000	0.00000	0.00000	0.01590	0.00048	0.16120	0.00004	0.00000	0.01888
45	0.00000	0.00000	0.00000	0.01551	0.00045	0.15991	0.00004	0.00000	0.01860
46	0.00000	0.00000	0.00000	0.01512	0.00043	0.15866	0.00004	0.00000	0.01832
47	0.00000	0.00000	0.00000	0.01476	0.00041	0.15744	0.00004	0.00000	0.01806
48	0.00000	0.00000	0.00000	0.01441	0.00039	0.15625	0.00003	0.00000	0.01780
49	0.00000	0.00000	0.00000	0.01408	0.00037	0.15509	0.00003	0.00000	0.01755
50	0.00000	0.00000	0.00000	0.01375	0.00035	0.15397	0.00003	0.00000	0.01731
55	0.00000	0.00000	0.00000	0.01232	0.00028	0.14875	0.00002	0.00000	0.01622
60	0.00000	0.00000	0.00000	0.01112	0.00022	0.14412	0.00002	0.00000	0.01527
65	0.00000	0.00000	0.00000	0.01011	0.00018	0.13996	0.00002	0.00000	0.01445
70	0.00000	0.00000	0.00000	0.00925	0.00015	0.13619	0.00001	0.00000	0.01373
75	0.00000	0.00000	0.00000	0.00851	0.00013	0.13277	0.00001	0.00000	0.01308
80	0.00000	0.00000	0.00000	0.00786	0.00011	0.12962	0.00001	0.00000	0.01251
85	0.00000	0.00000	0.00000	0.00729	0.00009	0.12673	0.00001	0.00000	0.01198
90	0.00000	0.00000	0.00000	0.00679	0.00008	0.12405	0.00001	0.00000	0.01151
95	0.00000	0.00000	0.00000	0.00634	0.00007	0.12155	0.00001	0.00000	0.01108
100	0.00000	0.00000	0.00000	0.00594	0.00006	0.11922	0.00000	0.00000	0.01068
110	0.00000	0.00000	0.00000	0.00526	0.00005	0.11500	0.00000	0.00000	0.00998
120	0.00000	0.00000	0.00000	0.00470	0.00004	0.11124	0.00000	0.00000	0.00938
130	0.00000	0.00000	0.00000	0.00423	0.00003	0.10788	0.00000	0.00000	0.00886
140	0.00000	0.00000	0.00000	0.00383	0.00002	0.10484	0.00000	0.00000	0.00839
150	0.00000	0.00000	0.00000	0.00349	0.00002	0.10207	0.00000	0.00000	0.00798
160	0.00000	0.00000	0.00000	0.00320	0.00002	0.09954	0.00000	0.00000	0.00762
170	0.00000	0.00000	0.00000	0.00295	0.00001	0.09721	0.00000	0.00000	0.00729
180	0.00000	0.00000	0.00000	0.00272	0.00001	0.09505	0.00000	0.00000	0.00699
190	0.00000	0.00000	0.00000	0.00253	0.00001	0.09305	0.00000	0.00000	0.00671
200	0.00000	0.00000	0.00000	0.00235	0.00001	0.09118	0.00000	0.00000	0.00646

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			SOagr			Spsq		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00000	0.00000	0.00000	0.00220	0.00001	0.08942	0.00000	0.00000	0.00623
220	0.00000	0.00000	0.00000	0.00206	0.00001	0.08778	0.00000	0.00000	0.00602
230	0.00000	0.00000	0.00000	0.00193	0.00001	0.08624	0.00000	0.00000	0.00583
240	0.00000	0.00000	0.00000	0.00182	0.00000	0.08478	0.00000	0.00000	0.00564
250	0.00000	0.00000	0.00000	0.00171	0.00000	0.08339	0.00000	0.00000	0.00547
260	0.00000	0.00000	0.00000	0.00162	0.00000	0.08208	0.00000	0.00000	0.00531
270	0.00000	0.00000	0.00000	0.00153	0.00000	0.08084	0.00000	0.00000	0.00517
280	0.00000	0.00000	0.00000	0.00145	0.00000	0.07966	0.00000	0.00000	0.00503
290	0.00000	0.00000	0.00000	0.00138	0.00000	0.07853	0.00000	0.00000	0.00489
300	0.00000	0.00000	0.00000	0.00131	0.00000	0.07745	0.00000	0.00000	0.00477

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			SZtb		
	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.23273	0.06670	0.51638	0.64322	0.38238	0.84930	0.44216	0.31151	0.57949
2	0.09457	0.01492	0.32491	0.40139	0.19993	0.63395	0.26095	0.15832	0.38996
3	0.04903	0.00450	0.24303	0.27074	0.10603	0.51066	0.17621	0.09343	0.29462
4	0.02895	0.00165	0.19660	0.19308	0.05819	0.43523	0.12812	0.06020	0.23651
5	0.01857	0.00069	0.16620	0.14340	0.03328	0.38371	0.09772	0.04117	0.19710
6	0.01262	0.00032	0.14451	0.10983	0.01980	0.34569	0.07710	0.02941	0.16851
7	0.00896	0.00016	0.12816	0.08619	0.01221	0.31611	0.06240	0.02172	0.14678
8	0.00658	0.00008	0.11533	0.06898	0.00776	0.29222	0.05152	0.01648	0.12970
9	0.00496	0.00005	0.10495	0.05611	0.00507	0.27240	0.04323	0.01277	0.11591
10	**0.00382**	**0.00003**	**0.09636**	**0.04628**	**0.00339**	**0.25560**	**0.03676**	**0.01009**	**0.10455**
11	0.00300	0.00002	0.08913	0.03863	0.00232	0.24112	0.03161	0.00809	0.09504
12	0.00239	0.00001	0.08294	0.03257	0.00162	0.22848	0.02744	0.00657	0.08696
13	0.00194	0.00001	0.07758	0.02771	0.00115	0.21731	0.02403	0.00540	0.08001
14	0.00159	0.00000	0.07289	0.02377	0.00082	0.20735	0.02119	0.00449	0.07397
15	0.00131	0.00000	0.06874	0.02053	0.00060	0.19840	0.01880	0.00376	0.06869
16	0.00110	0.00000	0.06505	0.01785	0.00044	0.19031	0.01679	0.00318	0.06403
17	0.00092	0.00000	0.06174	0.01561	0.00033	0.18294	0.01506	0.00271	0.05988
18	0.00078	0.00000	0.05875	0.01372	0.00025	0.17620	0.01358	0.00232	0.05618
19	0.00067	0.00000	0.05604	0.01212	0.00019	0.17000	0.01229	0.00200	0.05284
20	0.00058	0.00000	0.05357	0.01076	0.00015	0.16427	0.01117	0.00174	0.04984
21	0.00050	0.00000	0.05131	0.00958	0.00011	0.15897	0.01019	0.00151	0.04711
22	0.00043	0.00000	0.04923	0.00857	0.00009	0.15403	0.00932	0.00133	0.04462
23	0.00038	0.00000	0.04731	0.00769	0.00007	0.14943	0.00856	0.00117	0.04235
24	0.00033	0.00000	0.04554	0.00693	0.00006	0.14512	0.00787	0.00103	0.04026
25	0.00029	0.00000	0.04389	0.00625	0.00004	0.14108	0.00727	0.00091	0.03834
26	0.00026	0.00000	0.04236	0.00567	0.00004	0.13728	0.00672	0.00081	0.03657
27	0.00023	0.00000	0.04093	0.00515	0.00003	0.13370	0.00623	0.00072	0.03493
28	0.00021	0.00000	0.03959	0.00468	0.00002	0.13032	0.00579	0.00065	0.03341
29	0.00018	0.00000	0.03833	0.00428	0.00002	0.12713	0.00539	0.00058	0.03200
30	0.00016	0.00000	0.03715	0.00391	0.00002	0.12409	0.00503	0.00052	0.03068
31	0.00015	0.00000	0.03604	0.00358	0.00001	0.12122	0.00470	0.00047	0.02945
32	0.00013	0.00000	0.03499	0.00329	0.00001	0.11848	0.00440	0.00043	0.02830
33	0.00012	0.00000	0.03400	0.00303	0.00001	0.11588	0.00412	0.00039	0.02722
34	0.00011	0.00000	0.03306	0.00279	0.00001	0.11339	0.00387	0.00035	0.02620
35	0.00010	0.00000	0.03217	0.00258	0.00001	0.11102	0.00364	0.00032	0.02525

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			SZtb		
	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00009	0.00000	0.03133	0.00239	0.00001	0.10875	0.00342	0.00029	0.02435
37	0.00008	0.00000	0.03053	0.00221	0.00000	0.10658	0.00323	0.00027	0.02351
38	0.00008	0.00000	0.02977	0.00205	0.00000	0.10450	0.00305	0.00025	0.02271
39	0.00007	0.00000	0.02904	0.00191	0.00000	0.10251	0.00288	0.00023	0.02195
40	0.00006	0.00000	0.02834	0.00177	0.00000	0.10059	0.00272	0.00021	0.02123
41	0.00006	0.00000	0.02768	0.00165	0.00000	0.09875	0.00258	0.00019	0.02055
42	0.00005	0.00000	0.02705	0.00154	0.00000	0.09698	0.00244	0.00018	0.01991
43	0.00005	0.00000	0.02644	0.00144	0.00000	0.09527	0.00232	0.00016	0.01930
44	0.00005	0.00000	0.02586	0.00135	0.00000	0.09363	0.00220	0.00015	0.01871
45	0.00004	0.00000	0.02530	0.00126	0.00000	0.09205	0.00210	0.00014	0.01816
46	0.00004	0.00000	0.02477	0.00118	0.00000	0.09052	0.00199	0.00013	0.01763
47	0.00004	0.00000	0.02426	0.00111	0.00000	0.08905	0.00190	0.00012	0.01712
48	0.00003	0.00000	0.02376	0.00104	0.00000	0.08762	0.00181	0.00011	0.01664
49	0.00003	0.00000	0.02329	0.00098	0.00000	0.08624	0.00173	0.00010	0.01618
50	0.00003	0.00000	0.02283	0.00092	0.00000	0.08491	0.00165	0.00010	0.01574
55	0.00002	0.00000	0.02078	0.00069	0.00000	0.07884	0.00132	0.00007	0.01380
60	0.00002	0.00000	0.01905	0.00053	0.00000	0.07360	0.00107	0.00005	0.01222
65	0.00001	0.00000	0.01757	0.00041	0.00000	0.06904	0.00089	0.00004	0.01090
70	0.00001	0.00000	0.01630	0.00032	0.00000	0.06502	0.00074	0.00003	0.00980
75	0.00001	0.00000	0.01519	0.00026	0.00000	0.06145	0.00062	0.00002	0.00886
80	0.00001	0.00000	0.01421	0.00021	0.00000	0.05826	0.00053	0.00002	0.00805
85	0.00000	0.00000	0.01334	0.00017	0.00000	0.05539	0.00045	0.00001	0.00736
90	0.00000	0.00000	0.01256	0.00014	0.00000	0.05279	0.00039	0.00001	0.00675
95	0.00000	0.00000	0.01186	0.00011	0.00000	0.05042	0.00034	0.00001	0.00622
100	0.00000	0.00000	0.01124	0.00010	0.00000	0.04826	0.00030	0.00001	0.00575
110	0.00000	0.00000	0.01015	0.00007	0.00000	0.04444	0.00023	0.00001	0.00496
120	0.00000	0.00000	0.00923	0.00005	0.00000	0.04118	0.00018	0.00000	0.00432
130	0.00000	0.00000	0.00846	0.00004	0.00000	0.03836	0.00015	0.00000	0.00380
140	0.00000	0.00000	0.00780	0.00003	0.00000	0.03589	0.00012	0.00000	0.00337
150	0.00000	0.00000	0.00722	0.00002	0.00000	0.03372	0.00010	0.00000	0.00301
160	0.00000	0.00000	0.00672	0.00002	0.00000	0.03178	0.00008	0.00000	0.00271
170	0.00000	0.00000	0.00628	0.00001	0.00000	0.03005	0.00007	0.00000	0.00245
180	0.00000	0.00000	0.00588	0.00001	0.00000	0.02850	0.00006	0.00000	0.00222
190	0.00000	0.00000	0.00553	0.00001	0.00000	0.02709	0.00005	0.00000	0.00203
200	0.00000	0.00000	0.00522	0.00001	0.00000	0.02581	0.00004	0.00000	0.00186

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			SZtb		
	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00000	0.00000	0.00493	0.00001	0.00000	0.02464	0.00004	0.00000	0.00171
220	0.00000	0.00000	0.00467	0.00001	0.00000	0.02356	0.00003	0.00000	0.00158
230	0.00000	0.00000	0.00444	0.00000	0.00000	0.02257	0.00003	0.00000	0.00146
240	0.00000	0.00000	0.00422	0.00000	0.00000	0.02166	0.00003	0.00000	0.00135
250	0.00000	0.00000	0.00402	0.00000	0.00000	0.02082	0.00002	0.00000	0.00126
260	0.00000	0.00000	0.00384	0.00000	0.00000	0.02003	0.00002	0.00000	0.00118
270	0.00000	0.00000	0.00367	0.00000	0.00000	0.01930	0.00002	0.00000	0.00110
280	0.00000	0.00000	0.00352	0.00000	0.00000	0.01862	0.00002	0.00000	0.00103
290	0.00000	0.00000	0.00337	0.00000	0.00000	0.01798	0.00001	0.00000	0.00097
300	0.00000	0.00000	0.00324	0.00000	0.00000	0.01738	0.00001	0.00000	0.00091

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micro-grams per liter	Bedrock unit abbreviation					
	Zpg*			Zsg		
	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.01393	0.00098	0.09648	0.04051	0.00712	0.14958
2	0.00446	0.00022	0.04351	0.01576	0.00089	0.12002
3	0.00213	0.00008	0.02561	0.00848	0.00020	0.10841
4	0.00122	0.00004	0.01708	0.00529	0.00006	0.10152
5	0.00078	0.00002	0.01227	0.00361	0.00002	0.09673
6	0.00053	0.00001	0.00926	0.00261	0.00001	0.09310
7	0.00038	0.00001	0.00724	0.00197	0.00000	0.09020
8	0.00028	0.00001	0.00582	0.00153	0.00000	0.08780
9	0.00022	0.00000	0.00478	0.00122	0.00000	0.08577
10	**0.00017**	**0.00000**	**0.00400**	**0.00099**	**0.00000**	**0.08400**
11	0.00014	0.00000	0.00339	0.00082	0.00000	0.08245
12	0.00011	0.00000	0.00291	0.00069	0.00000	0.08107
13	0.00009	0.00000	0.00252	0.00059	0.00000	0.07982
14	0.00008	0.00000	0.00220	0.00050	0.00000	0.07869
15	0.00007	0.00000	0.00194	0.00044	0.00000	0.07766
16	0.00006	0.00000	0.00172	0.00038	0.00000	0.07670
17	0.00005	0.00000	0.00154	0.00033	0.00000	0.07582
18	0.00004	0.00000	0.00138	0.00030	0.00000	0.07500
19	0.00004	0.00000	0.00125	0.00026	0.00000	0.07424
20	0.00003	0.00000	0.00113	0.00023	0.00000	0.07352
21	0.00003	0.00000	0.00103	0.00021	0.00000	0.07285
22	0.00003	0.00000	0.00094	0.00019	0.00000	0.07221
23	0.00002	0.00000	0.00086	0.00017	0.00000	0.07161
24	0.00002	0.00000	0.00079	0.00016	0.00000	0.07104
25	0.00002	0.00000	0.00073	0.00014	0.00000	0.07050
26	0.00002	0.00000	0.00068	0.00013	0.00000	0.06998
27	0.00001	0.00000	0.00063	0.00012	0.00000	0.06949
28	0.00001	0.00000	0.00058	0.00011	0.00000	0.06901
29	0.00001	0.00000	0.00054	0.00010	0.00000	0.06856
30	0.00001	0.00000	0.00051	0.00009	0.00000	0.06813
31	0.00001	0.00000	0.00047	0.00009	0.00000	0.06771
32	0.00001	0.00000	0.00044	0.00008	0.00000	0.06731
33	0.00001	0.00000	0.00042	0.00008	0.00000	0.06693
34	0.00001	0.00000	0.00039	0.00007	0.00000	0.06656
35	0.00001	0.00000	0.00037	0.00007	0.00000	0.06620

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micro-grams per liter	Bedrock unit abbreviation					
	Zpg*			Zsg		
	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentra-tion listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00001	0.00000	0.00035	0.00006	0.00000	0.06585
37	0.00001	0.00000	0.00033	0.00006	0.00000	0.06551
38	0.00001	0.00000	0.00031	0.00005	0.00000	0.06519
39	0.00001	0.00000	0.00029	0.00005	0.00000	0.06488
40	0.00001	0.00000	0.00028	0.00005	0.00000	0.06457
41	0.00000	0.00000	0.00026	0.00004	0.00000	0.06427
42	0.00000	0.00000	0.00025	0.00004	0.00000	0.06399
43	0.00000	0.00000	0.00024	0.00004	0.00000	0.06371
44	0.00000	0.00000	0.00023	0.00004	0.00000	0.06344
45	0.00000	0.00000	0.00022	0.00004	0.00000	0.06317
46	0.00000	0.00000	0.00021	0.00003	0.00000	0.06291
47	0.00000	0.00000	0.00020	0.00003	0.00000	0.06266
48	0.00000	0.00000	0.00019	0.00003	0.00000	0.06242
49	0.00000	0.00000	0.00018	0.00003	0.00000	0.06218
50	0.00000	0.00000	0.00017	0.00003	0.00000	0.06195
55	0.00000	0.00000	0.00014	0.00002	0.00000	0.06086
60	0.00000	0.00000	0.00011	0.00002	0.00000	0.05988
65	0.00000	0.00000	0.00010	0.00001	0.00000	0.05900
70	0.00000	0.00000	0.00008	0.00001	0.00000	0.05820
75	0.00000	0.00000	0.00007	0.00001	0.00000	0.05746
80	0.00000	0.00000	0.00006	0.00001	0.00000	0.05677
85	0.00000	0.00000	0.00005	0.00001	0.00000	0.05614
90	0.00000	0.00000	0.00005	0.00001	0.00000	0.05554
95	0.00000	0.00000	0.00004	0.00001	0.00000	0.05499
100	0.00000	0.00000	0.00004	0.00000	0.00000	0.05447
110	0.00000	0.00000	0.00003	0.00000	0.00000	0.05351
120	0.00000	0.00000	0.00002	0.00000	0.00000	0.05265
130	0.00000	0.00000	0.00002	0.00000	0.00000	0.05187
140	0.00000	0.00000	0.00002	0.00000	0.00000	0.05116
150	0.00000	0.00000	0.00001	0.00000	0.00000	0.05051
160	0.00000	0.00000	0.00001	0.00000	0.00000	0.04990
170	0.00000	0.00000	0.00001	0.00000	0.00000	0.04934
180	0.00000	0.00000	0.00001	0.00000	0.00000	0.04882
190	0.00000	0.00000	0.00001	0.00000	0.00000	0.04833
200	0.00000	0.00000	0.00001	0.00000	0.00000	0.04787

Appendix 3. Probability of arsenic exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Arsenic, in micrograms per liter	Bedrock unit abbreviation					
	Zpg*			Zsg		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00000	0.00000	0.00001	0.00000	0.00000	0.04743
220	0.00000	0.00000	0.00000	0.00000	0.00000	0.04702
230	0.00000	0.00000	0.00000	0.00000	0.00000	0.04663
240	0.00000	0.00000	0.00000	0.00000	0.00000	0.04626
250	0.00000	0.00000	0.00000	0.00000	0.00000	0.04591
260	0.00000	0.00000	0.00000	0.00000	0.00000	0.04557
270	0.00000	0.00000	0.00000	0.00000	0.00000	0.04525
280	0.00000	0.00000	0.00000	0.00000	0.00000	0.04494
290	0.00000	0.00000	0.00000	0.00000	0.00000	0.04464
300	0.00000	0.00000	0.00000	0.00000	0.00000	0.04436

Appendix 4. Arsenic Log-Normal Fit Statistics by Bedrock Unit

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Grouped bedrock units with elevated-arsenic concentration					Bedrock unit abbreviation				
					Ops*				
Censoring information	Count				Censoring information	Count			
Uncensored value	142				Uncensored value	2			
Left censored value	13				Left censored value	8			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	0.842088	0.160891	0.526746	1.15743	Location	-3.21928	0.787011	-4.7618	-1.67677
Scale	1.98346	0.122107	1.75801	2.23782	Scale	1.78003	0.0901298	1.61186	1.96574
Log-likelihood	-484.214				Log-likelihood	-4.305			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	0.431				Anderson-Darling (adjusted)	2.245			
Correlation coefficient	0.999				Correlation coefficient	1			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	16.5957	4.65715	9.57473	28.7649	Mean	0.194946	0.152905	0.041906	0.906885
Standard deviation	117.486	59.1549	43.7925	315.189	Standard deviation	0.93028	0.759049	0.18797	4.60404
Median	2.32121	0.373462	1.69341	3.18174	Median	0.0399836	0.0314676	0.0085502	0.186977
First quartile (Q1)	0.609123	0.113368	0.422943	0.877259	First quartile (Q1)	0.0120355	0.0095863	0.0025262	0.0573391
Third quartile (Q3)	8.84551	1.54983	6.27455	12.4699	Third quartile (Q3)	0.132832	0.103893	0.0286776	0.615262
Interquartile range (IQR)	8.23639	1.48626	5.78278	11.7311	Interquartile range (IQR)	0.120796	0.0944301	0.0261001	0.559067

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
OZf					OZm				
Censoring information	Count				Censoring information	Count			
Uncensored value	7				Uncensored value	4			
Left censored value	1				Left censored value	6			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	0.203812	0.537881	-0.850415	1.25804	Location	-3.14197	2.2943	-7.63872	1.35477
Scale	1.46776	0.444717	0.810489	2.65803	Scale	4.40671	2.19624	1.65915	11.7042
Log-likelihood	-19.146				Log-likelihood	-20.355			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	3.106				Anderson-Darling (adjusted)	2.122			
Correlation coefficient	0.922				Correlation coefficient	0.956			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	3.60011	2.6815	0.836197	15.4997	Mean	711.633	5.84×10^{3}	0.0000725	6.99×10^{9}
Standard deviation	9.93912	13.636	0.675371	146.269	Standard deviation	1.17×10^{7}	2.09×10^{8}	0	1.68×10^{22}
Median	1.22607	0.659479	0.427238	3.51852	Median	0.0431974	0.0991078	0.0004814	3.87586
First quartile (Q1)	0.455585	0.306663	0.121789	1.70424	First quartile (Q1)	0.0022111	0.0077461	0.0000023	2.1211
Third quartile (Q3)	3.29959	1.82372	1.11684	9.7483	Third quartile (Q3)	0.843922	1.3722	0.0348552	20.4332
Interquartile range (IQR)	2.84401	1.67949	0.89385	9.04891	Interquartile range (IQR)	0.841711	1.36804	0.0348095	20.353

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
OZn					OZnb				
Censoring information	Count				Censoring information	Count			
Uncensored value	19				Uncensored value	17			
Left censored value	12				Left censored value	3			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-1.58309	0.352176	-2.27334	-0.892837	Location	0.779948	0.531552	-0.261874	1.82177
Scale	1.6106	0.349339	1.05283	2.46384	Scale	2.31159	0.437248	1.59552	3.34903
Log-likelihood	-33.677				Log-likelihood	-67.412			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	3.307				Anderson-Darling (adjusted)	1.281			
Correlation coefficient	0.981				Correlation coefficient	0.98			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.751202	0.37721	0.280759	2.00993	Mean	31.5531	33.5261	3.93202	253.203
Standard deviation	2.64349	2.77567	0.337609	20.6986	Standard deviation	455.321	914.887	8.87111	2.34×10^4
Median	0.20534	0.0723157	0.102968	0.409492	Median	2.18136	1.1595	0.769608	6.18279
First quartile (Q1)	0.0692924	0.035228	0.0255822	0.187687	First quartile (Q1)	0.458775	0.297545	0.128689	1.63553
Third quartile (Q3)	0.608499	0.193027	0.326771	1.13312	Third quartile (Q3)	10.3718	5.85262	3.43193	31.3452
Interquartile range (IQR)	0.539207	0.180896	0.279377	1.04069	Interquartile range (IQR)	9.91304	5.69917	3.21246	30.5898

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Sgr					SOagr				
Censoring information	Count				Censoring information	Count			
Uncensored value	7				Uncensored value	7			
Left censored value	0				Left censored value	5			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.0870687	0.221555	-0.521308	0.347171	Location	-0.996819	0.724544	-2.4169	0.423261
Scale	0.505699	0.101615	0.341076	0.749778	Scale	2.22697	0.632122	1.27674	3.88443
Log-likelihood	-9.715				Log-likelihood	-24.772			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	3.111				Anderson-Darling (adjusted)	1.726			
Correlation coefficient	0.954				Correlation coefficient	0.947			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	1.04164	0.20888	0.703116	1.54315	Mean	4.40564	5.98493	0.307381	63.1452
Standard deviation	0.562298	0.142746	0.341884	0.924815	Standard deviation	52.4085	140.438	0.274442	1.00×10^4
Median	0.916614	0.20308	0.593743	1.41506	Median	0.369052	0.267394	0.0891978	1.52693
First quartile (Q1)	0.651709	0.171367	0.389252	1.09113	First quartile (Q1)	0.0821762	0.078262	0.0127084	0.531378
Third quartile (Q3)	1.2892	0.252714	0.877936	1.89311	Third quartile (Q3)	1.6574	1.17954	0.410814	6.68669
Interquartile range (IQR)	0.637489	0.136533	0.418955	0.970013	Interquartile range (IQR)	1.57523	1.14191	0.380445	6.5222

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Spsq*					Spss				
Censoring information	Count				Censoring information	Count			
Uncensored value	4				Uncensored value	5			
Left censored value	5				Left censored value	2			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-2.41045	0.846842	-4.07023	-0.750667	Location	-0.867381	0.508521	-1.86406	0.129302
Scale	1.57953	0.495804	0.853772	2.92223	Scale	1.18838	0.332903	0.686285	2.0578
Log-likelihood	-10.109				Log-likelihood	-10.976			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	2.121				Anderson-Darling (adjusted)	2.799			
Correlation coefficient	0.966				Correlation coefficient	0.982			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.312551	0.199818	0.0892766	1.09422	Mean	0.851069	0.428686	0.317112	2.28411
Standard deviation	1.04229	1.26353	0.0968518	11.2168	Standard deviation	1.4997	1.27936	0.281753	7.98256
Median	0.0897751	0.0760253	0.0170735	0.472051	Median	0.42005	0.213604	0.155041	1.13803
First quartile (Q1)	0.0309363	0.0342062	0.0035424	0.270172	First quartile (Q1)	0.188449	0.119276	0.0545049	0.651556
Third quartile (Q3)	0.260522	0.171901	0.0714813	0.9495	Third quartile (Q3)	0.936287	0.436567	0.375418	2.33509
Interquartile range (IQR)	0.229585	0.144786	0.0667025	0.790216	Interquartile range (IQR)	0.747838	0.362431	0.289256	1.93345

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Ssqd					**SZtb**				
Censoring information	**Count**				**Censoring information**	**Count**			
Uncensored value	11				Uncensored value	29			
Left censored value	0				Left censored value	4			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					**Parameter estimates**				
Parameter	**Estimate**	**Standard error**	**95% normal CI**		**Parameter**	**Estimate**	**Standard error**	**95% normal CI**	
			Lower	**Upper**				**Lower**	**Upper**
Location	0.412493	0.343881	-0.261502	1.08649	Location	-0.203752	0.250689	-0.695093	0.287588
Scale	1.1237	0.320478	0.642518	1.96522	Scale	1.40051	0.187371	1.07747	1.8204
Log-likelihood	-21.008				Log-likelihood	-62.075			
Goodness-of-fit					**Goodness-of-fit**				
Anderson-Darling (adjusted)	2.392				Anderson-Darling (adjusted)	0.892			
Correlation coefficient	0.951				Correlation coefficient	0.992			
Characteristics of distribution					**Characteristics of distribution**				
Descriptor	**Estimate**	**Standard error**	**95% normal CI**		**Descriptor**	**Estimate**	**Standard error**	**95% normal CI**	
			Lower	**Upper**				**Lower**	**Upper**
Mean	2.8401	1.28763	1.16794	6.90631	Mean	2.17486	0.715688	1.1411	4.14514
Standard deviation	4.52184	3.94286	0.818658	24.9763	Standard deviation	5.3757	3.10934	1.7302	16.7023
Median	1.51058	0.51946	0.769894	2.96385	Median	0.815664	0.204478	0.499028	1.33321
First quartile (Q1)	0.707917	0.308919	0.30098	1.66505	First quartile (Q1)	0.317149	0.0951949	0.176104	0.571161
Third quartile (Q3)	3.22333	1.20405	1.55005	6.70291	Third quartile (Q3)	2.09778	0.545174	1.26051	3.49117
Interquartile range (IQR)	2.51541	1.10396	1.06423	5.94541	Interquartile range (IQR)	1.78063	0.49387	1.03392	3.06662

Appendix 4. Arsenic log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Zpg*					Zsg				
Censoring information	Count				Censoring information	Count			
Uncensored value	2				Uncensored value	7			
Left censored value	9				Left censored value	16			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-3.66411	0.771435	-5.17609	-2.15212	Location	-2.98176	0.999948	-4.94162	-1.0219
Scale	1.66617	0.100537	1.48032	1.87534	Scale	1.70893	0.748103	0.724607	4.03039
Log-likelihood		-3.006			Log-likelihood		-14.871		
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)		2.214			Anderson-Darling (adjusted)		2.733		
Correlation coefficient		1			Correlation coefficient		0.982		
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.102689	0.0779394	0.0231993	0.454541	Mean	0.218376	0.130661	0.0675934	0.705514
Standard deviation	0.398461	0.313134	0.0854009	1.85913	Standard deviation	0.914828	1.64495	0.0269649	31.037
Median	0.0256271	0.0197696	0.0056501	0.116237	Median	0.0507034	0.0507008	0.007143	0.35991
First quartile (Q1)	0.0083298	0.0065524	0.0017826	0.0389236	First quartile (Q1)	0.016012	0.0234942	0.0009026	0.284057
Third quartile (Q3)	0.0788433	0.0600783	0.0177073	0.351056	Third quartile (Q3)	0.160557	0.0958063	0.049855	0.517073
Interquartile range (IQR)	0.0705135	0.0536348	0.0158789	0.313129	Interquartile range (IQR)	0.144545	0.0768037	0.0510177	0.409532

Appendix 5. Probability of Uranium Exceeding a Given Concentration by Bedrock Unit

Appendix 5. Probability of uranium exceeding a given concentration by bedrock unit.

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Dcgr			Dfgr			Dl		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.95614	0.51366	0.99964	0.64549	0.32667	0.88405	0.15706	0.03907	0.40068
2	0.88401	0.43605	0.99464	0.53055	0.24734	0.79848	0.06707	0.00759	0.28505
3	0.81477	0.38671	0.98120	0.46145	0.20378	0.73716	0.03710	0.00226	0.23244
4	0.75269	0.34946	0.96018	0.41300	0.17473	0.69003	0.02333	0.00085	0.20043
5	0.69779	0.31902	0.93403	0.37627	0.15347	0.65213	0.01588	0.00037	0.17825
6	0.64925	0.29304	0.90509	0.34705	0.13703	0.62065	0.01140	0.00018	0.16167
7	0.60617	0.27025	0.87509	0.32303	0.12384	0.59389	0.00852	0.00010	0.14867
8	0.56776	0.24991	0.84521	0.30281	0.11296	0.57073	0.00656	0.00005	0.13812
9	0.53332	0.23154	0.81621	0.28545	0.10381	0.55040	0.00517	0.00003	0.12932
10	0.50229	0.21481	0.78853	0.27033	0.09599	0.53235	0.00416	0.00002	0.12185
11	0.47420	0.19950	0.76239	0.25702	0.08921	0.51615	0.00340	0.00001	0.11540
12	0.44867	0.18543	0.73789	0.24516	0.08328	0.50151	0.00282	0.00001	0.10976
13	0.42537	0.17247	0.71502	0.23452	0.07804	0.48817	0.00237	0.00001	0.10476
14	0.40402	0.16051	0.69373	0.22490	0.07337	0.47595	0.00201	0.00000	0.10031
15	0.38440	0.14947	0.67395	0.21615	0.06918	0.46470	0.00172	0.00000	0.09631
16	0.36631	0.13925	0.65557	0.20815	0.06541	0.45429	0.00148	0.00000	0.09268
17	0.34958	0.12980	0.63849	0.20079	0.06199	0.44461	0.00129	0.00000	0.08937
18	0.33407	0.12106	0.62261	0.19400	0.05887	0.43558	0.00112	0.00000	0.08635
19	0.31966	0.11296	0.60782	0.18771	0.05602	0.42713	0.00099	0.00000	0.08356
20	0.30623	0.10545	0.59404	0.18186	0.05341	0.41920	0.00087	0.00000	0.08099
21	0.29369	0.09850	0.58116	0.17640	0.05100	0.41173	0.00078	0.00000	0.07860
22	0.28197	0.09206	0.56912	0.17129	0.04877	0.40469	0.00069	0.00000	0.07638
23	0.27098	0.08609	0.55784	0.16650	0.04670	0.39802	0.00062	0.00000	0.07431
24	0.26066	0.08055	0.54726	0.16199	0.04478	0.39170	0.00056	0.00000	0.07236
25	0.25095	0.07541	0.53731	0.15775	0.04299	0.38569	0.00050	0.00000	0.07054
26	0.24181	0.07064	0.52794	0.15374	0.04132	0.37997	0.00046	0.00000	0.06882
27	0.23319	0.06621	0.51910	0.14994	0.03976	0.37453	0.00042	0.00000	0.06721
28	0.22505	0.06209	0.51074	0.14635	0.03830	0.36932	0.00038	0.00000	0.06568
29	0.21735	0.05827	0.50284	0.14293	0.03692	0.36435	0.00035	0.00000	0.06423
30	**0.21005**	**0.05471**	**0.49534**	**0.13968**	**0.03562**	**0.35958**	**0.00032**	**0.00000**	**0.06285**
31	0.20313	0.05140	0.48822	0.13659	0.03440	0.35501	0.00029	0.00000	0.06155
32	0.19657	0.04832	0.48146	0.13364	0.03325	0.35062	0.00027	0.00000	0.06031
33	0.19033	0.04545	0.47502	0.13082	0.03216	0.34640	0.00025	0.00000	0.05912
34	0.18439	0.04277	0.46887	0.12813	0.03113	0.34234	0.00023	0.00000	0.05799
35	0.17874	0.04028	0.46301	0.12555	0.03015	0.33843	0.00021	0.00000	0.05691

Appendix 5. Probability of uranium exceeding a given concentration by bedrock unit. —Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Dcgr			Dfgr			Dl		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.17335	0.03795	0.45740	0.12308	0.02922	0.33466	0.00020	0.00000	0.05588
37	0.16821	0.03577	0.45204	0.12071	0.02834	0.33103	0.00018	0.00000	0.05489
38	0.16331	0.03374	0.44690	0.11843	0.02750	0.32751	0.00017	0.00000	0.05394
39	0.15862	0.03185	0.44196	0.11624	0.02670	0.32411	0.00016	0.00000	0.05302
40	0.15413	0.03007	0.43723	0.11414	0.02593	0.32082	0.00015	0.00000	0.05215
41	0.14984	0.02841	0.43267	0.11211	0.02521	0.31764	0.00014	0.00000	0.05130
42	0.14573	0.02686	0.42829	0.11016	0.02451	0.31455	0.00013	0.00000	0.05049
43	0.14179	0.02540	0.42407	0.10828	0.02385	0.31156	0.00012	0.00000	0.04971
44	0.13801	0.02404	0.42001	0.10646	0.02321	0.30866	0.00011	0.00000	0.04896
45	0.13438	0.02275	0.41608	0.10470	0.02260	0.30584	0.00011	0.00000	0.04823
46	0.13090	0.02155	0.41229	0.10301	0.02202	0.30310	0.00010	0.00000	0.04752
47	0.12755	0.02043	0.40863	0.10137	0.02146	0.30044	0.00009	0.00000	0.04684
48	0.12433	0.01937	0.40508	0.09978	0.02093	0.29785	0.00009	0.00000	0.04619
49	0.12123	0.01837	0.40165	0.09824	0.02041	0.29533	0.00008	0.00000	0.04555
50	0.11825	0.01743	0.39833	0.09676	0.01992	0.29287	0.00008	0.00000	0.04493
55	0.10488	0.01351	0.38316	0.08995	0.01770	0.28149	0.00006	0.00000	0.04212
60	0.09366	0.01058	0.36997	0.08406	0.01586	0.27140	0.00005	0.00000	0.03968
65	0.08415	0.00836	0.35838	0.07890	0.01430	0.26236	0.00004	0.00000	0.03754
70	0.07600	0.00667	0.34806	0.07434	0.01297	0.25420	0.00003	0.00000	0.03565
75	0.06897	0.00537	0.33880	0.07028	0.01183	0.24678	0.00002	0.00000	0.03397
80	0.06286	0.00435	0.33042	0.06664	0.01083	0.23999	0.00002	0.00000	0.03245
85	0.05751	0.00355	0.32278	0.06335	0.00996	0.23375	0.00002	0.00000	0.03108
90	0.05281	0.00292	0.31578	0.06037	0.00919	0.22798	0.00001	0.00000	0.02983
95	0.04864	0.00241	0.30932	0.05765	0.00851	0.22263	0.00001	0.00000	0.02869
100	0.04493	0.00201	0.30335	0.05516	0.00790	0.21764	0.00001	0.00000	0.02765
110	0.03865	0.00141	0.29260	0.05076	0.00687	0.20862	0.00001	0.00000	0.02579
120	0.03356	0.00101	0.28316	0.04699	0.00603	0.20064	0.00001	0.00000	0.02419
130	0.02938	0.00073	0.27479	0.04373	0.00534	0.19352	0.00000	0.00000	0.02279
140	0.02590	0.00054	0.26728	0.04087	0.00476	0.18712	0.00000	0.00000	0.02156
150	0.02298	0.00040	0.26048	0.03835	0.00427	0.18131	0.00000	0.00000	0.02047
160	0.02050	0.00031	0.25429	0.03610	0.00385	0.17601	0.00000	0.00000	0.01949
170	0.01839	0.00024	0.24862	0.03409	0.00349	0.17115	0.00000	0.00000	0.01860
180	0.01656	0.00018	0.24339	0.03229	0.00318	0.16666	0.00000	0.00000	0.01780
190	0.01498	0.00014	0.23855	0.03065	0.00290	0.16251	0.00000	0.00000	0.01708
200	0.01361	0.00011	0.23404	0.02916	0.00266	0.15865	0.00000	0.00000	0.01641

Appendix 5. Probability of uranium exceeding a given concentration by bedrock unit. —Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Dcgr			Dfgr			Dl		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.01240	0.00009	0.22983	0.02780	0.00245	0.15505	0.00000	0.00000	0.01579
220	0.01134	0.00007	0.22589	0.02655	0.00226	0.15168	0.00000	0.00000	0.01523
230	0.01040	0.00006	0.22219	0.02541	0.00210	0.14852	0.00000	0.00000	0.01470
240	0.00956	0.00005	0.21869	0.02435	0.00195	0.14554	0.00000	0.00000	0.01422
250	0.00881	0.00004	0.21539	0.02337	0.00181	0.14273	0.00000	0.00000	0.01376
260	0.00815	0.00003	0.21227	0.02245	0.00169	0.14007	0.00000	0.00000	0.01334
270	0.00755	0.00003	0.20930	0.02161	0.00158	0.13755	0.00000	0.00000	0.01294
280	0.00700	0.00002	0.20648	0.02082	0.00148	0.13516	0.00000	0.00000	0.01257
290	0.00651	0.00002	0.20379	0.02007	0.00139	0.13289	0.00000	0.00000	0.01222
300	0.00607	0.00002	0.20122	0.01938	0.00130	0.13073	0.00000	0.00000	0.01189

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	DSw			Ops*			OZf		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.27948	0.09368	0.55948	0.0035097	0.0002758	0.0263434	0.22587	0.07024	0.48763
2	0.14055	0.02225	0.44187	0.0009592	0.0000546	0.0097475	0.08718	0.01214	0.32133
3	0.08590	0.00696	0.39223	0.0004182	0.0000196	0.005111	0.04339	0.00294	0.25130
4	0.05806	0.00263	0.36239	0.0002247	0.0000091	0.0031409	0.02476	0.00089	0.21056
5	0.04181	0.00114	0.34152	0.0001362	0.0000049	0.0021176	0.01542	0.00032	0.18314
6	0.03145	0.00054	0.32567	0.0000894	0.0000029	0.0015181	0.01021	0.00013	0.16310
7	0.02444	0.00028	0.31299	0.0000621	0.0000019	0.0011371	0.00708	0.00006	0.14764
8	0.01948	0.00015	0.30248	0.000045	0.0000013	0.0008804	0.00509	0.00003	0.13527
9	0.01584	0.00009	0.29355	0.0000337	0.0000009	0.0006995	0.00376	0.00001	0.12510
10	0.01309	0.00005	0.28580	0.000026	0.0000007	0.0005675	0.00285	0.00001	0.11655
11	0.01097	0.00003	0.27898	0.0000204	0.0000005	0.0004683	0.00220	0.00000	0.10924
12	0.00930	0.00002	0.27290	0.0000163	0.0000004	0.0003921	0.00173	0.00000	0.10290
13	0.00797	0.00001	0.26742	0.0000133	0.0000003	0.0003324	0.00138	0.00000	0.09735
14	0.00689	0.00001	0.26245	0.000011	0.0000002	0.0002847	0.00111	0.00000	0.09243
15	0.00600	0.00001	0.25790	0.0000091	0.0000002	0.0002462	0.00091	0.00000	0.08804
16	0.00526	0.00000	0.25372	0.0000077	0.0000001	0.0002146	0.00075	0.00000	0.08409
17	0.00464	0.00000	0.24984	0.0000066	0.0000001	0.0001884	0.00062	0.00000	0.08052
18	0.00412	0.00000	0.24624	0.0000056	0.0000001	0.0001665	0.00052	0.00000	0.07727
19	0.00368	0.00000	0.24288	0.0000049	0.0000001	0.000148	0.00044	0.00000	0.07429
20	0.00329	0.00000	0.23973	0.0000042	0.0000001	0.0001322	0.00038	0.00000	0.07156
21	0.00296	0.00000	0.23676	0.0000037	0.0000001	0.0001187	0.00032	0.00000	0.06904
22	0.00268	0.00000	0.23397	0.0000033	0.0000001	0.000107	0.00028	0.00000	0.06670
23	0.00243	0.00000	0.23132	0.0000029	0.0000000	0.0000969	0.00024	0.00000	0.06453
24	0.00221	0.00000	0.22882	0.0000026	0.0000000	0.0000881	0.00021	0.00000	0.06251
25	0.00202	0.00000	0.22643	0.0000023	0.0000000	0.0000803	0.00018	0.00000	0.06062
26	0.00184	0.00000	0.22417	0.000002	0.0000000	0.0000734	0.00016	0.00000	0.05885
27	0.00169	0.00000	0.22200	0.0000018	0.0000000	0.0000674	0.00014	0.00000	0.05719
28	0.00156	0.00000	0.21993	0.0000017	0.0000000	0.000062	0.00012	0.00000	0.05563
29	0.00143	0.00000	0.21795	0.0000015	0.0000000	0.0000572	0.00011	0.00000	0.05416
30	**0.00133**	**0.00000**	**0.21606**	**0.0000014**	0.0000000	**0.0000528**	**0.00010**	**0.00000**	**0.05276**
31	0.00123	0.00000	0.21423	0.0000012	0.0000000	0.000049	0.00009	0.00000	0.05145
32	0.00114	0.00000	0.21248	0.0000011	0.0000000	0.0000455	0.00008	0.00000	0.05020
33	0.00106	0.00000	0.21079	0.000001	0.0000000	0.0000423	0.00007	0.00000	0.04901
34	0.00099	0.00000	0.20917	0.0000009	0.0000000	0.0000394	0.00006	0.00000	0.04788
35	0.00092	0.00000	0.20760	0.0000009	0.0000000	0.0000368	0.00006	0.00000	0.04681

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	DSw			Ops*			OZf		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00086	0.00000	0.20608	0.0000008	0.0000001	0.0000344	0.00005	0.00000	0.04578
37	0.00080	0.00000	0.20462	0.0000007	0.0000001	0.0000323	0.00005	0.00000	0.04480
38	0.00075	0.00000	0.20320	0.0000007	0.0000000	0.0000303	0.00004	0.00000	0.04387
39	0.00071	0.00000	0.20183	0.0000006	0.0000000	0.0000285	0.00004	0.00000	0.04297
40	0.00066	0.00000	0.20050	0.0000006	0.0000000	0.0000268	0.00004	0.00000	0.04211
41	0.00062	0.00000	0.19921	0.0000005	0.0000000	0.0000252	0.00003	0.00000	0.04129
42	0.00059	0.00000	0.19796	0.0000005	0.0000000	0.0000238	0.00003	0.00000	0.04050
43	0.00055	0.00000	0.19674	0.0000005	0.0000000	0.0000225	0.00003	0.00000	0.03974
44	0.00052	0.00000	0.19555	0.0000004	0.0000000	0.0000213	0.00003	0.00000	0.03901
45	0.00049	0.00000	0.19440	0.0000004	0.0000000	0.0000201	0.00002	0.00000	0.03831
46	0.00047	0.00000	0.19328	0.0000004	0.0000001	0.0000191	0.00002	0.00000	0.03764
47	0.00044	0.00000	0.19219	0.0000004	0.0000001	0.0000181	0.00002	0.00000	0.03699
48	0.00042	0.00000	0.19113	0.0000003	0.0000000	0.0000172	0.00002	0.00000	0.03636
49	0.00040	0.00000	0.19009	0.0000003	0.0000000	0.0000163	0.00002	0.00000	0.03575
50	0.00038	0.00000	0.18908	0.0000003	0.0000000	0.0000155	0.00002	0.00000	0.03516
55	0.00029	0.00000	0.18436	0.0000002	0.0000000	0.0000123	0.00001	0.00000	0.03251
60	0.00023	0.00000	0.18014	0.0000002	0.0000000	0.0000099	0.00001	0.00000	0.03024
65	0.00019	0.00000	0.17633	0.0000001	0.0000000	0.000008	0.00001	0.00000	0.02827
70	0.00015	0.00000	0.17286	0.0000001	0.0000000	0.0000067	0.00000	0.00000	0.02654
75	0.00013	0.00000	0.16967	0.0000001	0.0000000	0.0000056	0.00000	0.00000	0.02502
80	0.00011	0.00000	0.16673	0.0000001	0.0000001	0.0000047	0.00000	0.00000	0.02367
85	0.00009	0.00000	0.16401	0.0000001	0.0000001	0.000004	0.00000	0.00000	0.02245
90	0.00008	0.00000	0.16148	0.0000000	0.0000000	0.0000035	0.00000	0.00000	0.02136
95	0.00007	0.00000	0.15911	0.0000000	0.0000000	0.000003	0.00000	0.00000	0.02036
100	0.00006	0.00000	0.15689	0.0000000	0.0000000	0.0000026	0.00000	0.00000	0.01946
110	0.00004	0.00000	0.15282	0.0000000	0.0000000	0.000002	0.00000	0.00000	0.01787
120	0.00003	0.00000	0.14918	0.0000000	0.0000000	0.0000016	0.00000	0.00000	0.01652
130	0.00003	0.00000	0.14590	0.0000000	0.0000000	0.0000013	0.00000	0.00000	0.01536
140	0.00002	0.00000	0.14290	0.0000000	0.0000000	0.000001	0.00000	0.00000	0.01434
150	0.00002	0.00000	0.14016	0.0000000	0.0000000	0.0000009	0.00000	0.00000	0.01346
160	0.00001	0.00000	0.13763	0.0000001	0.0000001	0.0000007	0.00000	0.00000	0.01267
170	0.00001	0.00000	0.13529	0.0000001	0.0000001	0.0000006	0.00000	0.00000	0.01197
180	0.00001	0.00000	0.13311	0.0000000	0.0000000	0.0000005	0.00000	0.00000	0.01133
190	0.00001	0.00000	0.13107	0.0000000	0.0000000	0.0000004	0.00000	0.00000	0.01077
200	0.00001	0.00000	0.12916	0.0000000	0.0000000	0.0000004	0.00000	0.00000	0.01025

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	DSw			Ops*			OZf		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00001	0.00000	0.12737	0.0000000	0.0000000	0.0000003	0.00000	0.00000	0.00978
220	0.00001	0.00000	0.12567	0.0000000	0.0000000	0.0000003	0.00000	0.00000	0.00935
230	0.00000	0.00000	0.12407	0.0000000	0.0000000	0.0000003	0.00000	0.00000	0.00895
240	0.00000	0.00000	0.12255	0.0000000	0.0000000	0.0000002	0.00000	0.00000	0.00859
250	0.00000	0.00000	0.12111	0.0000000	0.0000000	0.0000002	0.00000	0.00000	0.00825
260	0.00000	0.00000	0.11973	0.0000001	0.0000001	0.0000002	0.00000	0.00000	0.00794
270	0.00000	0.00000	0.11842	0.0000001	0.0000001	0.0000002	0.00000	0.00000	0.00764
280	0.00000	0.00000	0.11717	0.0000000	0.0000000	0.0000001	0.00000	0.00000	0.00737
290	0.00000	0.00000	0.11597	0.0000000	0.0000000	0.0000001	0.00000	0.00000	0.00712
300	0.00000	0.00000	0.11482	0.0000000	0.0000000	0.0000001	0.00000	0.00000	0.00688

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.39299	0.18635	0.63622	0.50445	0.36570	0.64266	0.20132	0.09010	0.36931
2	0.28816	0.11589	0.53119	0.31779	0.20138	0.45578	0.12168	0.04290	0.26921
3	0.23368	0.08203	0.47528	0.22434	0.12633	0.35520	0.08700	0.02593	0.21925
4	0.19878	0.06210	0.43859	0.16880	0.08553	0.29148	0.06729	0.01758	0.18780
5	0.17401	0.04905	0.41184	0.13241	0.06099	0.24710	0.05453	0.01276	0.16567
6	0.15529	0.03993	0.39107	0.10700	0.04518	0.21425	0.04559	0.00970	0.14902
7	0.14054	0.03324	0.37425	0.08842	0.03446	0.18887	0.03899	0.00763	0.13592
8	0.12856	0.02816	0.36021	0.07437	0.02691	0.16864	0.03392	0.00616	0.12529
9	0.11860	0.02420	0.34821	0.06346	0.02142	0.15212	0.02991	0.00507	0.11643
10	0.11016	0.02104	0.33778	0.05479	0.01732	0.13836	0.02667	0.00424	0.10892
11	0.10291	0.01847	0.32859	0.04778	0.01420	0.12673	0.02399	0.00360	0.10245
12	0.09659	0.01635	0.32039	0.04202	0.01179	0.11676	0.02175	0.00309	0.09681
13	0.09104	0.01458	0.31301	0.03724	0.00988	0.10813	0.01984	0.00268	0.09183
14	0.08611	0.01308	0.30630	0.03321	0.00836	0.10058	0.01821	0.00235	0.08740
15	0.08171	0.01180	0.30018	0.02979	0.00713	0.09392	0.01679	0.00207	0.08343
16	0.07774	0.01070	0.29454	0.02687	0.00613	0.08800	0.01555	0.00183	0.07985
17	0.07415	0.00975	0.28933	0.02434	0.00530	0.08272	0.01446	0.00164	0.07660
18	0.07088	0.00892	0.28449	0.02214	0.00461	0.07797	0.01349	0.00147	0.07362
19	0.06790	0.00819	0.27998	0.02022	0.00403	0.07367	0.01263	0.00132	0.07090
20	0.06515	0.00754	0.27575	0.01853	0.00354	0.06978	0.01185	0.00120	0.06839
21	0.06262	0.00697	0.27178	0.01703	0.00313	0.06622	0.01115	0.00109	0.06607
22	0.06028	0.00646	0.26805	0.01571	0.00277	0.06297	0.01052	0.00100	0.06392
23	0.05811	0.00600	0.26451	0.01452	0.00247	0.05999	0.00995	0.00091	0.06191
24	0.05609	0.00559	0.26117	0.01346	0.00221	0.05724	0.00942	0.00084	0.06004
25	0.05421	0.00522	0.25800	0.01250	0.00198	0.05470	0.00894	0.00077	0.05829
26	0.05244	0.00488	0.25498	0.01164	0.00178	0.05234	0.00850	0.00071	0.05665
27	0.05079	0.00457	0.25210	0.01086	0.00160	0.05016	0.00809	0.00066	0.05510
28	0.04923	0.00429	0.24935	0.01015	0.00145	0.04812	0.00772	0.00061	0.05364
29	0.04777	0.00404	0.24673	0.00951	0.00132	0.04623	0.00737	0.00057	0.05227
30	**0.04639**	**0.00380**	**0.24421**	**0.00892**	**0.00120**	**0.04445**	**0.00705**	**0.00053**	**0.05097**
31	0.04508	0.00359	0.24180	0.00838	0.00109	0.04279	0.00675	0.00050	0.04973
32	0.04385	0.00339	0.23948	0.00789	0.00100	0.04123	0.00647	0.00046	0.04856
33	0.04268	0.00321	0.23726	0.00743	0.00091	0.03976	0.00621	0.00043	0.04745
34	0.04157	0.00304	0.23511	0.00702	0.00084	0.03838	0.00596	0.00041	0.04639
35	0.04051	0.00288	0.23304	0.00663	0.00077	0.03708	0.00573	0.00038	0.04538

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.03950	0.00274	0.23105	0.00627	0.00071	0.03584	0.00552	0.00036	0.04442
37	0.03855	0.00260	0.22912	0.00594	0.00065	0.03468	0.00532	0.00034	0.04350
38	0.03763	0.00248	0.22726	0.00563	0.00060	0.03358	0.00513	0.00032	0.04262
39	0.03676	0.00236	0.22546	0.00535	0.00056	0.03253	0.00495	0.00030	0.04177
40	0.03592	0.00225	0.22372	0.00508	0.00052	0.03154	0.00478	0.00029	0.04096
41	0.03512	0.00215	0.22202	0.00483	0.00048	0.03060	0.00462	0.00027	0.04019
42	0.03435	0.00205	0.22038	0.00460	0.00045	0.02970	0.00446	0.00026	0.03944
43	0.03362	0.00196	0.21879	0.00439	0.00041	0.02885	0.00432	0.00024	0.03872
44	0.03291	0.00188	0.21725	0.00418	0.00039	0.02803	0.00418	0.00023	0.03803
45	0.03223	0.00180	0.21574	0.00399	0.00036	0.02725	0.00405	0.00022	0.03737
46	0.03158	0.00173	0.21428	0.00382	0.00034	0.02651	0.00393	0.00021	0.03673
47	0.03095	0.00166	0.21286	0.00365	0.00031	0.02580	0.00381	0.00020	0.03611
48	0.03035	0.00159	0.21148	0.00349	0.00029	0.02512	0.00370	0.00019	0.03551
49	0.02977	0.00153	0.21013	0.00334	0.00028	0.02447	0.00359	0.00018	0.03494
50	0.02921	0.00147	0.20881	0.00320	0.00026	0.02385	0.00349	0.00017	0.03438
55	0.02667	0.00121	0.20270	0.00261	0.00019	0.02109	0.00304	0.00014	0.03185
60	0.02453	0.00102	0.19725	0.00216	0.00014	0.01881	0.00268	0.00012	0.02968
65	0.02268	0.00086	0.19234	0.00181	0.00011	0.01691	0.00238	0.00010	0.02780
70	0.02108	0.00074	0.18788	0.00153	0.00009	0.01530	0.00213	0.00008	0.02615
75	0.01967	0.00064	0.18381	0.00131	0.00007	0.01392	0.00192	0.00007	0.02469
80	0.01843	0.00056	0.18006	0.00112	0.00005	0.01273	0.00174	0.00006	0.02338
85	0.01732	0.00049	0.17660	0.00098	0.00004	0.01169	0.00159	0.00005	0.02221
90	0.01633	0.00043	0.17338	0.00085	0.00004	0.01078	0.00145	0.00004	0.02115
95	0.01544	0.00038	0.17039	0.00075	0.00003	0.00998	0.00134	0.00004	0.02019
100	0.01464	0.00034	0.16758	0.00066	0.00002	0.00927	0.00123	0.00003	0.01932
110	0.01323	0.00028	0.16247	0.00052	0.00002	0.00807	0.00106	0.00003	0.01778
120	0.01206	0.00023	0.15791	0.00042	0.00001	0.00709	0.00092	0.00002	0.01647
130	0.01105	0.00019	0.15381	0.00034	0.00001	0.00629	0.00081	0.00002	0.01533
140	0.01019	0.00016	0.15009	0.00028	0.00001	0.00562	0.00072	0.00001	0.01435
150	0.00944	0.00013	0.14669	0.00024	0.00001	0.00505	0.00064	0.00001	0.01348
160	0.00878	0.00011	0.14357	0.00020	0.00000	0.00457	0.00058	0.00001	0.01271
170	0.00820	0.00010	0.14068	0.00017	0.00000	0.00415	0.00052	0.00001	0.01202
180	0.00769	0.00009	0.13800	0.00015	0.00000	0.00380	0.00047	0.00001	0.01140
190	0.00723	0.00008	0.13551	0.00013	0.00000	0.00348	0.00043	0.00001	0.01084
200	0.00681	0.00007	0.13318	0.00011	0.00000	0.00320	0.00039	0.00001	0.01033

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	OZm			OZn			OZnb		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00644	0.00006	0.13099	0.00010	0.00000	0.00296	0.00036	0.00000	0.00987
220	0.00610	0.00005	0.12893	0.00008	0.00000	0.00274	0.00033	0.00000	0.00944
230	0.00579	0.00005	0.12698	0.00007	0.00000	0.00255	0.00031	0.00000	0.00905
240	0.00550	0.00004	0.12514	0.00007	0.00000	0.00238	0.00029	0.00000	0.00869
250	0.00524	0.00004	0.12340	0.00006	0.00000	0.00222	0.00027	0.00000	0.00836
260	0.00500	0.00003	0.12174	0.00005	0.00000	0.00208	0.00025	0.00000	0.00805
270	0.00478	0.00003	0.12016	0.00005	0.00000	0.00195	0.00023	0.00000	0.00776
280	0.00457	0.00003	0.11866	0.00004	0.00000	0.00183	0.00022	0.00000	0.00749
290	0.00438	0.00003	0.11722	0.00004	0.00000	0.00173	0.00021	0.00000	0.00724
300	0.00421	0.00002	0.11585	0.00003	0.00000	0.00163	0.00019	0.00000	0.00700

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Ph			Sacgr			Sagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.47220	0.23247	0.72282	0.69951	0.59142	0.79240	0.57749	0.33202	0.79539
2	0.38398	0.16877	0.64392	0.55401	0.44593	0.65820	0.46876	0.24920	0.69856
3	0.33475	0.13536	0.59782	0.46387	0.35942	0.57089	0.40572	0.20238	0.63909
4	0.30141	0.11388	0.56571	0.40076	0.30036	0.50822	0.36234	0.17092	0.59719
5	0.27663	0.09862	0.54129	0.35345	0.25703	0.46036	0.32983	0.14795	0.56534
6	0.25715	0.08711	0.52173	0.31637	0.22376	0.42223	0.30418	0.13029	0.53991
7	0.24126	0.07806	0.50549	0.28639	0.19737	0.39093	0.28322	0.11624	0.51890
8	0.22794	0.07073	0.49165	0.26155	0.17592	0.36463	0.26564	0.10476	0.50111
9	0.21654	0.06466	0.47963	0.24061	0.15816	0.34213	0.25060	0.09519	0.48574
10	0.20662	0.05954	0.46903	0.22267	0.14321	0.32261	0.23755	0.08710	0.47226
11	0.19789	0.05515	0.45957	0.20712	0.13048	0.30546	0.22606	0.08015	0.46030
12	0.19012	0.05135	0.45104	0.19351	0.11951	0.29025	0.21586	0.07413	0.44956
13	0.18314	0.04803	0.44328	0.18147	0.10997	0.27664	0.20672	0.06885	0.43985
14	0.17682	0.04509	0.43618	0.17076	0.10162	0.26438	0.19846	0.06420	0.43099
15	0.17106	0.04248	0.42963	0.16116	0.09424	0.25325	0.19095	0.06006	0.42286
16	0.16578	0.04013	0.42357	0.15251	0.08768	0.24311	0.18409	0.05637	0.41537
17	0.16092	0.03802	0.41792	0.14466	0.08183	0.23382	0.17778	0.05304	0.40841
18	0.15643	0.03611	0.41265	0.13752	0.07657	0.22526	0.17196	0.05003	0.40194
19	0.15225	0.03437	0.40770	0.13099	0.07183	0.21735	0.16657	0.04730	0.39589
20	0.14836	0.03277	0.40305	0.12499	0.06754	0.21001	0.16156	0.04481	0.39021
21	0.14472	0.03131	0.39866	0.11947	0.06363	0.20319	0.15689	0.04254	0.38487
22	0.14130	0.02996	0.39450	0.11437	0.06007	0.19682	0.15251	0.04045	0.37983
23	0.13809	0.02872	0.39055	0.10964	0.05681	0.19085	0.14841	0.03852	0.37507
24	0.13507	0.02757	0.38680	0.10524	0.05381	0.18526	0.14455	0.03675	0.37054
25	0.13221	0.02649	0.38323	0.10115	0.05106	0.18000	0.14092	0.03510	0.36625
26	0.12950	0.02549	0.37981	0.09733	0.04851	0.17504	0.13748	0.03357	0.36215
27	0.12693	0.02456	0.37655	0.09375	0.04616	0.17036	0.13423	0.03215	0.35825
28	0.12448	0.02369	0.37343	0.09039	0.04397	0.16593	0.13115	0.03082	0.35452
29	0.12216	0.02287	0.37043	0.08724	0.04195	0.16174	0.12822	0.02958	0.35095
30	**0.11994**	**0.02210**	**0.36755**	**0.08428**	**0.04006**	**0.15776**	**0.12543**	**0.02842**	**0.34752**
31	0.11782	0.02137	0.36477	0.08148	0.03829	0.15397	0.12278	0.02734	0.34423
32	0.11580	0.02069	0.36211	0.07884	0.03665	0.15036	0.12025	0.02631	0.34107
33	0.11386	0.02004	0.35953	0.07634	0.03511	0.14693	0.11783	0.02535	0.33803
34	0.11200	0.01943	0.35705	0.07398	0.03366	0.14365	0.11552	0.02445	0.33510
35	0.11021	0.01886	0.35465	0.07174	0.03230	0.14052	0.11330	0.02359	0.33228

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Ph			Sacgr			Sagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.10850	0.01831	0.35233	0.06961	0.03103	0.13752	0.11118	0.02278	0.32955
37	0.10685	0.01779	0.35008	0.06758	0.02983	0.13465	0.10914	0.02202	0.32691
38	0.10526	0.01729	0.34790	0.06566	0.02869	0.13189	0.10719	0.02129	0.32436
39	0.10373	0.01682	0.34579	0.06383	0.02762	0.12925	0.10530	0.02061	0.32189
40	0.10226	0.01637	0.34374	0.06208	0.02661	0.12672	0.10349	0.01995	0.31950
41	0.10083	0.01594	0.34175	0.06041	0.02566	0.12428	0.10175	0.01933	0.31718
42	0.09946	0.01553	0.33981	0.05881	0.02475	0.12193	0.10007	0.01874	0.31493
43	0.09813	0.01514	0.33793	0.05729	0.02389	0.11967	0.09844	0.01818	0.31274
44	0.09684	0.01476	0.33610	0.05583	0.02308	0.11749	0.09688	0.01765	0.31061
45	0.09559	0.01440	0.33432	0.05443	0.02230	0.11539	0.09536	0.01713	0.30855
46	0.09438	0.01406	0.33258	0.05309	0.02156	0.11337	0.09390	0.01665	0.30654
47	0.09321	0.01373	0.33089	0.05180	0.02086	0.11141	0.09248	0.01618	0.30458
48	0.09208	0.01341	0.32924	0.05056	0.02020	0.10952	0.09111	0.01573	0.30267
49	0.09098	0.01311	0.32762	0.04938	0.01956	0.10769	0.08979	0.01531	0.30081
50	0.08991	0.01281	0.32605	0.04823	0.01895	0.10592	0.08850	0.01490	0.29900
55	0.08498	0.01150	0.31870	0.04313	0.01630	0.09786	0.08261	0.01309	0.29056
60	0.08067	0.01041	0.31210	0.03886	0.01415	0.09092	0.07750	0.01160	0.28303
65	0.07685	0.00948	0.30611	0.03524	0.01240	0.08488	0.07301	0.01035	0.27623
70	0.07343	0.00868	0.30064	0.03215	0.01094	0.07957	0.06904	0.00930	0.27004
75	0.07036	0.00799	0.29562	0.02947	0.00972	0.07486	0.06549	0.00841	0.26438
80	0.06757	0.00739	0.29097	0.02713	0.00869	0.07066	0.06230	0.00764	0.25918
85	0.06504	0.00686	0.28666	0.02508	0.00781	0.06688	0.05942	0.00698	0.25435
90	0.06271	0.00639	0.28263	0.02327	0.00705	0.06347	0.05679	0.00639	0.24987
95	0.06058	0.00597	0.27887	0.02165	0.00639	0.06037	0.05440	0.00588	0.24569
100	0.05860	0.00560	0.27532	0.02021	0.00582	0.05754	0.05220	0.00543	0.24177
110	0.05506	0.00496	0.26883	0.01775	0.00487	0.05257	0.04830	0.00467	0.23462
120	0.05199	0.00443	0.26301	0.01573	0.00413	0.04834	0.04495	0.00406	0.22824
130	0.04928	0.00398	0.25773	0.01405	0.00354	0.04471	0.04203	0.00356	0.22249
140	0.04687	0.00361	0.25292	0.01263	0.00306	0.04154	0.03947	0.00315	0.21726
150	0.04471	0.00329	0.24850	0.01143	0.00266	0.03876	0.03721	0.00280	0.21248
160	0.04277	0.00301	0.24441	0.01039	0.00234	0.03630	0.03518	0.00251	0.20809
170	0.04101	0.00277	0.24062	0.00949	0.00207	0.03411	0.03336	0.00226	0.20402
180	0.03940	0.00256	0.23709	0.00871	0.00183	0.03215	0.03172	0.00204	0.20025
190	0.03793	0.00237	0.23378	0.00802	0.00164	0.03038	0.03023	0.00186	0.19672
200	0.03657	0.00221	0.23068	0.00741	0.00147	0.02878	0.02887	0.00169	0.19343

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Ph			Sacgr			Sagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.03532	0.00206	0.22775	0.00687	0.00132	0.02732	0.02762	0.00155	0.19033
220	0.03416	0.00192	0.22499	0.00639	0.00120	0.02599	0.02647	0.00143	0.18741
230	0.03308	0.00180	0.22237	0.00596	0.00109	0.02477	0.02541	0.00131	0.18466
240	0.03207	0.00170	0.21989	0.00557	0.00099	0.02365	0.02443	0.00122	0.18205
250	0.03113	0.00160	0.21753	0.00522	0.00090	0.02262	0.02352	0.00113	0.17958
260	0.03024	0.00151	0.21527	0.00490	0.00083	0.02166	0.02268	0.00105	0.17723
270	0.02941	0.00143	0.21312	0.00460	0.00076	0.02077	0.02188	0.00097	0.17499
280	0.02863	0.00135	0.21107	0.00434	0.00070	0.01994	0.02114	0.00091	0.17285
290	0.02789	0.00128	0.20910	0.00410	0.00065	0.01917	0.02045	0.00085	0.17080
300	0.02719	0.00122	0.20721	0.00387	0.00060	0.01845	0.01980	0.00080	0.16885

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sb			Sbs			Se		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.44502	0.26442	0.63806	0.28874	0.12867	0.50739	0.35132	0.14117	0.62230
2	0.27017	0.13088	0.45922	0.09640	0.02179	0.27875	0.09921	0.01598	0.33459
3	0.18684	0.07521	0.36649	0.04108	0.00484	0.18692	0.03476	0.00195	0.22850
4	0.13866	0.04725	0.30833	0.02030	0.00133	0.13758	0.01425	0.00029	0.17273
5	0.10768	0.03156	0.26777	0.01108	0.00043	0.10695	0.00654	0.00005	0.13793
6	0.08634	0.02205	0.23754	0.00651	0.00016	0.08622	0.00327	0.00001	0.11407
7	0.07090	0.01596	0.21397	0.00403	0.00006	0.07136	0.00175	0.00000	0.09668
8	0.05933	0.01188	0.19497	0.00261	0.00003	0.06025	0.00099	0.00000	0.08345
9	0.05040	0.00904	0.17928	0.00175	0.00001	0.05168	0.00058	0.00000	0.07308
10	0.04335	0.00702	0.16607	0.00121	0.00001	0.04490	0.00036	0.00000	0.06473
11	0.03768	0.00554	0.15476	0.00086	0.00000	0.03943	0.00022	0.00000	0.05789
12	0.03305	0.00443	0.14495	0.00062	0.00000	0.03494	0.00015	0.00000	0.05218
13	0.02921	0.00359	0.13636	0.00046	0.00000	0.03120	0.00010	0.00000	0.04735
14	0.02600	0.00294	0.12876	0.00034	0.00000	0.02804	0.00007	0.00000	0.04323
15	0.02328	0.00243	0.12199	0.00026	0.00000	0.02536	0.00005	0.00000	0.03967
16	0.02095	0.00203	0.11590	0.00020	0.00000	0.02305	0.00003	0.00000	0.03656
17	0.01895	0.00171	0.11041	0.00016	0.00000	0.02105	0.00002	0.00000	0.03384
18	0.01721	0.00145	0.10542	0.00012	0.00000	0.01930	0.00002	0.00000	0.03144
19	0.01570	0.00123	0.10086	0.00010	0.00000	0.01777	0.00001	0.00000	0.02930
20	0.01437	0.00106	0.09668	0.00008	0.00000	0.01641	0.00001	0.00000	0.02738
21	0.01319	0.00091	0.09284	0.00006	0.00000	0.01520	0.00001	0.00000	0.02566
22	0.01215	0.00079	0.08929	0.00005	0.00000	0.01413	0.00001	0.00000	0.02411
23	0.01122	0.00069	0.08600	0.00004	0.00000	0.01316	0.00000	0.00000	0.02271
24	0.01039	0.00060	0.08294	0.00004	0.00000	0.01229	0.00000	0.00000	0.02143
25	0.00965	0.00053	0.08009	0.00003	0.00000	0.01150	0.00000	0.00000	0.02026
26	0.00898	0.00047	0.07742	0.00003	0.00000	0.01079	0.00000	0.00000	0.01919
27	0.00837	0.00041	0.07493	0.00002	0.00000	0.01014	0.00000	0.00000	0.01821
28	0.00782	0.00037	0.07258	0.00002	0.00000	0.00955	0.00000	0.00000	0.01730
29	0.00732	0.00033	0.07038	0.00002	0.00000	0.00901	0.00000	0.00000	0.01647
30	**0.00686**	**0.00029**	**0.06830**	**0.00001**	**0.00000**	**0.00851**	**0.00000**	**0.00000**	**0.01570**
31	0.00644	0.00026	0.06634	0.00001	0.00000	0.00805	0.00000	0.00000	0.01498
32	0.00606	0.00023	0.06448	0.00001	0.00000	0.00763	0.00000	0.00000	0.01431
33	0.00571	0.00021	0.06273	0.00001	0.00000	0.00724	0.00000	0.00000	0.01369
34	0.00539	0.00019	0.06106	0.00001	0.00000	0.00687	0.00000	0.00000	0.01311
35	0.00509	0.00017	0.05947	0.00001	0.00000	0.00654	0.00000	0.00000	0.01257

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sb			Sbs			Se		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00481	0.00016	0.05797	0.00001	0.00000	0.00623	0.00000	0.00000	0.01206
37	0.00456	0.00014	0.05653	0.00001	0.00000	0.00594	0.00000	0.00000	0.01158
38	0.00432	0.00013	0.05516	0.00000	0.00000	0.00566	0.00000	0.00000	0.01113
39	0.00410	0.00012	0.05386	0.00000	0.00000	0.00541	0.00000	0.00000	0.01071
40	0.00389	0.00011	0.05261	0.00000	0.00000	0.00517	0.00000	0.00000	0.01032
41	0.00370	0.00010	0.05141	0.00000	0.00000	0.00495	0.00000	0.00000	0.00994
42	0.00352	0.00009	0.05027	0.00000	0.00000	0.00474	0.00000	0.00000	0.00959
43	0.00336	0.00008	0.04917	0.00000	0.00000	0.00455	0.00000	0.00000	0.00925
44	0.00320	0.00008	0.04812	0.00000	0.00000	0.00436	0.00000	0.00000	0.00893
45	0.00306	0.00007	0.04711	0.00000	0.00000	0.00419	0.00000	0.00000	0.00863
46	0.00292	0.00006	0.04614	0.00000	0.00000	0.00403	0.00000	0.00000	0.00835
47	0.00279	0.00006	0.04520	0.00000	0.00000	0.00387	0.00000	0.00000	0.00808
48	0.00267	0.00006	0.04430	0.00000	0.00000	0.00372	0.00000	0.00000	0.00782
49	0.00256	0.00005	0.04344	0.00000	0.00000	0.00359	0.00000	0.00000	0.00758
50	0.00245	0.00005	0.04260	0.00000	0.00000	0.00346	0.00000	0.00000	0.00734
55	0.00200	0.00003	0.03884	0.00000	0.00000	0.00289	0.00000	0.00000	0.00632
60	0.00165	0.00002	0.03566	0.00000	0.00000	0.00246	0.00000	0.00000	0.00551
65	0.00138	0.00002	0.03292	0.00000	0.00000	0.00211	0.00000	0.00000	0.00484
70	0.00117	0.00001	0.03056	0.00000	0.00000	0.00182	0.00000	0.00000	0.00429
75	0.00100	0.00001	0.02848	0.00000	0.00000	0.00159	0.00000	0.00000	0.00383
80	0.00086	0.00001	0.02665	0.00000	0.00000	0.00140	0.00000	0.00000	0.00344
85	0.00075	0.00001	0.02503	0.00000	0.00000	0.00124	0.00000	0.00000	0.00310
90	0.00065	0.00000	0.02357	0.00000	0.00000	0.00110	0.00000	0.00000	0.00282
95	0.00057	0.00000	0.02226	0.00000	0.00000	0.00099	0.00000	0.00000	0.00257
100	0.00051	0.00000	0.02108	0.00000	0.00000	0.00089	0.00000	0.00000	0.00235
110	0.00040	0.00000	0.01902	0.00000	0.00000	0.00073	0.00000	0.00000	0.00199
120	0.00032	0.00000	0.01730	0.00000	0.00000	0.00061	0.00000	0.00000	0.00171
130	0.00026	0.00000	0.01584	0.00000	0.00000	0.00051	0.00000	0.00000	0.00148
140	0.00022	0.00000	0.01458	0.00000	0.00000	0.00044	0.00000	0.00000	0.00129
150	0.00018	0.00000	0.01349	0.00000	0.00000	0.00037	0.00000	0.00000	0.00114
160	0.00015	0.00000	0.01254	0.00000	0.00000	0.00032	0.00000	0.00000	0.00101
170	0.00013	0.00000	0.01169	0.00000	0.00000	0.00028	0.00000	0.00000	0.00090
180	0.00011	0.00000	0.01095	0.00000	0.00000	0.00025	0.00000	0.00000	0.00081
190	0.00010	0.00000	0.01028	0.00000	0.00000	0.00022	0.00000	0.00000	0.00073
200	0.00008	0.00000	0.00968	0.00000	0.00000	0.00020	0.00000	0.00000	0.00066

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sb			Sbs			Se		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00007	0.00000	0.00913	0.00000	0.00000	0.00018	0.00000	0.00000	0.00060
220	0.00007	0.00000	0.00864	0.00000	0.00000	0.00016	0.00000	0.00000	0.00055
230	0.00006	0.00000	0.00819	0.00000	0.00000	0.00014	0.00000	0.00000	0.00051
240	0.00005	0.00000	0.00778	0.00000	0.00000	0.00013	0.00000	0.00000	0.00046
250	0.00005	0.00000	0.00741	0.00000	0.00000	0.00012	0.00000	0.00000	0.00043
260	0.00004	0.00000	0.00706	0.00000	0.00000	0.00011	0.00000	0.00000	0.00040
270	0.00004	0.00000	0.00675	0.00000	0.00000	0.00010	0.00000	0.00000	0.00037
280	0.00003	0.00000	0.00645	0.00000	0.00000	0.00009	0.00000	0.00000	0.00034
290	0.00003	0.00000	0.00618	0.00000	0.00000	0.00008	0.00000	0.00000	0.00032
300	0.00003	0.00000	0.00592	0.00000	0.00000	0.00008	0.00000	0.00000	0.00030

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			So			SOagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.31386	0.10546	0.61071	0.32432	0.15913	0.53458	0.27049	0.11302	0.49520
2	0.18569	0.03382	0.51582	0.21113	0.08202	0.41552	0.20019	0.06910	0.42098
3	0.12859	0.01344	0.47890	0.15735	0.05103	0.35351	0.16471	0.04947	0.38190
4	0.09632	0.00620	0.45806	0.12521	0.03497	0.31333	0.14218	0.03819	0.35605
5	0.07572	0.00318	0.44411	0.10365	0.02546	0.28437	0.12621	0.03085	0.33704
6	0.06153	0.00176	0.43385	0.08815	0.01934	0.26212	0.11412	0.02570	0.32214
7	0.05124	0.00104	0.42584	0.07645	0.01515	0.24429	0.10457	0.02190	0.30999
8	0.04347	0.00064	0.41932	0.06730	0.01216	0.22956	0.09677	0.01898	0.29977
9	0.03744	0.00041	0.41385	0.05996	0.00995	0.21711	0.09025	0.01667	0.29099
10	0.03264	0.00027	0.40917	0.05393	0.00827	0.20639	0.08470	0.01481	0.28333
11	0.02874	0.00019	0.40509	0.04891	0.00697	0.19703	0.07991	0.01327	0.27653
12	0.02553	0.00013	0.40147	0.04465	0.00594	0.18876	0.07571	0.01199	0.27045
13	0.02285	0.00009	0.39824	0.04100	0.00511	0.18139	0.07200	0.01090	0.26496
14	0.02058	0.00007	0.39532	0.03785	0.00444	0.17475	0.06870	0.00997	0.25995
15	0.01864	0.00005	0.39266	0.03509	0.00388	0.16874	0.06572	0.00916	0.25536
16	0.01698	0.00004	0.39022	0.03266	0.00342	0.16326	0.06303	0.00846	0.25112
17	0.01553	0.00003	0.38797	0.03051	0.00303	0.15823	0.06058	0.00784	0.24720
18	0.01426	0.00002	0.38588	0.02859	0.00269	0.15360	0.05834	0.00729	0.24354
19	0.01314	0.00002	0.38394	0.02686	0.00241	0.14931	0.05629	0.00680	0.24013
20	0.01215	0.00001	0.38212	0.02531	0.00217	0.14533	0.05439	0.00637	0.23692
21	0.01127	0.00001	0.38041	0.02390	0.00196	0.14162	0.05263	0.00597	0.23391
22	0.01048	0.00001	0.37880	0.02262	0.00177	0.13815	0.05099	0.00562	0.23106
23	0.00978	0.00001	0.37728	0.02145	0.00161	0.13489	0.04947	0.00530	0.22837
24	0.00914	0.00001	0.37584	0.02038	0.00147	0.13183	0.04804	0.00500	0.22581
25	0.00856	0.00000	0.37447	0.01940	0.00134	0.12894	0.04671	0.00474	0.22338
26	0.00804	0.00000	0.37317	0.01849	0.00123	0.12622	0.04545	0.00449	0.22107
27	0.00756	0.00000	0.37193	0.01765	0.00113	0.12363	0.04427	0.00427	0.21886
28	0.00713	0.00000	0.37074	0.01687	0.00105	0.12119	0.04316	0.00406	0.21675
29	0.00673	0.00000	0.36960	0.01615	0.00097	0.11886	0.04210	0.00387	0.21473
30	**0.00636**	**0.00000**	**0.36851**	**0.01548**	**0.00089**	**0.11664**	**0.04110**	**0.00369**	**0.21279**
31	0.00602	0.00000	0.36747	0.01485	0.00083	0.11453	0.04015	0.00352	0.21093
32	0.00571	0.00000	0.36646	0.01427	0.00077	0.11252	0.03925	0.00337	0.20914
33	0.00542	0.00000	0.36549	0.01372	0.00072	0.11059	0.03840	0.00323	0.20742
34	0.00515	0.00000	0.36456	0.01320	0.00067	0.10874	0.03758	0.00309	0.20576
35	0.00491	0.00000	0.36366	0.01272	0.00063	0.10698	0.03680	0.00297	0.20415

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			So			SOagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00467	0.00000	0.36278	0.01226	0.00059	0.10528	0.03605	0.00285	0.20261
37	0.00446	0.00000	0.36194	0.01183	0.00055	0.10365	0.03534	0.00274	0.20111
38	0.00426	0.00000	0.36113	0.01143	0.00052	0.10208	0.03466	0.00264	0.19966
39	0.00407	0.00000	0.36034	0.01104	0.00048	0.10057	0.03400	0.00254	0.19826
40	0.00389	0.00000	0.35957	0.01068	0.00046	0.09912	0.03338	0.00245	0.19690
41	0.00373	0.00000	0.35882	0.01034	0.00043	0.09772	0.03277	0.00236	0.19559
42	0.00357	0.00000	0.35810	0.01001	0.00041	0.09637	0.03219	0.00228	0.19431
43	0.00343	0.00000	0.35740	0.00970	0.00038	0.09506	0.03163	0.00220	0.19306
44	0.00329	0.00000	0.35672	0.00941	0.00036	0.09380	0.03110	0.00213	0.19186
45	0.00316	0.00000	0.35605	0.00913	0.00034	0.09257	0.03058	0.00206	0.19068
46	0.00304	0.00000	0.35540	0.00886	0.00032	0.09139	0.03008	0.00199	0.18954
47	0.00292	0.00000	0.35477	0.00860	0.00031	0.09025	0.02960	0.00193	0.18842
48	0.00281	0.00000	0.35415	0.00836	0.00029	0.08914	0.02913	0.00187	0.18734
49	0.00271	0.00000	0.35355	0.00813	0.00028	0.08806	0.02868	0.00181	0.18628
50	0.00261	0.00000	0.35296	0.00791	0.00026	0.08702	0.02824	0.00176	0.18525
55	0.00219	0.00000	0.35022	0.00693	0.00021	0.08222	0.02626	0.00152	0.18044
60	0.00186	0.00000	0.34776	0.00613	0.00017	0.07803	0.02455	0.00133	0.17614
65	0.00160	0.00000	0.34552	0.00547	0.00013	0.07433	0.02307	0.00117	0.17226
70	0.00139	0.00000	0.34347	0.00492	0.00011	0.07102	0.02176	0.00104	0.16872
75	0.00121	0.00000	0.34159	0.00445	0.00009	0.06806	0.02060	0.00093	0.16549
80	0.00107	0.00000	0.33984	0.00404	0.00008	0.06538	0.01956	0.00084	0.16250
85	0.00095	0.00000	0.33822	0.00370	0.00007	0.06294	0.01862	0.00076	0.15974
90	0.00085	0.00000	0.33670	0.00339	0.00006	0.06071	0.01778	0.00069	0.15717
95	0.00076	0.00000	0.33527	0.00313	0.00005	0.05866	0.01701	0.00063	0.15477
100	0.00068	0.00000	0.33393	0.00289	0.00004	0.05676	0.01630	0.00058	0.15252
110	0.00056	0.00000	0.33146	0.00249	0.00003	0.05338	0.01506	0.00050	0.14840
120	0.00047	0.00000	0.32923	0.00218	0.00002	0.05044	0.01400	0.00043	0.14472
130	0.00040	0.00000	0.32720	0.00192	0.00002	0.04785	0.01308	0.00037	0.14141
140	0.00034	0.00000	0.32534	0.00170	0.00002	0.04556	0.01228	0.00033	0.13839
150	0.00029	0.00000	0.32362	0.00152	0.00001	0.04350	0.01157	0.00029	0.13562
160	0.00025	0.00000	0.32202	0.00137	0.00001	0.04165	0.01094	0.00026	0.13308
170	0.00022	0.00000	0.32054	0.00124	0.00001	0.03997	0.01037	0.00023	0.13072
180	0.00019	0.00000	0.31914	0.00113	0.00001	0.03844	0.00986	0.00021	0.12853
190	0.00017	0.00000	0.31784	0.00103	0.00001	0.03704	0.00940	0.00019	0.12649
200	0.00015	0.00000	0.31660	0.00095	0.00001	0.03575	0.00898	0.00017	0.12457

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Sgr			So			SOagr		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00014	0.00000	0.31543	0.00087	0.00000	0.03456	0.00859	0.00016	0.12277
220	0.00012	0.00000	0.31433	0.00080	0.00000	0.03346	0.00824	0.00014	0.12107
230	0.00011	0.00000	0.31327	0.00074	0.00000	0.03243	0.00792	0.00013	0.11947
240	0.00010	0.00000	0.31227	0.00069	0.00000	0.03147	0.00761	0.00012	0.11795
250	0.00009	0.00000	0.31131	0.00064	0.00000	0.03057	0.00734	0.00011	0.11651
260	0.00008	0.00000	0.31039	0.00060	0.00000	0.02973	0.00708	0.00011	0.11513
270	0.00008	0.00000	0.30951	0.00056	0.00000	0.02894	0.00683	0.00010	0.11382
280	0.00007	0.00000	0.30867	0.00053	0.00000	0.02820	0.00661	0.00009	0.11257
290	0.00006	0.00000	0.30786	0.00050	0.00000	0.02749	0.00639	0.00009	0.11138
300	0.00006	0.00000	0.30707	0.00047	0.00000	0.02683	0.00620	0.00008	0.11023

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SObo			Sp			Spsq*		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.48976	0.21348	0.77127	0.29427	0.16239	0.46127	0.0595698	0.011175	0.202584
2	0.39909	0.15728	0.68945	0.21950	0.10626	0.38165	0.0294494	0.0043667	0.123926
3	0.34817	0.12548	0.64337	0.18137	0.07987	0.33930	0.0186571	0.0023951	0.089506
4	0.31358	0.10434	0.61246	0.15701	0.06409	0.31122	0.0132263	0.0015282	0.069838
5	0.28781	0.08910	0.58970	0.13966	0.05349	0.29057	0.0100116	0.0010642	0.05704
6	0.26754	0.07753	0.57195	0.12650	0.04583	0.27442	0.0079139	0.0007848	0.048033
7	0.25097	0.06843	0.55754	0.11606	0.04003	0.26127	0.0064526	0.000603	0.041346
8	0.23707	0.06108	0.54550	0.10753	0.03547	0.25024	0.0053853	0.0004777	0.036188
9	0.22517	0.05502	0.53521	0.10038	0.03180	0.24080	0.0045774	0.0003876	0.032091
10	0.21482	0.04994	0.52626	0.09429	0.02877	0.23257	0.0039482	0.0003206	0.02876
11	0.20570	0.04562	0.51838	0.08902	0.02624	0.22530	0.003447	0.0002694	0.026002
12	0.19758	0.04190	0.51134	0.08440	0.02408	0.21881	0.0030402	0.0002293	0.023682
13	0.19028	0.03867	0.50501	0.08032	0.02223	0.21296	0.0027047	0.0001975	0.021705
14	0.18367	0.03584	0.49927	0.07667	0.02062	0.20765	0.0024243	0.0001717	0.020001
15	0.17765	0.03335	0.49401	0.07338	0.01921	0.20279	0.0021871	0.0001506	0.01852
16	0.17213	0.03113	0.48918	0.07041	0.01796	0.19832	0.0019846	0.000133	0.01722
17	0.16705	0.02915	0.48472	0.06771	0.01685	0.19419	0.0018099	0.0001183	0.016071
18	0.16235	0.02737	0.48057	0.06523	0.01586	0.19036	0.0016582	0.0001058	0.015049
19	0.15798	0.02576	0.47670	0.06295	0.01496	0.18678	0.0015255	0.0000951	0.014135
20	0.15391	0.02430	0.47307	0.06085	0.01415	0.18343	0.0014086	0.000086	0.013312
21	0.15010	0.02297	0.46967	0.05890	0.01342	0.18029	0.001305	0.000078	0.012569
22	0.14653	0.02176	0.46646	0.05708	0.01274	0.17733	0.0012128	0.0000711	0.011894
23	0.14317	0.02065	0.46342	0.05539	0.01213	0.17454	0.0011303	0.000065	0.011279
24	0.14000	0.01962	0.46055	0.05381	0.01157	0.17190	0.0010562	0.0000596	0.010716
25	0.13700	0.01868	0.45782	0.05233	0.01104	0.16939	0.0009893	0.0000549	0.0102
26	0.13417	0.01781	0.45523	0.05093	0.01056	0.16701	0.0009287	0.0000506	0.009725
27	0.13148	0.01700	0.45275	0.04962	0.01012	0.16474	0.0008736	0.0000469	0.009286
28	0.12893	0.01625	0.45039	0.04838	0.00970	0.16258	0.0008234	0.0000435	0.008879
29	0.12649	0.01555	0.44812	0.04720	0.00932	0.16051	0.0007775	0.0000404	0.008502
30	**0.12417**	**0.01490**	**0.44596**	**0.04609**	**0.00896**	**0.15853**	**0.0007354**	**0.0000377**	**0.008151**
31	0.12196	0.01429	0.44388	0.04504	0.00862	0.15663	0.0006967	0.0000352	0.007824
32	0.11984	0.01371	0.44188	0.04403	0.00830	0.15481	0.000661	0.0000329	0.007518
33	0.11781	0.01318	0.43995	0.04308	0.00801	0.15307	0.000628	0.0000309	0.007232
34	0.11586	0.01268	0.43810	0.04217	0.00773	0.15138	0.0005975	0.000029	0.006964
35	0.11400	0.01220	0.43631	0.04130	0.00746	0.14976	0.0005692	0.0000272	0.006712

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SObo			Sp			Spsq*		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.11221	0.01176	0.43458	0.04047	0.00722	0.14820	0.0005428	0.0000257	0.006475
37	0.11048	0.01133	0.43291	0.03968	0.00698	0.14670	0.0005183	0.0000242	0.006251
38	0.10882	0.01094	0.43130	0.03891	0.00676	0.14524	0.0004954	0.0000229	0.00604
39	0.10722	0.01056	0.42973	0.03818	0.00655	0.14383	0.000474	0.0000216	0.005841
40	0.10568	0.01020	0.42822	0.03748	0.00635	0.14247	0.000454	0.0000205	0.005653
41	0.10419	0.00987	0.42675	0.03681	0.00616	0.14116	0.0004352	0.0000194	0.005474
42	0.10275	0.00955	0.42532	0.03616	0.00598	0.13988	0.0004176	0.0000184	0.005305
43	0.10136	0.00924	0.42393	0.03554	0.00581	0.13864	0.0004011	0.0000175	0.005144
44	0.10001	0.00895	0.42259	0.03494	0.00565	0.13744	0.0003855	0.0000167	0.004991
45	0.09871	0.00867	0.42128	0.03436	0.00549	0.13627	0.0003708	0.0000159	0.004845
46	0.09745	0.00841	0.42000	0.03380	0.00534	0.13514	0.0003569	0.0000151	0.004706
47	0.09623	0.00816	0.41876	0.03326	0.00520	0.13403	0.0003438	0.0000144	0.004574
48	0.09504	0.00792	0.41755	0.03274	0.00507	0.13296	0.0003314	0.0000138	0.004448
49	0.09389	0.00769	0.41637	0.03224	0.00494	0.13192	0.0003197	0.0000132	0.004327
50	0.09277	0.00747	0.41521	0.03175	0.00481	0.13090	0.0003085	0.0000126	0.004212
55	0.08762	0.00651	0.40984	0.02953	0.00426	0.12618	0.0002608	0.0000102	0.003704
60	0.08312	0.00573	0.40503	0.02762	0.00381	0.12199	0.0002233	0.0000084	0.00329
65	0.07913	0.00508	0.40068	0.02596	0.00343	0.11823	0.0001933	0.000007	0.002946
70	0.07556	0.00454	0.39672	0.02449	0.00311	0.11483	0.0001689	0.0000059	0.002657
75	0.07236	0.00408	0.39308	0.02319	0.00283	0.11173	0.0001488	0.000005	0.002412
80	0.06945	0.00369	0.38972	0.02203	0.00260	0.10890	0.0001321	0.0000043	0.002201
85	0.06681	0.00335	0.38660	0.02098	0.00239	0.10628	0.000118	0.0000038	0.002018
90	0.06439	0.00305	0.38369	0.02003	0.00221	0.10386	0.000106	0.0000033	0.001859
95	0.06216	0.00280	0.38096	0.01916	0.00205	0.10161	0.0000957	0.0000029	0.001719
100	0.06010	0.00257	0.37840	0.01837	0.00191	0.09952	0.0000868	0.0000026	0.001595
110	0.05642	0.00219	0.37371	0.01698	0.00167	0.09571	0.0000724	0.000002	0.001386
120	0.05322	0.00189	0.36950	0.01578	0.00147	0.09234	0.0000611	0.0000016	0.001217
130	0.05040	0.00165	0.36568	0.01475	0.00131	0.08932	0.0000523	0.0000014	0.001079
140	0.04790	0.00145	0.36219	0.01384	0.00118	0.08659	0.0000452	0.0000011	0.000965
150	0.04566	0.00128	0.35898	0.01305	0.00106	0.08411	0.0000394	0.000001	0.000868
160	0.04364	0.00114	0.35601	0.01233	0.00097	0.08185	0.0000346	0.0000008	0.000786
170	0.04181	0.00102	0.35325	0.01170	0.00088	0.07976	0.0000307	0.0000007	0.000715
180	0.04015	0.00092	0.35068	0.01112	0.00081	0.07784	0.0000273	0.0000006	0.000654
190	0.03862	0.00083	0.34826	0.01060	0.00075	0.07605	0.0000245	0.0000005	0.0006
200	0.03722	0.00076	0.34599	0.01013	0.00069	0.07439	0.000022	0.0000005	0.000553

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SObo			Sp			Spsq*		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.03592	0.00069	0.34384	0.00970	0.00064	0.07283	0.0000199	0.0000004	0.000512
220	0.03472	0.00063	0.34181	0.00930	0.00060	0.07137	0.0000181	0.0000004	0.000475
230	0.03360	0.00058	0.33989	0.00893	0.00056	0.07000	0.0000165	0.0000003	0.000442
240	0.03256	0.00054	0.33806	0.00859	0.00052	0.06871	0.0000151	0.0000003	0.000413
250	0.03159	0.00050	0.33631	0.00828	0.00049	0.06749	0.0000139	0.0000003	0.000386
260	0.03067	0.00046	0.33465	0.00798	0.00046	0.06633	0.0000128	0.0000002	0.000362
270	0.02981	0.00043	0.33305	0.00771	0.00043	0.06523	0.0000118	0.0000002	0.000341
280	0.02901	0.00040	0.33153	0.00745	0.00041	0.06418	0.0000109	0.0000002	0.000321
290	0.02824	0.00037	0.33006	0.00721	0.00038	0.06319	0.0000101	0.0000002	0.000303
300	0.02752	0.00035	0.32865	0.00699	0.00036	0.06224	0.0000094	0.0000002	0.000286

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			St		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.10803	0.01801	0.35292	0.33125	0.15099	0.56326	0.26746	0.12567	0.46258
2	0.05713	0.00474	0.28624	0.22783	0.08919	0.44186	0.16133	0.05813	0.34187
3	0.03757	0.00185	0.25586	0.17694	0.06207	0.37577	0.11419	0.03347	0.28195
4	0.02733	0.00088	0.23708	0.14558	0.04675	0.33218	0.08731	0.02158	0.24424
5	0.02109	0.00048	0.22379	0.12400	0.03693	0.30050	0.06996	0.01493	0.21764
6	0.01693	0.00028	0.21367	0.10811	0.03014	0.27607	0.05786	0.01085	0.19756
7	0.01398	0.00018	0.20555	0.09586	0.02519	0.25646	0.04896	0.00817	0.18170
8	0.01179	0.00012	0.19883	0.08611	0.02145	0.24025	0.04218	0.00634	0.16875
9	0.01012	0.00008	0.19313	0.07814	0.01852	0.22656	0.03684	0.00502	0.15793
10	0.00880	0.00006	0.18819	0.07149	0.01619	0.21479	0.03255	0.00406	0.14871
11	0.00774	0.00004	0.18384	0.06586	0.01429	0.20452	0.02903	0.00333	0.14073
12	0.00687	0.00003	0.17998	0.06103	0.01273	0.19547	0.02610	0.00277	0.13374
13	0.00615	0.00002	0.17650	0.05683	0.01141	0.18740	0.02362	0.00233	0.12756
14	0.00554	0.00002	0.17335	0.05315	0.01030	0.18016	0.02151	0.00198	0.12203
15	0.00502	0.00001	0.17047	0.04990	0.00934	0.17360	0.01969	0.00169	0.11705
16	0.00458	0.00001	0.16783	0.04700	0.00852	0.16763	0.01811	0.00146	0.11255
17	0.00419	0.00001	0.16538	0.04440	0.00781	0.16217	0.01672	0.00127	0.10844
18	0.00386	0.00001	0.16311	0.04206	0.00718	0.15714	0.01550	0.00111	0.10468
19	0.00356	0.00001	0.16100	0.03994	0.00662	0.15250	0.01442	0.00098	0.10121
20	0.00330	0.00000	0.15902	0.03800	0.00613	0.14819	0.01345	0.00087	0.09801
21	0.00307	0.00000	0.15716	0.03624	0.00570	0.14418	0.01258	0.00077	0.09504
22	0.00286	0.00000	0.15540	0.03462	0.00530	0.14044	0.01180	0.00069	0.09228
23	0.00267	0.00000	0.15375	0.03312	0.00495	0.13693	0.01109	0.00061	0.08970
24	0.00251	0.00000	0.15218	0.03174	0.00463	0.13364	0.01044	0.00055	0.08728
25	0.00235	0.00000	0.15069	0.03047	0.00434	0.13054	0.00986	0.00050	0.08502
26	0.00221	0.00000	0.14927	0.02928	0.00408	0.12761	0.00932	0.00045	0.08288
27	0.00209	0.00000	0.14792	0.02817	0.00384	0.12485	0.00883	0.00041	0.08087
28	0.00197	0.00000	0.14663	0.02714	0.00362	0.12223	0.00838	0.00037	0.07897
29	0.00187	0.00000	0.14540	0.02617	0.00342	0.11974	0.00796	0.00034	0.07717
30	**0.00177**	**0.00000**	**0.14422**	**0.02527**	**0.00324**	**0.11738**	**0.00758**	**0.00031**	**0.07546**
31	0.00168	0.00000	0.14308	0.02442	0.00307	0.11513	0.00722	0.00029	0.07384
32	0.00160	0.00000	0.14199	0.02362	0.00291	0.11298	0.00689	0.00026	0.07230
33	0.00152	0.00000	0.14094	0.02286	0.00277	0.11093	0.00658	0.00024	0.07083
34	0.00145	0.00000	0.13993	0.02215	0.00263	0.10897	0.00630	0.00022	0.06942
35	0.00138	0.00000	0.13896	0.02147	0.00251	0.10709	0.00603	0.00021	0.06808

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			St		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.00132	0.00000	0.13802	0.02083	0.00239	0.10529	0.00578	0.00019	0.06680
37	0.00126	0.00000	0.13711	0.02023	0.00228	0.10357	0.00554	0.00018	0.06557
38	0.00121	0.00000	0.13623	0.01965	0.00218	0.10191	0.00532	0.00017	0.06439
39	0.00116	0.00000	0.13538	0.01911	0.00208	0.10031	0.00511	0.00015	0.06326
40	0.00111	0.00000	0.13456	0.01859	0.00199	0.09878	0.00492	0.00014	0.06218
41	0.00107	0.00000	0.13376	0.01809	0.00191	0.09730	0.00473	0.00013	0.06113
42	0.00103	0.00000	0.13299	0.01762	0.00183	0.09587	0.00456	0.00013	0.06013
43	0.00099	0.00000	0.13223	0.01717	0.00176	0.09450	0.00440	0.00012	0.05916
44	0.00095	0.00000	0.13150	0.01673	0.00169	0.09317	0.00424	0.00011	0.05822
45	0.00091	0.00000	0.13079	0.01632	0.00162	0.09189	0.00409	0.00010	0.05732
46	0.00088	0.00000	0.13010	0.01592	0.00156	0.09064	0.00396	0.00010	0.05645
47	0.00085	0.00000	0.12943	0.01555	0.00150	0.08944	0.00382	0.00009	0.05561
48	0.00082	0.00000	0.12877	0.01518	0.00145	0.08828	0.00370	0.00009	0.05480
49	0.00079	0.00000	0.12813	0.01483	0.00139	0.08715	0.00358	0.00008	0.05401
50	0.00077	0.00000	0.12751	0.01450	0.00134	0.08606	0.00347	0.00008	0.05325
55	0.00065	0.00000	0.12460	0.01300	0.00113	0.08105	0.00297	0.00006	0.04978
60	0.00056	0.00000	0.12200	0.01176	0.00096	0.07668	0.00258	0.00005	0.04677
65	0.00049	0.00000	0.11966	0.01070	0.00083	0.07284	0.00226	0.00004	0.04414
70	0.00043	0.00000	0.11753	0.00980	0.00072	0.06943	0.00199	0.00003	0.04182
75	0.00038	0.00000	0.11557	0.00902	0.00063	0.06637	0.00177	0.00002	0.03975
80	0.00034	0.00000	0.11377	0.00835	0.00055	0.06362	0.00159	0.00002	0.03789
85	0.00030	0.00000	0.11210	0.00775	0.00049	0.06111	0.00143	0.00002	0.03622
90	0.00027	0.00000	0.11055	0.00722	0.00044	0.05883	0.00130	0.00001	0.03469
95	0.00025	0.00000	0.10910	0.00675	0.00039	0.05674	0.00118	0.00001	0.03330
100	0.00022	0.00000	0.10774	0.00633	0.00035	0.05481	0.00108	0.00001	0.03203
110	0.00019	0.00000	0.10525	0.00561	0.00029	0.05137	0.00091	0.00001	0.02977
120	0.00016	0.00000	0.10303	0.00502	0.00024	0.04839	0.00077	0.00001	0.02783
130	0.00014	0.00000	0.10102	0.00452	0.00021	0.04578	0.00067	0.00000	0.02614
140	0.00012	0.00000	0.09919	0.00410	0.00018	0.04348	0.00058	0.00000	0.02465
150	0.00010	0.00000	0.09752	0.00375	0.00015	0.04142	0.00051	0.00000	0.02333
160	0.00009	0.00000	0.09597	0.00344	0.00013	0.03957	0.00045	0.00000	0.02216
170	0.00008	0.00000	0.09454	0.00317	0.00012	0.03789	0.00040	0.00000	0.02110
180	0.00007	0.00000	0.09321	0.00293	0.00010	0.03637	0.00036	0.00000	0.02014
190	0.00007	0.00000	0.09196	0.00272	0.00009	0.03498	0.00033	0.00000	0.01927
200	0.00006	0.00000	0.09080	0.00253	0.00008	0.03370	0.00029	0.00000	0.01847

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	Spss			Ssqd			St		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.00005	0.00000	0.08970	0.00237	0.00007	0.03253	0.00027	0.00000	0.01774
220	0.00005	0.00000	0.08866	0.00222	0.00006	0.03144	0.00024	0.00000	0.01707
230	0.00004	0.00000	0.08768	0.00209	0.00006	0.03043	0.00022	0.00000	0.01645
240	0.00004	0.00000	0.08675	0.00196	0.00005	0.02948	0.00021	0.00000	0.01587
250	0.00004	0.00000	0.08587	0.00185	0.00005	0.02860	0.00019	0.00000	0.01533
260	0.00003	0.00000	0.08503	0.00175	0.00004	0.02778	0.00017	0.00000	0.01483
270	0.00003	0.00000	0.08422	0.00166	0.00004	0.02701	0.00016	0.00000	0.01436
280	0.00003	0.00000	0.08346	0.00157	0.00004	0.02628	0.00015	0.00000	0.01393
290	0.00003	0.00000	0.08272	0.00150	0.00003	0.02559	0.00014	0.00000	0.01351
300	0.00003	0.00000	0.08202	0.00142	0.00003	0.02495	0.00013	0.00000	0.01313

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SZtb			Zpg			Zsg		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
1	0.0700933	0.0257274	0.158045	0.49898	0.26915	0.72915	0.92117	0.78082	0.97987
2	0.0383324	0.0105027	0.108813	0.38066	0.18437	0.61461	0.80805	0.63687	0.91795
3	0.026002	0.0058299	0.086296	0.31565	0.14087	0.54642	0.71006	0.53474	0.84611
4	0.0194307	0.0037291	0.072746	0.27262	0.11357	0.49918	0.62873	0.45674	0.77806
5	0.0153589	0.002593	0.063483	0.24138	0.09466	0.46369	0.56117	0.39469	0.71735
6	0.0125982	0.001906	0.05666	0.21738	0.08075	0.43561	0.50451	0.34407	0.66421
7	0.01061	0.0014581	0.051377	0.19820	0.07007	0.41260	0.45649	0.30207	0.61787
8	0.0091146	0.0011495	0.047139	0.18245	0.06163	0.39324	0.41537	0.26677	0.57735
9	0.0079521	0.0009279	0.043648	0.16922	0.05478	0.37663	0.37985	0.23682	0.54174
10	0.0070249	0.0007635	0.040712	0.15792	0.04913	0.36215	0.34890	0.21119	0.51024
11	0.0062697	0.0006382	0.038202	0.14814	0.04439	0.34936	0.32173	0.18912	0.48222
12	0.005644	0.0005406	0.036025	0.13957	0.04037	0.33795	0.29773	0.17000	0.45712
13	0.005118	0.0004631	0.034117	0.13199	0.03691	0.32767	0.27641	0.15334	0.43452
14	0.0046704	0.0004006	0.032428	0.12523	0.03391	0.31835	0.25735	0.13875	0.41406
15	0.0042854	0.0003495	0.030919	0.11916	0.03129	0.30984	0.24025	0.12593	0.39545
16	0.0039512	0.0003072	0.029563	0.11367	0.02899	0.30202	0.22483	0.11461	0.37843
17	0.0036588	0.0002719	0.028336	0.10868	0.02694	0.29480	0.21087	0.10458	0.36282
18	0.003401	0.000242	0.027219	0.10412	0.02512	0.28811	0.19818	0.09566	0.34843
19	0.0031723	0.0002166	0.026197	0.09994	0.02349	0.28188	0.18662	0.08770	0.33513
20	0.0029683	0.0001948	0.025258	0.09608	0.02201	0.27606	0.17604	0.08058	0.32280
21	0.0027852	0.000176	0.024392	0.09252	0.02068	0.27060	0.16634	0.07418	0.31132
22	0.0026202	0.0001597	0.023591	0.08921	0.01948	0.26548	0.15742	0.06843	0.30062
23	0.0024709	0.0001454	0.022846	0.08614	0.01838	0.26064	0.14920	0.06324	0.29061
24	0.0023352	0.0001328	0.022152	0.08327	0.01737	0.25607	0.14160	0.05854	0.28123
25	0.0022114	0.0001217	0.021504	0.08058	0.01645	0.25175	0.13456	0.05428	0.27241
26	0.002098	0.0001119	0.020897	0.07807	0.01560	0.24764	0.12802	0.05041	0.26411
27	0.001994	0.0001032	0.020326	0.07570	0.01482	0.24374	0.12195	0.04689	0.25629
28	0.0018982	0.0000953	0.019789	0.07347	0.01410	0.24002	0.11629	0.04367	0.24890
29	0.0018097	0.0000883	0.019283	0.07137	0.01343	0.23647	0.11100	0.04073	0.24190
30	**0.0017279**	**0.000082**	**0.018805**	**0.06939**	**0.01281**	**0.23308**	**0.10606**	**0.03804**	**0.23527**
31	0.0016519	0.0000763	0.018352	0.06751	0.01223	0.22984	0.10144	0.03557	0.22897
32	0.0015812	0.0000711	0.017922	0.06572	0.01169	0.22673	0.09711	0.03331	0.22299
33	0.0015154	0.0000664	0.017515	0.06403	0.01119	0.22375	0.09304	0.03122	0.21729
34	0.0014539	0.0000621	0.017127	0.06242	0.01072	0.22088	0.08921	0.02929	0.21186
35	0.0013964	0.0000582	0.016757	0.06089	0.01027	0.21813	0.08561	0.02751	0.20668

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SZtb			Zpg			Zsg		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
36	0.0013426	0.0000547	0.016405	0.05943	0.00986	0.21547	0.08221	0.02587	0.20173
37	0.001292	0.0000514	0.016068	0.05803	0.00947	0.21292	0.07900	0.02435	0.19700
38	0.0012444	0.0000484	0.015746	0.05670	0.00911	0.21045	0.07598	0.02294	0.19247
39	0.0011997	0.0000456	0.015438	0.05543	0.00876	0.20807	0.07311	0.02163	0.18813
40	0.0011574	0.000043	0.015143	0.05421	0.00843	0.20577	0.07040	0.02042	0.18396
41	0.0011176	0.0000407	0.01486	0.05304	0.00813	0.20354	0.06784	0.01929	0.17997
42	0.0010799	0.0000385	0.014589	0.05191	0.00784	0.20139	0.06540	0.01823	0.17613
43	0.0010442	0.0000365	0.014327	0.05084	0.00756	0.19930	0.06309	0.01725	0.17244
44	0.0010104	0.0000346	0.014076	0.04980	0.00730	0.19728	0.06089	0.01634	0.16889
45	0.0009784	0.0000328	0.013834	0.04881	0.00705	0.19531	0.05880	0.01548	0.16547
46	0.0009479	0.0000312	0.013601	0.04785	0.00682	0.19341	0.05681	0.01468	0.16217
47	0.000919	0.0000297	0.013377	0.04692	0.00659	0.19156	0.05492	0.01393	0.15899
48	0.0008914	0.0000283	0.01316	0.04603	0.00638	0.18976	0.05311	0.01323	0.15593
49	0.0008652	0.0000269	0.012951	0.04518	0.00618	0.18801	0.05139	0.01257	0.15296
50	0.0008401	0.0000257	0.012749	0.04435	0.00598	0.18631	0.04974	0.01195	0.15010
55	0.0007308	0.0000205	0.011832	0.04060	0.00514	0.17845	0.04254	0.00937	0.13714
60	0.0006426	0.0000166	0.011046	0.03741	0.00446	0.17149	0.03673	0.00745	0.12606
65	0.0005702	0.0000137	0.010364	0.03466	0.00391	0.16528	0.03197	0.00600	0.11648
70	0.00051	0.0000114	0.009766	0.03226	0.00345	0.15969	0.02803	0.00488	0.10812
75	0.0004593	0.0000097	0.009237	0.03016	0.00307	0.15462	0.02473	0.00400	0.10076
80	0.0004162	0.0000082	0.008766	0.02829	0.00275	0.14999	0.02195	0.00332	0.09423
85	0.0003791	0.0000071	0.008342	0.02663	0.00247	0.14575	0.01958	0.00277	0.08841
90	0.0003469	0.0000061	0.00796	0.02513	0.00223	0.14183	0.01755	0.00233	0.08318
95	0.0003189	0.0000053	0.007613	0.02378	0.00203	0.13820	0.01580	0.00197	0.07846
100	0.0002942	0.0000047	0.007296	0.02256	0.00185	0.13483	0.01428	0.00167	0.07419
110	0.0002531	0.0000037	0.006738	0.02043	0.00155	0.12873	0.01178	0.00123	0.06674
120	0.0002203	0.0000029	0.006262	0.01864	0.00132	0.12336	0.00985	0.00092	0.06048
130	0.0001936	0.0000024	0.005851	0.01711	0.00113	0.11857	0.00831	0.00070	0.05515
140	0.0001717	0.0000019	0.005492	0.01579	0.00098	0.11428	0.00709	0.00055	0.05057
150	0.0001533	0.0000016	0.005176	0.01464	0.00086	0.11040	0.00609	0.00043	0.04659
160	0.0001379	0.0000014	0.004896	0.01363	0.00076	0.10686	0.00528	0.00034	0.04310
170	0.0001247	0.0000012	0.004644	0.01274	0.00067	0.10362	0.00460	0.00027	0.04002
180	0.0001133	0.000001	0.004418	0.01195	0.00060	0.10064	0.00403	0.00022	0.03730
190	0.0001035	0.0000009	0.004214	0.01123	0.00054	0.09788	0.00355	0.00018	0.03486
200	0.0000949	0.0000007	0.004027	0.01059	0.00048	0.09533	0.00315	0.00015	0.03267

Appendix 5. Probability of uranium exceeding a given concentration, by bedrock unit.—Continued

[Probabilities with bold typeface apply to concentrations at the U.S. Environmental Protection Agency drinking-water standard for public supplies. Multiply probability values by 100 to obtain percent probability; *, fewer than five analyses were above the analytical reporting limit and the option to assume a common scale was used in the distribution fitting]

Uranium, in micrograms per liter	Bedrock unit abbreviation								
	SZtb			Zpg			Zsg		
	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound	Probability of concentration being greater than concentration listed in first column	Lower 95-percent confidence bound	Upper 95-percent confidence bound
210	0.0000874	0.0000006	0.003857	0.01001	0.00044	0.09295	0.00280	0.00012	0.03070
220	0.0000807	0.0000006	0.003701	0.00949	0.00040	0.09072	0.00251	0.00010	0.02892
230	0.0000748	0.0000005	0.003557	0.00901	0.00036	0.08863	0.00225	0.00009	0.02730
240	0.0000695	0.0000004	0.003424	0.00857	0.00033	0.08667	0.00202	0.00007	0.02582
250	0.0000648	0.0000004	0.0033	0.00816	0.00030	0.08483	0.00183	0.00006	0.02446
260	0.0000605	0.0000004	0.003186	0.00779	0.00028	0.08308	0.00166	0.00005	0.02322
270	0.0000567	0.0000003	0.003079	0.00745	0.00026	0.08143	0.00151	0.00004	0.02207
280	0.0000532	0.0000003	0.002979	0.00713	0.00024	0.07987	0.00137	0.00004	0.02102
290	0.00005	0.0000003	0.002885	0.00683	0.00022	0.07838	0.00125	0.00003	0.02004
300	0.0000471	0.0000002	0.002797	0.00655	0.00020	0.07697	0.00115	0.00003	0.01913

Appendix 6. Uranium Log-Normal Fit Statistics by Bedrock Unit

Appendix 6. Uranium log-normal fit statistics by bedrock unit.

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Dcgr					Dfgr				
Censoring information	Count				Censoring information	Count			
Uncensored value	7				Uncensored value	8			
Left censored value	0				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	2.31035	0.548184	1.23593	3.38477	Location	0.872357	0.890096	-0.872199	2.61691
Scale	1.35299	0.49093	0.664417	2.75519	Scale	2.33772	0.529608	1.49953	3.64445
Log-likelihood	-29.247				Log-likelihood	-32.057			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	3.306				Anderson-Darling (adjusted)	2.951			
Correlation coefficient	0.957				Correlation coefficient	0.973			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	25.1698	17.4269	6.47937	97.7751	Mean	36.7756	45.1462	3.31599	407.855
Standard deviation	57.6032	78.2128	4.02436	824.511	Standard deviation	564.077	1.30×10^3	6.16399	5.16×10^4
Median	10.0779	5.52457	3.44157	29.5112	Median	2.39254	2.12959	0.418031	13.6934
First quartile (Q1)	4.04616	2.97585	0.957207	17.1033	First quartile (Q1)	0.494398	0.531543	0.0601067	4.06659
Third quartile (Q3)	25.1016	13.2678	8.90814	70.7318	Third quartile (Q3)	11.5782	9.57458	2.28952	58.5518
Interquartile range (IQR)	21.0554	12.088	6.83416	64.8697	Interquartile range (IQR)	11.0838	9.18399	2.1847	56.2328

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
DI					DSw				
Censoring information	Count				Censoring information	Count			
Uncensored value	9				Uncensored value	8			
Left censored value	0				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-1.42001	0.492276	-2.38486	-0.455172	Location	-0.82093	0.518637	-1.83744	0.19558
Scale	1.4107	0.415304	0.792216	2.51203	Scale	1.40474	0.552648	0.64971	3.0372
Log-likelihood	-4.421				Log-likelihood	-32.057			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	2.64				Anderson-Darling (adjusted)	2.878			
Correlation coefficient	0.982				Correlation coefficient	0.989			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.653782	0.421119	0.184991	2.31055	Mean	1.18024	0.943965	0.246135	5.65936
Standard deviation	1.64306	1.99408	0.152267	17.7297	Standard deviation	2.93744	4.72115	0.12586	68.5566
Median	0.24171	0.118988	0.0921021	0.634339	Median	0.440022	0.228212	0.159225	1.21602
First quartile (Q1)	0.0933392	0.0592101	0.0269216	0.323614	First quartile (Q1)	0.170604	0.122943	0.0415511	0.700477
Third quartile (Q3)	0.625932	0.306129	0.240006	1.63242	Third quartile (Q3)	1.13491	0.618028	0.390328	3.29984
Interquartile range (IQR)	0.532592	0.279416	0.19047	1.48924	Interquartile range (IQR)	0.964306	0.588827	0.291375	3.19138

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Ops*					OZf				
Censoring information	Count				Censoring information	Count			
Uncensored value	3				Uncensored value	8			
Left censored value	7				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-4.59511	0.651571	-5.87217	-3.31806	Location	-0.861046	0.430412	-1.70464	-0.0174541
Scale	1.70447	0.0790912	1.55629	1.86675	Scale	1.14421	0.3512	0.626965	2.0882
Log-likelihood	-7.89				Log-likelihood	-6.792			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.393				Anderson-Darling (adjusted)	2.89			
Correlation coefficient	0.86				Correlation coefficient	0.986			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.0431743	0.0280004	0.0121111	0.15391	Mean	0.813481	0.388955	0.318682	2.07653
Standard deviation	0.179415	0.121157	0.0477589	0.674006	Standard deviation	1.3375	1.20545	0.228632	7.82445
Median	0.0101011	0.0065816	0.0028168	0.0362231	Median	0.42272	0.181944	0.181838	0.982697
First quartile (Q1)	0.0031995	0.002113	0.0008769	0.0116741	First quartile (Q1)	0.195381	0.108958	0.0654924	0.58287
Third quartile (Q3)	0.0318898	0.0206335	0.0089723	0.113345	Third quartile (Q3)	0.914585	0.379014	0.405954	2.0605
Interquartile range (IQR)	0.0286903	0.0185514	0.0080787	0.101889	Interquartile range (IQR)	0.719205	0.330712	0.292041	1.77117

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
OZm					OZn				
Censoring information	Count				Censoring information	Count			
Uncensored value	10				Uncensored value	30			
Left censored value	0				Left censored value	1			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.655272	0.788995	-2.20167	0.89113	Location	0.0159391	0.258203	-0.490129	0.522007
Scale	2.41324	0.682883	1.3859	4.20212	Scale	1.42905	0.185068	1.1087	1.84197
Log-likelihood	-18.878				Log-likelihood	-62.614			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	2.451				Anderson-Darling (adjusted)	1.108			
Correlation coefficient	0.977				Correlation coefficient	0.973			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	9.55049	15.6289	0.386439	236.032	Mean	2.82083	0.990952	1.41694	5.61568
Standard deviation	175.384	559.999	0.33582	9.16×10^4	Standard deviation	7.30561	4.39151	2.24898	23.7315
Median	0.519301	0.409726	0.110618	2.43788	Median	1.01607	0.262351	0.612547	1.68541
First quartile (Q1)	0.10198	0.102956	0.0140984	0.737666	First quartile (Q1)	0.387538	0.115277	0.21633	0.694244
Third quartile (Q3)	2.64437	2.13213	0.544513	12.8421	Third quartile (Q3)	2.66398	0.734496	1.55182	4.57318
Interquartile range (IQR)	2.54239	2.08213	0.51067	12.6574	Interquartile range (IQR)	2.27644	0.668797	1.27991	4.04884

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
OZnb					Ph				
Censoring information	Count				Censoring information	Count			
Uncensored value	14				Uncensored value	8			
Left censored value	6				Left censored value	1			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-1.75943	0.483527	-2.70713	-0.811735	Location	-1.75943	0.483527	-2.70713	-0.811735
Scale	2.1023	0.305023	1.58196	2.7938	Scale	2.1023	0.305023	1.58196	2.7938
Log-likelihood	-34.212				Log-likelihood	-25.95			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.676				Anderson-Darling (adjusted)	2.642			
Correlation coefficient	0.857				Correlation coefficient	0.896			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	1.56895	1.24124	0.332813	7.39637	Mean	91.6336	231.335	0.650347	1.29×10^4
Standard deviation	14.2135	19.3858	0.981158	205.902	Standard deviation	1.04×10^4	5.03×10^4	0.801103	1.35×10^8
Median	0.172143	0.0832357	0.0667283	0.444087	Median	0.806891	0.840909	0.104647	6.2216
First quartile (Q1)	0.0416934	0.0221509	0.0147177	0.118112	First quartile (Q1)	0.101305	0.123643	0.0092627	1.10796
Third quartile (Q3)	0.71074	0.369306	0.256697	1.96789	Third quartile (Q3)	6.42687	7.16985	0.721764	57.2274
Interquartile range (IQR)	0.669046	0.354301	0.236969	1.88895	Interquartile range (IQR)	6.32557	7.09744	0.701505	57.0385

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Sacgr					Sagr				
Censoring information	Count				Censoring information	Count			
Uncensored value	53				Uncensored value	10			
Left censored value	0				Left censored value	1			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	0.936261	0.246092	0.45393	1.41859	Location	0.494757	0.780732	-1.03545	2.02496
Scale	1.79023	0.178323	1.47273	2.17619	Scale	2.5312	0.64904	1.53131	4.18396
Log-likelihood	-157.38				Log-likelihood	-36.858			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.382				Anderson-Darling (adjusted)	2.278			
Correlation coefficient	0.959				Correlation coefficient	0.969			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	12.6636	5.00803	5.83356	27.4903	Mean	40.3759	68.0789	1.48213	1.10×10^3
Standard deviation	61.5898	42.368	15.9942	237.167	Standard deviation	993.15	3.22×10^3	1.7375	5.68×10^4
Median	2.55043	0.62764	1.57449	4.1313	Median	1.6401	1.28048	0.355067	7.57584
First quartile (Q1)	0.762438	0.212005	0.442097	1.3149	First quartile (Q1)	0.29745	0.286112	0.0451501	1.95961
Third quartile (Q3)	8.53142	2.3009	5.02868	14.474	Third quartile (Q3)	9.04329	7.44166	1.80251	45.3706
Interquartile range (IQR)	7.76898	2.17703	4.4858	13.4551	Interquartile range (IQR)	8.74584	7.29465	1.70545	44.8501

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Sb					Sbs				
Censoring information	Count				Censoring information	Count			
Uncensored value	16				Uncensored value	12			
Left censored value	0				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.202141	0.371811	-0.930878	0.526595	Location	-0.518142	0.27691	-1.06087	0.0245912
Scale	1.46215	0.283057	1.00048	2.13686	Scale	0.930099	0.211768	0.595285	1.45323
Log-likelihood	-27.626				Log-likelihood	-11.145			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.715				Anderson-Darling (adjusted)	2.019			
Correlation coefficient	0.97				Correlation coefficient	0.994			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	2.37929	1.19732	0.88736	6.3796	Mean	0.917962	0.27353	0.511902	1.64612
Standard deviation	6.50789	5.81329	1.13003	37.4792	Standard deviation	1.07649	0.582141	0.372989	3.10685
Median	0.816979	0.303762	0.394208	1.69316	Median	0.595626	0.164935	0.346153	1.0249
First quartile (Q1)	0.304725	0.136503	0.126651	0.733174	First quartile (Q1)	0.31807	0.108532	0.162958	0.620827
Third quartile (Q3)	2.19036	0.844705	1.02861	4.66421	Third quartile (Q3)	1.11539	0.31097	0.645817	1.92637
Interquartile range (IQR)	1.88563	0.772188	0.845045	4.20759	Interquartile range (IQR)	0.797316	0.261822	0.418903	1.51757

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Se					Sgr				
Censoring information	Count				Censoring information	Count			
Uncensored value	8				Uncensored value	7			
Left censored value	0				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.292614	0.287496	-0.856096	0.270868	Location	-0.822002	0.675265	-2.1455	0.501493
Scale	0.766477	0.228921	0.426849	1.37633	Scale	1.69502	0.788348	0.681216	4.21761
Log-likelihood	-7.605				Log-likelihood	-8.001			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	2.986				Anderson-Darling (adjusted)	3.238			
Correlation coefficient	0.963				Correlation coefficient	0.974			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	1.00113	0.282716	0.57559	1.74128	Mean	1.84882	2.39012	0.146717	23.2976
Standard deviation	0.895135	0.489043	0.306795	2.61174	Standard deviation	7.55348	19.7808	0.0445706	1.28×10^3
Median	0.74631	0.214561	0.424817	1.3111	Median	0.439551	0.296813	0.11701	1.65118
First quartile (Q1)	0.445038	0.164209	0.215935	0.917215	First quartile (Q1)	0.140117	0.137691	0.0204188	0.961507
Third quartile (Q3)	1.25153	0.346937	0.726907	2.15478	Third quartile (Q3)	1.37888	0.986436	0.339304	5.60359
Interquartile range (IQR)	0.806491	0.286032	0.402448	1.61618	Interquartile range (IQR)	1.23877	0.961806	0.270456	5.6739

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
So					SOagr				
Censoring information	Count				Censoring information	Count			
Uncensored value	12				Uncensored value	10			
Left censored value	2				Left censored value	2			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.910549	0.544193	-1.97715	0.156049	Location	-1.84542	0.919828	-3.64825	-0.0425933
Scale	1.99838	0.413305	1.3324	2.99726	Scale	3.01868	0.795339	1.80115	5.05924
Log-likelihood	-25.899				Log-likelihood	-19.087			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.719				Anderson-Darling (adjusted)	2.108			
Correlation coefficient	0.968				Correlation coefficient	0.969			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	2.96306	2.75646	0.478508	18.3481	Mean	15.0412	35.1856	0.153493	1.47×10^3
Standard deviation	21.6215	36.4911	0.791215	590.851	Standard deviation	1.43×10^3	6.66×10^3	0.157509	1.30×10^7
Median	0.402303	0.218931	0.138464	1.16888	Median	0.157959	0.145295	0.0260366	0.958301
First quartile (Q1)	0.104513	0.0670819	0.029705	0.367718	First quartile (Q1)	0.02062	0.0242945	0.0020484	0.207574
Third quartile (Q3)	1.54858	0.897307	0.497413	4.82117	Third quartile (Q3)	1.21003	1.13483	0.192528	7.60502
Interquartile range (IQR)	1.44407	0.859624	0.449662	4.63757	Interquartile range (IQR)	1.18941	1.12275	0.186997	7.56538

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
SObo					Sp				
Censoring information	Count				Censoring information	Count			
Uncensored value	6				Uncensored value	17			
Left censored value	1				Left censored value	5			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.077395	1.18885	-2.40749	2.2527	Location	-1.60967	0.664053	-2.91119	-0.308154
Scale	3.01338	1.16867	1.40908	6.44427	Scale	2.9756	0.556342	2.06266	4.29262
Log-likelihood	-21.941				Log-likelihood	-41.869			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	3.218				Anderson-Darling (adjusted)	1.409			
Correlation coefficient	0.982				Correlation coefficient	0.984			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	86.7332	297.632	0.104044	7.23×10^4	Mean	16.7339	27.7695	0.647216	432.658
Standard deviation	8.13×10^3	5.57×10^4	0.0119581	5.52×10^9	Standard deviation	1.40×10^3	4.55×10^3	2.40745	8.14×10^5
Median	0.925524	1.10031	0.0900407	9.51342	Median	0.199953	0.132779	0.0544107	0.734802
First quartile (Q1)	0.121251	0.191379	0.0054977	2.67421	First quartile (Q1)	0.0268715	0.0221378	0.0053461	0.135066
Third quartile (Q3)	7.06462	8.87495	0.602233	82.8731	Third quartile (Q3)	1.48786	1.03601	0.380072	5.82452
Interquartile range (IQR)	6.94337	8.80026	0.579067	83.2552	Interquartile range (IQR)	1.46099	1.0246	0.36957	5.77562

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Spsq*					Spss				
Censoring information	Count				Censoring information	Count			
Uncensored value	4				Uncensored value	7			
Left censored value	5				Left censored value	0			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-3.26786	0.765784	-4.76876	-1.76695	Location	-2.5205	0.796308	-4.08124	-0.959767
Scale	2.09694	0.118607	1.87689	2.34278	Scale	2.09694	0.118607	1.87689	2.34278
Log-likelihood	-11.6				Log-likelihood	-1.372			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.645				Anderson-Darling (adjusted)	2.819			
Correlation coefficient	0.948				Correlation coefficient	0.998			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.343254	0.271361	0.0728944	1.61635	Mean	0.724747	0.587722	0.147883	3.55185
Standard deviation	3.07434	2.73261	0.538474	17.5525	Standard deviation	6.49117	5.83285	1.11544	37.7744
Median	0.038088	0.0291672	0.0084909	0.170854	Median	0.0804192	0.0640385	0.0168866	0.382982
First quartile (Q1)	0.0092585	0.0071735	0.0020278	0.0422721	First quartile (Q1)	0.0195484	0.0157948	0.0040119	0.0952511
Third quartile (Q3)	0.156689	0.119878	0.0349793	0.701883	Third quartile (Q3)	0.330833	0.262209	0.0699794	1.56404
Interquartile range (IQR)	0.14743	0.112868	0.0328802	0.661059	Interquartile range (IQR)	0.311285	0.246747	0.0658315	1.47191

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
Ssqd					St				
Censoring information	Count				Censoring information	Count			
Uncensored value	10				Uncensored value	14			
Left censored value	1				Left censored value	1			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-0.977338	0.709125	-2.3672	0.412522	Location	-1.16725	0.499365	-2.14599	-0.188511
Scale	2.23919	0.386238	1.59686	3.13989	Scale	1.88108	0.379981	1.26609	2.7948
Log-likelihood	-26.615				Log-likelihood	-20.191			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	2.275				Anderson-Darling (adjusted)	1.712			
Correlation coefficient	0.975				Correlation coefficient	0.985			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	4.61653	4.38346	0.717942	29.6854	Mean	1.82574	1.42605	0.394987	8.43907
Standard deviation	56.4465	94.6883	2.10744	1.51×10^3	Standard deviation	10.5537	15.1096	0.637893	174.606
Median	0.376312	0.266852	0.093743	1.51062	Median	0.311222	0.155413	0.116953	0.828192
First quartile (Q1)	0.0831052	0.0683251	0.0165887	0.416337	First quartile (Q1)	0.0875086	0.0531504	0.0266105	0.287772
Third quartile (Q3)	1.70399	1.16261	0.447404	6.48982	Third quartile (Q3)	1.10685	0.565689	0.406499	3.01384
Interquartile range (IQR)	1.62088	1.11047	0.423246	6.20742	Interquartile range (IQR)	1.01935	0.535954	0.363726	2.85672

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation									
SZtb					Zpg				
Censoring information	Count				Censoring information	Count			
Uncensored value	21				Uncensored value	10			
Left censored value	12				Left censored value	1			
Distribution	Log normal				Distribution	Log normal			
Parameter estimates					Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI		Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Location	-3.4627	0.477822	-4.39922	-2.52619	Location	-0.005913	0.71992	-1.41693	1.4051
Scale	2.34744	0.380468	1.70857	3.22519	Scale	2.30151	0.483285	1.52501	3.47339
Log-likelihood	-18.676				Log-likelihood	-33.305			
Goodness-of-fit					Goodness-of-fit				
Anderson-Darling (adjusted)	1.832				Anderson-Darling (adjusted)	2.335			
Correlation coefficient	0.966				Correlation coefficient	0.958			
Characteristics of distribution					Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI		Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper				Lower	Upper
Mean	0.492893	0.403814	0.0989431	2.45539	Mean	14.0493	16.4147	1.42277	138.73
Standard deviation	7.73496	12.7591	0.305047	196.133	Standard deviation	198.055	429.793	2.81588	1.39×10^4
Median	0.0313449	0.0149773	0.012287	0.0799632	Median	0.994104	0.715676	0.242457	4.07595
First quartile (Q1)	0.0064348	0.0040499	0.0018742	0.0220932	First quartile (Q1)	0.210502	0.180952	0.0390432	1.13492
Third quartile (Q3)	0.152685	0.0669433	0.064654	0.360577	Third quartile (Q3)	4.6947	3.35313	1.15784	19.0357
Interquartile range (IQR)	0.14625	0.0646419	0.0614992	0.347795	Interquartile range (IQR)	4.4842	3.23448	1.09071	18.4358

Appendix 6. Uranium log-normal fit statistics by bedrock unit.—Continued

[CI, confidence interval; %, percent; *, fewer than five analyses were above the analytical reporting limit and the Minitab option to assume a common scale was used in the distribution fitting]

Bedrock unit abbreviation				
Zsg				
Censoring information	Count			
Uncensored value	23			
Left censored value	0			
Distribution	Log normal			
Parameter estimates				
Parameter	Estimate	Standard error	95% normal CI	
			Lower	Upper
Location	1.80621	0.268843	1.27929	2.33314
Scale	1.2783	0.201315	0.938816	1.74055
Log-likelihood	-81.557			
Goodness-of-fit				
Anderson-Darling (adjusted)	1.276			
Correlation coefficient	0.989			
Characteristics of distribution				
Descriptor	Estimate	Standard error	95% normal CI	
			Lower	Upper
Mean	13.7803	4.78246	6.97989	27.2062
Standard deviation	27.9866	16.9035	8.56714	91.4248
Median	6.08735	1.63654	3.59408	10.3102
First quartile (Q1)	2.57027	0.813775	1.38191	4.78056
Third quartile (Q3)	14.4171	4.10789	8.24788	25.2007
Interquartile range (IQR)	11.8468	3.68061	6.44387	21.7799

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