Idaho Department of Water Resources

Technical Summary

Arsenic Results From The Statewide Program, 1991-2001

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In this report, text that is highlighted in blue and underlined is linked to an Internet website. Text that is highlighted in *red, underlined, and italicized* is linked to another portion of text in this report.

1. INTRODUCTION

From 1991 through 2001, 1,691 wells and springs were sampled for arsenic as part of the Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program). The Statewide Program monitoring sites were selected using a stratified random process so that the data collected would be as unbiased as possible. Most of the Statewide Program sites have been sampled more than once during the time period from 1991 through 2001. The water uses of the monitoring sites in the Statewide Program include domestic, irrigation, commercial, public supply, stock, and a few other types.

This report summarizes the maximum arsenic values recorded at each site from 1991 through 2001. Statewide Program results indicate that arsenic is present in the ground water in many aquifers throughout Idaho. Arsenic concentrations in ground water are highest in southwestern and south central Idaho. Maximum arsenic concentrations at the Statewide Program sites ranged from 0.1 micrograms per Liter (µg/L) to 950 µg/L. Two Hundred and fifty-five Statewide Program sites (15 percent) had at least one ground water sample result from 1991 through 2001 where the arsenic concentration exceeded the revised maximum contaminant level (MCL) of 10 µg/L, which is equivalent to 10 parts per billion. The MCL is the standard set by the U.S. Environmental Protection Agency for public drinking water supplies.

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3. STATEWIDE PROGRAM OVERVIEW

The Idaho Department of Water Resources has administered the Statewide Program since 1990. About 1,700 ground water quality monitoring sites (existing wells and springs) have been sampled for a wide variety of parameters, such as common ions (calcium, magnesium, etc.), trace elements (iron, copper, arsenic, etc.), bacteria, nutrients, radioactivity, volatile organic compounds, and pesticides. The Statewide Program sites were selected using a stratified random process to eliminate as much bias as possible. Most of the monitoring sites (67 percent) are used for domestic purposes; other uses include irrigation, public supply, stock, commercial, industrial, and a few other types. Currently, most monitoring sites are scheduled to be sampled once every five years. About 100 sites, called Annual Sites, are sampled every year. The data from 1990 are not included in this report because the sites sampled that year were not selected subjectively and thus the data cannot be analyzed statistically with the later Statewide results.

The U.S. Geological Survey (USGS) has been a cooperative partner with IDWR in the Statewide Program since the project's beginning in 1990. The Idaho State Department of Agriculture (ISDA) has contributed funds for pesticide analyses throughout much of the program's life. The Idaho Department of Environmental Quality (IDEQ) had assisted with various technical elements related to the Statewide Program.

A more complete description of the Statewide Program can be found on IDWR's website: http://www.idwr.state.id.us/planpol/techserv/gwmon/statewide.htm.

4. WHAT IS ARSENIC?

4.1. Arsenic Occurrences

Arsenic is a trace element that occurs naturally as inorganic and organic forms in the earth's crust (ATSDR, 2001). Arsenic is present in some minerals such as orpiment and realgar (Figure 1). It is associate with felsic-volcanic rock types of intermediate and acidic composition, such as granite, rhyolite, pumice, and obsidian. Arsenic can also be in volcanic gases, and in geothermal water.

In most drinking water sources, the inorganic form of arsenic tends to be more predominant than the organic form, and is generally the more toxic of the two (Plumley, 2002). Arsenic can also be present in water and soil as the result of human activities; this type of occurrence is called anthropogenic.

Figure 1. Orpiment is a rare mineral that contains the element arsenic. Orpiment is often associated with the mineral realgar, which also contains arsenic.

4.2. Uses of Arsenic

Humans have used arsenic historically for many purposes, such as in paints, dyes, medicines, tickicides, pesticides, and for eliminating small animals (Total Environment Centre, 1998). Lead arsenic (an inorganic form of arsenic) was used widely as a pesticide in fruit orchards until about the end of World War II when its use was discontinued (Agcare, 2002). Inorganic arsenic compounds, such as chromated copper arsenic, are commonly used today to preserve wood products (home decking and landscaping materials) (EPA, 2002).

Organic arsenic compounds, such as cacodylic acid, disodium methylarsenate and monosodium methylarsenate, are used for pesticides, such as in the cotton industry (Report on Carcinogens). Organic arsenicals are fed to poultry and pigs to promote growth and to increase feeding efficiencies (Total Environment Centre, 1998). Arsenic has also been found in fertilizers (Washington Department of Ecology, 1998; Environmental News Service, 2001).

4.3. Arsenic Health Effects and History of Drinking Water Standards

People can ingest arsenic directly through certain foods (especially seafood), by smoking cigarettes, and from some drinking water supplies. People may also be exposed to arsenic from contact with certain products such as treated wood products, paints, dyes, metals, drugs, soaps, and semi-conductors. Agricultural applications, mining, and smelting may also be avenues of exposure.

Short-term (acute) exposures to arsenic can cause health problems, such as gastrointestinal effects, hematological effects, and peripheral neuropathy when arsenic concentrations are high (0.04 milligrams per kilograms per day (mg/kg/day)) (National Academy Press, 2001). Long-term (chronic) exposure to arsenic in concentrations lower than 0.04 mg/kg/day can cause an increased occurrence of other health effects and problems such as:

- *Cancerous effects:* skin, bladder, lung, kidney, nasal passages, liver, and prostate cancer; and

- *Non-cancerous effects:* cardiovascular, pulmonary, immunological, neurological, and endocrine (*e.g.*, diabetes) effects (EPA, 2001)

The MCL for arsenic in ground water for public water systems was originally established at 50 µg/L in 1943 by the U.S. Public Health Service. After much evaluation, the EPA revised the MCL to 10 µg/L in October, 2001 (EPA Newsroom). The new rule became effective in February, 2002. Public water supplies have until 2006 to comply with the new MCL. According to the EPA, the new MCL addresses the long-term, chronic effects of exposure to low concentrations of inorganic arsenic in drinking water (EPA, 2001).

4.4. Arsenic Geochemistry

The presence of naturally-occurring arsenic in ground water is affected by at least five factors: 1) existence of one or more *arsenic sources* in the flowsystem, 2) *geochemical processes* throughout the flowsystem, 3) *geochemical conditions* and changes along the flowsystem, 4) *bacterial activity*, and 5) existence of two major *arsenic species*. More than one factor may be present at points along the flowsystem, and it appears that these factors are not mutually exclusive, but probably exert effects on each other.

Naturally-occurring arsenic sources, which were discussed in the Section 4.1, include rock types (felsic-volcanic rocks of acidic and intermediate composition), certain minerals (arsenopyrite and cinnabar), and iron oxide. Welch et al. (2001) believes that iron oxide is the most common reason for arsenic releases into the ground waters of the United States. The relationship between iron oxide and arsenic is discussed later in this section.

Geochemical processes include adsorption (uptake), desorption (release), solid-phase precipitation, and dissolution. The USGS described the importance of these processes to the arsenic occurrences in the ground water of the Willamette Basin, Oregon (Hinkle and Polette, 1999). These four processes are driven by the chemistry of the ground water that can cause reactions with the surrounding aquifer materials and with the other ions in solution. Dissolved arsenic concentrations can be very low in the ground water because: 1) arsenic is not present in the flowsystem due to insignificant sources of arsenic both upgradient in the flowsystem, or locally in the aquifer, or 2) arsenic is present in the flowsystem but it is bonded to the aquifer materials (sand, clay, rock, etc.), or 3) arsenic is present in the flowsystem but it is bonded to solid particles that are moving through the aquifer. However, arsenic concentrations can be high in ground water if: 1) one or more arsenic sources exist, and 2) geochemical process and conditions are such that bonded arsenic can be released from the aquifer materials or solid particles.

Geochemical conditions, such as *pH*, *oxidation*-*reduction*, *associated or competing ions*, and *evaporatic environments* have significant effects on arsenic concentrations in ground water. These conditions influence how much arsenic is dissolved or precipitated into the water, and how much is bonded to the aquifer materials or to the solid particles in the water.

A geochemical parameter that can affect both adsorption and desorption of arsenic is pH. At lower pH levels (acidic conditions), arsenic can be adsorbed onto the aquifer materials. Therefore, low pH ground waters typically will have low dissolved arsenic concentrations. Generally, ground waters have lower pH levels (less than seven) in the upstream portions of their flowpaths, i.e, where they are nearer to recharge sources. At higher pH ranges (alkaline conditions), arsenic is desorbed, or released into the ground water, and the concentration of dissolved arsenic rises. Ground waters typically have higher pH values in the downstream parts of the flowpaths. Brown and Chute (2000) found that high arsenic concentrations in some ground water in Connecticut were associated with high pH levels (> 7.7). The USGS (2001) reported that arsenic and pH appeared to be related in some ground waters of southeast Michigan; however, they noted that the relationship was complex and not completely understood.

Oxidizing conditions often prevail in the upstream parts of the flowpaths. Oxidizing conditions, coupled with low pH values, can result in low dissolved arsenic concentrations in the ground water. However, oxidizing conditions can be also responsible for the release of arsenic that is bound to pyrite. This process is debated as a possible reason for high arsenic concentrations in the ground waters of Bangladesh that are currently threatening the health of millions of people (Tsushima, date unknown). In this situation, water level declines may have exposed pyrite-rich soils to oxygen causing oxidation and the subsequent release of arsenic.

Reducing conditions can develop as ground water moves along flowpaths. Reducing conditions can cause arsenic to be desorbed from aquifer materials and from solid particles passing through the aquifer. Thus, dissolved arsenic concentrations can be higher in the downstream parts of flowpaths if arsenic is present in the system, and if reducing conditions and/or other geochemical conditions are optimal for desorption.

Oxidation-reduction conditions and pH can work in conjunction with iron oxide to affect the concentration of arsenic in ground water. This can take place during the depositional, and post-depositional phases in fluvial/deltaic environments. Under certain conditions, iron oxide will coat sand, silt, and clay grains as they are carried along the fluvial/deltaic system and deposited. If the pH in water is acidic or near normal, and if there is an arsenic source, the arsenic can be adsorbed onto the iron oxide coatings. In the post depositional phase, the geochemical conditions in the sedimentary deposits may change resulting in reducing environments with associated high pH values. The reducing/high pH conditions can cause arsenic to be desorbed into the ground water system. Some scientists believe that this process may be responsible for the high arsenic concentrations in the ground water of Bangladesh (Nickson et al., 1998). Perhaps both oxidizing and reducing conditions (in different parts of the aquifer systems) are contributors to the arsenic problems in Bangladesh ground water. The Bangladesh situation demonstrates the complexity of arsenic geochemistry.

Associated and competing ions and minerals, such as sulfate and fluoride, can affect arsenic concentrations in ground water. In Michigan, the USGS (2001) noted that arsenic concentrations appeared to be linked to sulfate, but the relationship is complex and needs more study. Arsenic is also associated with high sulfate, fluoride and TDS in some ground waters (Owen-Joyce and Bell, date unknown). However, in Ghana, Africa, arsenic is associated with high TDS, but has no correlation with sulfate (Norman et al., date unknown).

Evaporitic conditions can result in high concentrations of arsenic in ground water (Welch et al., 2000). Some basins in the western United States (U.S.) have closed hydrologic conditions and evaporation rates exceed precipitation. Welch et al. (2000) noted that these conditions can lead to elevated arsenic levels. Welch et al. (2000) also recognized that the saline ground waters of these basins have high pH values, which can limit the adsorption of arsenic. The combination of these conditions can lead to moderate or high arsenic concentrations in ground water.

Bacteria in ground water may also play an important role in arsenic release. In Bangladesh, it is postulated that bacteria microbes steal oxygen from the iron oxide coatings on the grains in order to process nutrients. This action results in the release of iron and arsenic elements into the ground water (McArthur, 2000). Saikat et al., (date unknown) present another possible bacteria/arsenic relationship in which bacteria in the sediments of Bangladesh may cause transformation of arsenic species, thus affecting mobilization and immobilization of arsenic compounds. Saikat et al., (date unknown) noted that redox conditions play an important role in this process.

The existence of two arsenic species, arsenate and arsenite, adds an additional complication to understanding the element's geochemistry. Arsenate is the predominant species when conditions are oxidizing; arsenite prevails under reducing conditions (Hinkle and Polette, 1999). Arsenite is the more toxic of the two forms and harder to remove from water than arsenate (U.S. EPA, 1988; Hinkle and Polette, 1999). The drinking water arsenic rule addresses total arsenic; it does not distinguish between the species.

5. ARSENIC OCCURRENCE IN THE GROUND WATER OF THE UNITED STATES

5.1. Nationwide

Focazio et al. (1999) completed a retrospective analysis of arsenic in the ground water supplies in the U.S. Welch et al. (1999), Welch et al. (2000) and Welch, et al. (2001) discussed the occurrence and geochemistry of arsenic in the ground water of the U.S. The work presented in the Welch et al. (2000, 2001) publications is the summary of 30,000 arsenic analyses in the U.S; the main points of these reports are:

1. About 50 percent of the 30,000 arsenic results were less than 1 µg/L.
2. About 10 percent of the 30,000 arsenic results exceeded the new MCL of 10 µg/L.
3. Arsenic in ground water may be related to anthropogenic sources, or may be naturally occurring.
4. Arsenic concentrations greater than 10 µg/L were more common in the western U.S. than in the eastern U.S.
5. Iron oxide appears to be strongly associated with the arsenic concentrations greater than 10 µg/L.
6. Alkaline ground waters (pH >8) that are commonly associated with felsic-volcanic rocks (granite, rhyolite, pumice, and obsidian) often contain high arsenic concentrations.
7. High arsenic concentrations are associated with geothermal water and with evaporitic conditions, both of which are common in the western U.S.
8. Sulfide minerals can be either a source or a sink for arsenic in ground water depending on the geochemical conditions.

The U.S. Geological Survey (USGS) reported arsenic occurrences in ground water for places in the U.S. such as Michigan, New England (USGS NAWQA site), and the Willamette Valley of Oregon (Hinkle and Polette, 1999). Spencer (2000) discussed arsenic in ground waters of Arizona. The Minnesota Pollution Control Agency (1998) summarized arsenic in ground water data for their state. Brown and Chute (2001) presented arsenic results for ground water in Connecticut. The Geological Society of America's annual meeting in 2001 conducted a session on natural arsenic in ground water. Goldblatt et al. (1963) discussed the high arsenic concentrations in the ground water of Lane County, Oregon, and Nadakavukaren et al. (1984) analyzed seasonal variability of arsenic in the well water of Lane County, Oregon.

5.2. Western United States

Research conducted by Welch et al. (1988) showed that arsenic in the western U.S. is often naturally occurring. Welch et al. (1988) noted that arsenic concentrations in ground water are affected by a variety of geochemical processes. A couple important observations made by Welch et al. (1998) related to arsenic concentrations in ground waters of the western U.S. are: 1) high values are most commonly associated with volcanic rocks of acidic to intermediate composition, such as granite, rhyolite, pumice, and obsidian, and with the sediments derived from these rocks, 2) adsorption and precipitation-dissolution are probably the main geochemical controls, 3) the presence of iron oxide may result in high arsenic, and 4) arsenic may be elevated when evaporitic conditions prevail. Welch et al. (1988) also noted that high arsenic concentrations can be associated with geothermal water, and that shallow ground water affected by agricultural irrigation can have arsenic concentrations greater than 1,000 μg/L.

6. ARSENIC IN IDAHO'S GROUND WATER

6.1. Arsenic Data and Studies

Ground water samples are analyzed for arsenic in conjunction with Idaho's Statewide Program. A total of 4,454 individual arsenic results are available for 1,691 Statewide Program sites sampled during the time period from 1991 through 2001.

The USGS has collected arsenic samples from both geothermal (> 85 degrees Fahrenheit) and non-geothermal ground and surface waters in Idaho. Arsenic data stored in the USGS database system can be obtained by accessing their National Water Information System website (USGS NWISweb); some of the data in the USGS system will be the same as the Statewide Program data available at IDWR.

The Idaho Department of Environmental Quality (IDEQ) administers the Public Drinking Water Program for the state. Arsenic is a regulated contaminant for the approximately 745 community water systems (those that serve at least 25 residents or have 15 or more year-round service connections. IDEQ maintains a compliance database containing over 4,500 arsenic results that have been collected since January, 1991. Not all of the public water systems in Idaho are required to test for arsenic.

Howarth (1995) discussed the arsenic results from ground water quality testing conducted in southern Washington County. Fourteen domestic wells and one surface water location were sampled for arsenic in response to unusually high arsenic detections at two Statewide Program sites (240 and 950 µg/L). Arsenic for the 15 monitoring sites in Washington County ranged from less than the laboratory reporting limit of 10 µg/L to 920 µg/L. Thirteen of the 15 sites had arsenic concentrations that exceeded the new MCL. Howarth (1995) believed that the arsenic in Washington County is naturally occurring. Howarth (1995) noted that the higher arsenic concentrations were from the deeper water producing zones, and suggested that the clay-rich sediments of the Glenns Ferry Formation (a member of the Idaho Group) are a geologic control for the arsenic in the ground water of this area. Howarth (1995) also observed a relationship between high arsenic concentrations and elevated sodium levels. Goldblatt (1963) noted that ground waters enriched in sodium may be associated with clay deposits which can provide relatively high ion exchange capacity. This geochemical situation could remove calcium and enrich sodium; a condition similar to that inferred by Howarth (1995).

Before using the arsenic data listed above, it is important to know how it was collected. For example, some arsenic samples are collected after the water is filtered to remove solids, and some arsenic samples are collected unfiltered. In the case of public water systems, some samples may be a blend of water from more than one source. Finally, the analytical methods and reporting limits may vary between laboratories. Differences in collection methods, water systems, laboratory analytical methods, and laboratory reporting limits can introduce uncertainty that can complicate the interpretation of the arsenic results.

6.2. Natural or Anthropogenic Sources of Arsenic In Idaho's Ground Water?

Geographic and hydrogeologic distributions of arsenic in the ground waters of Idaho suggest natural sources. Most of the high arsenic concentrations occur in the southwestern part of the state where felsic-volcanic rocks (granite and rhyolite) and the sediments derived from them are common.

Inorganic arsenic is a possible source for arsenic in ground water since it was used in orchards until the end of World War II. Organic arsenic is now used in some agriculture operations. Presently, I am unaware of any arsenic data for Idaho that would indicate, or even suggest, that the arsenic in the ground water of the state is related to agricultural practices.

Having made the point for the arsenic in Idaho’s ground water being primarily associated with natural sources, it must be noted that agriculture practices have been, and still are, common in many of the areas of southwestern and south central Idaho where arsenic concentrations are high. The influence of arsenic used in agriculture practices on ground water quality is not well known. Therefore, the arsenic detected in the ground water of these areas of Idaho is most likely naturally occurring, but could be associated with human activities. In 2002, the IDWR is collecting samples for arsenic speciation at some of the Statewide Program sites in hopes that the results will be useful for determining arsenic sources as well as the distribution of arsenic species in the ground water.

7. ARSENIC RESULTS FROM THE STATEWIDE PROGRAM

7.1. General Results and Analyses

Ground water samples from the Statewide Program have been analyzed for arsenic since 1990. Arsenic samples are filtered through a 0.45 micron filter during field collection to remove solids. Thus, the laboratory measures the amount of dissolved arsenic in the water as opposed to the amount of total (dissolved plus suspended) arsenic in the water. Most of the Statewide Program sites have more than one arsenic result. In this report, the maximum arsenic concentration for each site is reported for the sampling period from 1991 through 2001. The data from 1990 were not used because the official network design was not developed and employed until 1991.

Maximum arsenic concentrations for the 1,691 Statewide Program sites ranged from 0.1 µg/L to 950 µg/L, with the median being 2 µg/L. Two hundred and fifty-five Statewide Program sites (15 percent) had at least one ground water sample result where the arsenic concentration exceeded the MCL of 10 µg/L. Arsenic concentrations in ground water are higher in certain parts of Idaho. Clearly, the ground water in southwest and south central Idaho has the highest density of arsenic concentrations over the MCL (*Figure 2*).

Spearman's rho correlation analyses were conducted on Statewide Program data to check for relationships between arsenic and iron, pH, sodium, sulfate, TDS, and well depth. Results from the Spearman's rho tests indicated that sodium, sulfate, and TDS had the highest *correlation coefficients*[1] with arsenic (rho = 0.55, 0.50, and 0.45, respectively). PH and iron had surprisingly low correlation coefficients (rho = 0.15 and –0.12, respectively) especially in light of the strong relationships that have been recognized in other arsenic studies as discussed in Sections 4.4 and 5.1. Additionally, arsenic concentrations did not correlate with well depth (rho = 0.03).

7.2. Subareas and Reports Areas

A diverse system of sedimentary and volcanic aquifers exists in Idaho. Meaningful analyses of the ground water quality data for the state can be accomplished by grouping similar aquifers. In the early phase of the Statewide Program, the 70 ground water basins identified by Graham and Campbell (1981) for Idaho were grouped into 22 hydrogeologic subareas to facilitate stratified random sampling (Neely, 1994). The subareas were created so that the hydrogeologic conditions within each subarea were as homogeneous as possible. In 1999, the 22 subareas were grouped into seven Reporting Areas for a comprehensive nitrate summary. The hydrogeology in each Reporting Area is less homogeneous than individual subareas; however, the conditions within each Reporting Area have enough similarities to allow for meaningful interpretations and reporting.

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[1] Correlation coefficients can range from –1 to 1 using the Spearman's rho test. Correlation coefficients near zero indicate no correlation between the two variables tested. Positive correlation coefficients indicate that as one variable increases, the other variable increases too. Negative correlation coefficients indicate that as one variable increases, the other variable decreases.

Figure 3 shows the seven Reporting Areas that were used for analyzing the Statewide arsenic data. Median arsenic values for the Reporting Areas ranged from less than 1 µg/L to 6 µg/L (*Figure 4*). The Southwest, South Central, and West Central Reporting Areas had the highest percentage of sites with arsenic concentrations over the MCL (*Figure 5*).

Additional statistical analyses were conducted for the three reporting areas that had the highest median arsenic values and the highest percentage of sites with arsenic over 10 µg/L (West Central, Southwest, and South Central). Spearman rho results for these reporting areas indicate that sodium, sulfate and TDS had the strongest relationships with arsenic (Table 1). Four out of six coefficients were highest (i.e., fartherest away from zero) for the West Central Reporting Area.

Table 1. Spearman's rho test results for arsenic and six water quality variable, for three reporting areas.

	Iron	**PH**	**Sodium**	**Sulfate**	**TDS**	**Well Depth**
West Central RA	-0.25	0.05	0.58	0.58	0.65	-0.14
Southwest RA	-0.02	-0.02	0.38	0.32	0.45	-0.25
South Central RA	-0.09	0.14	0.51	0.55	0.42	0.16

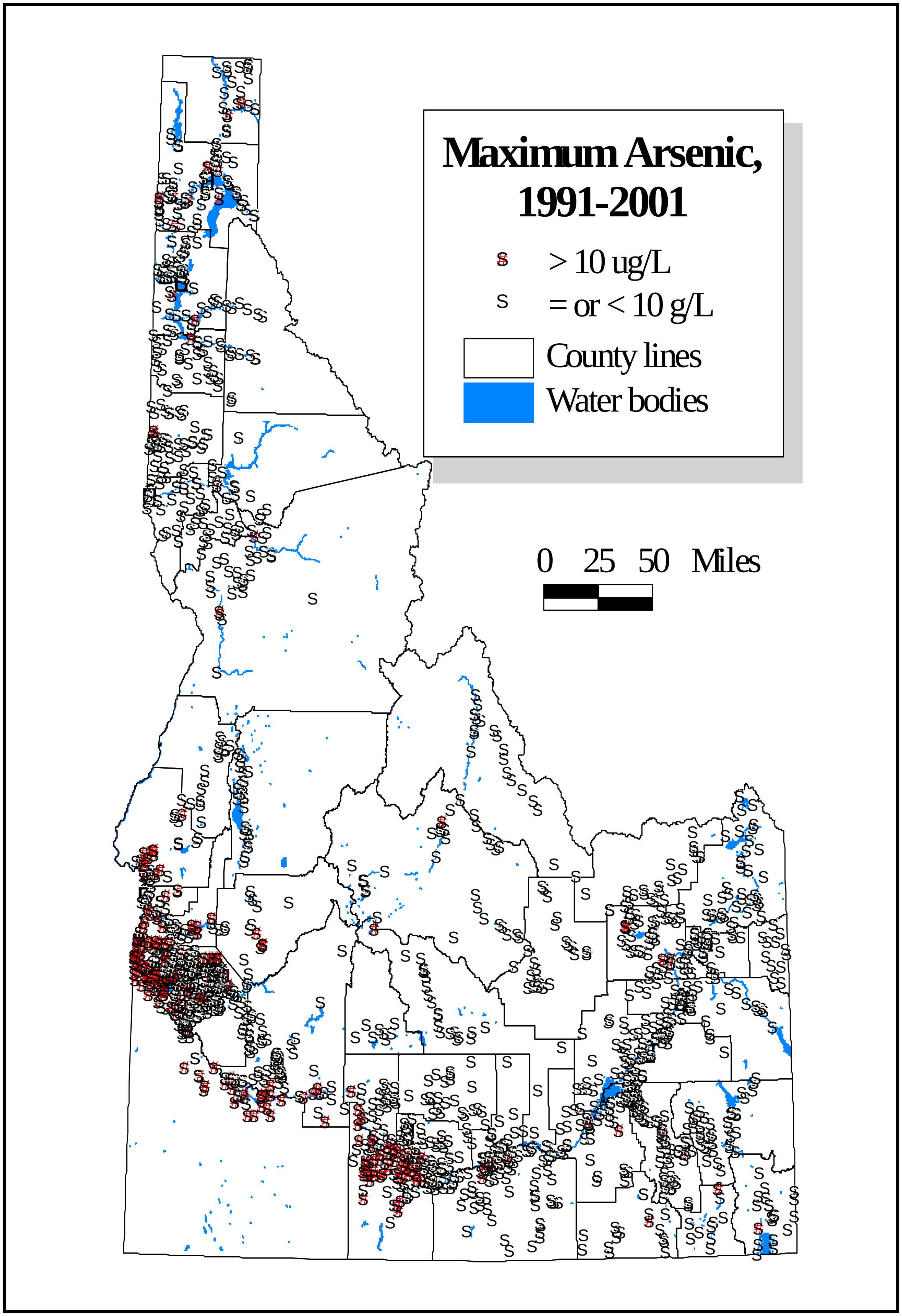


Figure 2. Arsenic in ground water, Statewide Program. Results are based on the maximum arsenic concentration at each site for the time period from 1991-2001.

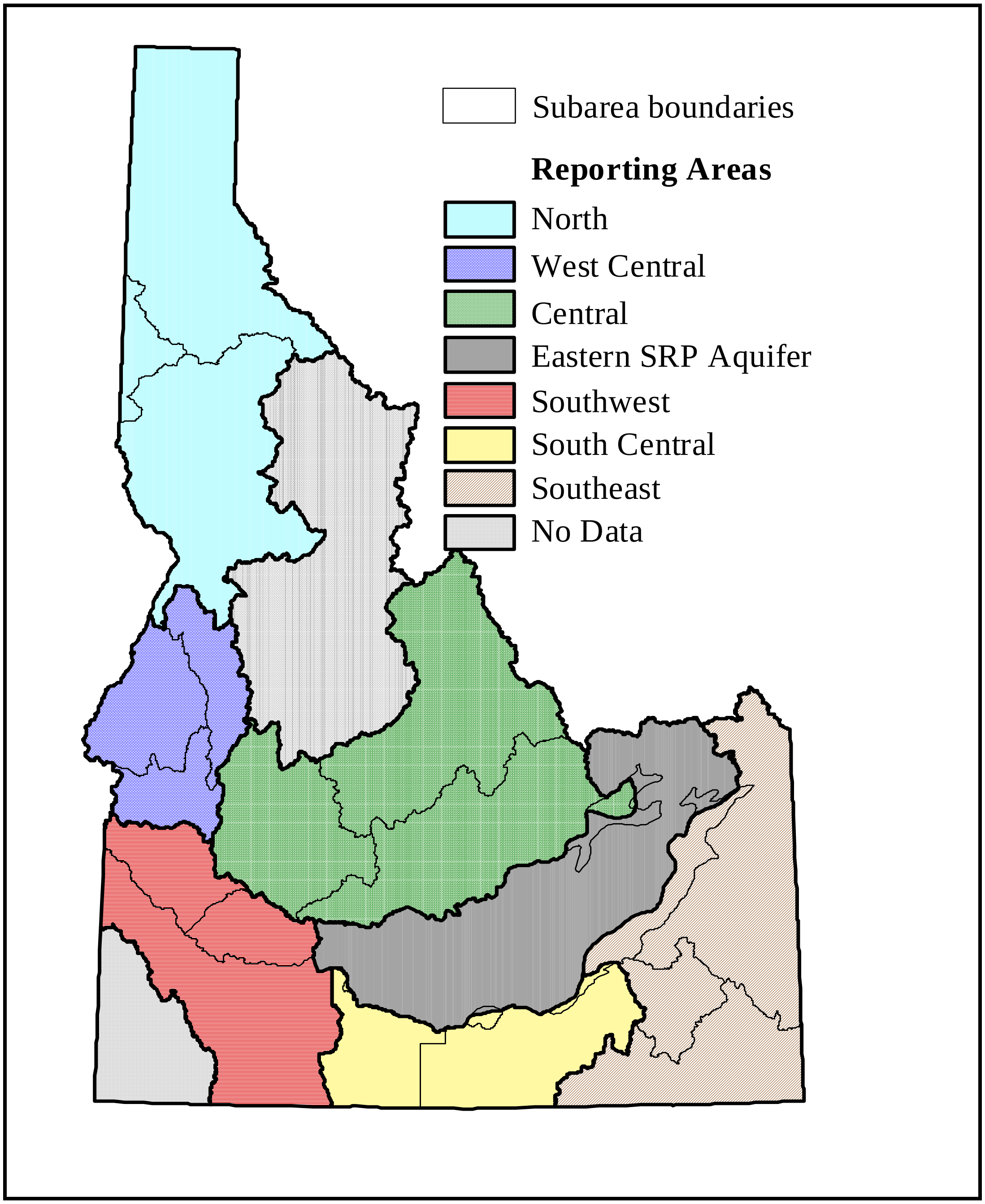


Figure 3. Reporting Areas for the Statewide Program arsenic data collected from 1991 through 2001.

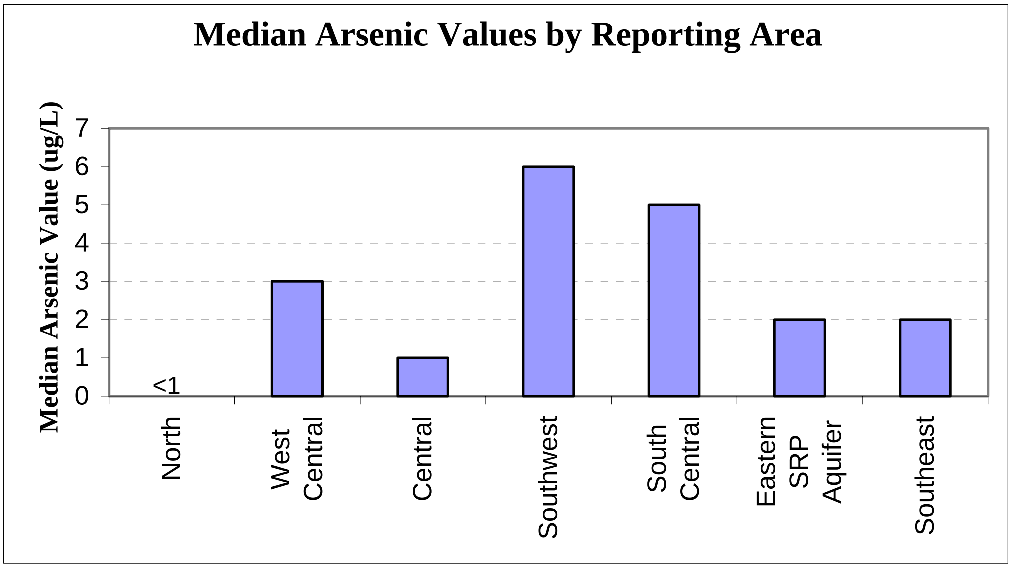


Figure 4. Median arsenic values for the seven Reporting Areas in the Statewide Program. Median values are based on the maximum value at each site during the time period from 1991 through 2001.

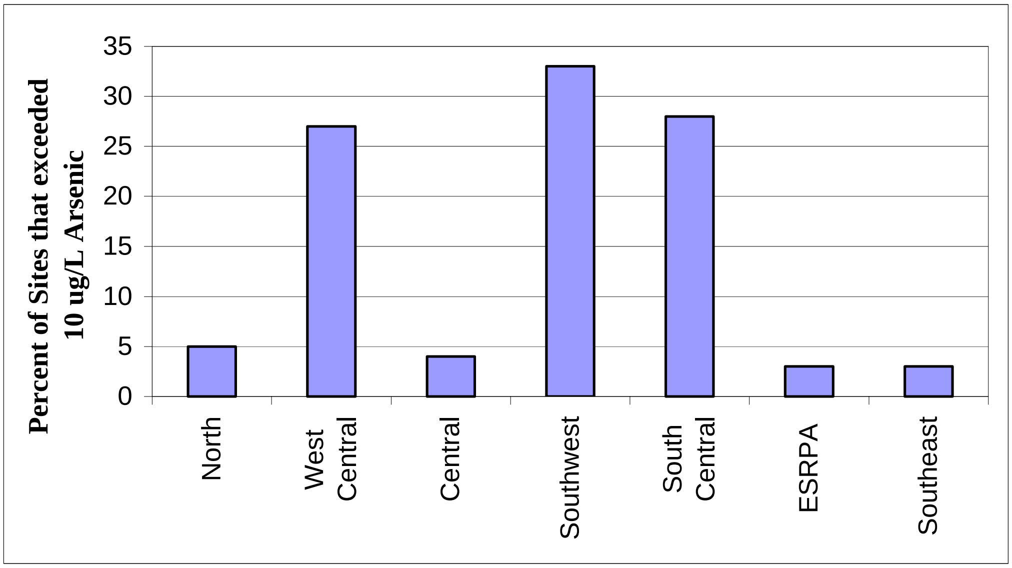
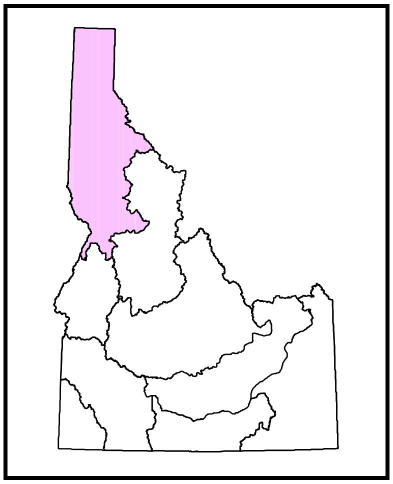


Figure 5. Percent of sites by Reporting Area where the maximum arsenic concentration was greater than the MCL of 10 µg/L. Results are based on sampling conducted during the time period from 1991 through 2001.

Click on the Reporting Area of Interest

North
West Central
Central
Southwest
South Central
Eastern Snake River Plain Aquifer
Southeast

7.3. North Reporting Area



The North Reporting area covers a large part of northern Idaho, including the Clearwater Plateau in the southern part of this area. Dryland agriculture and urban land uses are common in this region. Also, large areas in the North Reporting Area are covered by forests.

Alluvial and basalt aquifers are common in the North Reporting Area. Alluvial aquifers, which occur in the northern part of this reporting area, consist of cobbles, sand, gravel, silt, and clay. These alluvial aquifers were formed when sediments filled river valleys, or were deposited by the Lake Missoula flood, as in the case of the Rathdrum Prairie aquifer in Kootenai County. The Columbia River Basalt is found in the southern part of this reporting area in the Moscow/Lewiston Basins and under the Clearwater Plateau.

There are 312 Statewide Program sites in the North Reporting Area with arsenic results. *Well depths*[1] for the 301 North Reporting Area sites with well depth information range from 30 to 1,458 feet with an average well depth of 206 feet. Depth to static water levels ranged from -20 to 510 feet below the measuring points.

Maximum arsenic concentrations in the North Reporting Area ranged from 0.1 to 86 µg/L, with a median value of less than 1 µg/L. Seventeen sites (5%) had a maximum arsenic concentration that exceeded the MCL of 10 µg/L for the years 1991 – 2001 (*Figure 6*). Most

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[1] The well depth does not imply that the water is being withdrawn from this depth. In many cases, wells are perforated or screened at varying depths and sometimes in multiple aquifers. Pump settings can also affect where the water is drawn from and how much mixing of different aquifer waters is occurring.

of the sites with arsenic over the MCL were in the northern part of the reporting area. The highest arsenic concentration (86 µg/L) was from a well in Idaho County.

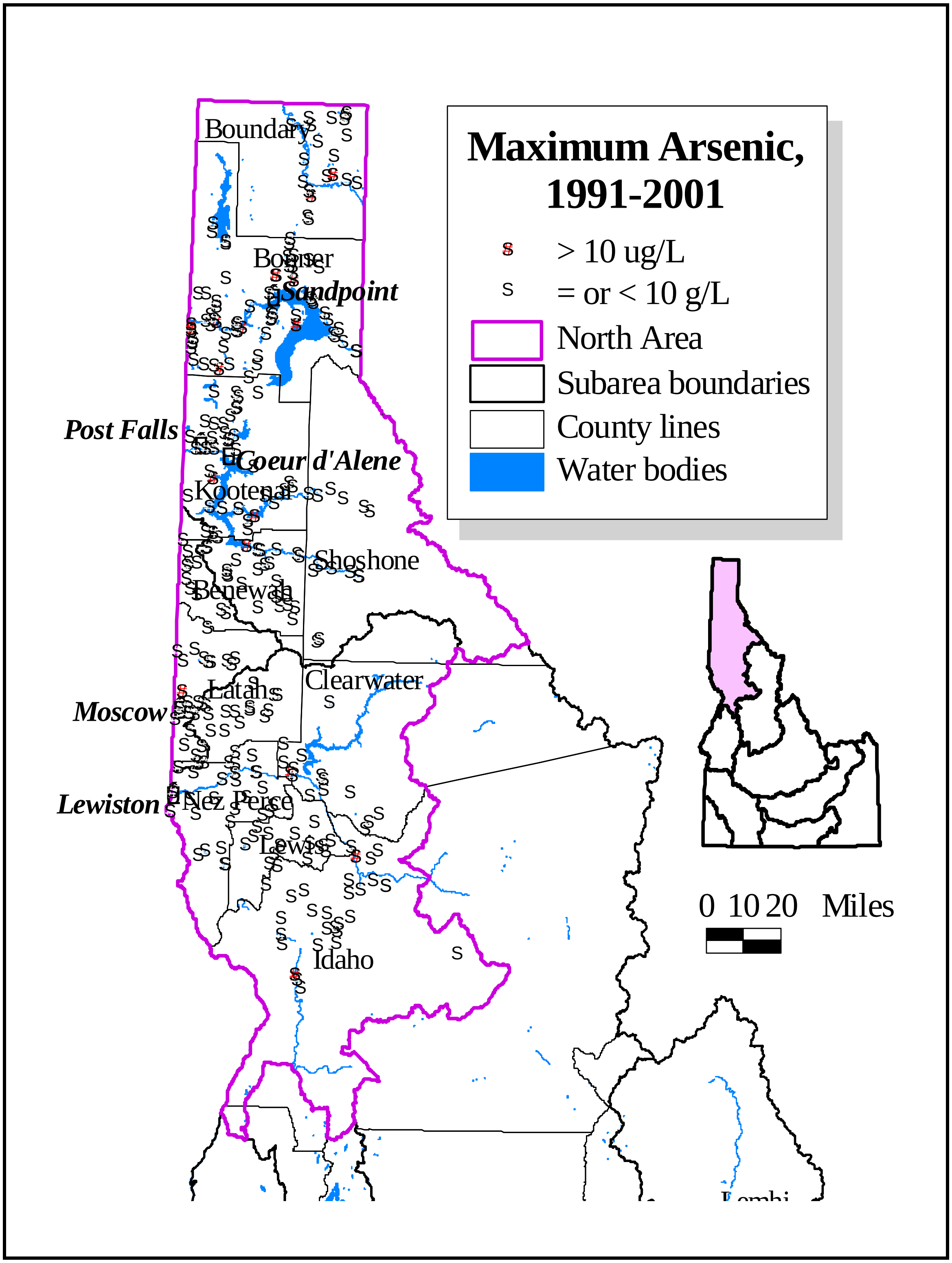
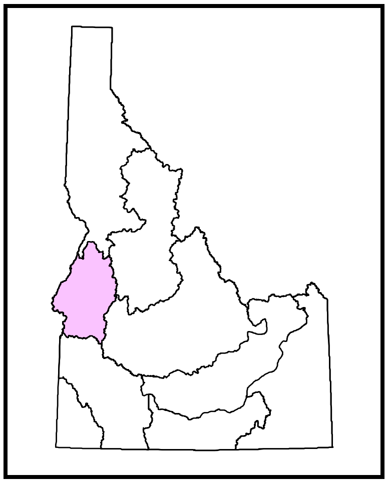


Figure 6. Arsenic values for Statewide Program sites in the North Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.4. West Central Reporting Area



The West Central Reporting Area covers the area south of the Clearwater Plateau and west of the Idaho Batholith, and the Weiser and Payette River Valleys. Dryland agriculture, urban and domestic land uses are common in this sparsely populated region. Also, some areas in the West Central Reporting Area are covered by forests.

Aquifers in the northern part of the West Central Reporting Area are found mainly in the valley-fill sediments and in the Columbia River Basalt. A few wells are completed in the granite of the Idaho Batholith.

There are 120 Statewide Program sites in the West Central Reporting Area with arsenic results. Well depths for the 119 West Central Reporting Area sites with well depth information range from 10 to 610 feet with an average well depth of 112 feet. Depth to static water levels ranged from 0 to 178 feet below the measuring points.

Maximum arsenic concentrations in the West Central Reporting Area ranged from 0.1 to 950 µg/L, with a median value of 3 µg/L. Thirty-two sites (27%) in the West Central Reporting Area had a maximum arsenic concentration that exceeded the MCL of 10 µg/L for the years 1991 – 2001. Most of the higher concentrations were found in the southern part of this reporting area (*Figure 7*). The maximum concentration was 950 µg/L in a well near Weiser (Washington County).

High arsenic concentrations in this reporting area are probably related to the common occurrence of the granitic-rich sediments in the Weiser and Lower Payette River Valley (Gem, Payette, and Washington Counties). In Washington County, Howarth (1995) noted that the high arsenic values from 14 wells tested as part of a regional study in response to detections at two Statewide Program wells were associated with the clay-rich sediments of the Glenns Ferry Formation.

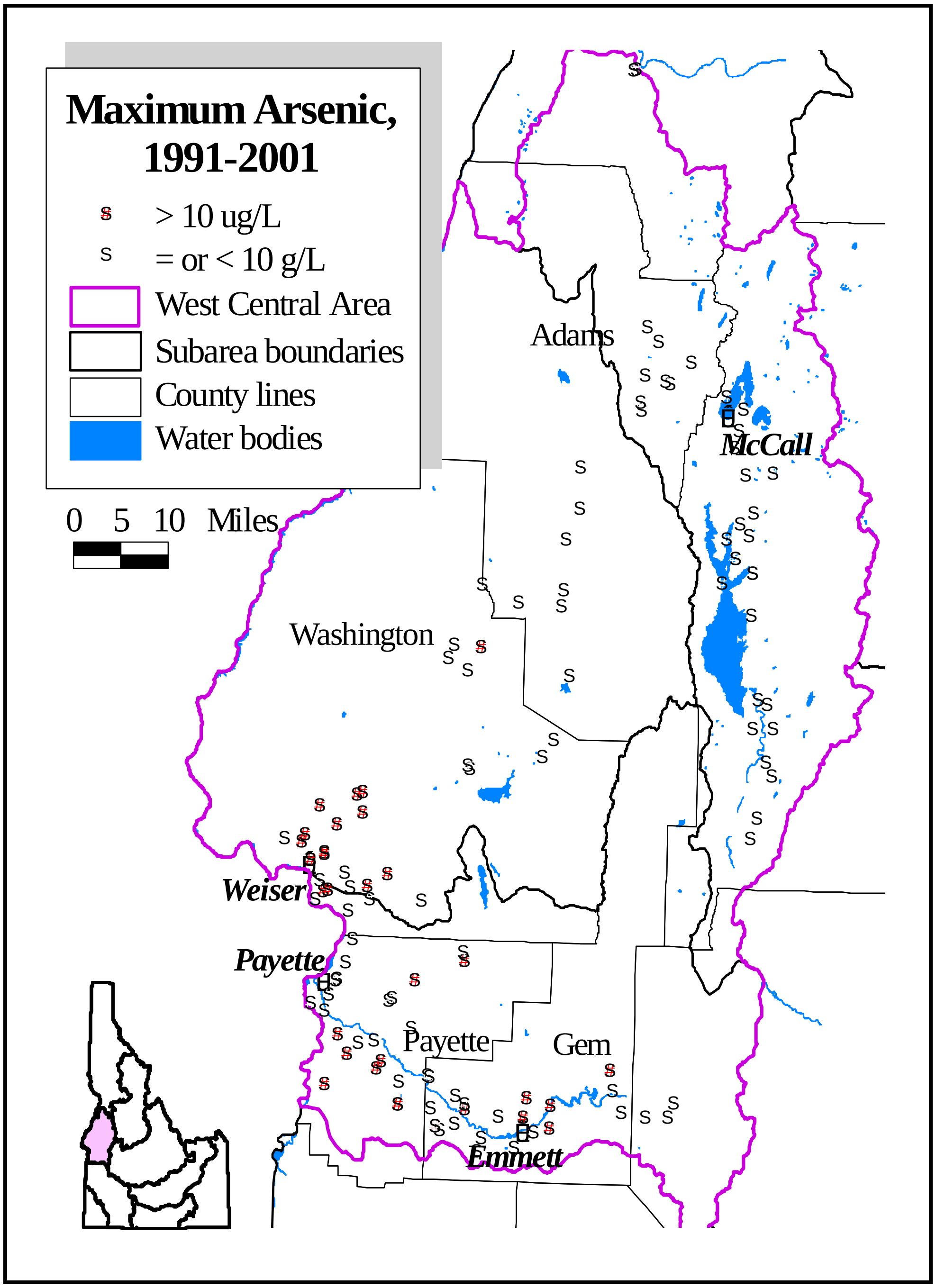
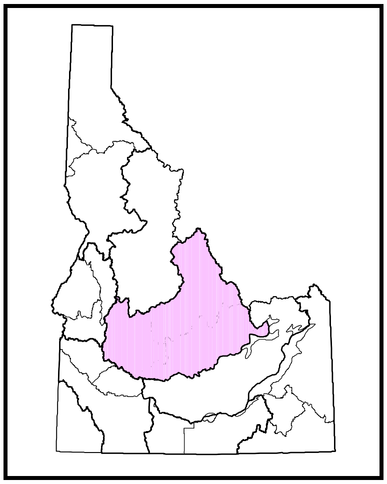


Figure 7. Arsenic values for Statewide Program sites in the West Central Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.5. Central Reporting Area



The Central Reporting Area encompasses the mountain ranges and intermountain river valleys in central Idaho that are north of the Snake River Plain; this reporting area also includes the Camas Prairie. Agriculture, urban, and rangeland are common land uses in this region. Also, large areas in the Central Reporting Area are covered by forests.

Aquifers in the Central Reporting Area are found in alluvial sediments that filled in the intermountain river valleys and that underlie part of the Camas Prairie. Granite of the Idaho Batholith, and the basalt found beneath a portion of the Camas Prairie are minor aquifers.

There are 115 Statewide Program sites in the Central Reporting Area with arsenic results. Well depths for the 112 Central Reporting Area sites with well depth information range from 30 to 1,020 feet with an average well depth of 127 feet. Depth to static water levels ranged from -18 to 250 feet below the measuring points.

Maximum arsenic concentrations in the Central Reporting Area ranged from 0.1 to 45 µg/L, with a median value of 1 µg/L. Five sites (4%) in the Central Reporting Area had maximum arsenic concentrations that exceeded the MCL of 10 µg/L for the years 1991 – 2001 (*Figure 8*). The maximum concentration was 45 µg/L in a well in Boise County.

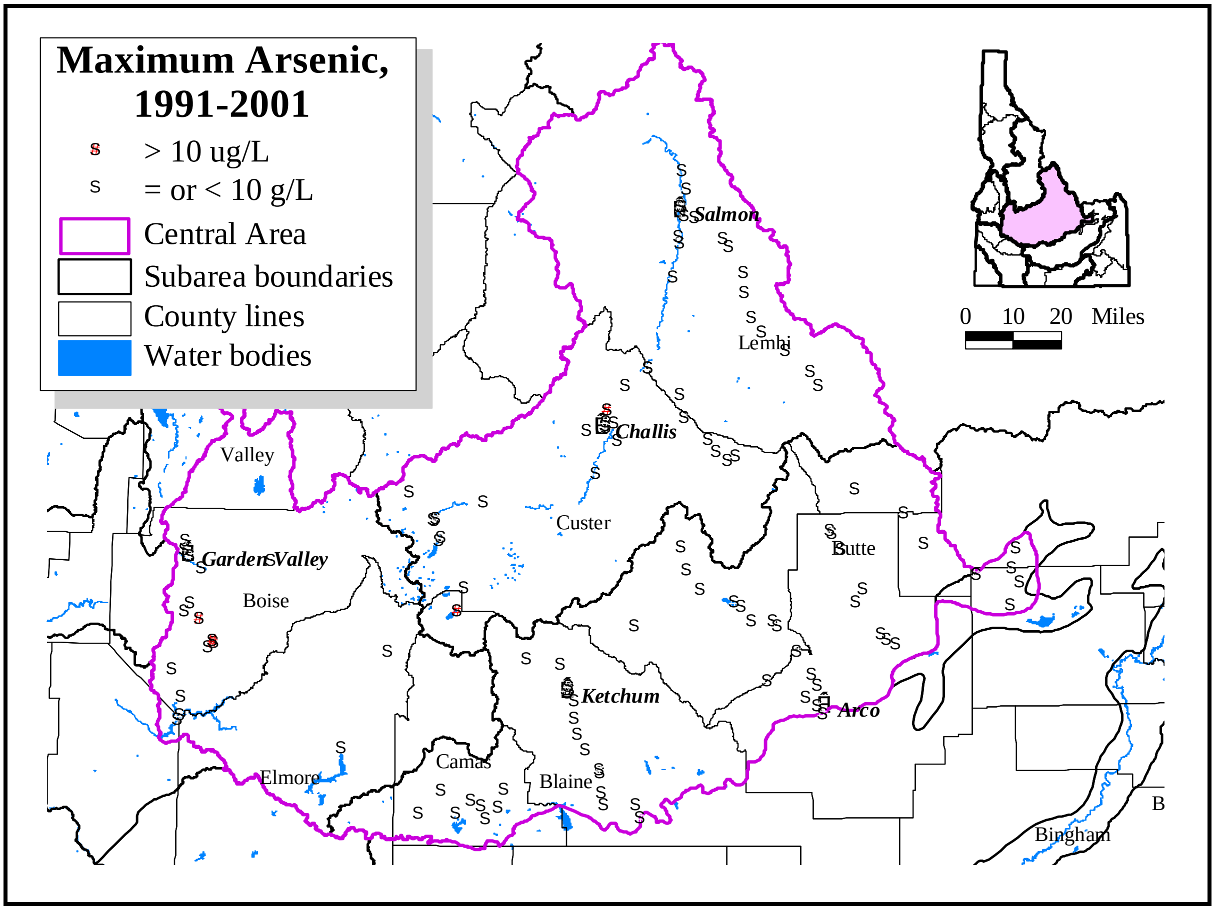
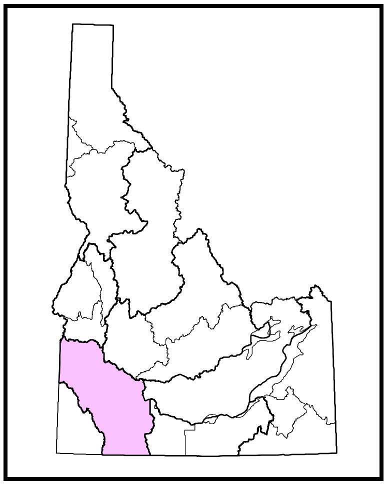


Figure 8. Arsenic values for Statewide Program sites in the Central Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.6. Southwest Reporting Area



The Southwest Reporting Area is located in the southwestern corner of Idaho. This reporting area is in the western half of the Snake River Basin, which is a complex drainage system covering over 72,000 square miles across five states (Johnson et al., 1998). The Snake River Plain, which is a large arcuate structure in the center of the Snake River Basin, extends from near the Idaho/Montana/Wyoming borders in the east, southward through central Idaho, and then to the northwest into Oregon. In addition to the Snake River, the Southwest Region includes the lower reaches of the Boise River. Irrigated agriculture, urban, industrial, rangeland, and animal feeding operations are common land uses in this region.

The geology in the Southwest Reporting Area includes a rich history of volcanism, ancient lakes, floods, depositional basins, and tectonic activity. Aquifer systems in this reporting area are highly variable due to complex geologic settings. Geologic units and formations in the reporting area include: Idaho Group, Glenns Ferry, Bruneau, and unconsolidated alluvial sediments. Aquifers in Elmore and Owyhee Counties occur mostly in volcanic rocks, although there are some sedimentary units. Aquifers in the Treasure Valley (Ada and Canyon Counties) are mainly in sedimentary deposits that vary with depth (*see discussion below*).

There are 378 Statewide Program sites in the Southwest Reporting Area with arsenic results. Well depths for the 375 Southwest Reporting Area sites with well depth information range from 19 to 1,250 feet with an average well depth of 269 feet. Depth to static water levels ranged from -25 to 687 feet below the measuring points.

Maximum arsenic concentrations in the Southwest Reporting Area ranged from 0.3 to 180 µg/L, with a median value of 6 µg/L. One hundred twenty-three sites (33%) in the Southwest Reporting Area had maximum arsenic concentrations that exceeded the MCL of 10 µg/L for the years 1991 – 2001. Clustering of sites with arsenic over the MCL was apparent in Canyon, Owyhee, and northern Ada Counites (*Figure 9*). The highest value (180 µg/L) was from a well in northwest Owyhee County.

High arsenic concentrations in this reporting area are probably related to the common occurrence of rhyolitic rocks in Owyhee County, and to the granitic-rich sediments deposited in the Treasure Valley (Ada and Canyon Counties) as the result of erosion from the Idaho Batholith.

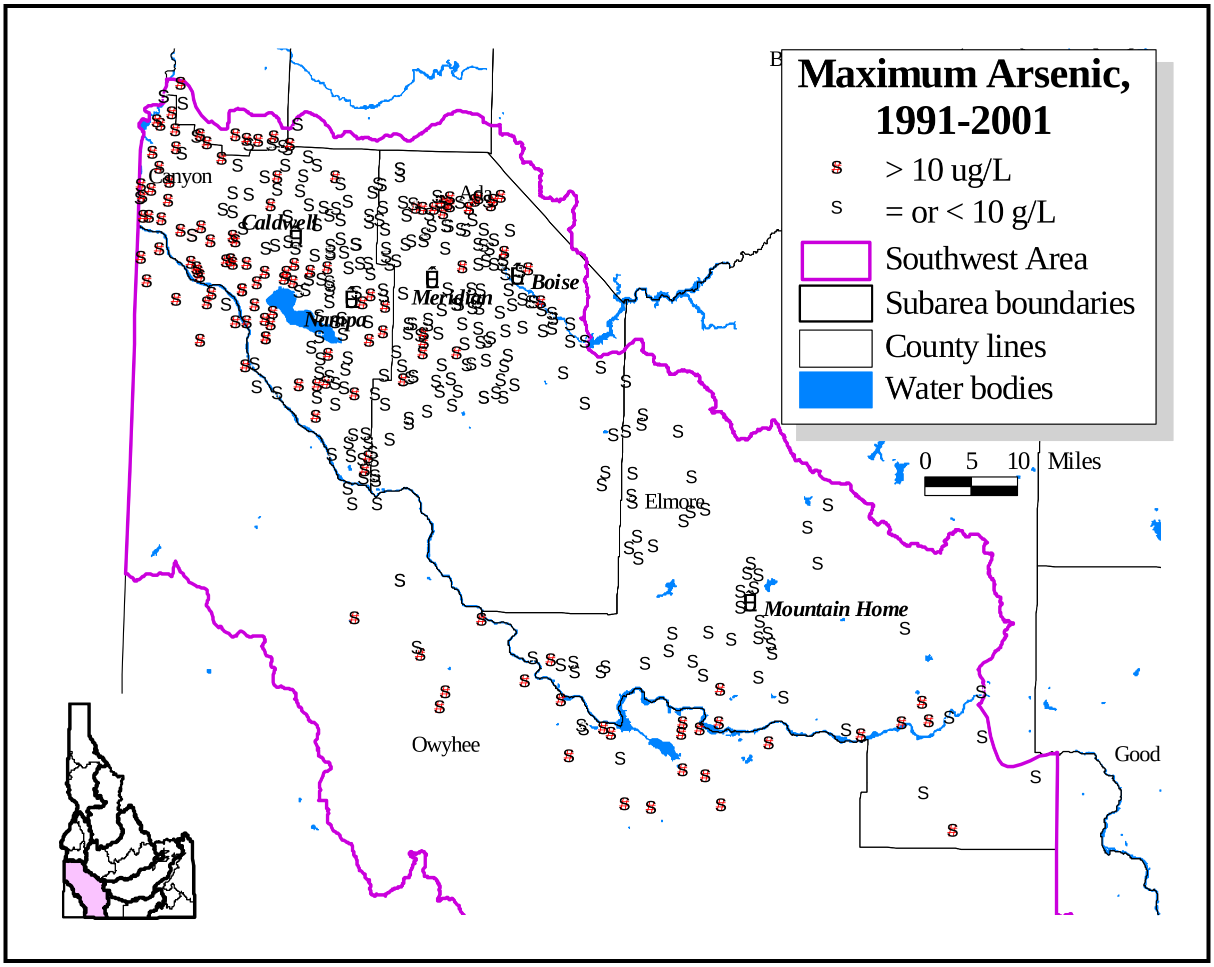


Figure 9. Arsenic values for Statewide Program sites in the Southwest Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

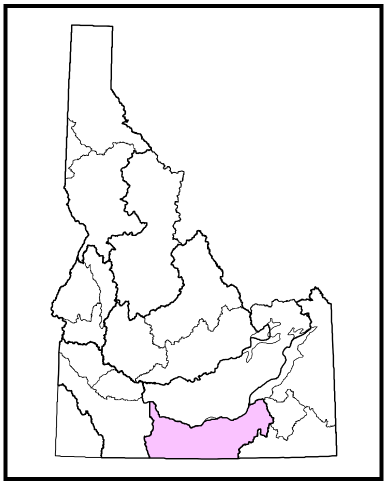
Additional study was conducted on the arsenic occurrences in the Treasure Valley. The hydrogeology in the Treasure Valley is a tiered system comprised of a geothermal (> 85 degrees Fahrenheit) aquifer overlain by two non-thermal (< 85 degrees Fahrenheit) aquifers (Neely, 2001). The two non-thermal systems contain sediments that eroded primarily from the granitic rocks of the Idaho Batholith, and were deposited in a lacustrine and fluvial environment (Squires et al., 1992; Othberg, 1994). The upper system is designated as the Treasure Valley Shallow (TVS) and the lower system is called the Treasure Valley Deep (TVD) (Neely and Crockett, 1998). Over the years, a variety of names have been used for these two systems. In all likelihood, the TVS system is equivalent to the Snake River Group, and the TVD is the Idaho Group (Neely and Crockett, 1998).

The TVS contains cobbles, gravels, sands, clay deposits, and basalt. Aquifers are unconfined to mildly confined. The TVS has a maximum thickness of about 200 to 250 feet. The Treasure Valley Deep (TVD) consists of fine grained sands interbedded with clay layers; total thickness is thousands of feet in some places. In about two thirds of the Statewide Program wells in the Treasure Valley, the TVD is below a lithologic layer describes as blue or gray clay in well driller's reports. The TVD aquifers are highly confined, and sometimes the wells are flowing artesian.

Neely and Crockett (1998) showed that ground water chemistries between the TVS and the TVD were not similar; the median values for 18 of 22 constituents and parameters tested were significantly different at the 95 percent confidence level. However, the median arsenic values for the TVS and TVD, as analyzed herein this study, were not significantly different at the 95 percent confidence level. These results suggest that the relationship between high arsenic concentrations and blue/gray clay observed by Howarth (1995) may not exist for the Treasure Valley. However, additional study is needed to determine if the TVD wells that actually encountered the blue/gray clay have significantly different arsenic concentrations than the wells that did not encounter blue/gray clay.

The median arsenic value for Canyon County was significantly higher than the median value for Ada County at the 95 percent confidence level. Although county lines are political boundaries and not useful for interpreting hydrologic data, this observation may indicate that arsenic concentrations increase along the flow paths as ground water moves from east to west in the Treasure Valley. However, detailed analyses that consider ground water flowpaths, aquifer materials, and geochemistry are needed to determine the reasons for the higher arsenic concentrations in the west half of the Treasure Valley. Additional information on the Treasure Valley ground water quality is available on the IDWR website.

7.7. South Central Reporting Area



The South Central Reporting Area covers three counties south of the Snake River Plain and small portions of two counties north of the Snake River. This area encompasses part of the fertile Magic Valley in Twin Falls County, and some broad intermountain valleys to the east. Irrigated agriculture, dairies, animal feeding operations, urban settings, and rangeland are found in this reporting area.

Aquifers in this reporting area include the basalts of the Snake River Group, the Idavada Formation, the Banbury Basalt, the Glenns Ferry Formation, the Raft River Formation, and unconsolidated alluvial sediments. The hydrogeologic setting south of the Snake River is much more complex than north of the Snake River. For example, in Twin Falls County, aquifers occur in at least four formations ((Neely (2001) summarized the aquifers and the ground water quality results for the Twin Falls area). Aquifers in Cassia and Power Counties are mostly in sedimentary rocks and alluvial sediments.

There are 196 Statewide Program sites in the South Central Reporting Area with arsenic results. Well depths for the 192 Southwest Reporting Area sites with well depth information range from 29 to 1,285 feet with an average well depth of 314 feet. Depth to static water levels ranged from 0 to 850 feet below the measuring points.

Maximum arsenic concentrations in the South Central Reporting Area ranged from less than 1 to 38 µg/L, with a median value of 5 µg/L. Fifty-five sites (28%) in the South Central Reporting Area had maximum arsenic concentrations that exceeded the MCL of 10 µg/L for the years 1991 – 2001. Most of the sites with arsenic over the MCL were in Twin Falls County, where almost half of the sites had a maximum arsenic value greater than 10 µg/L (*Figure 10*). The highest value in the South Central Region (38 µg/L) was in a well in western Twin Falls County. The common occurrence of elevated arsenic in Twin Falls County may be related to the Idavada Volcanics, a rhyolitic formation in the southern part of the county where natural recharge occurs.

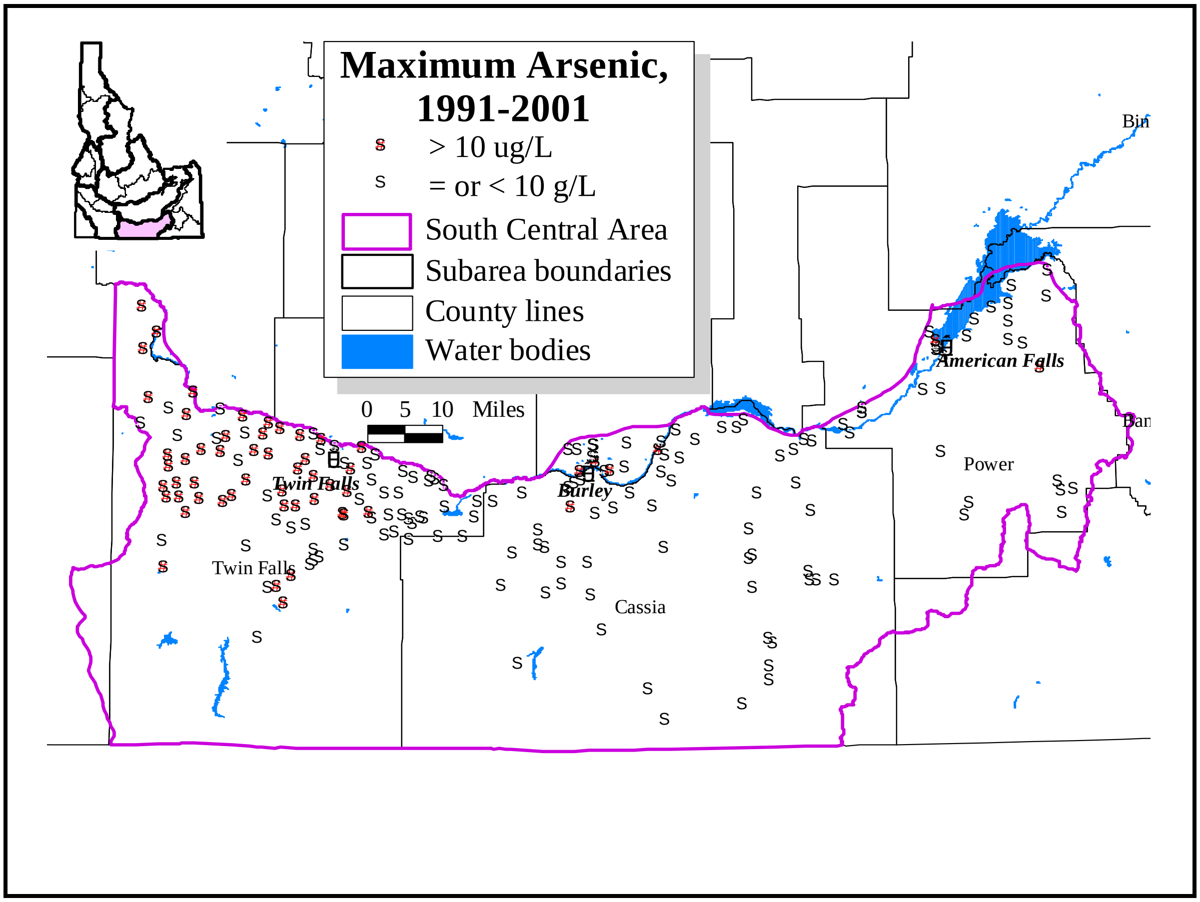
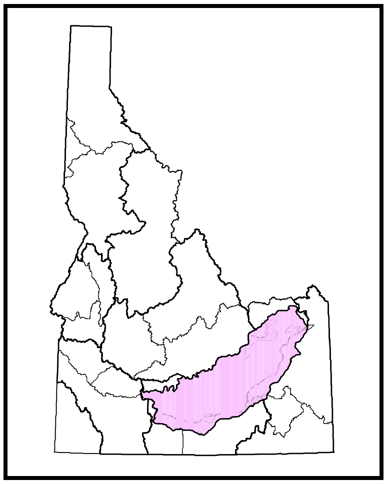


Figure 10. Arsenic values for Statewide Program sites in the South Central Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.8. Eastern Snake River Plain Aquifer Reporting Area



The Eastern Snake River Plain Aquifer (ESRPA) Reporting Area is located in the eastern part of the Snake River Plain. Irrigated and dryland agriculture, urban, and rangeland are common land uses in this reporting area.

The ESRPA is a series of basalt layers that are occasionally interbedded with sedimentary deposits (Johnson, et al., 1998; USGS, 2001; IDWR, 1999).

There are 266 Statewide Program sites in the ESRPA Reporting Area with arsenic results. Well depths for the 254 ESRPA Reporting Area sites with well depth information range from 14 to 1,115 feet with an average well depth of 291 feet. Depth to static water levels ranged from 1 to 1,011 feet below the measuring points.

Maximum arsenic concentrations in the ESRPA Reporting Area ranged from 0.4 to 34 µg/L, with a median value of 2 µg/L. Seven sites (3%) in the ESRPA Reporting Area had maximum arsenic concentrations that exceeded the MCL of 10 µg/L for the years 1991 – 2001 (*Figure 11*). The highest value (34 µg/L) was from a well in Jefferson County.

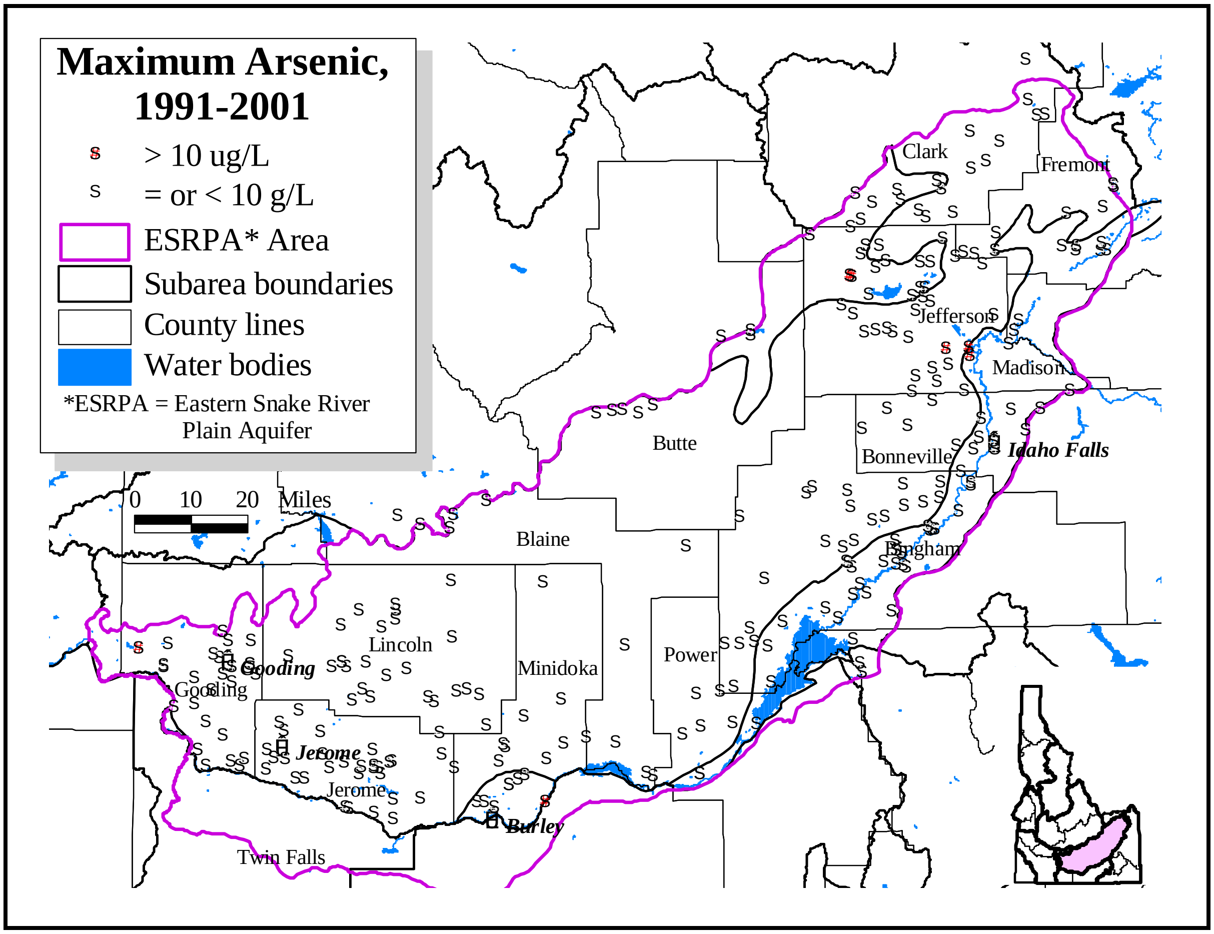
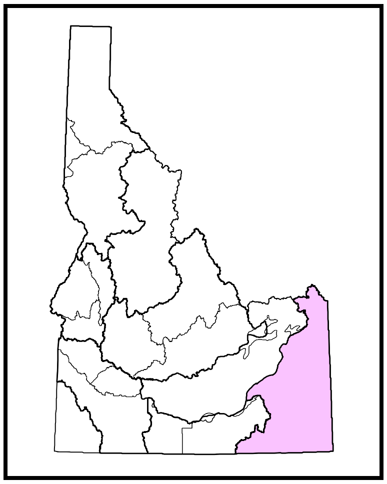


Figure 11. Arsenic values for Statewide Program sites in the Eastern Snake River Plain Aquifer Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.9. Southeast Reporting Area



The Southeast Reporting Area consists of a number of isolated basins in southeastern Idaho that are east of the Snake River Plain. This reporting area is typified by mountain ranges and river valleys, with irrigated and dryland agriculture, domestic, and urban land uses being common.

Aquifers in the Southeast Reporting Area are found in alluvial sediments, and in sedimentary and volcanic rocks. Some of the water-bearing geologic formations include: Big Hole Basalt, Michaud Gravel, Neeley, Salt Lake, Sunbeam, as wells as undifferentiated volcanic units of the Snake River Group, and alluvial deposits.

There are 265 Statewide Program sites in the Southeast Reporting Area with arsenic results. Well depths for the 254 Southeast Reporting Area sites with well depth information range from 21 to 1,340 feet with an average well depth of 162 feet. Depth to static water levels ranged from -13 to 687 feet below the measuring points.

Maximum arsenic concentrations in the Southeast Reporting Area ranged from 0.1 to 110 µg/L, with a median value of 2 µg/L. Seven sites (3%) in the Southeast Reporting Area had maximum arsenic concentrations that exceeded the MCL of 10 µg/L for the years 1991 – 2001 (*Figure 12*). The highest arsenic value (110 µg/L) in this reporting area occurred in a well in Jefferson County.

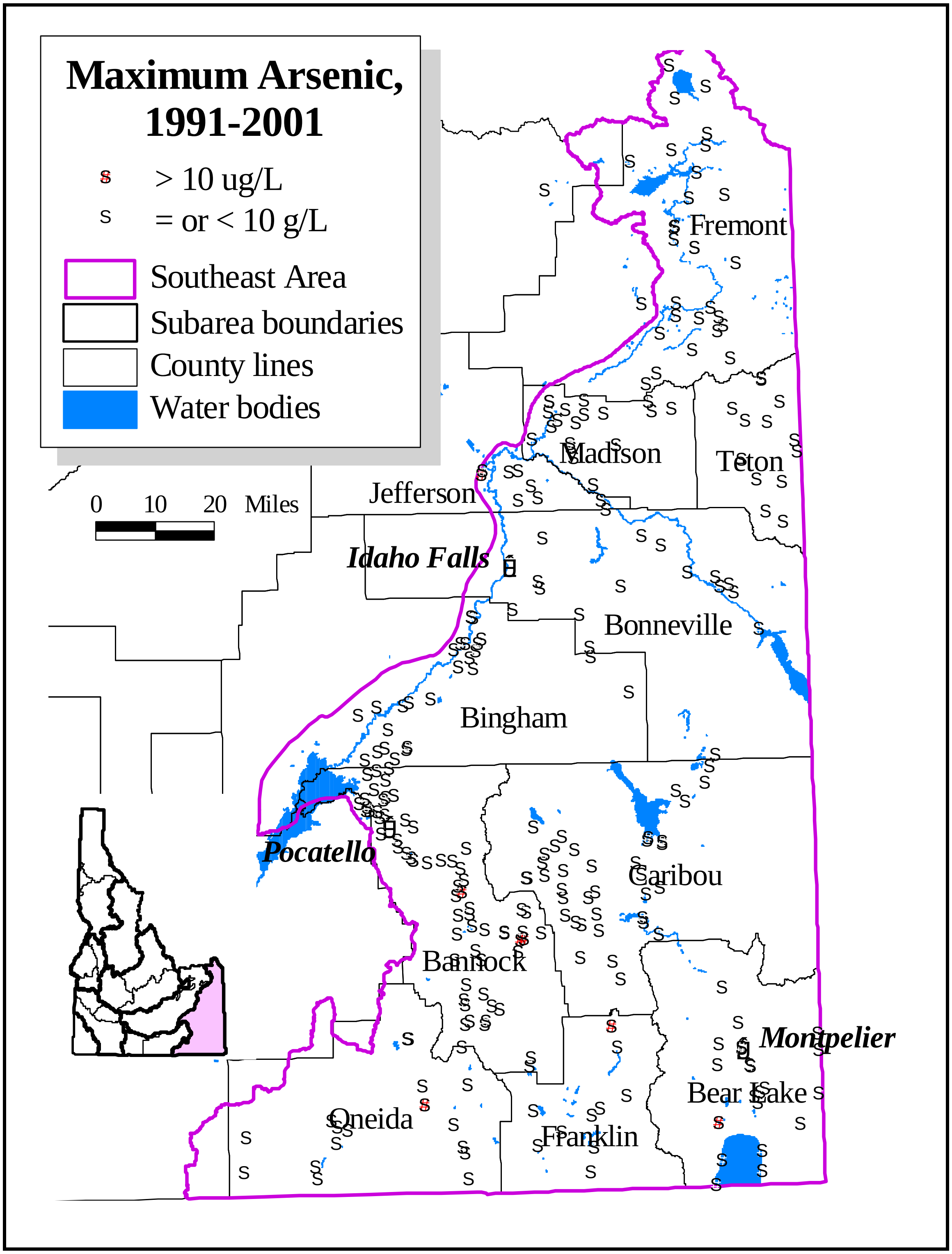


Figure 12. Arsenic values for Statewide Program sites in the Southeast Reporting Area, based on the maximum arsenic value measured at each site for the years 1991-2001.

7.10. Arsenic Results by County

Arsenic results are present on a county level in *Figure 13* to give the reader a quick look at local conditions. Data grouped by counties should not be used for making hydrologic interpretations since county lines are political, and do not generally reflect aquifer boundaries. *Table 2* shows detailed statistical results by county for dissolved arsenic from the Statewide Program.

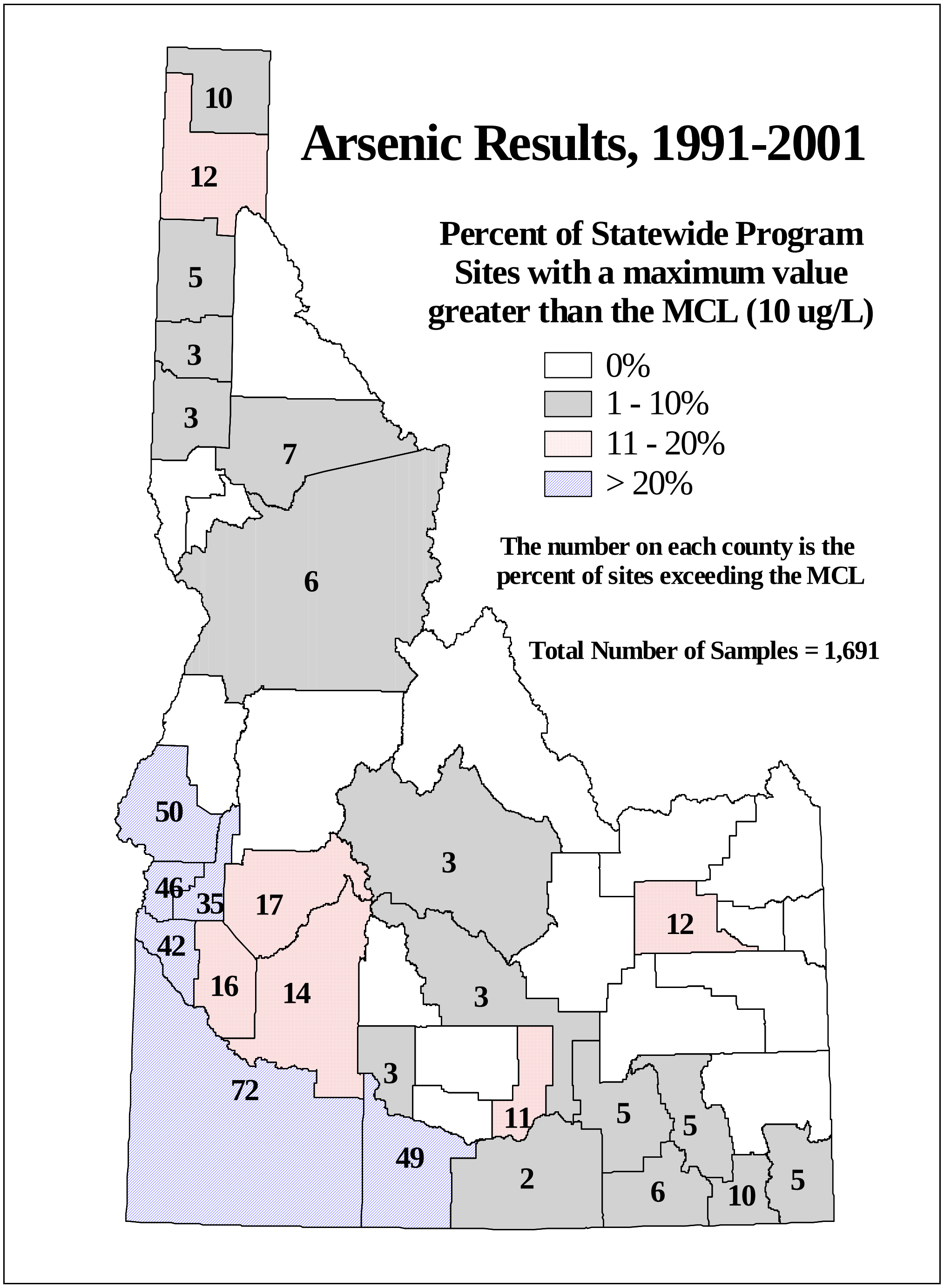


Figure 13. Dissolved arsenic in the ground water of Idaho by county according to Statewide Program data. Counties are color-coded according to the percent of sites that had a maximum arsenic concentration greater than the MCL of 10 µg/L during the time period from 1991 through 2001.

Table 2. Statistical summary of arsenic in ground water by county. Statistics are based on the maximum arsenic value recorded at each site sampled from 1991 through 2001. Individual county maps are available by contacting Ken Neely

County	# of Sites	Max. (ug/L)	Min. (ug/L)	Median (ug/L)	Mean (ug/L)	# > 10 ug/L	% > 10 ug/L
Ada	146	39	<1	4	6	24	16
Adams	16	4	<1	1	1	0	0
Bannock	64	45	<1	2	4	3	5
Bear Lake	22	38	<1	<1	3	1	5
Benewah	36	15	<1	<1	1	1	3
Bingham	74	8	1	3	3	0	0
Blaine	30	13	<1	2	2	1	3
Boise	18	45	<1	1	6	3	17
Bonner	68	23	<1	1	3	8	12
Bonneville	32	6	<1	2	2	0	0
Boundary	20	25	<1	<1	3	2	10
Butte	24	3	1	1	2	0	0
Camas	8	3	<1	<1	1	0	0
Canyon	153	130	<1	9	15	64	42
Caribou	38	7	<1	1	2	0	0
Cassia	55	12	<1	2	3	1	2
Clark	21	6	<1	2	2	0	0
Clearwater	15	16	<1	<1	2	1	7
Custer	33	16	<1	1	2	1	3
Elmore	63	110	<1	3	8	9	14
Franklin	10	11	<1	2	3	1	10
Fremont	43	5	<1	2	2	0	0
Gem	23	58	<1	7	11	8	35
Gooding	29	16	1	3	4	1	3
Idaho	32	86	<1	<1	4	2	6
Jefferson	49	110	1	2	7	6	12
Jerome	30	9	2	2	3	0	0
Kootenai	42	73	<1	1	4	2	5
Latah	39	17	<1	<1	1	1	3
Lemhi	23	9.8	<1	2	3	0	0
Lewis	15	<1	<1	<1	<1	0	0
Lincoln	26	4	<1	2	2	0	0
Madison	21	6	<1	1	2	0	0
Minidoka	27	19	1	3	5	3	11
Nez Perce	32	4	<1	<1	<1	0	0
Oneida	18	19	<1	2	3	1	6
Owyhee	39	180	<1	17	27	28	72
Payette	35	41	<1	9	11	16	46
Power	40	16	1	2	4	2	5
Shoshone	14	5	<1	<1	1	0	0
Teton	13	2	<1	<1	<1	0	0
Twin Falls	101	38	1	10	12	49	49
Valley	24	4	<1	<1	<1	0	0
Washington	30	950	<1	11	53	15	50
Total	1691	950	<1	2	7	255	15

8. RECOMMENDATIONS FOR WELL OWNERS

A common questions that we receive at IDWR related to ground water quality is "Should I have my water tested?". IDWR recommends that homeowners with private wells have their water tested for nitrate and for total coliform bacteria. For bacteria references, see EPA, 2001; Virginia Cooperative Extension, 1996. For nitrate references, see IDWR's Statewide Program website; EPA, 2001; Self and Waskom, 2001; Nitrate Removal Technologies; National Cancer Institute, 2001.

Before having your water tested, you may want to contact IDWR to see if there are any ground water quality data available for your area. *Figure 14* shows the areas of responsibilities for the three hydrogeologists at IDWR working on the Statewide Program. In addition to providing data for your area of interest, these people may be able to provide help with other ground water quality questions.

The IDEQ has posted a list of laboratories that are able to perform chemical analyses on your water sample.

When you receive your water test results, the hydrogeologists listed on *Figure 14* can assist you with understanding the information you receive from the laboratory. Based on the results from your water tests, you can obtain assistance regarding the frequency of future sampling, and whether sampling for other types of constituents is warranted.

If you have questions about a public water system, please contact the appropriate IDEQ regional office as shown on *Figure15.*

Citizens that have questions about their private domestic wells or concerns about the general ground water quality in their area can call their local health district (*Figure 16*).

The EPA (2002) provides recommendations for private drinking water wells. IDEQ has information for people who own their own wells.

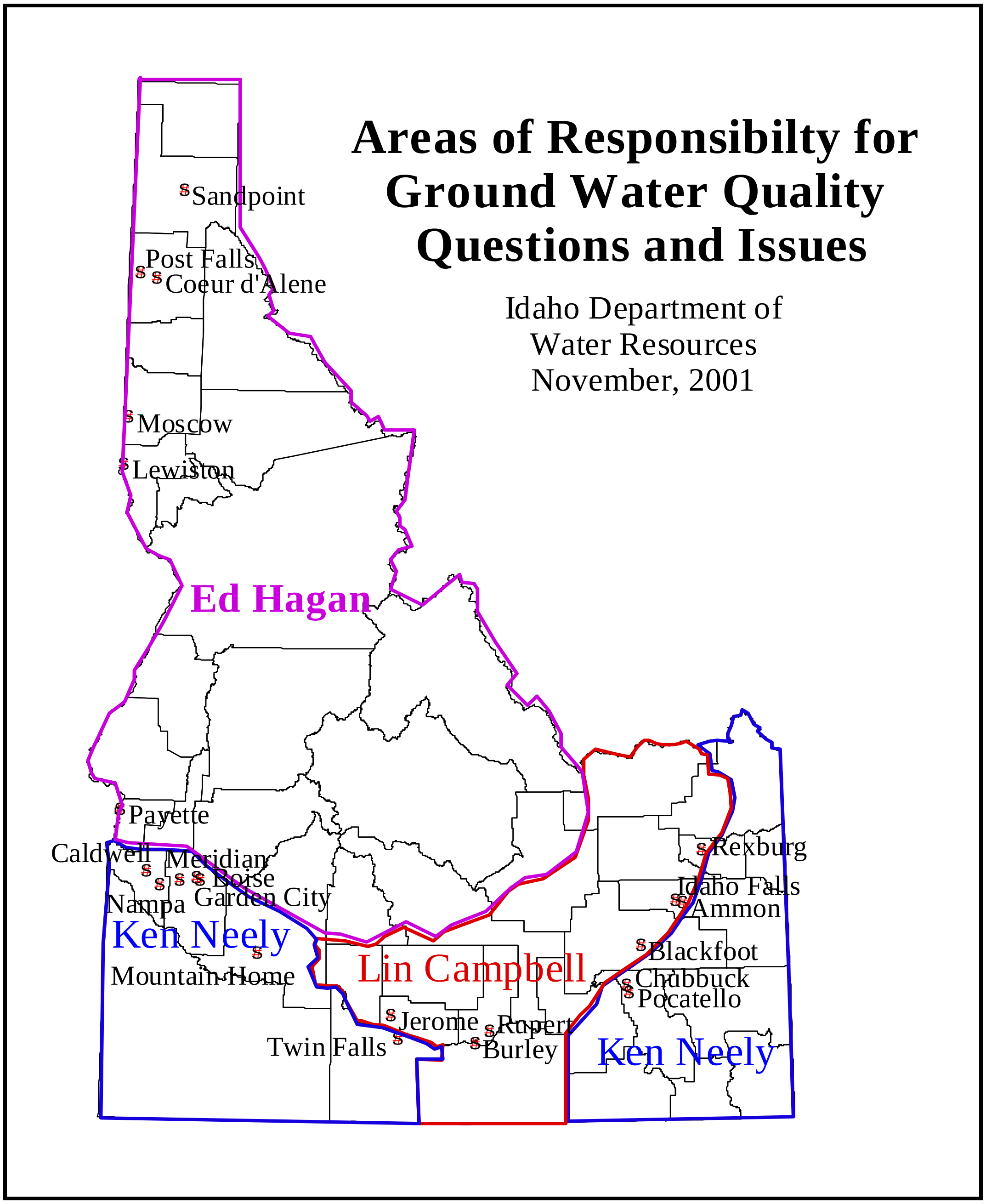


Figure 14. Hydrogeologists and their associated areas of responsibilities for the Statewide Program and for general ground water quality questions.

Contact the person for the area where you have a question:

Lin Campbell (208.327.7965)
Ed Hagan (208.327.5445)
Ken Neely (208.327.5455)

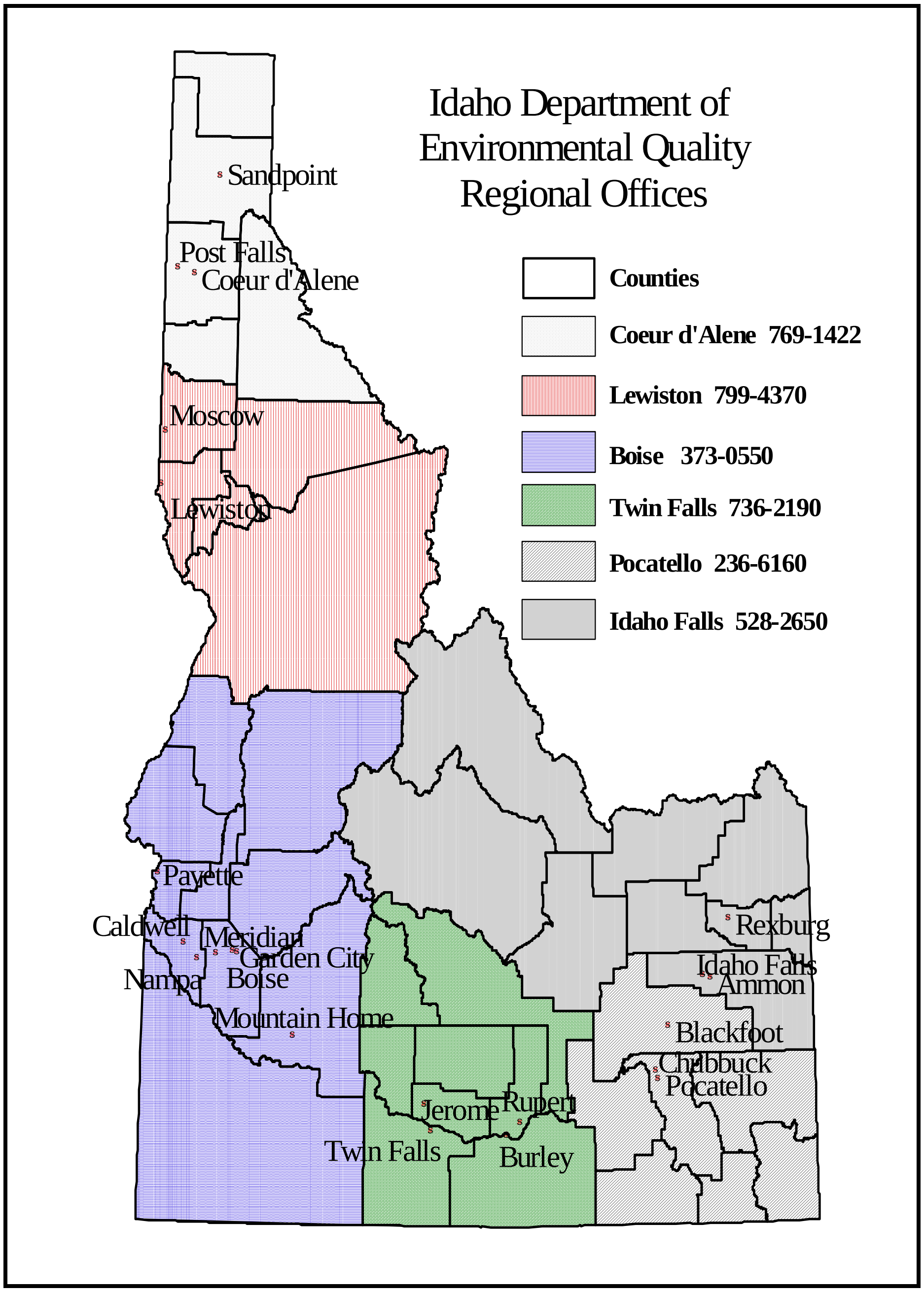


Figure 15. Idaho Department of Environmental Quality Regional Offices.

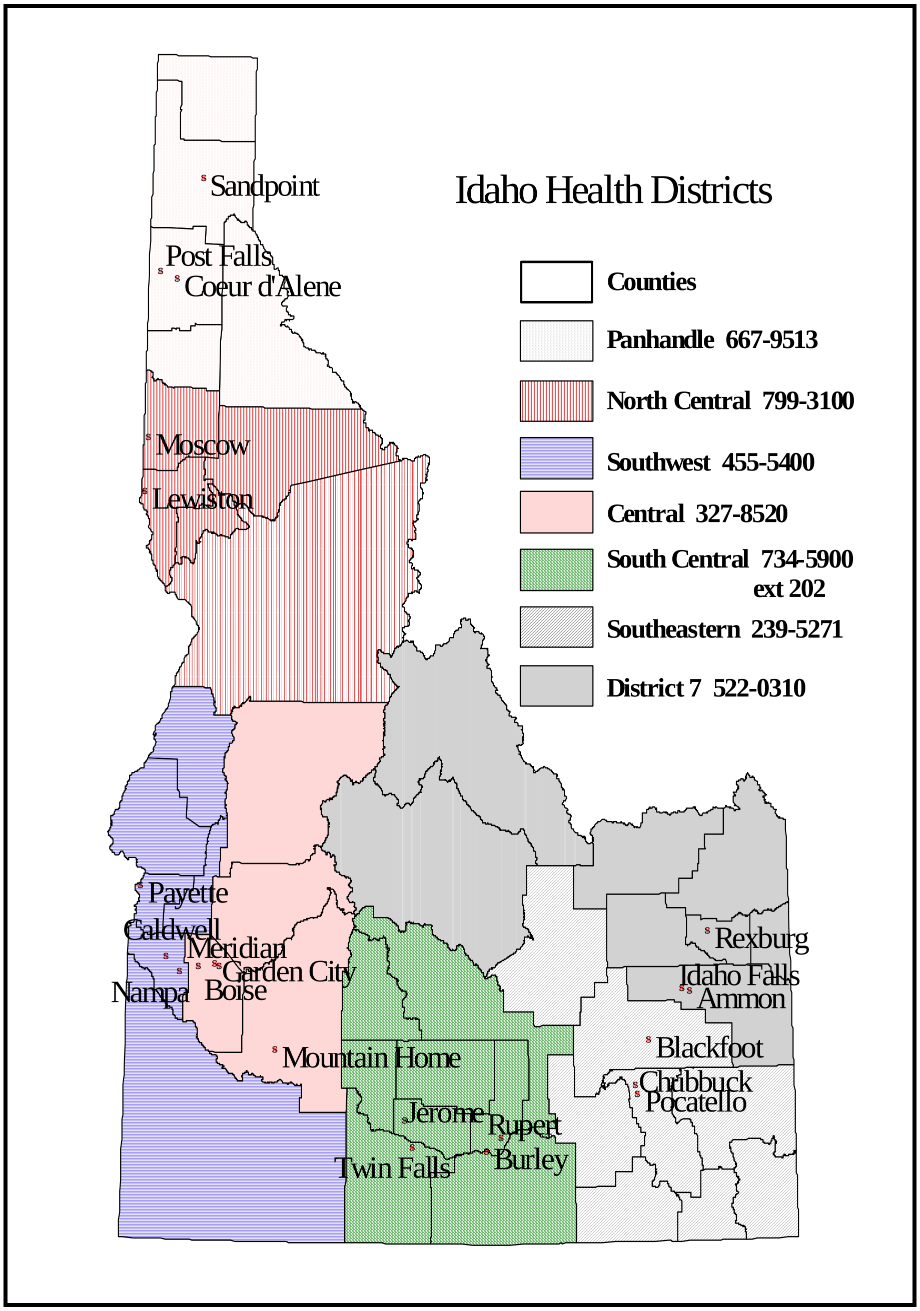


Figure 16. Idaho Health Districts.

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