Drinking Water From Private Wells and Risks to Children

Walter J. Rogan, MD, Michael T. Brady, MD, the Committee on Environmental Health, and the Committee on Infectious Diseases

ABSTRACT
Drinking water for approximately one sixth of US households is obtained from private wells. These wells can become contaminated by pollutant chemicals or pathogenic organisms, leading to significant illness. Although the US Environmental Protection Agency and all states offer guidance for construction, maintenance, and testing of private wells, there is little regulation, and with few exceptions, well owners are responsible for their own wells. Children may also drink well water at child care or when traveling. Illness resulting from children’s ingestion of contaminated water can be severe. This report reviews relevant aspects of groundwater and wells; describes the common chemical and microbiologic contaminants; gives an algorithm with recommendations for inspection, testing, and remediation for wells providing drinking water for children; reviews the definitions and uses of various bottled waters; provides current estimates of costs for well testing; and provides federal, national, state, and, where appropriate, tribal contacts for more information. Pediatrics 2009;123:e1123–e1137

BACKGROUND
Approximately 15% to 20% of households in the United States obtain their water from private wells.1 Public drinking water systems are regulated by the US Environmental Protection Agency (EPA), with national drinking water regulations providing the legally enforceable standards. Unlike municipal water supplies and some community wells, private wells are not subject to federal regulations and are minimally regulated by states. States sometimes require that a well be dug or drilled by a certified contractor and that the water from the well be tested at least once for nitrate and coliform bacteria. After that, the owner of the well is not required to inspect the well or test the water; only New Jersey requires testing at the time of resale. The states, the Navajo Nation, and the EPA offer suggested inspection and testing schedules (Appendix).

Well water is not sterile, nor does it need to be, but it should be free of fecal contamination; such contamination is usually detected by coliform bacteria counts. In Iowa wells in the 1990s, 27% had coliforms.2 Rigorous data are not available to compare the frequency of illness between children drinking well water versus municipal water. In a Canadian study of 235 rural households using well water, the odds of a child younger than 10 years having an episode of gastrointestinal illness, given the presence of at least 5 colony-forming units of Escherichia coli in the water, was 4.2 (95% confidence interval: 1.1–16.2) times higher than that for adults older than 50 years.3 However, the risk as compared with the child drinking uncontaminated water was not studied. In a clinical trial of reverse-osmosis water filters, which should remove all infectious agents, in families drinking municipal water meeting bacteriologic standards, approximately 30% of acute gastrointestinal illnesses were prevented by the filters, with no difference according to age group. This study showed that even bacteriologically “clean” water produces some illnesses and that, because the background rate of illness was higher in the young children, the use of reverse-osmosis water filters prevented more illnesses in that age group.4 It is likely, then, that contaminated water from a well would add to an already higher rate of such illness in children.

Well water can be a significant source of nitrate,5 which comes from both sewage and fertilizer. In Iowa2 and New York State,6 approximately 2% of wells had nitrate concentrations greater than 10 mg/L, which should not be

TECHNICAL REPORT

www.pediatrics.org/cgi/doi/10.1542/peds.2009-0752
doi:10.1542/peds.2009-0752

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The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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Key Words
water, drinking water, well, well water, private well, groundwater, nitrate, waterborne disease, fluoride, Escherichia coli

Abbreviations
EPA—US Environmental Protection Agency
MTBE—methyl tertiary butyl ether
PEDIATRICS (ISSN Numbers: Print; 0031-4005; Online, 1098-4275). Copyright © 2009 by the American Academy of Pediatrics
consumed by infants. Other chemicals, such as solvents, fuel additives, and pesticides, also may contaminate private wells.

According to the Centers for Disease Control and Prevention, 28 waterborne disease outbreaks were reported in the United States in 2005–2006, the latest years for which data are published. Twenty-three of the outbreaks were from drinking water, of those 8 were groundwater sources, usually private wells. Those caused illness in 458 people. The ages of the individuals were not reported. The etiology of 5 of the outbreaks is known: 1 was *Campylobacter*, 3 were norovirus, and 1 was Hepatitis A. Waterborne illness is undoubtedly underrecognized and underreported.

Although recommendations regarding wells note that infants are most susceptible to nitrate-induced methemoglobinemia, recommendations regarding well water specific to families with children are not available; similarly, recommendations that address events that might expose a child to untested water, such as the birth or adoption of a child, are not available. As a general principle, children are likely to be more susceptible to waterborne illness than adults, because they drink relatively more water, develop gastroenteritis more often, and become dehydrated more quickly when they develop gastrointestinal illness. Thus, the fact that adults can consume the water without incident is not a guarantee that the child can do so. What follows is a selective compilation of information and recommendations concerning wells and well water.

**GROUNDWATER AND WELLS**

Groundwater is water below the topsoil and above impervious bedrock. When groundwater collects in and saturates relatively porous fractured bedrock and soil, it is said to be in an aquifer. The water table is a depth below which the soil and fractured bedrock (ie, the aquifer) is saturated with water. The water table can vary from season to season and year to year. For a well to produce water reliably, it must be deep enough so that water can be pumped from the aquifer from which it draws under virtually all weather conditions. Aquifers are recharged from above by precipitation and runoff. Wells drilled into water under sufficient pressure to come out of the ground spontaneously are called artesian wells because of their existence in the French region of Artois (“artesian,” in old French, means “of Artois”) (Fig 1).

Groundwater is naturally filtered on its way from the surface to the water table, so it is relatively free of particulate organic material and bacteria. It will only remain so if it is protected on its way from the aquifer to the tap.

**WELL TYPES**

Dug wells usually are shallow holes, 10 to 30 ft deep, lined with rock, brick, tile, or concrete, with a pump in a nearby pump house or in the dwelling. Dug wells usually are relics on older home sites. They are easy to contaminate and unreliable in most of the United States. For driven wells, a pipe is driven through gravel or sandy soil. These wells also tend to be shallow, usually approximately 50 ft deep; the pump is installed at the top of the well or in the dwelling. Driven wells are still relatively easy to contaminate because of their shallowness but can be rapidly and inexpensively installed if the geologic conditions are right. Dug wells and driven wells are often the water source at camps or vacation homes.

Drilled wells are 100 to 400 ft deep and reach bedrock. Most drilled wells have an electric submersible pump at the bottom.

Although the recommended minimum distances vary on the basis of the contaminant, private wells should be as far as feasible and no less than 50 ft from septic fields; they should be even further from underground fuel tanks, sheds in which fertilizers or other chemicals are stored, livestock, and cultivated fields. Thus, when siting a new well or when there is concern about contamination of an existing well, consultation with the local health department should be sought. In addition, the well should be on relatively high ground (ie, uphill from septic tanks) and covered by a well housing unit of impermeable material such as concrete. Although it is occasionally necessary to access the wellhead, security of the well housing should take precedence over convenience of access. If a homeowner is in doubt about the safety or integrity of the well, inspection by the state or county health department or a licensed well contractor should be arranged. In addition, if there is a flood or if the well housing is damaged by a vehicle, tree, etc, professional inspection is warranted.

![FIGURE 1](image-url)
COMPOSITION OF WELL WATER

Chemicals

Nitrate
Nitrate is the most familiar and one of the most common contaminants of wells. Nitrate comes from either sewage or fertilizer. Agricultural scale application of fertilizer and permeable soil can lead to nitrate contamination of area groundwater. Nitrate is reported from the laboratory as nitrate nitrogen (NO₃-N); a level of 3 mg/L or greater indicates contamination. Water with a nitrate concentration of greater than 10 mg/L should not be used to prepare infant formula or other foods or given to a child younger than 1 year to drink. The presence of nitrate requires testing for coliforms. Nitrate with no coliforms is likely from fertilizer; if possible, neighboring wells should be tested to determine if the aquifer, rather than the well, is contaminated. Nitrate with coliforms is likely from sewage (either livestock or human). Septic fields or tanks, manure fields, or settling ponds also can be sources of contamination. Examination of neighboring wells may be helpful in determining the source. The standard for nitrate is set to protect infants from methemoglobinemia. There is some evidence that long-term effects, such as gastric cancer, might result from exposure to even smaller amounts of nitrate if they help form endogenous N-nitroso compounds, which are potent carcinogens in many species. So far, however, the data are largely ecological and inconsistent.9

Volatile Organic Compounds and Pesticides

Volatile organic compounds and pesticides are problems throughout the United States. Although individual sources of these compounds are sometimes identified, such as abandoned dry cleaning shops with underground storage tanks, these compounds are very mobile and can appear without specific sources. The US Geological Survey evaluated 1255 domestic wells between 1992 and 1999, and found volatile organic compounds in 44% and pesticides in 38%.10 Wells were more likely to be contaminated if they were shallow, were in a more urban area, or if they drew water from an aquifer with no impermeable layer between the surface and the water (see Fig 2). Inorganic Compounds

Most state health departments and many commercial sources offer testing for inorganic compounds including calcium, sodium, fluoride, chloride, iron, manganese, magnesium, pH, hardness, and total dissolved solids. Total dissolved solids usually consist of calcium and magnesium as their bicarbonates. These bicarbonates make water “hard.” Hard water is not toxic; however, the calcium and magnesium precipitate when the water is heated, and this precipitation will eventually cause electric hot water heaters, coffee pots, kettles, and any electrical device in which water is heated repeatedly to fail as the precipitate insulates the heating element. Hard water also forms scum with soaps and detergents.

Manganese and iron can appear as rust-colored to black flecks and can stain clothing, plumbing, and fixtures. However, their levels are not usually high enough to be toxic. So-called iron and manganese bacteria can grow in such water and form black slimy colonies of microorganisms, sometimes clogging pipes and faucets.

Sodium Chloride

Sea salt is a problem near the ocean and in areas where there was formerly salt water. Most people cannot or will not drink enough salt water for it to be toxic. Domestic desalinization is neither economic nor practical except under extraordinary circumstances.

Lead

Lead is not often present in groundwater but can be leached from the brass in a submersible pump, from solder, and, in some cases, old lead pipes if the water is naturally acidic or made acidic by treatment. For example, techniques such as anion exchange remove nitrate and sulfate but leave the water acidic.

Arsenic

Arsenic occurs in specific rock formations, for example, the “slate belt” in the southeastern United States. Its presence in well water is sometimes predictable from geologic data. Arsenic has been reported to be a common well contaminant in Maine,11 parts of North Carolina,12 Alaska, and parts of the western United States. Arsenic is extremely toxic and is known to cause bladder, skin, and
lungs cancers in humans13; however, there have been no reports of acute or subacute arsenic poisoning from well water in the United States. A substantial fraction of the population of Bangladesh must drink from arsenic-contaminated wells, with resulting intoxication.14

**Radon**
Radon is a naturally occurring radioactive gas. Radon, similar to uranium, emits α particles containing 2 protons and 2 neutrons. α particles are strongly ionizing but do not penetrate far into tissue or other substances. Miners exposed to radon in underground mines develop excess lung cancer.13 Some radon exposure from water occurs by ingestion, although showering, bathing, cleaning, and spraying water are likely to produce higher exposures. Radon in well water commonly exceeds the concentrations allowed in municipal water but does not correlate well with indoor air measurements.15

**Fluoride**
Fluoride is the lightest halogen on the periodic table. It occurs naturally in water in a few parts of the United States. Fluoride is an accepted preventive for dental caries; if a child’s drinking water contains none, fluoride supplements are recommended. The American Academy of Pediatrics recommends no fluoride supplementation before 6 months of age; from 6 months to 3 years of age, children require fluoride supplementation if the water has <0.3 ppm (3 μg/L) fluoride. Supplementation from 3 to 16 years of age is recommended for children in areas where drinking water fluoride concentrations are <0.6 ppm.16 Fluorosis, a condition that results from excess fluoride intake, produces tooth discoloration in children. The discoloration can range from mild white specks to brown streaks with pitting. According to the American Academy of Pediatric Dentistry,17 fluorosis is most commonly caused by giving fluoride supplements to a child who already has adequate fluoride in drinking water or by the child’s ingestion of fluoridated toothpaste rather than from excess fluoride in well water. However, because caries prevention is achieved at drinking water concentrations of 1 ppm and the risk of dental fluorosis increases with concentration,18 children younger than 9 years should not drink water with a fluoride concentration of >2 ppm.1 Determining fluoride concentration in well water should be performed as part of the initial evaluation of the well.

**Uranium**
Uranium in groundwater, although mostly found in the Western mountains in the United States, can also be found in areas that have granite outcrops, the result of granite intrusion into existing subterranean strata and subsequent weathering. There have been reports of high uranium concentrations in waters of Connecticut and South Carolina.19,20 Those who drink uranium-containing water absorb and then excrete it; urinary concentrations as high as 25% of peak can be present 6 months after exposure has ceased.19 Exposures likely to be encountered in drinking water have not resulted in acute toxicity. Radiation carcinogenesis, however, is currently thought to have no threshold, and the biological effects of ionizing radiation reports13 estimated that some cancer may be attributable to background uranium exposure, including uranium in water.

**Methyl Tertiary Butyl Ether (MTBE)**
Methyl tertiary butyl ether (MTBE) is a partially oxidized hydrocarbon fuel additive used to oxygenate gasoline. The oxygenation of gasoline during certain seasons was mandated by the Clean Air Act in 1990 (Pub L No. 101–549) to reduce carbon monoxide emissions. Motor vehicle exhausts are the primary source of ambient carbon monoxide levels, and carbon monoxide is highest during the cold-weather months. Oxygenated gasoline is designed to increase the combustion efficiency of gasoline, thereby reducing carbon monoxide emissions. The tertiary butyl group on MTBE hinders breakdown by sterically protecting the molecule; as a result, uncombusted MTBE can persist in the environment. MTBE is now found in water supplies throughout the United States. Because it has no other uses, its presence indicates contamination by gasoline; its concentrations are higher in wells near gas stations and particularly high near gas stations that sell oxygenated fuel.22 MTBE is toxic and carcinogenic in experimental animals23 and is now banned in most states. Ethanol will likely replace MTBE entirely for oxygenating fuel.

**Perchlorate**
Perchlorate is an oxidizing agent used in rocket fuels, fireworks, and airbag inflators. It also occurs naturally. Perchlorate is a well-studied steric inhibitor of the thyroid symporter, which transports iodine across the gland’s membrane before hormone synthesis. It is now recognized as a water pollutant. There is evidence that perchlorate interferes with thyroid function in adult women in the United States, even at background exposures.24

**Microorganisms**
Microorganisms, including bacteria, viruses, fungi, and parasites, may contaminate the groundwater that supplies wells (Table 1). The major source of these organisms is fecal material from animals and humans. Analyzing well water at its point of use for “total coliforms” is the most common way of detecting fecal contamination of the water. Coliform bacteria may be pathogenic or nonpathogenic. Coliforms include many species of

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**TABLE 1 Most Common Pathogenic Microorganisms Found in Well Water**

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Viruses</th>
<th>Parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em>, including O157: H7</td>
<td>Small round-structured viruses, including norovirus</td>
<td><em>Giardia intestinalis</em></td>
</tr>
<tr>
<td><em>Salmonella</em> species</td>
<td>Rotavirus</td>
<td><em>Cryptosporidium parvum</em></td>
</tr>
<tr>
<td><em>Shigella</em> species</td>
<td>Entero viruses</td>
<td><em>Cyclospora</em></td>
</tr>
<tr>
<td><em>Campylobacter jejuni</em></td>
<td>Hepatitis A and E</td>
<td><em>Microsporidia</em></td>
</tr>
<tr>
<td><em>Yersinia enterocolitica</em></td>
<td></td>
<td><em>Isospora</em></td>
</tr>
<tr>
<td><em>M. avium</em> intracellular*</td>
<td></td>
<td><em>Naegleria fowleri</em></td>
</tr>
</tbody>
</table>

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*Note: MTBE is methyl tertiary butyl ether.*

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Gram-negative bacteria found in the intestinal tract of animals and humans, in the soil, on vegetation, and in surface water runoff. Although coliforms do not reproduce in water, they can survive there for extended periods of time. Thus, assessing total coliforms in a water sample is a useful screening tool, because it does not require sophisticated technology and is inexpensive. No coliforms of any sort should be detectable in 100 mL of water. The absence of coliforms is good but not absolute evidence that significant fecal contamination is not present. The presence of coliforms does not mean that pathogens are present, but it does make fecal contamination and, thus, contamination by pathogens much more likely. Samples that contain any coliforms should be retested to determine if they are fecal coliforms; specimens that test positive should be examined for the presence of *Escherichia coli* or other pathogens.

Much of the information describing the pathogens that may be present in well water has been obtained from investigations of waterborne outbreaks. In the United States, most waterborne outbreaks are associated with noncommunity water systems, chiefly private or communal wells. The microorganisms listed in Table 1 typically cause a gastrointestinal illness. However, there are notable exceptions; for example, enterovirus exposure may be asymptomatic but may also result in a febrile illness associated with sore throat, rash, myalgia, or, less commonly, aseptic meningitis syndrome. *Naegleria* species may cause a fatal meningoencephalitis. *Mycobacterium avium*-intracellulare and *Cryptosporidium* species may be found in well water, producing systemic or pulmonary disease in specific vulnerable populations. *Legionella* species and *M. avium*-intracellulare are present naturally in water and do not represent fecal contamination. However, disease from *Legionella* species typically results from inhalation rather than ingestion of bacteria. Outbreaks caused by *Legionella* species typically occur in large buildings after colonization of the water-distribution system and have not been identified as a result of contamination of well water.

Iron and sulfur bacteria also may be present in well water. Although these bacteria do not pose a health threat, they can cause the water to smell (like “rotten egg”) and taste bad; they also increase the likelihood that plumbing equipment will become plugged or corroded.

**MITIGATION**

If test results confirm bacterial contamination, the well must be inspected to identify any structural defects that may have permitted the contamination. After any such defects are repaired, the well must be treated to eliminate pathogenic bacteria immediately, usually by “shock chlorination,” which uses concentrations of chlorine that are 100 to 400 times the amount found in municipal water supplies. This can be done by the homeowner using household bleach, (many Web sites have instructions [www.water-research.net/shockwelldisinfection.htm]), but consultation with the health department or other experienced individuals is advisable the first time. The highly chlorinated water needs to be held within the water system pipes for 12 to 24 hours before it is completely flushed out of the system. The water should be retested in 1 to 2 weeks. If shock chlorination does not eliminate the bacteria, a continuous disinfection system or further repairs to the well are needed. A consultation with the local health department can help the well owner understand which additional treatment measures are required.

If the contamination is ongoing but under the control of the homeowner, such as from a failing septic field, that problem must be fixed before the well can be used for drinking water again. Successful, lasting decontamination of a well may require more persistent efforts. Swistock and Sharpe disinfected and installed sanitary well caps on 16 wells with coliform contamination; coliforms were again present in 7 of the wells within 60 days and in all but 2 within a year. The 2 wells that did not have coliforms after 1 year had low initial coliform counts and no *E. coli*. The authors suggested that contamination may occur far from the well head and may commonly be an aquifer problem. Such a problem is beyond the scope of the homeowner. If the well cannot be used, it should not be abandoned, because it would still provide access for contamination of groundwater. A certified well contractor should fill or seal the contaminated well.

Chemical contaminants are approached by investigating the possibility that the contamination from fertilizers, pesticides, or fuel from leaking tanks exists on the homeowner’s or on an adjacent homeowner’s property. However, remediation may be inconvenient and/or expensive. If the water supply cannot be remediated and the well is still contaminated or the chemicals in question are naturally occurring, it is possible to treat for or filter most chemicals. An illustration of the relative sizes of filterable contaminants versus filter pore size is provided in Fig 3.

Carafe and faucet-mounted filters usually are designed to reduce lead, some organic materials, *Giardia and Cryptosporidium* cysts, and sediment. These units are intended for municipal water and would not be suitable for more heavily contaminated well water. Most other treatment measures require the service of a trained home water-treatment professional, at least for initial installation. Chemical disinfection with chlorine, ozone or hydrogen peroxide, distillation, and ultraviolet light can remove or kill many microorganisms. Chlorine is effective at killing bacteria and viruses but is less effective against *Giardia* species and not effective against *Cryptosporidium* species. Reverse-osmosis filters, usually used in conjunction with activated charcoal and mechanical filtration, can remove inorganic materials, microorganisms, and all but a few organic compounds; however, they are expensive. Treatment systems must be properly maintained to ensure safe water. Most filters, membranes, or ultraviolet lights need to be replaced at least once per year and more frequently if damaged or not working properly.

*Consumer Reports* magazine periodically reviews home water-treatment devices, including the inexpensive carafe and faucet-mounted types. Although the emphasis is on treating municipal water, they also review reverse-osmosis filters. *Consumer Reports* is available in libraries and through a subscription Web site. NSF International (www.nsf.com) is a not-for-profit, nongovernmental, independent agency...
that tests and certifies consumer products, including water-
treatment devices. The NSF Web site allows the consumer
to pick the contaminants that are present, and the NSF will
provide names of appropriate products and manufacturers.
NSF certification is a voluntary program paid for by the
manufacturer of the device. Some states and universities,
such as Purdue University (www.purdue.edu/dp/envirosoft/groundwater/src/treat.htm#menu), provide descrip-
tions of water-treatment devices. All sites recommend that
the water first be tested and then the treatment device or
devices selected to deal with the contaminants that are
present.

Because there are no standards for private wells for
many contaminants of concern, those seeking a specific
centration to indicate potability have little choice but
to apply the same standards that municipalities do under
the Safe Drinking Water Act amendments of 1996 (Pub
L No. 104–182 [for the current list of drinking water
contaminants, see www.epa.gov/safewater/mcl.html]).
Municipalities regard water that is persistently above
these federal standards as not potable. Nonetheless, well
owners or home occupants are under no obligation to
apply this same standard to their well water.

BOTTLED WATER
Bottled water is often labeled to describe its characteris-
tics, source, or method of treatment. Bottled water is
regulated as a packaged food by the US Food and Drug
Administration under the Federal Food, Drug and Cos-
metic Act (21 USC §301 et seq [1938]) if it is in interstate
commerce (ie, crosses a state line). Food and Drug Ad-
ministration rules for bottled water mirror EPA rules for
municipal water. Thus, bottled water in interstate com-
merce should be free of coliform bacteria and have <1
mg/L of nitrate nitrogen.

Distilled water is boiled (killing microbes), and the
steam is condensed to remove salts, metals, minerals,
asbestos, particles, and some organic materials, giving it
a “flat” taste. Purified water originates from any source
but has been treated to be essentially pure H₂O. It must
contain <10 ppm of total dissolved solids and may also
be free of microbes if treated by distillation or reverse
osmosis. Sterilized water originates from any source but
has been treated to be free from all microbes. These
waters should be sterile until opened. Other bottled wa-
ters may or may not be sterile.

Artesian water, groundwater, spring water, and well
water are from underground aquifers, the waters of
which may or may not be treated. It may or may not be sterile. Bottled drinking water is intended for human
consumption and sealed in bottles and may contain dis-
fectants. Some of these are fluoridated, which should
be noted on the label. Mineral water is groundwater that
naturally contains ≥250 ppm of total dissolved solids.
Carbonated water, soda water, seltzer water, sparkling
water, and tonic water are considered soft drinks and are
not regulated as bottled water.

CONCLUSIONS
Well water can be used safely by families, but regular
testing is recommended by all relevant authorities. A rec-
ommended approach to testing is given in the accompanying
policy statement25 and outlined as a flowchart in that
statement. In much of the United States, well water is hard
and must be softened in order not to damage hot water
heaters, kettles, and other devices, but softening per se does
not remove most other contaminants or microorganisms.

Whether and how water is treated should be guided by the
results of testing. Testing can be expensive, and the Amer-
ican Academy of Pediatrics encourages states and counties
to provide free or low-cost testing to families who need
their water tested and cannot afford it. A list of current
costs is provided in the accompanying policy statement27;
these costs are, of course, subject to change. Inexpensive
water filters can remove lead, Cryptosporidium species, and
some volatile hydrocarbons, but these are designed more
for tap water from municipal water supplies and may not be
suitable for well water. Water contamination is inher-
ently local, and families with wells and pediatricians are encouraged to keep in contact with state and any local programs. A list of contacts, all of which are current as of May 2007, is provided in the Appendix. Within states, private well water programs, resources, guidance, testing groups, and regulations are found in a variety of state Departments of Health, Public Health, Environment, Natural Resources, Licensure or Water, and sometimes within multiple departments within a state. Many states also have university-based Cooperative Extension services with private well water resources. Unfortunately, website addresses change frequently. In addition to web site addresses, the Appendix includes both document titles, and, when available, authorship organization names to aid in internet searches for relevant information. Bottled water should be considered for travel or other circumstances in which an infant might need water and the source of the water is unknown, but bottled water is subject to limited regulation.

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<th>Organization</th>
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<th>Web Site/Document Title/ Description</th>
<th>Telephone No.</th>
<th>Telephone Contact Organization</th>
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<td>The EPA Office of Ground Water and Drinking Water, together with states, tribes, and its many partners, ensures safe drinking water and protects ground water. This office, along with the EPA's 10 regional drinking water programs, also oversees implementation of the national Safe Drinking Water Act</td>
<td>(800) 426-4791</td>
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<td>EPA-Region 9 Tribal Program</td>
<td><a href="http://earth1.epa.gov/region09/indian/success/03/water.html">http://earth1.epa.gov/region09/indian/success/03/water.html</a></td>
<td>The EPA-Region 9 Tribal Program serves 147 federally recognized tribes in the American Southwest. For other tribes, EPA regional offices coordinate tribal programs within their respective regions. The Navajo Nation has its own EPA (see below)</td>
<td>(415) 972-3560</td>
<td>EPA Regional Drinking Water Office</td>
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<tr>
<td>Navajo Nation Environmental Protection Agency</td>
<td><a href="http://www.navajopublicwater.org/index.html">www.navajopublicwater.org/index.html</a>  <a href="http://www.navajonationepa.org">www.navajonationepa.org</a></td>
<td>The Navajo Nation EPA serves the Navajo Nation in the states of Arizona, New Mexico, and Utah. The Navajo Nation EPA Surface and Groundwater Protection Department is responsible for protecting the waters of the Navajo Nation and enforcing the Navajo Nation Safe Drinking Water Act</td>
<td>(928) 729-4320</td>
<td>Navajo Nation Division of Natural Resources  Department of Water Resources  Navaho Nation EPA Public Water Systems Supervision Program</td>
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<tr>
<td>Indian Health Service</td>
<td><a href="http://www.dehs.ihs.gov/index.cfm">www.dehs.ihs.gov/index.cfm</a></td>
<td>The Indian Health Service is the federal health program for American Indian and Alaska Native individuals. The Indian Health Service provides information on safe water to American Indian/Alaska Native communities on reservations, many of which depend on wells (usually community wells) for drinking water</td>
<td>(301) 443-1247</td>
<td>Indian Health Service Office of Environmental Health and Engineering</td>
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<tr>
<td>Centers for Disease Control and Prevention</td>
<td><a href="http://www.cdc.gov/ncidod/dpd/healthywater/privatewell.htm">www.cdc.gov/ncidod/dpd/healthywater/privatewell.htm</a></td>
<td>The Centers for Disease Control and Prevention Division of Paralytic Diseases maintains this Web site with information on contaminants that can be found in water from private wells</td>
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<td>US Department of Agriculture</td>
<td><a href="http://www.csrees.usda.gov/qlinks/partners/state_partners.html">www.csrees.usda.gov/qlinks/partners/state_partners.html</a> or <a href="http://www.csrees.usda.gov/Extension/index.html">www.csrees.usda.gov/Extension/index.html</a></td>
<td>Department of Agriculture CSREES maintains these Web sites with links to all states’ state and national (university) partners and to all states’ Local Cooperative Extension System Offices. These offices have extensive information on local and regional well water issues</td>
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<td>US Food and Drug Administration</td>
<td><a href="http://www.fda.gov/oca/health.htm">www.fda.gov/oca/health.htm</a></td>
<td>The Food and Drug Administration maintains this Web site with links to all state health departments or agencies</td>
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<td>Oak Ridge National Laboratory</td>
<td><a href="http://rais.ornl.gov/CRE/CRE_eco_state.html">http://rais.ornl.gov/CRE/CRE_eco_state.html</a></td>
<td>The Oak Ridge National Laboratory maintains this Web site with listings of all state departments of environment and/or natural resources protection. Information on local contaminants in well water can be found within state departments</td>
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<td>National Organizations</td>
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<td>NSF International</td>
<td><a href="http://www.nsf.org/consumer/drinking_water/dw_well.asp?program=WaterTre">www.nsf.org/consumer/drinking_water/dw_well.asp?program=WaterTre</a></td>
<td>NSF International maintains this Web site with information about private well water systems and groundwater</td>
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<td>State Contacts</td>
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<td>AZ</td>
<td><a href="http://www.azdeq.gov/environment/water/dw/download/privatewells.pdf">www.azdeq.gov/environment/water/dw/download/privatewells.pdf</a></td>
<td>AZ Department of Environmental Quality: &quot;Private Wells After the Fire”</td>
<td>(602) 771-4644 (602) 364-0720</td>
<td>AZ Department of Environmental Quality AZ Department of Health Services Bureau of State Laboratory Services</td>
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<td>AR</td>
<td><a href="http://www.healthyarkansas.com/eng/index.html">www.healthyarkansas.com/eng/index.html</a></td>
<td>AR Department of Health and Human Services, Division of Health: “Drinking Water Information for Arkansans”</td>
<td>(501) 661-2623</td>
<td>AR Department of Health and Human Services, Division of Health</td>
</tr>
<tr>
<td>CA</td>
<td><a href="http://www.water.ca.gov/drought/wellinfo.cfm">www.water.ca.gov/drought/wellinfo.cfm</a></td>
<td>California Department of Water Resources, Drought Preparedness: “Well Information”</td>
<td>(916) 653-5791</td>
<td>CA Department of Water Resources</td>
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<td><a href="http://www.groundwater.water.ca.gov/technical_assistance/gw_wells/gww_domown/index.cfm">www.groundwater.water.ca.gov/technical_assistance/gw_wells/gww_domown/index.cfm</a></td>
<td>“Domestic Well Owners”</td>
<td>(916) 653-6192</td>
<td>CA State Water Resources Control Board</td>
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<td>(916) 341-5779</td>
<td>Groundwater Ambient Monitoring and Assessment Program</td>
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<td>CO</td>
<td><a href="http://www.ext.colostate.edu/PUBS/NATRES/06700.html">www.ext.colostate.edu/PUBS/NATRES/06700.html</a></td>
<td>Colorado State University Cooperative Extension: “Private Wells for Home Use”</td>
<td>(303) 692-3500, ext 4</td>
<td>CO Department of Public Health and Environment Water Program</td>
</tr>
<tr>
<td>CT</td>
<td><a href="http://www.drought.state.ct.us/well.htm">www.drought.state.ct.us/well.htm</a></td>
<td>State of CT Drought Response: “Guidance for Private Well Users”</td>
<td>(860) 509-7389</td>
<td>CT Department of Public Health Lab Certification Program</td>
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<tr>
<td>DC</td>
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<td>There are no private water wells in the District of Columbia. All public water is through the Washington Aqueduct. See <a href="http://washingtonaqueduct.nab.usace.army.mil">http://washingtonaqueduct.nab.usace.army.mil</a></td>
<td>NA</td>
<td>NA</td>
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<td>FL</td>
<td><a href="http://www.doh.state.fl.us/environment/water/index.html#Public">www.doh.state.fl.us/environment/water/index.html#Public</a></td>
<td>FL Department of Health Bureau of Water Programs</td>
<td>(904) 791-1599</td>
<td>FL Department of Environmental Protection</td>
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<td>(850) 245-8059</td>
<td>FL Bureau of Water Programs</td>
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<td>(850) 245-4240</td>
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<td>GA</td>
<td><a href="http://www.engr.uga.edu/service/publications/c819-9c.html">www.engr.uga.edu/service/publications/c819-9c.html</a></td>
<td>University of Georgia Cooperative Extension</td>
<td>(404) 656-4807</td>
<td>GA Department of Natural Resources, Drinking Water Permitting Program</td>
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<tr>
<td>ID</td>
<td><a href="http://www.deq.state.id.us/water/prog_issues/ground_water/wells/overview.cfm">www.deq.state.id.us/water/prog_issues/ground_water/wells/overview.cfm</a></td>
<td>ID Department of Environmental Quality: “Ground Water Quality in Idaho: Ground Water and Private Wells”</td>
<td>(208) 334-2235, ext 233</td>
<td>ID State Department Health</td>
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<td>IL</td>
<td><a href="http://www.idph.state.il.us/envhealth/waterwells.htm">www.idph.state.il.us/envhealth/waterwells.htm</a></td>
<td>IL Department of Public Health: “Water Wells”</td>
<td>(217) 782-5830</td>
<td>IL Department of Public Health, Drinking Water Section</td>
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<td>IN</td>
<td><a href="http://www.in.gov/isdh/23258.htm">www.in.gov/isdh/23258.htm</a></td>
<td>IN Department of Natural Resources, Division of Water: “Recommended Standards for Private Water Wells” and “Ground Water Wells”</td>
<td>(317) 921-5500</td>
<td>IN State Department of Health Drinking Water Compliance Officer</td>
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<td><a href="http://www.in.gov/dnr/water/2457.htm">www.in.gov/dnr/water/2457.htm</a></td>
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<td>(317) 308-3286</td>
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<td>IA</td>
<td><a href="http://www.iowadnr.com/water/wells/index.html">www.iowadnr.com/water/wells/index.html</a></td>
<td>IA Department of Natural Resources, Water Supply Operations: “Iowa’s Private Water Well Program”</td>
<td>(800) 421-4692</td>
<td>University of Iowa Hygienic Labs</td>
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<td>(319) 335-4500</td>
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<td>KS</td>
<td><a href="http://www.oznet.ksu.edu/library/H20QL2/MF871.PDF">www.oznet.ksu.edu/library/H20QL2/MF871.PDF</a></td>
<td>Kansas State University: “Recommended Water Tests for Private Wells”</td>
<td>(785) 296-1639</td>
<td>KS Health and Environmental Lab</td>
</tr>
<tr>
<td>KY</td>
<td><a href="http://www.water.ky.gov/dw/profitips/welltest.htm">www.water.ky.gov/dw/profitips/welltest.htm</a></td>
<td>KY Division of Water: “Well Testing”</td>
<td>(502) 564-3410</td>
<td>KY Department of Environmental Protection Drinking Water Management</td>
</tr>
<tr>
<td>ME</td>
<td><a href="http://www.maine.gov/dhhs/eng/water/Template/PrivateWells/privatewells.htm">www.maine.gov/dhhs/eng/water/Template/PrivateWells/privatewells.htm</a></td>
<td>ME Division of Environmental Health Drinking Water Program: “Private Well Information for Homeowners”</td>
<td>(207) 287-1929</td>
<td>ME Division of Environmental Health, Drinking Water Program</td>
</tr>
<tr>
<td>MI</td>
<td><a href="http://web1.msue.msu.edu/waterqual/docs/wq02p1.html">http://web1.msue.msu.edu/waterqual/docs/wq02p1.html</a></td>
<td>Michigan State University Extension: “Testing of Private Wells”</td>
<td>(517) 353-5459</td>
<td>Michigan State University, Center for Environmental Toxicology</td>
</tr>
<tr>
<td>MN</td>
<td><a href="http://www.health.state.mn.us/divs/eh/wells">www.health.state.mn.us/divs/eh/wells</a></td>
<td>MN Department of Health: “Well Management: Protect Your Health—Test Your Private Well Water”</td>
<td>(800) 383-9808</td>
<td>MN Department of Health</td>
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<td>MO</td>
<td><a href="http://www.scchealth.org/docs/ph/ph_docs/phnews/jun01.html">www.scchealth.org/docs/ph/ph_docs/phnews/jun01.html</a></td>
<td>St Charles County, MO Division of Public Health: “Private Drinking Water Supplies”</td>
<td>(573) 751-4090, (800) 361-4827</td>
<td>MO Public Drinking Water Program</td>
</tr>
<tr>
<td>MT</td>
<td><a href="http://waterquality.montana.edu/docs/homeowners/qanda.shtml">http://waterquality.montana.edu/docs/homeowners/qanda.shtml</a></td>
<td>MT State University Bozeman, Department of Land Resources and Environmental Sciences: “Q&amp;A: Water Quality testing for Private Well Owners”</td>
<td>(406) 444-2642</td>
<td>MT Department of Public Health and Human Services, State Environmental Lab</td>
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<td><a href="http://www.dphhs.mt.gov/PHSD/Lab/Environmental/environ-lab-private-well-testing.shtml">www.dphhs.mt.gov/PHSD/Lab/Environmental/environ-lab-private-well-testing.shtml</a></td>
<td>MT Department of Public Health and Human Services: “Private Well Testing Program at the State Environmental Laboratory”</td>
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<td>NE</td>
<td><a href="http://www.hhs.state.ne.us/enh/recwrprac.htm">www.hhs.state.ne.us/enh/recwrprac.htm</a></td>
<td>NE Department of Health and Human Services: “Recommended Water Supply Practices”</td>
<td>(402) 471-2122</td>
<td>NE Department of Health and Human Services, Division of Labs</td>
</tr>
<tr>
<td>NH</td>
<td><a href="http://des.nh.gov/organization/divisions/water/dwgb/well_testing/index.htm">http://des.nh.gov/organization/divisions/water/dwgb/well_testing/index.htm</a></td>
<td>NH Department of Environmental Services, Water Division: Private Well Testing Program</td>
<td>(603) 271-3139</td>
<td>NH Department of Environmental Services</td>
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<td>(603) 271-2952</td>
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<td>NJ</td>
<td><a href="http://www.state.nj.us/dep/pwta">www.state.nj.us/dep/pwta</a></td>
<td>NJ Department of Environmental Protection: “Private Well Testing Act: Buying or Selling a Home With a Private Well?”</td>
<td>(609) 292-3950</td>
<td>NJ Department of Environmental Protection</td>
</tr>
<tr>
<td>NM</td>
<td><a href="http://www.nmenv.state.nm.us/dwb/Documents/Drought%20Fact%20Sheet.pdf">www.nmenv.state.nm.us/dwb/Documents/Drought%20Fact%20Sheet.pdf</a></td>
<td>NM Department of Health: “Information for Well Owners: Safe Drinking Water During a Drought”</td>
<td>(877) 654-8720</td>
<td>NM Drinking Water Bureau</td>
</tr>
<tr>
<td>NY</td>
<td><a href="http://www.health.state.ny.us/environmental/water/drinking/part15/appendixB/index.htm">www.health.state.ny.us/environmental/water/drinking/part15/appendixB/index.htm</a></td>
<td>NY Department of Health Drinking Water Protection Program: “Information on Protection of Water Wells”</td>
<td>(518) 485-5570</td>
<td>NY Department of Health Drinking Water Protection Program</td>
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<tr>
<td>NC</td>
<td><a href="http://h2o.enr.state.nc.us/aps/gpu/well_construction.htm">http://h2o.enr.state.nc.us/aps/gpu/well_construction.htm</a></td>
<td>NC Department of Environmental and Natural Resources Division of Water Quality, Aquifer Protection Section: “Well Construction: Technical Assistance”</td>
<td>(919) 733-3221</td>
<td>NC Department of Environmental and Natural Resources Division of Water Quality, Aquifer Protection Section</td>
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<td><a href="http://www.terraquestpc.com/downloads/brochures/WellAbandonment.pdf">www.terraquestpc.com/downloads/brochures/WellAbandonment.pdf</a></td>
<td>Division of Water Quality, Groundwater Section “Well Abandonment: Know the Rules to Protect Yourself and Our Groundwater”</td>
<td>(919) 733-7308</td>
<td>NC Department of Health and Human Services, referral to county health departments</td>
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<tr>
<td>ND</td>
<td><a href="http://www.health.state.nd.us/wq/gw/pubs/WellTestingBrochure.pdf">www.health.state.nd.us/wq/gw/pubs/WellTestingBrochure.pdf</a></td>
<td>ND Board of Water Well Contractors: “Private Water Well Construction Requirements”</td>
<td>(701) 328-6140</td>
<td>ND Department of Health Division of Chemistry</td>
</tr>
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<td>OH</td>
<td><a href="http://www.dnr.state.oh.us/water/pubs/fs.div/fctsh03/tabid/4083/Default.aspx">www.dnr.state.oh.us/water/pubs/fs.div/fctsh03/tabid/4083/Default.aspx</a></td>
<td>OH Department of Natural Resources Division of Water: “Water Efficiency for Private Well Owners” Sheet 92–3</td>
<td>(614) 265-6740</td>
<td>OH Department of Natural Resources Division of Water</td>
</tr>
<tr>
<td>OK</td>
<td><a href="http://www.owrb.ok.gov/supply/wd/wd_forms.php">www.owrb.ok.gov/supply/wd/wd_forms.php</a></td>
<td>OK Water Resources Board: “Water Well Drilling Forms”</td>
<td>(405) 530-8800</td>
<td>OK Water Resources Board</td>
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<td>OR</td>
<td><a href="http://oregon.gov/DHS/ph/dwp/index.shtml">http://oregon.gov/DHS/ph/dwp/index.shtml</a></td>
<td>OR Department Human Services Drinking Water Program: “Ensuring that Oregonians have Safe Drinking Water”</td>
<td>(971) 673-0405</td>
<td>OR Department of Human Resources Drinking Water Program</td>
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<td><a href="http://wellwater.oregonstate.edu/wells.php">http://wellwater.oregonstate.edu/wells.php</a></td>
<td>Oregon State University: “The Oregon Well Water Program: Wells”</td>
<td>(541) 766-3556</td>
<td>Oregon State University Well Water Program</td>
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<td>PA</td>
<td><a href="http://www.dep.state.pa.us/dep/deputate/watermg/wc/subjects/SrceProt/well/default.htm">www.dep.state.pa.us/dep/deputate/watermg/wc/subjects/SrceProt/well/default.htm</a></td>
<td>PA Department of Environmental Protection: “Private Water Wells in Pennsylvania”</td>
<td>(717) 787-8184</td>
<td>PA Department of Environmental Protection Bureau of Water Standards and Facility Regulation</td>
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<td>SD</td>
<td><a href="http://www.state.sd.us/denr/des/drinking/privatewell.htm">www.state.sd.us/denr/des/drinking/privatewell.htm</a></td>
<td>SD Department of Environment and Natural Resources: “General Private Well Sampling”</td>
<td>(605) 773-3754</td>
<td>SD Department of Environment and Natural Resources Drinking Water Program</td>
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<td>TN</td>
<td><a href="http://www.state.tn.us/environment/dws/WWregprog.shtml#well">www.state.tn.us/environment/dws/WWregprog.shtml#well</a></td>
<td>TN Department of Environment and Conservation Division of Water Supply: “Well Program”</td>
<td>(615) 532-0191</td>
<td>TN Department of Environmental Conservation Division of Water Supply</td>
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<td>TX</td>
<td><a href="http://www.license.state.tx.us/wwd/welldisinfection.pdf">www.license.state.tx.us/wwd/welldisinfection.pdf</a></td>
<td>TX Department of Licensing and Regulation Water Well Driller Program: “Private Well Disinfection”</td>
<td>(512) 463-7880 (800) 803-9202 (512) 458-7591</td>
<td>TX Department of Licensing and Regulation Well Driller/Pump Installer Program UT Department of Health UT Public Health Laboratory UT Division of Health</td>
</tr>
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<td>VA</td>
<td><a href="http://www.vdh.state.va.us/EnvironmentalHealth/ONSITE/regulations/PrivateWellInfo/index.htm">www.vdh.state.va.us/EnvironmentalHealth/ONSITE/regulations/PrivateWellInfo/index.htm</a></td>
<td>VA Department of Health Office of Environmental Health Services “Private Well Water Information”</td>
<td>(804) 864-7473</td>
<td>VA Department of Health</td>
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<td>WA</td>
<td><a href="http://www.doh.wa.gov/ehp/dw/Publications/331-349.pdf">www.doh.wa.gov/ehp/dw/Publications/331-349.pdf</a></td>
<td>WA Department of Health Office of Drinking Water: “Important Information for Private Well Owners”</td>
<td>SW: (360) 236-3030 NW: (253) 395-6750 E: (509) 456-3115</td>
<td>WA Department of Health Water Quality</td>
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<td>WV</td>
<td><a href="http://www.wvdhr.org/phs/water/index.asp">www.wvdhr.org/phs/water/index.asp</a></td>
<td>WV Department Heath and Human Resources Office of Environmental Health Services Public Health Sanitation Division: “Individual Water Supplies: Wells, Cisterns, and Springs”</td>
<td>(304) 293-5785 (304) 558-6732</td>
<td>WV University Office of Environmental Health and Safety WV Department of Health and Human Resources Office of Environmental Health Services Public Health Sanitation Division</td>
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<tr>
<td>WI</td>
<td><a href="http://www.dnr.state.wi.us/org/water/dwg/wells.htm">www.dnr.state.wi.us/org/water/dwg/wells.htm</a></td>
<td>WI Department of Natural Resources: “Drinking Water &amp; Groundwater”</td>
<td>(608) 266-2621</td>
<td>WI Department of Natural Resources</td>
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<td><a href="http://www.uwsp.edu/cnt/gndwater/privatewells">www.uwsp.edu/cnt/gndwater/privatewells</a></td>
<td>Groundwater Center University WI at Stevens Point: “For Private Well Users: Water Testing and Private Wells”</td>
<td>(715) 346-4270</td>
<td>Groundwater Center University WI at Stevens Point</td>
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<td><a href="http://wdh.state.wy.us/phsd/lab/waterlab.html">http://wdh.state.wy.us/phsd/lab/waterlab.html</a></td>
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**Drinking Water From Private Wells and Risks to Children**

Walter J. Rogan and Michael T. Brady

*Pediatrics* 2009;123;e1123

DOI: 10.1542/peds.2009-0752

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