American Academy of Pediatrics
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POLICY STATEMENT

Drinking Water From Private Wells and Risks to Children

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of All Children

Committee on Environmental Health and 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 and cause illness. Although the US Environmental Protection Agency and all states offer guidance for construction, maintenance, and testing of private wells, there is little regulation. 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 policy statement provides recommendations for inspection, testing, and remediation for wells providing drinking water for children. *Pediatrics* 2009;123:1599–1605

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Key Words
water, drinking water, well, well water, private well, groundwater, nitrate, waterborne disease

Abbreviation
EPA—Environmental Protection Agency

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

INTRODUCTION

Approximately 15% to 20% of households in the United States obtain their water from private wells.[1] Private wells are not subject to federal regulations of the US Environmental Protection Agency (EPA) or those of the Navajo Nation (which has its own EPA) and are minimally regulated by states. Coliform contamination of home private wells in Iowa in the 1990s was as high as 27%.[2] According to the Centers for Disease Control and Prevention, there were 31 waterborne disease outbreaks reported in the United States in 2005–2006, the latest years for which data are published.[3] Twenty of the outbreaks were from drinking water, of those, 8 were groundwater sources, usually private wells. Those caused illness in 458 people. 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.

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 under virtually all weather conditions. Aquifers are recharged from above by precipitation and runoff.

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, 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 installed rapidly and inexpensively 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. Because the water has been filtered by soil on the way down and is relatively safe from contamination while in the aquifer, water from these deeper wells is less likely to be contaminated.

TABLE 1 Relevant Chemicals in Well Water

Chemical	Source	Effects
Nitrates	Sewage Fertilizer	Methemoglobinemia Possible promoter of carcinogenesis
Volatile organics and pesticides	Dry-cleaning agents, gasoline, etc Often a source cannot be identified	Compound-specific effects
Lead	Leached from the brass in a submersible pump, from solder, or from old lead pipes	Impairs neurocognitive development
Arsenic	Occurs in specific rock formations (eg, the "slate belt" in the southeastern United States, Nevada, Alaska, and other areas in the western United States)	Acutely toxic carcinogenic (bladder, skin, and lung) in humans
Chromium VI	Used in the electroplating and other industries	Toxic and carcinogenic in laboratory animals
Radon	Naturally occurring radioactive gas	Carcinogenic (lung) in humans
Fluoride	Naturally in water in a few parts of the United States	Accepted preventive for dental caries, supplement if low concentrations Too much can cause dental fluorosis
Uranium	Naturally occurring in western mountains in the United States and in areas that have granite outcrops in the eastern United States	High dose is acutely toxic A source of ionizing radiation, which causes cancer
Methyl tertiary butyl ether	Partially oxidized hydrocarbon fuel additive used to oxygenate gasoline	Carcinogenic in laboratory animals
Perchlorate	Oxidizing agent used in rocket fuels, fireworks, and airbag inflators, among other applications Can occur naturally	Inhibits synthesis of thyroid hormone

COMPOSITION OF WELL WATER

Chemicals

The chemical composition of well water varies with region, underlying geologic formation, and environmental contamination and can be harmful, beneficial, or merely undesirable. For example, some fluoride is desirable in drinking water, whereas iron is undesirable. Many other chemicals, some of them potentially toxic, can contaminate well water, with their presence or absence attributable to naturally occurring geologic factors or dispersion from industry, farms, or business (Table 1). The presence of nitrates is particularly problematic for infants.[4] The most commonly occurring pollutant chemicals are volatile organics and pesticides, which may be identifiable in more than one third of US wells,[5] albeit mostly at concentrations below federal public water standards.

Many commercial sources will measure water hardness and concentrations of iron and manganese. Calcium and magnesium carbonate make water hard. Hard water is not toxic, but it may require treatment to prevent precipitation from clogging pipes and causing other problems, such as coating electric hot water heater elements and causing them to burn out. Manganese and iron can appear as rust-colored to black flecks and can stain clothing, plumbing, and fixtures. So-called iron and manganese bacteria can grow in such water and form visible black slimy colonies of microorganisms, sometime clogging pipes and faucets.

Microorganisms

Microorganisms, including bacteria, viruses, fungi, and parasites, can contaminate the ground water that supplies wells (Table 2). 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 commonest way of detecting fecal contamination of the water. Where available, testing for fecal coliforms and/or *Escherichia coli* may be performed as a combined assay with total coliforms and used for the annual bacterial testing. The absence of coliforms is good but not absolute evidence that significant fecal contamination is not present. 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 *E coli* or other pathogens.

Much of the information describing the pathogens that can 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.[3]

MITIGATION

Bacterial

If test results confirm bacterial contamination, the water system must be treated. The first approach is to inspect the well to make sure that there are no structural defects that may have fostered the contamination. "Shock chlorination," using concentrations of chlorine that are 100

TABLE 2 Pathogenic Microorganisms Found in Well Water

Bacteria	Viruses	Parasites
Escherichia coli, including O157:H7	Norovirus, sapovirus	*Giardia intestinalis*
Salmonella species	Rotavirus	*Cryptosporidium*
Shigella species	Enteroviruses	*Cyclospora*
Campylobacter jejuni	Hepatitis A and E	Microsporidia
Yersinia enterocolitica		*Isospora*
Mycobacterium avium-intracellulare		*Naegleria fowleri*

to 400 times the amount found in municipal water supplies, should be performed initially. This can be performed by the homeowner using household bleach (many Web sites [eg, www.water-research.net/shockwelldisinfection.htm] have instructions), but consultation with the health department or other experienced individuals is advisable before the first time.

Most other treatment measures require the service of a trained home water-treatment professional. If bacterial contamination persists despite efforts at continuous disinfection, natural or structural factors may be present that may not be under the control of the well owner. This may require that the well be closed and a new well be drilled. A certified well contractor should fill or seal the contaminated well.

Chemical

Chemical contaminants are approached by investigating the possibility that the contamination exists on the homeowner's or on an adjacent homeowner's property, such as from agricultural application of nitrogen-containing fertilizers, pesticide application, or fuel tanks. If the water supply cannot be remediated further and the well is still contaminated or the chemicals in question are naturally occurring, then it is possible to filter out or treat for virtually any chemical or biological contaminant.[6] However, treatment can become complex and/or expensive and can require meticulous or professional maintenance.

Because there are no standards for private wells for many contaminants of concern, those seeking a specific concentration 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.

RECOMMENDATIONS FOR PEDIATRICIANS

1. Pediatricians should ask whether a family drinks water from a private well at home, on vacation, when traveling, in child care, or other locations where they might drink water. This is particularly important for families with an infant. Families with children of high school age or younger should follow the algorithm in Appendix 1. A description of the tests and some rationale for their use is provided as follows.

Routine Testing

A. Purchase of a New Home With a Well

The builder should provide the results of coliform, nitrate, inorganic (total dissolved solids, iron, magnesium, calcium, chloride), fluoride, radon, and lead testing. If the well was shock-chlorinated after drilling, it should be retested for coliforms after some period of time as recommended by the local health department or agricultural extension agent. Have the builder or agent provide a site plan with the well, its water lines, and the septic tank and field.

B. Purchase/Rental/Lease of an Existing Home With a Well

Recommend including the well and septic field in any general inspection. If this cannot be performed, families should arrange for well inspection and testing as described in 1A and have the septic tank located and inspected to determine if it needs to be pumped. If there are filters, softeners, or other devices in the water-supply lines, determine from the seller or landlord what they are treating.

C. Vacation Homes, Camps, etc

A vacation home or camp with a shallow well and no other water source should be tested each season, if possible. If not, consider bottled water for infants or anyone with a compromised immune system. For a short stay, it may be safer and more convenient to use bottled water for drinking and cooking for everyone. Boiling water and filtration systems on the tap can reduce the risk of acquiring microorganisms from the untested well water. Boiling water means that the water must be brought to a full boil for 1 to 3 minutes, but recommendations vary and local advice should be sought. Filtration will allow viruses and possibly some *Giardia* cysts through.

Test kits are available for coliforms and nitrate, but it is difficult for the consumer to judge the accuracy and quality control for each product. Thus, for families with an infant, for whom it is crucial to know that the nitrate concentration is below 10 mg/L, home testing is inadvisable.

D. Child Care and School

Child care in rural and suburban areas can be in a setting where the water comes from a private well. Parents should inquire about the child care center's water source if they have any doubt. If the water comes from a well, parents should ask whether the well has been regularly and recently tested for nitrate and coliforms and what the results were. If recent results are not available, infants should be given bottled water until the well is shown not to have excessive nitrate concentrations.

E. Scheduled Testing

Every spring, the well should be examined to make sure that there are no mechanical problems. Well water should be tested annually for coliforms and nitrates. Testing more than once per year may be warranted in the following special situations: (1) someone in the household is pregnant or nursing; (2) there are unexplained illnesses in the household; (3) neighbors find a dangerous contaminant in their well water; (4) there is a change in the odor or taste of the well water; (5) there is a chemical spill in proximity of the well; or (6) there was a significant repair or replacement in the well. Routine testing for *Giardia* and *Cryptosporidium* organisms is not recommended because of the technical difficulty

(filtering very large volumes of water) and expense. However, in the following situations, it may be prudent to test for these parasites: (1) members of family have developed gastrointestinal disease attributable to *Giardia* and/or *Cryptosporidium* species; (2) the well is at the bottom of a hill and/or is shallow (vulnerable to runoff); or (3) the well is in a rural area where animals graze. The risk factors for *E coli* O157:H7 are similar to those for *Giardia* and *Cryptosporidium* species. So when these situations exist, vigilance should be maintained for *E coli* O157:H7 contamination and/or clinical symptoms. Much information about potential for contamination is local lore, so national sources of information about drinking water, such as the EPA Web site, repeatedly advise contact with local experts. Thus, the time of annual testing for nitrates and coliforms is a reminder to check with the health department about any water-quality problems that have emerged.

Occasional Testing

F. New Infant

A new infant or a child younger than 1 year in the home should prompt testing if the yearly test has indicated any fluctuation in nitrate concentrations or has never been performed. Even a breastfed infant may need water at some time, and boiling does not remove and can concentrate nitrate.

G. Damage or Disturbance to the Well

If a new submersible pump is installed or the well integrity is compromised, such as by a falling tree, a vehicle collision, a flood, or a cut to the water line during landscaping, the well should be tested and, if necessary, shock-chlorinated.

H. Sentinel Illnesses

Every episode of gastroenteritis does not require well testing or an investigation of the cause of the illness. However, if multiple individuals become ill with gastroenteritis, if the gastroenteritis is recurrent, or if a pathogen causing the gastroenteritis is a bacteria or parasite that may have been present in the well water as a result of fecal contamination, then well testing for pathogens is indicated. Any occurrence of methemoglobinemia in an infant consuming well water requires testing the well water for nitrate. An elevated blood lead concentration in a child living in a home built after 1978, or a persistently elevated blood lead concentration, requires testing for lead in well water. At some point in the evaluation of unusual or cryptogenic illness, the possibility of contaminated well water should be considered. For a list of symptoms associated with various well contaminants, see the work by Wagenet et al[6]

2. Fluoride is an accepted preventive for dental caries, and if a child's drinking water contains little or none, then supplements (available as drops or chewable tablets) are necessary. The American Academy of Pediatrics recommends no fluoride supplementation before 6 months of age; from 6 months to 3 years of age, children (including those who are breastfed) require fluoride supplementation if the water has a fluoride concentration of less than 0.3 ppm. Supplementation from 3 to 16 years of age is recommended where drinking water fluoride concentrations are less than 0.6 ppm.[7] To avoid dental fluorosis, water with fluoride concentrations greater than 2 ppm should not be consumed by children younger than 9 years.
3. Become familiar with well water considerations in your area. Advocate for water safety practices that will protect the health of children.

RECOMMENDATIONS TO GOVERNMENT

1. Local governments should provide access to information about local groundwater conditions. Recommendations for testing should be easily available with a telephone call or a Web-page visit. If water contamination becomes a public health issue, then multiple means of alerting and informing the public should be considered. In areas where agricultural land is being developed, paved, or put to any new use, local governments should consider mailing or using some other active means of getting their policies and recommendations concerning well testing to homes with permitted wells and the possibility of being affected by the new use.
2. Tests determined to be necessary for the safety and health of the families drinking well water should be convenient and, if possible, free or inexpensive (see Appendix 2 for current costs).
3. Community wells that serve just enough households to be regulated are sometimes exempted from testing that is required of larger systems. Although this may be appropriate, it should not be routine, and adequate local data should justify any exemption.
4. For housing that has drinking water supplied by a private well, states should require testing for coliforms, nitrate, fluoride, and any contaminant of local concern when a dwelling is sold, and the results should be made available to the buyer before closing.

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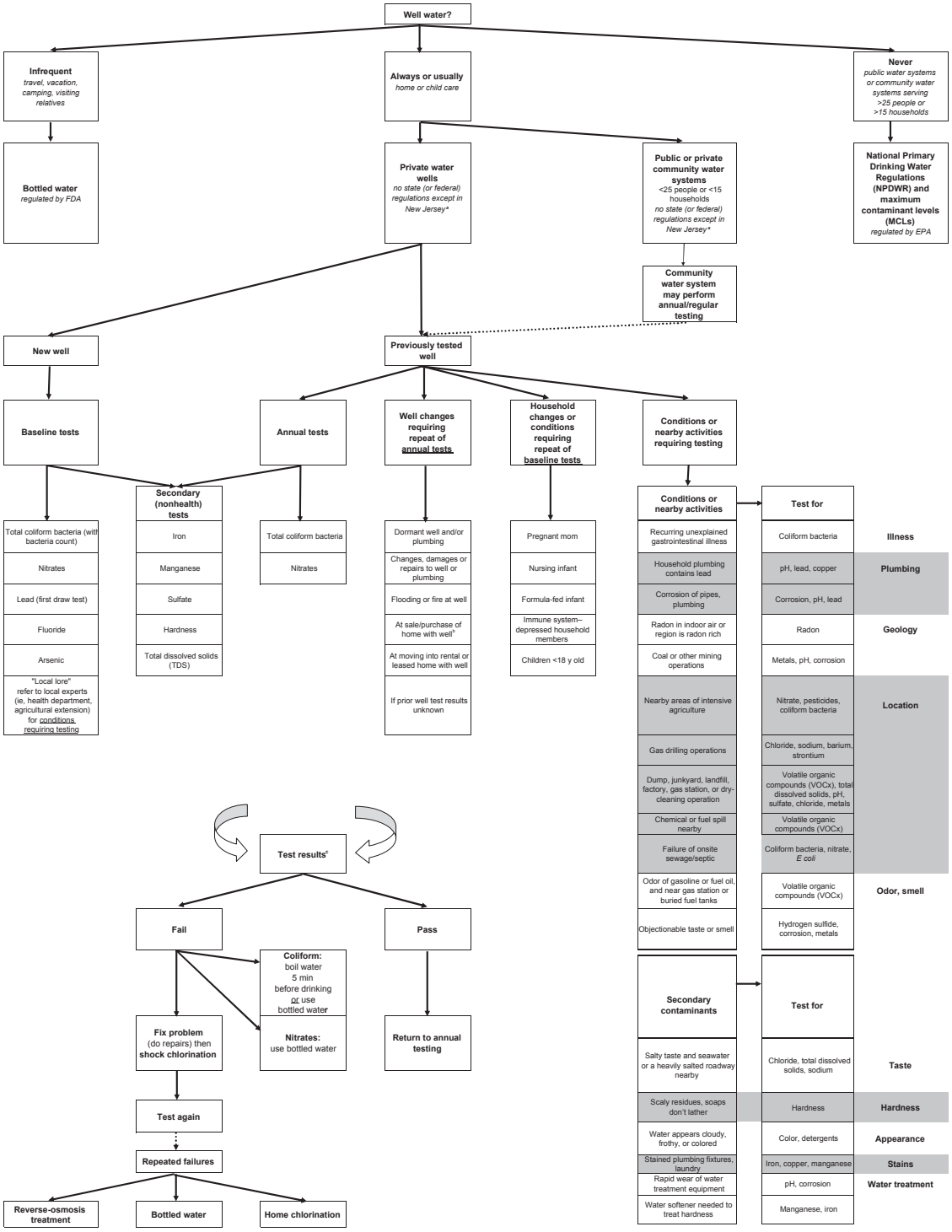
APPENDIX 1 Flowchart for Testing Well Water



[a] Testing at sale/purchase of home is required by law in state of New Jersey.
[b] Testing at sale/purchase of homes is often required by mortgage lender/bank, VA/FHA (Veteran Affairs/Federal Housing Administration), or county health department.
[c] Maximum contaminant levels from the EPA, same as those used by public water systems. FDA indicates Food and Drug Administration.

APPENDIX 2 Well Water Tests, Recommended Frequency, and Approximate Costs

Test	Frequency	Approximate Costs, 2006 $
Annual tests	Annually	30
Total coliform bacteria		
Nitrate		
Common inorganic test battery		25
Fluoride		
Chloride		
Hardness		
Copper	Every 3–5 y	
Iron		
pH		
Manganese		
Uranium		
Arsenic		10
FHA/VA loan for new well; additional 1-time tests		10
Color		
Turbidity		
Odor	Every 3–5 y	
Sodium		
Lead (first draw) (1-time test free for FHA/VA loans)	Every 10 y for homes built before 1985	15, stand-alone lead test
Additional "more thorough" 1-time tests		25
Zinc		
Cadmium		
Detergents		
Miscellaneous individual tests		15 each
Nitrate, chloride, hardness, copper, iron, pH, manganese, color, turbidity		
Fluoride, sodium, detergents, conductivity, total solids, ammonia nitrogen		
Arsenic, barium, cadmium, chromium, lead, silver, selenium, uranium		
Organic compound tests		
Volatile petroleum screen (gasoline, MTBE), in water		60
Volatile petroleum screen (gasoline, MTBE), in soil		80
Diesel organics and fuel oil		140
Volatile organics screen (especially solvents, degreasers)		135
Semivolatiles organic screen (including wood preservatives)		200
Semivolatiles organic screen plus chlordane, PCBs, and toxaphene		275
PCBs		150
Chlorinated acids: herbicides screen		200
Carbamate pesticides		125
Radiologic tests		
Radon in water		25
Radon in air		20
Radon in air (long-term) "α track"		25
Gross α (radioactivity in water; does not test for radon)	Every 5–10 y	55
Gross β		55
Radium (if gross $\alpha > 5$ pCi)		195
Radium 228 (only)		150
Gamma		50

FHA indicates Federal Housing Administration; VA, Veteran Affairs; MTBE, methyl tertiary butyl ether; PCB, polychlorinated biphenyl.

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