# Evaluation of Household Water Quality in Warren County, Virginia

**JUNE 2012**

**VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM**

## Background

More than 1.7 million Virginians use private water supplies such as wells, springs, and cisterns. The Virginia Household Water Quality Program (VAHWQP) began in 1989 with the purpose of improving the water quality of Virginians reliant on private water supplies. Since then drinking water clinics have been conducted in 86 counties across Virginia and samples analyzed from more than 14,500 households. In 2007, the Virginia Master Well Owner Network (VAMWON) was formed to support the VAHWQP. Virginia Cooperative Extension agents and volunteers participate in a 1 day VAMWON training workshop that covers private water system maintenance and protection, routine water testing, and water treatment basics. They are then able to educate others about their private water supplies. More information about these programs may be found at our website: www.wellwater.bse.vt.edu.

Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for maintaining their water systems, for monitoring water quality, and for taking appropriate steps to address problems should they arise. The EPA Safe Drinking Water Standards are good guidelines for assessing water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining. Testing water annually, and routinely inspecting and maintaining a water supply system will help keep water safe.

### Geology

Most of Warren County lies within the ***Valley and Ridge*** physiographic province of Virginia; the far western strip of the county lies within the **Blue Ridge** province. The Valley and Ridge is located to the west of the Blue Ridge province and is underlain by consolidated sedimentary rocks deposited by ancient seas. In the lowlands, such as the Shenandoah Valley, limestone and dolomite occur beneath the surface. These rock types have openings to yield water to wells and form the most productive aquifers in Virginia's consolidated rock formations. In contrast, the ridges and upland areas are often composed of sandstone and shale, which lack the cracks and pores to transmit or store water. Therefore, in ridges and upland areas, there is often only enough water for rural and domestic water supplies.

The connection between groundwater and surface water plays a major role in groundwater recharge in the Valley and Ridge. Streams often cross fault zones leading to recharge of aquifers and wells in the fault zone area. Recharge also occurs through surface runoff travelling into limestone sinkholes, bypassing filtration through the soil. This can cause serious water quality problems since polluted surface water may be introduced directly into the groundwater system. In addition, calcium and magnesium from carbonate formations contribute to high mineral content and can cause hard water

The Blue Ridge Province is a relatively narrow zone to the west of the Piedmont, from 4 to 25 miles wide, with mountains of some of the highest elevations in the state. Beneath a thin layer of soil and weathered rock lies the bedrock, a relatively impervious zone containing water primarily in joints, fractures, and faults. On the eastern flank of the Blue Ridge, igneous and metamorphic rocks are most common; sedimentary rocks are more common on the western flank. Steep terrain and thin soil covering result in rapid surface run-off and low ground water recharge. There has been little residential or industrial development in the Blue Ridge itself, so ground water use has been mainly for domestic needs rather than for public wells. The lower slopes of the mountains are the most favorable areas for ground water accumulation. Springs are common and are often used for private water supplies. Because the rocks in the Blue Ridge are relatively insoluble, the ground water is not severely mineralized, but iron content is high in some locations. (GWPSC, 2008).

**Overview**

In June 2012, 44 residents from Warren County participated in a drinking water clinic sponsored by local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. Clinic participants received a confidential water sample analysis and attended educational meetings where they learned how to interpret their water test results and address potential issues. The most common household water quality issues identified as a result of the analyses for the participants in Warren County were high levels of hardness, sodium, iron and manganese, and the presence of total coliform bacteria. In addition, levels of lead and copper exceeding recommendations for household water were detected in some first draw samples. *Figure 1*, found at the end of this report, shows these common water quality issues along with basic information on standards, causes, and treatment options.

**Drinking Water Clinic Process**

Any resident relying on a well, spring, or cistern was welcome to participate in the clinic. Advertising began about 8 weeks prior to an initial kickoff meeting and utilized local media outlets, announcements at other VCE meetings, and word of mouth. Pre-registration was encouraged.

***Kickoff meeting:*** Participants were given a brief presentation that addressed common water quality issues in the area, an introduction to parameters included in the analysis, and instructions for collecting their sample. Sample kits with sampling instructions and a short questionnaire were distributed. The questionnaire was designed to collect information about characteristics of the water supply (e.g. age, depth, and location), the home (e.g. age, plumbing materials, existing water treatment), and any existing perceived water quality issues. The questionnaire also gathered basic demographic information about the household, including household income, age and education level of residents, and whether or not household members drink the water from the private water supply being tested. The purpose of the clinic was to build awareness among private water supply users about protection, maintenance, and routine testing of their water supply.

Participants were instructed to drop off their samples and completed questionnaires at a predetermined location on a specific date and time.

***Sample collection:*** Following collection at a central location, all samples were iced in coolers and promptly transported to Virginia Tech for analysis.

***Analysis:*** Samples were analyzed for the following water quality parameters: iron, manganese, nitrate, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, copper, lead, arsenic, total coliform bacteria, and *E. coli*. General water chemistry and bacteriological analyses were performed by the Department of Biological Systems Engineering Water Quality Laboratory at Virginia Tech. All water quality analyses were performed using standard analytical procedures.

The EPA Safe Drinking Water Standards, which are enforced for public water systems in the U.S., were used as guidelines for this program. Water quality parameters not within range of these guidelines were identified on each water sample report. Reports were prepared and sealed in envelopes for confidential distribution to clinic participants.

***Interpretation meeting:*** At the interpretation meeting, participants received their confidential water test reports, and VCE personnel made a presentation providing a general explanation of what the numbers on the reports indicated. In addition, general tips for maintenance and care of private water supply systems, routine water quality testing recommendations, and possible options for correcting water problems were discussed. Participants were encouraged to ask questions and discuss findings either with the rest of the group or one-on-one with VCE personnel after the meeting.

## Findings and Results

**Profile of Household Water Supplies**

The questionnaire responses, provided by all 44 participants at the clinic, helped to characterize the tested water supplies. All of the participants in the Warren County clinic indicated their water supply was a well.

The major source of potential contamination near the home (within 100 feet of the well) was identified as a septic system (18.8%) or an oil tank (9%). According to participants, larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies. Forty-five percent of Warren respondents indicated that their water supply was located within one-half mile of a major farm animal operation and 34% indicated that their supply was within one half-mile of a field crop operation. Other nearby sources of potential contamination included commercial storage tanks and golf courses.

On the questionnaire, participants also described the type of material used for water distribution in each home. The two most common pipe materials in Warren County were copper (52.3%) and plastic (50%). Many homes were reported as having more than one type of plumbing material, which is quite common.

To properly evaluate the quality of water supplies in relation to the sampling point, participants were asked if their water systems had water treatment devices currently installed, and if so, the type of device. Almost 55% percent of Warren participants reported at least one treatment device installed. The most commonly reported treatment device was a sediment filter (31.8%) followed by a water softener, installed by 29.5% of participants.

**Participants' Perceptions of Household Water Quality**

Participants were asked whether they perceived their water supply to have any of the following characteristics: (1) corrosive to pipes or plumbing fixtures; (2) unpleasant taste; (3) objectionable odor; (4) unnatural color or appearance; (5) floating, suspended, or settled particles in the water; and (6) staining of plumbing fixtures, cooking appliances/utensils, or laundry.

Staining problems were reported by 50% of clinic participants in Warren County. Rusty (36%) was the most commonly reported stain. An objectionable odor was reported by 22% of clinic participants, mainly citing a rotten egg smell in their water. About 22% reported unpleasant tastes, indicating sulfur and metallic as the most common. About 25% reported having particles in their water, the most common being white flakes. About 16% of participants reported having corrosion problems. Finally, nearly 16% reported an unnatural appearance in their water, observed most commonly as yellow or muddy.

**Bacteriological Analysis**

Private water supply systems can become contaminated with potentially harmful bacteria and other microorganisms. Microbiological contamination of drinking water can cause short-term gastrointestinal disorders, such as cramps and diarrhea that may be mild to very severe. Other diseases that may be contracted from drinking contaminated water include viral hepatitis A, salmonella infections, dysentery, typhoid fever, and cholera.

Microbiological contamination of a water supply is typically detected with a test for total coliform bacteria. Coliform bacteria are present in the digestive systems of humans and animals and can be found in the soil and in decaying vegetation. While coliform bacteria do not cause disease, they are indicators of the possible presence of disease causing bacteria, so their presence in drinking water warrants additional testing.

Positive total coliform bacteria tests are often confirmed with a re-test. If coliform bacteria are present in a water supply, possible pathways or sources include: (1) improper well location or inadequate construction or maintenance (e.g. well too close to septic, well not fitted with sanitary cap); (2) contamination of the household plumbing system (e.g. contaminated faucet, water heater); and (3) contamination of the groundwater itself (perhaps due to surface water/groundwater interaction).

The presence of total coliform bacteria in a water sample triggers testing for the presence of *E. coli* bacteria. If *E. coli* are present, it indicates that human or animal waste is entering the water supply.

Of the 44 samples collected in Warren County, 47.7% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 4.5% of the samples tested positive for *E. coli* bacteria.

Program participants whose water tested positive (present) for total coliform bacteria were encouraged to retest their water to rule out possible cross contamination, and were given information regarding emergency disinfection, well improvements, and septic system maintenance. Any participant with a sample that tested positive for *E. coli*, was encouraged to take more immediate action, such as boiling water or using another source of water known to be safe until the source of contamination could be addressed and the water supply system disinfected. After taking initial corrective measures, participants were advised to have their water retested for total coliform, followed by testing for *E. coli*, if warranted. In addition, participants were provided with resources that discussed continuous disinfection treatment options.

Table 1, found at the end of this report, shows the general water chemistry and bacteriological analysis contaminant levels for the Warren drinking water clinic participants.

**Chemical Analysis**

As mentioned previously, all samples were tested for the following parameters: iron, manganese, nitrate, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, lead, arsenic, and copper. Selected parameters of particular interest for the Warren County drinking water clinic samples are discussed below.

**Lead**

Lead is not commonly found in groundwater, but may enter household water as it travels through plumbing materials. Lead can cause irreversible damage to the brain, kidneys, nervous system, and blood cells, and is a cumulative poison, meaning that it can accumulate in the body until it reaches toxic levels. Young children are most susceptible, and mental and physical development can be irreversibly stunted by lead poisoning. Lead may be found in household water from homes built prior to 1930 with lead pipes, prior to 1986 with lead solder, or in new homes with “lead-free” brass components, which may legally contain up to 8% lead. The EPA limit for lead in public drinking water is 0 mg/L, and the health action limit is 0.015 mg/L. In these drinking water clinics, participants collect two samples from their taps: 1) a *first draw* sample, which is drawn first thing in the morning after the water hasn’t been used in at least 6 hours, and therefore has a substantial contact time with the plumbing and 2) a *flushed* sample, taken after water has been run for 5 minutes, and therefore has not had significant contact with pipes. If lead is present above 0.015 mg/L in the first draw sample, but is not detected in the flushed sample, simply running the water for a few minutes prior to collecting water for drinking may remedy the problem. Alternatively, addressing the corrosiveness (acidity) of your water by installing an acid neutralizing filter may solve the problem. Reverse osmosis systems or activated carbon filters (labeled for lead removal) can remove it from your water.

In the Warren County clinic, 16.7% of first draw samples exceeded 0.015 mg/L lead. No flushed samples exceeded 0.015 mg/L.

**Sodium**

The EPA limit for sodium in drinking water (20 mg/L) is targeted for the most at-risk segment of the population, which are those with severe heart or high-blood pressure problems. The variation in sodium added to water by softeners is very large (ranging from around 50 mg/L to above 300 mg/L). Sodium in drinking water should be considered with respect to sodium intake in the diet. The average American adult consumes 2000 - 4000 mg of sodium per day. If concerned about sodium in water, intake should be discussed with a physician.

Of the 44 Warren clinic samples, 31.8% exceeded the EPA standard of 20 mg/L. Some of this sodium could result from sodium naturally present in the geology (rocks, sediment) where well water originates, but the primary source of sodium is a water softener. There are several options for addressing sodium levels in softened water. Since only water used for washing needs to be softened, a water treatment specialist can bypass cold water lines around the softener, softening only the hot water and reducing the sodium in the cold drinking water. Another option is using potassium chloride instead of sodium chloride for the softener, although this option is more expensive.

**Hardness**

Hard water contains high levels of calcium and magnesium ions that dissolve into groundwater while the water is in contact with limestone and other minerals. Hard water is a nuisance and not a health risk.

In Warren County, 22.7% of the clinic samples were considered "very hard" (exceeding 180mg/L of hardness). Hard water is indicated by scale build-up in pipes and on appliances, decreased cleaning action of soaps and detergents, and reduced efficiency and lifespan of water heaters. Ion exchange water softeners are typically used to remove water hardness.

**Iron and Manganese**

Iron and manganese generally originate from certain rock formations, and do not usually present a health risk. These minerals can be objectionable if present in amounts greater than 0.3 mg/L for iron and 0.05 mg/L for manganese. They tend to occur together, but don't always. Excessive iron can leave red-brown or orange stains on plumbing fixtures and laundry, and manganese tends to result in similar, but brown-black stains. Both can give water a bitter or metallic taste. In Warren County, iron and manganese were each present in levels exceeding recommendations in 16.7% of the samples.

## Conclusion

Clinic participants received objective information about caring for and maintaining their private water supply systems, and specific advice about addressing any problems that were identified through the analysis of their water sample.

**References**

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Virginia Department of Environmental Protection Groundwater Protection Steering Committee. Virginia's Five Physiographic Provinces. http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/GroundwaterProtectionSteeringCommittee.aspx. Accessed online 8/2012.

**Additional Resources**

For more information about the water quality problems described in this document, please refer to our website. Here you will find resources for household water testing and interpretation, water quality problems, and solutions: www.wellwater.bse.vt.edu/resources.php

**Acknowledgements**

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**Figure 1.** The most common household water quality issues found in the 44 Warren clinic participant samples were high levels of sodium, hardness, iron and manganese, and the presence of total coliform bacteria.

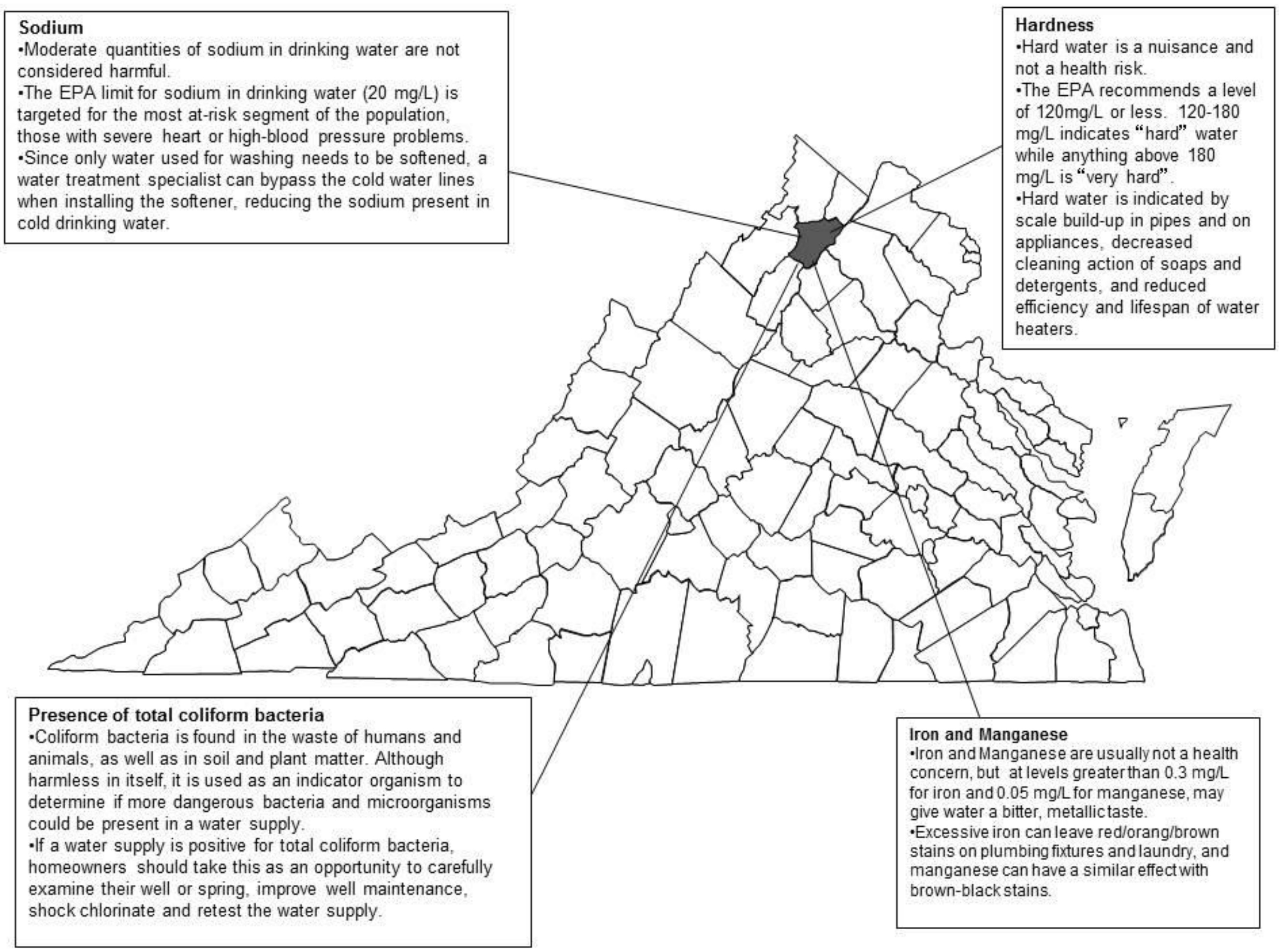

**Table 1.** General water chemistry and bacteriological analysis contaminant levels for the Warren County drinking water clinic participants (N=44). This program uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems, as guidelines for private water supplies.

| *2012 Warren County<br>VAHWQP Drinking Water Clinic Results<br>N = 44 samples* | | | | |
|---|---|---|---|---|
| **Test** | **EPA Standard** | **Average** | **Maximum Value** | **% Exceeding Standard** |
| Iron (mg/L) | 0.3 | 0.237 | 2.804 | 18.2 |
| Manganese (mg/L) | 0.05 | 0.073 | 1.102 | 18.2 |
| Hardness (mg/L) | 180 | 90.7 | 373.5 | 22.7 |
| Sulfate (mg/L) | 250 | 101 | 1344 | 6.8 |
| Fluoride (mg/L) | 2.0/4.0 | 0.16 | 1.35 | 0.0 |
| Total Dissolved Solids | 500 | 273 | 941 | 11.4 |
| pH | 6.5 to 8.5 | 7.0 | 6.1 (min)<br>7.9 (max) | 13.6 (<6.5)<br>0 (>8.5) |
| Sodium (mg/L) | 20 | 43.26 | 248.2 | 31.8 |
| Nitrate - N (mg/L) | 10 | 1.799 | 17.338 | 2.3 |
| Copper-First Draw (mg/L) | 1.0/1.3 | 0.591 | 5.367 | 15.9 |
| Copper-Flushed (mg/L) | 1.0/1.3 | 0.065 | 1.417 | 2.3 |
| Lead-First Draw (mg/L) | 0.015 | 0.006 | 0.029 | 13.6 |
| Lead-Flushed (mg/L) | 0.015 | 0 | 0.002 | 0.0 |
| Arsenic-First Draw (mg/L) | 0.010 | DL | 0 | 0.0 |
| Arsenic-Flushed (mg/L) | 0.010 | DL | 0 | 0.0 |
| Total Coliform Bacteria | ABSENT | 91 | 1708 | 47.7 |
| E. coli Bacteria | ABSENT | 0 | 12 | 4.5 |