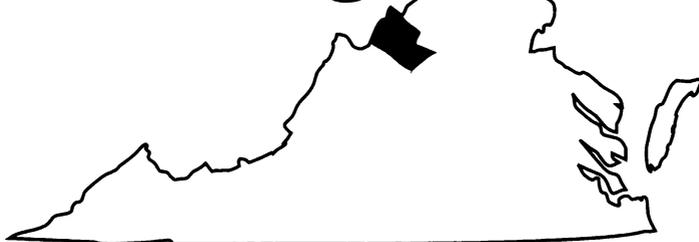


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# Evaluation of Household Water Quality in Rockingham County, Virginia



August 2000

Household Water Quality Series 45  
Department of Biological Systems Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24061-0303

Virginia Cooperative Extension



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# **EVALUATION OF HOUSEHOLD WATER QUALITY IN ROCKINGHAM COUNTY, VIRGINIA**

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Household Water Quality Series 45

August 2000

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# Evaluation of Household Water Quality in Rockingham County, Virginia

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## ABSTRACT

During Summer 1999, a program of household water quality education, which included water sampling, testing, and diagnosis, was conducted in Rockingham County, Virginia. Participation in the water quality program was made available to any Rockingham County resident who utilized a private, individual water supply. During the course of the project, 300 households submitted water samples which were analyzed for iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index, copper, sodium, nitrate, and total coliform and E. coli bacteria. These analyses identified the major household water quality problems in Rockingham County as iron/manganese, hardness, total dissolved solids, and bacteria. Additionally, a number of samples were determined to have concentrations of sodium and nitrate high enough to possibly lead to health complications for at-risk segments of the population.

After the completion of the general water testing program, water supplies from 16 households were resampled for the testing of 23 pesticides and other chemical compounds. None of the samples had a concentration of any of these contaminants exceeding EPA Health Advisory or Maximum Contaminant Levels. A total of eleven detections were observed in seven separate samples.

Following completion of the program, a survey was mailed to the 300 participants. One hundred and thirty-eight participants returned survey forms on which they identified their reason(s) for participating in such a program; the primary reason being concern about safety of their water supply. Returned survey forms also provided insight into measures participants had already taken, or planned to take, to improve the quality of their water supply. More than one-half of the households who reported having at least one water quality problem had taken, or planned to take, at least one measure to improve the quality of their water supply. Fifteen percent or more of all participants had taken, or planned to take, one or both of the following actions: purchase or rent water treatment equipment and shock chlorinate the water system.

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## **ACKNOWLEDGMENTS**

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Many thanks are due the residents of Rockingham County who participated in the educational program. Without their enthusiasm and cooperation, the program could not have succeeded. In addition to their monetary support through testing fees, CSREES/USDA Water Quality Program Support 3-d funds were available for this program. The Rockingham County Board of Supervisors is especially acknowledged for the funding support they provided.

Special thanks are extended to all others who provided support in terms of publicity, encouragement, and interest, thus contributing to the success of the household water quality educational program. Especially supportive were personnel of the Virginia Department of Health and USDA-Natural Resources Conservation Service who shared their expertise at the public meetings and followed up on individual requests.

Additional Virginia Cooperative Extension personnel contributed substantial time toward the project. Rockingham Cooperative Extension secretaries, Virginia Croushorn and Crystal Collins were instrumental in handling mailings, addressing telephone requests for information and pre-registration, and recordkeeping. The following Extension Agents also played important roles: Kelly Coggsdale, Peter F. Martens III, and Phil Schroeder, Rockingham County; Cristin Campbell and Jerry Swisher, Augusta County; and Brenda Mosby, Rockbridge County. Also contributing to the project was Janis Lucas, Augusta County SCNEP Program Assistant.

Responsible for the majority of the water quality analyses, as well as coordination among the various labs and for much of the data management, was the Water Quality Laboratory of the Department of Biological Systems Engineering at Virginia Tech. Julie Jordan, Laboratory Supervisor, and her staff, are especially acknowledged for their efforts. Assisting with the general water chemistry analysis was the Soils Testing Laboratory of the Department of Crop and Soil Environmental Sciences at Virginia Tech. The Pesticide Research Laboratory, of the Biochemistry and Anaerobic Microbiology Department of Virginia Tech, performed the pesticide analyses.

Additional support from Virginia Tech should also be noted. Judy Poff of the Virginia Water Resources Research Center was instrumental in providing educational publications for participants at the public meetings. Joe Gray of the Virginia Cooperative Extension Distribution Center is appreciated for his assistance in preparing and mailing the evaluation survey packets to participants. Appreciation is due Diane Mahaffey for her efforts in preparing project forms and in typing this manuscript. In addition, Bev Brinlee and Tim FisherPoff are acknowledged for their editorial contributions.

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# INTRODUCTION

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The water supply and wastewater disposal requirements of the vast majority of rural homes and farms throughout Virginia are met by individual water supply and wastewater disposal systems. In Rockingham County, for example, nearly two-thirds (66%) of all housing units are served by individual water systems (Koebel et al., 1993). Virtually all of these homes depend on groundwater sources.

In the rural areas of Rockingham County, most wells were drilled only for farm or domestic water supply. George and Gray (1988) have estimated that 95% of Rockingham County's drilled wells and essentially all of its dug/bored wells are inadequately constructed. It was also estimated that nearly one in one hundred households have failing or inadequate waste disposal systems.

Rockingham County has a land area of 851 square miles and lies almost wholly within the Valley and Ridge physiographic province with its far southeastern portion in the Blue Ridge physiographic province. The entire county drains into various tributaries of the Shenandoah River. The Blue Ridge Mountains form the southeastern border of Rockingham County, while West Virginia borders the northwestern edge of the county.

County population increased by more than 7% during the period 1980-90. Some new home sites are rural-based without public water and sewage services. As rural home sites encroach on agricultural land, the water supply becomes suspect to residents. Of equal importance is the potential failure of septic systems, since a number of home sites are on land less than ideal for a properly functioning septic system.

In addressing similar concerns, Ross et al. (1991) initiated a pilot program of household water quality education in Warren County, Virginia, which included water sampling, testing, and diagnosis. Based on requests and support from local interests, subsequent programs have been conducted in 61 additional counties. During the course of these projects, more than 9,000 households submitted water samples through local Virginia Cooperative Extension offices to be analyzed for the following: iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index, copper, sodium, nitrate, and total coliform and fecal coliform/E. coli bacteria.

Major household water quality problems identified, as a result of these previous analyses, were determined to be iron/manganese, hardness, fluoride, total dissolved solids, and because of their potential health significance, corrosivity, bacteria, and to a lesser extent, sodium and nitrate, although the occurrence and extent of these problems varied across counties. In most county programs, a limited number of additional samples from "high-risk" households were tested for over two dozen pesticides and other chemical compounds. Most of these compounds have been detected in measurable quantities in one or more samples, with several values exceeding a corresponding U.S. Environmental Protection Agency Health Advisory Level (HAL) or Maximum Contaminant Level (MCL). It was the need to assess the current state of rural household water supplies in Rockingham County, in addressing the above water quality issues, that led to the implementation of the Rockingham County Household Water Quality Education Program.

# **OBJECTIVES**

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The primary goal of this project was to conduct an educational program on household water quality to include water testing/diagnosis in Rockingham County, Virginia. The general program objectives were to: (1) improve the quality of life of rural homeowners by increasing awareness and understanding of water quality problems, protection strategies, and treatment alternatives; and (2) create a groundwater quality data inventory to assist local governments in land use and groundwater management planning.

# **METHODS**

---

A household water quality educational program was offered through the local Virginia Cooperative Extension Office in Harrisonburg, Virginia, during Summer 1999 to Rockingham County residents who utilized private, individual water supplies. The program was patterned after the model developed under the pilot educational program completed in 1989 in Warren County (Ross et al., 1991) and followed a corresponding program in neighboring Augusta County. Local news media and agency newsletters publicized the program, and a program fact sheet was prepared (see Appendix).

The program was launched through meetings held in Bridgewater, Broadway, McGaheysville, and Montezuma throughout August. Attendees of these initial meetings, who paid \$30 per household water sample to be submitted, were presented with information on local hydrogeologic characteristics in relation to groundwater pollution, likely sources of, and activities contributing to, groundwater contamination, the nature of household water quality problems (both nuisance and health-related), and specifics of the water testing program to follow.

Provisions were made to analyze up to several hundred household water samples in Rockingham County. Water sampling kits, for use by the participants themselves, were made available at the meeting and at the Rockingham County Cooperative Extension Office after the meetings for late registrants. Two types of water sampling kits were distributed: (1) general water chemistry analysis for iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index (Langlier), copper, sodium, and nitrate; and (2) bacteriological analysis (total coliform and E. coli).

The sampling kits included a 250 ml plastic bottle for general water chemistry samples and a sample identification form (see Appendix). The form included sampling instructions and a questionnaire on which participants were asked to describe the characteristics of their water supply. Also included in the kits was a 125 ml sterilized plastic bottle for bacteriological sampling. Instructions called for sampling from a drinking water tap and for flushing water systems prior to sampling to minimize contaminants contributed by the plumbing system. Persons who already had a water treatment device, such as a water softener, were requested to provide information about the type of equipment so that effective evaluation of their water quality and proper interpretation of results could be obtained, as further explained below.

Water samples were collected on August 10, 17, 24, and 31 at various locations throughout the county. At the close of each collection day, all samples were packed in ice and immediately delivered to Virginia Tech in Blacksburg for analysis.

The water quality analysis was coordinated by the Department of Biological Systems Engineering Water Quality Laboratory at Virginia Tech. The Soils Testing Laboratory of the Department of Crop and Soil Environmental Sciences at Virginia Tech was subcontracted to analyze samples for several of the constituents. Water quality analyses were performed using standard analytical procedures (USEPA, 1979).

After the analysis had been completed, participants were reminded by mail to attend subsequent meetings held throughout the county during September to obtain and discuss the test results and management practices to reduce or prevent water contamination. Complete test results were ultimately mailed to those participants who could not attend any of the meetings. A sample report form and accompanying report interpretation are shown in the Appendix.

At the conclusion of the general water testing program described above, participating households were given the opportunity to have their water further tested, for the presence of 23 pesticides and other chemical compounds, at a cost of \$75 per sample. The Pesticide Research Laboratory of the Biochemistry and Anaerobic Microbiology Department at Virginia Tech performed the analysis. Sample jars and forms (see Appendix) were provided, whereby local project personnel assisted in collecting the samples on December 6, 1999.

At the conclusion of the program, an evaluation survey was mailed to participants (see Appendix). The objectives of the survey were to determine (1) the reasons for participation in the educational program and for having household water tested, and (2) what actions to correct water quality problems the participants had taken, or planned to take, as a result of participation in the program. Limited socio-economic information was also requested to obtain a profile of the total audience reached by the program.

In addressing overall project objective 2, local government and public officials were kept apprised of water quality test results, during the course of the program and at its completion. While the project was designed to involve voluntary participation, and quality control in sampling was not assured, the information gathered was nevertheless deemed useful for water quality assessment and planning at county and regional levels.

## **FINDINGS AND RESULTS**

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During the course of the project, 300 individual household water samples were returned for general water chemistry and bacteriological analysis from all areas of the county. Two surveys were distributed to all water testing participants: One, the questionnaire with the water sampling kit, to be completed and returned by all participants with the sample submitted for analysis, and the other, an evaluation of the completed programs (see Appendix). For the latter, of the 300 forms mailed, 138 were returned (a 46% response rate). Both surveys provided insight into the characteristics of the households and their water supplies.

### **Profile of Participant Households**

The average length of the respondents' residence in Rockingham County was 19 years. The length of residence reported ranged from 1 to 64 years. Twenty-two percent of those responding had lived in Rockingham County for 5 years or less. The size of the respondents'

households ranged from one to eleven members; average household size was 3.02. It can, therefore, be estimated that more than 900 Rockingham County residents were directly impacted by the water analysis/diagnosis aspect of the program.

More than one-half (53%) of the respondents were college graduates and a substantial majority of those indicating educational level achieved had at least a complete high school education (see Figure 1); facts that are not surprising, since it is likely that such individuals would have a greater awareness and understanding of water quality issues and be more likely to participate in such a program.

Participation in the program was on the high end of income distribution. Figure 2, which shows the family income (before taxes) of the respondents, indicates that a majority of the respondents exceeded the median family income (\$33,442 according to the 1990 Census) of Rockingham County (Koebel et al., 1993). Sixteen percent of respondents declined to indicate family income.

## **Profile of Household Water Supplies**

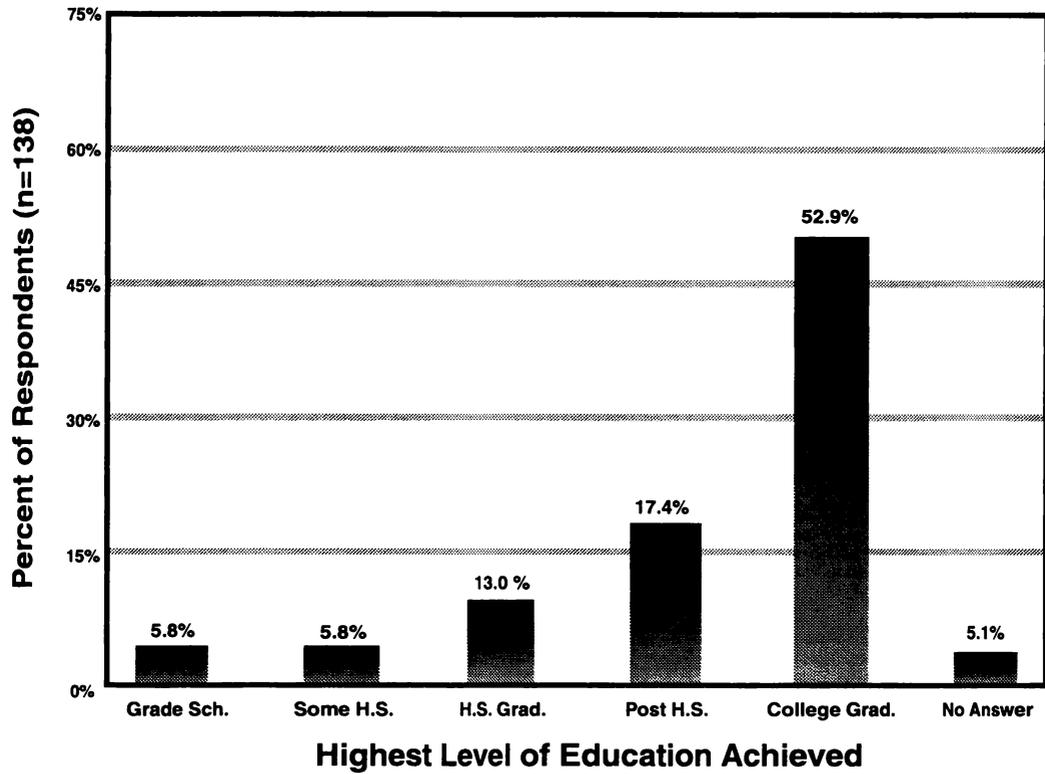
The initial survey answers, provided by all 300 participants in the water testing program, helped to characterize their water supplies (see Appendix). One set of questions dealt with the proximity of the household water supply to potential sources of groundwater contamination. One such question sought to define housing density, which may have an impact primarily from the standpoint of contamination from septic systems and related water quality problems. Participants were asked to classify their household environs as one of the following four categories, ranging from low to high density: (1) on a farm, (2) on a remote, rural lot, (3) in a rural community, and (4) in a housing subdivision. As shown in Figure 3, farm (45%) was the most common and subdivision, selected by only 5% of households, the least common.

Participants were also asked to identify potential contamination sources within 100 feet of their water supply. The major sources identified were home heating oil storage tanks and septic system drainfields, both by 14% of participants. Indications of proximity (within one-half mile) to larger activities, which could potentially contribute to groundwater pollution, were also sought. Agricultural activities were the most commonly identified; 72% of the participants indicated that their water supply was located within one-half mile of a farm animal operation and 59% within one-half mile of field crop/orchard production.

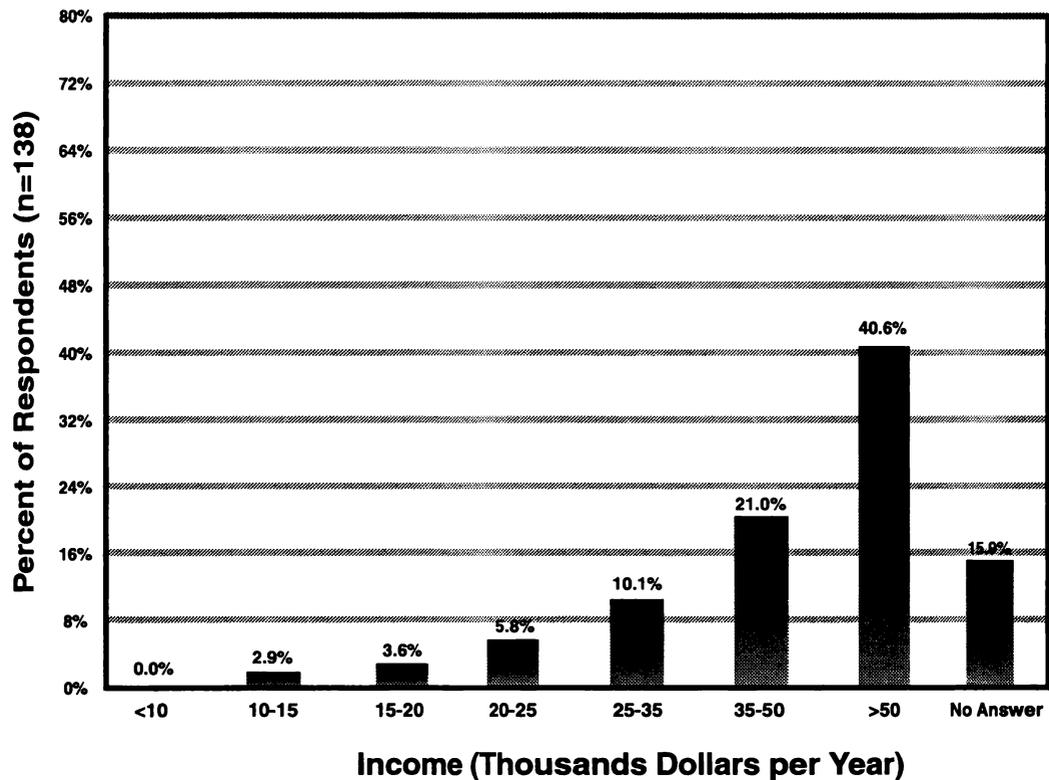
Information was also obtained regarding characteristics of the participants' water supply systems. Regarding the type of water source supplying the household, 95% of the participants reported that they rely on a well and 4% depend on a spring. Two participants indicated the use of a cistern for household water. Participants who had a well were asked to provide an estimate of the well depth, if known. Of those participants indicating well depths, 96% reported depths of more than 50 feet, while 4% reported less than or equal to 50 feet. The maximum well depth reported was 999 feet; the average well depth was 269 feet. Twenty-one percent of the wells were constructed in or prior to 1970. The earliest reported well construction date was 1945.

Household water systems were further identified with respect to the type of material used in the piping network for water distribution throughout the dwellings. The most widely used material was copper (60%), while plastic was reported by 19% of the participants. Six percent of participants reported, "Don't know".

**Figure 1. Educational Level Achieved by Participants**

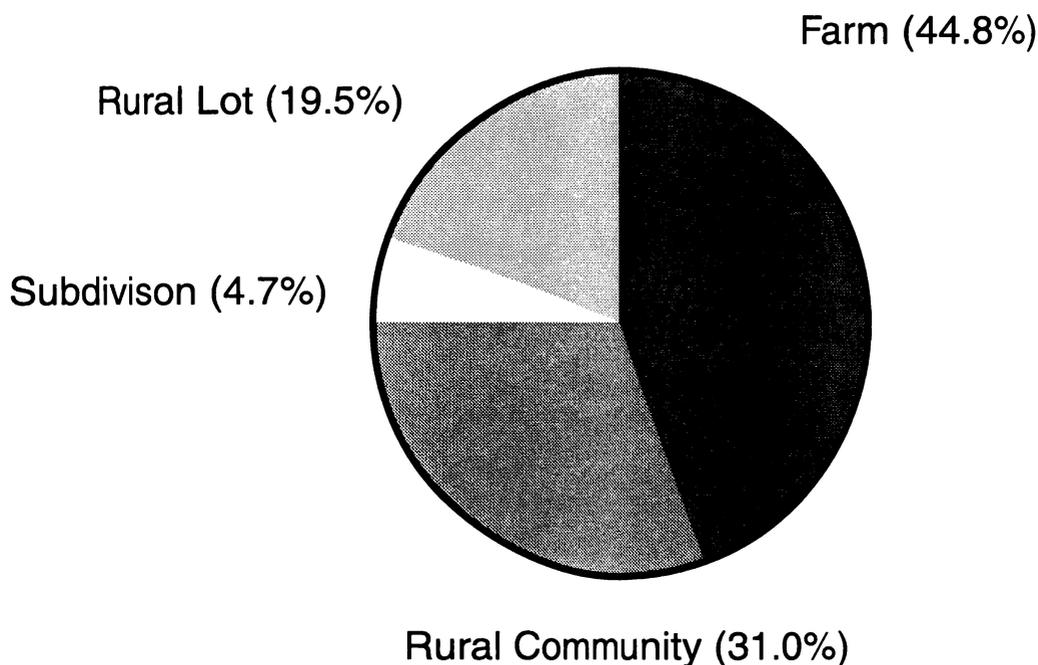


**Figure 2. Family Income of Participants**



**Figure 3. Housing Environs of Participants**

## **Housing Environs Distribution (N=297\*)**



\* Three participants did not respond.

To properly evaluate the quality of water supplies in relation to the point of sampling, participants were asked if their household water systems had water treatment devices currently installed, and if so, the type of device. The results of the inquiry are presented in Figure 4. Forty-eight percent of the participants reported at least one treatment device installed, with the most common type of treatment device in use being a water softener (75%) .

### **Participants' Perceptions of Household Water Quality**

Participants were also asked about problems they were experiencing in their household water systems (see Appendix). They were asked initially whether or not they experienced one or more of the following conditions: (1) corrosion of 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. With the exception of (1) above, with which 19% of the participants identified, participants were given several more specific descriptions from which to choose if answering positively.

Eleven percent of the participants responded that their water had an unpleasant taste. For these participants, the identification of tastes is presented in Figure 5. “Metallic” taste was the most common problem, identified by 41% of those who reported taste problems; followed by “sulfur” at 32%. Twelve percent indicated “other” tastes, the most commonly identified of which was indescribable.

An objectionable odor was reported by 11% of the participants. Of these, the description of odors selected is shown in Figure 6. The most prevalent odor described, by far, was “rotten egg”, identified by 73% of those reporting odor problems, followed by “musty” at 15%. “Other” odors, such as fishy, were noted by 15%.

Eight percent of the participants affirmed their water had an unnatural color or appearance. “Muddy” and “milky” were each identified by 52% and 44%, respectively, of those who reported appearance problems (Figure 7). “Other” unnatural colors or appearances, such as reddish tint, were identified by 16% of participants noting such problems.

A related question sought to identify the presence of solid particles in participants’ water supplies. Twenty-six percent described such a condition; nearly three-fourths (73%) reported that they noticed “white flakes” in their water with “brown sediment” noted by 16% (Figure 8).

Staining problems were reported by 38% of the participants. As presented in Figure 9, the major problem was that of “rusty” identified by 60% of those with staining problems, followed by “white/chalky” stains, reported by 44%.

## **Household Water Quality Analysis**

Ultimately, two sample groups resulted: the “tap water” and “raw water” samples. The “tap water” group consisted of the 300 individual household water supplies analyzed to represent the actual water quality at the drinking water tap (including treated water). The “raw water” group consisted of samples from untreated groundwater (wells and springs) systems only - a total of 154 samples.

The raw water sample results presented below may not be entirely indicative of the status of raw groundwater quality in Rockingham County. This may be particularly true for many of the nuisance contaminants, for which treatment systems have been installed since many of the already treated supplies likely represented the worst cases for specific contaminants correctable by treatment devices. Therefore, the inclusion of actual raw water (before treatment) analyses, if they had been available from those households with treatment devices installed, would likely have tended to worsen the overall assessment of Rockingham County raw water quality.

## **General Water Chemistry Analysis**

The tests included in the general water chemistry analysis are listed in Table 1, along with the detection limits, where appropriate, for each test as determined by laboratory equipment and testing procedure constraints. Also presented are the averages and ranges for each sample group defined. Table 2 provides, for both sample groups, the percentage of constituent values exceeding a given water quality standard or guideline. The percentages for the tap water samples group are further summarized for each of the 5 magisterial districts of Rockingham County. The results and importance of each test for both of the sample groups are individually discussed below.

Iron. Iron in water does not usually present a health risk. It can, however, be very objectionable, if present in amounts greater than 0.3 mg/L. Excessive iron can leave brown-orange stains on plumbing fixtures and laundry. It may give water and/or beverages a bitter metallic taste and may also discolor beverages.

Three percent of samples in the tap water group and 5% in the raw water sample group had iron concentrations exceeding the U.S. Environmental Protection Agency (EPA) Secondary Maximum Contaminant Level (SMCL) of 0.3 mg/L. This result was not surprising in view of the generally accepted notion that excessive iron is prevalent in rural water supplies throughout much of Virginia. Ten participants reported the installation of an iron removal filter and the results of the sample questionnaire (see Appendix) revealed that 60% of the 115 who reported staining problems, or 23% of all participants, classified the color of those stains as “rusty” (red/orange/brown). Stains of this color on plumbing fixtures, cooking appliances/utensils, and/or laundry are usually attributed to excessive iron concentrations.

It should be noted that the SMCL for iron is likely based more on taste considerations than long-term staining tendencies, particularly on plumbing fixtures. It has been suggested that concentrations below 0.1 mg/L are preferred, when stain prevention is of concern. When a value of 0.1 mg/L was used as the threshold concentration, an additional 5% and 7% of samples in the tap water and raw water groups, respectively, exceeded this limit.

Manganese. Manganese does not present a health risk. However, if present in amounts greater than 0.05 mg/L, it may give water a bitter taste and produce black stains on laundry, cooking utensils, and plumbing fixtures.

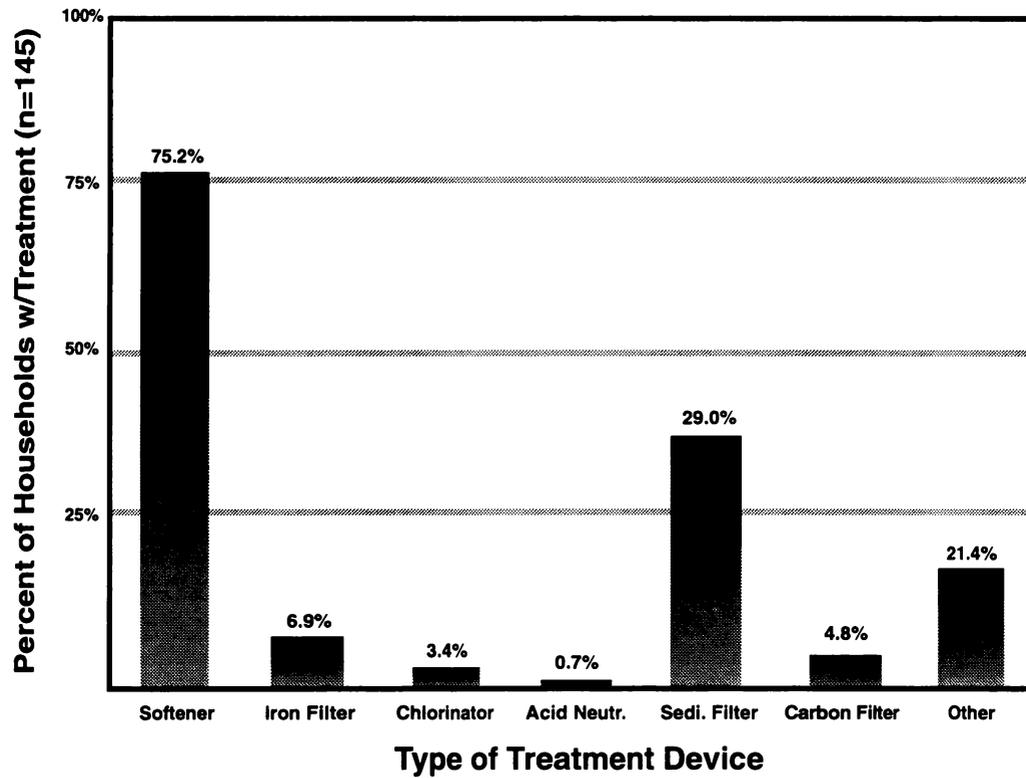
The results of these analyses indicated that the extent of manganese problems in Rockingham County may be similar to that of iron. While manganese stains are generally dark and only eight participants indicated “black” stains, 3% of the tap water and 4% of the raw water samples exceeded the SMCL for manganese of 0.05 mg/L. The “particles in water” description of “black specks”, reported by seven participants, may also provide evidence of excessive manganese concentrations.

Hardness. Hardness is a measure of calcium and magnesium in water. Hard water does not present a health risk. However, it keeps soap from lathering, decreases the cleaning action of soaps and detergents, and leaves soap “scum” on plumbing fixtures, and scale deposits in water pipes and hot water heaters. Softening treatment is highly recommended for very hard water (above 180 mg/L). Water with a hardness of about 60 mg/L or less does not need softening.

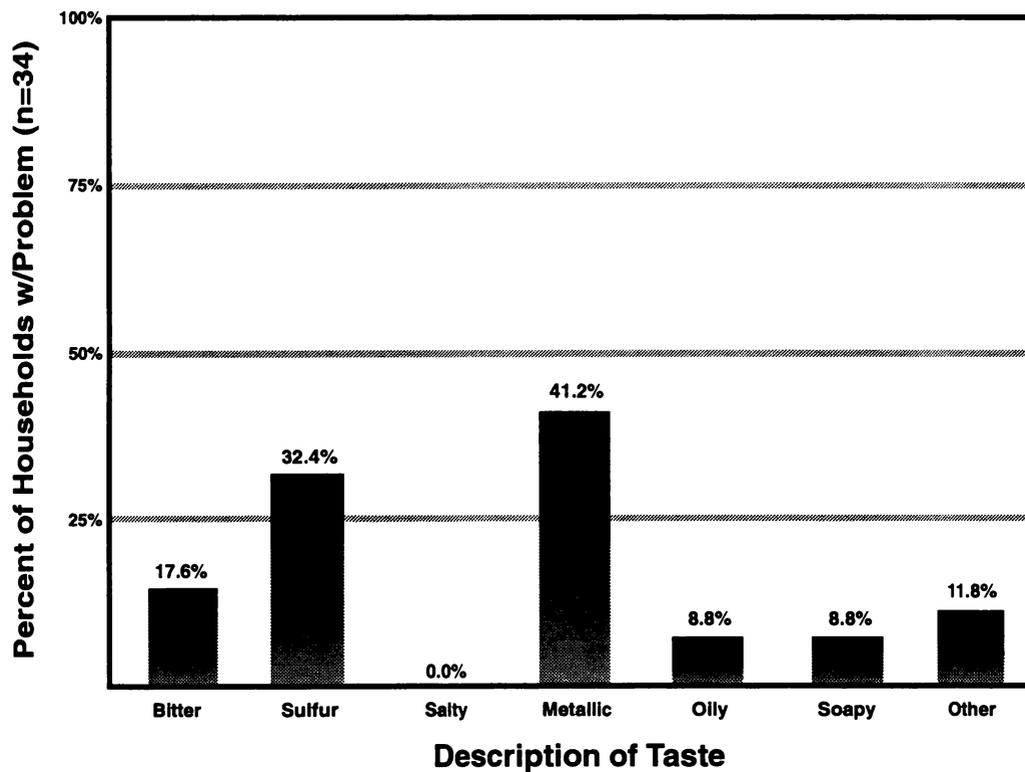
Hardness is an additional “natural” parameter usually linked to karst terrain and limestone formations that are prevalent throughout much of Rockingham County. This observation appears to be correct, since three-fourths (75%) of those households using water treatment equipment, or 36% of all participant households, had installed water softeners (Figure 4). Extensive use of water softeners is warranted, as 52% of the tap water and 79% of the raw water samples exceeded the maximum recommended hardness level of 180 mg/L.

Hardness tolerance, like that of many nuisance contaminants, is somewhat relative to individual preferences. For example, water with total hardness between 60 mg/L and 180 mg/L may warrant the installation of a commercial water softener in the view of some household water users while others are satisfied with untreated water. Fourteen percent of tap water and 16% of raw water samples were in the range of 60 mg/L to 180 mg/L total hardness, indicating that nearly two-thirds of all samples could be classified as “moderately hard” or “harder.”

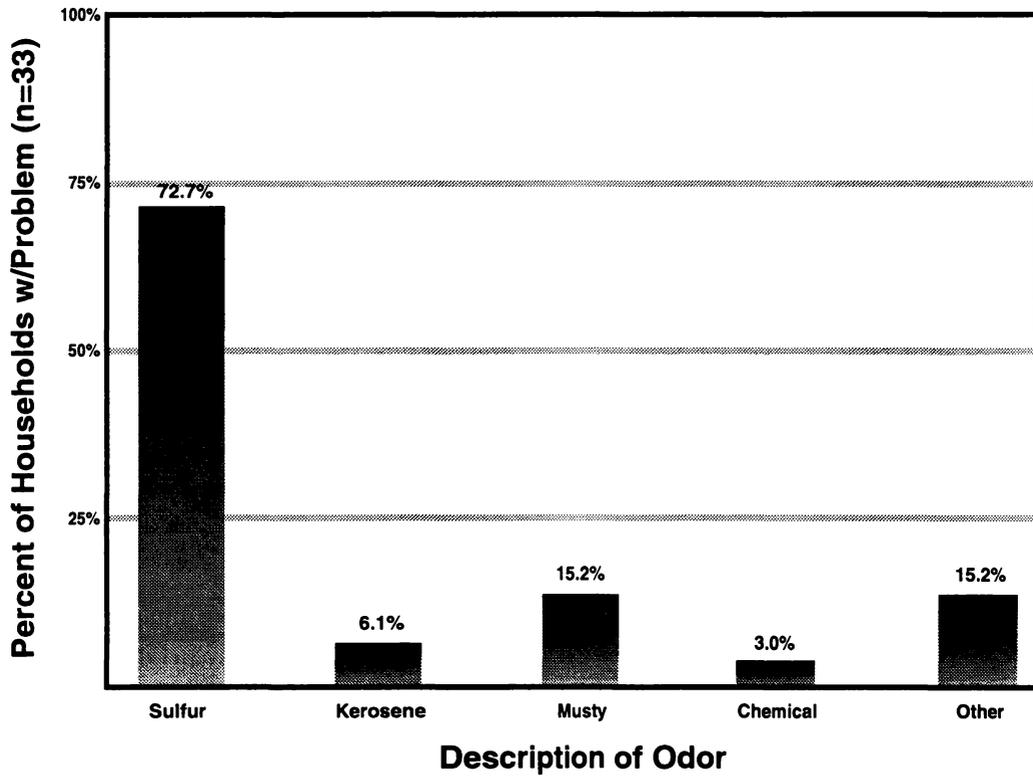
**Figure 4. Household Water Treatment Devices Installed**



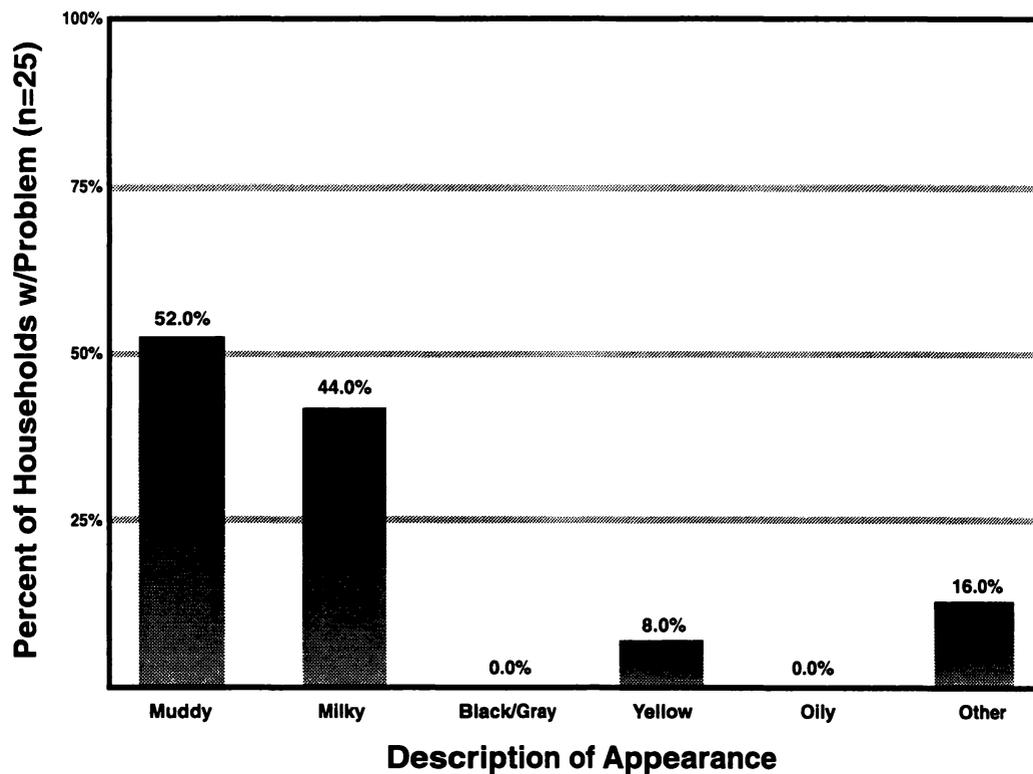
**Figure 5. Unpleasant Tastes Reported by Participants**



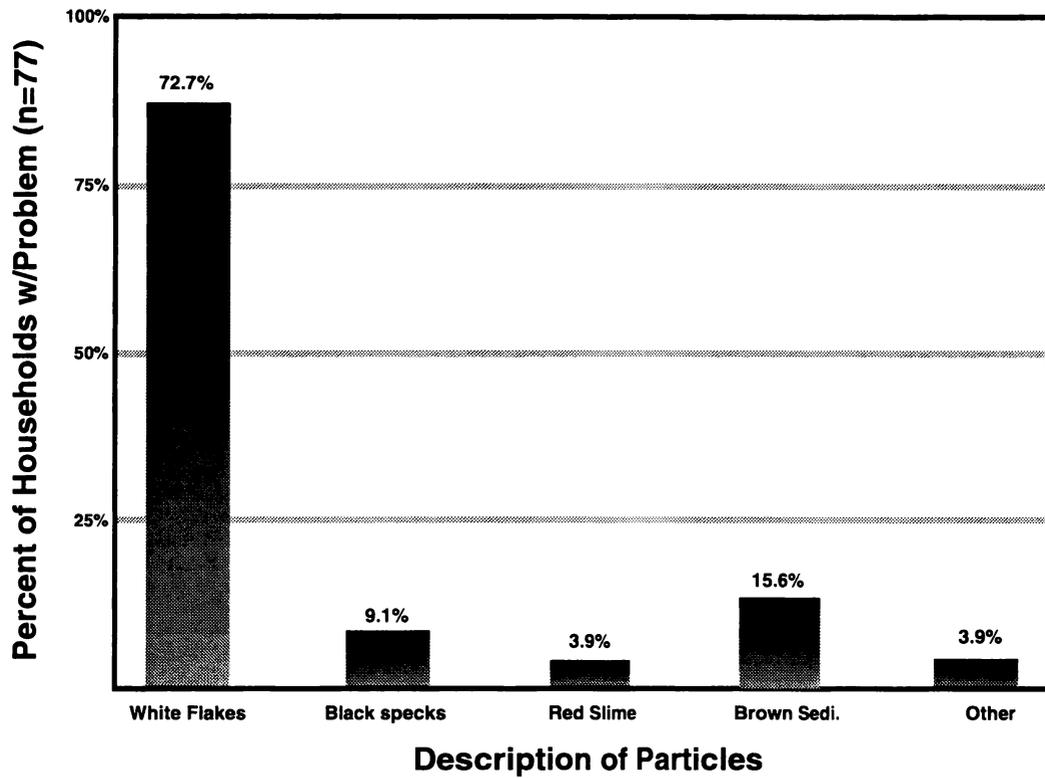
**Figure 6. Objectionable Odors Reported by Participants**



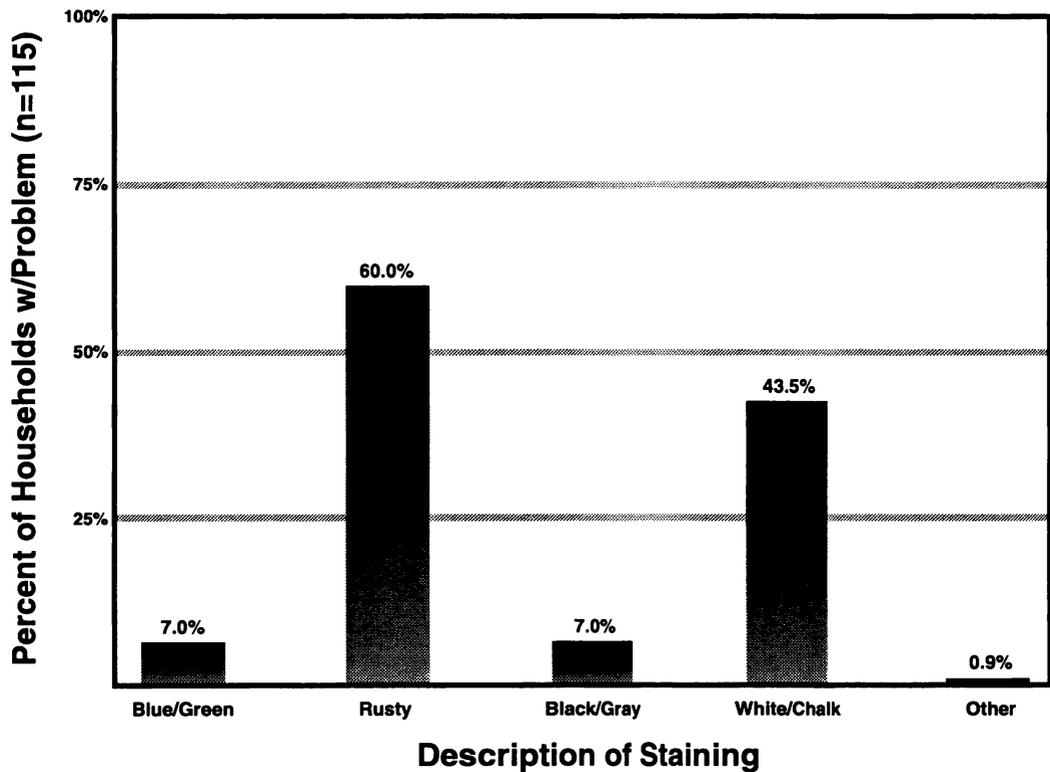
**Figure 7. Unnatural Appearance Reported by Participants**



**Figure 8. Particles in Water Reported by Participants**



**Figure 9. Staining Problems Reported by Participants**



**Sulfate.** High sulfate concentrations may result in adverse taste or may cause a laxative effect. The SMCL for sulfate is 250 mg/L. Sulfates are generally naturally present in ground-water and may be associated with other sulfur-related problems, such as hydrogen sulfide gas. This gas may be caused by the action of sulfate-reducing bacteria, as well as by other types of bacteria (possibly disease-causing bacteria) on decaying organic matter. While it is difficult to test for the presence of this gas in water, it can be easily detected by its characteristic “rotten egg” odor, which may be more noticeable in hot water. Water containing this gas may also corrode iron and other metals in the water system, and may stain plumbing fixtures and cooking utensils.

Sulfate concentrations were relatively low for both the raw water and tap water sample groups. None of the samples in either group exceeded 250 mg/L. The complaints of a “rotten egg/sulfur” odor by nearly three-fourths of those reporting odor problems indicate that hydrogen sulfide gas may be a problem in a number of household water systems in Rockingham County; a conclusion that can not be confirmed by the presence of sulfate.

**Chloride.** Chloride in drinking water is not a health risk. Natural levels of chloride are generally low, and high levels in drinking water usually indicate contamination from a septic system, road salts, fertilizers, industry, or animal wastes. High levels of chloride may speed corrosion rates of metal pipes and cause pitting and darkening of stainless steel. The EPA has set an SMCL for chloride of 250 mg/L. One of the samples in the tap water sample group only exceeded the SMCL for chloride.

**Fluoride.** Fluoride is of concern primarily from the standpoint of its effect on teeth and gums. Small concentrations of fluoride are considered to be beneficial in preventing tooth decay, whereas moderate amounts can cause brownish discoloration of teeth, and high fluoride concentrations can lead to tooth and bone damage. For these reasons, the EPA has set both a SMCL of 2 mg/L and a Maximum Contaminant Level (MCL) of 4 mg/L. None of the samples in either sample group exceeded the SMCL or the MCL for fluoride.

**Total Dissolved Solids (TDS).** High concentrations of dissolved solids may cause adverse taste effects and may also deteriorate household plumbing and appliances. The EPA SMCL is 500 mg/L total dissolved solids. Average TDS concentrations were 330 mg/L and 356 mg/L for the raw water and tap water sample groups, respectively. Nine percent of the raw water and 15% of the tap water samples exceeded the standard with a maximum TDS concentration of 1303 mg/L.

**pH.** The pH indicates whether water is acidic or alkaline. Acidic water can cause corrosion in pipes and may cause toxic metals from the plumbing system to be dissolved in drinking water. The life of plumbing systems may be shortened due to corrosion, requiring expensive repair and replacement of water pipes and plumbing fixtures. Treatment is generally recommended for water with a pH below 6.5. Alkaline water with a pH above 8.5 is seldom found naturally and may indicate contamination by alkaline industrial wastes. The EPA has set a suggested range of between 6.5 and 8.5 on the pH scale for drinking water.

The average pH reading was 7.5 for both the raw water and the tap water sample groups. None of the tap water or raw water samples exceeded a pH of 8.5. For the tap water and raw water samples, only 1% of the measured pH values in either group were less than 6.5. While the remaining samples had a pH above 6.5, slightly acidic water with a pH between 6.5 and 7.0 can lead to less immediate staining and corrosion problems. An additional 2% of both tap water and raw water samples fell into this category.

Saturation Index. The saturation index (Langlier) is used, in addition to pH, to evaluate the extent of potential corrosion of metal pipes, plumbing fixtures, etc. It is a calculated value based on the calcium concentration, total dissolved solids concentration, measured pH, and alkalinity. A saturation index greater than zero indicates that protective calcium carbonate deposits may readily form on pipe walls. A saturation index less than zero indicates that the water does not have scale-forming properties and pipes may be subject to corrosion. Saturation index values between -1 and +1 are considered acceptable for household water supplies.

No saturation index values were determined to be above +1 in either sample group. Values of less than -1, however, were determined for 33% of the tap water and 7% of the raw water samples. Average saturation index values were -0.83 and -0.34 for the tap water and raw water sample groups, respectively, with minimum values of -4.78 for both sample groups. There is an apparent partial explanation for this discrepancy. It is well documented that water softeners, which impacted 36% of the tap water samples, tend to enhance corrosion potential by removing scale-forming calcium from the water. For this reason, as well as the additional sodium imparted to the water (see below), it is sometimes recommended that water softeners be installed for hot water only or, in the case of extremely hard water, that at least drinking water lines bypass the water softening equipment.

Copper. The EPA health standard for copper in public drinking water supplies is 1.3 mg/L, the maximum level recommended to protect people from acute gastrointestinal illness. Even lower levels of dissolved copper may give water a bitter or metallic taste and produce blue-green stains on plumbing fixtures. Consequently, EPA has established an SMCL for copper of 1.0 mg/L in household water.

None of the samples in either sample group exceeded the recommended health level of 1.3 mg/L or the SMCL of 1.0 mg/L. Since natural levels of copper in groundwater are low, and the primary contributor of copper in drinking water is corrosion of copper water pipes and fittings, low copper levels were expected, even in the case of tap water samples, assuming that water lines were flushed properly prior to sampling.

Sodium. Sodium may be a health hazard to people suffering from high blood pressure or cardiovascular or kidney diseases. For those on low-sodium diets, 20 mg/L is suggested as a maximum level for sodium in drinking water, although a physician should be consulted in individual cases. Average sodium concentrations were 45.6 mg/L and 8.1 mg/L for the tap water and raw water sample groups, respectively, while the maximum concentrations were 321 mg/L for the former and 153 mg/L for the latter group. For the tap water samples, 34% exceeded 20 mg/L, while only 7% of the raw water samples exceeded 20 mg/L. These discrepancies were likely primarily due to the impact of installed water softeners on the tap water sample group (36% of all participants reported the use of a water softener).

It should be reemphasized, however, that the suggested threshold of 20 mg/L for sodium is relatively low and applicable only to individuals suffering from health problems, such as heart disease or high blood pressure. To evaluate the presence of high sodium levels in the context of an otherwise healthy individual, a threshold value of 100 mg/L sodium has been suggested. Only one of the raw water samples exceeded this value while 23% of the tap water samples did. Again, the influence of water softeners on sodium concentration can be seen, even under a higher threshold value.

Nitrate. High levels of nitrate may cause methemoglobinemia or “blue-baby” disease in infants. Though the EPA has set a MCL for nitrate (as N) of 10 mg/L, it suggests that water

**Table 1. Average and range of concentration of contaminants comprising general water chemistry analysis for Rockingham County.**

Test	Detection Limit	Measured Concentrations					
		Raw Water (n=66)			Tap Water (n=300)		
		Avg. <sup>1</sup>	Min.	Max.	Avg.	Min.	Max.
Iron (mg/L)	0.005	0.067	DL <sup>2</sup>	1.802	0.050	DL	1.802
Manganese (mg/L)	0.001	0.010	DL	0.275	0.009	DL	0.451
Hardness (mg/L)	0.3	249.2	DL	601.4	173.9	DL	601.4
Sulfate (mg/L)	0.3	15.0	0.9	99.9	17.8	DL	159.9
Chloride (mg/L)	40.0	42.0	DL	180.0	45.0	DL	353.0
Fluoride (mg/L)	0.5	0.54	DL	1.10	0.55	DL	1.46
TDS (mg/L)	1.0	330.0	14.0	791.0	356.0	14.0	1303.0
pH	-	7.51	5.95	8.46	7.54	5.23	8.46
Saturation Index	-	-0.34	-4.78	0.34	-0.83	-4.78	0.34
Copper (mg/L)	0.002	0.014	DL	0.517	0.013	DL	0.517
Sodium (mg/L)	0.01	8.13	0.40	152.80	45.63	DL	320.70
Nitrate (mg/L)	0.005	4.553	DL	29.751	3.994	DL	40.383

<sup>1</sup>Averages calculated on the basis of below detection limit (DL) values set equal to the DL.

<sup>2</sup>Sample concentration non-detectable, i.e., below the detection limit for the given contaminant.

**Table 2. Percent of concentrations exceeding established standards for contaminants comprising general water chemistry and bacteriological analysis for Rockingham County.**

Test	Standard	Percent of Values Exceeding Standard						
		Raw Water	Tap Water					
		Total (n=154)	Total (n=300)	Ash. <sup>1</sup> (n=109)	Cen. (n=39)	Lin. (n=31)	Pla. (n=72)	Sto. (n=49)
Iron (mg/L)	0.3	4.5	2.7	1.8	2.6	3.2	2.8	4.1
Manganese (mg/L)	0.05	3.8	3.4	1.8	2.6	3.2	5.6	4.1
Hardness (mg/L)	180.0	78.6	52.3	54.1	56.4	61.3	55.6	34.7
Sulfate (mg/L)	250.0	0	0	0	0	0	0	0
Chloride (mg/L)	250.0	0	0.3	0	0	0	1.4	0
Fluoride (mg/L)	$\frac{2}{4}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
TDS (mg/L)	500.0	7.8	14.6	11.9	15.4	16.1	23.6	6.1
pH - Low	6.5	1.3	1.3	0.9	2.6	0	0	4.1
pH - High	8.5	0	0	0	0	0	0	0
Saturation Index - Low	-1.0	7.1	33.0	31.2	35.9	22.6	37.5	34.7
Saturation Index - High	+1.0	0	0	0	0	0	0	0
Copper (mg/L)	$\frac{1.0}{1.3}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
Sodium (mg/L)	20.0	7.1	34.4	36.7	35.9	35.5	38.9	20.3
Nitrate (mg/L)	10.0	14.3	10.7	17.4	12.8	9.7	4.2	4.1
Total Coliform	ABSENT	46.8	44.7	47.7	46.2	51.6	48.6	26.5
E. coli	ABSENT	16.9	12.3	11.0	7.7	22.6	18.1	4.1

<sup>1</sup> Rockingham County Magisterial Districts: Ash. = Ashby, Cen. = Central, Lin. = Linville, Pla. = Plains, and Sto. = Stonewall.

with greater than 1 mg/L not be used for feeding infants. Levels of 3 mg/L or higher may indicate excessive contamination of the water supply by commercial fertilizers and/or organic wastes from septic systems or farm animal operations, which may be subject to seasonal and climatic influences.

The maximum concentration of nitrate obtained was 40.4 mg/L for the tap water and 28.8 mg/L for the raw water sample group. Eleven percent of the nitrate concentrations in the tap water sample group and 14% in the raw water sample group exceeded the MCL of 10 mg/L, indicating that nitrate contamination may pose a risk to a number of households in Rockingham County. When a 1 mg/L threshold value was selected, a much higher occurrence of nitrate was determined. In this case, approximately two-thirds of the samples, 68% of the tap water and 73% of the raw water samples, exceeded the level of potential concern to infant health. Furthermore, 44% of the tap water samples and 49% of the raw water samples had nitrate concentrations exceeding 3 mg/L, indicating that health-impacting levels would likely be approached in a substantial number of cases.

### **Bacteriological Analysis**

A common hazard of private household water supplies is contamination by 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. Of the non-gastrointestinal disorders, one particularly important disease transmissible through drinking water is Viral Hepatitis A. Other diseases include salmonella infections, dysentery, typhoid fever, and cholera.

Coliform bacterial detection is simply an indication of the possible presence of pathogenic, or disease-causing organisms. Detection of coliform bacteria is confirmed by a total coliform analysis result above zero. Coliforms are always present in the digestive systems of all warm-blooded animals and can be found in their wastes. Coliforms are also present in the soil and in plant material. While a water sample with total coliform bacteria present may have been inadvertently contaminated during sampling, other possibilities include surface water contamination due to include poor well construction, contamination of the household plumbing system, or water table contamination. To determine whether or not the bacteria were from human and/or animal waste, positive total coliform tests were followed up by an analysis for *E. coli* bacteria. Therefore, most probable quantitative bacteria counts were obtained for both total coliform and *E. coli* bacteria.

Of the 300 Rockingham County household water samples analyzed for total coliform bacteria, 134 (45%) tested positive (present). Subsequent *E. coli* analysis for these total coliform positive samples resulted in 37, or 22%, positive results, or 12% of all household water samples undergoing bacteriological analysis. The percentages of positive total coliform and *E. coli* results for the raw water sample group were 47 and 17, respectively. Quantitative bacteria counts ranged from zero up to the detection limit of 2400 colonies/100ml for total coliform and 727 colonies/100ml for *E. coli* bacteria.

The susceptibility of household water supplies to bacteriological contamination has often been associated with the type of water source. For example, it is generally accepted that the likelihood of bacteriological contamination of springs is greater than that of well water supplies, which usually offer better protection from surface, or near surface, contaminants. This contention is clearly borne out by the results of this program, which indicated that the incidence of total coliform contamination of springs and wells, was 92%, and 43%, respectively. For *E. coli* contamination, the corresponding percentages were 67 and 10.

**Table 3. Pesticides and Other Chemical Compounds Analyzed in 16 Selected Household Water Supplies (Rockingham County).**

Common Name	Trade name	Maximum Desired Concentration <sup>1</sup> (ppb) <sup>2</sup>	Maximum Measured Concentration (ppb)	Frequency of Sample Detection
Alachlor	Lasso	2.0	ND <sup>3</sup>	0
Atrazine	Aatrex	3.0	ND	0
Captan	Orthocide	–	ND	0
Chlordane		2.0	ND	0
Chlorpyrifos	Dursban	20.0	ND	0
Cyanazine	Bladex	1.0	ND	0
DDTs		–	ND	0
Diazinon	Spectracide	0.6	ND	0
Dicamba	Banvel	200.0	0.041	3
Heptachlor		0.4	ND	0
Lindane		0.2	ND	0
Malathion	Cythion	200.0	ND	0
Methoxychlor	Marlate	40.0	ND	0
Metolachlor	Dual	70.0	ND	0
Metribuzin	Lexone	100.0	ND	0
PCBs		0.5	ND	0
Picloram	Tordon	500.0	0.231	4
Pyrethrins	Pounce	–	ND	0
Simazine	Princep	4.0	ND	0
Triclopyr	Garlon	–	0.286	3
2, 4-D		70.0	0.185	1
2, 4, 5-T		70.0	ND	0
2, 4, 5-TP	Silvex	50.0	ND	0

<sup>1</sup> U.S. EPA MCL or HAL, if available

<sup>2</sup> ppb - parts per billion, equivalent to micrograms per liter in water

<sup>3</sup> ND - Non-detectable (below laboratory detection limit of 0.01 ppb)

**Table 4. Measures taken or planned by respondents, since water quality analysis, to improve water supply (Rockingham County)**

Measure	Percent of All Respondents (n=138)	Percent of Respondents who Reported the Following Problems			
		Health Only (n=37)	Nuisance Only (n=30)	Health & Nuisance (n=42)	None (n=29)
Contact an Agency, such as the Health Department	6.5	8.1	0	14.3	0
Seek Additional Water Testing from Another Lab	10.9	16.2	3.3	14.3	6.9
Determine Source of Undesirable Condition	7.2	8.1	0	14.3	3.4
Pump Out Septic System	4.3	5.4	0	7.1	3.4
Improve Physical Condition of Water Source	2.9	8.1	0	2.4	0
Shock-Chlorinate Water System	15.2	18.9	0	31.0	3.4
Obtain New Water Source	0.7	2.7	0	0	0
Use Bottled Water for Drinking/Cooking	10.1	10.8	3.3	21.4	0
Temporary Disinfection, such as Boiling Water	4.3	8.1	0	7.1	0
Purchase or Rent Water Treatment Equipment	15.9	16.2	16.7	23.8	3.4
Improve Existing Water Treatment Equipment	10.1	21.6	3.3	7.1	6.9
Take Other Measures to Eliminate/Reduce Contaminant(s)	0	0	0	0	0
Have Not Done Anything	51.4	27.0	80.0	31.0	82.8

The age of a water source/system is an additional factor which may have an influence on contamination susceptibility. With respect to wells in particular, deterioration of the well structure over time, cumulative damage caused by equipment traffic, etc., and prolonged exposure of the wellhead area to potentially harmful pollutants may all contribute to the eventual contamination of the well. A major age-related impact could relate to the development of, and conformance with, well construction standards through the years. Major legislation in Virginia to address such issues, has been enacted in recent years, most notably in the early 1970's and early 1990's. Therefore, for the purpose of examining the occurrence of bacteriological contamination with well age, the sample results were evaluated for the following three construction date categories: (1) pre-1970, (2) 1970-1989, and (3) 1990 to date. With respect to total coliform bacteria, for each of the above categories, the percentages of well water samples determined to be positive were as follows: (1) 31, (2) 45, and (3) 36. For E. coli bacteria, the corresponding percentages were: (1) 12, (2) 8, and (3) 5. An overall improvement was noted with time, likely influenced not only by the newness of the wells, but also recent legislation. Perhaps not surprisingly, however, the extent of this reduction may have been somewhat tempered by the influence of the karst topography of the region.

Fecal bacteria present in household water supplies may have originated from animal waste generation or human waste from septic systems. Although, positive results should be viewed with concern, they are not a cause for panic. Individuals have probably been drinking this water for some time with no ill effects and could possibly continue to do so. Nevertheless, such problems should be further investigated and remedied, if possible. Program participants whose water tested positive were given information regarding emergency disinfection, well improvements, septic system maintenance and other steps to correct the source of contamination. After taking initial corrective measures, they were advised to have the water retested for total coliform, followed by E. coli tests, if warranted.

### **Pesticide Analysis**

As mentioned earlier, several of the original participating households opted to pay for additional testing of pesticides and other chemical compounds. Ultimately, 16 household water supplies, of the original total of 300, were resampled. The 23 constituents analyzed were considered to be the most likely to be found in groundwater partly because they are currently, or were recently, in common use in the county. These pesticides and other compounds are listed in Table 3.

Analysis of these constituents revealed little evidence of excessive contamination in terms of human health implications. Out of a total of 368 test results, 357, or 97%, resulted in concentrations below the laboratory detection limit (considered to be approximately 0.01 parts per billion, or ppb). Seven separate water samples had at least one compound present at a detectable concentration. As shown in Table 3, four detections of picloram, three each of dicamba, and triclopyr, and one of 2,4-D resulted, all of which were well below the respective EPA MCL or Health Advisory Level (HAL).

### **Post-Program Survey**

Following the completion of the basic educational program, a survey form (see Appendix) was mailed to the 300 households whose water supply had been tested. The objectives of the survey were to determine: 1) reasons for program participation and for having water tested, and 2) what the respondents had done to correct water quality problems as a result of participation in the educational program. One hundred and thirty-eight (46%) had returned the survey forms by the deadline.

## **Household Water Testing History**

Participants were asked to indicate their previous experience with water testing and, specifically, if and when they had last had a laboratory analysis of their present household water supply. Forty-six percent of the respondents indicated that they had previously obtained water test results. Of those reporting a prior testing date, 46% had done so within the past five years and 20% within the past two years.

## **Reasons for Program Participation**

People participated in the water quality program for one or more reasons. Eighty-seven percent of the respondents were prompted to participate by concern about the safety of their water supply. Fourteen percent of the respondents were prompted by nuisance problems, such as staining, objectionable taste, and odor, etc. Sixteen percent wanted to follow up on previous tests of their household water. Fifteen percent cited other reasons, such as general curiosity and low-cost opportunity.

## **Follow-up Activities Taken or Planned**

Participants were asked to indicate the measures they planned to take, or had already taken, to improve the quality of their water supply, since receiving the results of their water quality analysis. Table 4 presents the results of this inquiry, with the greatest number of households (15% or more) indicating one or both of the following actions: purchase or rent water treatment equipment and shock chlorinate the water system.

Participants were asked if the water analysis showed that their water was unsatisfactory for one or more of the following: bacteria, nitrate, sodium, iron, manganese, hardness, and pH. Responses were grouped in four categories: 1) households with potential health problems (positive coliform test results and/or unsatisfactory levels of nitrate or sodium in their water samples), 2) households with unsatisfactory levels of nuisance contaminants (one or more of the following: iron, manganese, hardness, and pH), 3) households with potential health problems and unsatisfactory levels of nuisance contaminants, and 4) households with neither potential health problems nor unsatisfactory levels of nuisance contaminants.

The measures planned or already taken to improve household water as follow-up to the water quality analysis were generally in agreement with the water quality problems identified by the testing. Of the households with potential health problems only and those with health problems in combination with unsatisfactory levels of nuisance contaminants, 71% had taken, or planned to take, at least one measure to improve their water supply. The measure taken by the greatest number of households in these two categories was: shock chlorinate the water system.

As expected, respondents were more likely to address health-related problems than nuisance problems. Of the households with unsatisfactory levels of one or more nuisance contaminants only and those with nuisance problems in combination with potential health problems, 49% had taken, or planned to take, at least one measure to improve their water supply. Not unexpectedly, the group of households that reported the fewest follow-up measures (17%) were the households with neither potential health problems nor unsatisfactory levels of nuisance contaminants.

# CONCLUSIONS

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The Rockingham County Household Water Quality Educational Program was considered to be successful. The opportunity to participate in the program was well-received by Rockingham County residents. Individuals participated in the program primarily because of concern about the safety of their water supply. Despite being a voluntary program, a geographically distributed sample, representing diverse household and water supply characteristics, was obtained. While the project was designed for voluntary participation and quality control in sampling was not assured, the type of information gathered and summarized was, nevertheless, deemed useful for water quality assessment at county and regional levels.

Water quality analysis, for many nuisance constituents, generally supported the participants' descriptions of their water supplies regarding such problems as staining, taste and odor, and appearance. The severity of these symptoms is confirmed by the high incidence of water treatment devices installed -- 48% of all households participating had one or more water treatment devices installed.

Considering the results for both the raw and tap water sample groups, and the influence of water treatment devices, the major remaining household water quality problems in Rockingham County, existing from a nuisance standpoint, were iron/manganese, hardness, and total dissolved solids. The major health-related concern was bacteria. Furthermore, elevated nitrate and sodium concentrations may present a health risk to infants and some adults, respectively, in a number of cases. Forty-five percent of the samples tested positive for total coliform and 12% were positive for E. coli bacteria. In these positive cases, participants were advised of ways to improve water supply conditions and were encouraged to pursue retesting for coliform bacteria.

The limited analysis for pesticides and other chemical compounds revealed few problems with such contamination. None of the 16 tested samples had a concentration of any of the 23 pesticides and other chemical compounds analyzed present in a quantity exceeding the corresponding EPA MCL or HAL. A total of eleven detections were found in seven separate samples.

Fifty-seven percent of the households that reported having at least one water quality problem had taken, or planned to take, at least one measure to improve the quality of their water supply. Fifteen percent or more of all respondents had taken, or planned to take, one or both of the following actions: purchase or rent water treatment equipment and shock chlorinate the water system.

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# **APPENDIX**

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- (1) Program Fact Sheet
- (2) Sample Identification and Questionnaire Form
- (3) Sample Water Quality Analysis Report
- (4) Report Interpretation
- (5) Pesticide Analysis Form
- (6) Post-Program Survey

(1) Program Fact Sheet



## Virginia Cooperative Extension

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May 25, 1999

# 1999 VCE-Rockingham Household Water Testing Program

Dear Friends of Extension and Other Interested Parties,

This summer the Rockingham County Extension Office is sponsoring a household water testing program. We will offer water testing for private, individual water supplies only. Samples from wells, springs and cisterns will be accepted. Public water supplies will not be tested. During the month of August meetings will be held to distribute water sampling kits. Results will be reviewed at a September meeting. There is a limit of one sample per household.

With the help of the Rockingham County Board of Supervisors, the cost for water testing will be only \$30.00 and will include testing for total hardness, nitrate, iron, chloride, sodium, pH, fluoride, copper, corrosion index, sulfate, manganese, total dissolved solids, total coliform counts and E. coli bacteria counts. If done in a private lab, these tests would cost more than \$150.

Attendance at one of the meetings in August (listed below) is **required** for participation in the household water testing program. Please call the Rockingham County Extension Office at (540) 564-3080 to register for one of the meetings:

**August 4 in McGaheysville (7 P. M.)**

**August 11 in Montezuma (1 P. M.)**

**August 18 in Broadway (7 P. M.)**

**August 25 in Bridgewater (7 P. M.)**

Due to limited capacity at the Virginia Tech water testing lab, space in the program will be limited to 600 samples. Signups will be taken on a first come first serve basis.

Sincerely,

*Beth Dransfield*

**Beth Dransfield**  
Extension Agent  
Dairy Science

*Phil Schroeder*  
**Phil Schroeder**  
Extension Agent  
Environmental Science

*Sarah Ann Whitmore*  
**Sarah Ann Whitmore**  
Extension Agent  
Family & Consumer Sciences

**Jerry Swisher**  
Extension Agent  
Dairy Science

**Cristin Campbell**  
Extension Agent  
Family & Consumer Sciences

If you are a person with a disability and desire any assistive devices, services or other accommodations to participate in this activity, please contact the Rockingham County Extension Office at (540-564-3080) during business hours of 8 a.m. and 4:30 p.m. to discuss accommodations 2 weeks prior to the event.

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Virginia Cooperative Extension programs and employment are open to all, regardless of race, color, religion, sex, age, veteran status, national origin, disability, or political affiliation. An equal opportunity/affirmative action employer.

## (2) Sample Identification and Questionnaire Form

### ROCKINGHAM COUNTY HOUSEHOLD WATER QUALITY PROGRAM

Rockingham County Cooperative Extension  
965 Pleasant Valley Road  
Harrisonburg, VA 22801-9630  
(540) 564-3080

**SAMPLE IDENTIFICATION** (Please print clearly and provide complete information on both sides of form.)

Sample No.: \_\_\_\_\_ Date collected: \_\_\_\_\_

Sample submitted by:

Name: \_\_\_\_\_

Mailing address: \_\_\_\_\_  
\_\_\_\_\_

Telephone: \_\_\_\_\_

**FOR OFFICE USE ONLY**

Map Grid No. \_\_\_\_\_

Lab Sample No. \_\_\_\_\_

Household water supply source **drawn for sample** (check **one**):

well  spring  cistern  other (Specify: \_\_\_\_\_)

- If **well** is checked above:
- (a) is it a  dug or bored well,  drilled well,  don't know;
  - (b) what is its approximate depth, if known? \_\_\_\_\_ feet
  - (c) what year was well constructed, if known? \_\_\_\_\_

Do other households share the same water supply?  yes  no If yes, approximately how many? \_\_\_\_\_

Water treatment devices currently installed and affecting **cold water only** drawn at faucet for sample (check **all** that apply):

none  acid water neutralizer  
 water softener (conditioner)  sediment filter (screen or sand type)  
 iron removal filter  activated carbon (charcoal) filter  
 automatic chlorinator  other (specify: \_\_\_\_\_)

**SAMPLING INSTRUCTIONS:** You must take your water samples only on the collection day you have been assigned. For the general water analysis sample, use the larger plastic bottle as described below. A separate, smaller bottle is provided for bacteriological samples which should be taken last. If you have any questions about sampling procedures, call the Extension Office at 564-3080.

1. Do not remove caps from sample bottles until you are ready to take each sample. Do not touch inside of cap or mouth of either bottle.
2. Turn on the cold water faucet in the kitchen or bathroom (select a stationary, non-swivel faucet, if possible) and allow the water to run until it becomes as cold as it will get; then let it run for one more minute.
3. Slowly and carefully fill the larger bottle to avoid splashing or overflowing. Pour out this rinse water and then refill bottle completely. Tighten cap on bottle securely.
4. Let the water run for an additional two or three minutes. Reduce flow to prevent splashing and carefully fill the smaller bottle only once to the shoulder (just below the threaded top). **DO NOT RINSE BOTTLE.** Replace cap tightly.
5. Do not write anything on the bottle labels. If samples are not to be delivered immediately, store in refrigerator or on ice until ready to deliver later that day.
6. Fill out this Sample Identification Form and Questionnaire (on reverse side) completely and bring it, along with both water sample bottles, to the designated collection site on your assigned collection day.

## Sample Identification and Questionnaire Form (cont.)

**QUESTIONNAIRE** (Please answer the following questions as completely as possible, considering how you view the present condition of the water sampled, including improvements due to any treatment devices identified on other side of form.)

1. Describe the location of your home. (Check **one**)  
 on a farm     on a remote, rural lot     in a rural community     in a housing subdivision
2. What pipe material is primarily used throughout your house for water distribution? (Check **one**)  
 copper     lead     galvanized steel     plastic (PVC, PE, etc.)     other (specify: \_\_\_\_\_)     don't know
3. Do you have problems with corrosion or pitting of pipes or plumbing fixtures?  yes     no
4. Does your water have an unpleasant taste?  yes     no
5. If yes, how would you describe the taste? (Check **all** that apply)  
 bitter     sulfur     salty     metallic     oily     soapy     other (specify: \_\_\_\_\_)
6. Does your water have an objectionable odor?  yes     no
7. If yes, how would you describe the odor? (Check **all** that apply)  
 "rotten egg" or sulfur     kerosene     musty     chemical     other (specify: \_\_\_\_\_)
8. Does your water have an unnatural color or appearance?  yes     no
9. If yes, how would you describe the color or appearance? (Check **all** that apply)  
 muddy     milky     black/gray tint     yellow tint     oily film     other (specify: \_\_\_\_\_)
10. Do you have problems with staining of plumbing fixtures, cooking appliances/utensils, or laundry?  yes     no
11. If yes, how would you describe the color of stains? (Check **all** that apply)  
 blue-green     rusty (red/orange/brown)     black or gray     white or chalk     other (specify: \_\_\_\_\_)
12. In a standing glass of water, do you notice floating, suspended, or settled particles?  yes     no
13. If yes, how would you describe this material? (Check **all** that apply)  
 white flakes     black specks     reddish-orange slime     brown sediment     other (specify: \_\_\_\_\_)
14. If your water supply is located **100 feet or less** from any of the following, please indicate. (Check **all** that apply)  
 septic system drain field     home heating oil storage tank (above or below ground)  
 pit privy or outhouse     stream, pond, or lake  
 cemetery     sinkhole
15. If your water supply is located **½ mile or closer** to any of the following, please indicate. (Check **all** that apply)  
 landfill     golf course  
 illegal dump     field crop/orchard  
 active quarry     farm animal operation  
 abandoned quarry, industry, etc.     manufacturing/processing operation (specify: \_\_\_\_\_)  
 commercial underground storage tank or supply lines (gasoline service station, heating oil supplier, etc.)

This material is based upon work supported by the U.S. Department of Agriculture, Extension Service.

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(3) Sample Water Quality Analysis Report

Rockingham County  
Household Water Quality Program

Rockingham County Cooperative Extension  
965 Pleasant Valley Road  
Harrisonburg, VA 22801  
(540) 564-3080

Sample No: R

Keezletown, VA 22832  
(502) 694-

Source: Drilled Well

Treatment: None

Water Quality Results  
Date of Sample: 8/10/99

Test	Household Water Sample	Maximum Recommended Level or Range
Iron (mg/l)	0.0117	0.3
Manganese (mg/l)	< 0.001	0.05
Hardness (mg/l)	287.5**	180
Sulfate (mg/l)	15.454	250
Chloride (mg/l)	< 40	250
Fluoride (mg/l)	0.5642	2
Total Dissolved Solids (mg/l)	370	500
pH	7.2	6.5 to 8.5
Saturation Index	-0.32	-1 to 1
Copper (mg/l)	< 0.002	1.0
Sodium (mg/l)	1.14	20
Nitrate-N (mg/l)	2.444	10
Total Coliform Bacteria (col/100ml)	4**	0
E. Coli Bacteria (col/100ml)	0	0

\*\* Measured Value exceeds recommendation for household water.

Analysis coordinated by Water Quality Laboratory, Dept. of Biological Systems Engineering, Virginia Tech, Blacksburg, VA. The information provided is for the exclusive use of the homeowner and should not be used as official documentation of water quality. This material is based upon work supported by the U.S. Department of Agriculture, Extension Service.

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## (4) Report Interpretation

### Rockingham County Household Water Quality Program

#### INTERPRETING YOUR HOUSEHOLD WATER QUALITY ANALYSIS REPORT

##### IRON

Iron in water does not usually present a health risk. It can, however, be very objectional if present in amounts greater than 0.3 mg/l. Excessive iron can leave red-orange-brown stains on plumbing fixtures and laundry. It may give water and/or beverages a bitter, metallic taste and discolor beverages.

##### MANGANESE

Manganese does not present a health risk. However, if present in amounts greater than 0.05 mg/l it may give water a bitter taste and produce black stains on laundry, cooking utensils, and plumbing fixtures.

##### HARDNESS

Hardness is a measure of calcium and magnesium in water. Hard water does not present a health risk. However, it keeps soap from lathering, decreases cleaning action of soaps and detergents, leaves soap "scum" on plumbing fixtures, and leaves scale deposits on water pipes and hot water heaters. Softening treatment is highly recommended for very hard water (above 180 mg/l). Water with a hardness of about 50 mg/l or less does not need softening. Water hardness may also be reported in units of grains per gallon, or gpg (1 gpg = 17.1 mg/l hardness). In all but extremely hard water situations, it may be desirable to soften only the hot water.

##### SULFATE

High sulfate concentrations may result in adverse taste as well as cause a laxative effect. The Secondary Maximum Contaminant Level for sulfate is 250 mg/l. Sulfates are generally naturally present in groundwater and be linked to other sulfur-related problems, such as hydrogen sulfide gas. This gas may be caused by the action of sulfate reducing bacteria as well as other types of bacteria on decaying organic matter. While it is difficult to test for the presence of hydrogen sulfide gas in water, it can be easily detected by its characteristic "rotten egg" odor which may be more noticeable in hot water. Water containing this gas may also corrode iron and other metals in the water system as well as stain plumbing fixtures and cooking utensils.

##### CHLORIDE

Chloride in drinking water is not a health risk. Natural levels of chlorides are low; high levels in drinking water usually indicate contamination from a septic system, road salts, fertilizers, industry, or animal wastes. High levels of chloride may speed corrosion rates of metal pipes, and causing pitting and darkening of stainless steel. The EPA has set a Secondary Maximum Contaminant Level for chloride of 250 mg/l.

##### FLUORIDE

Fluoride is of concern primarily from the standpoint of its effect on teeth and gums. Small concentrations of fluoride are considered to be beneficial in preventing tooth decay while moderate amounts can cause brownish discoloration of teeth and high fluoride concentrations can lead to tooth and bone damage. For these reasons, the EPA has set both a Secondary Maximum Contaminant Level and a Maximum Contaminant Level of 2 and 4 mg/l, respectively.

##### TOTAL DISSOLVED SOLIDS (TDS)

High concentrations of dissolved solids may cause adverse taste effects and may also lead to increased deterioration of household plumbing and appliances. The EPA Secondary Maximum Contaminant Level is 500 mg/l total dissolved solids.

##### pH

The pH of water indicates whether it is acidic (below 7.0) or alkaline (above 7.0). Acidic water can cause corrosion in pipes, and may cause toxic metals from plumbing systems, such as copper and lead, to be dissolved in drinking water. Dissolved copper may give water a bitter or metallic taste, and produce blue-green stains on plumbing fixtures. The life of plumbing systems may be shortened due to corrosion requiring expensive repair and replacement of water pipes and plumbing fixtures. The use of plastic pipes throughout the water distribution system should lessen these concerns. Water with a pH below 6.5 is considered to be acidic enough to require treatment. Alkaline water with a pH above 8.5 is seldom found naturally, and may indicate contamination by alkaline industrial wastes. The EPA has set a suggested range of between 6.5 and 8.5 on the pH scale for drinking water.

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## Report Interpretation (cont.)

### SATURATION INDEX

The saturation (Langlier) index, in addition to pH, is used to evaluate the extent of potential corrosion of metal pipes, plumbing fixtures, etc. It is a calculated value based on the calcium concentration, total dissolved solids concentration, measured pH, and alkalinity, and is a measure of the scale formation potential of the water. A saturation index greater than zero indicates that protective calcium carbonate deposits may readily form on pipe walls. A saturation index less than zero indicates that the water does not have scale-forming properties and pipes may be subject to corrosion. Saturation index values between -1 and +1 are considered acceptable for household water supplies. NOTE: Values of less than -1 need not be of concern if the water is not acidic (indicated by a pH of 7.0 or above). Water softener owners may note a saturation index reading lower than desired. While these treatment devices correct hardness, they may enhance the corrosion potential of the water. Concerns about resulting drinking water quality may be lessened by softening only the hot water or bypassing drinking water lines.

### COPPER

The EPA drinking water standard for copper is 1.3 mg/l, based on concerns about acute gastrointestinal illness. Since dissolved copper also leaves blue-green stains on plumbing fixtures, a Secondary Maximum Contaminant Level of 1.0 mg/l is also provided for copper. While copper in household water most often comes from the corrosion of brass and copper plumbing materials, this type of contamination is not likely to be detected under the sampling procedure followed in this program which called for flushing the water lines. Therefore, any excessive amounts of copper from the water source itself may indicate contamination from industrial wastes or dumps/landfills.

### SODIUM

Excessive sodium has been linked to problems with high blood pressure, and heart and kidney diseases. Moderate quantities of sodium in drinking water are not considered harmful since an individual normally receives most (over 90%) of his/her sodium intake from food. For those on low-sodium diets, both the American Heart Association and EPA suggest 20 mg/l as a maximum level for sodium in drinking water; a physician should be consulted in individual cases. Water softening by ion-exchange will increase sodium levels in water. To reduce sodium in drinking water requiring such treatment, soften only the hot water or bypass drinking water lines.

### NITRATE

High levels of nitrate may cause methemoglobinemia or "blue-baby" disease in infants. Though the EPA has set a Maximum Contaminant Level for nitrate-nitrogen of 10 mg/l, they suggest that water with greater than 1 mg/l be used with caution for feeding infants. Levels of higher than 3 mg/l may indicate excessive contamination of water supply by commercial fertilizers as well as organic wastes from septic systems or farm animal operations.

### TOTAL COLIFORM BACTERIA

Microbiological contamination of drinking water can cause short term gastrointestinal disorders, resulting in cramps and diarrhea that may be mild to very severe. Other diseases of concern are Viral Hepatitis A, salmonella infections, dysentery, typhoid fever, and cholera. While coliform bacteria do not cause disease, they serve as indicators of the possible presence of disease bacteria. Coliform bacteria are always present in the digestive systems of humans and animals and could also come from other sources such as soil or decaying vegetation. Analysis for total coliform bacteria is the EPA standard test for microbiological contamination of a water supply, for which none should be present.

### E COLI

In the event that there are coliform bacteria present, a test for fecal bacteria, such as E.coli, is necessary to determine whether or not any bacteria are from human and/or animal waste. E. coli bacteria, this species of which is harmless, always originate within the intestinal tract of warmblooded animals and humans and do not survive very long outside of the digestive system. The presence of E. coli bacteria indicates that waste from a septic system or nearby animals is likely contaminating the water supply.

### Glossary

EPA - U. S. Environmental Protection Agency

mg/l - Concentration unit of milligrams per liter in water, equivalent to one part per million (ppm).

Maximum Contaminant Level (MCL) - Legally enforceable national standard set by the EPA to protect the public from exposure to water hazards. Standards only apply to public drinking water systems, but, they also serve as a guide for individual water supplies.

Secondary Maximum Contaminant Level (SMCL) - Concentration limits for nuisance contaminants and physical problems. These standards are not enforced by governments. However, they are useful guidelines for individual water supplies.

Compiled by Blake Ross, Extension Agricultural Engineer, and Kathy Parrott, Extension Specialist, Housing, Virginia Tech, Blacksburg, VA

September 1999

This material is based upon work supported by the U. S. Department of Agriculture-Extension Service.

(5) Pesticide Analysis Form

**ROCKINGHAM COUNTY  
HOUSEHOLD WATER QUALITY PROGRAM  
PESTICIDE ANALYSIS**

Department of Biological Systems Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24061-0303

SAMPLE NUMBER: \_\_\_\_\_

DATE COLLECTED: \_\_\_\_\_

SAMPLE SUBMITTED BY:

NAME: \_\_\_\_\_

MAILING ADDRESS: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

WAS THE WATER TREATED BEFORE SAMPLING? \_\_\_\_ YES \_\_\_\_ NO (IF AT ALL POSSIBLE, SAMPLE WATER BEFORE TREATMENT)

IF YES, WHAT TREATMENT DEVICE(S) DID THE WATER PASS THROUGH PRIOR TO SAMPLING?

\_\_\_\_\_

COMMENTS REGARDING LIKELIHOOD OF CHEMICAL CONTAMINATION (SPILLS, NEARBY USE, STORAGE, ETC.):

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**SAMPLING INSTRUCTIONS:**

1. Do not remove cap from Sample Jar until you are ready to take sample. Do not touch inside of cap or mouth of the jar.
2. Take the sample as close to the water source (well or spring) as possible. If there are no water treatment devices in use, the sample may be taken from a kitchen or bathroom tap. If there is a treatment device in the house, the sample should be taken from a spigot not affected by a treatment device.
3. Turn on the Cold Water and allow it to run until it is as cold as it will get. Then allow it to run one minute more.
4. Slowly and carefully fill the jar to avoid splashing and overflowing. Pour out this water and refill the jar completely.
5. Place the Aluminum Foil Sheet over the mouth of the jar with the Dull Side down. Tighten cap on the jar securely.
6. If sample is not to be delivered immediately, store on ice until ready to deliver.

\_\_\_\_\_

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(6) Post-Program Survey

Rockingham County

HOUSEHOLD WATER QUALITY PROGRAM EVALUATION SURVEY

Please answer each question below as instructed in reference to your household water supply only. Your answers are completely confidential and cannot be identified with any individual participant.

1. Have you had a laboratory test of your water supply before this Household Water Quality Education Program? Yes \_\_\_\_\_ No \_\_\_\_\_

If Yes, about what year was your last test? \_\_\_\_\_

2. What prompted you to participate in this program? (Check all that apply.)

\_\_\_\_\_ Concern about safety of my water supply  
\_\_\_\_\_ Nuisance problems such as staining, objectionable taste or odor, corrosion, etc.  
\_\_\_\_\_ Follow-up to previous test of my water supply  
\_\_\_\_\_ Other (explain) \_\_\_\_\_

3. Did your household water analysis in this program show that your water was unsatisfactory for any of the following tests? (Check one response for each test.)

Nitrate	Yes _____	No _____
Sodium	Yes _____	No _____
Iron	Yes _____	No _____
Manganese	Yes _____	No _____
Hardness	Yes _____	No _____
pH	Yes _____	No _____

4. What were the results of the tests for the following? (Check one response for each test.)

Total coliform bacteria	Present _____	Absent _____
E. coli bacteria	Present _____	Absent _____

5. Since receiving the results of your water quality analysis, which of the following measures do you plan to take, or have already taken, to improve the quality of your water supply? (Check all that apply.)

\_\_\_\_\_ Contact a state agency such as the Health Dept., Dept. of Environmental Quality, etc. for assistance or additional information  
\_\_\_\_\_ Seek additional water testing from a laboratory  
\_\_\_\_\_ Determine source of undesirable condition  
\_\_\_\_\_ Pump out septic system  
\_\_\_\_\_ Improve physical condition of water source (well, spring, or cistern)  
\_\_\_\_\_ Shock chlorinate water system  
\_\_\_\_\_ Obtain new water source  
\_\_\_\_\_ Use bottled water for drinking/cooking  
\_\_\_\_\_ Temporary disinfection, such as boiling water  
\_\_\_\_\_ Purchase or rent water treatment equipment  
\_\_\_\_\_ Improve functioning of existing water treatment equipment  
\_\_\_\_\_ Take other measures to eliminate or reduce contaminant(s) in your water (explain)

---

Haven't done anything because \_\_\_\_\_

---

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## Post-Program Survey (cont.)

The following questions are designed to provide us with a profile of the total audience we've reached with this program. **Be assured that answers cannot be identified with individual participants.**

6. How many years have you lived at your present location? \_\_\_\_\_
7. Number of persons in your household. \_\_\_\_\_
8. What is the highest grade in school you've completed? (Check **one**.)
- \_\_\_\_\_ Grade school
  - \_\_\_\_\_ Some high school
  - \_\_\_\_\_ High school graduate
  - \_\_\_\_\_ Some education after high school
  - \_\_\_\_\_ College graduate
9. What is your **family** income before taxes? (Check **one**.)
- \_\_\_\_\_ Less than \$10,000
  - \_\_\_\_\_ \$10,000 to \$14,999
  - \_\_\_\_\_ \$15,000 to \$19,999
  - \_\_\_\_\_ \$20,000 to \$24,999
  - \_\_\_\_\_ \$25,000 to \$34,999
  - \_\_\_\_\_ \$35,000 to \$49,000
  - \_\_\_\_\_ \$50,000 or more
10. Other comments about the Household Water Quality Education Program:
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
11. Are there other educational programs that you would like to see offered by the Rockingham County Extension Office?
- \_\_\_\_\_
- \_\_\_\_\_
12. How did you hear about this Household Water Quality Education Program? (Check **all** that apply.)
- \_\_\_\_\_ Newspaper
  - \_\_\_\_\_ Radio
  - \_\_\_\_\_ Television
  - \_\_\_\_\_ Extension Newsletter
  - \_\_\_\_\_ Flyer from child's school
  - \_\_\_\_\_ Friend or Neighbor
  - \_\_\_\_\_ Other (explain)
- \_\_\_\_\_

Thank you for your participation. Please return this survey form by **November 20, 1999**. A postage-paid envelope has been provided for your use in returning this form to:

Sarah Ann Whitmore, Rockingham County  
Virginia Cooperative Extension  
Extension Distribution Center  
112 Landsdowne Street  
Blacksburg, VA 24060-9984







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