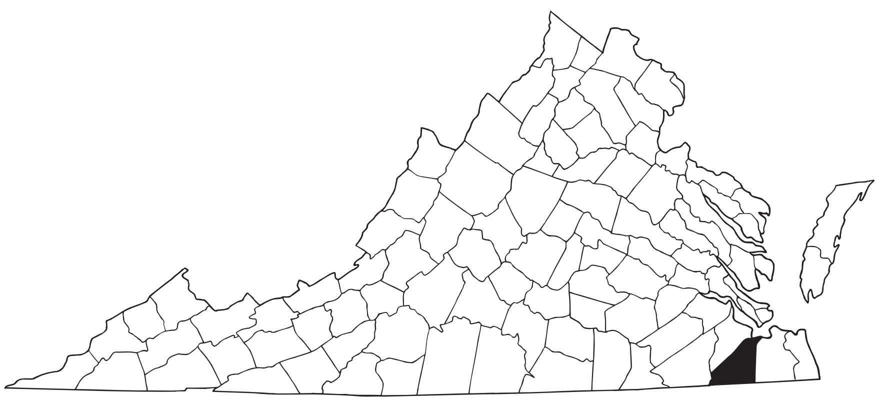
Evaluation of Household Water Quality in Suffolk, Virginia



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Abstract

During the fall of 2007, a household drinking-water-quality clinic – including water sampling, testing, and interpretation – was conducted in Suffolk, Va. Any Suffolk resident who used a private water supply was eligible to participate in this educational program. More than 200 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. Laboratory analyses identified the major household water-quality issues to be elevated levels of fluoride, total dissolved solids, iron, manganese, and bacteria. A number of samples had concentrations of sodium, manganese, nitrates, and total dissolved solids high enough to have potential health implications for at-risk individuals. In several instances, sampled water exhibited a high corrosion potential, which could lead to damage of metal plumbing, plumbing fixtures, and water-using appliances.

Acknowledgements

Many thanks to the residents of Suffolk who participated in the Household Water-Quality Program drinking-water clinic. Additional thanks to those who provided support in terms of publicity, encouragement, and interest. The enthusiasm and cooperation of all involved contributed to the success of this program.

The Water Quality Laboratory of the Department of Biological Systems Engineering at Virginia Tech was responsible for the majority of the water-quality analyses, as well as for coordination among the various labs and for much of the data management. The Soil Testing Laboratory of the Department of Crop and Soil Environmental Sciences at Virginia Tech assisted with the general water-chemistry analysis.

Introduction

The city of Suffolk, Va., has a land area of 400 square miles and is located in the Coastal Plain physiographic province. It lies on the Virginia-North Carolina border and west of the Tidewater metropolitan area. The far eastern portion of Suffolk is comprised of the Great Dismal Swamp. The northern area drains into the James River and the southern portion drains into the Chowan River. Between 2000 and 2006, Suffolk's population increased nearly 27 percent. Many homes in Suffolk that are located in rural areas do not use public water or sewage services. Throughout Virginia, the water-supply needs and wastewater-disposal requirements for the majority of rural homes and farms are the responsibility of the individual. Virtually all of these homes depend on groundwater sources.

As rural home sites encroach on agricultural land, residents' uncertainties about water supplies may arise. Additionally, septic systems – upon which most rural homes rely – may adversely impact the quality of a home's water supply because the design of the septic system was less than adequate to begin with or, more likely, the system has not been properly maintained.

To help homeowners deal with these issues, Virginia Cooperative Extension (VCE) initiated a pilot Household Water-Quality Education Program in Warren County, Va., in 1989. This program included collecting a household water-quality sample, analyzing that sample, and interpreting those analyses with the program's participants. Subsequent county-based programs – facilitated and organized by local VCE offices – have been conducted in 82 counties. From 1989 to 2007, approximately 12,000 household water samples have been analyzed for iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index/corrosivity, copper, sodium, nitrate, and total coliform and *E. coli* bacteria.

Objectives

The primary goal of this educational program was to provide household water-quality testing for individuals dependent on private water supplies in Suffolk. The objective was to improve the quality of life of rural homeowners by increasing awareness and understanding about water-quality problems, should they exist; groundwater protection strategies; and treatment alternatives.

Methods

The Household Water-Quality Education Program was offered through the VCE Suffolk Office during the fall of 2007. Any household resident of the city who used a private water supply was eligible to participate. The program was patterned after the model developed from the 1989 pilot program in Warren County. A program announcement (see appendix 1) was prepared and distributed, and local news media and agency newsletters publicized the program. The program was launched through local meetings held in downtown Suffolk in late September 2007. Attendees of these initial meetings were presented with information on local hydrogeologic characteristics, likely sources of and activities contributing to groundwater contamination, the nature of household water-quality problems (both health-related and nuisance), and details about the water-testing program to follow. Individuals were invited to participate in the Suffolk testing program for a fee of $33 per sample.

Sampling kits included a 250 ml Nalgene-brand bottle for general water-chemistry analysis (iron, manganese, hardness, sulfate, chloride, fluoride, total dissolved solids, pH, saturation index, copper, sodium, and nitrate), as well as a 125 ml sterilized Nalgene-brand bottle for bacteriological analysis (total coliform and *E. coli*). The sample identification form (see appendix 2) included sampling instructions and a questionnaire on which participants were asked to describe characteristics of their water supply, observed condition of their water, types of water-treatment equipment in use, and potential sources of contamination located near the water source. 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.

Water samples were collected from participants' taps on the morning of September 25, and were subsequently gathered and packed in ice at the VCE Suffolk Office. At the close of the collection period, all samples were immediately delivered to Virginia Tech in Blacksburg for analysis.

The general water-chemistry and bacteriological analysis was coordinated and conducted by the Water Quality Laboratory, Department of Biological Systems Engineering at Virginia Tech. The Soil Testing Laboratory in Virginia Tech's Department of Crop and Soil Environmental Sciences was subcontracted to analyze samples for several of the constituents (primarily metals). Water-quality analyses were performed using standard analytical procedures.

After the analysis was completed, participants were reminded by mail to attend an interpretation meeting in downtown Suffolk to obtain and discuss the test results and management practices to reduce the potential for contamination. A sample analysis report and accompanying report interpretation sheet are shown in the appendix (appendix 3 and 4).

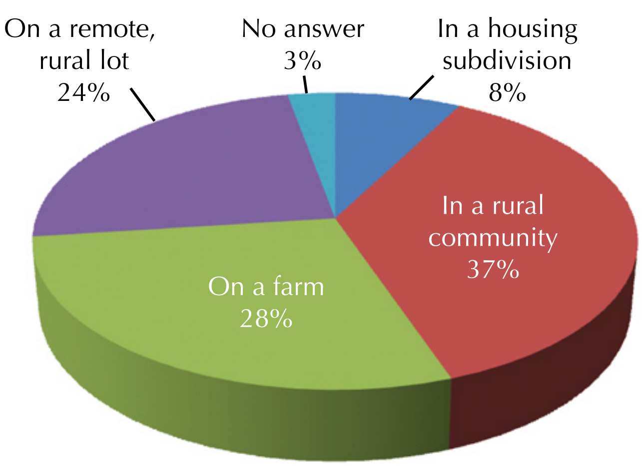
Findings and Results

During the course of the Suffolk program, 204 individual household water samples were submitted for analysis. Questionnaires completed by participants were also analyzed to gain an understanding of general characteristics of water sources, water condition, and treatment systems in use.

Profile of Household Water Supplies and Supply Systems

Questionnaire responses provided by the clinic participants helped to characterize water supplies in Suffolk (see appendix 2). One question sought to define housing density around each participant, which may impact the potential for contamination from septic systems, runoff, and other development-related, water-quality problems. Participants were asked to characterize their home's location into one of the following categories, which range from low- to high-density development: on a farm; on a remote, rural lot; in a rural community; or in a housing subdivision. The most commonly reported housing location of the Suffolk respondents was in a rural community (37 percent); followed by on a farm (28 percent); and remote, rural lot (24 percent). Eight percent of respondents reported living in a subdivision; 3 percent of participants did not respond.

Figure 1. Housing Environs Distribution in Suffolk



Information was also obtained regarding characteristics of the participants' water-supply systems. All but one of the 204 participants reported that they rely on wells; the other participant uses a spring. Most wells were drilled. About one in 10 wells was either dug or bored, while 15 percent of participants did not know what type of well they had (figure 2). Participants using a well were asked to provide an estimate of well depth, if known. Seventeen percent of participants had wells less than 50 feet deep; 10 percent reported wells between 51 feet and 300 feet deep; and the majority – 59 percent – had wells deeper than 300 feet. The maximum well depth reported was 800 feet; the average well depth was 371 feet (figure 3). Eighteen percent of the wells were constructed prior to 1981; 19 percent were constructed between 1981 and 1990; 20 percent between 1991 and 2000; and 29 percent since 2000 (figure 4). The earliest reported well construction was 1946.

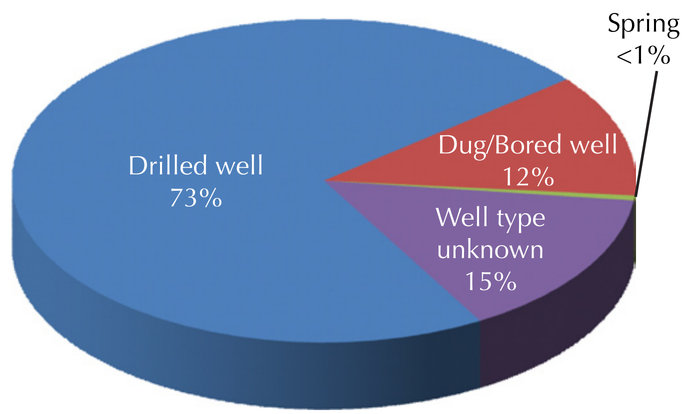


Figure 2. Type of Water Source

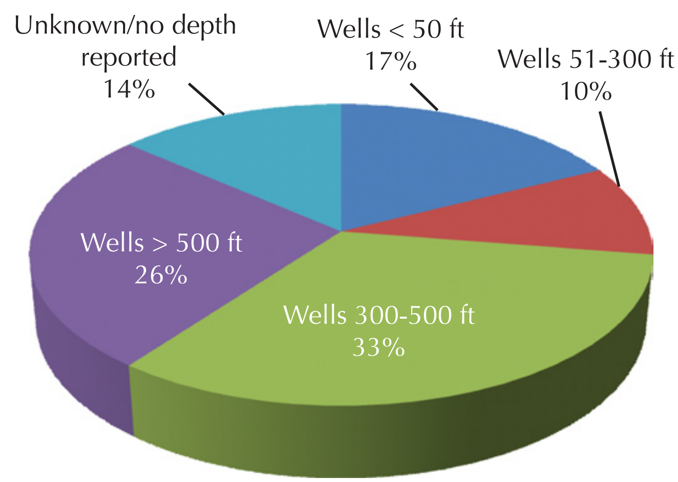


Figure 3. Well Depth Reported by Participants

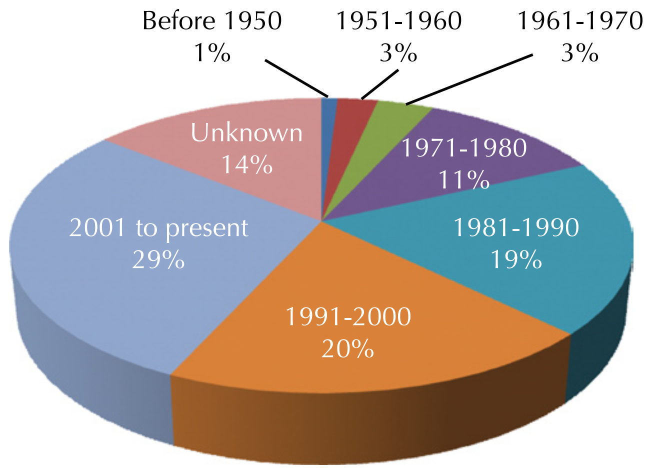


Figure 4. Year Well Constructed

Participants were also asked to identify potential sources of contamination near their water sources. Almost 25 percent of participants reported having some potential contaminant source within 100 feet of their water source (figure 5). The most common potential contaminant source was a septic-system drain field (14.7 percent); followed by streams/ponds (4.9 percent); and home-heating-oil storage (3.9 percent). Another question was asked about nearby land-use activities that could potentially contribute to groundwater contamination. All but two participants reported activities that might contribute to groundwater contamination within a one-half mile radius of their water source (figure 6). Agricultural activities – including field-crop or orchard production – were the most commonly identified activity (62 percent). A major farm-animal operation within one-half mile was reported by 24 percent of participants. Less commonly reported but potentially contamination-causing activities included manufacturing or processing facilities (4 percent); landfills (4 percent); and commercial, underground storage-tank or gas station (2 percent). Less than 1 percent of participants reported their water source being within one-half mile of an illegal dump, industrial site, or golf course.

Household water systems were further identified with respect to the type of material used for water distribution throughout the house (figure 7). The most widely used pipe material was copper (49 percent), while plastic was reported by 43 percent of the participants, and 3 percent claimed to have predominantly galvanized-steel plumbing. Five percent of participants reported, "don't know."

Figure 5. Potential Contamination Sources Within 100 Feet of Water Supplies

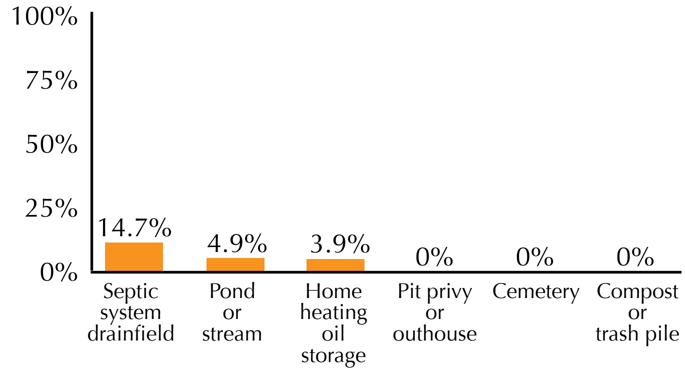


Figure 6. Pollution Sources Within One-Half Mile of Water Supplies

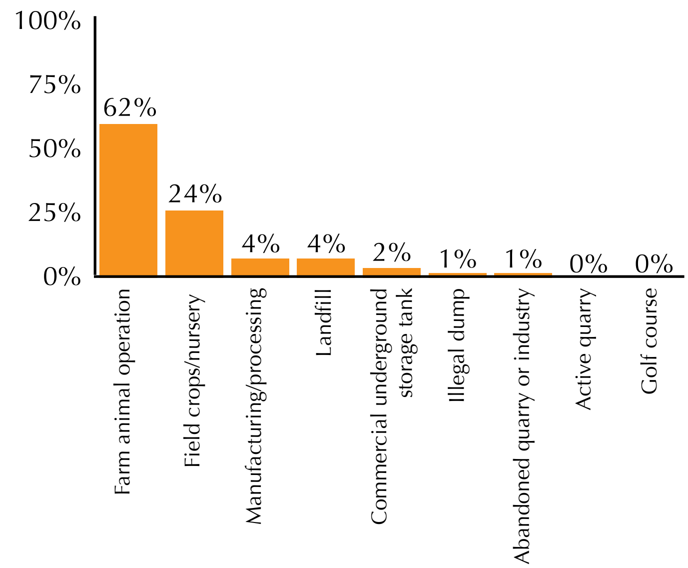
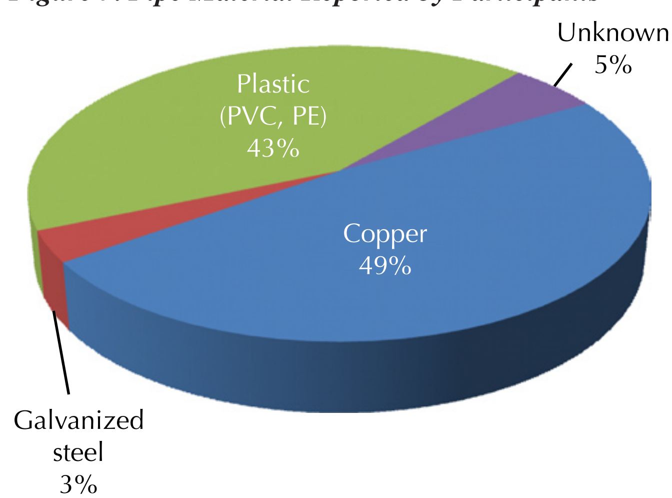
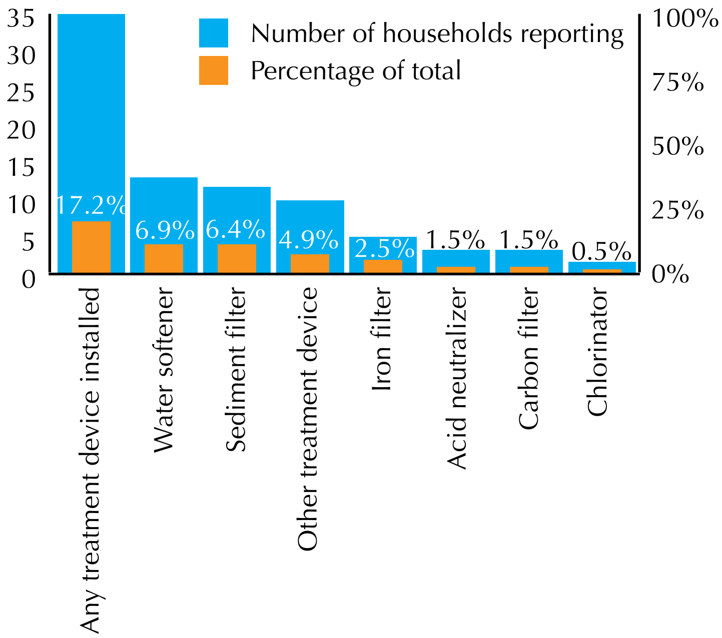


Figure 7. Pipe Material Reported by Participants



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 (figure 8). Seventeen percent of the participants reported at least one treatment device installed, with the most common type being a water softener (6.9 percent). Sediment filters were used by 6.4 percent of participants, while nearly 5 percent reported using some type of nonspecified, "other" treatment device. Participants also reported using reverse osmosis and various types of filters, including "whole-house" filtration. Less than 3 percent had installed an acid neutralizer, carbon filter, or chlorinator.

Figure 8. Households With Treatment Devices

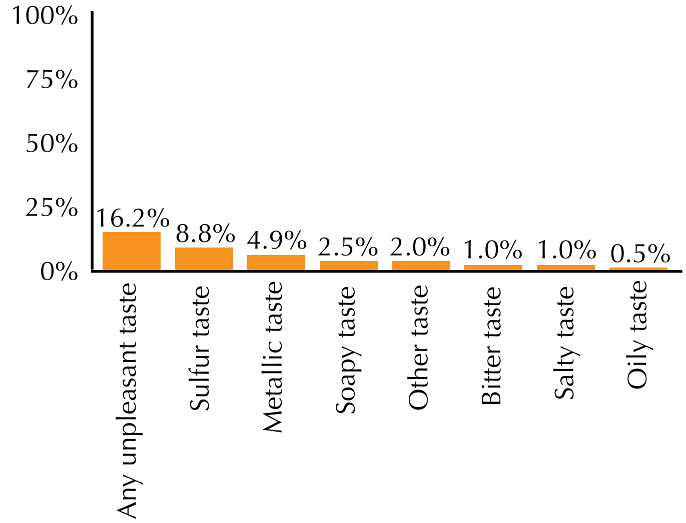


Participants' Perceptions of Household Water Quality

Participants were asked about problems they were experiencing with their household water quality (see appendix 2 for sample questionnaire). They were asked whether or not they had experienced: an unpleasant taste; objectionable odor; odd color or appearance; floating, suspended, or settled particles in the water; corrosion of pipes or plumbing fixtures; and/or staining of plumbing fixtures, cooking appliances/utensils, or laundry.

Sixteen percent of those responding reported that their water had an unpleasant taste (figure 9), with a "sulfur" taste being the most commonly described (8.8 percent). "Metallic," "soapy," and "other" tastes were reported by 4.9 percent, 2.5 percent, and 2 percent of respondents, respectively. "Bitter," "salty," and "oily" tastes were each indicated by 1 percent or less of the respondents.

Figure 9. Participants Reporting Unpleasant Taste



Water with an objectionable odor was reported by 21 percent of the participants (figure 10). The most prevalent odor was "rotten egg" (sulfur), identified by 19 percent. Two percent reported a "musty" odor. Three percent indicated their water had an unnatural color or appearance.

Particles in the water were a problem for about 8 percent of participants (figure 11), with 5.4 percent reporting "white flakes," followed by "black specks" (1.5 percent), "brown sediment" (1.5 percent), and "red slime" (0.5 percent). Three participants reported a "yellow" tint, two described water with a "black/grey" tint, and one participant indicated water with an oily film.

Figure 10. Participants Reporting Objectionable Odor

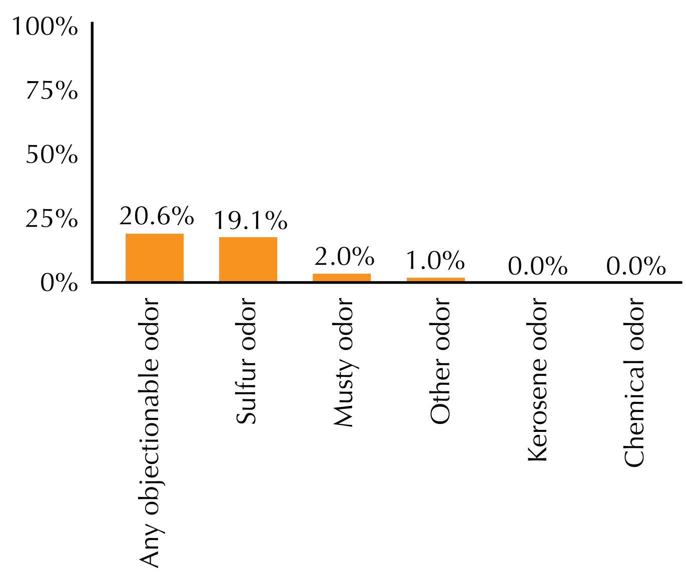
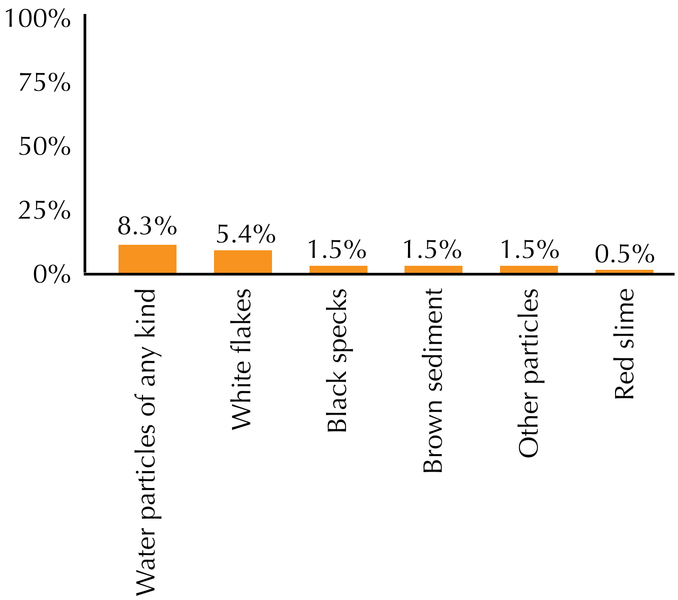
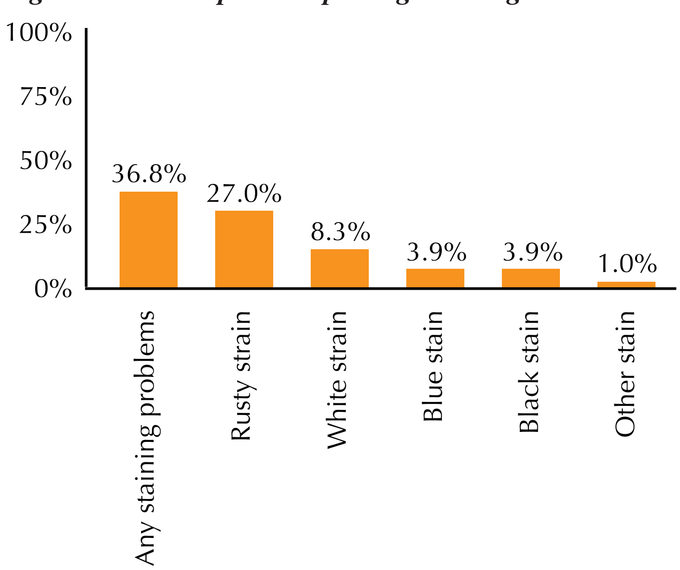


Figure 11. Participants Reporting Particles in Water



The majority of Suffolk participants reported no problems with pitting or corrosion of pipes (85.3 percent). Staining problems on plumbing fixtures, cooking appliances/utensils, and/or laundry were the most commonly reported aesthetic issues, with almost 37 percent of clinic participants reporting some staining problem (figure 12). The problem recorded most often was "rusty" stains (27 percent), followed by "white/chalky" stains (8.3 percent), then "blue" stains and "black" stains (3.9 percent each).

Figure 12. Participants Reporting Staining Problems



Household Water-Quality Analysis

General Water-Chemistry Analysis

Table 1 shows the average, maximum and minimum values for the constituents that were measured or assessed. Also included are the analysis detection limits (where applicable). Table 2 shows the percentage of samples not meeting (either too high or too low) each corresponding U.S. Environmental Protection Agency (EPA) water-quality standard. EPA established drinking-water standards to assess the quality of publicly supplied drinking water. Although water quality in private drinking-water wells is not regulated, EPA standards are good guidelines for assessing the quality of privately supplied water. Primary drinking-water standards – or Maximum Contaminant Levels (MCLs) – apply to contaminants that can adversely affect health and are legally enforceable for public-water systems. Secondary drinking-water standards – or Secondary Maximum Contaminant Levels (SMCLs) – are nonregulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining. The results and importance of each constituent or parameter included in the analysis are discussed below.

Table 1. General Water-Chemistry Analysis Results for 2007 Suffolk Drinking-water Clinic

Constituent	Detection limit	Measured level n = 204 Avg.[1]	Min.	Max.
Iron (mg/L)	0.005	0.15	DL[2]	7.96
Manganese (mg/L)	0.001	0.03	DL	2.11
Hardness (mg/L)	0.3	27.42	DL	372.00
Sulfate (mg/L)	0.3	7.9	DL	57.40
Chloride (mg/L)	1.0	46.47	16.00	286.00
Fluoride (mg/L)	0.1	2.29	DL	4.90
TDS (mg/L)	1.0	336.95	28.00	893.00
pH	N/A	7.70	4.61	8.60
Saturation index	N/A	-1.59	-6.22	0.15
Copper (mg/L)	0.002	0.026	0.002	0.55
Sodium (mg/L)	0.010	151.21	2.49	379.45
Nitrate (mg/L)	0.005	1.497	0.10	27.90

[1]Averages calculated with below detection limit (DL) sample results set equal to DL.
[2]Sample concentration below detection limit (DL).

Table 2. Percent of Samples Not Meeting Established EPA Drinking-water Standards for Public Water Systems

Constituent	Primary standard (Maximum Contaminant Level – MCL)	Secondary standard (Secondary Maximum Contaminant Level – SMCL)	Percent of samples exceeding standard (n = 204)
Iron (mg/L)	—	0.3	3.5
Manganese (mg/L)	—	0.05	7.3
Hardness (mg/L)	—	180.0	2.9
Sulfate (mg/L)	—	250.0	0
Chloride (mg/L)	—	250.0	0.5
Fluoride (mg/L)	4	2.0	19.0/60.0
TDS (mg/L)	—	500.0	16.2
pH - Low	—	6.5	9.8
pH - High	—	8.5	1.0
Saturation index – low	—	-1.0	69.2
Saturation index – high	—	1.0	0
Copper (mg/L)	1.3	1.0	0
Sodium (mg/L)	20	—	78.0
Nitrate (mg/L)	10	—	3.4
Total coliform	Absent	—	21.1
E. coli	Absent	—	2.0

Iron

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

About 3 percent of samples from the Suffolk drinking-water clinic had iron concentrations exceeding EPA's SMCL of 0.3 mg/L. It should be noted that the SMCL for iron is likely based more on taste considerations than on 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 the issue. Eight percent of the Suffolk samples exceeded 0.1 mg/L.

Manganese

Manganese generally does not present a health risk in drinking water. 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. Seven percent of the Suffolk drinking-water-clinic samples exceeded the manganese SMCL of 0.05 mg/L.

Hardness

Hardness is a measure of the concentration of calcium and magnesium in water. Drinking hard water does not present a health risk in itself. Hard water does have nuisance effects, including reduced soap lathering – resulting in decreased cleaning action of soaps and detergents – and build up of soap-scum residue on plumbing fixtures. Scale deposits may also accumulate in water pipes and hot-water heaters. Water softeners are highly recommended for very hard water (greater than 180 mg/L) and should be considered for hardness levels greater than 120 mg/L. Water with a hardness of 60 mg/L or less does not require softening.

Hardness is more prevalent in the karst or limestone areas of western Virginia and less common in the Suffolk area. Three percent of Suffolk drinking-water clinic samples were classified as "very hard" (exceeding 180 mg/L); 4 percent were classified as "hard" (between 120 mg/L and 180 mg/L); and 7.3 percent were "moderately hard" (between 60 mg/L and 120 mg/L). Fourteen participants (6.9 percent) in the Suffolk samples reported having a water softener (figure 8).

Sulfate

High sulfate concentrations in drinking water may cause a laxative effect or impart an objectionable taste. EPA has established an SMCL for sulfate of 250 mg/L. Sulfate concentrations were relatively low in the Suffolk clinic samples. The average concentration was 2.7 mg/L, and the maximum was 19.1 mg/L. None of the samples exceeded the 250 mg/L SMCL.

Sulfate is often naturally present in groundwater and may be associated with other sulfur-related problems, such as hydrogen sulfide gas. While it is difficult to test for the presence of this gas in water, most people can smell the characteristic "rotten-egg" odor, which is often more noticeable in hot water. In addition to the sulfur smell, hydrogen sulfide gas may also corrode metals in the water system and stain plumbing fixtures and cooking utensils. The complaints of a rotten-egg/sulfur odor by 19 percent of participants indicate that hydrogen sulfide gas may be problem among the Suffolk drinking-water-clinic participants. Those who experience a hydrogen sulfide gas-odor issue are encouraged to follow up with a reputable, local water-treatment professional.

Chloride

Low levels of chloride in drinking water generally do not present a health risk. Naturally occurring levels of chloride are generally low, so high levels in drinking water may 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's SMCL for chloride is 250 mg/L. The average chloride level for the Suffolk drinking-water clinic samples was 46.5 mg/L, and only one sample exceeded the SMCL.

Fluoride

Fluoride in drinking water is a concern because of its effect on teeth and gums. Small concentrations of fluoride are considered to be beneficial in preventing tooth decay, but moderate to high amounts can cause brownish discoloration of teeth, and high fluoride concentrations can lead to tooth and bone damage. For these reasons, the EPA's SMCL for fluoride is 2 mg/L, and the maximum level (MCL) is 4 mg/L. Sixty percent of samples had fluoride levels greater than or equal to 2 mg/L, and 19 percent of samples exceeded the 4 mg/L MCL. Fluoride levels exceeding 4 mg/L may be especially harmful to teeth and bones of children less than 8 years old.

Total Dissolved Solids

High concentrations of total dissolved solids (TDS) may cause adverse taste effects and can deteriorate household plumbing and appliances. High levels of TDS are often considered an indication that other contamination may be occurring, because it is a measure of all particles in the water larger than 2 micrometers (µm) in diameter. The EPA's SMCL for total dissolved solids is 500 mg/L. The average TDS concentration found in the Suffolk participants' samples was 337 mg/L. Thirty-three of the samples (16 percent) exceeded the SMCL. The maximum TDS concentration among the water samples was 893 mg/L.

pH

The measure that indicates whether a substance is acidic or alkaline is known as pH. Acidic water can cause corrosion in pipes and may cause toxic metals from the plumbing system – such as lead or copper – to be dissolved in drinking water. The life of a plumbing system may be shortened due to corrosion, eventually requiring expensive repair and replacement of water pipes and plumbing fixtures. Neutralizing treatment is generally recommended for water with a pH less than 6.5. Alkaline water (pH greater than 8.5) is seldom found naturally and may indicate contamination by alkaline industrial wastes. The EPA-suggested pH range for drinking water is between 6.5 and 8.5.

The average pH reading for the Suffolk drinking-water clinic samples was 7.70. Two samples had a pH greater than 8.5. About 10 percent of the samples had a pH less than 6.5. Five percent of the samples had a pH between 6.5 and 7.0, which is considered slightly acidic. Water that is slightly acidic can cause staining and corrosion problems over time. The remaining samples had pH values between 7.0 and 8.5.

Saturation Index

The saturation index (Langelier Saturation Index was used for this clinic), in addition to pH, is used to evaluate water's potential to corrode or to build up a mineral scale (scaling) on pipes and fixtures. The saturation index is a calculated parameter that incorporates the water's concentration of calcium and total dissolved solids, and its pH and alkalinity levels.

A saturation index value between -1 and 1 is considered balanced, meaning that there is most likely not a problem with either corrosion or scaling. A saturation index greater than 1 indicates that scaling is likely, meaning that a thin protective layer of calcium carbonate may form on the inside of pipes and plumbing fixtures. A saturation index greater than 3 indicates that scaling may be severe, causing problems with reduced flow in pipes and a reduction in the efficiency of water heaters and other water-using appliances. A saturation index less than -1 (negative 1) indicates that the water may be corrosive. Saturation index values less than -1 are of less concern if the pH of the water is 7.0 or more.

The Suffolk drinking-water clinic included no samples with a saturation index greater than 1. Thirty percent of samples had "balanced" water (saturation index between -1 and 1). Fifty-five percent of the samples had a saturation index between -1 and -3. Fifteen percent had a saturation index between -3 and -5, which indicates that severe corrosion is possible.

NOTE: While water softeners reduce hardness, they may increase the corrosion potential of the treated water. Owners of water softeners may note a saturation index reading that is less than desired. Concerns about drinking-water quality may be lessened by softening only hot water or by bypassing drinking-water lines. Contact a reputable water-treatment professional for additional information.

Copper

The EPA's MCL for copper in public drinking-water supplies is 1.3 mg/L – the maximum level recommended to protect people from acute gastrointestinal illness. Lower levels of dissolved copper may produce a bitter or metallic taste and may result in blue/green stains on plumbing fixtures. Because of these nuisance effects, EPA has also established a secondary maximum level for copper of 1.0 mg/L. No samples from the Suffolk drinking-water clinic exceeded either the MCL or SMCL. Natural levels of copper in groundwater are usually low. The primary contributor to copper in drinking water is corrosion of copper pipes and fittings.

Sodium

Sodium may be a health hazard to people suffering from high blood pressure or cardiovascular or kidney disease. For those on a severe, salt-restricted diet, 20 mg/L is the EPA suggested drinking-water threshold. Those on a salt-restricted diet with water containing more than 20 mg/L sodium should consult a physician and consider contacting a reputable water-treatment professional. Seventy-eight percent of the Suffolk drinking-water clinic samples exceeded 20 mg/L, and 71 percent were greater than 100 mg/L (table 2).

The Food and Nutrition Board of the National Research Council recommends that most healthy adults consume between 500 mg and 2,400 mg of sodium each day. Most American adults tend to consume between 4,000 mg and 6,000 mg of sodium per day. For healthy adults, the American Heart Association suggests that no more than 10 percent of one's sodium intake should come from water. If a person drank 2 liters of water per day (approximately eight 8-oz glasses) that contained 100 mg/L of sodium, their water-related sodium intake would be 200 mg/day, which is 40 percent of a 500 mg/day diet, or about 10 percent of a 2,400 mg/day diet. Those with a sodium concentration greater than 100 mg/L may want to take steps to reduce the sodium in their drinking water.

Nitrate

High levels of nitrate may cause methemoglobinemia, or "blue-baby" syndrome, in infants younger than 6 months of age. Although EPA has set an MCL of 10 mg/L for nitrate, it suggests that water with more than 1 mg/L not be used for infants. Nitrate levels of 3 mg/L or more may indicate contamination of the water supply by commercial fertilizers and/or organic wastes from septic systems or farm-animal operations. Nitrate levels may vary seasonally, depending on rainfall and the timing of application of nitrogen sources such as fertilizers. Slightly more than 3 percent of the samples exceeded the MCL of 10 mg/L, and 26 percent of the samples exceeded the 1 mg/L level.

Bacteriological Analysis

Private household water supplies may be contaminated 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 severe. Diseases that may be carried in water include salmonellosis, dysentery, typhoid fever, cholera, and forms of hepatitis. One particularly threatening disease transmissible through drinking water is viral hepatitis A.

While coliform bacteria do not cause disease, they serve as indicators of the possible presence of disease-causing organisms. Coliforms are always present in the digestive systems of warm-blooded animals and can be found in their waste. Coliforms are also present in the soil and in plant material. A positive total-coliform-bacteria test result (reported as "present") indicates the presence of coliform bacteria and thus contamination of the water source. A positive total-coliform test may be an indication of surface-water contamination due to poor well construction, contamination of the household plumbing system, or contamination of the groundwater itself. It may also indicate that the sample or the sample container was contaminated or fouled during collection.

A positive *E. coli* test result (reported as "present") indicates that waste from either human or animal waste is contaminating the water supply. This is a more serious situation that requires immediate attention. Although people who have been drinking the contaminated water with no ill effects for some time may have developed some immunity to bacteria present in the water, there is no assurance that they won't suffer harmful effects in the future as a result of continued exposure. Guests in the home who have not developed this immunity may experience more immediate problems.

Learning that a water supply is contaminated with bacteria should encourage a homeowner to take action. After receiving a positive bacteria test, homeowners should consider retesting the water to verify that bacteria are present and seek an alternative source of drinking water until the problem is resolved. To prevent the problem from getting worse, try to find and eliminate sources of contamination (e.g., infiltration of surface water) and take corrective steps to purify the contaminated water.

Of the 204 household water samples analyzed for total coliform bacteria, 43 (21 percent) tested positive (present). These positive samples were then analyzed for *E. coli*. A total of four samples, or 2 percent, tested positive for *E. coli*.

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, because wells usually offer better protection from surface – or near-surface – contaminants. Similarly, deep-drilled wells are better protected than shallow-dug and bored wells.

The age of a water source or system is an additional factor that 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 was enacted in the early 1970s and early 1990s.

Fecal bacteria in household water supplies may have originated from animal waste and/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. The Suffolk drinking-water clinic 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.

Conclusions

The Virginia Household Water-Quality Program conducted in Suffolk was considered to be a successful educational endeavor. The opportunity to participate in this program was well received by those residents who chose to take part. Individuals participated primarily because of concern about the safety of their water supply. Despite being a voluntary program, a geographically distributed sample that represents diverse households 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 may be useful for water-quality assessment at county and regional scales.

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Glossary

EPA – U. S. Environmental Protection Agency

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

µg/L – Concentration unit of micrograms per liter in water, equivalent to one part per billion (ppb).

Maximum Contaminant Level (MCL) – Legally enforceable national standard set by 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. Governments do not enforce these standards; however, they are useful guidelines for individual water supplies.

Appendix

1. Program Press Release
2. Sample Identification and Questionnaire Form
3. Sample Water Quality Analysis Report
4. Report Interpretation Fact Sheet

(1) Program Press Release

Virginia Cooperative Extension Offers Water Quality Testing Program

Cumberland County Extension Office will be conducting household water quality testing programs during the month of October with results to follow in November. Testing is available for water from wells, springs, or cisterns. The programs will be made up of a three part series. The first meeting, which will be held on October 6th at 7:00 p.m. in the Cumberland Elementary School Cafeteria, will include information on water quality, why you should test your drinking water, and what type of information your tests will include. Participants will receive the test kits and detailed information on how to collect the water samples. The second part of the series involves participants collecting their water samples and dropping them off at the Cumberland County Extension Office on October 12th from 7:00 – 11:00 a.m. A final meeting will be held in mid-November at the Cumberland Elementary School Cafeteria where test results will be distributed and information will be presented on how to take care of problems with your drinking water.

The cost of the program will be $21 for the first 300 households and $26 for any additional participants. This fee is due when picking up the Test Kit on October 6 and is non-refundable. Cumberland County and Virginia Tech have contributed to significantly reduce the cost of the test from the usual $45 fee. For additional information or to sign up, please contact the Cumberland County Extension Office at 804-492-4390, Monday – Friday from 8:00 to 4:30 p.m. This program, like all Virginia Cooperative Extension programs, is open to all people on a non-discriminatory basis.

SUFFOLK HOUSEHOLD WATER QUALITY PROGRAM

Suffolk Cooperative Extension
440 Market Street
P.O. Box 218
Suffolk, VA 23439-0218
(757) 923-2052

SAMPLE IDENTIFICATION

Please print clearly and provide complete information on both sides of form.

Sample No.:________________ Date Collected: _____________________

Sample submitted by:

Name:____

Telephone:____

Mailing Address:____

____

Sample Address:____

(if different from mailing)_________________________________

FOR OFFICE USE ONLY

Lab Sample No.______________________

SAMPLE CHARACTERISTICS

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
_____water softener (conditioner)
_____iron removal filter
_____automatic chlorinator
_____acid water neutralizer
_____sediment filter (screen or sand type)
_____activated carbon (charcoal) filter
_____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 (757) 923-2052.

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.

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.

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.

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.

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.

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.

(2) Sample Identification and Questionnaire Form (cont.)

<u>QUESTIONNAIRE</u> 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** please.

   _____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?

   ___copper   __lead   __galvanized steel   __plastic (PVC, PE, etc.)   ___ don't know   ___other → specify: _______________

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. Please check **all** that apply.

    _____septic system drain field   _____home heating oil storage tank (above or below ground)
    _____pit privy or outhouse   _____ pond or freshwater stream
    _____cemetery   _____tidal shoreline or marsh

15. If your water supply is located **½ mile or closer** to any of the following, please indicate. Please check **all** that apply.

    _____landfill   _____golf course
    _____illegal dump   _____field crops/nursery
    _____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.)

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(3) Sample Water Quality Analysis Report

Suffolk City
Household Water Quality Program
Suffolk Cooperative Extension
P.O. Box 218
Suffolk, VA 23439-0218

Sample No: S

Suffolk, VA 23437
(757)

Source: Drilled Well
Treatment: Sediment Filter

Water Quality Results
Date of Sample: 9/25/07

Test	Household Water Sample	Maximum Recommended Level or Range
Iron (mg/L)	0.014	0.3
Manganese (mg/L)	0.009	0.05
Hardness (mg/L)	5.84	180
Sulfate (mg/L)	5.82	250
Chloride (mg/L)	42.0	250
Fluoride (mg/L)	4.50**	2.0
Total Dissolved Solids (mg/L)	363.0	500
pH	8.08	6.5 to 8.5
Saturation Index	-1.08**	- 1 to 1
Copper (mg/L)	0.002	1.0
Sodium (mg/L)	193.63**	20
Nitrate-N (mg/L)	0.20	10
Total Coliform Bacteria	ABSENT	ABSENT
E. Coli Bacteria	ABSENT	ABSENT

**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.

Suffolk 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 objectionable 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 concentration 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 are 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 for 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.

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 calls 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 warm blooded 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.