In cooperation with the
Maryland Department of the Environment

Occurrence and Distribution of Microbiological Contamination and Enteric Viruses in Shallow Ground Water in Baltimore and Harford Counties, Maryland

Water-Resources Investigations Report 01-4216

U.S. Department of the Interior
U.S. Geological Survey

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By William S.L. Banks (U.S. Geological Survey) and

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Conversion Factors and Vertical Datum

Multiply	By	To obtain
inch (in.)	2.54	centimeter
inch per year (in/yr)	2.54	centimeter per year
million gallons per day (Mgal/d)	3,785	cubic meter per day
gallon per day (gal/d)	3.785	liter per day
gallon (gal)	3.785	liter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
acre	4,047	square meter

Temperature in degrees Fahrenheit ($^\circ$F) can be converted to degrees Celsius ($^\circ$C) as follows:

$$^\circ C = (^\circ F - 32) / 1.8$$

Vertical datum: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (μg/L), or molarity.

Concentrations of microbiological constituents in water are given either in plaque-forming units (pfu) or colony-forming units (cfu) per unit volume.

Occurrence and Distribution of Microbiological Contamination and Enteric Viruses in Shallow Ground Water in Baltimore and Harford Counties, Maryland

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Abstract

The U.S. Geological Survey, in cooperation with the Maryland Department of the Environment and the Wisconsin State Laboratory of Hygiene, conducted a study to characterize the occurrence and distribution of viral contamination in small (withdrawing less than 10,000 gallons per day) public water-supply wells screened in the shallow aquifer in the Piedmont Physiographic Province in Baltimore and Harford Counties, Maryland. Two hundred sixty-three small public water-supply wells were in operation in these counties during the spring of 2000. Ninety-one of these sites were selected for sampling using a methodology that distributed the samples evenly over the population and the spatial extent of the study area. Each site, and its potential susceptibility to microbiological contamination, was evaluated with regard to hole depth, casing interval, and open interval. Each site was evaluated using characteristics such as on-site geology and on-site land use.

Samples were collected by pumping between 200 and 400 gallons of untreated well water through an electropositive cartridge filter. Water concentrates were subjected to cell-culture assay for the detection of culturable viruses and reverse-transcription polymerase chain reaction/gene probe assays to detect viral ribonucleic acid; grab samples were analyzed for somatic and male-specific coliphages, *Bacteroides fragilis*, *Clostridium perfringens*, enterococci, *Escherichia coli*, total coliforms, total oxidized nitrogen, nitrite, organic nitrogen, total phosphate, orthophosphate, calcium, magnesium, sodium, potassium, chloride, sulfate, iron, acid-neutralizing capacity, pH, specific conductance, temperature, and dissolved oxygen.

One sample tested positive for the presence of the ribonucleic acid of rotavirus through polymerase chain-reaction analysis. Twenty-nine percent of the samples (26 of 90) had bacterial contamination. About 7 percent of the samples (6 of 90) were contaminated with either male-specific coliphage, somatic coliphage, or bacteriophages of *Bacteroides fragilis.* About 3 percent of the samples (3 of 87) had oxidized nitrogen concentrations that exceeded the U.S. Environmental Protection Agency's Maximum Contaminant Level of 10.0 milligrams per liter. A statistical analysis showed that no significant relation exists between the presence of bacteria or coliphage and all variables, except the mean temperature of the water sample as measured in the field. Additionally, the concentration of total coliform bacteria had a statistically significant, moderately strong correlation with the concentration of sulfate and sample pH as measured at the U.S. Geological Survey National Water-Quality Laboratory in Denver, Colorado.

Introduction

In response to the 1996 Amendments to the Safe Drinking Water Act, the U.S. Environmental Protection Agency (USEPA) is developing the Ground-Water Rule (GWR) to protect users of public ground-water supplies from viral contamination (U.S. Environmental Protection Agency, 2001a). Because total coliform bacteria often is used as an indicator of the possibility or likely presence of pathogenic contamination from microbial pathogens, many ground-water suppliers use the absence of coliform as justification for not disinfecting source water. In addition, because of the high cost and complex analytical methods involved, direct

monitoring for viruses seldom is done in public-water supplies (U.S. Environmental Protection Agency, 1986).

In 1998, the U.S. Geological Survey (USGS), in cooperation with the Maryland Department of the Environment (MDE) and the Wisconsin State Laboratory of Hygiene (WSLH), began a study to characterize the occurrence and distribution of enteric viruses in small (less than 10,000 gallons per day, or gal/d) public water-supply wells in the aquifers of the Piedmont Physiographic Province of Baltimore and Harford Counties, Maryland. Because of difficulties associated with direct monitoring for viral contamination (such as cost and turn-around time), it has not been feasible to routinely document the presence or absence of viruses in public-water supplies. Therefore, studies are needed to characterize the occurrence and distribution of viral contamination in ground water used for drinking water throughout the United States.

Background

Viruses are among the smallest of the disease-causing microorganisms found in the aquatic environment. In 1996, the U.S. Congress amended the Safe Drinking Water Act to require that all states develop methods for assessing the vulnerability of drinking-water supplies to various regulated contaminants. In addition, states were granted the authority to include other contaminants that might present a threat to public health. For this reason, Maryland included enteric viruses as a part of its assessment criteria. More than 120 different types of potentially harmful enteric viruses are excreted in human feces, and are widely distributed in type and number in domestic sewage, agricultural wastes, and septic drainage systems (Gerba, 1988). Many of these viruses are stable in natural waters and have long survival times with half-lives ranging from weeks to months. Because they may cause disease even when just a few virus particles are ingested, low levels of environmental contamination may affect water consumers. From 1971 to 1979, approximately 57,974 people in the United States were affected by outbreaks of waterborne pathogens (Craun, 1986). Outbreaks of waterborne disease attributed to enteric viruses are poorly documented, even though viruses are commonplace in natural waters contaminated with human feces. Illnesses in humans caused by waterborne viruses range from severe infections such as myocarditis, hepatitis, diabetes, and paralysis to relatively mild conditions such as self-limiting gastroenteritis. It has not been possible to identify the etiologic agent or agents responsible for community illness in approximately half of the reported waterborne outbreaks because the isolation and identification of the causative agent was either unsuccessful or not attempted (Craun and McCabe, 1973; Craun, 1986; Sobsey, 1989). Additional analyses indicate that caliciviruses such as the Norwalk virus and other enteric viruses may be responsible for as much as 60 percent of the reported waterborne outbreaks of gastroenteritis since the clinical features of the cases in many of these epidemics are consistent with viral infections, and bacterial pathogens were ruled out as disease agents (Keswick and Gerba, 1980; Kaplan and others, 1982; U.S. Environmental Protection Agency, 1988; Herwaldt and others, 1992). Despite the inherent difficulties associated with the identification of viruses in water, disease outbreaks have been attributed to specific episodes of viral contamination in ground water (Craun and others, 1976; Hejkal and others, 1982; Herwaldt and others, 1992; Divizia and others, 1993; Beller and others, 1997). Because approximately half of the reported outbreaks of waterborne disease in the United States from 1970 through 1990 had undefined etiologies, establishing causality between specific viral agents and illness caused by contaminated water supplies remains difficult. Nevertheless, enteric viruses such as the Norwalk and Norwalk-like viruses have been established as the major cause of viral gastroenteritis among adults world-wide (Beller and others, 1997).

The USEPA has identified numerous potential sources of viral contamination in ground water, including wastewater in commercial and industrial settings, septic systems in residential and municipal settings, and condensed animal-feeding operations in rural or agricultural areas. Currently (summer 2001), the Total Coliform Rule is used to screen for fecal contaminants, and is the only Federal drinking-water regulation in effect for determining the presence of microbes in public ground-water systems not directly under the influence of surface water.

Other nonpathogenic microorganisms also have been suggested as viral indicators. Coliphages are bacterial viruses that infect the coliform bacterial group. Some coliphages are superficially similar to the enteric viruses in that they share symmetrical structures, morphologies, and sizes, and have similar half-lives in natural waters. Some coliphages, particularly those that infect "male" strains of *Escherichia coli* (*E. coli*), or "male-specific" coliphages, can be found in human feces and have been identified in large numbers in human wastewater (Havelaar, 1986). Male-specific coliphages and other bacteriophages have been proposed as viral indicator microorganisms because (1) outbreaks of viral etiology have been documented in waters that met coliform criteria for drinking purposes (Kukkula and others, 1999); (2) viruses may be considerably more resilient in the environment than coliforms; and (3) the infectious dose of many viral diseases is considerably lower than that observed for enteric bacterial disease (Hejkal and others, 1982).

Other microorganisms under consideration as viral indicators include fecal streptococci and enterococci, certain anaerobic bacteria such as *Clostridium perfringens* (*C. perfringens*), *Bacteroides fragilis* (*B. fragilis*) and the Bifidobacteria. Low recovery rates have been reported for *B. fragilis* and Bifidobacteria; however, both of these bacteria are relatively sensitive to inactivation by chlorine and their reported presence in water has sometimes been inconsistent, rendering them equivocal as an indicator organism for human enteric viruses (Sartory, 1980; Allsop and Stickler, 1985).

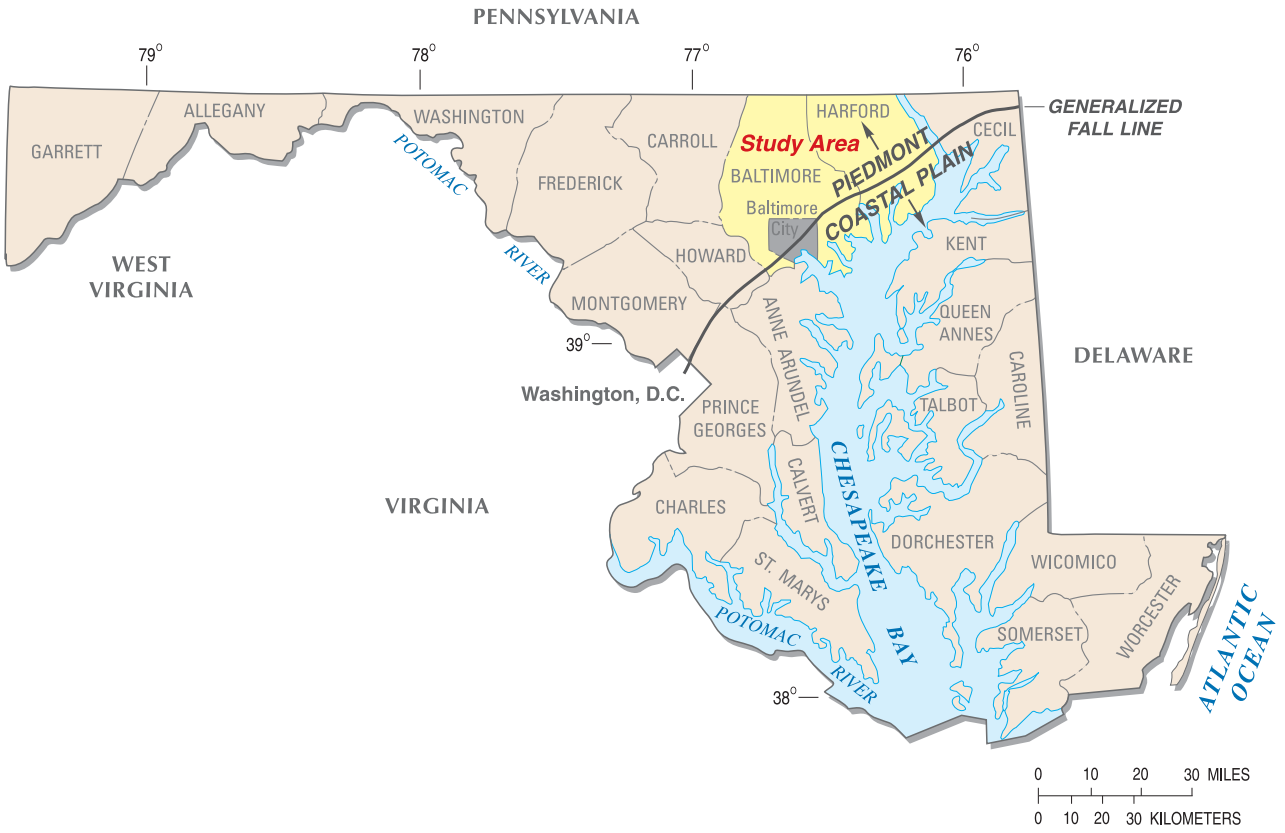

Figure 1. Location of study area, Baltimore and Harford Counties, Maryland.

Purpose and Scope

The purpose of this report is to describe microbiological occurrence in ground water in small public water-supply systems and possible factors affecting well vulnerability to microbiological contamination in the aquifers of the Piedmont Physiographic Province in Baltimore and Harford Counties, Maryland. The report relates the occurrence of microorganisms to well information, on-site geology, on-site land use, and selected chemical constituents.

One hundred and one samples were collected from April 10, 2000 to November 13, 2000. Ninety of these samples were selected based on a random, spatially distributed sample population. Ten replicate samples were collected to assess variability. One additional, randomly selected site in Baltimore County also was sampled.

Location and Description of Study Area

Baltimore and Harford Counties compose 1,039 mi^2 (square miles) of north-central Maryland. The area is bordered to the north by York and Lancaster Counties, Pennsylvania, to the west by Carroll and Howard Counties, Maryland, and to the east and south by Cecil County, the Chesapeake Bay, and Anne Arundel County, Maryland, (fig. 1). The study area includes parts of the two counties where public water-supply wells have been drilled into consolidated crystalline rock. This area generally is west of the Fall Line in both counties. The Fall Line (fig. 1) is a zone trending northeast to southwest that separates the unconsolidated sediments of the Atlantic Coastal Plain Physiographic Province from the igneous and metamorphic rocks of the Piedmont Physiographic Province. The study area is characterized by rolling hills and moderately to deeply incised valleys, with altitudes ranging from sea level to more than 900 ft (feet) above sea level.

The northern part of the study area is mostly rural, while areas to the south and east tend to be more urban. The total population of both counties in the year 2000 was 972,882. Towson, the county seat of Baltimore County, is located in the central part of Baltimore County and has a population of 51,793. The town of Bel Air is the Harford County seat. The town and its suburbs have a combined population of 75,589 (U.S. Bureau of the Census, 2001).

The climate of the study area is temperate. Average temperatures range from about 35 °F (degrees Fahrenheit) in the winter to about 70 °F in the summer. Rain and snowfall vary seasonally, and average about 41 in/yr (inches per year) (National Oceanic and Atmospheric Administration, 1977).

Hydrogeologic Setting Ground water in the study area can be found under water-table or confined conditions. As in the Coastal Plain Physiographic Province, ground water fluctuates seasonally in response to variations in precipi-

tation, evapotranspiration, and local ground-water withdrawals. Ground water in the Piedmont Province is found under water-table conditions in the saprolite overburden and in the joints and fractures of the crystalline rock. The saprolite layer is formed by the chemical weathering of native rock material. The thickness of the saprolite layer and its capability to transmit water are dependent on the lithology and structure of the parent rock. As the rock is weathered, many features (such as joints and fractures) are preserved in the saprolite. The joints and fractures found in crystalline rock are the result of stresses in the Earth's crust and occur with greater frequency and more interconnections closer to the Earth's surface. In addition, these structures tend to be more localized in topographic lows than in topographic highs. Nutter and Otton (1969) noted that this localization is partly because valleys in the Piedmont Province develop along zones of fracture.

The hydraulic properties of the Maryland Piedmont tend to reflect both unconsolidated material and crystalline rock. The porosity of 34 saprolite samples from Maryland and Georgia averaged 46.8 percent (Nutter and Otton, 1969). Where saprolite is present, its porosity varies with depth, reaching a maximum at about 30 to 40 ft below land surface. At greater depths, porosity decreases as saprolite grades to unweathered rock (Nutter and Otton, 1969). The porosity of unweathered rock is much lower on average than that of the saprolite, ranging from about 0.01 to 2 percent (Heath , 1984). The hydraulic conductivity of saprolite also decreases with depth, but tends to increase near the contact between the saprolite and the unweathered rock. Well drillers often report encountering sand and gravel in this zone and many wells are finished to take advantage of this phenomenon. The most productive wells tend to be located in areas where multiple fractures or joints occur and where the overburden has sufficient hydraulic head and permeability. Because permeability decreases with depth in crystalline rock, well yields also tend to decrease with depth. The lower boundary of the surficial aquifer is defined as the base of the zone where interconnected fractures cease to be present (Davis and DeWiest, 1966; Heath, 1984; Bolton, 1998). Further information on the hydrogeology of the Maryland Piedmont can be found in Dingman and Ferguson (1956), Otton and others (1964), and Bolton (1998).

Ground-Water Use Shallow ground water in northern Baltimore and northwestern Harford Counties is the major water-supply source for industry, agriculture, and domestic self-supplied drinking water. Approximately 10.63 Mgal/d (million gallons per day) of ground water is pumped from the water-table aquifer in the Piedmont Province of Baltimore and Harford Counties (Judith Wheeler, U.S. Geological Survey, oral commun., 2001). The majority of shallow ground water used in the two-county area is for domestic self-supply (8.2 Mgal/d) and commercial use (1.1 Mgal/d). Public water supply accounts for about 0.37 Mgal/d. Agricultural activities account for about 0.7 Mgal/d, and industry and mining use approximately 0.33 Mgal/d. Well depths in the study area range from tens of feet in settings where fractures and joints are closely spaced and ground-water yields are substantial, to well over 300 ft in areas where fractures and joints are farther apart. Nutter (1977) noted that well yields generally do not improve with depth and suggested that most, if not all, water-bearing fractures are within 300 ft of the land surface.

The interconnected nature of joints and fractures in the Piedmont Province often obscures the source and direction of ground-water flow. This makes identification of contaminant sources difficult. Although no direct correlation has been established in the study area between the consumption of fecally contaminated water from a public water-supply system and waterborne illnesses, the relatively shallow depth to the water table and the common use of septic systems as a means of sewage disposal increase the potential for enteric viruses and other microbiological contamination to be transported to the water table.

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Study Design and Methods

Viruses are not capable of reproduction outside of a suitable host or host cell; therefore, the occurrence of viruses in a water supply is directly related to the supply's proximity to fecal contamination. Various studies have indicated that pathogen occurrence in ground-water supplies and pathogen transport in porous media may be affected by hydrogeology, soil type, and well-construction characteristics (Bales and others, 1995; DeBorde and others, 1998; Abbaszadegan and others, 1998; Gerba, 1999). Numerous studies on the travel-times and inactivation rates of viruses in ground water have been conducted, and the results do not compare well. In experiments with live attenuated viruses, Noonan and McNabb (1979) documented that viruses could travel more than 2,953 ft, whereas Vaughn and Landry (1977) showed a maximum travel distance of 150 ft. Wellings and others (1975) suggested that virus survival time in ground water may be as little as 28 days, whereas Gerba and others (1975) suggested that at very low temperatures (below 4 °C, or degrees Celsius), viruses can survive in ground water for months to years. In laboratory studies, Gerba (1999) related virus survival to soil moisture and depth to the water table stating that although many viruses are resistant to inactivation by desiccation, viruses that must pass through an unsaturated soil zone may be permanently adsorbed to soil particles, thus rendering them either inactive or unavailable for transport.

One hundred forty-nine small public water supplies were available for sampling in Baltimore County, but only 114 sites were available in Harford County. To ensure an approximately equal number of samples in each county, sites were chosen based on a modification of Madow's (1949) method for constructing a spatially structured list frame. Samples were selected through a hierarchical randomization process that increased the probability of well selection in Harford County. After all sampling sites had been chosen, a geographic information system (GIS) was used to identify potential mappable characteristics that may be related to sources of fecal contamination. Land-use data (Maryland Department of the Environment, 1994) was used as a surrogate for potential sources of enteric viruses. Data on well depth, casing depth, open interval, and on-site geology (Cleaves, 1968) were used to evaluate the small public water-supply well's susceptibility to contamination.

Target Population

For this study, only public water-supply systems that rely on ground water were evaluated. A public ground-water supply system in the State of Maryland includes any system that provides piped water for human consumption and has at least 15 service connections, or regularly serves at least 25 individuals daily at least 60 days out of the year (State of Maryland, [n.d.]). Small public water supplies in Baltimore and Harford Counties can be classified this way and provide less than 10,000 gal/d for public use, draw water from shallow wells (typically less than 300 ft deep), and are located in rural and low-density suburban areas. Currently (2001), many small public water supplies do not have the regulatory need or the financial resources necessary to disinfect their finished water. As a result, they are among the most susceptible to contamination from viral pathogens.

Small public supplies are divided into two categories, community water systems and non-community water systems. Community systems serve at least 15 connections used by year-round residents, or serve at least 25 residents throughout the year. Examples of community systems include mobile home parks and small apartment buildings. Non-community systems are further divided into transient and non-transient systems. A non-transient, non-community system serves at least 25 of the same people for more than 6 months per year. Schools and day-care facilities are typical examples of non-transient non-community systems. A transient non-community system serves less than 25 of the same people for more than 6 months per year. Examples include offices, churches, and markets (State of Maryland, [n.d.]).

Site Selection

Sites were selected from the 263 small public water-supply systems that were active in Baltimore and Harford Counties in the spring of 2000. Some sites were east of the Fall Line, but were finished in the crystalline rock below a veneer of Coastal Plain sediment, and were therefore included in the study. Site selection was based on a modification of Madow's (1949) method that used an inclusion probability proportional to an arbitrary weight for each county. The intended sample size was 90, with an approximately equal number of sites from each county. The proportion of the target population was computed based on 149 sites in Baltimore County and 114 sites in Harford County. This assigned a weight of 1.0 to Baltimore County and a weight of 1.31 to Harford County (149/114 = 1.31). The total weight was 298.34 [(1.31*114) + 149]. To compute the inclusion probability for any given site, the weight of each site was multiplied by the sample size. The product was then divided by the total weight. Thus, the inclusion probabilities for Baltimore and Harford Counties were 0.334 and 0.438, respectively.

The sample selection procedure was used to increase the probability of selecting a near-equal distribution of sites between the two counties. The final result yielded 45 sites for both Baltimore and Harford Counties, after accounting for replacements. Sample selection began by placing all 263 sites in random order. Each site was assigned a normalized weight equivalent to the total number of sites multiplied by the appropriate county weight. A cumulative sum for the normalized weight was kept for each site. A random starting point between 0 and 2.99 (total weight divided by sample size) was selected and a systematic sampling (Cochran, 1977) was performed. This method was used to make three separate selections without replacements of 100 sites each, and provided 2 alternate sites in case the primary site was found unsuitable for sampling.

Site canvassing began in March 2000. The owner or operator of each public water-supply system was contacted, and given a general description of the purpose of the study and asked to voluntarily participate. If the owner or operator declined participation, an alternate site was contacted. In 12 cases, the alternate site was the same as the primary site, so a second alternate site was contacted. Approximately 20 percent of the owners or operators contacted declined to participate in the study. Reasons for declining included a fear of increased resource regulation to a general distrust of Government. Selected sampling sites are shown in figure 2.

Sample Collection

One hundred and one samples were collected from April 10, 2000 to November 13, 2000. Ninety of these sample sites were selected based on the procedure described in the previous section. An additional site in Baltimore County, selected randomly, also was sampled. Ten replicate samples were collected to monitor the reproducibility of laboratory results. All samples were analyzed for a suite of enteric constituents, nutrients, and field parameters (table 1). Samples for microbiological analyses were submitted to the WSLH in Madison, Wisconsin. Nutrient samples were analyzed at the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado. Specific conductance, acid-neutralizing capacity, dissolved oxygen, water temperature, and pH were measured in the field by employees of the USGS Baltimore, Maryland office using methods described in Wilde and Radtke (1998).

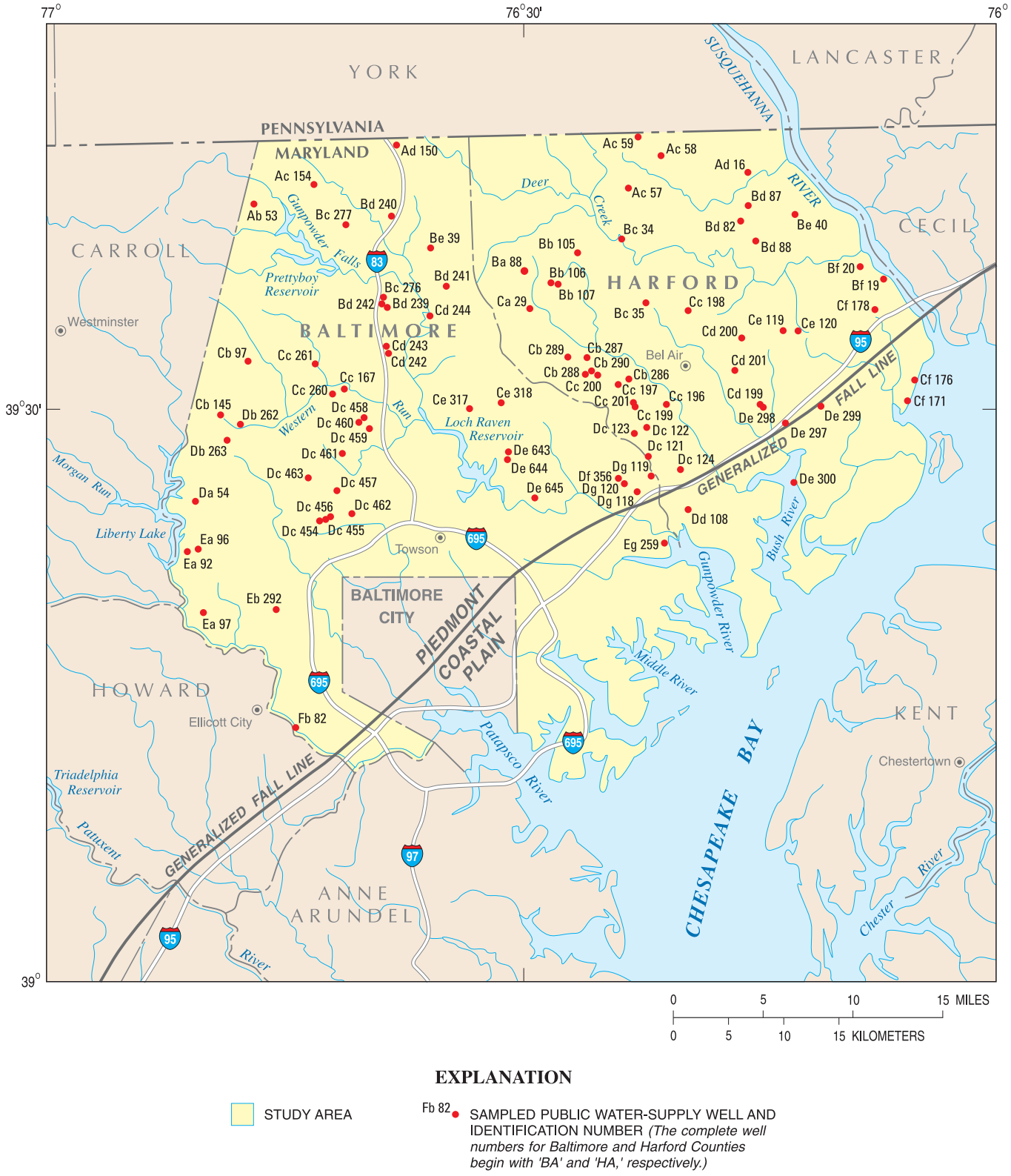


Figure 2. Location of sampled public water-supply wells in Baltimore and Harford Counties, Maryland.

Table 1. *Microbiological, nutrient, and field constituents sampled in Baltimore and Harford Counties, Maryland*

[mL, milliliter; mg/L, milligrams per liter; °C, degrees Celsius; WSLH, Wisconsin State Laboratory of Hygiene; USGS NWQL, U.S. Geological Survey National Water-Quality Laboratory; USEPA, U.S. Environmental Protection Agency; MPN, most probable number]

Constituent	Method	Units	Analytical laboratory	Reference
Enteric virus	cell-culture	presence / absence	WSLH, Madison Wi.	USEPA, 1996
Enteric virus	reverse-transcriptase, polymerase chain reaction (RT-PCR)	Electrophoresis (presumptive) and Membrane Hybridization (confirmatory)	WSLH, Madison Wi.	Abbaszadegan and others, 1999
Somatic coliphage	quantitative, 1 MDS filter / elution and enrichment	plaque-forming units per 500 mL	WSLH, Madison, Wi.	Sinton and others, 1996
Male-specific coliphage	quantitative, 1 MDS filter / elution and enrichment	plaque-forming units per 500 mL	WSLH, Madison Wi.	Sinton and others, 1996
Bacteroides fragilis phages	quantitative, 1 MDS filter / elution and enrichment	plaque-forming units per 500 mL	WSLH, Madison Wi.	USEPA, 1996
Total coliforms	Colilert	colonies per 100 mL	WSLH, Madison, Wi.	USEPA, 1996
Clostridium perfringens	quantitative, membrane filtration	colonies per 200 mL	WSLH, Madison, Wi.	Bisson and Cabelli, 1979
Enterococci	Enterolert	MPN / 100 mL	WSLH, Madison, Wi.	USEPA, 1996
Escherichia coli	Colilert	colonies per 100 mL	WSLH, Madison, Wi.	USEPA, 1996
Total organic carbon	infrared analyzer	mg/L	USGS NWQL, Denver, Co.	Wershaw and others, 1987
Nitrogen (nitrate, nitrite, ammonium, and organic nitrogen)	colorimetry	mg/L	USGS NWQL, Denver, Co.	Fishman and Friedman, 1989
Phosphorus (total, ortho)	colorimetry	mg/L	USGS NWQL, Denver, Co.	Fishman and Friedman, 1989
pH	electrode	pH units	USGS, Field	Wilde and Radtke, 1998
Specific conductance	contact-type electrode	microsiemens per centimeter at 25 °C	USGS NWQL, Denver, Co.	Wilde and Radtke, 1998
Acid-neutralizing capacity	titration	mg/L as bicarbonate	USGS, Field	Wilde and Radtke, 1998
Temperature	thermistor	°C	USGS, Field	Wilde and Radtke, 1998
Dissolved oxygen	idometric	mg/L	USGS, Field	Wilde and Radtke, 1998

Samples for microbiological analysis were collected based on protocols established under the Information Collection Rule (U.S. Environmental Protection Agency, 1996). All equipment and sampling containers used to collect microbiological samples were sanitized and sealed at WSLH. Prior to sampling, public water-supply system wells were purged of standing water. Purging was done in accordance with protocols for measuring pH, water temperature, and specific conductance established for the USGS National Water-Quality Assessment Program and described in Koterba and others (1995). USGS personnel collected samples by passing between 200 and 400 gal (gallons) through a Virosorb 1 MDS [A] positively charged cartridge filter. Samples were collected from the hose connection closest to the well head. Systems using chlorination, filtration, or water-softening equipment were evaluated and samples from the well were collected before treatment. Sites with treatment systems that could not be bypassed were not sampled. Samples with a pH of greater than 8.0 were neutralized by continuously injecting a 1.0 Normal solution of hydrochloric acid to the sample stream through a one-way vacuum valve prior to filtration. Samples were shipped on ice by overnight courier to NWQL in Denver, Colorado, and WSLH in Madison, Wisconsin. Sample holding times were within USEPA standards for routine monitoring of ground water (U.S. Environmental Protection Agency, 1996). Holding times for two samples (samples BA Bd 239 and HA Cc 196) exceeded 24 hours. The USEPA recommends that viral samples not be held more than 48 hours (U.S. Environmental Protection Agency, 1996). The WSLH requires that sample temperatures be below 19 °C upon arrival at the laboratory. Both samples arrived within the criteria outlined above, and when analyzed, did not contain microbiological contamination.

Sample Analysis Viral analysis was performed at WSLH by cell culture and a modification to the reverse-transcript-ase, polymerase chain reaction (RT-PCR) method developed by Abbaszadegan and others (1999). Viruses were eluted from the 1 MDS filter using alkaline beef extract/glycine solution. The extract was concentrated and eluted again with a 1.5 molar sodium phosphate solution. Gene probe assays were conducted by subjecting a portion of the water concentrate (650 µL, or microliters) to guanidinium isothio-cyanate-phenol/chloroform extraction under acid conditions to extract viral ribonucleic acid (RNA). Samples then were purified through molecular exclusion drip columns com-posed of sephadex G-100 and RNA was ethanol-precipitat-ed in a vacuum evaporator. Viral RNA then was reverse-transcribed and subjected to PCR in a thermal cycler [B] according to a thermal profile specific to each virus group. For hepatitis A viruses, enteroviruses, and rotaviruses, the thermal profile included a 4-minute pre-incubation at 95 °C to denature viral RNA, followed by 35 cycles of de-naturation (75 seconds), annealing (75 seconds), and polymerization (75 seconds) at 95 °C, 55 °C, and 72 °C, respectively. For the caliciviruses, following the initial 95 °C denaturation step, the thermal profile included 40 cycles of 94 °C (75 seconds), 50 °C (75 seconds), and 60 °C (120 seconds). Following PCR, all virus samples were incubated at 72 °C for 10 minutes to extend incompletely polymerized deoxyribonucleic acid (DNA) strands. Following nucleic acid amplification, samples were subjected to agarose gel electrophoresis to identify presumptive viral-positive samples. DNA then was transferred to nylon membranes under vacuum [C], membranes were crosslinked by ultraviolet irradiation and then were probed using 3'-digoxigenin end-labeled oligoprimers specific to each virus group to confirm identity. Only the samples that were confirmed by oligoprobing were considered positive for viral nucleic acid.

A portion of the water concentrate also was reserved for inoculation into cell cultures in order to determine if culturable viruses were present. An inoculum equivalent to 100 liters of the original sample was divided into 10 aliquots and introduced onto confluent monolayers of Buffalo green monkey kidney (BGMK) cells in 25-cm^2 (square centimeter) tissue culture flasks according to the Information Collection Rule (ICR) method (U.S. Environmental Protection Agency, 1996). Following a 60-minute adsorption period, flasks were supplemented with maintenance medium containing 2 percent fetal calf serum [D] and flasks were incubated for 2 weeks at 37 °C. Flasks were examined on days 1, 2, 3, 7, and 14 following infection to identify if viral cytopathic effects (CPE) were evident. Samples negative for viral CPE were reinoculated onto a second series of flasks that were examined using the same method for 2 weeks. Samples confirmed as positive for culturable viruses were serotyped to identify viral species.

Samples for total coliforms, *E. coli*, and enterococci were collected in two 100-mL (milliliter) sterile containers prior to the installation of the virus filtration apparatus at the sampling sites. The Enterolert Quanti-tray system was used to enumerate enterococci. *E. coli* and total coliforms were analyzed using the Colilert Quanti-tray system. Both kits are approved for use by the USEPA (U.S. Environmental Protection Agency, 1996). The kits commonly are used and are available from Idexx Laboratories in Westbrook, Maine. Analysis for *C. perfringens* was performed according to methods previously described (U.S. Environmental Protection Agency, 1996). These methods require that a 200-mL sample be anaerobically incubated after membrane-filtration onto mCP medium.

Samples were analyzed for male-specific and somatic coliphage using a two-step enrichment method that was recently incorporated into the USEPA draft method for

A. Cuno Corporation, Meriden, Connecticut.
B. Stratagene, La Jolla, California.
C. Bio-Rad Corporation, Hercules, California.
D. Hyclone Laboratories, Logan, Utah.

coliphage detection (U.S. Environmental Protection Agency, 2001b). For this study, 500 mL grab samples were supplemented with magnesium chloride and bacterial nutrients and were then inoculated with 2.5 mL log-phase host bacteria specific for each bacteriophage group (somatic or male-specific). Following overnight enrichment at 35 °C, 10 µL droplets from the enriched cultures were spotted onto nutrient agar plates containing confluent lawns of host bacteria. Plates were examined for zones of lysis following a second incubation at 36 °C. Samples with clear zones within the bacterial lawn were considered positive for bacteriophages. *B. fragilis*, a class of bacteriophage that infect anaerobic bacteria, were extracted from a 100-mL sample and plated under anaerobic conditions using a *B. fragilis* HSP40 host cell. Inoculated plates were incubated for 24 hours.

Quality Assurance and Quality Control Quality-assurance and quality-control (QA/QC) samples were collected to ensure that equipment cleaning and sterilization techniques were adequate, to assess possible field contamination of samples, and to determine sampling and analytical variability. Replicate samples are used to assess the variability introduced by sampling or analytical procedures. Ten replicate samples were collected for this study. Because none of the environmental samples or their associated replicates were reported to be contaminated with viral or coliphage contamination, no measure of variability can be quantified for these constituents. Two samples, BA Fb 82 and HA Dc 122, were contaminated with total coliforms, however. The environmental sample for site BA Fb 82 had 28 cfu/100 mL (colony-forming units per 100 mL). Its replicate sample had 27 cfu/100 mL. Sample HA Dc 122 had 3 cfu/100 mL and its replicate had 2 cfu/100 mL. These values are not sufficient to quantify variability, but they do indicate qualitatively that sampling and analytical methods are capable of detecting total coliform bacteria at levels above the method reporting level. Two samples collected for a companion study using the same sample-collection and analytical procedures served as negative controls (Klohe and Feehley, 2001). The samples were collected from public water-supply wells with properties not vulnerable to contamination and were located outside the study area. Negative controls are used to identify the reliability of contamination at or near a censoring level, and to ensure that sampling equipment is sterilized and that no contamination of the sample occurs in the field. Ground water from the study area was not used as a negative control because no single source could be guaranteed to be free of pathogens. Additionally, it was considered impractical to sterilize a sufficient volume of source water to create a secure supply of microbial-free water. Therefore, wells that were deep (greater than 500 ft) and distant from the study area were used as a probable virus-free source of negative control water. The two wells selected were located in St. Marys County, Maryland (fig. 1), and were part of a network of wells being monitored in a water-resource study (Klohe and Feehley, 2001). The two wells sampled were finished 575 ft and 600 ft below sea level. Neither negative-control sample contained detectable microbiological material.

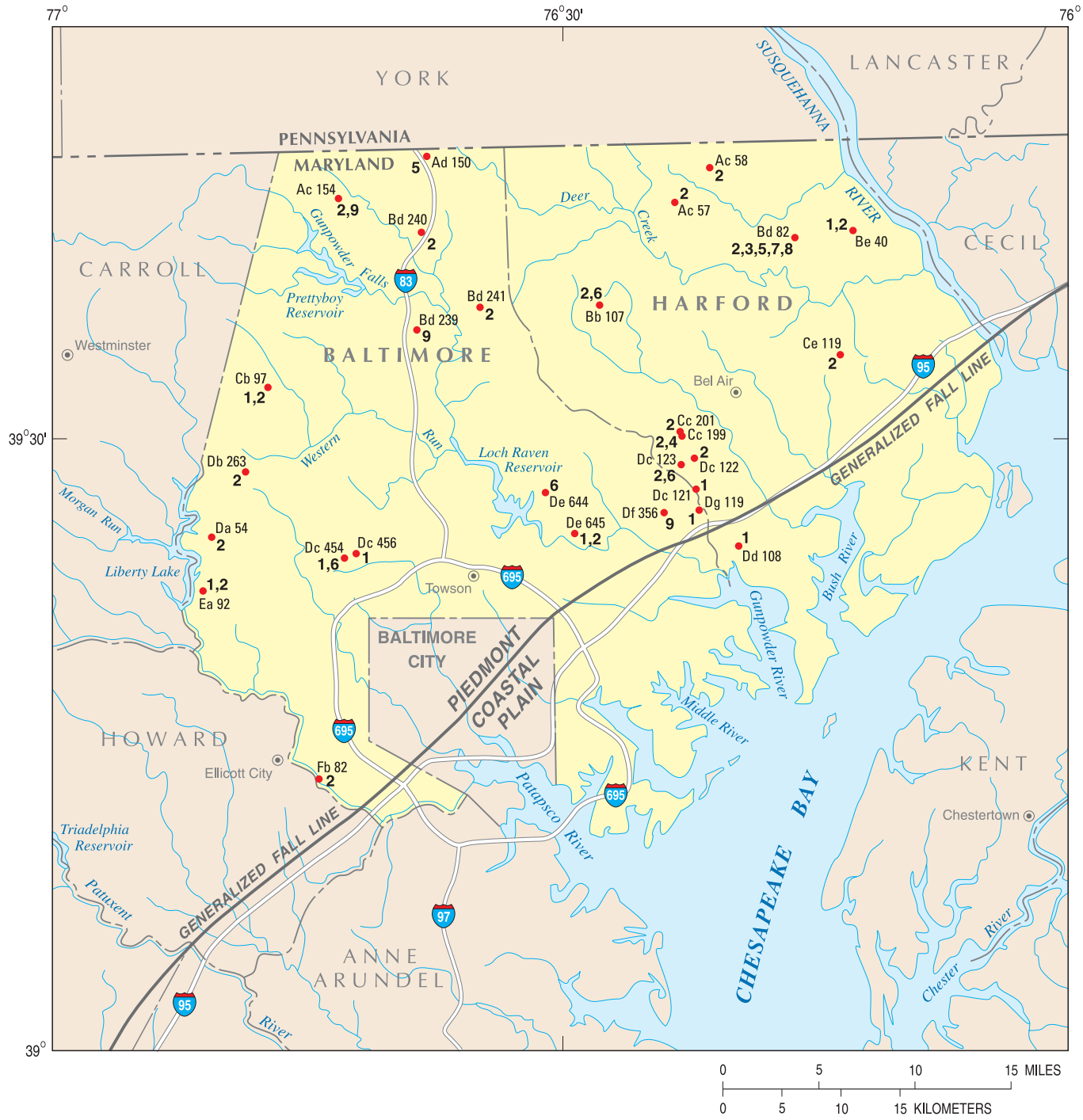
Field spikes provide information on sampling and analytical bias. Because the use of live attenuated poliovirus near a public water supply was considered an unacceptable health risk, field spikes were not collected for this study.

Occurrence and Distribution of Viral Contamination

Results from enteric virus, coliphage, bacteria, and nutrient contamination are shown in figure 3. All other data including microbiological data are presented in the Appendix. Twenty-nine percent of the environmental samples (26 out of 90), had detections for one or more fecal-indicator bacteria (enterococci and (or) *C. perfringens* or *E. coli*). Nineteen of 90 samples contained total coliform bacteria. About 7 percent of the environmental samples had detections of bacteriophage (male-specific coliphage and (or) *B. fragilis* or somatic coliphage). The viral RNA for rotavirus was detected at site HA Bd 82. No sites were contaminated with culturable viruses. Three samples (BA Ac 154, BA Bd 239, and BA Df 356) had nitrate levels that were above the USEPA maximum contaminant level for drinking water of 10 mg/L (milligrams per liter).

For statistical analysis, bacteria and coliphage results were recoded to a nominal scale of presence or absence. Any sample showing a positive result for one or multiple occurrences of bacterial contamination was identified as having a positive bacterial presence. A similar procedure was used for the three types of coliphage. These nominal data were compared among variables such as well depth, well age, casing depth, open interval, and all nutrient and field data using the large sample approximation of the rank-sum test (Helsel and Hirsch, 1992). Kruskal-Wallis contingency tables for ordinal response variables were used to compare the categorical components such as on-site land use and on-site geology. Null hypotheses, that the distribution of data in each response category are the same, were rejected at the 95-percent confidence level ($\alpha = 0.05$).

Twenty-six of 90 samples were contaminated with fecal-indicator bacteria (19 of 26 contained total coliform bacteria) and 6 of 90 samples (1 sample did not have coliphage or bacterial analysis performed) were contaminated with one or multiple forms of coliphage. A rank-sum analysis determined that no significant relation could be determined between the presence of bacteria and coliphage and virtually all continuous variables, including the concentration of total oxidized nitrogen. The rank-sum test did indicate that a significant difference was present between the mean temperature of the water sample measured in the field as a function of bacterial contamination ($p = 0.035$). Water temperature was measured continuously during the well-



EXPLANATION

STUDY AREA

Fb 82 / 2 — PUBLIC WATER-SUPPLY WELL (AND IDENTIFICATION NUMBER) WHERE MICROBIOLOGICAL CONSTITUENTS OR TOTAL OXIDIZED NITROGEN ABOVE 10.0 MILLIGRAMS PER LITER WAS DETECTED

MICROBIOLOGICAL DETECTIONS AND TOTAL OXIDIZED NITROGEN

(Numbers 1-9 indicate detection of constituent in well.)

1 ENTEROCOCCI
2 TOTAL COLIFORM
3 *ESCHERICHIA COLI*
4 *CLOSTRIDIUM PERFRINGENS*
5 MALE-SPECIFIC COLIPHAGE
6 SOMATIC COLIPHAGE
7 *BACTEROIDES FRAGILIS*
8 VIRAL RIBONUCLEIC ACID
9 TOTAL OXIDIZED NITROGEN ABOVE 10.0 MILLIGRAMS PER LITER

Figure 3. Location of detected microbiological constituents and total oxidized nitrogen detection above 10.0 milligrams per liter in sampled public water-supply wells in Baltimore and Harford Counties, Maryland.

purging procedure. Once temperature stabilized (when there was less than a 0.2 ˚C change between three measurements over a 3- to 5-minute sample interval), a final water temperature was recorded. Samples contaminated with fecal-indicator bacteria and (or) total coliform bacteria had a mean water temperature of 13.9 ˚C. Samples in which no bacteria were detected had a mean water temperature of 14.4 ˚C. No significant relations were found among bacteria or coliphage contamination and well depth, well age, casing depth, or the open interval of the sampled well.

Categorical data for on-site land use and on-site geology (rock type) were compared among nominal data for bacteria contamination using Kruskal-Wallis contingency tables. Land use was based on a MDE 1:63,360 scale map (Maryland Department of the Environment, 1994) and for this study, aggregated into four categories: agricultural, urban, residential, and forest. Site geology was based on 1:24,000 scale maps produced by the Maryland Geological Survey (Cleaves, 1968). Aquifer lithologies used by Bolton (1998) in Baltimore County (carbonate, schist, gneiss, and mafic) were extended into Harford County and used to categorize geology for this study. No significant relations were found between bacteria contamination and any categorical data for land use or geology.

Nineteen of the 26 water-supply wells that contained some form of bacteria were contaminated with total coliform bacteria. The concentration of total coliform bacteria in samples ranged from 1 to 1,046 cfu/100 mL. Kendall's Tau, a test of monotonic correlation between two variables, was used to determine if the concentration of total coliform bacteria was related to continuous variables such as well depth, well age, casing depth, open interval, and all nutrient and field data (table 2). Kendall's Tau is calculated on the ranked values of the data pairs and generally is more robust for variables that are non-normal, such as water-quality data. Tau generally will have lower values than other means that assess correlation with the same strength. Strong linear correlations of 0.9 or above correlate to Tau values of about 0.7 and above (Helsel and Hirsch, 1992).

A moderately strong, statistically significant correlation is present between the concentration of total coliform bacteria and pH as measured at NWQL (table 2). A somewhat weaker but still significant correlation is present between the age of the well, the pH as measured at WSLH, the acid-neutralizing capacity as measured at NWQL, and the concentration of total coliform bacteria. Finally, a moderate to weak but statistically significant correlation is present between sulfate concentration and the concentration of total-coliform bacteria.

The randomly distributed nature of the study design and the absence of detected culturable viruses (and a single detection of viral RNA) strongly indicate that viruses are not frequently detected among small, public water-supply wells in Baltimore and Harford Counties, Maryland. These same data, however, do not indicate which combination of environmental or anthropogenic factors are responsible for the absence of viral contamination. Inferences made beyond the study area on the occurrence and distribution of viruses in public-supply wells assume that the factors that contribute to the absence of viruses within the study area are present elsewhere. Similarly, Banks and others (2001) in a study of microbiological contamination of a similar population in two Maryland counties in the Coastal Plain Physiographic Province failed to identify any factors that related to viral occurrence even though 11 percent of the wells sampled showed some form of viral contamination. The incidence of fecal-indicator bacteria and total coliform bacteria contamination in both studies indicates that several environmentally controlled factors such as pH for total coliform bacteria in the Piedmont and a mean overall vulnerability-rank score for sites in the Coastal Plain correlate with the occurrence of bacteria in the sampled wells (Banks and others, 2001). These relations are not clearly understood, and should not be used as surrogates for the environmental occurrence of bacterial contamination.

Table 2. *Kendall's Tau correlation coefficient for total coliform concentrations and continuous explanatory variables*

[USGS NWQL, U.S. Geological Survey National Water-Quality Laboratory; WSLH, Wisconsin State Laboratory of Hygiene; *p*, probability]

Variable	Kendall's Tau correlation coefficient	Significance of Correlation (*p* value)	Number of samples
pH of sample at USGS NWQL	0.473	0.005	19
Age of well	.409	.017	19
Acid-neutralizing capacity at USGS NWQL	.353	.038	19
pH at WSLH	.350	.047	18
Sulfate, dissolved	.341	.045	19
Acid-neutralizing capacity, field	.333	.068	17
pH, field	.329	.061	18
Water temperature, field	.226	.208	19
Magnesium, dissolved	.162	.342	19
Air temperature	.085	.621	19
Specific conductance	.078	.647	19
Phosphorus, dissolved	.047	.797	19
Calcium, dissolved	.018	.916	19
Cased interval of well	.006	.972	19
Iron, dissolved	.000	1.000	19
Chloride, dissolved	-.102	.549	19
Oxygen, dissolved	-.120	.492	18
Sodium, dissolved	-.138	.418	19
Well depth	-.177	.305	19
Uncased interval of well	-.192	.260	19
Potassium, dissolved	-.258	.130	19
Total oxidized nitrogen	-.305	.073	19
Ammonia, dissolved	-.372	.059	19

Summary and Conclusions

In 1999, the U.S. Geological Survey, in cooperation with the Maryland Department of the Environment and the Wisconsin State Laboratory of Hygiene, began to assess the occurrence and distribution of viral contamination in small (less than 10,000 gallons per day) public water-supply wells in Baltimore and Harford Counties, Maryland.

Ninety sites were selected based on a method that used an inclusion probability proportional to an arbitrary weight for each county. An additional site, selected randomly in Baltimore County, also was sampled. Forty-six sampling sites were in Baltimore County, and 45 sampling sites were in Harford County.

None of the 91 environmental samples contained culturable viruses; however, viral ribonucleic acid for rotavirus was detected at one site in Harford County. These data indicate that viruses are not frequently found in small public water-supply wells in the Piedmont Physiographic Province of Baltimore and Harford Counties, Maryland.

Twenty-nine percent of the environmental samples (26 out of 90) had detections for one or more fecal-indicator bacteria and (or) total coliform bacteria. About 7 percent of the environmental samples had detections of bacteriophage. Three sites had nitrate levels that were above the U.S. Environmental Protection Agency maximum contaminant level for drinking water (10 milligrams per liter).

A statistical analysis determined that no significant relation is present between the presence of bacteria and coliphage, and all variables except the mean temperature of the water sample as measured in the field. Additionally, the concentration of total coliform bacteria had a statistically significant, moderately strong correlation with the age of the well, the sulfate concentration, and sample pH as measured at the U.S. Geological Survey National Water-Quality Laboratory in Denver, Colorado and the sample pH as measured at the Wisconsin State Laboratory of Hygiene. These relations are not clearly understood and should not be used as surrogates for the environmental occurrence of bacterial contamination.

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Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000*

[cfu/mL, colony-forming units per milliliter; pfu/mL, plaque-forming units per milliliter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; NGVD, National Geodetic Vertical Datum of 1929, also referred to as sea level; <, less than; n/a, not applicable; ND, not detected; –, no data collected; **P**, present; **E**, estimated value (not quantitative); **R**, replicate sample]

Local well number	Date sampled	Total coliforms, membrane filtered (cfu/100mL)	*Escherichia coli*, filtered (cfu/100mL)	Male-specific coliphage (pfu/1,000mL)	Somatic coliphage (pfu/500mL)	*Bacteroides fragilis*, bacteriophage (pfu/500mL)	*Clostridium perfringens* (cfu/200mL)
BA Ab 53	10/10/2000	<1	<1	ND	ND	ND	<1
BA Ac 154	11/01/2000	1	<1	–	–	ND	<1
BA Ad 150	09/18/2000	<1	<1	**P**	ND	ND	<1
BA Bc 276	08/21/2000	<1	<1	–	–	ND	<1
BA Bc 277	10/30/2000	<1	<1	ND	ND	ND	<1
BA Bd 239	10/16/2000	<1	<1	ND	ND	ND	<1
BA Bd 240	10/25/2000	3	<1	ND	ND	ND	<1
BA Bd 241	11/01/2000	1	<1	ND	ND	ND	<1
BA Bd 242	11/06/2000	<1	<1	ND	ND	ND	<1
BA Be 39	09/19/2000	<1	<1	ND	ND	ND	<1
BA Cb 97	07/24/2000	119	<1	ND	ND	ND	<1
BA Cb 145	06/21/2000	<1	<1	ND	ND	ND	<1
BA Cc 167	08/08/2000	<1	<1	ND	ND	ND	<1
BA Cc 260	11/06/2000	<1	<1	ND	ND	ND	<1
BA Cc 261	11/09/2000	<1	<1	ND	ND	ND	<1
BA Cd 242	08/16/2000	<1	<1	ND	ND	ND	<1
BA Cd 243	08/16/2000	<1	<1	ND	ND	ND	<1
BA Cd 244	08/23/2000	<1	<1	ND	ND	ND	<1
BA Ce 317	06/13/2000	–	–	–	–	–	–
BA Ce 318	07/19/2000	<1	<1	ND	ND	ND	<1
BA Da 54	08/07/2000	358	<1	ND	ND	ND	<1
BA Db 262	10/30/2000	<1	<1	ND	ND	ND	<1
BA Db 263	11/09/2000	30	<1	ND	ND	ND	<1
BA Dc 454	05/03/2000	<1	<1	ND	**P**	ND	<1
BA Dc 455	05/01/2000	<1	<1	ND	ND	ND	<1
BA Dc 456	05/01/2000	<1	<1	ND	ND	ND	<1
BA Dc 457	05/09/2000	<1	<1	ND	ND	ND	<1
BA Dc 458	05/30/2000	<1	<1	ND	ND	ND	<1
BA Dc 459	05/30/2000	<1	<1	ND	ND	ND	<1
BA Dc 460	06/13/2000	<1	<1	ND	ND	ND	<1

Enterococci (cfu/100mL)	Cell culture	Cytopathic effects	Resolved	Hepatitis A virus	Enterovirus	Rotavirus	Calicivirus genotypes I, II	Local well number
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ab 53
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ac 154
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ad 150
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bc 276
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bc 277
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bd 239
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bd 240
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bd 241
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Bd 242
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Be 39
2	negative	n/a	n/a	negative	negative	negative	negative	BA Cb 97
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cc 145
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cc 167
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cc 260
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cc 261
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cd 242
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cd 243
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Cd 244
–	negative	n/a	n/a	negative	negative	negative	negative	BA Ce 317
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ce 318
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Da 54
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Db 262
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Db 263
1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 454
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 455
2	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 456
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 457
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 458
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 459
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 460

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Total coliforms, membrane filtered (cfu/100mL)	*Escherichia coli*, filtered (cfu/100mL)	Male-specific coliphage (pfu/1,000mL)	Somatic coliphage (pfu/500mL)	*Bacteroides fragilis*, bacteriophage (pfu/500mL)	*Clostridium perfringens* (cfu/200mL)
BA Dc 461	06/29/2000	<1	<1	ND	ND	ND	<1
BA Dc 462	10/31/2000	<1	<1	ND	ND	ND	<1
BA Dc 462 [R]	10/31/2000	<1	<1	ND	ND	ND	<1
BA Dc 463	11/13/2000	<1	<1	ND	ND	ND	<1
BA De 643	07/18/2000	<1	<1	ND	ND	ND	<1
BA De 644	08/30/2000	<1	<1	ND	**P**	ND	<1
BA De 645	08/30/2000	9	<1	ND	ND	ND	<1
BA Df 356	11/13/2000	<1	<1	ND	ND	ND	<1
BA Dg 118	04/25/2000	<1	<1	ND	ND	ND	<1
BA Dg 119	05/10/2000	<1	<1	ND	ND	ND	<1
BA Dg 120	05/08/2000	<1	<1	ND	ND	ND	<1
BA Dg 120 [R]	05/08/2000	<1	<1	ND	ND	ND	<1
BA Ea 92	04/10/2000	22	<1	ND	ND	ND	<1
BA Ea 96	09/20/2000	<1	<1	ND	ND	ND	<1
BA Ea 97	10/18/2000	<1	<1	ND	ND	ND	<1
BA Eb 292	04/10/2000	<1	<1	ND	ND	ND	<1
BA Eg 259	11/07/2000	<1	<1	ND	ND	ND	<1
BA Eg 259 [R]	11/07/2000	<1	<1	ND	ND	ND	<1
BA Fb 82	04/11/2000	28	<1	ND	ND	ND	<1
BA Fb 82 [R]	04/11/2000	27	<1	ND	ND	ND	<1
HA Ac 57	07/10/2000	1	<1	ND	–	ND	<1
HA Ac 58	09/11/2000	4	<1	ND	ND	ND	<1
HA Ac 59	10/25/2000	<1	<1	ND	ND	ND	<1
HA Ad 16	09/18/2000	<1	<1	ND	ND	ND	<1
HA Ba 88	10/17/2000	<1	<1	ND	ND	ND	<1
HA Bb 105	07/31/2000	<1	<1	ND	ND	ND	<1
HA Bb 106	08/28/2000	<1	<1	ND	ND	ND	<1
HA Bb 107	08/29/2000	<1	<1	ND	**P**	ND	<1
HA Bc 34	06/14/2000	<1	<1	ND	ND	ND	<1
HA Bc 34 [R]	06/14/2000	<1	<1	ND	ND	ND	<1

Enterococci (cfu/100mL)	Cell culture	Cytopathic effects	Resolved	Hepatitis A virus	Enterovirus	Rotavirus	Calicivirus genotypes I, II	Local well number
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 461
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 462
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 462 R
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dc 463
<1	negative	n/a	n/a	negative	negative	negative	negative	BA De 643
<1	negative	n/a	n/a	negative	negative	negative	negative	BA De 644
15	negative	n/a	n/a	negative	negative	negative	negative	BA De 645
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Df 356
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dg 118
1	negative	n/a	n/a	negative	negative	negative	negative	BA Dg 119
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dg 120
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Dg 120 R
1	negative	n/a	n/a	negative	negative	negative	negative	BA Ea 92
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ea 96
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Ea 97
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Eb 292
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Eg 259
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Eg 259 R
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Fb 82
<1	negative	n/a	n/a	negative	negative	negative	negative	BA Fb 82 R
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ac 57
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ac 58
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ac 59
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ad 16
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ba 88
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bb 105
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bb 106
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bb 107
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bc 34
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bc 34 R

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Total coliforms, membrane filtered (cfu/100mL)	*Escherichia coli*, filtered (cfu/100mL)	Male-specific coliphage (pfu/1,000mL)	Somatic coliphage (pfu/500mL)	*Bacteroides fragilis*, bacteriophage (pfu/500mL)	*Clostridium perfringens* (cfu/200mL)
HA Bc 35	10/23/2000	<1	<1	ND	ND	ND	<1
HA Bd 82	07/31/2000	50	3	**P**	ND	**P**	<1
HA Bd 87	10/11/2000	<1	<1	ND	ND	ND	<1
HA Bd 88	10/17/2000	<1	<1	ND	ND	ND	<1
HA Be 40	10/24/2000	162	<1	ND	ND	ND	<1
HA Bf 19	09/06/2000	<1	<1	ND	ND	ND	<1
HA Bf 20	09/06/2000	<1	<1	ND	–	ND	<1
HA Ca 29	09/07/2000	<1	<1	ND	ND	ND	<1
HA Cb 286	07/12/2000	<1	<1	ND	ND	ND	<1
HA Cb 287	08/01/2000	<1	<1	ND	ND	ND	<1
HA Cb 288	08/08/2000	<1	<1	ND	ND	ND	<1
HA Cb 289	08/23/2000	1	<1	ND	ND	ND	<1
HA Cb 290	10/23/2000	<1	<1	ND	ND	ND	<1
HA Cc 196	06/19/2000	<1	<1	ND	ND	ND	<1
HA Cc 197	07/11/2000	<1	<1	ND	ND	ND	<1
HA Cc 197 **R**	07/11/2000	<1	<1	ND	ND	ND	<1
HA Cc 198	07/24/2000	<1	<1	ND	ND	ND	<1
HA Cc 199	08/22/2000	276	<1	ND	ND	ND	2
HA Cc 200	09/07/2000	<1	<1	ND	ND	ND	<1
HA Cc 201	10/18/2000	2	<1	ND	ND	ND	<1
HA Cd 199	07/13/2000	<1	<1	ND	ND	ND	<1
HA Cd 200	07/17/2000	<1	<1	ND	ND	ND	<1
HA Cd 201	07/25/2000	<1	<1	ND	ND	ND	<1
HA Cd 201 **R**	07/25/2000	<1	<1	ND	ND	ND	<1
HA Ce 119	08/23/2000	1,046	<1	ND	ND	ND	<1
HA Ce 120	09/18/2000	<1	<1	ND	ND	ND	<1
HA Cf 171	07/20/2000	<1	<1	ND	ND	ND	<1
HA Cf 176	08/03/2000	<1	<1	ND	ND	ND	<1
HA Cf 176 **R**	08/03/2000	<1	<1	ND	ND	ND	<1

Enterococci (cfu/100mL)	Cell culture	Cytopathic effects	Resolved	Hepatitis A virus	Enterovirus	Rotavirus	Calicivirus genotypes I, II	Local well number
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bc 35
<1	negative	n/a	n/a	negative	negative	**positive**	negative	HA Bd 82
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bd 87
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bd 88
4	negative	n/a	n/a	negative	negative	negative	negative	HA Be 40
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bf 19
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Bf 20
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ca 29
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cb 286
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cb 287
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cb 288
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cb 289
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cb 290
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 196
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 197
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 197 **R**
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 198
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 199
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 200
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cc 201
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cd 199
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cd 200
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cd 201
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cd 201 **R**
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ce 119
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Ce 120
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cf 171
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cf 176
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cf 176 **R**

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Total coliforms, membrane filtered (cfu/100mL)	*Escherichia coli*, filtered (cfu/100mL)	Male-specific coliphage (pfu/1,000mL)	Somatic coliphage (pfu/500mL)	*Bacteroides fragilis*, bacteriophage (pfu/500mL)	*Clostridium perfringens* (cfu/200mL)
HA Cf 178	08/28/2000	<1	<1	ND	ND	ND	<1
HA Dc 121	05/24/2000	<1	<1	ND	ND	ND	<1
HA Dc 122	06/26/2000	3	<1	ND	ND	ND	<1
HA Dc 122 [R]	06/26/2000	2	<1	ND	ND	ND	<1
HA Dc 123	08/01/2000	2	<1	ND	**P**	ND	<1
HA Dc 124	10/16/2000	<1	<1	ND	ND	ND	<1
HA Dd 108	05/02/2000	<1	<1	ND	ND	ND	<1
HA De 297	05/31/2000	<1	<1	ND	ND	ND	<1
HA De 297 [R]	05/31/2000	<1	<1	ND	ND	ND	<1
HA De 298	06/20/2000	<1	<1	ND	ND	ND	<1
HA De 299	07/18/2000	<1	<1	ND	ND	ND	<1
HA De 300	10/11/2000	<1	<1	ND	ND	ND	<1

Enterococci (cfu/100mL)	Cell culture	Cytopathic effects	Resolved	Hepatitis A virus	Enterovirus	Rotavirus	Calicivirus genotypes I, II	Local well number
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Cf 178
1	negative	n/a	n/a	negative	negative	negative	negative	HA Dc 121
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Dc 122
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Dc 122 R
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Dc 123
<1	negative	n/a	n/a	negative	negative	negative	negative	HA Dc 124
2	negative	n/a	n/a	negative	negative	negative	negative	HA Dd 108
<1	negative	n/a	n/a	negative	negative	negative	negative	HA De 297
<1	negative	n/a	n/a	negative	negative	negative	negative	HA De 297 R
<1	negative	n/a	n/a	negative	negative	negative	negative	HA De 298
<1	negative	n/a	n/a	negative	negative	negative	negative	HA De 299
<1	negative	n/a	n/a	negative	negative	negative	negative	HA De 300

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Viral presence [a]	Bacterial presence [b]	Bacteriophage presence [c]	Water temperature (°C)	Air temperature (°C)	Specific conductance, laboratory (µS/cm)	Oxygen, dissolved (mg/L)
BA Ab 53	10/10/2000	no	no	no	13	12.5	–	8.91
BA Ac 154	11/01/2000	no	**yes**	no	13	9.5	–	9.37
BA Ad 150	09/18/2000	no	no	**yes**	14	23	–	5.84
BA Bc 276	08/21/2000	no	no	no	14.5	20	–	8.90
BA Bc 277	10/30/2000	no	no	no	15	11	–	7.70
BA Bd 239	10/16/2000	no	no	no	14	15.5	–	6.84
BA Bd 240	10/25/2000	no	**yes**	no	14.5	20.5	–	9.55
BA Bd 241	11/01/2000	no	**yes**	no	12.5	13.5	–	9.20
BA Bd 242	11/06/2000	no	no	no	14	6.5	–	9.28
BA Be 39	09/19/2000	no	no	no	13.5	18.5	–	2.87
BA Cb 97	07/24/2000	no	**yes**	no	14	19	–	9.17
BA Cb 145	06/21/2000	no	no	no	13	26	306	6.04
BA Cc 167	08/08/2000	no	no	no	18	34	–	7.77
BA Cc 260	11/06/2000	no	no	no	12.5	12.5	127.4	8.46
BA Cc 261	11/09/2000	no	no	no	12	15	–	5.39
BA Cd 242	08/16/2000	no	no	no	15.5	28	–	3.25
BA Cd 243	08/16/2000	no	no	no	13.4	28	–	2.90
BA Cd 244	08/23/2000	no	no	no	13.5	23	–	7.42
BA Ce 317	06/13/2000	no	–	–	16.5	19	1,535	8.42
BA Ce 318	07/19/2000	no	no	no	13.5	21	29	9.37
BA Da 54	08/07/2000	no	**yes**	no	13	31	136	1.32
BA Db 262	10/30/2000	no	no	no	13	12	85.8	7.64
BA Db 263	11/09/2000	no	**yes**	no	13.5	14.5	110	4.53
BA Dc 454	05/03/2000	no	**yes**	**yes**	13	21	172	8.93
BA Dc 455	05/01/2000	no	no	no	13.5	19	403	6.57
BA Dc 456	05/01/2000	no	**yes**	no	13.5	19	410	6.65
BA Dc 457	05/09/2000	no	no	no	14.5	28.5	50	7.90
BA Dc 458	05/30/2000	no	no	no	14	14	430	7.30
BA Dc 459	05/30/2000	no	no	no	13	16	145	7.81
BA Dc 460	06/13/2000	no	no	no	14	21	468	9.16

pH whole water, field (standard units)	Acid-neutral-izing capacity, field (mg/L as $CaCO_3$)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Elevation of land surface (feet above NGVD)	Depth of well (feet below land surface)	Depth of casing (feet below land surface)	Local well number
5.78	12	**E** 0.05	2.26	<0.02	760	140	52	BA Ab 53
5.39	9.5	< .08	11.05	< .02	780	125	40	BA Ac 154
5.15	9	**E** .07	7.66	.01	820	125	42	BA Ad 150
5.40	7	< .10	2.39	< .01	600	350	62	BA Bc 276
5.21	12	< .08	8.47	.02	800	305	47	BA Bc 277
5.58	18	**E** .05	10.09	< .02	650	150	57	BA Bd 239
6.50	34	< .08	2.33	.03	580	400	100	BA Bd 240
5.78	26	< .08	6.38	.02	620	500	63	BA Bd 241
5.30	3.5	< .08	9.63	< .02	660	170	25	BA Bd 242
5.69	52	< .10	1.84	.02	600	300	80	BA Be 39
6.02	14.5	< .10	5.00	.04	590	142	50	BA Cb 97
6.07	42	< .10	2.17	.02	720	125	77	BA Cb 145
6.03	32	< .10	6.35	< .01	450	250	30	BA Cc 167
5.99	24.5	< .08	4.29	.03	380	116	79	BA Cc 260
6.13	36	< .08	.68	< .02	450	294	–	BA Cc 261
6.93	90	< .10	.19	< .01	460	225	24	BA Cd 242
6.37	100	.18	.14	< .01	460	400	34	BA Cd 243
5.68	72.5	**E** .08	4.94	< .01	300	175	39	BA Cd 244
5.52	8.5	**E** .07	1.16	< .01	680	200	36	BA Ce 317
6.56	8	**E** .08	.98	< .01	600	250	24	BA Ce 318
–	–	**E** .05	2.70	< .01	580	250	60	BA Da 54
6.00	19.5	.14	2.58	.03	560	145	50	BA Db 262
5.82	28	< .08	3.88	.05	640	118	67	BA Db 263
6.52	58	**E** .06	1.09	< .01	480	100	69	BA Dc 454
6.05	35	< .10	.94	< .01	540	525	50	BA Dc 455
6.15	34	< .10	.93	< .01	540	250	25	BA Dc 456
5.70	8	**E** .07	1.86	< .01	670	308	66	BA Dc 457
7.68	164	**E** .06	2.23	< .01	370	250	45	BA Dc 458
8.30	64	< .10	.25	.02	380	300	64	BA Dc 459
7.76	215	**E** .05	.89	< .01	370	223	50	BA Dc 460

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Viral [a] presence	Bacterial [b] presence	Bacteriophage [c] presence	Water temperature (°C)	Air temperature (°C)	Specific conductance, laboratory (µS/cm)	Oxygen, dissolved (mg/L)
BA Dc 461	06/29/2000	no	no	no	13.5	25	90	7.55
BA Dc 462	10/31/2000	no	no	no	13.6	15.5	765	6.09
BA Dc 462 **R**	10/31/2000	no	no	no	13.6	15.5	–	6.09
BA Dc 463	11/13/2000	no	no	no	15	11	178	6.58
BA De 643	07/18/2000	no	no	no	15	31	421	1.50
BA De 644	08/30/2000	no	no	**yes**	13.5	25	134	8.21
BA De 645	08/30/2000	no	**yes**	no	13	21	120	6.08
BA Df 356	11/13/2000	no	no	no	16.5	10.5	470	7.72
BA Dg 118	04/25/2000	no	no	no	15	10	217	2.69
BA Dg 119	05/10/2000	no	**yes**	no	13.5	26	356	7.26
BA Dg 120	05/08/2000	no	no	no	15	29	260	4.75
BA Dg 120 **R**	05/08/2000	no	no	no	15	29	–	4.75
BA Ea 92	04/10/2000	no	**yes**	no	14	15	190	7.23
BA Ea 96	09/20/2000	no	no	no	14	22	409	3.77
BA Ea 97	10/18/2000	no	no	no	16	15.5	99.1	7.10
BA Eb 292	04/10/2000	no	no	no	13.5	9.5	193	7.29
BA Eg 259	11/07/2000	no	no	no	14	10	915	–
BA Eg 259 **R**	11/07/2000	no	no	no	14	10	–	–
BA Fb 82	04/11/2000	no	**yes**	no	15	10	1,475	2.75
BA Fb 82 **R**	04/11/2000	no	**yes**	no	15	10	–	2.75
HA Ac 57	07/10/2000	no	**yes**	no	14.5	30	–	3.35
HA Ac 58	09/11/2000	no	**yes**	no	13	25	–	8.75
HA Ac 59	10/25/2000	no	no	no	15	20.5	–	5.49
HA Ad 16	09/18/2000	no	no	no	12	18	–	10.05
HA Ba 88	10/17/2000	no	no	no	14.5	13	–	6.80
HA Bb 105	07/31/2000	no	no	no	15	30	–	1.09
HA Bb 106	08/28/2000	no	no	no	16.5	23	–	8.83
HA Bb 107	08/29/2000	no	no	**yes**	13.5	24	–	9.61
HA Bc 34	06/14/2000	no	no	no	13	20	–	9.05
HA Bc 34 **R**	06/14/2000	no	no	no	13	20	–	9.05

pH whole water, field (standard units)	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Elevation of land surface (feet above NGVD)	Depth of well (feet below land surface)	Depth of casing (feet below land surface)	Local well number
5.68	14	<0.10	0.44	0.02	660	180	–	BA Dc 461
7.27	280	< .08	3.62	< .02	400	200	30	BA Dc 462
7.30	284	–	–	–	400	200	30	BA Dc 462 R
7.98	110	< .08	1.21	E .01	600	300	93	BA Dc 463
6.75	41	< .10	.07	< .01	490	250	46	BA De 643
5.60	24	< .10	3.03	.05	500	294	20	BA De 644
5.35	19	E .06	1.00	< .01	500	150	20	BA De 645
6.78	160	E .04	10.28	.03	260	72	22	BA Df 356
6.25	78	E .06	< .05	< .01	100	125	34	BA Dg 118
5.80	34	.11	5.00	< .01	110	200	–	BA Dg 119
6.01	50	E .08	6.61	< .01	300	185	47	BA Dg 120
5.94	51	–	–	–	300	185	47	BA Dg 120 R
6.75	52	< .10	3.25	.02	540	420	44	BA Ea 92
6.48	84	< .10	4.35	< .01	600	500	70	BA Ea 96
6.13	29	E .06	2.93	.05	480	294	58	BA Ea 97
6.20	54	< .10	3.07	.04	480	150	58	BA Eb 292
6.70	485	4.24	< .05	< .02	60	115	100	BA Eg 259
6.69	475	–	–	–	60	115	100	BA Eg 259 R
6.90	213	.10	2.85	< .01	100	200	120	BA Fb 82
6.90	217	.11	2.63	< .01	100	200	120	BA Fb 82 R
5.47	–	E .05	8.46	< .01	500	175	21	HA Ac 57
5.80	32	< .10	8.13	.07	500	250	68	HA Ac 58
5.94	12	< .08	7.93	E .01	580	60	34	HA Ac 59
5.68	14	< .10	1.17	.03	300	175	38	HA Ad 16
6.36	29.5	< .08	4.68	< .02	740	108	20	HA Ba 88
5.95	15	E .06	7.23	< .01	620	350	32	HA Bb 105
6.65	95	E .05	2.46	.01	550	250	39	HA Bb 106
4.83	3	E .05	6.16	< .01	550	300	40	HA Bb 107
5.85	9	< .10	1.04	.01	300	150	20	HA Bc 34
5.66	8	< .10	1.04	.01	300	150	20	HA Bc 34 R

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Viral presence [a]	Bacterial presence [b]	Bacteriophage presence [c]	Water temperature (°C)	Air temperature (°C)	Specific conductance, laboratory (µS/cm)	Oxygen, dissolved (mg/L)
HA Bc 35	10/23/2000	no	no	no	14	14	–	6.00
HA Bd 82	07/31/2000	**yes**	**yes**	**yes**	15	30	–	16.43
HA Bd 87	10/11/2000	no	no	no	14	24	–	8.70
HA Bd 88	10/17/2000	no	no	no	15.5	14.5	–	3.14
HA Be 40	10/24/2000	no	**yes**	no	14	13	–	4.54
HA Bf 19	09/06/2000	no	no	no	13	19	–	8.36
HA Bf 20	09/06/2000	no	no	no	15	19.5	–	1.82
HA Ca 29	09/07/2000	no	no	no	13	19	–	6.70
HA Cb 286	07/12/2000	no	no	no	14.5	27	–	1.90
HA Cb 287	08/01/2000	no	no	no	15	31	–	3.69
HA Cb 288	08/08/2000	no	no	no	15	32	–	5.68
HA Cb 289	08/23/2000	no	**yes**	no	14	19	–	3.49
HA Cb 290	10/23/2000	no	no	no	15	11	–	5.48
HA Cc 196	06/19/2000	no	no	no	14.5	20	317.6	18.22
HA Cc 197	07/11/2000	no	no	no	13.5	29	310	5.26
HA Cc 197 **R**	07/11/2000	no	no	no	13.5	29	–	5.26
HA Cc 198	07/24/2000	no	no	no	16.5	19	–	1.77
HA Cc 199	08/22/2000	no	**yes**	no	14.5	23.5	582	3.00
HA Cc 200	09/07/2000	no	no	no	14.5	14.5	–	7.50
HA Cc 201	10/18/2000	no	**yes**	no	14.5	16	168.6	3.13
HA Cd 199	07/13/2000	no	no	no	17	24	237	–
HA Cd 200	07/17/2000	no	no	no	15	25.5	–	8.23
HA Cd 201	07/25/2000	no	no	no	15	21.5	–	–
HA Cd 201 **R**	07/25/2000	no	no	no	15	21.5	–	–
HA Ce 119	08/23/2000	no	**yes**	no	15.5	23	–	6.60
HA Ce 120	09/18/2000	no	no	no	15	14	–	5.57
HA Cf 171	07/20/2000	no	no	no	14	28	78	1.38
HA Cf 176	08/03/2000	no	no	no	14	29	150	3.10
HA Cf 176 **R**	08/03/2000	no	no	no	14	29	–	3.10

pH whole water, field (standard units)	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Elevation of land surface (feet above NGVD)	Depth of well (feet below land surface)	Depth of casing (feet below land surface)	Local well number
5.96	41	<0.08	7.24	0.03	540	500	75	HA Bc 35
7.00	80	< .10	2.77	< .01	450	64	55	HA Bd 82
6.30	49	< .08	4.56	.03	380	199	42	HA Bd 87
6.45	87	**E** .05	4.54	< .02	440	62	62	HA Bd 88
7.11	116	< .08	1.71	**E** .02	410	250	50	HA Be 40
6.61	52	< .10	.65	< .01	150	200	20	HA Bf 19
7.77	101	**E** .05	.06	< .01	150	405	24	HA Bf 20
5.60	15.5	**E** .06	6.78	.03	550	100	40	HA Ca 29
7.35	41	< .10	.08	< .01	520	162	75	HA Cb 286
6.59	120	< .10	1.88	.01	570	550	42	HA Cb 287
6.08	27	< .10	5.38	.01	540	200	51	HA Cb 288
5.61	28	.14	3.17	.03	500	280	58	HA Cb 289
5.36	15	< .08	5.83	**E** .01	520	225	79	HA Cb 290
6.33	108	< .10	2.60	.03	360	107	20	HA Cc 196
6.59	–	< .10	4.09	.03	460	300	111	HA Cc 197
6.59	–	< .10	4.05	.03	460	300	111	HA Cc 197 **R**
7.51	207	**E** .07	1.82	.01	480	59	25	HA Cc 198
6.61	182	**E** .06	.33	.04	450	205	22	HA Cc 199
5.33	11.5	< .10	3.08	< .01	400	300	30	HA Cc 200
5.97	34.5	**E** .07	3.95	.05	450	150	20	HA Cc 201
5.82	22	.33	1.02	< .01	240	200	45	HA Cd 199
5.94	14	**E** .06	2.92	.04	400	200	80	HA Cd 200
5.68	20	< .10	5.75	.01	400	150	47	HA Cd 201
5.68	20	< .10	6.28	.01	400	150	47	HA Cd 201 **R**
5.65	54	**E** .07	8.16	.02	350	39	24	HA Ce 119
6.60	45	.16	7.60	.02	400	125	43	HA Ce 120
6.64	30	< .10	.69	< .01	42	144	112	HA Cf 171
6.35	31	< .10	2.61	.02	40	70	60	HA Cf 176
6.35	31	< .10	2.57	.02	40	70	60	HA Cf 176 **R**

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Viral presence [a]	Bacterial presence [b]	Bacteriophage presence [c]	Water temperature (°C)	Air temperature (°C)	Specific conductance, laboratory (µS/cm)	Oxygen, dissolved (mg/L)
HA Cf 178	08/28/2000	no	no	no	16	26	–	8.82
HA Dc 121	05/24/2000	no	**yes**	no	13.5	21	204	7.20
HA Dc 122	06/26/2000	no	**yes**	no	13.5	27	105	–
HA Dc 122 **R**	06/26/2000	no	**yes**	no	13.5	27	–	–
HA Dc 123	08/01/2000	no	**yes**	**yes**	14	31	617	4.52
HA Dc 124	10/16/2000	no	no	no	15	17	219	.67
HA Dd 108	05/02/2000	no	**yes**	no	14	20.5	254	2.88
HA De 297	05/31/2000	no	no	no	14.5	15.5	387	4.42
HA De 297 **R**	05/31/2000	no	no	no	14.5	15.5	–	4.42
HA De 298	06/20/2000	no	no	no	15	26	251	1.08
HA De 299	07/18/2000	no	no	no	16	31	229	.60
HA De 300	10/11/2000	no	no	no	14	14.5	18.4	5.69

a. Viral presence; positive cell culture or the positive presence of Hepatitis A, Enterovirus, Rotavirus, or Calicivirus Ribonucleic acid.

b. Bacterial presence; positive presence of either Total coliforms, *Escherichia coli*, or Enterococci.

c. Bacteriophage presence; positive presence of either Male-specific coliphage, Somatic coliphage, or *Bacteroides fragilis*.

pH whole water, field (standard units)	Acid-neutralizing capacity, field (mg/L as $CaCO_3$)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Elevation of land surface (feet above NGVD)	Depth of well (feet below land surface)	Depth of casing (feet below land surface)	Local well number
5.81	10	<0.10	1.64	<0.01	400	110	65	HA Cf 178
6.36	46	< .10	4.23	.03	140	200	60	HA Dc 121
6.18	26	< .10	2.24	.03	380	125	53	HA Dc 122
6.18	26	< .10	2.32	.03	380	125	53	HA Dc 122 R
7.04	80	< .10	4.42	< .01	300	150	30	HA Dc 123
6.89	106	E .05	< .05	< .02	180	350	90	HA Dc 124
7.94	120	.15	< .05	.02	–	300	56	HA Dd 108
7.75	143	E .06	< .05	< .01	–	245	64	HA De 297
7.72	142	–	–	–	–	245	64	HA De 297 R
7.14	125	< .10	< .05	.05	160	200	60	HA De 298
7.30	110	E .06	< .05	< .01	100	400	72	HA De 299
5.45	5.5	< .08	E .02	< .02	8	170	163	HA De 300

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Length of open hole (feet)	Acid-neutralizing capacity, bicarbonate, field (mg/L as $CaCO_3$)	Nitrogen ammonia, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)
BA Ab 53	10/10/2000	88	14.6	<0.04	<0.01	<0.10	<0.01	0.11
BA Ac 154	11/01/2000	85	11.6	< .04	< .01	< .10	**E** .01	.01
BA Ad 150	09/18/2000	83	11	< .02	< .01	< .10	.01	.01
BA Bc 276	08/21/2000	288	9	< .02	< .01	< .10	< .01	< .01
BA Bc 277	10/30/2000	258	14.6	< .04	< .01	< .10	.03	.03
BA Bd 239	10/16/2000	93	22	< .04	< .01	< .10	< .01	.01
BA Bd 240	10/25/2000	300	41.5	< .04	< .01	**E** .05	.03	.04
BA Bd 241	11/01/2000	437	31.7	< .04	< .01	< .10	.01	.01
BA Bd 242	11/06/2000	145	4.3	< .04	< .01	**E** .07	< .01	**E** .00
BA Be 39	09/19/2000	220	63	< .02	< .01	< .10	.02	.03
BA Cb 97	07/24/2000	92	17	< .02	< .01	**E** .06	.05	.05
BA Cb 145	06/21/2000	48	51	< .02	< .01	< .10	.03	.03
BA Cc 167	08/08/2000	220	39	< .02	< .01	< .10	**E** .00	< .01
BA Cc 260	11/06/2000	37	29.9	< .04	< .01	**E** .08	.04	.05
BA Cc 261	11/09/2000	–	44	< .04	< .01	**E** .06	**E** .00	.01
BA Cd 242	08/16/2000	201	110	< .02	< .01	< .10	.01	**E** .00
BA Cd 243	08/16/2000	366	122	< .02	< .01	< .10	< .01	.02
BA Cd 244	08/23/2000	136	88	< .02	< .01	< .10	.01	**E** .01
BA Ce 317	06/13/2000	164	10	< .02	< .01	**E** .05	< .01	< .01
BA Ce 318	07/19/2000	226	10	< .02	< .01	< .10	.01	.01
BA Da 54	08/07/2000	190	–	< .02	.03	< .10	.01	.01
BA Db 262	10/30/2000	95	23.8	< .04	< .01	< .10	.04	.04
BA Db 263	11/09/2000	51	34	< .04	< .01	< .10	.05	.05
BA Dc 454	05/03/2000	31	71	< .02	< .01	< .10	.01	**E** .01
BA Dc 455	05/01/2000	475	43	< .02	< .01	< .10	< .01	**E** .00
BA Dc 456	05/01/2000	225	41	< .02	< .01	< .10	< .01	**E** .00
BA Dc 457	05/09/2000	242	10	< .02	< .01	< .10	< .01	< .01
BA Dc 458	05/30/2000	205	200	< .02	< .01	< .10	< .01	< .01
BA Dc 459	05/30/2000	236	78	< .02	< .01	< .10	.02	.02
BA Dc 460	06/13/2000	173	262	< .02	< .01	< .10	< .01	< .01

Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Iron, dissolved (mg/L as Fe)	pH whole water, Denver laboratory (standard units)	pH whole water, Wisconsin laboratory (standard units)	Local well number
5.86	3.25	19.05	1.02	38.18	0.54	35.09	5.78	5.78	BA Ab 53
14.21	6.90	8.82	1.20	23.27	2.36	<10	5.46	5.39	BA Ac 154
18.45	12.45	78.80	7.32	158.02	27.32	**E** 9.15	5.25	5.19	BA Ad 150
2.25	2.57	2.52	1.47	5.44	.62	16.07	6.21	5.40	BA Bc 276
12.84	6.72	13.73	1.06	33.75	.68	<10	5.34	5.21	BA Bc 277
57.29	30.50	86.16	5.93	306.33	7.89	32.70	7.33	5.58	BA Bd 239
25.13	10.75	12.98	1.04	68.94	.43	<10	6.24	6.50	BA Bd 240
9.86	4.65	4.07	2.46	7.65	.93	<10	5.83	5.78	BA Bd 241
5.90	7.78	7.56	2.48	19.33	.30	<10	5.73	5.30	BA Bd 242
13.27	3.26	7.67	1.38	5.43	1.45	<10	6.00	5.69	BA Be 39
15.80	6.70	9.02	1.33	28.18	15.07	<10	6.22	6.02	BA Cb 97
23.23	7.44	16.46	3.40	60.39	1.62	16.68	6.47	6.57	BA Cb 145
23.50	10.33	6.53	3.13	34.36	10.66	25.10	6.07	6.03	BA Cc 167
15.44	5.21	7.44	1.16	7.59	24.08	**E** 5.13	6.24	5.91	BA Cc 260
29.61	14.92	31.93	3.53	114.97	7.47	<10	6.33	6.13	BA Cc 261
35.13	6.55	10.02	2.33	18.01	21.92	**E** 5.42	7.08	–	BA Cd 242
36.50	6.60	10.03	2.33	17.49	22.05	<10	7.57	–	BA Cd 243
25.70	9.97	15.69	5.29	16.02	31.78	<10	6.41	5.65	BA Cd 244
44.06	23.75	206.34	7.37	486.50	15.09	**E** 6.38	5.52	6.24	BA Ce 317
1.27	.84	2.24	.96	2.53	< .31	<10	6.20	6.56	BA Ce 318
7.69	5.76	6.65	2.61	6.01	10.15	<10	7.01	7.00	BA Da 54
8.52	3.16	5.45	2.00	4.00	14.94	**E** 7.53	6.39	6.00	BA Db 262
10.41	4.39	8.57	2.10	7.95	9.54	<10	6.12	5.82	BA Db 263
17.86	5.40	5.29	2.62	10.11	1.46	<10	6.63	6.50	BA Dc 454
32.71	13.59	11.15	4.11	88.42	8.52	116.54	6.31	–	BA Dc 455
32.58	13.64	11.19	4.03	86.54	8.53	133.81	6.65	–	BA Dc 456
2.13	1.66	3.51	1.34	2.31	3.79	**E** 6.20	5.92	6.31	BA Dc 457
63.23	12.49	4.45	1.22	15.62	9.39	<10	7.63	7.64	BA Dc 458
16.93	5.94	1.83	1.50	3.11	1.30	<10	8.11	7.96	BA Dc 459
44.24	23.67	1.83	2.47	4.64	3.54	<10	7.56	7.77	BA Dc 460

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Length of open hole (feet)	Acid-neutralizing capacity, bicarbonate, field (mg/L as $CaCO_3$)	Nitrogen ammonia, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)
BA Dc 461	06/29/2000	–	17	<0.02	<0.01	<0.10	0.03	0.03
BA Dc 462	10/31/2000	170	342	< .04	< .01	< .10	< .01	< .01
BA Dc 462 R	10/31/2000	170	347	–	–	–	–	–
BA Dc 463	11/13/2000	207	134	< .04	< .01	< .10	.01	.01
BA De 643	07/18/2000	204	50	< .02	< .01	< .10	< .01	.15
BA De 644	08/30/2000	274	29	< .02	< .01	< .10	.06	.06
BA De 645	08/30/2000	130	23	< .02	< .01	< .10	E .01	.01
BA Df 356	11/13/2000	50	195	< .04	< .01	< .10	.03	.03
BA Dg 118	04/25/2000	91	95	< .02	< .01	< .10	E .00	.02
BA Dg 119	05/10/2000	–	41	< .02	< .01	E .07	.01	.01
BA Dg 120	05/08/2000	138	61	< .02	< .01	E .07	.01	E .00
BA Dg 120 R	05/08/2000	138	–	–	–	–	–	–
BA Ea 92	04/10/2000	376	63.4	< .02	.01	< .10	.01	.02
BA Ea 96	09/20/2000	430	102	< .02	.01	< .10	.01	.01
BA Ea 97	10/18/2000	236	35.4	< .04	< .01	E .05	.06	.06
BA Eb 292	04/10/2000	92	66	< .02	< .01	< .10	.05	.05
BA Eg 259	11/07/2000	15	592	3.23	.01	4.30	E .00	.01
BA Eg 259 R	11/07/2000	15	580	–	–	–	–	–
BA Fb 82	04/11/2000	80	260	< .02	< .01	.11	E .00	E .00
BA Fb 82 R	04/11/2000	80	–	< .02	< .01	.11	E .00	.01
HA Ac 57	07/10/2000	154	–	< .02	< .01	< .10	.01	.01
HA Ac 58	09/11/2000	182	39	< .02	< .01	< .10	.08	.09
HA Ac 59	10/25/2000	26	14.6	< .04	< .01	E .05	.02	.02
HA Ad 16	09/18/2000	137	17	< .02	< .01	< .10	.03	.03
HA Ba 88	10/17/2000	88	36	< .04	< .01	< .10	E .00	.01
HA Bb 105	07/31/2000	318	18	< .02	< .01	.11	.01	.03
HA Bb 106	08/28/2000	211	116	< .02	< .01	< .10	< .01	.01
HA Bb 107	08/29/2000	260	4	< .02	< .01	< .10	< .01	< .01
HA Bc 34	06/14/2000	130	11	< .02	< .01	< .10	.02	.01
HA Bc 34 R	06/14/2000	130	–	< .02	< .01	< .10	.01	.01

Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Iron, dissolved (mg/L as Fe)	pH whole water, Denver laboratory (standard units)	pH whole water, Wisconsin laboratory (standard units)	Local well number
3.26	2.05	9.16	1.49	15.83	2.71	<10	5.77	5.68	BA Dc 461
70.06	40.49	58.85	1.09	134.53	11.67	<10	7.29	7.27	BA Dc 462
–	–	–	–	–	–	–	–	7.30	BA Dc 462 R
29.08	7.86	2.64	1.82	4.72	3.04	<10	7.81	7.98	BA Dc 463
27.01	13.73	13.56	6.10	74.15	24.70	<10	6.68	6.75	BA De 643
8.62	3.86	7.31	2.09	12.87	<0.31	<10	5.84	5.60	BA De 644
13.81	5.41	12.30	2.53	32.33	15.37	<10	5.63	5.35	BA De 645
58.93	15.31	28.63	5.63	28.31	44.45	<10	6.93	6.63	BA Df 356
15.25	8.73	6.23	3.07	17.70	1.16	5,884	6.45	6.25	BA Dg 118
19.52	6.75	33.14	2.12	57.84	17.15	19.44	5.91	6.21	BA Dg 119
20.09	7.95	14.64	1.24	22.79	7.17	<10	–	6.64	BA Dg 120
–	–	–	–	–	–	–	6.08	6.00	BA Dg 120 R
12.14	10.42	2.90	2.84	11.03	3.14	<10	6.82	6.35	BA Ea 92
30.25	22.37	7.58	1.81	42.49	24.80	<10	6.66	6.48	BA Ea 96
8.56	2.28	9.22	1.41	8.87	4.40	<10	6.16	6.13	BA Ea 97
12.56	12.16	3.17	.34	7.88	11.57	<10	6.35	6.20	BA Eb 292
86.07	39.59	59.13	13.70	58.46	69.56	30,378	6.67	6.70	BA Eg 259
88.69	40.11	53.95	14.20	56.43	70.38	30,196	6.62	6.69	BA Eg 259 R
141.61	37.81	63.11	6.50	258.74	102.60	18.13	6.91	6.90	BA Fb 82
140.75	37.27	67.07	4.84	258.62	109.64	23.35	6.93	6.98	BA Fb 82 R
78.98	21.89	43.82	3.69	257.97	2.16	<10	5.48	5.47	HA Ac 57
13.41	20.70	10.25	.86	12.83	47.33	<10	6.16	5.80	HA Ac 58
26.40	5.92	12.06	1.31	43.66	5.89	<10	5.70	5.94	HA Ac 59
4.60	1.22	3.21	.42	5.31	E .22	<10	6.05	5.47	HA Ad 16
8.79	8.64	11.83	1.86	27.70	.81	11.47	7.84	6.36	HA Ba 88
9.97	7.56	8.56	2.82	22.44	4.53	<10	5.91	5.95	HA Bb 105
5.33	3.77	101.20	2.05	64.91	.42	<10	6.88	6.65	HA Bb 106
2.56	5.62	2.76	1.51	8.96	< .31	<10	5.07	4.80	HA Bb 107
3.07	2.36	4.55	.80	10.82	.83	<10	5.90	5.96	HA Bc 34
3.04	2.35	4.55	.79	11.18	.79	<10	5.73	6.01	HA Bc 34 R

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Length of open hole (feet)	Acid-neutralizing capacity, bicarbonate, field (mg/L as $CaCO_3$)	Nitrogen ammonia, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)
HA Bc 35	10/23/2000	425	50	<0.04	<0.01	**E** 0.08	0.03	0.04
HA Bd 82	07/31/2000	9	98	< .02	< .01	< .10	< .01	< .01
HA Bd 87	10/11/2000	157	59.8	< .04	< .01	**E** .09	.03	.04
HA Bd 88	10/17/2000	0	106.1	< .04	< .01	< .10	< .01	**E** .00
HA Be 40	10/24/2000	200	141.5	< .04	< .01	**E** .06	.02	.02
HA Bf 19	09/06/2000	180	63	< .02	< .01	< .10	< .01	< .01
HA Bf 20	09/06/2000	381	123	.05	< .01	< .10	< .01	< .01
HA Ca 29	09/07/2000	60	20	< .02	< .01	< .10	.04	.04
HA Cb 286	07/12/2000	87	50	< .02	< .01	< .10	< .01	.01
HA Cb 287	08/01/2000	508	146	< .02	< .01	< .10	< .01	< .01
HA Cb 288	08/08/2000	149	33	< .02	< .01	< .10	.01	.03
HA Cb 289	08/23/2000	222	34	.05	< .01	**E** .08	.04	.04
HA Cb 290	10/23/2000	146	18.3	< .04	< .01	**E** .07	.01	.02
HA Cc 196	06/19/2000	87	132	< .02	< .01	< .10	.03	.03
HA Cc 197	07/11/2000	189	–	< .02	< .01	< .10	.03	.03
HA Cc 197 **R**	07/11/2000	189	–	< .02	< .01	< .10	.03	.03
HA Cc 198	07/24/2000	34	253	< .02	< .01	< .10	.01	.01
HA Cc 199	08/22/2000	183	222	< .02	< .01	**E** .05	.04	.04
HA Cc 200	09/07/2000	270	15	< .02	< .01	< .10	**E** .01	**E** .01
HA Cc 201	10/18/2000	130	42.1	< .04	< .01	< .10	.06	.07
HA Cd 199	07/13/2000	155	27	< .02	.04	< .10	< .01	1.05
HA Cd 200	07/17/2000	120	17	< .02	< .01	< .10	.04	.05
HA Cd 201	07/25/2000	103	24	< .02	< .01	< .10	.02	.01
HA Cd 201 **R**	07/25/2000	130	–	< .02	< .01	< .10	.02	.01
HA Ce 119	08/23/2000	15	66	< .02	< .01	**E** .05	.02	.02
HA Ce 120	09/18/2000	82	55	.08	< .01	**E** .05	.02	.02
HA Cf 171	07/20/2000	32	37	< .02	< .01	< .10	< .01	< .01
HA Cf 176	08/03/2000	10	38	< .02	< .01	**E** .08	.01	**E** .01
HA Cf 176 **R**	08/03/2000	10	–	< .02	< .01	**E** .06	.01	.01

Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Iron, dissolved (mg/L as Fe)	pH whole water, Denver laboratory (standard units)	pH whole water, Wisconsin laboratory (standard units)	Local well number
–	–	–	–	–	–	–	5.82	5.96	HA Bc 35
14.38	18.81	2.65	0.29	28.55	6.40	<10	6.55	7.00	HA Bd 82
11.71	6.48	5.58	.65	10.22	1.28	<10	6.67	6.34	HA Bd 87
27.20	17.98	12.01	.34	42.07	7.52	20.49	6.56	6.45	HA Bd 88
18.55	23.45	4.62	.54	12.36	16.95	<10	6.77	7.11	HA Be 40
21.42	2.06	5.55	1.46	3.11	8.98	<10	7.61	6.61	HA Bf 19
21.12	8.77	18.69	.71	3.56	22.36	<10	5.81	5.61	HA Bf 20
16.37	9.00	49.54	3.02	106.81	5.06	**E** 7.0	6.86	7.35	HA Ca 29
7.06	4.51	6.54	3.12	6.41	10.66	417.18	6.22	6.59	HA Cb 286
59.96	23.01	35.99	6.58	159.12	10.64	<10	5.96	6.08	HA Cb 287
20.13	10.21	14.42	3.84	59.55	3.28	<10	5.91	5.60	HA Cb 288
28.24	13.44	45.26	4.83	133.27	8.42	**E** 8.42	5.40	5.36	HA Cb 289
–	–	–	–	–	–	–	–	–	HA Cb 290
29.88	15.90	6.43	.52	23.89	15.27	<10	6.61	7.22	HA Cc 196
24.54	17.98	3.96	.98	28.53	7.64	<10	6.83	6.59	HA Cc 197
24.17	17.76	3.91	.98	28.12	7.69	<10	6.74	6.59	HA Cc 197 **R**
27.90	153.30	27.24	.82	392.81	24.97	<10	7.68	7.51	HA Cc 198
46.09	26.54	26.33	**E** .19	45.07	32.45	<10	6.89	–	HA Cc 199
5.39	4.88	20.09	1.77	50.99	4.10	40.6	5.63	–	HA Cc 200
13.43	7.27	14.05	1.58	15.32	21.89	<10	6.06	5.97	HA Cc 201
8.78	8.47	8.33	3.13	41.68	1.81	244.57	6.03	5.82	HA Cd 199
16.59	2.96	18.97	.70	52.31	.45	56.06	6.20	5.94	HA Cd 200
30.17	19.76	30.96	2.82	133.07	5.57	**E** 5.03	5.80	5.68	HA Cd 201
30.11	19.72	30.78	2.85	134.03	5.58	<10	5.83	5.68	HA Cd 201 **R**
49.69	23.64	11.60	.71	112.33	14.44	**E** 6.90	6.39	5.61	HA Ce 119
16.64	8.23	5.26	.47	11.45	2.22	13.31	6.59	6.51	HA Ce 120
5.55	2.01	6.32	.75	4.95	2.64	221.72	6.43	6.64	HA Cf 171
8.38	4.73	10.71	1.01	17.09	3.95	<10	5.86	6.35	HA Cf 176
8.49	4.81	10.79	1.02	16.86	3.95	<10	5.87	6.35	HA Cf 176 **R**

Appendix. *Microbiological and water-quality data for 91 public water-supply wells in Baltimore and Harford Counties, Maryland, April through November 2000—Continued*

Local well number	Date sampled	Length of open hole (feet)	Acid-neutralizing capacity, bicarbonate, field (mg/L as $CaCO_3$)	Nitrogen ammonia, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)
HA Cf 178	08/28/2000	45	12	<0.02	<0.01	<0.10	**E** 0.00	**E** 0 .01
HA Dc 121	05/24/2000	140	56	< .02	< .01	< .10	.03	.03
HA Dc 122	06/26/2000	72	32	< .02	< .01	< .10	.03	.04
HA Dc 122 **R**	06/26/2000	72	–	< .02	< .01	< .10	.03	.03
HA Dc 123	08/01/2000	120	98	< .02	< .01	< .10	.01	.01
HA Dc 124	10/16/2000	260	129.3	**E** .03	.01	< .10	< .01	**E** .00
HA Dd 108	05/02/2000	244	146	.07	< .01	**E** .06	.02	.02
HA De 297	05/31/2000	181	174	.02	< .01	< .10	.01	**E** .01
HA De 297 **R**	05/31/2000	181	–	–	–	–	–	–
HA De 298	06/20/2000	140	153	< .02	< .01	< .10	.02	.82
HA De 299	07/18/2000	328	134	< .02	< .01	< .10	< .01	< .01
HA De 300	10/11/2000	7	6.7	< .04	< .01	< .10	< .01	< .01

Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Iron, dissolved (mg/L as Fe)	pH whole water, Denver laboratory (standard units)	pH whole water, Wisconsin laboratory (standard units)	Local well number
8.50	3.92	7.27	0.53	2.37	**E** 0.17	<10	5.99	5.80	HA Cf 178
18.99	6.55	8.59	.73	6.86	18.49	**E** 5.13	6.45	6.49	HA Dc 121
8.83	3.81	5.08	.79	5.20	1.49	<10	6.85	6.18	HA Dc 122
9.15	3.94	5.31	.86	5.17	1.42	<10	7.15	6.24	HA Dc 122 **R**
51.95	21.37	9.00	.75	111.98	.70	<10	6.51	7.04	HA Dc 123
22.31	11.76	6.63	1.45	7.12	11.88	3,619.90	6.88	6.89	HA Dc 124
17.94	2.29	32.18	3.64	1.51	6.54	16.40	7.93	7.90	HA Dd 108
32.25	19.58	11.34	2.55	32.12	2.74	157.65	–	7.66	HA De 297
–	–	–	–	–	–	–	7.64	7.64	HA De 297 **R**
22.12	10.05	12.41	2.19	4.78	9.98	896.32	6.97	7.20	HA De 298
21.29	11.76	5.74	1.57	4.59	3.21	610.99	7.49	7.30	HA De 299
.83	.33	2.19	0.43	2.20	1.70	18.63	5.97	5.45	HA De 300