

Ground-Water Quality in the Upper Susquehanna River Basin, New York, 2004–05

By Kari K. Hetcher-Aguila and David A.V. Eckhardt

In cooperation with New York State Department of Environmental Conservation

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Conversion Factors, Abbreviations, and Datum

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3148	meter (m)
mile (mi)	1.609	kilometer (km)
square miles (mi ²)	2.589	square kilometers (km ²)
inch per year (in/yr)	2.54	centimeters per year (cm/yr)
gallon	3.78	liter (L)
gallons per minute (gal/min)	3.785	liters per minute (L/min)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

Other abbreviations used in this report

micrometers (μm)

micrograms per liter (μg/L)

milligrams per liter (mg/L)

picocuries per liter (pCi/L)

microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C)

milliliter per minute (mL/min)

Maximum Contaminant Level (MCL)

Secondary Maximum Contaminant Level (SMCL)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Abstract

Water samples were collected from 20 production wells and 13 private residential wells throughout the upper Susquehanna River Basin (upstream from the Pennsylvania border) during the fall of 2004 and the spring of 2005 and analyzed to describe the chemical quality of ground water in the upper basin. Wells were selected to represent areas of greatest ground-water use and highest vulnerability to contamination, and to provide a representative sampling from the entire (4,516 square-mile) upper basin. Samples were analyzed for physical properties, nutrients, inorganic constituents, metals, radionuclides, pesticides, volatile organic compounds, and bacteria.

The cations that were detected in the highest concentrations were calcium, magnesium, and sodium; the anions that were detected in the greatest concentrations were bicarbonate, chloride, and sulfate. The predominant nutrient was nitrate, the concentrations of which were greater in samples from sand and gravel aquifers than in samples from bedrock. The metals barium, boron, cobalt, copper, and nickel were detected in every sample; the metals with the highest concentrations were barium, boron, iron, manganese, strontium, and lithium. The pesticide compounds detected most frequently were atrazine, deethylatrazine, alachlor ESA, and two degradation products of metolachlor (metolachlor ESA and metolachlor OA); the compounds detected in highest concentration were metolachlor ESA and OA. Volatile organic compounds were detected in 11 samples, and concentrations of 3 of these compounds exceeded 1 microgram per liter ($\mu\text{g/L}$).

Several analytes were found in concentrations that exceeded Federal and New York State water-quality standards, which are typically identical. Chloride concentrations exceeded the U.S. Environmental Protection Agency (USEPA) Secondary Maximum Contaminant Level (SMCL) of 250 milligrams per liter (mg/L) in two samples, and sulfate concentrations exceeded the SMCL of 250 mg/L in one sample. Sodium concentrations exceeded the USEPA Drinking Water Advisory of 60 mg/L in six samples. Nitrate concentrations exceeded the USEPA Maximum Contaminant Level (MCL) of 10 mg/L in one sample and approached this

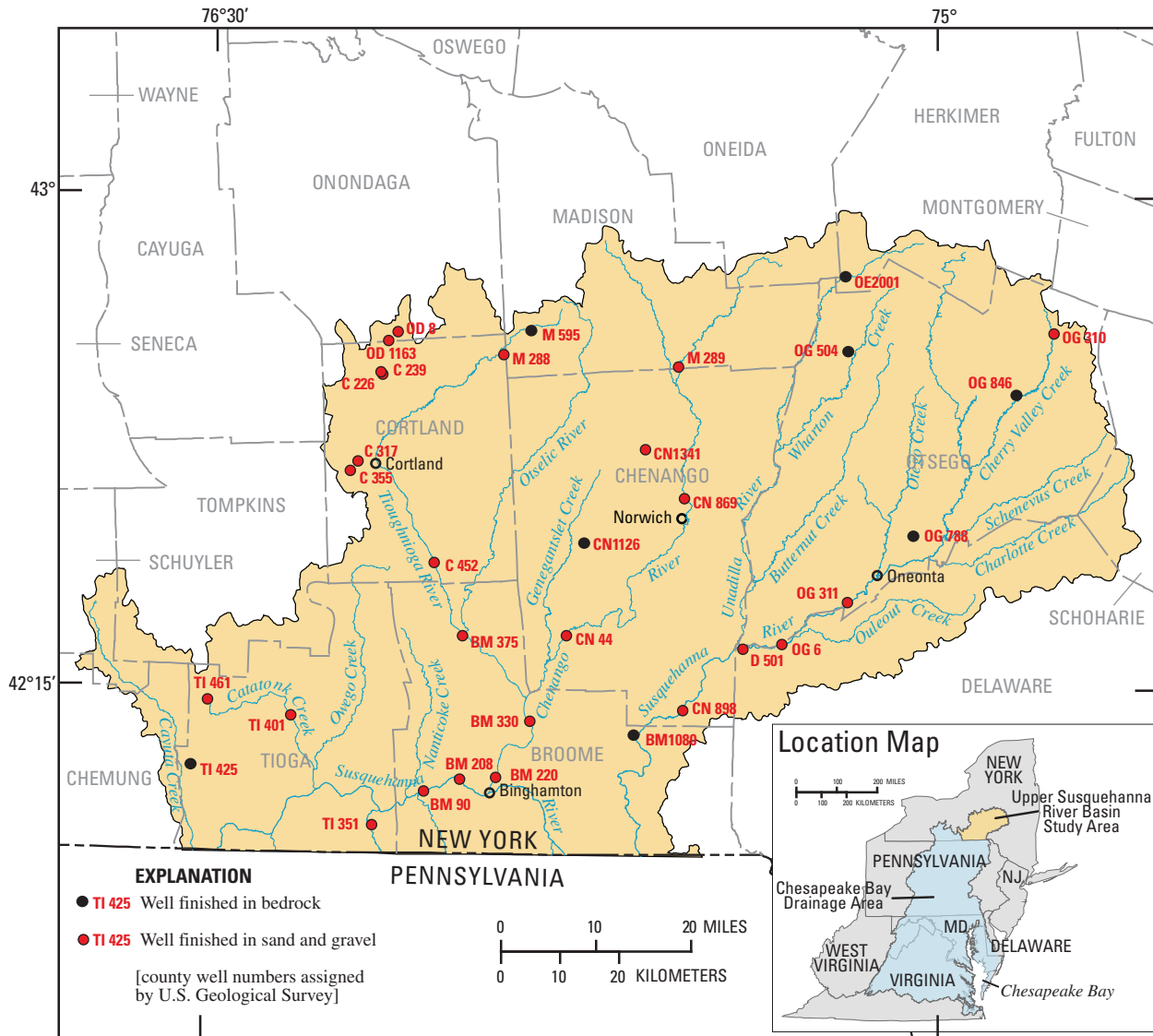
limit (at 9.84 mg/L) in another sample. Barium concentrations exceeded the MCL of 2,000 $\mu\text{g/L}$ in one sample. Iron concentrations exceeded the SMCL of 300 $\mu\text{g/L}$ in five samples, and manganese concentrations exceeded the SMCL of 50 $\mu\text{g/L}$ in 14 samples. Arsenic was detected in seven samples, and the MCL for arsenic (10 $\mu\text{g/L}$) was exceeded in two samples. Radon-222 exceeded the proposed MCL of 300 picocuries per liter in 24 samples. Any detection of total coliform or fecal coliform bacteria is considered a violation of New York State health regulations; in this study, total coliform was detected in six samples; fecal coliform was detected in one sample, and *Escherichia coli* was not detected in any sample.

Introduction

The upper Susquehanna River Basin encompasses 4,516 mi^2 in south-central New York north of the Pennsylvania border. The main valley of the Susquehanna River trends northeast-southwest and is about 1 mi wide in most places. The Susquehanna River Basin drains most of south-central New York and half of Pennsylvania and eventually flows into Chesapeake Bay, the nation's largest estuary (fig. 1). Concentrations of nutrients, sediment, and other constituents in Chesapeake Bay have increased over the past 50 years as a result of deforestation, growth of urban areas, poor land management, and water-treatment-plant effluent within its basin (Sprague, 2001; U.S. Environmental Protection Agency, 1988; Bell and others, 1996; Belval and others, 1995; Belval and Sprague, 1999). In 2001, Hetcher and others (2003) described the chemical quality of base flow within a part of the upper Susquehanna River Basin, but a comprehensive assessment of the quality of ground water throughout the basin has been needed.

Section 305(b) of the Federal Clean Water Act Amendments of 1977 (U.S. Environmental Protection Agency, 1997) requires all states to undertake a comprehensive water-quality monitoring program for surface-water and ground-water resources. In 2001, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC) and the

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Base from U. S. Geological Survey, Digital Line Graph, 1983, 1:100,000

Figure 1. Location of upper Susquehanna River Basin in New York and of the 33 wells sampled in 2004–05. (Well data are given in table 1.)

U.S. Environmental Protection Agency (USEPA), initiated an assessment of ground-water quality in river basins throughout the State, as specified in Section 305(b). As part of this program, a ground-water-quality study was conducted in the Mohawk River Basin during 2002, the Chemung River Basin during 2003, and the Lake Champlain Basin during 2004.

As part of the cooperative program with NYSDEC, the USGS sampled ground water in the fall of 2004 and the spring of 2005 from selected aquifers within the upper Susquehanna River Basin (fig. 1) for chemical and bacteriological analysis. Sampling was done at production wells and private residential wells that tap sand and gravel aquifers and bedrock aquifers. The analytical results were compared with drinking-water standards established by the USEPA and New York State and used to define the pattern of ground-water quality throughout the study area.

Study Area

The northernmost part of the study area is characterized by low relief and contains mostly farm land and wetlands, whereas the central and southern parts are characterized by moderate to high relief and a mixture of forested and farm land. The study area is predominantly rural, although it contains several small cities (Oneonta, Binghamton, Norwich, and Cortland [fig. 1]) and many scattered villages. Most of the developed areas are within the Susquehanna, Unadilla, Chenango, and Tioughnioga River valleys (fig. 1). Total population of the study area in 2000 was 460,000 (U.S. Bureau of Census, 2000). Community-water-supply systems provide water to more than 250,000 people in the villages, towns, and cities within the study area (U.S. Environmental Protection Agency, 2005). Most of the water-supply systems use ground water, although some use surface water from reservoirs and lakes, and others use a combination of surface water and ground water. Most rural homeowners rely on ground water for their domestic water use.

During deglaciation of the region, thick deposits of glaciofluvial sand and gravel (deposited beneath, in front of, or alongside a glacier by meltwater streams) and glaciolacustrine clay, silt, and fine sand (deposited within proglacial lakes) were left within the valleys. As a result, glacially derived landforms are found within the valleys throughout the study area; these include valley trains of outwash, kames and kame terraces, eskers, kettles, and morainal valley plugs and ridges. Recent alluvium covers some of the glacial deposits and forms the flood plains of the larger streams and rivers. The glacial and fluvial deposits within the study area are described in detail by Randall (2001), Fleisher (1977a,b; 1986), MacNish and Randall (1982), and (Coates, 1966).

The most productive aquifers within the study area are the glaciofluvial deposits of sand and gravel (fig. 2). The glaciolacustrine deposits of sand, silt, and clay are relatively impermeable and yield little water to wells but may confine

underlying aquifers. Bedrock aquifers are tapped for water use in areas where significant thicknesses of saturated sand and gravel are not available. The bedrock aquifers are relatively flat-lying, inter-bedded sedimentary units of shale and sandstone that extend throughout most of the study area; some carbonate-rock aquifers of limestone and dolostone are present but limited to a small area in the northern part of the basin.

Purpose and Scope

This report describes the sampling and analytical methods used for, and presents the results of, the water-quality analyses conducted on ground-water samples from 33 wells throughout the upper Susquehanna River Basin. Results are given in tables 1–8 (at end of report). Analytical results for selected constituents are compared with drinking-water standards, which include Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs) established by the U.S. Environmental Protection Agency (1996; 2002; 2004; 2005) and New York State (1998a,b).

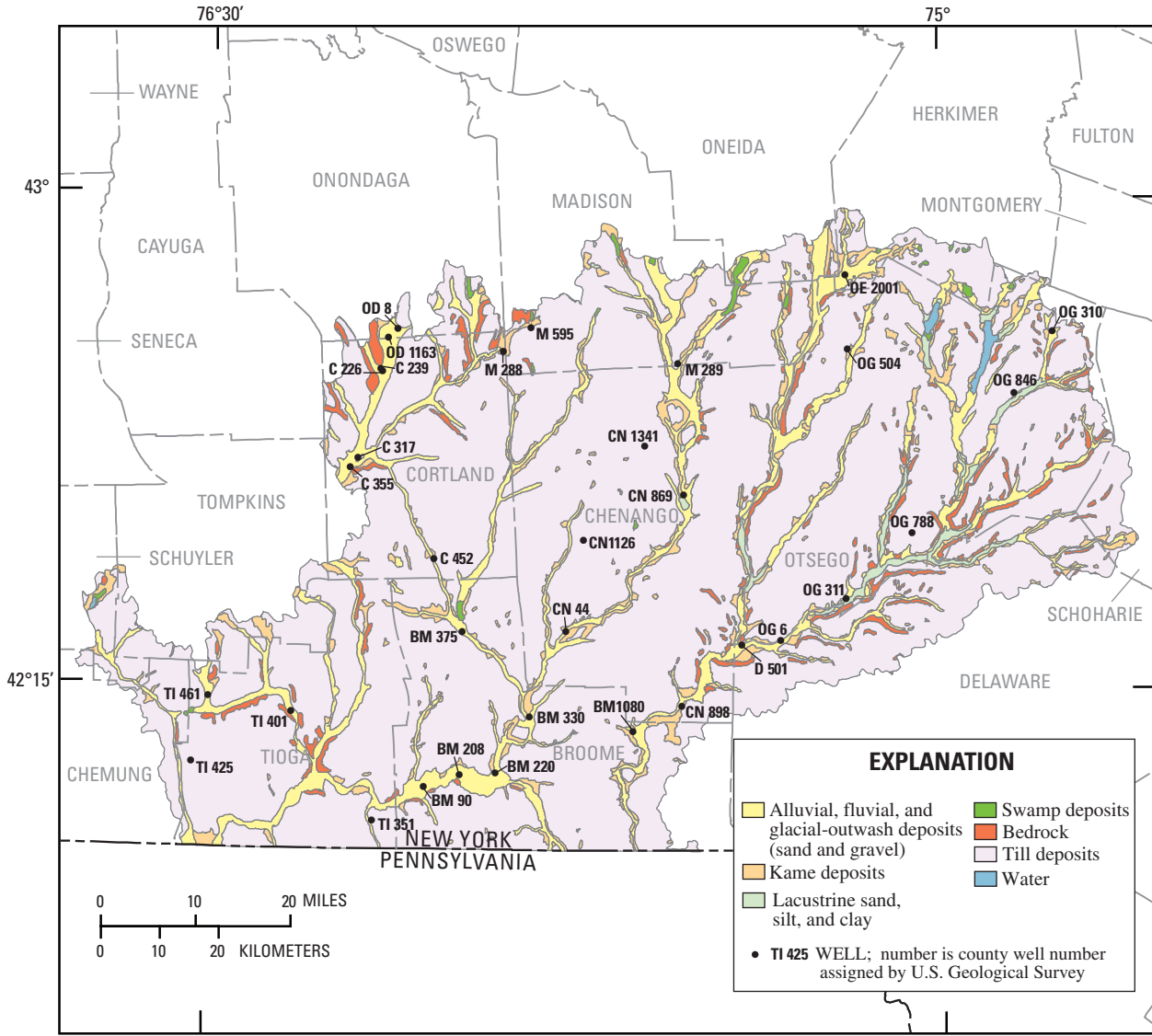
Methods

Water samples were collected from 13 private residential wells and 20 production wells and analyzed for 202 constituents and 5 physical properties. The following paragraphs describe the criteria used to select these wells, the sampling methods used in the field, and the analytical methods. Three samples were collected for quality assurance (QA) and quality control (QC)—one field blank and two replicate samples—as required for the Federal 305(b) program.

Site Selection

Residential wells were identified in the USGS Ground-Water Site Inventory (GWSI) database and through the NYSDEC Water-Well Reporting Program. The Water-Well Reporting Program was implemented in 2000 to collect information about newly drilled wells throughout New York from licensed well drillers and was useful in locating wells suitable for ground-water studies. A letter was sent to the owner of each well that was identified as a potential sampling site. The letter described the project, requested permission to sample the water, and included a questionnaire asking the location of the well, the most convenient times for sampling, any safety concerns around the well, and other well-related information. Well owners who did not return the questionnaire received a phone call to ask permission to sample the well water and for other information about the well. Well owners who responded favorably to the questionnaire or called were contacted a week before sampling to establish the date and time.

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Base from U. S. Geological Survey, Digital Line Graph, 1983, 1:100,000

Geology modified from Cadwell and Muller, 1986

Figure 2. Surficial geology of the upper Susquehanna River Basin and locations of the wells sampled in 2004–05. (Well data are given in table 1.)

Production wells were identified in the GWSI database and through contact with local officials (including the Cortland County and Otsego County Departments of Health) and with water managers of villages and cities throughout the basin. The water managers were sent a project description and a questionnaire similar to those sent to residential-well owners. Telephone calls were made to well owners to clarify information about the wells and to arrange sampling dates.

Site selection did not target specific municipalities, industries, or agricultural practices; rather, sample sites were selected to represent areas of greatest ground-water use and highest vulnerability to contamination, and to obtain a thorough geographical representation of the upper basin (fig. 2). Site selection included (1) wells finished in sand and gravel and wells finished in bedrock; (2) wells in the main valley of the Susquehanna, Unadilla, Chenango, and Tioughnioga Rivers, in the tributary valleys, and in the uplands surrounding the valleys; (3) wells in each of four predominant land-use categories—agriculture, forest, urban, or mixed; and (4) public-supply and residential wells.

The land-use classification was done through satellite-image analysis to describe the predominant land uses within a half-mile radius of each well. Most (20 of the 33 well sites) were surrounded by a single land use that represented more than 50 percent of well-site area; the other 13 well sites contained a combination of the three land uses (table 1). Most of the wells finished in sand and gravel were in the valleys and ranged from 25 to 233 feet deep. The bedrock wells, which were generally in the uplands, ranged from 55 to 358 feet deep. The well data, land-use data, and water-quality physical properties are given in table 1.

Shallow wells that tap sand and gravel aquifers are susceptible to contamination by several types of compounds, including volatile organic compounds (VOCs), pesticides, deicing chemicals, and nutrients from nearby highways and industrial, agricultural, and residential areas. The movement of these contaminants to the water table through the soils and the sand and gravel can be relatively rapid. Bedrock wells in the uplands are generally less susceptible to contamination from industrial and urban sources, which are mainly in the valleys; also, water movement in the bedrock is generally slower than in sand and gravel. The agricultural areas that surround most of the upland wells are a potential source of contamination from fertilizers, animal wastes, and domestic septic systems. In addition to manmade contaminants, all aquifers contain naturally derived minerals that may adversely affect water quality, such as sodium, chloride, iron, manganese, and trace elements, and some may also contain radon gas.

Well categorization according to predominant land use within a half-mile radius of each well allows a general indication of potential types of manmade contamination; for example, water from wells surrounded mostly by agricultural land could have elevated concentrations of nutrients or pesticides, whereas water from wells surrounded by urban land (industrial, commercial, parks, or highways) might have elevated concentrations of chloride, VOCs, or pesticides.

Water from wells surrounded by forested, undeveloped land, in contrast, tends to be relatively uncontaminated.

The assignment of land-use categories to a well does not always accurately denote the potential sources of contamination that may affect that well. For example, a well completed in sand and gravel adjacent to the Susquehanna River may pump river water, which may contain chemicals discharged to the river upstream from the site. Also, a well might yield water consisting of a mixture of recent precipitation and deeper water that might have entered the system tens to hundreds of years ago. Therefore, land-use descriptions at well sites provide only a general indication of the potential for contamination, and a single water-quality analysis cannot indicate whether a specific land use affects specific wells. Delineation of the flow paths and travel times of water at the sampled wells would require additional sampling and hydrogeologic analysis, which were beyond the scope of this study.

Sampling and Analytical Methods

Water samples that were analyzed for nutrients (table 3), inorganic constituents (table 4), metals and radionuclides (table 5), and VOCs (table 7) were collected from every well and processed by methods described in the USGS manual for the collection of water-quality data (U.S. Geological Survey, 2004). In addition, pesticide samples (table 6) were collected and processed by the methods of Shelton (1994) and Sandstrom and others (2001). These samples were analyzed at the USGS National Water Quality Laboratory (NWQL) and the USGS Kansas Organic Geochemistry Research Laboratory (OGRL) for 116 pesticides and pesticide degradates through methods described by Zaugg and others (1995), Meyer and others (1993), and Ferrer and others (1997). The analytical method devised by Zaugg and others (1995) was developed in cooperation with the USEPA and allows detection of the nation's most commonly used pesticides. Samples for bacteria analyses (table 8) were collected and processed in accordance with NYSDEC and New York State Department of Health (NYSDOH) regulations.

Sampling entailed the following steps: the well pump was turned on (many of the production wells were already running) and allowed to run about 20 minutes, or until at least five casing-volumes of well water had passed the sampling point. A raw-water spigot between the well and the pressure tank was opened, and the water was allowed to run for several more minutes to flush the spigot. During this time, a general visual evaluation of the area surrounding the sampling site was conducted to identify obvious potential nonpoint and point sources of contamination that could affect the well water. Samples were collected from the raw-water spigot to avoid all water-treatment systems and to ensure that the water collected was representative of the water in the aquifer.

At each sampling site, a Teflon discharge line was connected to the spigot, and samples were analyzed with

a multiprobe meter for physical properties, including temperature, specific conductance, dissolved-oxygen concentration, and pH. The water was run slowly enough (100 to 250 mL/min) for the water-quality sensors to react, yet fast enough to cause the pump in the well to run continuously (this sometimes required opening other faucets to waste). Once these properties had stabilized, a second Teflon discharge line was connected to the first with a stainless-steel quick-connect fitting, and the second line was directed into a sampling-chamber bag mounted on a plastic box; this sample-collection chamber was used to minimize sample exposure to dust and other potential sources of contamination. The bottom of the sampling-chamber bag was pierced above a plastic funnel in the top of the box to allow water to run to waste for several minutes to flush the Teflon line. Bottles were filled within the chamber bag according to standard USGS field methods (U.S. Geological Survey, 2004).

Analyses for physical properties, most metals, radionuclides, and VOCs were conducted on unfiltered water samples (tables 1, 5, and 7) to obtain the whole-water concentrations. Concentrations of most nutrients, major inorganic constituents, three metals, and pesticides were obtained from filtered samples (tables 3, 4, 5, and 6). Unfiltered-water concentrations were compared with filtered concentrations to estimate the difference between the total and dissolved concentrations of some constituents. Sulfuric acid was added to some nutrient samples to prevent biologic degradation of the sample, and nitric acid was added to some metal samples to prevent constituent loss by precipitation. If a filtered sample was required for inorganic analytes, a 0.45- μm capsule filter was attached to the Teflon discharge line inside the sample chamber bag; pesticide samples were filtered in the laboratory through 0.7- μm plate filters.

All Teflon discharge lines were cleaned in the laboratory before each sampling day and in the field between each sample. New chamber bags were used at each sampling site. Samples for radon analysis were obtained through an in-line septum chamber with a disposable syringe to avoid atmospheric contamination. Samples for bacterial analysis were collected within the sampling chamber in sterile containers provided by the bacteriological laboratory; the connection of the sampling tube to the well tap was not sterilized.

All samples were stored on ice in coolers and delivered directly or shipped by overnight delivery to one of four laboratories: (1) the USGS National Water Quality Laboratory in Denver, Colo., for analysis for nutrients (table 3), inorganic constituents (table 4), metals (table 5), some pesticides (table 6), and VOCs (table 7); (2) the USGS Kansas Organic Geochemical Research Laboratory in Lawrence, Kans., for other pesticides (table 6); (3) a New York State-certified private laboratory in Newburgh, N.Y., for total organic carbon and phenolic compounds (table 3); and (4) a local laboratory in Ithaca, N.Y., approved by New York State for bacteriological analysis (table 8).

Most well sites allowed easy access to a raw-water spigot that was not affected by treatment or pressure tanks. Twelve wells had the following unusual situations: (1) Eight wells (OG 310, D 501, M 288, BM 220, C 317, M 289, C 355, and BM 330, fig. 2) had no spigot, but rather had either a tube at the top of the well, or a kitchen faucet, from which a raw-water sample could be obtained. The Teflon sampling apparatus and chamber bags could not be used at these wells; therefore, the well pump was allowed to run for several minutes to flush the tube or faucet before the bottles were rinsed and filled. An extra 3-L Teflon bottle was filled, and samples that required filtration were filtered from this bottle with a peristaltic pump and clean silicone tubing. (2) Two wells (CN 869 and BM 90, fig. 2) did not have access to a raw-water sample because phosphate was injected into the well for the sequestering of manganese. (3) One well (OE 2001) had no spigot, but raw-water samples were collected from a pipe that discharged to a farm pond. (4) One well (OD 1163) did not have access to a raw, untreated sample because the owner's water softener system interfered; therefore, the well casing was opened and the well was pumped with a peristaltic pump for 20 minutes while faucets inside the home were run to flush the well casing and cause the well pump to run. Clean silicone tubing was then used to draw water out of the well and into the sample chamber, from which samples were collected and filtered.

Ground–Water Quality

The 33 ground-water samples collected during this study were analyzed for 202 chemical constituents. Most (127) constituents were not detected in any samples (table 2); the concentrations of the 75 constituents that were detected are listed in tables 3–8. Concentrations of several constituents exceeded recommended MCLs or SMCLs set by the U.S. Environmental Protection Agency (1996) and New York State (1998a,b).

The QA/QC field blank contained no constituent in concentrations above the laboratory reporting levels; this indicates that no constituents were affected by artificial contamination from the sampling or analytical procedures. The results of the two QA/QC replicate samples showed that variability in sample results met the precision requirements of the study. The largest percent differences between concentrations in a ground-water sample and the replicate sample were in acid-neutralizing capacity, residue on evaporation, and low-concentration metals (concentrations near or below the reporting level for the metals).

Physical Properties

The pH of the samples (table 1) ranged from 7.1 to 9.1, and 7 of the 33 samples exceeded the accepted SMCL range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 1996).

Specific conductance of the samples (table 1) ranged from 245 to 2,140 $\mu\text{S}/\text{cm}$. Water temperature (table 1) ranged from 5.7 to 12.9°C. The color of two samples exceeded the SMCL of 15 (table 1).

Nutrients

Nitrate was the predominant nutrient in the ground-water samples (table 3); the concentrations ranged from less than 0.06 (the analytical detection limit) to 10.5 mg/L as nitrogen (N). The nitrate MCL of 10 mg/L as N was exceeded in one sample and approached this limit (at 9.84 mg/L) in another sample. Samples from wells finished in sand and gravel had higher nitrate concentrations than those from wells finished in bedrock.

Inorganic Ions

The cations that were detected in the highest concentrations were calcium, magnesium, and sodium (table 4). Calcium concentrations ranged from 13.0 to 254 mg/L, and magnesium concentrations ranged from 2.38 to 162 mg/L. Calcium and magnesium contribute to water hardness, and 32 of the 33 wells yielded water that is moderately hard to very hard (Hem, 1985). Sodium concentrations ranged from 2.5 to 275 mg/L, and six samples exceeded the USEPA Drinking Water Advisory, which recommends that sodium concentrations in drinking water not exceed 60 mg/L to minimize the taste. This recommendation is not federally enforceable but is intended as a guideline for States (U.S. Environmental Protection Agency, 2002).

The anions that were detected in the highest concentrations were bicarbonate (alkalinity), chloride, and sulfate. Alkalinity concentrations ranged from 94 to 283 mg/L (as CaCO_3), chloride concentrations ranged from 0.55 to 408 mg/L, and sulfate concentrations ranged from 1.0 to 1,120 mg/L (table 4). The chloride SMCL of 250 mg/L was exceeded in two samples, and the sulfate SMCL of 250 mg/L was exceeded in one sample.

Metals and Radionuclides

The most commonly detected metals were barium, boron, cobalt, copper, lithium, nickel, strontium, and uranium, all of which were detected in every sample. The metals detected in the highest concentrations were barium, boron, iron, manganese, strontium, and lithium (table 5). Barium concentrations ranged from 6 to 2,220 $\mu\text{g}/\text{L}$, and the MCL for barium (2,000 $\mu\text{g}/\text{L}$) was exceeded in one sample (well BM 1080, which is finished in bedrock). Boron concentrations ranged from 8.5 to 1,730 $\mu\text{g}/\text{L}$; cobalt concentrations ranged from 0.066 to 1.22 $\mu\text{g}/\text{L}$; and copper concentrations ranged from 0.3 to 34.3 $\mu\text{g}/\text{L}$. MCLs for boron or cobalt have not been established. The SMCL for copper (1,000 $\mu\text{g}/\text{L}$) was

not exceeded in any sample. Dissolved iron was detected in 16 filtered samples at concentrations ranging from less than 6 to 1,230 $\mu\text{g}/\text{L}$, and the SMCL for iron (300 $\mu\text{g}/\text{L}$) was exceeded in five samples. Dissolved manganese was detected in 25 filtered samples at concentrations ranging from 0.6 to 969 $\mu\text{g}/\text{L}$, and the SMCL for manganese (50 $\mu\text{g}/\text{L}$) was exceeded in 14 samples. Uranium was detected in every sample; concentrations ranged from 0.007 to 0.869 $\mu\text{g}/\text{L}$, but none exceeded the MCL of 30 $\mu\text{g}/\text{L}$. Arsenic was detected in 7 samples, and the MCL for arsenic (10 $\mu\text{g}/\text{L}$) was exceeded in 2 samples (table 4); lead was detected in 32 samples, but the MCL (15 $\mu\text{g}/\text{L}$) was not exceeded.

Radon also was detected in every sample, and concentrations ranged from 60 to 1,490 pCi/L. The proposed MCL of 300 pCi/L for radon-222 in drinking water was exceeded in 24 samples, but the proposed Alternate Maximum Contaminant Level (ACML) of 4,000 pCi/L was not exceeded in any sample. The AMCL is the proposed allowable concentration of radon in a raw-water sample from a drinking-water system that has programs to address the health risks of radon in indoor air, but none of the 33 wells sampled had such a system. The proposed MCL and AMCL for radon are under review and have not been adopted (U.S. Environmental Protection Agency, 2004).

Pesticides

Fifteen pesticides including three pesticide degradates were detected in water from 20 of the 33 wells (table 6). Most (17) of the samples containing pesticides were from sand and gravel aquifers; the other three samples were from bedrock aquifers. Caffeine, which is not a pesticide but is included in table 6 because it is measured as part of the pesticide analyses, was detected at trace levels in 22 samples. The pesticide compounds that were detected most frequently were the herbicides atrazine, deethylatrazine (a degradation product of atrazine), alachlor ESA (the ethanesulfonic acid degradate of alachlor), and metolachlor ESA and metolachlor OA (the ethanesulfonic acid and oxanilic acid degradation products of metolachlor). Atrazine was detected in five samples; the concentrations ranged from 0.003 to 0.095 $\mu\text{g}/\text{L}$ and did not exceed the MCL of 3 $\mu\text{g}/\text{L}$ (U.S. Environmental Protection Agency, 1996). Deethylatrazine (2-chloro-4-isopropylamino-6-amino-*s*-triazine) was detected in 11 samples at concentrations ranging from 0.003 to 0.051 $\mu\text{g}/\text{L}$. Alachlor ESA was detected in 11 samples at concentrations ranging from 0.02 to 0.16 $\mu\text{g}/\text{L}$. Metolachlor ESA was detected in 14 samples at concentrations ranging from 0.06 to 2.91 $\mu\text{g}/\text{L}$, and Metolachlor OA was detected in 7 samples at concentrations ranging from 0.02 to 0.29 $\mu\text{g}/\text{L}$. No Federal MCLs currently have been established for deethylatrazine, alachlor ESA, metolachlor ESA, or metolachlor OA, and no pesticide concentration exceeded the New York State MCL of 50 $\mu\text{g}/\text{L}$ (New York State, 1998a). These findings are similar to those reported by Eckhardt and

others (2001) and Phillips and others (1999) from studies of pesticides in ground water throughout New York State.

Volatile Organic Compounds

Volatile organic compounds (VOCs) were detected in 11 samples (table 7), and none of the concentrations exceeded MCLs. The compound 1,1,1-trichloroethane was detected in five samples, and *cis*-1,2-dichloroethene and trichloroethene were detected in four samples; no MCLs have yet been established for these compounds. Methyl *tert*-butyl ether (MTBE), a gasoline additive that can infiltrate into ground water from leaking fuel tanks, was not detected in any sample. No MCL has been established for MTBE, although the USEPA has suggested a limit of 20 to 40 µg/L on the basis of taste and odor of drinking water (U.S. Environmental Protection Agency, 1996).

Bacteria

All samples were analyzed for total coliform, fecal coliform, and *Escherichia coli* (*E. coli*) (table 8). Total coliform was detected in six samples, and fecal coliform in one sample; *E. coli* was not detected in any sample. Any detection of total coliform or fecal coliform is considered a violation of New York State health regulations. Bacteria were detected in samples from sand and gravel and bedrock aquifers. Most of the production wells have chlorination systems that eliminate bacteria before the water is distributed to consumers, but private residential wells are generally not chlorinated. The results of this study indicate that some residential wells may contain high concentrations of bacteria.

Summary

In 2001, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Environmental Protection Agency (USEPA), initiated an assessment of ground-water quality in river basins throughout the State. Water samples collected from 33 private and production wells throughout the upper Susquehanna River Basin in the fall of 2004 and the spring of 2005 were analyzed for physical properties, nutrients, inorganic constituents, metals, radionuclides, VOCs, pesticides, and bacteria. Of the 75 constituents that were detected, several exceeded Federal MCLs, SMCLs, and AMCLs.

The cations that were detected in the highest concentrations were calcium, magnesium, and sodium; the anions that were detected in the highest concentrations were bicarbonate, chloride, and sulfate. The predominant nutrient

was nitrate. The SMCL for chloride was exceeded in two samples; the sodium Drinking Water Advisory was exceeded in six samples; the sulfate SMCL was exceeded in one sample; and the MCL for nitrate was exceeded in one sample.

The metals detected in the highest concentrations were barium, boron, iron, manganese, strontium, and lithium. The MCL for barium was exceeded in 1 sample; the SMCL for iron was exceeded in 5 samples; and the SMCL for manganese was exceeded in 14 samples. Uranium was detected in every sample, but no detections exceeded the MCL. Arsenic was detected in 7 samples, and the MCL for arsenic (10 µg/L) was exceeded in 2 samples; lead was detected in 32 samples, but the MCL (15 µg/L) was not exceeded. Radon also was detected in every sample; the proposed MCL for radon-222 in drinking water was exceeded in 24 samples, but the proposed AMCL was not exceeded in any sample.

Of the 15 pesticides or pesticide degradates detected during this study, those detected most frequently were atrazine, deethylatrazine, alachlor ESA, metolachlor ESA, and metolachlor OA. The pesticide compounds detected at the highest concentrations were Metolachlor ESA and OA. Most (17) of the samples containing pesticides were from sand and gravel aquifers; the other three samples were from bedrock aquifers. No pesticide concentrations exceeded Federal or New York State MCLs, although Federal MCLs have not been established for deethylatrazine, alachlor ESA, metolachlor ESA, or metolachlor OA.

VOCs were detected in 11 samples; most of the concentrations were at or near the detection limits, and no concentration exceeded an MCL. Bacteria were detected in water from bedrock as well as sand and gravel aquifers—total coliform was detected in six samples and fecal coliform was detected in one sample, but *E. coli* was not detected in any sample.

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Tables 1–8

Table 1. Well information and physical properties of ground-water samples from selected wells in the upper Susquehanna River Basin, New York, 2004–05.

[mi, mile; mg/L, milligrams per liter; °C, degrees Celsius; µS/cm, microSiemens per centimeter at 25° C; 00080, USGS National Water Information System (NWIS) parameter code; --, sample lost at lab; UNK, unknown.; <, less than. Well locations are shown in figure 1]

Well number ¹	Well data						Water data					
	Type: P, public supply R, private residential	Location: U, uplands; V, valley flat	Aquifer: SG, sand and gravel; B, bedrock	Depth (feet below land surface)	Casing depth (feet below land surface)	Land-use percentages within 0.5-mi radius of well: (f, forested; u, urban; a, agricultural)	Sample date	Water color, filtered, (platinum cobalt units) (00080)	Dissolved-oxygen concentration, unfiltered (mg/L) (00300)	pH, field, unfiltered, (standard units) (00400)	Specific conductance, unfiltered, field (µS/cm) (00095)	Temperature (°C) (00010)
TI 401	R	V	SG	59	59	51a 39f 10u	10/06/2004	2	0.6	7.7	373	11.6
TI 461	R	V	SG	39	39	76a 21f 3u	10/07/2004	2	7.2	7.6	702	10.9
OG 310	P	V	SG	32	26	71a 17u 12f	10/12/2004	5	22.0	8.5	650	10.5
TI 351	R	U	SG	37	37	75f 25a	10/14/2004	5	3.6	7.7	298	11.9
OE 2001	R	V	B	175	65	63a 21u 15f	10/14/2004	2	2.7	8.2	2,140	10.1
OG 504	R	U	B	109	57	64f 35a	10/13/2004	10	.3	8.6	307	9.6
OG 846	R	U	B	230	34	51a 49f	11/08/2004	<1	3.5	8.8	455	9.5
CN 1126	R	U	B	299	162	98f 2a	11/08/2004	<1	3.8	9.1	288	9.8
CN 1341	R	U	SG	131	131	48f 48a 4u	11/09/2004	<1	3.9	8.9	408	9.4
OG 788	R	U	B	119	59.5	58f 41a	12/01/2004	--	.6	8.9	308	8.3
OG 311	P	V	SG	77	62	49a 34f 13u	11/30/2004	<1	2.3	7.9	245	9.4
D 501	P	V	SG	95	75	48u 31f 18a	11/30/2004	<1	5.9	7.9	392	11.8
BM 1080	R	V	B	249	101	49a 32f 14u	12/01/2004	--	.6	8.9	1,060	10.0
OG 6	P	V	SG	108	90	17f 29u 21a	12/14/2004	<1	2.3	8.0	566	10.5
CN 898	P	V	SG	133	123	44a 31f 19u	12/15/2004	<1	1.6	8.0	246	9.9
M 288	P	V	SG	58	52	45a 42f 12u	02/17/2005	8	5.8	8.0	702	10.0
CN 869	P	V	SG	233	204	48u 27f 24a	02/16/2005	5	6.3	8.4	477	10.1
CN 44	P	V	SG	172	162	28a 25f 20u	02/16/2005	8	4.0	8.5	494	9.4
BM 208	P	V	SG	101	66	51u 28f 4a	02/15/2005	5	4.9	7.9	1,030	11.3
BM 90	P	V	SG	145	UNK	59u 14f 12a	02/23/2005	25	7.2	7.6	969	11.8
BM 220	P	V	SG	51	36	63u 21f 4a	02/23/2005	8	7.4	7.4	1,310	12.9
C 317	P	V	SG	68	UNK	63u 25f 12a	03/09/2005	2	8.2	7.6	581	7.6
BM 375	P	V	SG	25	20	39u 36f 23a	03/09/2005	2	6.9	7.1	1,010	8.4
M 595	R	U	B	358	63	79f 20a	03/08/2005	2	6.5	8.6	1,330	8.4
M 289	P	V	SG	130	100	53a 39f 7u	03/08/2005	2	3.3	7.6	376	6.6
OD 8	P	V	SG	79	66	74a 19u 7f	03/02/2005	2	6.8	7.9	822	10.1
C 355	P	V	SG	63	49	43u 33f 25a	03/02/2005	5	9.2	8.1	516	7.1
TI 425	R	U	B	55	55	64f 36a	03/15/2005	2	3.9	7.6	255	7.2
BM 330	P	V	SG	41	32	58f 21a 9u	03/17/2005	2	7.2	7.4	546	9.7
C 452	P	V	SG	28	21	41f 37u 22a	03/16/2005	2	7.8	7.3	598	5.7
OD 1163	R	V	SG	29	29	35f 18a 8u	03/22/2005	30	2.1	8.4	346	7.9
C 226	P	V	SG	38	32	89a 7u 3f	03/30/2005	2	8.8	8.5	603	8.8
C 239	P	V	SG	59	42	81a 11u 8f	03/30/2005	2	5.4	7.6	411	7.7

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

Table 2. Constituents for which ground-water samples from the upper Susquehanna River Basin, New York, were analyzed but not detected.

[01012, USGS National Water Information System (NWIS) parameter code]

Elements	<i>trans</i> -1,2-Dichloroethene 34546	Methomyl 49296
Beryllium 01012	Dichloromethane 34423	Methyl <i>tert</i> -butyl ether 78032
Silver 01077	Dichloroprop 49302	Methyl <i>tert</i> -pentyl ether 50005
Thallium 01059	1,2-Dichloropropane 34541	Metsulfuron 61697
Organic Compounds	Dieldrin 39381	<i>N</i> -4-Chlorophenyl- <i>N'</i> -methylurea 61692
Acetochlor 49260	2,6-Diethylaniline 82660	Napropamide 82684
Acifluorfen 49315	Diethyl ether 81576	Neburon 49294
Aldicarb 49312	Diisopropyl ether 81577	Nicosulfuron 50364
Aldicarb sulfone 49313	Dimethenamid ESA 61951	Norflurazon 49293
Aldicarb sulfoxide 49314	Dimethenamid OXA 62482	Oryzalin 49292
Azinphos-methyl 82686	Dinoseb 49301	Oxamyl 38866
Bendiocarb 50299	Diphenamid 04033	Parathion 39542
Benfluralin 82673	Disulfoton 82677	Pebulate 82669
Benomyl 50300	Diuron 49300	Pendimethalin 82683
Bensulfuron 61693	EPTC 82668	<i>cis</i> -Permethrin 82687
Bentazon 38711	Ethalfuralin 82663	Phorate 82664
Benzene 34030	Ethoprop 82672	Picloram 49291
Bromacil 04029	Ethylbenzene 34371	Prometon 04037
Bromoxynil 49311	Fenuron 49267	Propachlor 04024
Butylate 04028	Fipronil 62166	Propachlor ESA 62766
<i>tert</i> -Butyl ethyl ether 50004	Fipronil sulfide 62167	Propachlor OXA 62767
Carbaryl 49310	Fipronil sulfone 62168	Propanil 82679
Carbofuran 82674	Flufenacet ESA 61952	Propargite 82685
Chlorobenzene 34301	Flufenacet OXA 62483	Propham 49236
Chlorpyrifos 38933	Flumetsulam 61694	Propiconazole 50471
Cyanazine 04041	Fluometuron 38811	Propoxur 38538
2,4-D 39732	Fonofos 04095	Propyzamide 82676
2,4-DB 38746	<i>alpha</i> -HCH 34253	Siduron 38548
2,4-D methyl ester 50470	3-Hydroxycarbofuran 49308	Simazine 04035
Dacthal monoacid 49304	Imazaquin 50356	Sulfometuron 50337
DCPA 82682	Imazethapyr 50407	Styrene 77128
<i>p,p'</i> -DDE 34653	Imidacloprid 61695	Tebuthiuron 82670
Desulfinyl fipronil 62170	3-Ketocarbofuran 50295	Terbacil 82665
Desulfinyl fipronil amide 62169	Lindane 39341	Terbufos 82675
Diazinon 39572	Linuron 38478	Tetrachloromethane 32101
Dibromochloromethane 32105	Mathathion 39532	Thiobencarb 82681
Dicamba 38442	MCPA 38482	Triallate 82678
1,3-Dichlorobenzene 34566	MCPB 38487	Tribromomethane 32104
1,2-Dichlorobenzene 34536	Methyl parathion 82667	Trichlopyr 49235
1,4-Dichlorobenzene 34571	Metribuzin 82630	Trichlorofluoromethane 34488
Dichlorodifluoromethane 34668	Molinate 82671	1,1,2-Trichloro-1,2,2-trifluoroethane 77652
1,2-Dichloroethane 32103	Metalaxal 50359	Trifluralin 82661
1,1-Dichloroethene 34501	Methiocarb 38501	Xylenes 81551

Table 3. Concentrations of nutrients, total organic carbon, and total phenols in ground-water samples from upper Susquehanna River Basin, New York, 2004–05.

[mg/L, milligrams per liter; N, nitrogen; P, phosphorus; 00623, USGS National Water Information System (NWIS) parameter code. Well locations are shown in figure 1]

Well number ¹	Ammonia plus organic nitrogen, filtered (mg/L as N) (00623)	Ammonia, filtered, (mg/L as N) (00608)	Nitrite plus nitrate, filtered, (mg/L as N) (00631)	Nitrite, filtered, (mg/L as N) (00613)	Nitrate, filtered, (mg/L) (00618)	Orthophosphate, filtered, (mg/L as P) (00671)	Total organic carbon, unfiltered, (mg/L) (00680)	Phenols, total recoverable, unfiltered (mg/L) (46002)
TI 401	<0.10	² E.02	<0.06	<0.008	<0.06	0.12	<1.00	<.0050
TI 461	E.05	<0.04	9.84	<.008	9.84	<0.02	1.37	0.0080
OG 310	0.25	<.04	2.17	<.008	2.17	<.02	1.15	0.0060
TI 351	<.10	<.04	1.25	<.008	1.25	<.02	<1.00	0.0070
OE 2001	1.3	1.30	<.06	<.008	<.06	<.02	<1.00	0.0100
OG 504	<.10	0.06	<.06	<.008	<.06	<.02	<1.00	<.0050
OG 846	0.22	0.16	E.05	E.005	E.045	0.02	<1.00	<.0050
CN 1126	<.10	<.04	<.06	<.008	<.06	<.02	<1.00	<.0050
CN 1341	0.14	0.10	<.06	<.008	<.06	<.02	<1.00	<.0050
OG 788	0.10	0.07	<.06	<.008	<.06	0.02	<1.00	0.0200
OG 311	<.10	<.04	0.51	<.008	0.51	<.02	<1.00	0.0160
D 501	E.05	<.04	1.04	<.008	1.04	<0.02	1.13	<.0050
BM 1080	0.37	0.36	<.06	<.008	<.06	0.09	<1.00	<.0050
OG 6	<.10	E.02	3.89	<.008	3.89	<.02	<1.00	<.0050
CN 898	E.09	E.04	<.06	<.008	<.06	E.01	<1.00	<.0050
M 288	E.08	<.04	3.91	<.008	3.91	<.02	1.09	<.0050
CN 869	E.07	E.04	<.06	<.008	<.06	<.02	<1.00	<.0050
CN 44	<.10	0.05	2.23	<.008	2.23	<.02	<1.00	<.0050
BM 208	E.07	<.04	1.17	<.008	1.17	<.02	1.23	0.0100
BM 90	0.26	0.25	<.06	<.008	<.06	-- ³	1.46	<.0050
BM 220	E.08	<.04	4.39	<.008	4.39	<.02	1.41	<.0050
C 317	E.06	<.04	3.30	<.008	3.30	<.02	1.25	<.0050
BM 375	E.05	<.04	3.36	<.008	3.36	<.02	1.50	<.0050
M 595	0.36	0.34	<.06	<.008	<.06	0.02	<1.00	<.0050
M 289	E.09	E.02	<.06	<.008	<.06	<.02	<1.00	<.0050
OD 8	E.08	<.04	2.82	<.008	2.82	<.02	1.09	<.0050
C 355	0.12	<.04	1.75	<.008	1.75	<.02	<1.00	<.0050
TI 425	<.10	<.04	0.38	E.006	0.37	<.02	<1.00	<.0050
BM 330	<.10	<.04	0.73	<.008	0.73	<.02	<1.00	0.0067
C 452	E.06	<.04	1.53	<.008	1.53	<.02	1.02	0.0052
OD 1163	0.11	0.06	<.06	E.004	<.06	<.02	<1.00	0.0052
C 226	<.10	<.04	10.5	<.008	10.5	<.02	1.22	<.0050
C 239	E.06	<.04	3.83	<.008	3.83	<.02	<1.00	<.0050

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

² E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

³ --, no data

Table 4. Concentrations of inorganic constituents in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.

[Concentration in milligrams per liter (mg/L) for filtered samples, unless noted; 90410, USGS National Water Information System (NWIS) parameter code; °C, degrees Celsius; well locations are shown in figure 1]

Well number ¹	Acid-neutralizing capacity ² unfiltered (90410)	Alkalinity ³ filtered (29801)	Bicarbonate ³ filtered (29805)	Calcium filtered (00915)	Magnesium filtered (00925)	Potassium filtered (00935)	Sodium filtered (00930)	Chloride filtered (00940)	Fluoride filtered (00950)	Silica filtered (00955)	Sulfate filtered (00945)	Residue on evaporation, dried at 180 °C filtered (70300)
TI 401	151	151	184	39.3	8.0	0.46	26.5	28.1	0.2	7.63	1.0	205
TI 461	168	278	339	94.6	21.8	3.45	17.8	27.4	E0.1	9.56	19.2	394
OG 310	114	282	344	122	6.17	1.73	15.5	29.5	E.1	6.64	12.2	372
TI 351	128	127	155	47.5	7.01	0.48	8.22	4.89	0.2	10.2	19.0	179
OE 2001	117	190	232	254	162	6.60	85.4	24.0	0.9	12.2	1,120	1,890
OG 504	127	154	188	41.0	6.98	0.49	15.1	2.92	0.1	13.6	3.6	175
OG 846	147	146	174	13.0	2.38	0.50	76.8	50.6	0.4	8.07	2.4	251
CN 1126	124	148	175	38.6	9.07	0.87	12.0	0.55	E0.1	12.9	7.1	173
CN 1341	139	175	207	43.6	10.2	0.60	28.0	24.8	E0.1	13.3	2.4	229
OG 788	165	165	196	17.8	4.87	0.43	48.8	3.64	0.2	9.93	5.5	187
OG 311	94	94	115	35.5	3.89	0.73	7.68	10.7	E0.1	9.80	10.5	136
D 501	122	129	157	59.7	4.25	1.02	12.7	30.5	E0.1	8.46	16.6	221
BM 1080	141	138	162	30.2	5.77	1.86	275	408	0.3	7.66	2.2	813
OG 6	159	203	248	87.3	7.48	2.00	21.5	39.5	E0.1	9.28	17.5	325
CN 898	114	113	138	38.4	4.27	0.70	8.47	6.55	0.2	12.4	9.4	148
M 288	199	237	289	101	10.7	1.41	30.9	60.8	E0.1	8.28	23.8	394
CN 869	147	147	179	57.3	11.6	1.04	21.7	43.6	0.1	10.7	25.9	260
CN 44	177	177	216	71.4	14.5	0.83	9.77	31.9	E0.1	9.74	20.9	274
BM 208	228	231	282	107	18.4	2.03	83.7	173	E0.1	8.87	42.6	586
BM 90	258	258	315	126	19.9	2.00	53.7	140	E0.1	11.2	33.9	546
BM 220	283	283	345	114	20.1	5.00	136	222	0.1	9.17	32.1	739
C 317	198	198	242	77.1	14.0	0.98	23.0	44.6	<0.1	7.49	14.3	295
BM 375	254	254	310	104	14.7	1.29	85.6	144	E0.1	7.34	17.2	518
M 595	188	197	240	32.1	4.83	0.65	23.4	297	0.8	8.40	3.2	705
M 289	168	168	205	59.5	12.0	0.54	2.49	2.05	E0.1	10.6	22.9	204
OD 8	254	254	310	100	18.9	2.71	49.3	102	E0.1	6.80	16.6	434
C 355	184	184	224	62.5	10.7	1.27	35.2	45.9	<.1	6.58	12.0	280
TI 425	105	105	128	33.6	5.94	0.56	10.9	5.09	0.1	9.13	15.7	140
BM 330	182	182	222	75.4	15.3	0.90	22.6	50.1	E0.1	9.56	32.7	307
C 452	139	139	170	60.4	9.10	1.97	50.7	92.1	E0.1	5.33	12.1	314
OD 1163	170	170	207	51.2	15.1	0.63	5.12	7.91	E0.1	6.28	10.2	193
C 226	239	256	312	92.1	24.4	1.01	7.85	11.1	<0.1	7.57	16.2	358
C 239	166	166	203	56.9	14.3	1.00	10.9	15.6	E0.1	6.37	10.2	238

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.² fixed-endpoint (pH 4.5) titration on unfiltered samples; (mg/L as CaCO₃).³ fixed-endpoint (pH 4.5) titration on filtered samples; (mg/L as CaCO₃).⁴ fixed-endpoint (pH 4.5) titration on filtered samples; (mg/L as HCO₃⁻¹)

E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

Table 5. Concentrations of metals and radionuclides in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.

[All values are in micrograms per liter except as noted; 01105, USGS National Water Information System (NWIS) parameter code; >, less than. Well locations are shown in figure 1]

Well number ¹	Aluminum, unfiltered, recoverable (01105)	Arsenic, unfiltered, recoverable (01002)	Barium, unfiltered, recoverable (01007)	Boron, filtered (01020)	Cadmium, unfiltered (01027)	Chromium, unfiltered, recoverable (01034)	Cobalt, unfiltered, recoverable (01037)	Copper, unfiltered, recoverable (01042)	Iron, filtered (01046)	Iron, unfiltered, recoverable (01045)	Lead, unfiltered, recoverable (01051)	Lithium, unfiltered, recoverable (01132)
TI 401	3	27	277	21	<.04	E.4	0.151	0.7	898	840	0.10	3.8
TI 461	<2	<2	166	18	<.04	<.8	0.425	3.3	<6	<6	0.38	4.8
OG 310	² E1	<2	137	28	<.04	<.8	0.385	11.2	<6	<6	0.38	4.0
TI 351	E1	<2	6	20	<.04	<.8	0.177	13.3	12	210	0.22	3.0
OE 2001	E2	<2	42	1,730	<.04	<.8	1.22	10.3	10	30	<.06	503
OG 504	E2	<2	55	118	<.04	<.8	0.145	E.3	303	350	E.05	14.2
OG 846	11	<2	48	489	<.04	<.8	0.066	1.8	6	50	0.14	132
CN 1126	E1	E1	206	39	<.04	E.4	0.381	1.5	16	190	1.46	13.8
CN 1341	E2	E1	222	101	<.04	<.8	0.218	E.5	407	410	0.21	20.9
OG 788	3	<2	125	244	<.04	<.8	0.080	3.0	45	170	0.78	38.0
OG 311	E1	<2	10	15	<.04	<.8	0.124	6.0	<6	<6	6.19	3.5
D 501	E2	<2	121	15	<.04	<.8	0.197	1.6	<6	<6	E.05	4.0
BM 1080	35	19	2,220	180	0.42	E.6	0.164	3.6	<6	440	0.33	544
OG 6	2	<2	109	43	<.04	1.5	0.481	1.6	<6	M ³	0.08	3.2
CN 898	E1	E1	105	25	<.04	2.2	0.193	1.8	E3	10	0.09	5.0
M 288	<2	<2	107	43	<.04	<.8	0.387	1.4	<6	<6	0.91	12.0
CN 869	E1	<2	101	21	<.04	<.8	0.237	1.0	12	10	0.55	7.2
CN 44	4	<2	130	15	<.04	E.5	0.292	3.6	<6	10	0.27	13.0
BM 208	<2	<2	79	38	<.04	E.7	0.398	2.4	<6	M	0.26	7.8
BM 90	E1	7	508	47	<.04	<.8	0.507	7.5	1,230	1,150	E.04	10.8
BM 220	E1	<2	99	70	<.04	E.5	0.560	3.0	<6	M	0.12	12.9
C 317	<2	<2	36	16	<.04	E.5	0.288	8.8	E4	<6	E.04	3.5
BM 375	<2	<2	61	31	<.04	<.8	0.354	2.0	<6	<6	0.07	1.0
M 595	13	<2	1,420	624	<.04	E.5	0.110	2.6	<6	240	0.31	425
M 289	<2	E2	118	14	<.04	<.8	0.214	1.9	55	70	0.10	6.2
OD 8	E1	<2	115	28	<.04	E.4	0.444	2.8	<6	<6	1.04	4.3
C 355	E1	<2	29	13	<.04	E.6	0.272	34.3	<6	<6	E.05	3.3
TI 425	E2	<2	59	32	E.04	<.8	0.146	1.5	<6	M	0.19	4.5
BM 330	<2	<2	60	10	<.04	E.4	0.305	1.9	16	40	0.31	5.7
C 452	<2	<2	64	16	<.04	E.4	0.277	2.3	<6	<6	0.08	1.1
OD 1163	E1	<2	163	8.5	<.04	<.8	0.292	1.4	1,130	5,270	<.06	3.5
C 226	6	<2	171	17	<.04	E.6	0.434	2.8	<6	20	0.18	3.3
C 239	E2	<2	67	12	<.04	E.5	0.263	4.7	E3	10	0.68	1.9

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

² E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

³ M, constituent was detected in the sample but was not quantified.

Table 5. Concentrations of metals and radionuclides in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.—Continued

Well number ¹	Manganese, filtered (01056)	Manganese, unfiltered, recoverable (01055)	Mercury, unfiltered, recoverable (71900)	Molybdenum, unfiltered, recoverable (01062)	Nickel, unfiltered, recoverable (01067)	Selenium, unfiltered (01147)	Strontium, unfiltered, recoverable (01082)	Radon-222, unfiltered, (picocuries per liter) (82303)	Antimony unfiltered (01097)	Uranium (natural), unfiltered (28011)	Zinc, unfiltered, recoverable (01092)
TI 401	410	408	<.01	1.6	0.46	<.4	227	1,000	<.2	E0.007	E1
TI 461	<.6	<.6	<.01	E.2	1.83	<.4	120	750	<.2	0.344	3
OG 310	<.6	<.6	<.01	0.3	1.85	0.5	276	660	<.2	0.393	E2
TI 351	0.8	1.1	<.01	<.2	1.76	0.5	44.5	1,290	<.2	0.157	8
OE 2001	16.5	14.8	<.01	0.3	4.67	5.1	11,600	60	<.2	0.386	4
OG 504	138	134	<.01	0.5	0.61	E.4	281	280	<.2	0.088	7
OG 846	41.1	37.6	<.01	0.2	0.55	0.8	322	110	<.2	0.018	E1
CN 1126	134	110	<.01	0.5	0.93	<.4	250	1,490	<.2	0.256	3
CN 1341	148	129	<.01	E.2	0.78	0.7	945	210	<.2	0.149	13
OG 788	51.5	46.0	E.01	0.3	0.44	<.4	281	640	<.2	0.015	4
OG 311	59.4	52.0	E.01	0.6	0.36	<.4	134	630	<.2	0.375	E2
D 501	360	343	<.01	E.1	0.46	0.5	93.1	1,050	E.1	0.388	E1
BM 1080	190	159	E.01	2.5	2.23	7.4	2,140	430	<.2	0.042	E2
OG 6	<.6	<.6	E.01	<.2	1.26	0.5	117	1,180	<.2	0.182	E1
CN 898	444	420	<.01	0.5	0.70	E.3	161	430	<.2	0.783	3
M 288	2.1	2.0	<.01	<.2	2.93	<.4	199	700	<.2	0.544	12
CN 869	264	260	<.01	0.4	0.82	0.5	381	180	<.2	0.600	<.2
CN 44	15.3	32.3	E.01	0.3	1.00	0.5	104	660	0.2	0.832	3
BM 208	E.4	<.6	<.01	0.5	1.45	0.9	177	730	<.2	0.305	6
BM 90	969	975	<.01	0.4	2.45	0.6	340	290	<.2	0.869	19
BM 220	<.6	<.6	<.01	E.1	2.82	1.2	215	560	<.2	0.301	E1
C 317	<.6	<.6	E.01	E.1	0.84	E.4	103	650	<.2	0.212	<.2
BM 375	0.6	² E.5	<.01	<.2	1.05	0.6	127	840	<.2	0.505	5
M 595	62.1	59.5	<.01	0.5	0.53	3.0	2,400	90	<.2	0.033	E2
M 289	157	143	<.01	0.5	0.56	E.3	130	120	<.2	0.709	E2
OD 8	1.1	0.9	<.01	E.2	3.50	0.9	478	480	<.2	0.246	E1
C 355	<.6	<.6	<.01	<.2	1.98	0.5	81.4	640	<.2	0.097	2
TI 425	156	170	0.02	0.2	0.38	<.4	87.7	1,040	<.2	0.307	9
BM 330	E.4	E.4	<.01	E.1	0.76	0.5	98.5	700	<.2	0.291	9
C 452	14.4	18.8	E.01	E.1	1.11	0.6	104	850	<.2	0.183	4
OD 1163	49.0	63.4	<.01	0.5	0.80	0.5	65.9	60	<.2	0.314	E1
C 226	<.6	E.3	<.01	<.2	0.84	<.4	95.4	380	<.2	0.221	<.2
C 239	<.6	<.6	0.02	<.2	0.70	<.4	65.7	410	<.2	0.105	4

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

² E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

³ M, constituent was detected in the sample but was not quantified.

Table 6. Concentrations of pesticides detected in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.

[04040, USGS National Water Information System (NWIS) parameter code. All concentrations are in micrograms per liter for filtered samples. Dashes (--) indicate no data. Well locations are shown in figure 1]

Well number ¹	2-Chloro-4-isopropyl-amino-6-amino-s-triazine (04040)	2-Chloro-6-ethyl-amino-4-amino-s-triazine (04038)	2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine (50355)	Alachlor (46342)	Atrazine (39632)	Caffeine (50305)	Chloro-diamino-s-triazine (04039)	Metolachlor (39415)
TI 401	<.006	<.08	<.032	<.004	<.007	E.0050	<.04	<.013
TI 461	² E.007	<.08	<.032	<.004	E.006	<.0180	E.01	<.013
OG 310	E.005	<.08	<.032	<.004	<.007	E.0100	<.04	<.013
TI 351	<.006	<.08	<.032	<.004	<.007	<.0180	<.04	<.013
OE 2001	<.006	<.08	<.032	<.004	<.007	E.0061	<.04	<.013
OG 504	<.006	<.08	<.032	<.004	<.007	E.0090	<.04	<.013
OG 846	<.006	<.08	<.032	<.004	<.007	<.0180	<.04	<.013
CN 1126	<.006	<.08	<.032	<.004	<.007	<.0180	<.04	<.013
CN 1341	<.006	<.08	<.032	<.004	<.007	E.0084	<.04	<.013
OG 788	<.006	<.08	<.032	<.004	<.007	E.0099	<.04	<.013
OG 311	<.006	<.08	<.032	<.004	<.007	E.0063	<.04	<.013
D 501	E.004	<.08	<.032	<.004	E.005	0.0282	<.04	<.013
BM 1080	<.006	<.08	<.032	<.004	<.007	<.0180	<.04	<.013
OG 6	E.003	<.08	<.032	<.004	<.007	E.006	<.04	<.013
CN 898	<.006	<.08	<.032	<.004	<.007	E.005	<.04	<.013
M 288	E.051	E.01	E.006	0.120	0.095	E.0106	<.04	0.517
CN 869	<.006	<.08	<.032	<.004	<.007	<.0180	<.04	<.013
CN 44	<.006	<.08	<.032	<.004	<.007	E.0131	<.04	<.013
BM 208	E.003	<.08	<.032	<.004	E.003	E.0101	<.04	<.013
BM 90	<.006	<.08	<.032	<.004	<.007	E.0118	<.04	<.013
BM 220	E.003	<.08	<.032	<.004	<.007	E.0168	<.04	<.013
C 317	E.012	<.08	<.032	<.005	<.007	<.020	<.04	<.006
BM 375	<.006	<.08	<.032	<.005	<.007	E.004	<.04	<.006
M 595	<.006	<.08	<.032	<.005	<.007	E.0069	<.04	<.006
M 289	<.006	<.08	<.032	<.005	<.007	E.0088	<.04	<.006
OD 8	E.004	<.08	<.032	<.004	<.007	<.0180	<.04	0.131
C 355	E.013	<.08	<.032	<.004	E.006	<.0180	<.04	<.013
TI 425	<.006	<.08	<.032	<.005	<.007	E.013	<.04	<.006
BM 330	<.006	<.08	<.032	<.005	<.007	E.006	<.04	<.006
C 452	E.005	<.08	<.032	<.005	<.007	E.017	<.04	<.006
OD 1163	<.006	<.08	<.032	<.005	<.007	<.0180	<.04	<.006
C 226	<.006	<.08	<.032	<.005	<.007	E.015	<.04	<.006
C 239	<.006	<.08	<.032	<.005	<.007	<.0180	<.04	<.006

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

² E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

³ M, constituent was detected in the sample but was not quantified.

Table 6. Concentrations of pesticides detected in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.—Continued

Well number ¹	Dinoseb (49301)	Acetochlor ESA (61029)	Alachlor ESA (50009)	Alachlor OA (61031)	Metolcahlor ESA (61043)	Metolachlor OA (61044)	Acetochlor/ Metolachlor ESA - 2 nd Amide (62850)	Hydroxy- alachlor (63783)
TI 401	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
TI 461	<.04	<.02	<.02	<.02	0.78	0.06	0.06	--
OG 310	<.04	<.02	<.02	<.02	0.06	<.02	<.02	--
TI 351	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OE 2001	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OG 504	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OG 846	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
CN 1126	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
CN 1341	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OG 788	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OG 311	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
D 501	<.04	<.02	<.02	<.02	0.09	<.02	<.02	--
BM 1080	<.04	<.02	<.02	<.02	<.02	<.02	<.02	--
OG 6	<.04	<.02	<.02	<.02	0.06	<.02	<.02	<.02
CN 898	<.04	<.02	<.02	<.02	<.02	<.02	<.02	<.02
M 288	M ³	<.02	0.02	0.16	0.10	0.12	<.02	0.03
CN 869	<.04	<.02	<.02	<.02	<.02	<.02	<.02	<.02
CN 44	<.04	<.02	<.02	<.02	0.10	<.02	<.02	<.02
BM 208	<.04	<.02	<.02	<.02	<.02	<.02	<.02	<.02
BM 90	<.04	<.02	<.02	<.02	<.02	<.02	<.02	<.02
BM 220	<.04	<.02	<.02	<.02	0.15	0.02	<.02	<.02
C 317	<.04	<.02	0.04	<.02	2.91	0.03	<.02	<.02
BM 375	<.04	0.08	0.09	<.02	<.02	<.02	<.02	<.02
M 595	<.04	<.02	0.06	<.02	<.02	<.02	<.02	<.02
M 289	<.04	<.02	0.04	<.02	<.02	<.02	<.02	<.02
OD 8	<.04	<.02	0.07	<.02	0.39	0.29	<.02	<.02
C 355	<.04	<.02	0.09	<.02	0.38	<.02	<.02	<.02
TI 425	<.04	<.02	0.04	<.02	0.07	<.02	<.02	<.02
BM 330	<.04	<.02	0.16	<.02	<.02	<.02	<.02	<.02
C 452	<.04	<.02	0.04	<.02	0.57	0.04	<.02	<.02
OD 1163	<.04	<.02	<.02	<.02	<.02	<.02	<.02	<.02
C 226	<.04	<.02	0.02	<.02	2.46	0.04	0.05	<.02
C 239	<.04	<.02	<.02	<.02	1.13	<.02	<.02	<.02

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

² E, estimated value; constituent was detected in the sample but with low or inconsistent recovery.

³ M, constituent was detected in the sample but was not quantified.

Table 7. Concentrations of volatile organic compounds in ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.

[34506, USGS National Water Information System (NWIS) parameter code. All values are in micrograms per liter for unfiltered samples. Well locations are shown in figure 1]

Well number ¹	1,1,1-Trichloroethane (34506)	1,1-Dichloroethane (34496)	Bromo-dichloromethane (32101)	<i>cis</i> -1,2-Dichloroethene (77093)	Dibromo-chloromethane (32015)	Methyl <i>tert</i> -butyl ether (78032)	Tetrachloroethene (34475)	Vinyl chloride (39175)	Trichloroethene (39180)	Trichloromethane (32106)	Toluene (34010)	Tetrachloromethane (32102)
TI 401	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	0.1	<.2
TI 461	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 310	<.1	<.1	0.2	<.1	<.2	<.2	<.1	<.2	<.1	0.2	<.1	<.2
TI 351	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OE 2001	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 504	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 846	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
CN 1126	<.1	<.1	<.1	<.1	<.2	<.2	0.1	<.2	<.1	<.1	<.1	<.2
CN 1341	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 788	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 311	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
D 501	<.1	<.1	<.1	1.9	<.2	<.2	<.1	<.2	2.0	<.1	<.1	<.2
BM 1080	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OG 6	0.7	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
CN 898	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
M 288	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
CN 869	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
CN 44	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
BM 208	0.9	0.2	<.1	0.4	<.2	<.2	<.1	<.2	0.8	<.1	<.1	<.2
BM 90	0.1	1.2	<.1	2.5	<.2	<.2	<.1	0.4	<.1	<.1	<.1	<.2
BM 220	0.2	0.4	0.1	0.3	<.2	<.2	<.1	<.2	0.6	0.9	<.1	<.2
C 317	0.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	0.1	<.1	<.1	<.2
BM 375	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
M 595	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	0.1	<.2
M 289	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OD 8	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	0.4
C 355	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
TI 425	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
BM 330	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
C 452	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
OD 1163	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2
C 226	<.1	<.1	0.3	<.1	0.2	<.2	<.1	<.2	<.1	0.2	<.1	<.2
C 239	<.1	<.1	<.1	<.1	<.2	<.2	<.1	<.2	<.1	<.1	<.1	<.2

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by U.S. Geological Survey.

Table 8. Concentrations of bacteria in unfiltered ground-water samples from the upper Susquehanna River Basin, New York, 2004–05.

[mL, milliliter; >, less than. Well locations are shown in figure 1]

Well number ¹	<i>Esherichia coli</i> (colonies per 100 mL)	Fecal coliform (colonies per 100 mL)	Standard plate count (colonies per mL)	Total coliform (colonies per 100 mL)
TI 401	<1	5	83	157
TI 461	<1	<5	<1	<1
OG 310	<1	<5	2	<1
TI 351	<1	<5	<1	<1
OE 2001	<1	<5	1	1
OG 504	<1	<5	<1	<1
OG 846	<1	<5	248	39
CN 1126	<1	<5	<1	<1
CN 1341	<1	<5	1	1
OG 788	<1	<5	1	<1
OG 311	<1	<5	<1	<1
D 501	<1	<5	<1	<1
BM 1080	<1	<5	<1	<1
OG 6	<1	<5	<1	<1
CN 898	<1	<5	<1	<1
M 288	<1	<5	1	<1
CN 869	<1	<5	<1	<1
CN 44	<1	<5	1	<1
BM 208	<1	<5	<1	<1
BM 90	<1	<5	<1	<1
BM 220	<1	<5	<1	<1
C 317	<1	<5	2	1
BM 375	<1	<5	2	18
M 595	<1	<5	<1	<1
M 289	<1	<5	<1	<1
OD 8	<1	<5	<1	<1
C 355	<1	<5	<1	<1
TI 425	<1	<5	1	<1
BM 330	<1	<5	<1	<1
C 452	<1	<5	<1	<1
OD 1163	<1	<5	<1	<1
C 226	<1	<5	<1	<1
C 239	<1	<5	<1	<1

¹ TI, Tioga County; CN, Chenango County; C, Cortland County; OG, Onondaga County; BM, Broome County; D, Delaware County; M, Madison County; OE, Otsego County; number is local well-identification number assigned by the U.S. Geological Survey.