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Prepared in cooperation with the
New York State Department of Environmental Conservation

Groundwater Quality in Central New York, 2012

Open-File Report 2014–1226

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

Cover. Along the Jim Schug Trail, Dryden, New York. Photograph by Megan Reddy, 2014, used with permission.

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2014

Suggested citation:
Reddy, J.E., 2014, Groundwater quality in central New York, 2012: U.S. Geological Survey Open-File Report 2014–1226, 13 p., *http://dx.doi.org/10.3133/ofr20141226*.

ISSN 2331-1258 (online)

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Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as
°F = (1.8 × °C) + 32.

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

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

Abbreviations

AMCL	alternative maximum contaminant level
CFCL	USGS Chlorofluorocarbon Laboratory
CFU/mL	colony-forming units per milliliter
EPA	U.S. Environmental Protection Agency
LRL	laboratory reporting level
LT–MDL	long-term method detection level
MCL	maximum contaminant level
NWQL	USGS National Water Quality Laboratory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health

Pt-Co units	platinum-cobalt units
QC	quality control
SDWS	secondary drinking-water standard
THM	trihalomethane
TNTC	too numerous to count
USGS	U.S. Geological Survey
VOC	volatile organic compound

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Abstract

Water samples were collected from 14 production wells and 15 private wells in central New York from August through December 2012 in a study conducted by the U.S. Geological Survey in cooperation with the New York State Department of Environmental Conservation. The samples were analyzed to characterize the groundwater quality in unconsolidated and bedrock aquifers in this area. Fifteen of the wells are finished in sand-and-gravel aquifers, and 14 are finished in bedrock aquifers. Six of the 29 wells were sampled in a previous central New York study, which was conducted in 2007. Water samples from the 2012 study were analyzed for 147 physiochemical properties and constituents, including major ions, nutrients, trace elements, radionuclides, pesticides, volatile organic compounds, dissolved gases (argon, carbon dioxide, methane, nitrogen, oxygen), and indicator bacteria. Results of the water-quality analyses are presented in tabular form for individual wells, and summary statistics for specific constituents are presented by aquifer type. The results are compared with Federal and New York State drinking-water standards, which typically are identical. The results indicate that the groundwater generally is of acceptable quality, although for all of the wells sampled, at least one of the following constituents was detected at a concentration that exceeded current or proposed Federal or New York State drinking-water standards: color (2 samples), pH (7 samples), sodium (9 samples), chloride (2 samples), fluoride (2 samples), sulfate (2 samples), dissolved solids (8 samples), aluminum (4 samples), arsenic (1 sample), iron (9 samples), manganese (13 samples), radon-222 (13 samples), total coliform bacteria (6 samples), and heterotrophic bacteria (2 samples). Drinking-water standards for nitrate, nitrite, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, gross alpha radioactivity, uranium, fecal coliform, and *Escherichia coli* were not exceeded in any of the samples collected. None of the pesticides or volatile organic compounds analyzed exceeded drinking-water standards. Methane was detected in 11 sand-and-gravel wells and 9 bedrock wells. Five of the 14 bedrock wells had water with methane concentrations approaching 10 mg/L; water in one bedrock well had 37 mg/L of methane.

Introduction

Section 305(b) of the Federal Clean Water Act Amendments of 1977 requires that States monitor and report biennially on the chemical quality of surface water and groundwater within State boundaries (U.S. Environmental Protection Agency, 1997). In 2002, the U.S. Geological Survey (USGS) developed a program in cooperation with the New York State Department of Environmental Conservation (NYSDEC) to evaluate groundwater quality throughout the major river basins in New York on a rotating basis. The program parallels the NYSDEC Rotating Intensive Basin Study Program, which evaluates surface-water quality in 2 or 3 of the 14 major river basins in the State each year. The groundwater-quality program began in 2002 with a pilot study in the Mohawk River Basin and has continued throughout upstate New York since then (table 1). Sampling completed in 2008 represented the conclusion of a first round of groundwater-quality sampling throughout New York State (excluding Long Island, which is monitored through county programs). Groundwater-quality sampling was conducted in 2012 in the Central Lake Ontario, Oneida River, Oswego River, and Seneca River Basins in central New York; these basins also were sampled in 2007 as part of the NYSDEC and USGS 305(b) groundwater program. This report presents the results of the 2012 groundwater study in central New York.

Groundwater characteristics are affected by the geology and the land use of the area. Shallow wells that tap sand-and-gravel aquifers are susceptible to contamination by several kinds of compounds, including deicing chemicals, nutrients, pesticides, and volatile organic compounds (VOCs) from agricultural, industrial, and residential areas, and upgradient highways. The movement of these contaminants to the water table through the soils and surficial sand and gravel can be relatively rapid. Bedrock wells that tap into sandstone and shale aquifers in rural upland areas generally are less susceptible to contamination from industrial and urban sources, which are mainly in the valleys, but bedrock wells in lowland areas underlain by carbonate bedrock (limestone and dolostone; Eckhardt and others, 2008) may be more vulnerable to contamination from surface runoff because infiltration rates and groundwater flow can be relatively rapid through bedrock solution features. Agricultural land upgradient of wells may be a potential source of contamination by fecal

Table 1. Previous groundwater-quality studies and reports for New York State.

Study area	Year	Report	Reference
Mohawk River Basin	2002	Water-Data Report NY–02–1	Butch and others, 2003
Chemung River Basin	2003	Open-File Report 2004–1329	Hetcher-Aguila, 2005
Lake Champlain Basin	2004	Open-File Report 2006–1088	Nystrom, 2006
Upper Susquehanna River Basin	2004–5	Open-File Report 2006–1161	Hetcher-Aguila and Eckhardt, 2006
Delaware River Basin	2005–6	Open-File Report 2007–1098	Nystrom, 2007b
Genesee River Basin	2005–6	Open-File Report 2007–1093	Eckhardt and others, 2007
St. Lawrence River Basin	2005–6	Open-File Report 2007–1066	Nystrom, 2007a
Mohawk River Basin	2006	Open-File Report 2008–1086	Nystrom, 2008
Western New York	2006	Open-File Report 2008–1140	Eckhardt and others, 2008
Central New York	2007	Open-File Report 2009–1257	Eckhardt and others, 2009
Upper Hudson River Basin	2007	Open-File Report 2009–1240	Nystrom, 2009
Eastern Lake Ontario Basin	2008	Open-File Report 2011–1074	Risen and Reddy, 2011a
Chemung River Basin	2008	Open-File Report 2011–1112	Risen and Reddy, 2011b
Lower Hudson River Basin	2008	Open-File Report 2010–1197	Nystrom, 2010
Lake Champlain Basin	2009	Open-File Report 2011–1180	Nystrom, 2011
Upper Susquehanna River Basin	2009	Open-File Report 2012–1045	Reddy and Risen, 2012
Delaware River Basin	2010	Open-File Report 2011–1320	Nystrom, 2012
St. Lawrence River Basin	2010	Open-File Report 2011–1320	Nystrom, 2012
Genesee River Basin	2010	Open-File Report 2012–1135	Reddy, 2012
Mohawk River Basin	2011	Open-File Report 2013–1021	Nystrom and Scott, 2013
Western New York	2011	Open-File Report 2013–1095	Reddy, 2013
Upper Hudson River Basin	2012	Open-File Report 2014–1084	Scott and Nystrom, 2014

waste from livestock, fertilizers, and pesticides; lawns and residential septic systems also are a potential source of these contaminants. In addition to anthropogenic contaminants, the aquifers contain naturally derived constituents that may diminish the quality of groundwater, such as arsenic, chloride, hydrogen sulfide, iron, manganese, methane, radon gas, sodium, and sulfate.

Purpose and Scope

This report supplements the water-quality study completed in 2007 for central New York (Eckhardt and others, 2009) and presents analytical results from the resampling of 6 of the production wells from that study (CY 10, CY 265, OW 454, OW 503, SY 402, and WN 593) and the sampling of 23 new wells (fig. 1). This report briefly describes the study area and the sampling methods and presents results of the water-quality analyses for the 29 wells sampled in 2012. Summary statistics of the number of samples exceeding Federal or State drinking-water standards and the minimum, median, and maximum concentrations of selected analytes in sand and gravel and bedrock aquifers are provided in tables 2 through 5; information on the sampled wells and detailed analytical results for all analytes are provided in the appendix (tables 1–1 through 1–9). A comparison of results for the 6 wells sampled in 2007 and 2012 is provided in the appendix (tables 1–10 through 1–13).

Study Area

The 5,799-square mile (mi^2) study area includes all or parts of 18 counties in central New York (fig. 1). It encompasses the Central Lake Ontario Basin (between Oswego and Rochester) and the Oswego River, Seneca River, and Oneida River Basins and contains Oneida Lake, Onondaga Lake, and the seven easternmost Finger Lakes (fig. 1). A complete description of the study area is included in Eckhardt and others (2009).

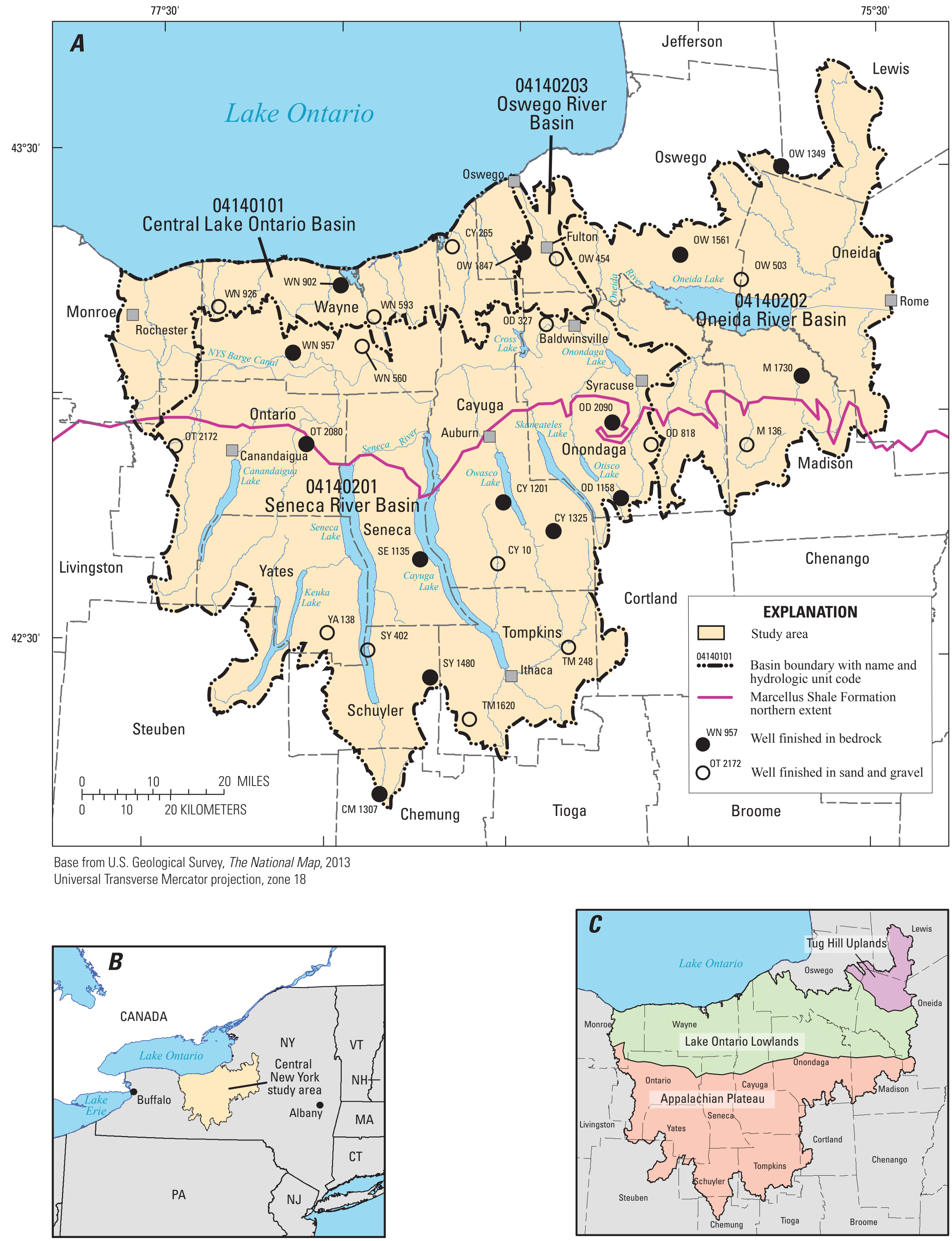

Figure 1. *A*, Pertinent geographic features of study area in central New York and locations of the 29 wells sampled in 2012, *B*, general location and *C*, physiographic features of the study area. Well data are listed in table 1–1. Well numbers are assigned by the U.S. Geological Survey; the one- or two-letter prefix denotes the county.

Table 2. Drinking-water standards and summary statistics for physiochemical properties of groundwater samples from central New York, 2012.

[All concentrations in milligrams per liter in filtered water except as noted. No., number; Pt-Co units, platinum-cobalt; µS/cm @ 25 °C, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; <, less than; --, not applicable]

Constituent	Drinking-water standard[1]	No. of samples exceeding standard	Sand-and-gravel aquifers (15 samples)			Bedrock aquifers (14 samples)		
			Minimum	Median	Maximum	Minimum	Median	Maximum
Color, filtered, Pt-Co units	15	2	<1	<1	18	<1	<1	300
pH	6.5–8.5	7	7.0	7.5	8.7	7.1	8.4	9.2
Specific conductance, unfiltered, µS/cm @ 25 °C	--	--	157	710	2,600	286	526	2,320
Temperature, °C	--	--	8.8	11.6	17.4	10.5	12.2	14.7

[1]U.S. Environmental Protection Agency secondary drinking water standard.

Table 3. Drinking-water standards and summary statistics for concentrations of major ions in groundwater samples from central New York, 2012.

[All concentrations in milligrams per liter in filtered water. No., number; $CaCO_3$, calcium carbonate; --, not applicable; <, less than; °C, degrees Celsius]

	Constituent	Drinking-water standard	No. of samples exceeding standard	Sand-and-gravel aquifers (15 samples)			Bedrock aquifers (14 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Cations	Calcium	--	--	17.1	88.0	158	1.92	35.4	485
	Magnesium	--	--	6.31	23.3	40.5	0.338	10.8	77.8
	Potassium	--	--	0.46	1.35	5.31	0.42	1.18	8.72
	Sodium	[1]60	9	1.42	17.9	308	2.67	60.5	259
Anions	Bicarbonate	--	--	88	316	473	143	254	529
	Chloride	[2,3]250	2	1.82	35.2	688	1.41	8.92	260
	Fluoride	[4]4.0 [3]2.2 [2]2.0	0 0 2	<0.04	0.08	0.22	<0.04	0.26	2.20
	Silica	--	--	6.30	9.57	13.1	7.04	9.90	15.8
	Sulfate	[2,3]250	2	0.51	30.9	88.2	4.33	27.6	989
Hardness, as $CaCO_3$		--	--	78.8	314	547	6.19	132	1,380
Alkalinity, as $CaCO_3$		--	--	72.3	259	388	117	208	434
Dissolved solids, dried at 180 °C		[3]500	8	92	425	1,440	162	318	1,850

[1]U.S. Environmental Protection Agency drinking water advisory taste threshold.

[2]New York State Department of Health maximum contaminant level.

[3]U.S. Environmental Protection Agency secondary drinking water standard.

[4]U.S. Environmental Protection Agency maximum contaminant level.

Table 4. Drinking-water standards and summary statistics for concentrations of nutrients and organic carbon in groundwater samples from central New York, 2012.

[All concentrations in milligrams per liter in filtered water except as noted. No., number; N, nitrogen; P, phosphorus; --, not applicable; <, less than]

Constituent	Drinking-water standard	No. of samples exceeding standard	Sand-and-gravel aquifers (15 samples)			Bedrock aquifers (14 samples)		
			Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia plus organic N, as N	--	--	<0.07	0.10	0.86	<0.07	0.32	0.79
Ammonia, as N	--	--	<0.010	0.010	0.209	<0.010	0.194	0.707
Nitrate plus nitrite, as N	[1,2]10	0	<0.040	0.323	5.50	<0.040	<0.040	1.29
Nitrite, as N	[1,2]1	0	<0.001	<0.001	0.010	<0.001	<0.001	0.213
Orthophosphate, as P	--	--	<0.004	<0.004	7.75	<0.004	0.006	0.045
Total organic carbon, unfiltered	--	--	<0.5	0.6	17.9	<0.5	0.8	2.2

[1]U.S. Environmental Protection Agency maximum contaminant level.

[2]New York State Department of Health maximum contaminant level.

The central and southern parts of the study area lie within the Appalachian Plateau Physiographic Province (fig. 1). The northern part lies in the Lake Ontario Lowlands and the Tug Hill Uplands. Forest and pasture dominate the upland rolling hills and narrow valleys of the southern and eastern parts of the study area. The central region has several deep and wide glacial valleys that drain northward and contain the Finger Lakes. Cultivation of row crops, apples, and grapes is common in the Lake Ontario Lowlands, and row-crop, forage-crop, and dairy farming are concentrated in the fertile soils of the Appalachian Plateau. The Syracuse and Rochester metropolitan areas lie near the central and northwestern parts of the study area, respectively, and the New York State Barge (Erie) Canal traverses the area from Rochester to Rome and from Syracuse to Oswego.

During deglaciation of the region, sand and gravel were deposited by meltwater streams, and clay, silt, and fine sand were deposited in proglacial lakes. The glaciofluvial and glaciolacustrine deposits within the study area are described in detail by Coates (1966) and Randall (2001). The most productive aquifers within the study area are the glaciofluvial deposits of sand and gravel in the valleys. Bedrock aquifers typically are used for water supply in upland areas where sand-and-gravel aquifers generally are absent. The bedrock aquifers throughout most of the study area are relatively flat-lying interbedded sedimentary units of shale, siltstone, sandstone, limestone, dolostone, and evaporites of Silurian and Devonian age (Fisher and others, 1970). The northern extent of the Marcellus Shale bisects the study area from east to west (fig. 1). The Utica Shale underlies the Marcellus and encompasses the entire study area. These geologic formations are of much current interest because of their reserves of natural gas.

Methods

A total of 29 wells (table 1–1) were selected for sample collection as described by Eckhardt and others (2009); 15 are finished in sand-and-gravel aquifers, and 14 are finished in bedrock aquifers. Of the 15 wells that tap into sand-and-gravel aquifers, 14 are production wells and 1 is a private residential well. All 14 bedrock wells are private residential wells. Samples were collected from August through December 2012. The water samples were analyzed for 147 physiochemical properties and constituents, including major ions, nutrients, trace elements, radionuclides, pesticides, VOCs, dissolved gases (argon, carbon dioxide, methane, nitrogen, oxygen), and indicator bacteria.

Wells were selected to provide adequate spatial coverage of the study area. The study did not target specific municipalities, industries, or agricultural practices. The private residential wells were selected on the basis of information from the NYSDEC Water Well Program, which began in 2000. Production wells were selected by using information from the NYSDEC Water Well Program and the New York State Department of Health (NYSDOH) Drinking Water Protection Program.

Most of the wells that are finished in sand and gravel are in the valleys and range in depth from 19 to 136 feet (ft; table 1–1). The wells that are finished in bedrock are generally in the uplands and range in depth from 70 to 360 ft; all the bedrock wells are finished in sedimentary units of shale, siltstone, sandstone, limestone, dolostone, and evaporites (table 1–1).

In addition to the 29 groundwater samples, 3 quality control (QC) samples—2 field blanks and 1 concurrent replicate sample—were collected. The QC blank samples

Table 5. Drinking-water standards and summary statistics for concentrations of trace elements and radionuclides in groundwater samples from central New York, 2012.

[All concentrations in micrograms per liter in unfiltered water except as noted. No., number; pCi/L, picocuries per liter; mrem/yr, millirem per year; <, less than; --, not applicable]

Constituent	Drinking-water standard	No. of samples exceeding standard	Sand-and-gravel aquifers (15 samples)			Bedrock aquifers (14 samples)		
			Minimum	Median	Maximum	Minimum	Median	Maximum
Aluminum	[1]50–200	4	<3.8	<3.8	1,730	<3.8	5.2	5,500
Antimony	[2,3]6	0	<0.18	<0.18	0.24	<0.18	<0.18	0.64
Arsenic	[2,3]10	1	<0.28	0.44	2.90	<0.28	0.68	17.8
Barium	[2,3]2,000	0	11.7	129	1,240	10.6	63.5	503
Beryllium	[2,3]4	0	<0.02	<0.02	0.05	<0.02	<0.02	0.60
Boron, filtered	--	--	5.0	25	126	11	340	1,350
Cadmium	[2,3]5	0	<0.016	<0.016	0.028	<0.016	<0.016	0.14
Chromium	[2,3]100	0	<0.30	<0.30	0.78	<0.30	<0.30	8.1
Cobalt	--	--	<0.02	<0.02	0.12	<0.02	0.05	3.8
Copper	[1]1,000	0	<0.70	3.2	76.1	<0.70	3.0	8.9
Iron, filtered	[1,3]300	5	<4.0	54	982	<4.0	13.0	1,800
Iron	[1,3]300	9	<4.6	71	2,400	<4.6	106	7,740
Lead	[4]15	0	<0.04	0.28	1.08	<0.04	0.30	6.22
Lithium	--	--	1.5	6.4	40.7	4.6	57.7	441
Manganese, filtered	[3]300 [1]50	2 12	<0.16	52.7	328	<0.16	4.9	456
Manganese	[3]300 [1]50	3 13	<0.20	53.9	318	0.2	10.0	422
Molybdenum	--	--	<0.05	0.6	4.2	<0.05	0.8	3.5
Nickel	--	--	<0.19	<0.51	2.50	<0.19	0.23	9.8
Selenium	[2,3]50	0	<0.05	0.06	0.46	<0.05	<0.05	0.94
Silver	[1,3]100	0	<0.015	<0.015	0.021	<0.015	<0.015	0.069
Strontium	--	--	24.8	183	2,240	118	516	16,600
Thallium	[2,3]2	0	<0.06	<0.06	0.10	<0.06	<0.06	0.27
Zinc	[1,3]5,000	0	<3.0	3.3	89.4	<3.0	4.8	26.2
Gross alpha radioactivity, pCi/L	[2,3]15	0	<0.46	<1.1	3.0	<0.57	1.2	13.0
Gross beta radioactivity, pCi/L	[2,3]4 mrem/yr	--	<0.80	1.9	4.6	<0.87	1.6	13.1
Radon-222, pCi/L	[5]300 [6]4,000	13 0	35	310	760	19	147	2,400
Uranium	[2,3]30	0	0.017	0.450	1.35	<0.014	0.16	4.51

[1]U.S. Environmental Protection Agency secondary drinking water standard.

[2]U.S. Environmental Protection Agency maximum contaminant level.

[3]New York State Department of Health maximum contaminant level.

[4]U.S. Environmental Protection Agency treatment technique.

[5]U.S. Environmental Protection Agency proposed maximum contaminant level.

[6]U.S. Environmental Protection Agency proposed alternative maximum contaminant level.

contained no constituents in concentrations greater than the laboratory reporting levels (LRLs), except silica and manganese (filtered), which were detected at trace concentrations. This indicates that little to no contamination occurred through the sampling or analytical procedures. The variability between the replicate sample and the corresponding environmental sample was greatest for unfiltered trace elements. The LRL is generally equal to twice the annual determined long-term method detection level (LT–MDL). The LRL controls false negative error. The probability of falsely reporting a nondetection result for a sample that contains an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent. The value of the LRL is indicated as less than (<) for samples in which the analyte was not detected. The USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, collects quality-control data from selected analytical methods on a continuing basis to determine LT–MDLs and to establish LRLs. These values are reevaluated annually on the basis of the most current quality-control data and, therefore, may change (Childress and others, 1999).

Groundwater-sample collection and processing followed standard USGS procedures as documented in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Twenty-eight of the 29 samples were collected before any water-treatment system to be as representative of the aquifer water quality as possible. The sample from production well M 136 was inadvertently collected from a treated-water spigot. The sample from this well was treated with a softener, corrosion inhibitor, and then chlorinated. These treatments may have affected the results for certain constituents, specifically sodium (tables 3 and 1–4), orthophosphate (tables 3 and 1–5), trichloromethane (table 1–8), and bacteria (table 1–9). The sample from production well OW 454 may have been affected by runoff from a road-salt storage area, which could have affected the results for calcium, magnesium, potassium, sodium, and chloride (tables 3 and 1–4). Most samples from domestic wells were collected from a spigot near the pressure tank; samples from production wells were collected at the spigot used for collection of raw-water samples by water managers.

All samples except those for radionuclide analyses were chilled to 4 degrees Celsius (°C) or less and were kept chilled until delivery to the analyzing laboratory. The samples were delivered directly or shipped by overnight delivery to four laboratories: (1) the NWQL for analysis of inorganic major ions, nutrients, total organic carbon, inorganic trace elements, radon-222, pesticides and pesticide degradates, and VOCs; (2) the USGS Chlorofluorocarbon Laboratory (CFCL) in Reston, Virginia, for selected dissolved gases; (3) a NYSDOH-certified laboratory in Richmond, California, for gross-alpha and gross-beta radioactivities; and (4) a NYSDOH-certified laboratory in Ithaca, New York, for bacterial analysis. Physiochemical properties, such as water temperature, pH, dissolved oxygen concentration, and specific conductance, were measured at the sampling site.

Groundwater Quality

Samples from 29 wells were analyzed for 147 physiochemical properties and constituents. Many of these (71) were not detected above the LRLs in any sample (table 1–2). Results for the remaining 76 physiochemical properties and constituents that were detected are presented in tables 1–3 through 1–9. The categories of physiochemical properties and the concentrations of constituents are presented in appendix 1 as follows: physiochemical properties in table 1–3, major ions in table 1–4, nutrients and total organic carbon in table 1–5, trace elements and radionuclides in table 1–6, pesticides in table 1–7, VOCs in table 1–8, and bacterial water-quality indicators in table 1–9. Some concentrations were reported as estimated when the detected value was less than the established LRL or when recovery of a compound has been documented to be highly variable (Childress and others, 1999).

Analytical results for selected constituents were compared with Federal and New York State drinking-water standards, which are typically identical. The standards include maximum contaminant levels (MCLs) and secondary drinking-water standards (SDWS) established by the U.S. Environmental Protection Agency (EPA; U.S. Environmental Protection Agency, 1999, 2002, 2009) and the NYSDOH (New York State Department of Health, 2011). The MCLs are enforceable standards that specify the highest level of a contaminant that is allowed in public-water drinking supplies; they are not enforceable for private residential wells but are presented here as a guideline for evaluation of the water-quality results. The SDWS are nonenforceable guidelines and are based on cosmetic and aesthetic criteria, such as taste, odor, or staining of plumbing fixtures.

The quality of the sampled groundwater generally was acceptable, although in samples from all 29 wells, the concentration of at least one constituent exceeded recommended MCLs or SDWSs set by the EPA or the NYSDOH. Exceedances generally involved minerals and chemical elements that occur from natural interactions of water and rock (aluminum, arsenic, chloride, color, fluoride, iron, manganese, pH, radon-222, sodium, sulfate, and total dissolved solids) but also included total coliform and heterotrophic bacteria.

Physiochemical Properties

The color of water samples (tables 2, 1–3) ranged from less than 1 platinum-cobalt (Pt-Co) unit (the LRL) to 300 Pt-Co units. The NYSDOH MCL and EPA SDWS of 15 Pt-Co units were exceeded in two samples. The pH of the samples ranged from 7.0 to 9.2; the median was 7.5 for sand-and-gravel wells and 8.4 for bedrock wells. Seven of the 29 wells had pH values outside the accepted EPA SDWS range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 2009). The specific conductance of the samples ranged from 157 to

2,600 microsiemens per centimeter (µS/cm) at 25 °C; the median was 710 µS/cm at 25 °C for sand-and-gravel wells and 526 µS/cm at 25 °C for bedrock wells. The temperature of the water ranged from 8.8 to 17.4 °C; the median was 11.6 °C for sand-and-gravel wells and 12.2 °C for bedrock wells.

Dissolved-oxygen concentrations ranged from 0.3 to 7.0 milligrams per liter (mg/L); the median was 0.9 mg/L for sand-and-gravel wells and 0.5 mg/L for bedrock wells. Methane concentrations ranged from less than 0.0010 (the LRL) to 37.3 mg/L; the median was 0.007 mg/L for sand-and-gravel wells and 0.608 mg/L for bedrock wells. The maximum methane concentration (37.3 mg/L) was measured in a sample from a bedrock well finished in shale. Although the EPA and NYSDOH do not have MCLs for methane, dissolved methane concentrations greater than 28 mg/L (1 sample) can pose explosion hazards as a result of methane accumulation in confined spaces. In addition, the Office of Surface Mining recommends that methane concentrations ranging from 10 to 28 mg/L in water (1 sample) signify an action level at which the situation should be closely monitored, and if the concentration increases, the area should be vented to prevent methane gas buildup (Eltschlager and others, 2001). The odor of hydrogen sulfide gas, which may occur in the absence of oxygen, was noted by field personnel in water from 3 sand-and-gravel wells and 4 bedrock wells.

Major Ions

The cations that were detected in the greatest concentrations were calcium and sodium (tables 3, 1–4). Calcium concentrations ranged from 1.92 to 485 mg/L; the median was 88.0 mg/L for sand-and-gravel wells and 35.4 mg/L for bedrock wells. Magnesium concentrations ranged from 0.338 to 77.8 mg/L; the median was 23.3 mg/L for sand-and-gravel wells and 10.8 mg/L for bedrock wells. Potassium concentrations ranged from 0.42 to 8.72 mg/L; the median was 1.35 mg/L for sand-and-gravel wells and 1.18 mg/L for bedrock wells. Sodium concentrations ranged from 1.42 to 308 mg/L; the median was 17.9 mg/L for sand-and-gravel wells and 60.5 mg/L for bedrock wells. The EPA nonregulatory drinking-water advisory threshold for taste recommends that sodium concentrations in drinking water not exceed the range of 30 to 60 mg/L (U.S. Environmental Protection Agency, 2002, 2009). The concentration of sodium in samples from 2 sand-and-gravel wells (M 136 and OW 454) and 7 bedrock wells exceeded the upper limit of the EPA threshold. The maximum concentration of sodium (308 mg/L) in the sample collected from production well OW 454 may have been affected by runoff from a road-salt storage area. The sample from production well M 136 was inadvertently collected from a treated-water spigot; the treatments may have affected the sodium concentration.

The anions detected in the highest median concentrations were bicarbonate, chloride, and sulfate (tables 3, 1–4). Bicarbonate concentrations ranged from 88 to 529 mg/L; the median was 316 mg/L for sand-and-gravel wells and 254 mg/L for bedrock wells. Chloride concentrations ranged from 1.41 to 688 mg/L; the median was 35.2 mg/L for sand-and-gravel wells and 8.92 mg/L for bedrock wells. The NYSDOH MCL and EPA SDWS of 250 mg/L for chloride were exceeded in samples from 1 sand and gravel well (OW 454) and 1 bedrock well (WN 902). The maximum concentration of chloride (688 mg/L) in the sample collected at production well OW 454 may have been affected by runoff from a road-salt storage area. Fluoride concentrations ranged from less than 0.04 (the LRL) to 2.20 mg/L; the median was 0.08 mg/L for sand-and-gravel wells and 0.26 mg/L for bedrock wells. The NYSDOH MCL of 2.0 mg/L for fluoride was exceeded in samples from two bedrock wells, but the EPA maximum contaminant level (MCL) of 4.0 mg/L and secondary drinking-water standard (SDWS) of 2.2 mg/L were not exceeded. Silica concentrations ranged from 6.30 to 15.8 mg/L; the median was 9.57 mg/L for sand-and-gravel wells and 9.90 mg/L for bedrock wells. Sulfate concentrations ranged from 0.51 to 989 mg/L; the median was 30.9 mg/L for sand-and-gravel wells and 27.6 mg/L for bedrock wells. The NYSDOH MCL and EPA SDWS of 250 mg/L for sulfate were exceeded in samples from two bedrock wells.

Calcium and magnesium contribute to water hardness. Water hardness in the study area (tables 3, 1–4) ranged from 6.19 to 1,380 mg/L as $CaCO_3$; the median was 314 mg/L for sand-and-gravel wells and 132 mg/L for bedrock wells. Nine of the samples were soft to moderately hard (equal to or less than 120 mg/L as $CaCO_3$), and 20 wells yielded water that was hard to very hard (greater than 120 mg/L as $CaCO_3$) (Hem, 1985). Samples from wells finished in sand and gravel had slightly higher alkalinity (median of 259 mg/L as $CaCO_3$) than those finished in bedrock (median of 208 mg/L as $CaCO_3$). Concentrations of dissolved solids ranged from 92 to 1,850 mg/L, with a median of 425 mg/L for sand-and-gravel wells and 318 mg/L for bedrock wells. The EPA SDWS of 500 mg/L for dissolved solids was exceeded in 4 sand-and-gravel wells and 4 bedrock wells.

Nutrients and Organic Carbon

Nitrate plus nitrite was the predominant nutrient in the groundwater samples (tables 4, 1–5). Concentrations of nitrate plus nitrite ranged from less than 0.040 (the LRL) to 5.50 mg/L as N; the median concentration was 0.323 mg/L as N in samples from sand-and-gravel wells and less than 0.040 mg/L as N in samples from bedrock wells. The concentration of nitrate plus nitrite did not exceed the EPA and NYSDOH MCLs of 10 mg/L as N in any sample. Concentrations of ammonia ranged from less than 0.010 (the LRL) to 0.707 mg/L as nitrogen (N); the median concentration was 0.010 mg/L as N in samples from sand and gravel wells and 0.194 mg/L as N in samples from bedrock wells. Nitrite was detected in 11 samples; the highest concentration was 0.213 mg/L as N. The concentration of nitrite did not exceed the MCL (1 mg/L as N) in any sample. Orthophosphate concentrations ranged from less than 0.004 (the LRL) to 7.75 mg/L as phosphorus (P). The maximum concentration of orthophosphate was detected in the treated-water sample from production well M 136 and may be due to the addition of phosphates to inhibit corrosion. Organic carbon was detected in 23 of the 29 samples; the maximum concentration was 17.9 mg/L. The maximum concentration of organic carbon was detected in the sample from private well WN 926; the well is situated on a parcel of land that is used in part as a small retail nursery for garden plants.

Trace Elements and Radionuclides

The trace elements detected in at least one sample at concentrations greater than 100 µg/L were aluminum, barium, boron, iron, lithium, manganese, and strontium (tables 5, 1–6). The largest detected concentration of a trace element, 16,600 µg/L, was of strontium in a sample from a bedrock well. The concentration of aluminum in 1 sample from a sand and gravel well and 2 samples from bedrock wells exceeded the upper limit of the EPA SDWS of 200 µg/L. The lower limit of the EPA SDWS for aluminum (50 µg/L) was exceeded in one sample from a third bedrock well with a concentration of 57.3 µg/L. The concentration of arsenic in one sample from a bedrock well, 17.8 µg/L, exceeded the EPA and NYSDOH MCLs of 10 µg/L. The concentration of iron in 5 filtered samples and 9 unfiltered samples exceeded the EPA SDWS and the NYSDOH MCL of 300 µg/L. The concentration of manganese in 12 filtered samples and 13 unfiltered samples exceeded the EPA SDWS of 50 µg/L; the NYSDOH MCL of 300 µg/L was exceeded in 2 filtered samples and 3 unfiltered samples. Drinking-water standards for antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, uranium, and zinc were not exceeded. Additionally, mercury was not detected in any sample (table 1–2).

Three measures of radioactivity were employed: gross-alpha, gross-beta, and radon-222 (tables 5, 1–6). Gross-alpha activity ranged from less than 0.46 to 13.0 picocuries per liter (pCi/L). The median activity was less than 1.1 pCi/L in samples from sand-and-gravel wells and 1.2 pCi/L in samples from bedrock wells. The gross-alpha activity did not exceed the EPA and NYSDOH MCLs of 15 pCi/L in any sample. Gross-beta activity ranged from less than 0.80 to 13.1 pCi/L. The median activity was 1.9 pCi/L in samples from sand-and-gravel wells and 1.6 pCi/L in samples from bedrock wells. The EPA and NYSDOH MCLs for gross beta are expressed as a dose of 4 millirems per year; therefore, gross-beta activity could not be evaluated for exceedance of the MCL. Radon-222 was detected in every sample, and activity ranged from 19 to 2,400 pCi/L. The median activity was 310 pCi/L in samples from sand-and-gravel wells and 147 pCi/L in samples from bedrock wells. Radon currently is not regulated in drinking water. However, the EPA-proposed MCL of 300 pCi/L for radon-222 in drinking water was exceeded in 13 samples, but the EPA-proposed alternate maximum contaminant level (AMCL) of 4,000 pCi/L was not exceeded. The AMCL is the proposed allowable activity of radon in raw-water samples where the State has implemented mitigation programs to address the health risks of radon in indoor air. The proposed MCL and AMCL for radon are under review and have not been adopted (Krieger and Whitaker, 1980; U.S. Environmental Protection Agency, 1999, 2009).

Pesticides

Eight pesticides (1 insecticide metabolite, 6 herbicides, and 1 herbicide degradate) were detected in samples from 12 wells (table 1–7). The pesticides were detected in samples from 10 sand-and-gravel wells and 2 bedrock wells. All pesticide concentrations were in hundredths or thousandths of micrograms per liter. A total of 28 pesticide were detected; 10 of those have estimated concentrations. The herbicide atrazine was detected in 7 samples; 1 of those samples, from a sand and gravel well, had the highest concentration (0.083 µg/L) of all pesticide detections. The atrazine degradate CIAT was the constituent detected most frequently (9 samples). The sample from one sand and gravel well (a production well in an agricultural setting) had the most (five) pesticide detections. None of the pesticides analyzed was present in concentrations that exceeded established drinking-water standards.

Volatile Organic Compounds

Eight VOCs were detected in samples from 3 sand-and-gravel wells and 2 bedrock wells (table 1–8). Bromodichloromethane and trichloromethane were detected in samples from 2 sand-and-gravel wells; trichloromethane was also detected in a sample from 1 bedrock well. These two compounds are trihalomethanes (THMs), which typically are formed as byproducts when chlorine or bromine is used to disinfect water. The sample from production well M 136 was inadvertently collected from a treated-water spigot. The sample from this well was chlorinated which may account for the presence of THMs. The maximum THM concentration detected was 20.7 µg/L for trichloromethane in a sample from a private residential sand and gravel well. The concentration of total THMs did not exceed the EPA and NYSDOH MCLs of 80 µg/L.

Of the remaining VOCs detected, which include 1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, styrene, methyl *tert*-butyl ether (MTBE), and tetrachloro-ethene, the highest concentration was 1.2 µg/L of tetrachloroethene.

Bacteria

All samples were analyzed for total coliform, fecal coliform, *Escherichia coli* (*E. coli*), and heterotrophic bacteria. Total coliform bacteria were detected in 6 samples (table 1–9): 2 from sand-and-gravel wells and 4 from bedrock wells. The concentration of total coliform bacteria in one of the bedrock well samples was very high, too numerous to count (TNTC). The EPA and NYSDOH MCLs for total coliform bacteria are exceeded when 5 percent of finished water samples collected in 1 month test positive for total coliform (if 40 or more samples are collected per month) or when two samples are positive for total coliform (if fewer than 40 samples are collected per month). Fecal coliform and *E. coli* were not detected in any sample. Heterotrophic plate counts ranged from less than 1 to 3,348 colony-forming units per milliliter (CFU/mL); the EPA MCL (500 CFU/mL) was exceeded in two samples. The sample from production well M 136 was inadvertently collected from a treated-water spigot; the sample from this well was chlorinated.

Wells Sampled in 2007 and 2012

Six of the wells sampled in 2012 (CY10, CY 265, OW 454, OW 503, SY 402, and WN 593) were sampled previously in 2007 as part of the program. Of the 147 physiochemical properties and constituents analyzed in samples in 2012, 140 had also been included in the 2007 analysis (tables 1–10 through 1–13). The differences between results from 2007 and those from 2012 for a single well were typically smaller than the differences between the results from different wells. However, at well OW 454, a sand and gravel production well, concentrations of some constituents (calcium, magnesium, sodium, chloride, and dissolved solids) more than doubled from 2007 to 2012 (table 1–10). According to the operator at OW 454, these increases are due to runoff from a de-icing road-salt storage area. Detections of organic compounds and coliform bacteria in samples from the six wells were fairly consistent from 2007 to 2012, with the exception of CY 10, a sand and gravel production well, which had a new metolachlor detection in 2012 (table 1–12) and decreases in VOC concentrations from 2007 to 2012 (table 1–13).

Summary

In 2002, the U.S. Geological Survey began an assessment of groundwater quality in bedrock and sand-and-gravel aquifers throughout New York State in cooperation with the New York State Department of Environmental Conservation. As a part of this assessment, Central Lake Ontario, Oneida River, Oswego River, and Seneca River Basins in central New York were studied in 2007 and again in 2012. The 2012 study (this report) included analysis of 29 water samples collected from 14 production wells and 15 private residential wells from August through December 2012. The depths of sand-and-gravel wells range from 19 to 136 feet (ft) below land surface; the bedrock wells are 70 to 360 ft deep and are finished in sedimentary units of shale, siltstone, sandstone, limestone, dolostone, and evaporates. Water samples were analyzed for 147 physiochemical properties and constituents that included major ions, nutrients, trace elements, radionuclides, pesticides, volatile organic compounds (VOCs), dissolved gases (argon, carbon dioxide, methane, nitrogen, oxygen), and indicator bacteria. Six wells (CY 10, CY 265, OW 454, OW 503, SY 402, and WN 593) were tested in both studies, and a comparison was made of the results. The concentrations of most of the constituents changed little between 2007 and 2012.

The results indicate that groundwater generally is of acceptable quality, although in samples from all 29 wells, at least one of the following constituents was detected at a concentration that exceeded current or proposed Federal or New York State drinking-water standards: color (2 samples), pH (7 samples), sodium (9 samples), chloride (2 samples), fluoride (2 samples), sulfate (2 samples), total dissolved solids (8 samples), aluminum (4 samples), arsenic (1 sample), iron (9 samples), manganese (13 samples), radon-222 (13 samples), total coliform bacteria (6 samples), and heterotrophic bacteria (2 samples). Drinking-water standards for nitrate, nitrite, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, gross alpha radioactivity, uranium, fecal coliform, and *Escherichia coli* were not exceeded in any of the samples collected. None of the pesticides or VOCs analyzed exceeded drinking-water standards.

Sample pH was typically near neutral or slightly basic. Methane was detected in 20 of the 29 samples; 1 sample had a methane concentration greater than 28 milligrams per liter (mg/L). The water typically was moderately hard, and the median dissolved-solids concentration was 389 mg/L. The ions detected in the highest median concentration were bicarbonate, calcium, sodium, and chloride. The dominant nutrient was ammonia. Strontium and boron were the trace elements with the highest median concentrations. Seven pesticides and 1 pesticide degradate were detected at trace concentrations in 12 samples. Eight VOCs were detected in 5 samples. Radon-222 activities in 13 samples exceeded a proposed maximum contaminant level. Coliform bacteria were detected in 6 samples. Fecal coliform and *Escherichia coli* bacteria were not detected in any samples.

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Appendix 1. Data Tables

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Reddy—**Groundwater Quality in Central New York, 2012**—Open-File Report 2014–1226

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20141226