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Groundwater Quality in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015

Open-File Report 2019–1005

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

Cover. View of the landscape in the Delaware River Basin. Photograph by Elizabeth Nystrom, U.S. Geological Survey.

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U.S. Geological Survey
James F. Reilly II, Director

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
inch (in.)	25,400	micrometer (µm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
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

$$°F = (1.8 \times °C) + 32.$$

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).

Elevation, as used in this report, refers to distance above the vertical datum.

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), micrograms per liter (µg/L), or nanograms per liter (ng/L).

Activities for radioactive constituents in water are given in picocuries per liter (pCi/L).

Concentrations of bacteria in water are given in colony-forming units per 100 milliliters (CFU/100 mL); heterotrophic plate counts are in colony-forming units per milliliter (CFU/mL).

Color is reported in platinum-cobalt (Pt-Co) units.

Abbreviations and Symbols

>	greater than
<	less than
AMCL	alternative maximum contaminant level
bls	below land surface
$CaCO_3$	calcium carbonate
CFU	colony-forming units
CIAT	2-chloro-4-isopropylamino-6-amino-*s*-triazine
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
GC–MS	gas chromatography-mass spectrometry
gross-α	gross-alpha
gross-β	gross-beta
ICP–AES	inductively coupled plasma-atomic emission spectrometry
LRL	laboratory reporting level
MCL	maximum contaminant level
N	nitrogen
NWQL	USGS National Water Quality Laboratory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
P	phosphorus
SDWS	secondary drinking-water standard
THM	trihalomethane
USGS	U.S. Geological Survey
VOC	volatile organic compound

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Abstract

The U.S. Geological Survey, in cooperation with the New York State Department of Environmental Conservation, collected groundwater samples from 5 production wells and 5 domestic wells in the Delaware River Basin, 8 production wells and 7 domestic wells in the Genesee River Basin, and 1 municipal well, 7 production wells, and 13 domestic wells in the St. Lawrence River Basin in New York. All samples were collected from May through November 2015 in an effort to characterize groundwater quality in these basins. The samples were collected and processed by using standard U.S. Geological Survey procedures and were analyzed for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds, radionuclides, and indicator bacteria.

The Delaware River Basin study area covers 2,360 square miles (mi^2) in southeastern New York. Of the 10 wells sampled in the Delaware River Basin, 3 are completed in sand and gravel, and 7 are completed in bedrock. Groundwater in the Delaware River Basin was generally of good quality, although properties and concentrations of some constituents—pH, iron, manganese, aluminum, radon-222, and total coliform bacteria—sometimes equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (10 of 10 samples) was radon-222.

The Genesee River Basin study area includes the entire 2,439 mi^2 of the basin in western New York. Of the 15 wells sampled in the Genesee River Basin, 6 are completed in sand and gravel, and 9 are completed in bedrock. Groundwater in the Genesee River Basin was generally of good quality, although properties and concentrations of some constituents—chloride, sodium, dissolved solids, iron, manganese, aluminum, arsenic, radon-222, methane, total coliform bacteria, fecal coliform bacteria, and *Escherichia coli* bacteria—sometimes equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (12 of 15 samples) was radon-222.

The St. Lawrence River Basin study area includes the entire 5,650 mi^2 of the basin in northeastern New York. Of the 21 wells sampled in the St. Lawrence River Basin, 7 are completed in sand and gravel, and 14 are completed in bedrock. Groundwater in the St. Lawrence River Basin was generally of good quality, although properties and concentrations of some constituents—pH, chloride, sodium, dissolved solids, iron, manganese, sulfate, nitrate, radon-222, total coliform bacteria, fecal coliform bacteria, and *Escherichia coli* bacteria—sometimes equaled or exceeded primary, secondary, or proposed drinking-water standards. The constituent most frequently detected in concentrations exceeding drinking-water standards (14 of 21 samples) was radon-222.

Introduction

Groundwater is used as a source of drinking water by approximately one-quarter of the population of New York State, or 4.5 million people (U.S. Census Bureau, 2016) (Kenny and others, 2009). In 2002, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), developed a program to evaluate groundwater quality throughout the major river basins in Upstate New York on a rotating basis. The program parallels the NYSDEC Rotating Integrated Basin Study program (https://www.dec.ny.gov/chemical/30951.html), which evaluates surface-water quality on a 5-year cycle by sampling in 2 or 3 of the 14 major river basins in the State each year. This program also supports NYSDEC's responsibilities under Section 305(b) of the Clean Water Act Amendments of 1977 (Public Law 95–95, 91 Stat. 685) to report on the chemical quality of groundwater within New York (U.S. Environmental Protection Agency, 1997). The groundwater-quality program began with a pilot study in the Mohawk River Basin in 2002 and still continues throughout Upstate New York, that part of New York State north of New York City (table 1). Sampling completed in 2008 represents the conclusion of the first round of groundwater-quality sampling throughout Upstate New York. Groundwater-quality sampling was conducted in 2015 in the Delaware, Genesee, and St. Lawrence River Basins, representing the third round of groundwater-quality sampling for this program.

Table 1. Previous groundwater-quality studies and reports of the rotating-basin groundwater monitoring program in New York.

[**Bold** listing indicates the previous groundwater-quality studies in the Delaware River Basin, Genesee River Basin, and St. Lawrence River Basin]

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
Susquehanna River Basin	2004	Open-File Report 2006–1161	Hetcher-Aguila and Eckhardt, 2006
Delaware River Basin	**2005**	**Open-File Report 2007–1098**	**Nystrom, 2007a**
Genesee River Basin	**2005**	**Open-File Report 2007–1093**	**Eckhardt and others, 2007**
St. Lawrence River Basin	**2005**	**Open-File Report 2007–1066**	**Nystrom, 2007b**
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
Chemung River Basin	2008	Open-File Report 2011–1112	Risen and Reddy, 2011a
Eastern Lake Ontario Basin	2008	Open-File Report 2011–1074	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
Susquehanna River Basin	2009	Open-File Report 2012–1045	Reddy and Risen, 2012
Delaware River Basin	**2010**	**Open-File Report 2011–1320**	**Nystrom, 2012**
Genesee River Basin	**2010**	**Open-File Report 2012–1135**	**Reddy, 2012**
St. Lawrence River Basin	**2010**	**Open-File Report 2011–1320**	**Nystrom, 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
Central New York	2012	Open-File Report 2014–1226	Reddy, 2014
Upper Hudson River Basin	2012	Open-File Report 2014–1084	Scott and Nystrom, 2014
Chemung River Basin	2013	Open-File Report 2015–1168	Scott and others, 2015
Eastern Lake Ontario Basin	2013	Open-File Report 2015–1168	Scott, and others, 2015
Lower Hudson River Basin	2013	Open-File Report 2015–1168	Scott, and others, 2015
Lake Champlain Basin	2014	Open-File Report 2016–1153	Scott, and others, 2016
Susquehanna River Basin	2014	Open-File Report 2016–1153	Scott, and others, 2016

Objective and Approach

The objective of the groundwater-quality monitoring program is to quantify and report on ambient groundwater quality in bedrock and glacial-drift aquifers in Upstate New York. Consistent, standardized methods were used to collect groundwater-quality samples from existing domestic and production wells equipped with permanently installed pumps. Wells were selected to represent an approximately equal number of domestic and production wells, to represent an approximately equal number of bedrock and glacial-drift wells, and to provide a representative geographic distribution of samples with emphasis on areas of greatest groundwater use. Approximately 20 percent of samples collected in 2015 were collected from wells that had been sampled in previous study cycles. Samples were analyzed for a broad suite of constituents, including physiochemical properties and concentrations of dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and indicator bacteria. The resulting dataset will be used to establish a groundwater-quality baseline for New York State that characterizes naturally occurring and ambient conditions and to identify long-term trends. The data are made available online through the USGS National Water Information System (https://nwis.waterdata.usgs.gov/ny/nwis/qw; U.S. Geological Survey, 2018) and published reports.

Groundwater-quality samples were collected in the Delaware, Genesee, and St. Lawrence River Basins in 2005–6, 2010, and 2015. Samples were collected in May through November for the 2015 cycle of this study. Ten environmental samples and 2 quality-assurance samples were collected in the Delaware River Basin. Fifteen environmental samples and 1 quality-assurance sample were collected in the Genesee River Basin. Twenty-one environmental samples and 1 quality-assurance sample were collected in the St. Lawrence River Basin. Two of the Delaware River Basin wells sampled in 2015 were also sampled in 2005–6 and 2010 (Nystrom, 2007a; Nystrom 2012). Three of the Genesee River Basin wells were also sampled in 2010 (Reddy, 2012). Five of the St. Lawrence River Basin wells were also sampled in 2005–6 and 2010 (Nystrom, 2007b; Nystrom, 2012).

Purpose and Scope

This report presents the findings of the 2015 groundwater-quality study in the Delaware, Genesee, and St. Lawrence River Basins. Ten samples from the Delaware River Basin, 15 samples from the Genesee River Basin, and 21 samples from the St. Lawrence River Basin were collected from May through November 2015. This report (1) describes the hydrogeologic setting, the methods of site selection, wells that were sampled, sample collection, and chemical analysis; (2) presents the analytical results; (3) presents comparisons of analytical results to drinking-water standards, and (4) presents comparisons of the results of this study with results for selected wells in the study areas that were sampled in 2005–6 and 2010 (Nystrom, 2007a, b; Nystrom, 2012; Reddy, 2012).

Hydrogeologic Setting

The study areas described in this report cover more than 10,000 square miles (mi^2), or 18 percent of New York State, and represent a wide range of geologic, hydrologic, and topographic settings, and land uses. Bedrock lithology is primarily shale and sandstone in the Delaware and Genesee River Basins; in the St. Lawrence River Basin, bedrock lithology consists of complex mixtures of crystalline, metamorphic, carbonate, and sandstone (Fisher and others, 1970). Surficial material in the study areas mainly consists of glacial and alluvial deposits.

Delaware River Basin

The Delaware River Basin encompasses approximately 12,700 mi^2 in New York, Pennsylvania, New Jersey, and Delaware. This study addressed the 2,360 mi^2 portion of the Delaware River Basin that lies within New York (fig. 1). The study area includes parts of eight counties, including most of Delaware and Sullivan Counties, part of Broome, Orange, and Ulster Counties, and small parts of Chenango, Greene, and Schoharie Counties (fig. 1). The West Branch Delaware River forms the boundary between New York and Pennsylvania for 9 miles (mi) before joining with the East Branch to form the main stem of the Delaware River, which forms the boundary for another 76 mi. Major tributaries to the Delaware River in New York include the West Branch Delaware River, East Branch Delaware River, Monguap River, and Neversink River. Drinking water for New York City is diverted out of the basin at three reservoirs: Cannonsville (on the West Branch Delaware River), Pepacton (on the East Branch Delaware River), and Neversink (on the Neversink River).

The highest elevations in the Delaware River Basin study area are more than 4,000 feet (ft) above the North American Vertical Datum of 1988 (NAVD 88) along the eastern edge of the basin, in the Catskill Mountains (fig. 1). The lowest elevations in the basin are at the Delaware River's exit from New York State at Port Jervis (fig. 1) (about 420 ft above NAVD 88). Precipitation in the Delaware River valley lowland areas averages about 40 inches per year (in/yr), whereas precipitation in the cooler Catskill Mountains averages about 50 in/yr (Randall, 1996). The Delaware River Basin is mostly rural, with larger population centers in the southern part of the basin at Port Jervis, Liberty, and Monticello (fig. 1). Land use in the basin is primarily forested, especially in the upland areas, with urban and agriculture uses mainly in valleys and other low-lying areas (Homer and others, 2015).

Bedrock in the Delaware River Basin study area (fig. 2) is mainly Middle to Upper Devonian sedimentary sandstone and shale with a narrow band of carbonate rocks that runs parallel to the southern edge of the basin (Isachsen and others, 2000). Bedrock wells in the study area produce small to moderate yields of 10 to 100 gallons per minutes (gal/min) (Barksdale, 1970). The surficial material throughout the study area (fig. 3) was deposited primarily during the Pleistocene epoch Wisconsinan glaciation, when glacial ice covered most of the northeastern United States (Isachsen and others, 2000). Till was directly deposited by the glaciers over most of the study area; alluvial, outwash, and ice-contact sand-and-gravel deposits are present mainly in the valleys (fig. 3). In the Delaware River Basin, till generally has low yields of water, whereas the well-sorted valley deposits form important aquifers in the basin that may produce yields of 1,000 gal/min or more (Barksdale, 1970). The depths of sand-and-gravel wells sampled in the Delaware River Basin range from 42 to 120 ft below land surface (bls); the depths of bedrock wells sampled range from 195 to 400 ft bls, and all are completed in shale and sandstone.

Genesee River Basin

The Genesee River Basin encompasses 2,534 mi^2, of which 95 mi^2 is in Pennsylvania. The Genesee River Basin study area encompasses the 2,439 mi^2 that is located in western New York. The study area contains parts of nine counties, including Genesee, Monroe, Livingston, Wyoming, Ontario, Steuben, Allegany, Orleans, and Cattaraugus Counties (fig. 4). Major tributaries to the Genesee River include Black Creek, Oatka Creek, Conesus Creek, Honeoye Creek, Canaseraga Creek, Wiscoy Creek, Caneadea Creek, Van Campen Creek, Dyke Creek, Silver Creek, and Silver Lake (fig. 4). Other major contributing tributaries in the Genesee River Basin include Keshequa Creek, which is a tributary to Canaseraga

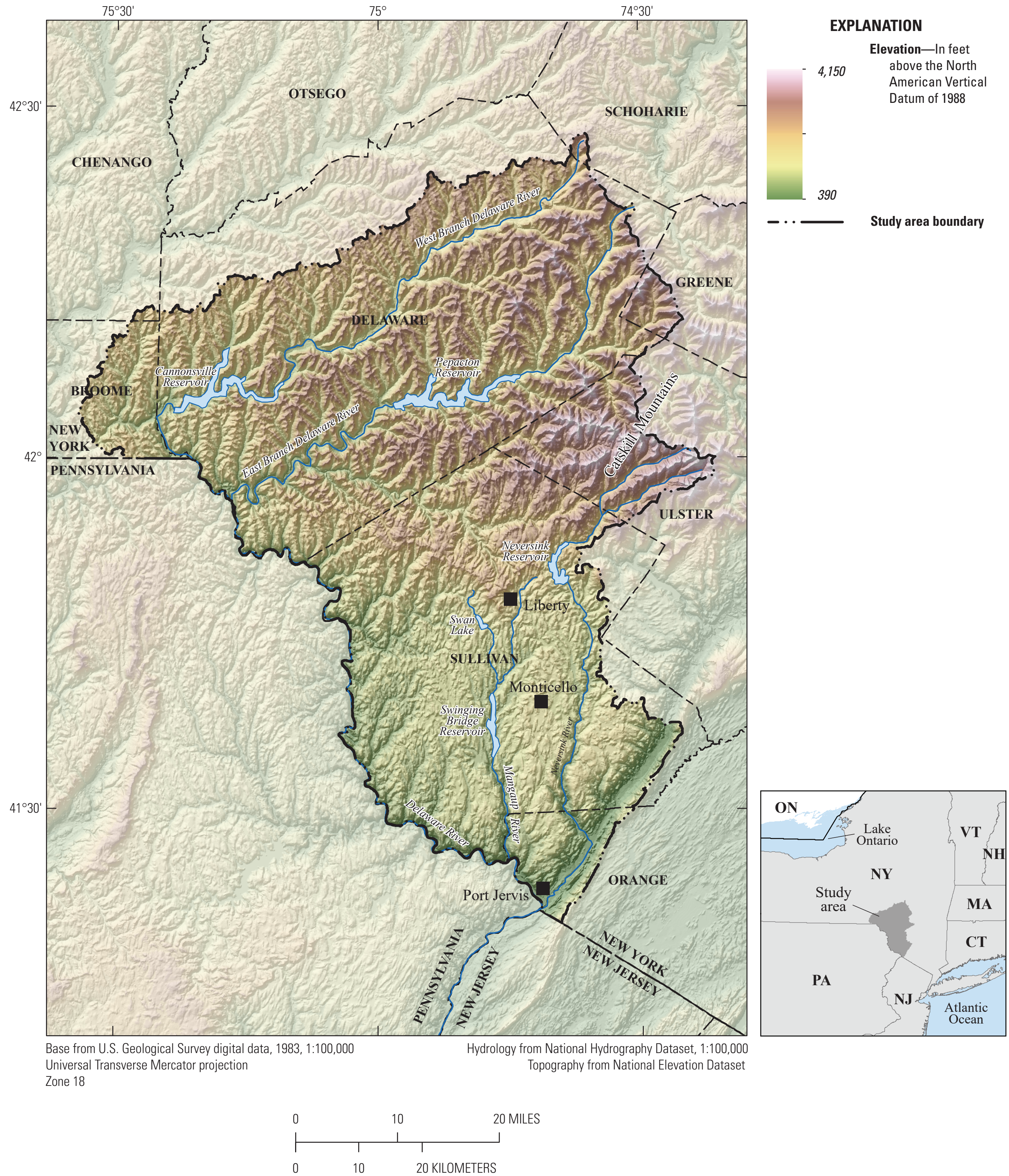

Figure 1. Topography and geography of the Delaware River Basin, New York.

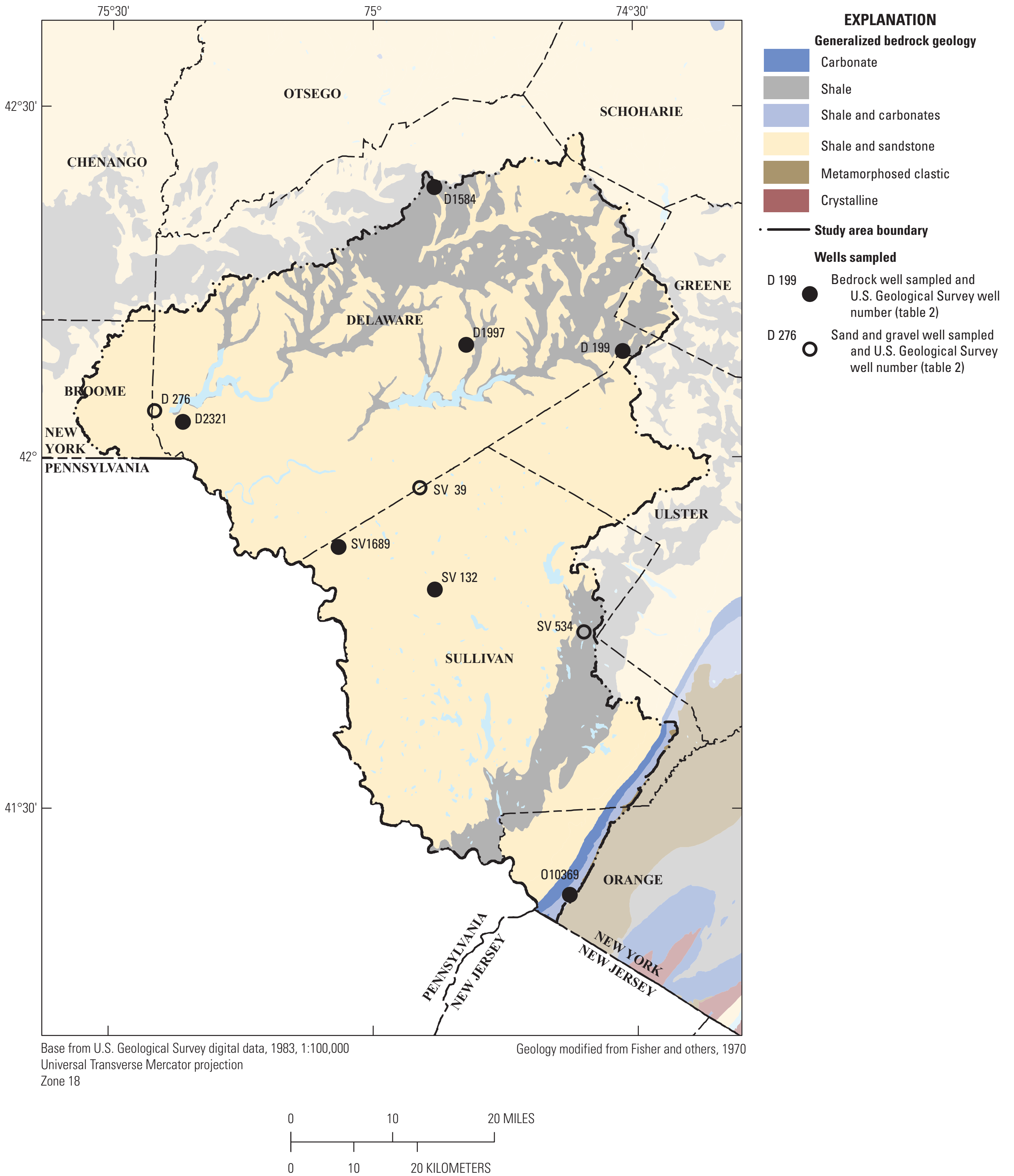

Figure 2. Generalized bedrock geology of the Delaware River Basin, New York, and locations of wells sampled in 2015.

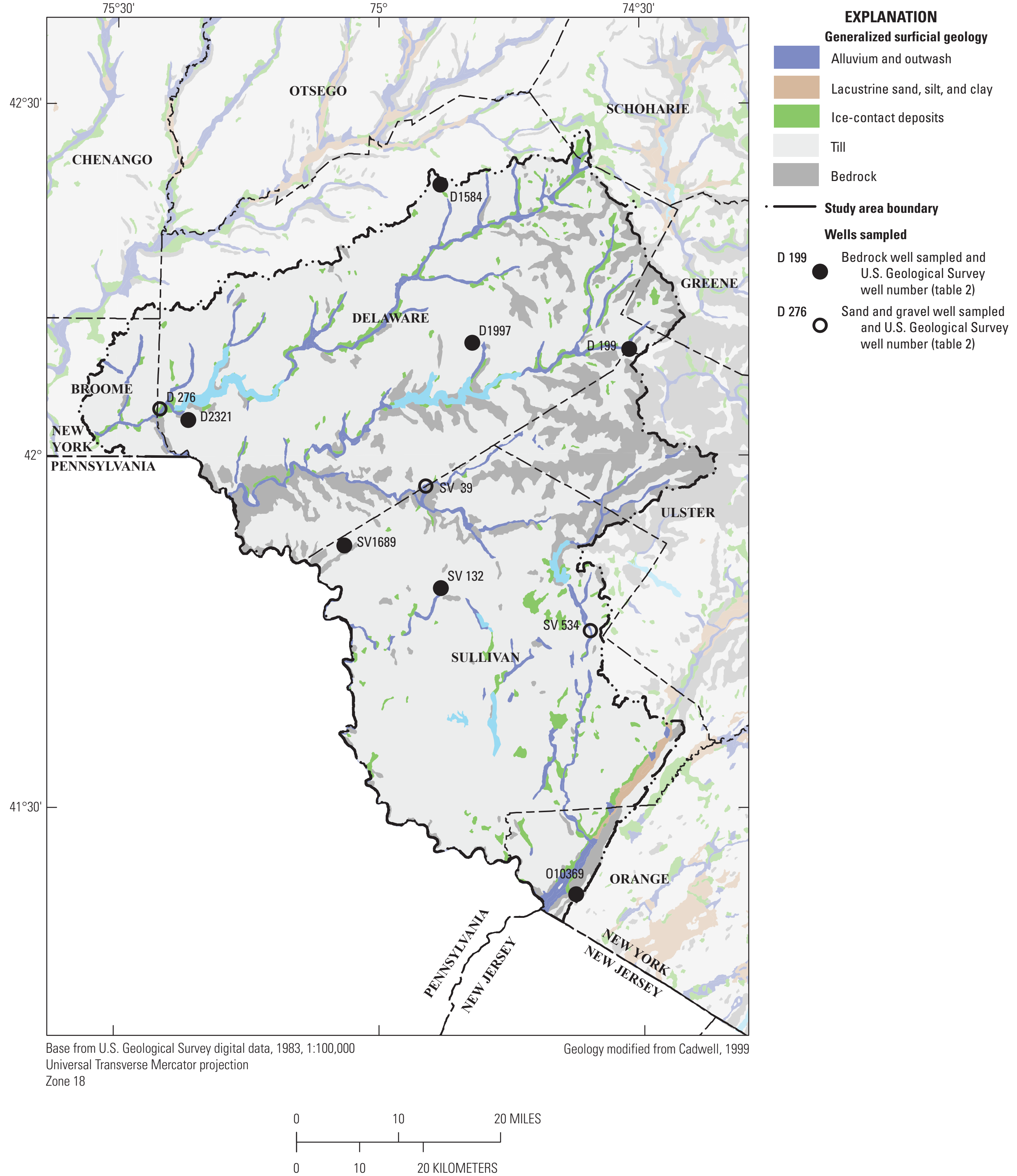

Figure 3. Generalized surficial geology of the Delaware River Basin, New York, and locations of wells sampled in 2015.

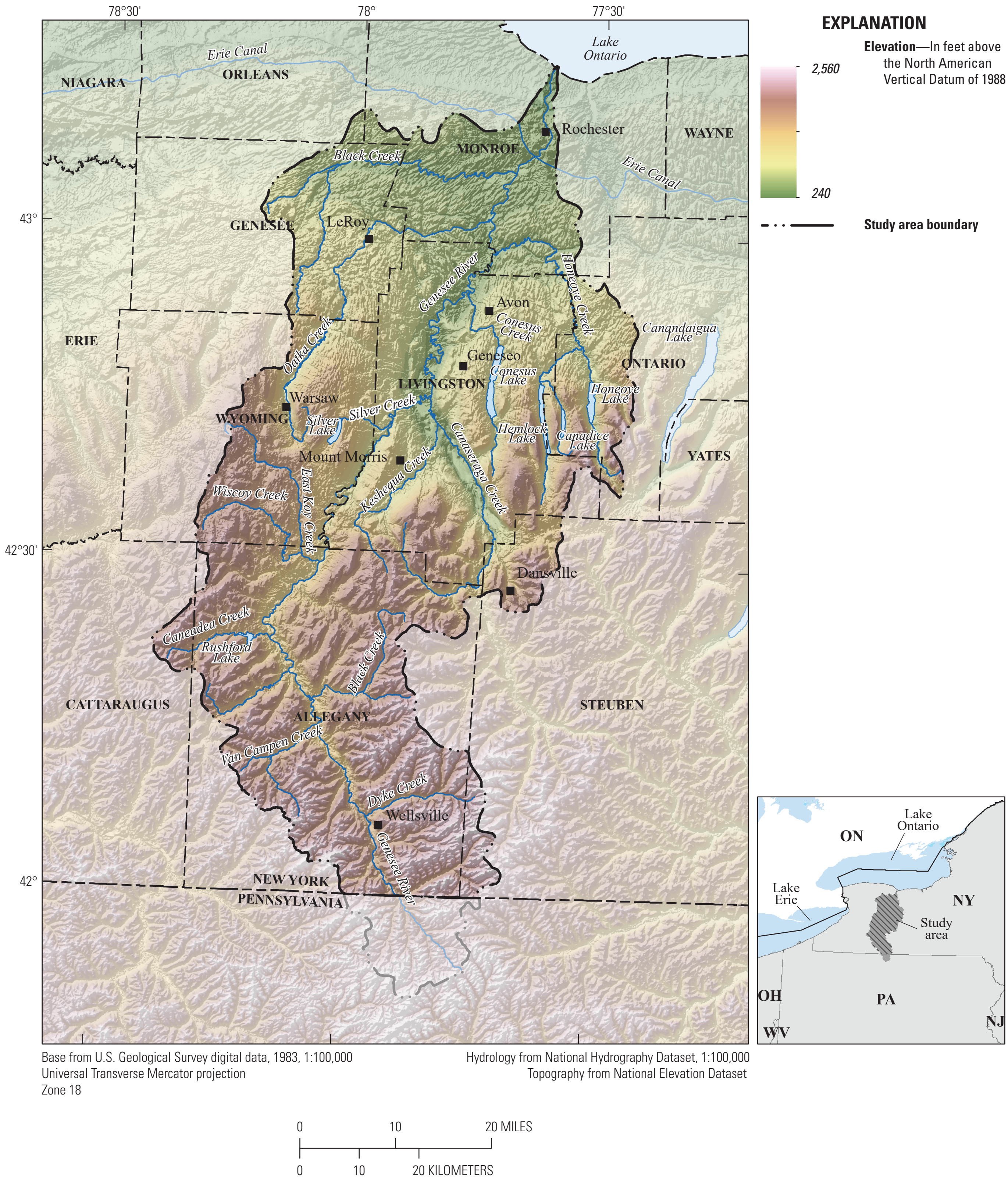

Figure 4. Topography and geography of the Genesee River Basin, New York.

Creek, and East Koy Creek, which is a tributary to Wiscoy Creek. The Genesee River Basin contains four of the western Finger Lakes (Conesus, Hemlock, Canadice, and Honeoye Lakes) and ultimately drains into Lake Ontario (fig. 4).

The highest elevations in the Genesee River Basin study area are more than 2,500 ft above NAVD 88 in the central and southern uplands (fig. 4). The lowest elevations in the study area are about 250 ft above NAVD 88, near where the Genesee River discharges into Lake Ontario (fig. 4). Precipitation in the Genesee River Basin averages around 33 in/yr (Randall, 1996). Land use is primarily forested and pasture in the steep uplands and narrow valleys that dominate the southern area of the basin; row-crop and dairy agriculture is concentrated in the broad alluvial valley and the low rolling hills of the central basin; and the Rochester metropolitan area dominates the relatively flat plain of the northern basin (fig. 4).

Bedrock in the Genesee River Basin (fig. 5) mainly consists of flat-lying, interbedded sedimentary units of shale, siltstone, sandstone, limestone, and dolostone of Silurian and Devonian age (Eckhardt and others, 2007). The surficial material throughout the Genesee River Basin was deposited primarily during the Pleistocene epoch Wisconsinan glaciation, when glacial ice covered most of the northeastern United States (Isachsen and others, 2000). Till, which was directly deposited by the glaciers, discontinuously overlies bedrock in the uplands (fig. 6). Ice-contact and outwash sand and gravel and lacustrine sand, silt, and clay were deposited mainly in valleys. Recent alluvium overlies the glacial deposits in the flood plains of the larger streams and rivers (Coates, 1966; Randall, 2001). In the Genesee River Basin, the most productive aquifers are the glacial and alluvial deposits of sand and gravel in the valleys. Lacustrine and till deposits are relatively impermeable and yield little water to wells (Coates, 1966; Randall, 2001). In the Genesee River Basin, the depths of sand-and-gravel wells sampled range from 25 to 199 ft bls, and the depths of bedrock wells sampled range from 50 to 262 ft bls. The bedrock wells are completed in clastic (shale and sandstone) or carbonate (limestone and dolostone) bedrock.

St. Lawrence River Basin

The St. Lawrence River Basin encompasses an area of nearly 300,000 mi^2 in the United States and Canada. The St. Lawrence River Basin study area encompasses 5,650 mi^2 in northeastern New York and lies downstream from Lake Ontario (fig. 7). The study area contains parts of eight counties, including St. Lawrence, Franklin, Clinton, Essex, Hamilton, Herkimer, Jefferson, and Lewis Counties (fig. 7). Major tributaries to the St. Lawrence River include the St. Regis River, Grass River, Raquette River, and Oswegatchie River (fig. 7). Other major contributing tributaries in the St. Lawrence River Basin include the Indian River, which is a tributary to the Oswegatchie River. The St. Lawrence River Basin contains many freshwater lakes, ponds, and reservoirs, the largest of which are Black Lake, Cranberry Lake, Raquette Lake, Tupper Lake, and Long Lake. The St. Lawrence River forms the outlet of the Great Lakes Basin, the largest fresh surface-water system in the world (Government of Canada and U.S. Environmental Protection Agency, 1995), and ultimately drains into the North Atlantic Ocean (fig. 7).

The highest elevations in the St. Lawrence River Basin study area are more than 4,000 ft above NAVD 88, along the southeastern edge of the basin in the Adirondack Mountains (fig. 7). The lowest elevations in the study area are about 150 ft above NAVD 88, along the northern edge of the study area in the St. Lawrence valley (fig. 7). Precipitation in the St. Lawrence River Basin study area (which only includes the area located in New York State) averages around 35 in/yr in the valley and lowlands and averages around 45 in/yr in the uplands (Randall, 1996). Land use is primarily forested; however, agricultural and urban areas in the study area are present mainly in the St. Lawrence Valley (Homer and others, 2015). Population centers include Malone, Massena, Lisbon, Ogdensburg, Potsdam, Canton, Gouverneur, Tupper Lake, and Blue Mountain Lake (fig. 7).

Bedrock in the St. Lawrence River Basin (fig. 8) is mainly crystalline, but two wide bands of carbonate and sandstone bedrock are present along the northern edge of the basin. As in the Delaware and Genesee River Basins, the surficial material throughout the St. Lawrence River Basin was deposited primarily during the Pleistocene epoch Wisconsinan glaciation, when glacial ice covered most of the northeastern United States (Isachsen and others, 2000). Till was directly deposited by the glaciers, and ice-contact and outwash sand and gravel and lacustrine sand, silt, and clay were deposited mainly in valleys. Recent alluvium overlies the glacial deposits in the flood plains of the larger streams and rivers (fig. 9) (Coates, 1966; Randall, 2001). Sand-and-gravel deposits generally produce the highest yields in the St. Lawrence study area, but the sandstone and carbonate aquifers along the northern edge of the basin in the St. Lawrence Valley (fig. 9) also produce moderate yields (Great Lakes Basin Commission, 1975). The crystalline bedrock in the Adirondack Mountains generally produces the lowest yields of the aquifers in the basin. Most wells in the St. Lawrence study area are completed in bedrock; production wells are completed in sand-and-gravel deposits where they are present. In the St. Lawrence River Basin, the depths of sand-and-gravel wells sampled range from 34 to 236 ft bls; the depths of bedrock wells that were sampled range from 80 to 600 ft bls. The bedrock wells are completed in clastic (sandstone), carbonate, or crystalline bedrock.

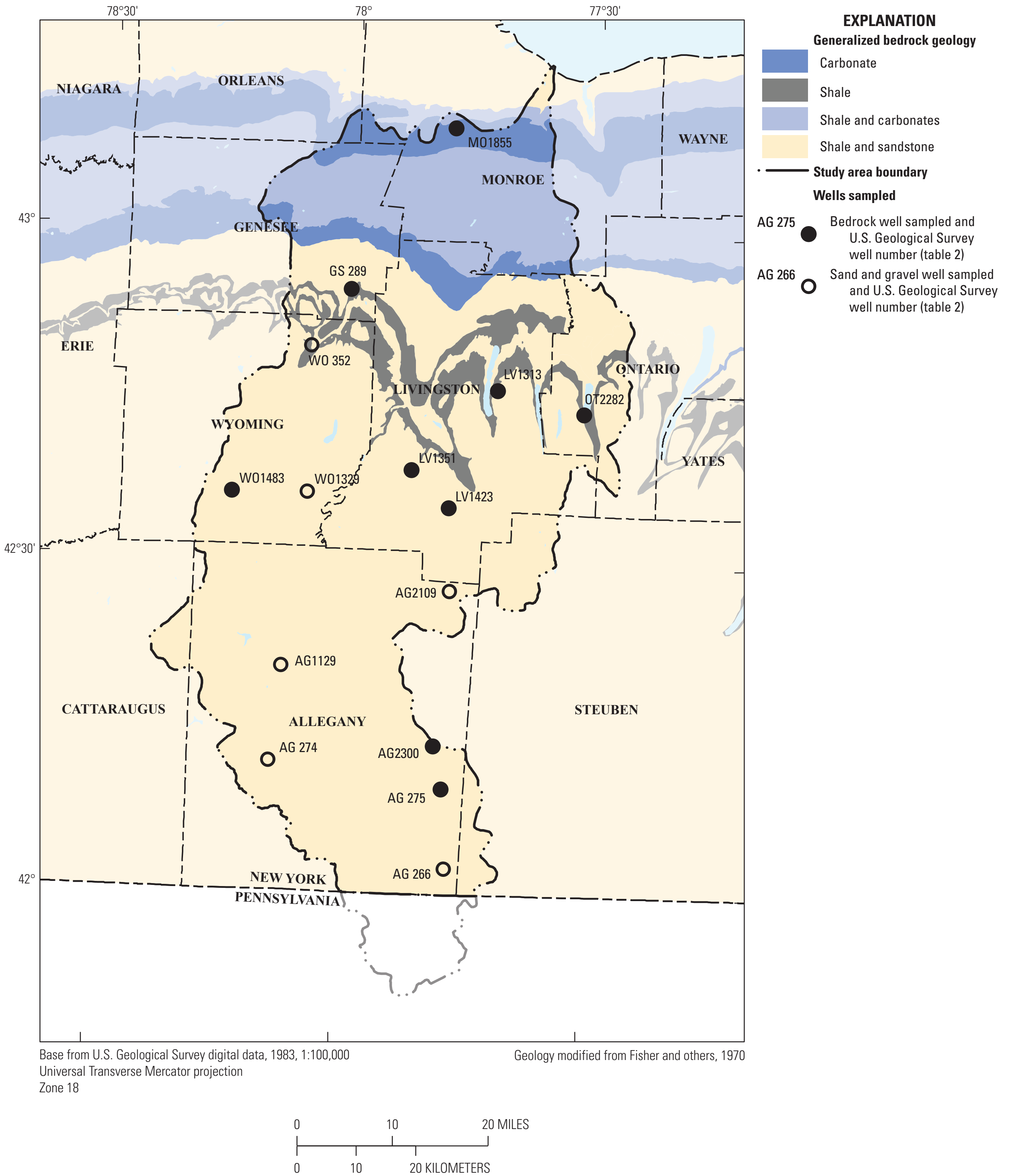

Figure 5. Generalized bedrock geology of the Genesee River Basin, New York, and locations of wells sampled in 2015.

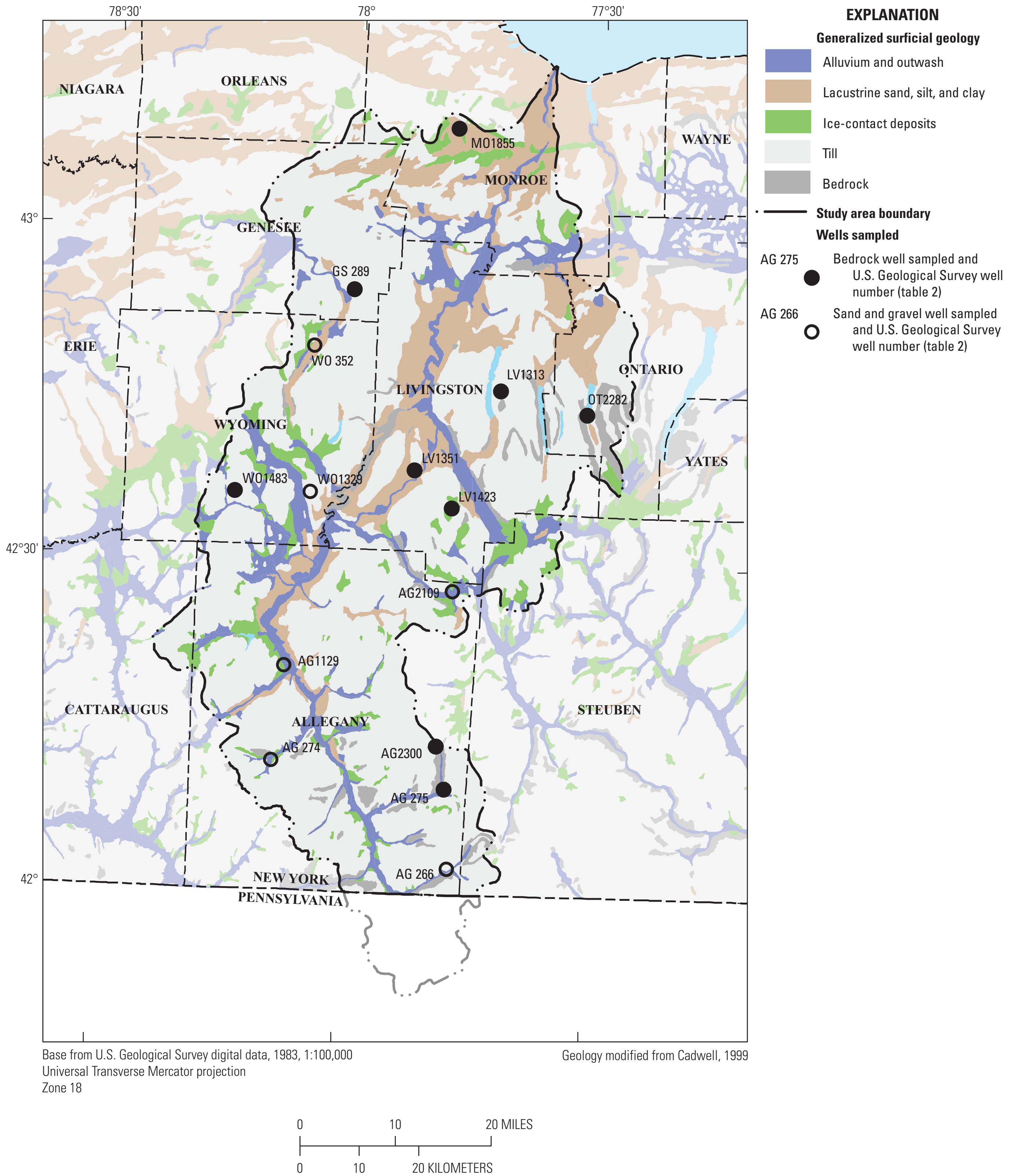

Figure 6. Generalized surficial geology of the Genesee River Basin, New York, and locations of wells sampled in 2015.

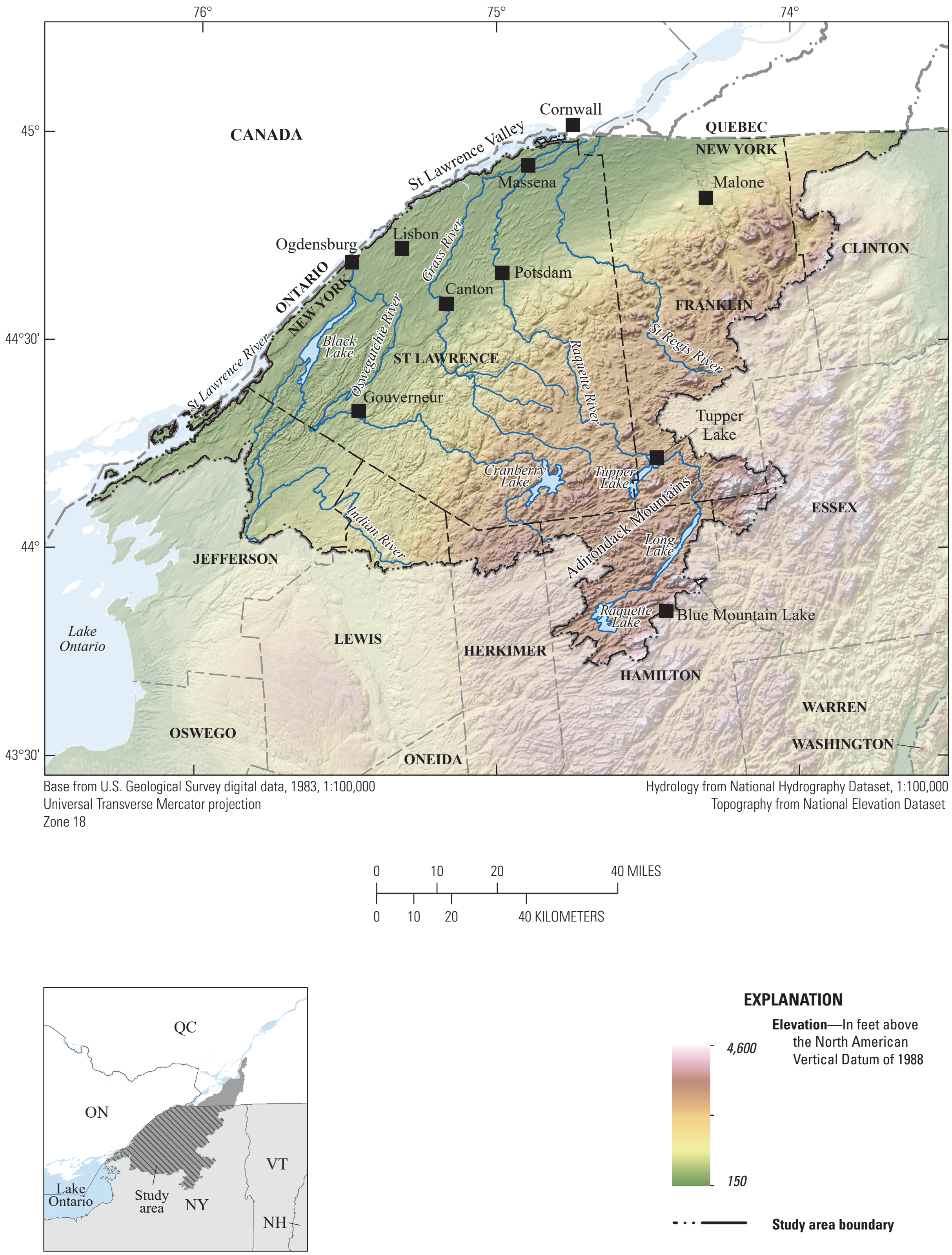

Figure 7. Topography and geography of the St. Lawrence River Basin, New York.

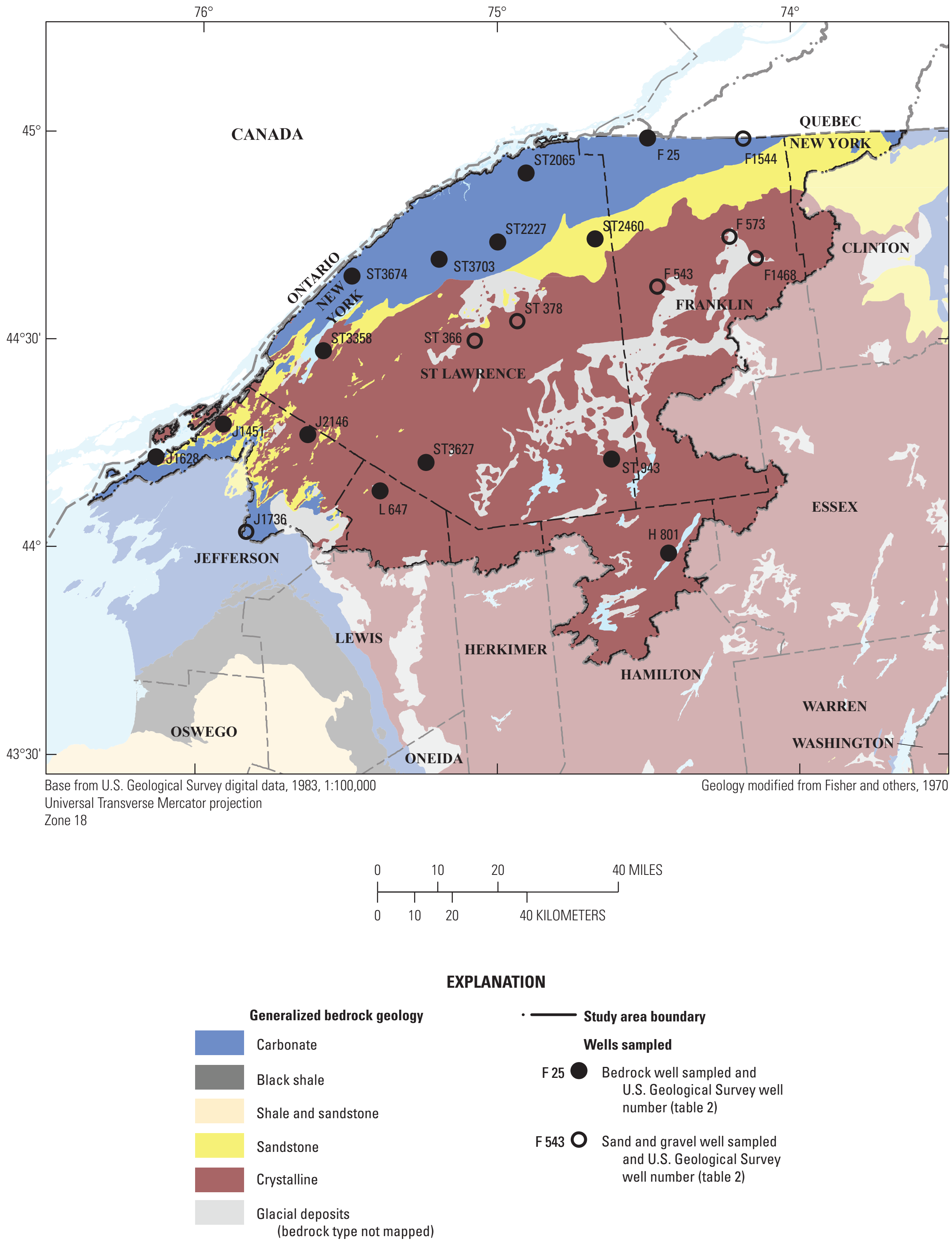

Figure 8. Generalized bedrock geology of the St. Lawrence River Basin, New York, and locations of wells sampled in 2015.

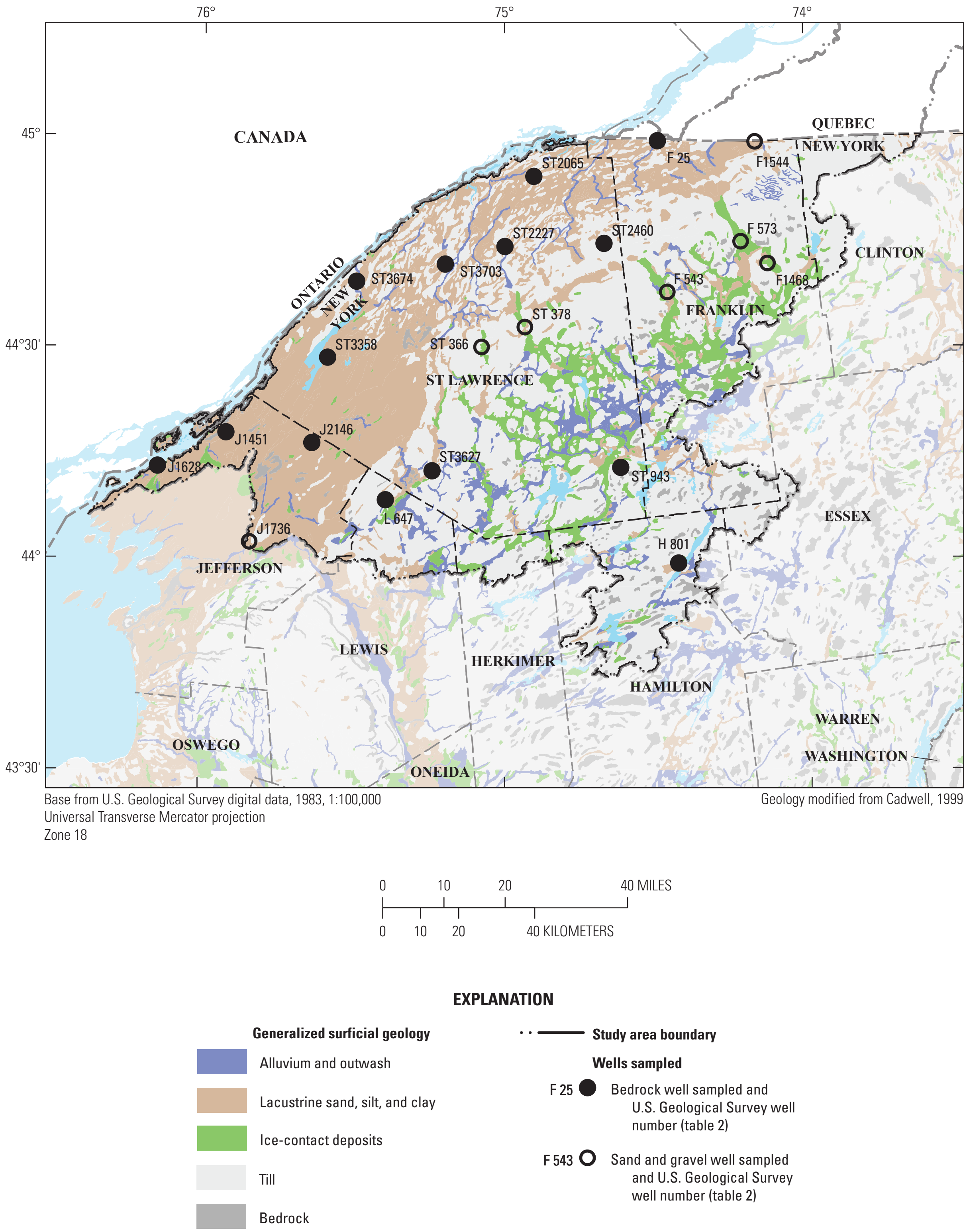

Figure 9. Generalized surficial geology of the St. Lawrence River Basin, New York, and locations of wells sampled in 2015.

Methods of Investigation

Well-selection criteria, sampling methods, and analytical methods were designed to maximize data precision, accuracy, and comparability. 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). Samples were analyzed at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, and other certified laboratories using published methods.

Well Selection

The 46 wells selected for sampling (figs. 2, 5, and 8) represent forested, developed, and agricultural areas (table 2). The final selection of each well for sampling was based on the availability of well-construction data and hydrogeologic information for the well and its surrounding area. The study did not target specific municipalities, industries, or agricultural practices. Wells were selected to represent an approximately equal number of domestic and production wells.

The domestic wells were selected on the basis of information from the NYSDEC Water Well program, which began in 2000. The program requires that licensed well drillers file a report with NYSDEC containing basic information about each well drilled, such as well and casing depth, diameter, yield, and a driller's log. Evaluation of data from well-completion reports identified several hundred wells as potential sampling sites; well owners were sent a letter requesting permission to sample the well and a questionnaire about the well. Well owners who granted permission were contacted later by phone to verify well information and to arrange for sampling.

Production wells considered for sampling were identified through the U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System, the New York State Department of Health (NYSDOH) Drinking Water Protection Program, and the NYSDEC Water Well Program. Town officials and (or) water managers were sent letters requesting permission to sample a well, and follow-up phone calls were made to arrange a time for sampling. Well information, such as depth, was provided by water managers if a well-completion report was unavailable. The aquifer type indicated for sampled wells was assigned through evaluation of driller's logs and published geologic maps, including Fisher and others (1970) and Cadwell (1999).

The characteristics of the wells sampled, the USGS-assigned county well numbers, and the type of land cover surrounding each well are listed in table 2. The depths of the wells and the aquifer units from which samples were collected are summarized in tables 2 and 3. Two Delaware River Basin wells sampled in 2015 (SV 534 and SV1689) were also sampled in 2010 (Nystrom, 2012); one of those wells (SV1689) was sampled as part of the 2005–6 round of the study as well (Nystrom, 2007a). Three Genesee River Basin wells sampled in 2015 (AG 266, AG1129, and WO 352) were also sampled in 2010 (Reddy, 2012). Four St. Lawrence River Basin wells sampled in 2015 (F 543, F 573, J1736, and ST 378) were also sampled in 2010 (Nystrom, 2012); three of those wells (F 543, F 573, ST 378) and one other well (ST 366) were sampled as part of the 2005–6 round of the study as well (Nystrom, 2007b). Domestic wells that are completed in sand-and-gravel aquifers are often finished with open-ended casing so that groundwater enters the well only through the end of the casing. Production wells, however, are typically completed with a well screen to maximize the well yield; the difference between the casing depth and the well depth in table 2 is the approximate screened interval for these wells. In some cases, production wells with lower yields are completed open-ended in sand-and-gravel aquifers with no screen. Bedrock wells, both domestic and production, are completed with a surface casing cemented several feet into competent bedrock, and the balance of the well is completed as an open hole in bedrock. In bedrock wells, groundwater moves mainly through bed partings, joints, and other fractures in the rock towards the wellbore under pumping conditions.

Sampling Methods

Water-quality samples were collected and processed in accordance with documented USGS protocols (U.S. Geological Survey, 2006). The samples were collected before any water-treatment system to be representative of the native aquifer water. Samples from domestic wells were collected from a spigot near the pressure tank; samples from production wells were collected at the spigot or faucet used for collection of raw-water samples by water managers.

Samples were collected from garden-hose-thread spigots at all sites where possible. Domestic wells were purged by pumping groundwater to waste for at least 20 minutes at pumping rates ranging from about 2 to 5 gal/min or until at least one well-casing volume of water had passed the sampling point. Generally, three casing volumes were evacuated from wells prior to sampling (U.S. Geological Survey, 2006); however, for wells that had been used recently, less than three casing volumes were purged, and wells were sampled when field physiochemical measurements (for example, temperature, pH, specific conductivity) stabilized. During well purging, notes about the well, surrounding land, and land use were recorded, including a global positioning system measurement of latitude and longitude. Field measurements of water temperature, pH, specific conductance, and dissolved oxygen concentration were recorded at the site by using portable instruments (U.S. Geological Survey, variously dated).

The flow rate for sample collection was adjusted to less than 0.5 gal/min when possible. The sampling tube was then connected to a sample-collection chamber constructed of a polyvinyl chloride frame and a clear plastic chamber bag, the purpose of which is to minimize the possibility of any airborne contaminants getting into the water samples. The tubing and spigot-attachment equipment for each sample were precleaned by using standard methods (U.S. Geological Survey, 2006).

Samples were collected and preserved in the sampling chamber according to standard USGS procedures (U.S. Geological Survey, 2006). Samples for nutrient, major-ion, and some trace-element analyses were filtered through disposable (one-time use) 0.45-micrometer (µm) pore-size polyether sulfone capsule filters that were preconditioned in the laboratory with 3 liters (L) of deionized water on the day of sample collection and stored on ice until use in the field. Since the time of the sampling for this project, advanced preconditioning of capsule filters prior to use has been found to be a source of total nitrogen and total Kjeldahl nitrogen contamination (U.S. Geological Survey, Office of Water Quality, Water-Quality Information Note 2017.03, written commun., 2017). Samples for pesticide analyses were filtered through baked 0.7-µm pore-size glass-fiber filters. Ultrapure nitric acid preservation was required for trace-element samples, except mercury, which was preserved with ultrapure hydrochloric acid. Hydrochloric acid was added to samples analyzed for VOCs to reduce the sample pH below 2.0 and kill bacteria that might degrade VOCs. Samples for major-cation analysis and some samples for radiochemical analysis were preserved with ultrapure nitric acid. Acid preservative was added after the collection of other samples to prevent the possibility of cross contamination by the acid preservative; for example, samples preserved with nitric acid were acidified after the collection of samples for nutrient analysis. Water samples for radon analysis were collected through a septum chamber with a glass syringe, according to standard USGS procedures (U.S. Geological Survey, 2006). Bottles containing water samples for the analysis of dissolved gases were filled and sealed while submerged in a beaker of well water to prevent exposure to the atmosphere. Samples for bacterial analysis were collected in accordance with NYSDEC and NYSDOH protocols (American Public Health Association, 1998), except that the tap from which each water sample was collected was not flame sterilized. Water samples for bacterial analysis were collected in sterilized bottles provided by the NYSDOH-certified analyzing laboratory. After collection, all water samples except those for radiochemical analyses were chilled to 4 degrees Celsius (°C) or less and were kept chilled until delivery to the analyzing laboratory. Bacterial samples were hand delivered to the analyzing laboratory within 6 hours of collection; all other samples were shipped by overnight delivery to the designated laboratories.

Analytical Methods

Samples were measured for 148 physiochemical properties and constituents, including dissolved gases, major ions, nutrients, trace elements, pesticides, pesticide degradates, VOCs, radionuclides, and bacteria. Water temperature, pH, dissolved oxygen concentration, and specific conductance were measured at the sampling site. Major ions, nutrients, total organic carbon, trace elements, radon-222, pesticides, pesticide degradates, and VOCs were analyzed at the USGS NWQL in Denver, Colo. Selected dissolved gases were analyzed at the USGS Chlorofluorocarbon Laboratory in Reston, Virginia. Gross-alpha (gross-α) and gross-beta (gross-β) radioactivities were analyzed at ALS Environmental in Fort Collins, Colo. Samples were analyzed for indicator bacteria at the following NYSDOH-certified laboratories: Delaware River Basin samples were analyzed at the St. Peter’s Bender Laboratory in Albany, New York; Genesee River Basin samples were analyzed at Community Science Institute in Ithaca, N.Y.; St. Lawrence River Basin samples were analyzed at the Life Science Laboratories in Waddington, N.Y.

Anion concentrations were measured by ion-exchange chromatography, and cation concentrations were measured by inductively coupled plasma-atomic emission spectrometry (ICP–AES), as described in Fishman (1993). Color was determined by visual comparison using method I–1250–85 (Fishman and Friedman, 1989). Nutrients were analyzed by colorimetry, as described by Fishman (1993), and Kjeldahl digestion with photometric finish, as described by Patton and Truitt (2000). Nitrate was calculated by subtracting the nitrite from the measured values of nitrate plus nitrite. Total organic carbon samples were analyzed by high-temperature combustion and catalytic oxidation for measurement by infrared detection according to Standard Method 5310B (American Public Health Association, 1998). Mercury concentrations were measured through cold vapor-atomic fluorescence spectrometry according to methods described by Garbarino and Damrau (2001). Arsenic, chromium, and nickel were analyzed by use of collision/reaction cell inductively coupled plasma-mass spectrometry, as described by Garbarino and others (2006). The remaining trace elements were analyzed by ICP–AES (Struzeski and others, 1996), inductively coupled plasma-optical emission spectrometry, and inductively coupled plasma-mass spectrometry (Garbarino and Struzeski, 1998). Procedures for in-bottle digestions for trace-element analyses described by Hoffman and others (1996) were followed. Radon-222 activities were measured through liquid-scintillation counting (ASTM International, 2006). Samples for pesticide analyses were processed as described by Wilde and others (2009) and were analyzed by gas chromatography-mass spectrometry (GC–MS) and high-performance liquid chromatography-mass spectrometry, as described by Zaugg and others (1995), Sandstrom and others (2001), and Furlong and others (2001). VOCs were analyzed by GC–MS according to methods described by Connor and others (1998).

Gross-α and gross-β radioactivities were measured according to EPA method 900.0 (U.S. Environmental Protection Agency, 1980). Carbon dioxide and methane concentrations were measured through gas chromatography with flame ionization detection; dissolved nitrogen gas and argon concentrations were measured using gas chromatography with thermal conductivity detection (Busenberg and others, 1998). Indicator bacteria samples were tested for total coliforms, fecal coliforms (also known as thermotolerant coliforms),

Table 2. Description of wells from which water samples were collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[Well locations are shown in figures 2 and 3 (Delaware Basin), figures 5 and 6 (Genesee River Basin), and figures 8 and 9 (St. Lawrence River Basin). Well types: P, production; D, domestic; M, municipal. Land-cover categories: D, developed; F, forested; A, agricultural; W, open water; WL, wetlands. --, unknown]

Well number[1]	Station identification number	Date sampled (mm/dd/yyyy)	Well depth, in feet below land surface	Casing depth, in feet below land surface	Well type	Bedrock type	Land cover,[2] percentage by category, within 0.5-mile radius surrounding the well				
							D	F	A	W	WL
Delaware River Basin											
Sand-and-gravel wells											
D 276	420357075245901	10/19/2015	120	110	P	--	45	22	23	5	5
SV 39	415601074544901	10/20/2015	90	--	P	--	5	73	14	1	7
SV 534	414504074355301	10/21/2015	42	34	P	--	17	46	31	3	3
Bedrock wells											
D 199	420924074315601	10/14/2015	200	--	P	Shale and sandstone	20	80			
D1584	422309074525301	10/13/2015	195	47	D	Shale and sandstone	3	55	37		4
D1997	420940074492001	10/6/2015	198	90	D	Shale and sandstone	1	96	2		
D2321	420302075214301	10/19/2015	200	100	D	Shale and sandstone	4	87	1	7	1
O10369	412234074374001	10/5/2015	320	100	D	Shale and sandstone	23	71		4	2
SV 132	414831074531101	10/21/2015	400	--	P	Shale and sandstone	7	81	12		
SV1689	415220075034801	10/7/2015	380	10	D	Shale and sandstone	4	96			
Genesee River Basin											
Sand-and-gravel wells											
AG 266	420219077462301	7/21/2015	78	--	P	--	13	60	26		
AG 274	421139078082901	7/20/2015	85	85	P	--	5	47	48		
AG1129	422018078071901	7/15/2015	199	198	P	--	29	11	55		5
AG2109	422729077465601	7/28/2015	94	92	P	--	18	20	56		6
WO 352	424924078045901	7/14/2015	25	--	P	--	14	7	43		36
WO1329	423606078044901	5/27/2015	115	103	P	--	5	27	55	1	12
Bedrock wells											
AG 275	420927077471501	7/27/2015	262	49	P	Shale and sandstone	31	50	17	1	2
AG2300	421317077481701	6/16/2015	123	55	D	Shale and sandstone	2	58	40		
GS 289	425437078001601	6/24/2015	50	--	P	Shale	12	19	64		4
LV1313	424550077414701	7/13/2015	110	76.5	D	Shale and sandstone	4	47	50		
LV1351	423823077520501	5/26/2015	105	42.5	D	Shale and sandstone	7	44	48		1
LV1423	423500077472501	6/9/2015	75	19	D	Shale and sandstone	3	45	52		1
MO1855	430933077480001	6/17/2015	50	19	D	Carbonate	9	6	78		7
OT2282	424349077310401	6/10/2015	89	60.5	D	Shale	11	44	1	45	
WO1483	423559078140601	7/1/2015	130	30.5	D	Shale and sandstone	4	24	72		

Table 2. Description of wells from which water samples were collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.—Continued

[Well locations are shown in figures 2 and 3 (Delaware Basin), figures 5 and 6 (Genesee River Basin), and figures 8 and 9 (St. Lawrence River Basin). Well types: P, production; D, domestic; M, municipal. Land-cover categories: D, developed; F, forested; A, agricultural; W, open water; WL, wetlands. --, unknown]

Well number[1]	Station identification number	Date sampled (mm/dd/yyyy)	Well depth, in feet below land surface	Casing depth, in feet below land surface	Well type	Bedrock type	Land cover,[2] percentage by category, within 0.5-mile radius surrounding the well: D	F	A	W	WL
St. Lawrence River Basin											
Sand-and-gravel wells											
F 543	443758074273001	11/18/2015	90	78	M	--	8	77	2	7	7
F 573	444455074124102	11/18/2015	236	152	P	--	7	88	2		3
F1468	444204074073301	11/18/2015	140	133.5	D	--	8	31		35	26
F1544	445916074095001	11/16/2015	151.6	151.6	D	--	1	24	43		11
J1736	440229075501101	11/5/2015	41	20	P	--	54	21	21		4
ST 366	443021075042901	11/17/2015	34	8	P	--	1	78	12	1	9
ST 378	443306074555101	11/17/2015	65	54	P	--	12	60	5	13	9
Bedrock wells											
F 25	445933074291801	11/16/2015	260	80	P	Carbonate	21	18	38	4	10
H 801	435928074263901	11/2/2015	482	60	D	Crystalline	2	93			4
J1451	441758075550101	11/4/2015	80	20	D	Sandstone	3	32	47		18
J1628	441307076082501	11/4/2015	220	20	D	Sandstone	4	55	15	26	
J2146	441636075375701	11/4/2015	165	92	D	Crystalline	2	39	38	1	19
L 647	440824075232501	11/5/2015	290	20	D	Carbonate	1	43		44	11
ST 943	441301074364801	11/2/2015	600	96	P	Crystalline	3	76			20
ST2065	445435074540402	11/19/2015	256	39	D	Carbonate	15	41	20	11	13
ST2227	444439074594601	11/16/2015	260	43	P	Carbonate	38	37	9	4	11
ST2460	444456074400301	11/3/2015	98	85	D	Sandstone	1	60	34		4
ST3358	442844075350101	11/19/2015	80	20	D	Carbonate	5	40	9	1	46
ST3627	441245075142601	11/3/2015	120	100	D	Carbonate	1	69	8	2	20
ST3674	443927075291301	11/16/2015	85	20	D	Carbonate	5	38	32	12	14
ST3703	444200075114801	11/3/2015	197	70	D	Sandstone	2	9	57		33

[1]Prefix denotes county: AG, Allegany; D, Delaware; F, Franklin; GS, Genesee; H, Hamilton; J, Jefferson; L, Lewis; LV, Livingston; MO, Monroe; O, Orange; OT, Ontario; ST, St. Lawrence; SV, Sullivan; WO, Wyoming. Number is local well-identification number assigned by the U.S. Geological Survey.

[2]Determined from the National Land Cover Database (Homer and others, 2015).

Table 3. Summary of 46 wells from which water samples were collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[bls, below land surface]

Basin and type of well	Number of wells		
	Production	Domestic	Total
Delaware River Basin			
Wells completed in sand and gravel (depth 42 to 120 feet bls)	3	0	**3**
Wells completed in bedrock (depth 195 to 400 feet bls)	2	5	**7**
Total for all well types	5	5	**10**
Genesee River Basin			
Wells completed in sand and gravel (depth 25 to 199 feet bls)	6	0	**6**
Wells completed in bedrock (depth 50 to 262 feet bls)	2	7	**9**
Total for all well types	8	7	**15**
St. Lawrence River Basin			
Wells completed in sand and gravel (depth 34 to 236 feet bls)	[1]5	2	**7**
Wells completed in bedrock (depth 80 to 600 feet bls)	3	11	**14**
Total for all well types	8	13	**21**
Total for all basins	**21**	**25**	**46**

[1]Includes one municipal well.

and *Escherichia coli* (*E. coli*) by using membrane filtration and Standard Method 9222; a heterotrophic plate count test (SM 9215 B) also was done (American Public Health Association, 1998).

Quality-Control Samples

In addition to the 46 groundwater samples, 3 field blank samples and 1 replicate sample were collected for quality assurance. Additionally, 27 topical blank samples were collected for analysis of ammonia and ammonia-plus-organic nitrogen, and 3 partial replicates were collected for analysis of bacteria, radon, gross-α, gross-β, and dissolved gasses. Only the following constituents were detected in blanks; no other constituents were detected in any blanks. Silica was detected in all three of the complete field blanks, one of which was collected in each of the three basins. Silica was measured at 0.050 milligram per liter (mg/L) in the blank collected in the Delaware River Basin, 0.523 mg/L in the blank collected in the Genesee River Basin, and 0.078 mg/L in the blank collected in the St. Lawrence River Basin. The laboratory reporting level (LRL), which is the concentration at which the false negative error rate is minimized to be no more than 1 percent of the reported results (Childress and others, 1999), for silica is 0.018 mg/L. The minimum silica concentration in the environmental samples was 3.59 mg/L. Manganese (unfiltered) was measured at 13.5 micrograms per liter (µg/L) in one of the field blanks, collected in the Delaware River Basin. Six samples from the Delaware River Basin had manganese detections less than 13.5 µg/L and were given a "V" remark code in the associated tables and discussion in this report. The "V" remark codes indicate that a value may be affected by contamination; the analyte was detected in environmental samples and the associated blanks.

An additional emphasis was placed on analyzing blanks specifically for ammonia and ammonia-plus-organic nitrogen during the 2015 round of sampling to investigate an issue with low-level ammonia detections in field blanks from past rounds of sampling. A combination of field blanks, equipment blanks, and source solution blanks were analyzed with 30 blank samples from all 3 basins (3 blanks from the previously mentioned field blanks and 27 additional blanks) for ammonia and ammonia-plus-organic nitrogen. Thirteen of the blank samples had an ammonia concentration right at the LRL (0.01 mg/L), and one blank sample had a slightly higher detection (0.02 mg/L). Ammonia was detected in all types of blanks, including source solution blanks, indicating that the blank water itself was contaminated, possibly from atmospheric sources. Ammonia plus organic nitrogen was detected in three field blanks, one from the Delaware River Basin (0.10 mg/L) and two from the Genesee River Basin (0.07 and 0.25 mg/L). These ammonia plus organic nitrogen detections in blanks were found to be the result of contamination from the advanced preconditioning of capsule filters with deionized water prior to filtration (U.S. Geological Survey, Office of Water Quality, Water-Quality Information Note 2017.03, written commun., 2017). It is possible that the ammonia blank detections are also a result of this practice. The LRL for ammonia plus organic nitrogen is 0.07 mg/L. For both ammonia and ammonia-plus-organic nitrogen, a "V" remark code was assigned to detections to indicate possible contamination.

A complete replicate sample was collected at one Delaware River Basin well, and three partial replicate samples were collected, one in each basin. The variability between the complete replicate samples from the Delaware River Basin well was less than 12 percent for all constituents. For the partial replicates, which only compared results from bacteria, radon, gross-α, gross-β, and dissolved gas analyses, variability between replicate samples was less than 20 percent for all constituents with the exception of heterotrophic plate count (in samples from all three basins) and low-level gross-α and gross-β (in samples from the Delaware and St. Lawrence River Basins).

Groundwater Quality

Many of the constituents for which the groundwater samples were analyzed were not detected in any sample. Some concentrations are reported as "E" for estimated. Estimated concentrations are typically reported when the detected value is less than the established LRL or when recovery of a compound has been shown to be highly variable (Childress and others, 1999). Some concentrations are reported with a "V" remark code, which indicates that a value may be affected by contamination; the analyte was detected in environmental samples and the associated blank sample.

Concentrations of some constituents exceeded maximum contaminant levels (MCLs) or secondary drinking-water standards (SDWSs) set by the EPA (U.S. Environmental Protection Agency, 2012) or NYSDOH (New York State Department of Health, 2011), or proposed alternative MCLs set by the EPA (U.S. Environmental Protection Agency, 1999) (table 4). MCLs are enforceable standards for finished water in public water supplies; they are not enforceable for private homeowner wells but are presented here as standards for evaluation of the water-quality results. SDWSs are nonenforceable drinking-water standards that typically relate to aesthetic concerns such as taste, odor, or staining of plumbing fixtures. Well owners were notified promptly if any constituent exceeded EPA or NYSDOH MCLs. Copies of the complete analytical results were mailed to each well owner.

The results of analyses of the 46 groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins from May through November 2015 are presented in appendix 1 (tables 1.1 through 1.9) and are available online through the USGS National Water Information System (https://nwis.waterdata.usgs.gov/ny/nwis/qw; U.S. Geological Survey, 2018) by using the station identification number given in table 2. Of the 148 constituents and physiochemical properties analyzed for, 78 (or 53 percent) were not detected at levels greater than the LRLs in any sample (appendix table 1.1). Results for the remaining 70 constituents and properties that were detected in the Delaware, Genesee, and St. Lawrence River Basins are presented in appendix tables 1.2 through 1.9.

Physiochemical Properties

Groundwater samples were analyzed in the field for physiochemical properties, including water temperature, pH, specific conductance, and dissolved oxygen. Samples were collected for analysis of color. Qualitative assessment of the presence of hydrogen sulfide (based on odor) was noted. Results of analyses are reported in table 5 and in appendix table 1.2. The numbers of samples that exceeded drinking-water standards for physiochemical properties are reported in table 6. No drinking-water standards exist for specific conductance or water temperature.

Most samples from the Delaware River Basin had a color of less than (<) 1 platinum-cobalt (Pt-Co) unit (tables 5, 6, and appendix table 1.2). One sample, from a bedrock well (D 199) had a color of 2 Pt-Co units. Two samples, one from a bedrock well (SV 132) and one from a sand-and-gravel well (SV 39), had color of 5 Pt-Co units. One sample, from a bedrock well (O10369), had a color of 15 Pt-Co units, which was equal to the EPA SDWS of 15 Pt-Co units (U.S. Environmental Protection Agency, 2012). Sample pH was typically slightly below neutral (median of 6.6 for sand-and-gravel wells, 6.8 for bedrock wells) and ranged from 5.3 to 7.2. The pH values for samples from two bedrock wells (D1584 and O10369) and one sand-and-gravel well (SV 534) were 5.7, 5.3 and 5.4, respectively, and are lower than the EPA SDWS range of 6.5–8.5 for pH (U.S. Environmental Protection Agency, 2012). Specific conductance ranged from 91 to 287 microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C); the median specific conductance was 282 μS/cm at 25 °C for sand-and-gravel wells and 158 μS/cm at 25 °C for bedrock wells. Water temperature ranged from 8.4 to 12.6 °C; the median temperature was 10.7 °C for sand-and-gravel wells and 10.2 °C for bedrock wells. Hydrogen sulfide odor was not detected in any wells sampled in the Delaware River Basin.

Most samples from the Genesee River Basin had a color of <1 Pt-Co units (tables 5, 6, and appendix table 1.2). Three samples, two from sand-and-gravel wells (AG1129, AG2109) and one from a bedrock well (LV1423), had colors of 2 Pt-Co units. One sample from a bedrock well (LV1313) had a color of 8 Pt-Co units. One sample from a bedrock well (LV1351) had a color of 15 Pt-Co units, which is equal to the EPA SDWS. Sample pH was typically near neutral (median of 7.9 for sand-and-gravel wells, 7.4 for bedrock wells) and ranged from 7.0 to 8.2. Specific conductance ranged from 268 to 2,270 μS/cm at 25 °C; the median specific conductance was 435 μS/cm at 25 °C for sand-and-gravel wells and 744 μS/cm at 25 °C for bedrock wells. Water temperature ranged from 9.8 to 16.1 °C; the median temperature was 10.5 °C for sand-and-gravel wells and 13.1 °C for bedrock wells. Hydrogen sulfide odor was detected in two sand-and-gravel wells (AG 274, AG2109) and four bedrock wells (GS 289, LV1351, OT2282, WO1483).

Most samples from the St. Lawrence River Basin had a color of <1 Pt-Co units (tables 5, 6, and appendix table 1.2). Two samples from bedrock wells (J1628, ST3703) had low

Table 4. Constituents that exceeded primary, secondary, and (or) proposed drinking-water standards in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[Well locations are shown in figures 2 and 3 (Delaware River Basin), figures 5 and 6 (Genesee River Basin), and figures 8 and 9 (St. Lawrence River Basin). Well types: P, production; D, domestic; M, municipal. --, not applicable; pAMCL, proposed alternative maximum contaminant level; pMCL, proposed maximum contaminant level; f, in filtered water; u, in unfiltered water]

Well number[1]	Well type	Bedrock type	Constituents that exceeded drinking-water standards
Delaware River Basin			
Sand-and-gravel wells			
D 276	P	--	Radon[5] (pAMCL)
SV 39	P	--	Manganese (f,u),[6] radon[5] (pAMCL)
SV 534	P	--	pH,[6] radon[5] (pAMCL)
Bedrock wells			
D 199	P	Shale and sandstone	Radon[5] (pAMCL)
D1584	D	Shale and sandstone	pH,[6] radon[5] (pAMCL), total coliform[2,3,4]
D1997	D	Shale and sandstone	Radon[5] (pAMCL), total coliform[2,3,4]
D2321	D	Shale and sandstone	Iron (u),[3,6] manganese (f,u),[6] radon[5] (pAMCL)
O10369	D	Shale and sandstone	pH,[6] iron (f,u),[3,6] manganese (f,u),[6] radon[5] (pAMCL)
SV 132	P	Shale and sandstone	Radon[5] (pAMCL)
SV1689	D	Shale and sandstone	Aluminum,[6] radon[5] (pAMCL)
Genesee River Basin			
Sand-and-gravel wells			
AG 266	P	--	Radon[5] (pAMCL)
AG 274	P	--	Iron (f,u),[3,6] manganese (f,u),[6] radon[5] (pAMCL)
AG1129	P	--	Arsenic,[2,3] sodium,[7] methane,[8] iron (f,u),[3,6] manganese (u),[6] radon[5] (pAMCL)
AG2109	P	--	Iron (f,u),[3,6] manganese (f,u),[6] radon[5] (pAMCL)
WO 352	P	--	Radon[5] (pAMCL)
WO1329	P	--	Iron (f,u),[3,6] manganese (f,u)[6]
Bedrock wells			
AG 275	P	Shale and sandstone	Sodium,[7] radon[5] (pAMCL), total coliform[2,3,4]
AG2300	D	Shale and sandstone	Aluminum,[6] iron (u),[3,6] manganese (u),[3,6] radon[5] (pAMCL)
GS 289	P	Shale	Sodium,[7] dissolved solids,[6] iron (f,u),[3,6] total coliform[2,3,4]
LV1313	D	Shale and sandstone	Methane,[8] manganese (f,u)[6]
LV1351	D	Shale and sandstone	Arsenic,[2,3] iron (f,u),[3,6] manganese (f,u),[6] radon[5] (pAMCL)
LV1423	D	Shale and sandstone	Manganese (f,u),[6] radon[5] (pAMCL), total coliform,[2,3,4] fecal coliform,[2,3,4] *E. coli*[2,3,4]
MO1855	D	Carbonate	Sodium,[7] dissolved solids,[6] radon,[5] total coliform[2,3,4]
OT2282	D	Shale	Methane,[8] sodium,[7] dissolved solids,[6] chloride,[3,6] manganese (f,u),[6] aluminum,[6] iron (f,u),[3,6] radon[5] (pAMCL), total coliform[2,3,4]
WO1483	D	Shale and sandstone	Sodium,[7] aluminum,[6] iron (u),[3,6] radon[5] (pAMCL), total coliform[2,3,4]

Table 4. Constituents that exceeded primary, secondary, and (or) proposed drinking-water standards in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.—Continued

[Well locations are shown in figures 2 and 3 (Delaware River Basin), figures 5 and 6 (Genesee River Basin), and figures 8 and 9 (St. Lawrence River Basin). Well types: P, production; D, domestic; M, municipal. --, not applicable; pAMCL, proposed alternative maximum contaminant level; pMCL, proposed maximum contaminant level; f, in filtered water; u, in unfiltered water]

Well number[1]	Well type	Bedrock type	Constituents that exceeded drinking-water standards
St. Lawrence River Basin			
Sand-and-gravel wells			
F 543	M	--	pH,[6] radon[5] (pAMCL)
F 573	P	--	Radon[5] (pAMCL)
F1468	D	--	Radon[5] (pAMCL)
F1544	D	--	Manganese (f,u),[6] radon[5] (pAMCL)
J1736	P	--	Sodium,[7] dissolved solids,[6] chloride,[3,6] manganese (f,u)[6]
ST 366	P	--	Radon[5] (pAMCL)
ST 378	P	--	Radon[5] (pAMCL)
Bedrock wells			
F 25	P	Carbonate	--
H 801	D	Crystalline	Radon[5] (pAMCL)
J1451	D	Sandstone	Radon5 (pAMCL)
J1628	D	Sandstone	Sodium,[7] dissolved solids6
J2146	D	Crystalline	Dissolved solids,[6] manganese (f,u),[6] radon[5] (pAMCL)
L 647	D	Carbonate	Radon[5] (pAMCL)
ST 943	P	Crystalline	Radon[5] (pAMCL)
ST2065	D	Carbonate	Sodium,[7] dissolved solids,[6] chloride,[3,6] sulfate[3,6]
ST2227	P	Carbonate	Iron (f,u),[3,6] manganese (f,u)[6]
ST2460	D	Sandstone	Radon[5] (pAMCL)
ST3358	D	Carbonate	Dissolved solids,[6] nitrate,[2,3] radon[5] (pAMCL), total coliform,[2,3,4] fecal coliform,[2,3,4] *E. coli*[2,3,4]
ST3627	D	Carbonate	Radon[5] (pAMCL)
ST3674	D	Carbonate	Iron (f,u)[3,6]
ST3703	D	Sandstone	--

[1]Prefix denotes county: AG, Allegany; D, Delaware; F, Franklin; GS, Genesee; H, Hamilton; J, Jefferson; L, Lewis; LV, Livingston; MO, Monroe; O, Orange; OT, Ontario; ST, St. Lawrence; SV, Sullivan; WO, Wyoming. Number is local well-identification number assigned by the U.S. Geological Survey.

[2]U.S. Environmental Protection Agency (2012) maximum contaminant level.

[3]New York State Department of Health (2011) maximum contaminant level.

[4]Maximum contaminant level exceedances for bacteria in public drinking-water supplies are generally defined in terms of a certain number of positive samples per month on the basis of the number of samples collected.

[5]U.S. Environmental Protection Agency (1999) proposed alternative maximum contaminant level of 300 picocuries per liter for areas that do not implement an indoor-air radon mitigation program.

[6]U.S. Environmental Protection Agency (2012) secondary drinking water standard.

[7]U.S. Environmental Protection Agency (2012) drinking water advisory taste threshold.

[8]Methane concentration above recommended monitoring concentration (Eltschlager and others, 2001).

Table 5. Summary statistics for physiochemical properties of and dissolved gases in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[**Bold** values exceed one or more drinking-water or safety standards. All concentrations in unfiltered water; Pt-Co units, platinum-cobalt units; mg/L, milligram per liter; µS/cm at 25 ºC, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius; <, value less than laboratory reporting level]

Constituent	Delaware River Basin						Genesee River Basin						St. Lawrence River Basin					
	Sand-and-gravel aquifers (3 samples)			Bedrock aquifers (7 samples)			Sand-and-gravel aquifers (6 samples)			Bedrock aquifers (9 samples)			Sand-and-gravel aquifers (7 samples)			Bedrock aquifers (14 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Color, filtered, Pt-Co units	<1	<1	5	<1	<1	15	<1	<1	2	<1	<1	15	<1	0	12	<1	<1	12
Dissolved oxygen, mg/L	2.7	4.4	6.0	<0.3	4.1	7.7	0.4	0.6	3.6	<0.3	0.7	6.3	<0.3	3.6	11.6	<0.3	0.4	9.2
pH	**5.4**	6.6	6.6	**5.3**	6.8	7.2	7.0	7.9	8.2	7.0	7.4	8.1	**6.4**	7.4	8.0	6.7	7.4	8.3
Specific conductance, µS/cm at 25 °C	144	282	287	91	158	233	268	435	819	453	744	2,270	92	229	1,620	124	629	5,010
Temperature, °C	10.3	10.7	12.6	8.4	10.2	11.5	9.8	10.5	13.1	11.1	13.1	16.1	7.3	9.0	12.8	8.3	9.6	11.6
Carbon dioxide, mg/L	14	14	94	7.8	13	128	2.1	5.95	14	3.1	21	133	2.1	7.8	57	0.4	15.5	169
Argon, mg/L	0.665	0.722	0.724	0.686	0.765	0.839	0.642	0.748	0.755	0.072	0.777	0.856	0.724	0.743	0.833	0.738	0.820	1.39
Nitrogen gas, mg/L	18.29	20.00	20.39	18.59	21.52	26.51	16.28	22.53	24.21	25.54	22.86	29.32	19.85	21.20	24.41	20.78	24.73	55.76
Methane, mg/L	<0.001	0.011	0.043	<0.001	<0.001	0.522	0.001	0.086	**53.4**	<0.001	0.813	**54.5**	<0.001	<0.001	0.501	<0.001	0.007	1.73

Table 6. Drinking-water standards for physiochemical properties and dissolved gases and number of groundwater samples exceeding those standards collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations in unfiltered water. Pt-Co units, platinum-cobalt units; mg/L, milligram per liter]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (46 samples)	Delaware Basin (10 samples)	Genesee River Basin (15 samples)	St. Lawrence River Basin (21 samples)
Color, filtered, Pt-Co units	[1]15	0	0	0	0
pH	[1]6.5–8.5	4	3	0	1
Methane, mg/L	[2]28	3	0	3	0

[1]U.S. Environmental Protection Agency (2012) secondary drinking water standard.

[2]Methane recommended monitoring concentration (Eltschlager and others, 2001).

colors of 2 and 5 Pt-Co units, respectively. Four samples, two from sand-and-gravel wells (F1468, F1544) and two from bedrock wells (ST2227, ST3674), had higher colors ranging from 8 to 12 Pt-Co units. No samples from the St. Lawrence River Basin exceeded the EPA SDWS for color. Sample pH was typically near neutral (median of 7.4 for sand-and-gravel wells, 7.4 for bedrock wells) and ranged from 6.4 to 8.3. The pH value for a sample from one sand-and-gravel well (F 543) was 6.4, which is lower than the EPA SDWS range for pH. Specific conductance ranged from 92 to 5,010 µS/cm at 25 °C; the median specific conductance was 229 µS/cm at 25 °C for sand-and-gravel wells and 629 µS/cm at 25 °C for bedrock wells. Water temperature ranged from 7.3 to 12.8 °C; the median temperature was 9.0 °C for sand-and-gravel wells and 9.6 °C for bedrock wells. Hydrogen sulfide odor was detected in one sand-and-gravel wells (F1544) and six bedrock wells (F 25, J1628, J2146, ST2065, ST2227, ST2460).

Dissolved Gases

Groundwater samples were collected and analyzed for carbon dioxide, argon, nitrogen, and methane—dissolved oxygen was measured in the field. Results are reported in table 5 and appendix table 1.2. The concentrations of carbon dioxide, argon, nitrogen gas, and methane were determined twice for each site; therefore, the statistics given include two samples per well. These data are listed in appendix table 1.2. The number of samples that exceeded drinking-water standards for methane is reported in table 6. No drinking-water standards exist for dissolved oxygen, carbon dioxide, argon, and nitrogen gas.

In the Delaware River Basin, dissolved oxygen concentrations ranged from <0.3 to 7.7 mg/L (table 5 and appendix table 1.2) and typically were similar in samples from sand-and-gravel wells (median 4.4 mg/L) and bedrock wells (median 4.1 mg/L). Median concentrations of dissolved gases in samples from sand-and-gravel wells were 20.00 mg/L for nitrogen, 14 mg/L for carbon dioxide, 0.722 mg/L for argon, and 0.011 mg/L for methane. Median concentrations of dissolved gases in samples from bedrock wells were 21.52 mg/L for nitrogen, 13 mg/L for carbon dioxide, 0.765 mg/L for argon, and <0.001 mg/L for methane.

In the Genesee River Basin, dissolved oxygen concentrations ranged from <0.3 to 6.3 mg/L (table 5 and appendix table 1.2), and samples in sand-and-gravel wells (median 0.6 mg/L) were typically similar to samples from bedrock wells (median 0.7 mg/L). Median concentrations of dissolved gases in samples from sand-and-gravel wells were 22.53 mg/L for nitrogen, 5.95 mg/L for carbon dioxide, 0.748 mg/L for argon, and 0.086 mg/L for methane. Median concentrations of dissolved gases in samples from bedrock wells were 22.86 mg/L for nitrogen, 21 mg/L for carbon dioxide, 0.776 mg/L for argon, and 0.813 mg/L for methane. Methane was detected in samples from 14 of the 15 wells, and 8 of those detections were at trace level. Although the EPA and NYSDOH do not have MCLs for methane, dissolved methane concentrations greater than 28 mg/L can pose explosion hazards as a result of methane accumulation in confined spaces (Eltschlager and others, 2001). The U.S. Department of Interior, Office of Surface Mining Reclamation and Enforcement, recommends that methane concentrations ranging from 10 to 28 mg/L in water signify an action level where the situation should be closely monitored; if the concentration increases, enclosed areas should be vented to prevent methane gas buildup (Eltschlager and others, 2001). The concentrations of methane in the two duplicate samples from two bedrock wells (OT2282, 54.5 and 52.6 mg/L; LV1313, 28.2 and 28.1 mg/L), and from one sand-and-gravel well (AG1129, 53.4 and 53.6 mg/L) were greater than the safety threshold of 28 mg/L (table 6).

In the St. Lawrence River Basin, dissolved oxygen concentrations ranged from <0.3 to 11.6 mg/L (table 5 and appendix table 1.2) and typically were greater in samples from sand-and-gravel wells (median 3.6 mg/L) than samples from bedrock wells (median 0.4 mg/L). Median concentrations of dissolved gases in samples from sand-and-gravel wells were 21.20 mg/L for nitrogen, 7.8 mg/L for carbon dioxide, 0 743 mg/L for argon, and <0.001 mg/L for methane. Median concentrations of dissolved gases in samples from bedrock wells were 24.73 mg/L for nitrogen, 15.5 mg/L for carbon dioxide, 0.820 mg/L for argon, and 0.007 mg/L for methane.

Major Ions and Dissolved Solids

Groundwater samples were analyzed for anions including bicarbonate, chloride, fluoride, silica, and sulfate; cations including calcium, magnesium, potassium, and sodium; hardness; alkalinity; and dissolved solids. Results for dissolved concentrations of major ions, hardness, alkalinity, and dissolved solids are reported in table 7 and in appendix table 1.3. The numbers of samples that exceeded drinking-water standards for major ions and dissolved solids are reported in table 8. No drinking-water standards exist for calcium, magnesium, potassium, bicarbonate, silica, hardness, or alkalinity.

In the Delaware River Basin, the anions detected in the highest concentrations were bicarbonate (median of 36 mg/L in sand-and-gravel wells, 50 mg/L in bedrock wells) and chloride (median of 54.6 mg/L in sand-and-gravel wells, 9.21 mg/L in bedrock wells) (table 7 and appendix table 1.3). The cations detected in the highest concentrations were calcium (median of 16.0 mg/L in sand-and-gravel wells, 12.3 mg/L in bedrock wells) and sodium (median of 21.4 mg/L in sand-and-gravel wells, 8.22 mg/L in bedrock wells). The concentrations of sodium, chloride, fluoride, and sulfate did not exceed established drinking-water standards in any sample (table 8 and appendix table 1.3).

For samples in the Delaware River Basin, seven samples were classified as "soft" (0 to 60 mg/L as calcium carbonate, [$CaCO_3$]) and three as "moderately hard" (61 to 120 mg/L as $CaCO_3$) (Hem, 1985). The median hardness was 50.7 mg/L as $CaCO_3$ for sand-and-gravel wells and 41.2 mg/L as $CaCO_3$ for bedrock wells; the maximum hardness was 87.4 mg/L as $CaCO_3$ (bedrock well, D2321; appendix table 1.3). Alkalinity ranged from 2.65 to 26.4 mg/L as $CaCO_3$; the median was 21.4 mg/L as $CaCO_3$ for sand-and-gravel wells and 8.22 mg/L as $CaCO_3$ for bedrock wells. Dissolved solids concentrations ranged from 62 to 173 mg/L with a median of 165 mg/L for sand-and-gravel wells and 89 mg/L for bedrock wells.

In the Genesee River Basin, the anions detected with the highest concentrations were bicarbonate (median of 199 mg/L in sand-and-gravel wells, 317 mg/L in bedrock wells), and chloride (median of 38.7 mg/L in sand-and-gravel wells, 63.4 mg/L in bedrock wells) (table 7 and appendix table 1.3). The cations detected in the highest concentrations were calcium (median of 56.9 mg/L in sand-and-gravel wells, 67.6 mg/L in bedrock wells) and sodium (median of 19.9 mg/L in sand-and-gravel wells, 72.4 mg/L in bedrock wells). The concentration of sodium in one sample from a sand-and-gravel well (AG1129, 104 mg/L) and six samples from bedrock wells (AG 275, 72.4 mg/L; GS 289, 174 mg/L; LV1351, 92.5 mg/L; MO1855, 85.0 mg/L; OT2282, 446 mg/L; and WO1483, 69.8 mg/L) exceeded the EPA drinking-water advisory taste threshold of 60 mg/L (U.S. Environmental Protection Agency, 2012). The concentration of chloride in one sample from a bedrock well (OT2282, 323 mg/L) exceeded the EPA SDWS and the NYSDOH MCL of 250 mg/L (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011). The concentrations of fluoride and sulfate did not exceed established drinking-water standards in any sample (table 8 and appendix table 1.3).

For samples in the Genesee River Basin, 2 samples were classified as "moderately hard," 3 samples as "hard" (121 to 180 mg/L as $CaCO_3$), and 10 samples as "very hard" (greater than [>] 180 mg/L as $CaCO_3$) (Hem, 1985). The median hardness was 206 mg/L as $CaCO_3$ for sand-and-gravel wells and 221 mg/L as $CaCO_3$ for bedrock wells; and the maximum hardness was 493 mg/L as $CaCO_3$. Alkalinity ranged from 58.9 to 579.7 mg/L as $CaCO_3$; the median was 165.0 mg/L as $CaCO_3$ for sand-and-gravel wells and 243.6 mg/L as $CaCO_3$ for bedrock wells. Dissolved solids concentrations ranged from 159 to 1,280 mg/L with a median of 244 mg/L for sand-and-gravel wells and 456 mg/L for bedrock wells. Dissolved solids concentration in three samples from bedrock wells (GS 289, 963 mg/L; MO1855, 613 mg/L; OT2282, 1,280 mg/L) exceeded the EPA SDWS for total dissolved solids of 500 mg/L (U.S. Environmental Protection Agency, 2012; table 8 and appendix table 1.3).

In the St. Lawrence River Basin, the anions detected with the highest concentrations were bicarbonate (median of 118 mg/L in sand-and-gravel wells, 224 mg/L in bedrock wells) and sulfate (median of 7.74 mg/L in sand-and-gravel wells, 37.8 mg/L in bedrock wells) (table 7 and appendix table 1.3). The cations detected in the highest concentrations were calcium (median of 28.0 mg/L in sand-and-gravel wells, 71.8 mg/L in bedrock wells), magnesium (median of 9.33 mg/L in sand-and-gravel wells, 22.7 mg/L in bedrock wells), and sodium (median of 4.17 mg/L in sand-and-gravel wells, 23.4 mg/L in bedrock wells). The concentration of sodium in one sample from a sand-and-gravel well (J1736, 168 mg/L) and two samples from bedrock wells (J1628, 69.5 mg/L; and ST2065, 514 mg/L) exceeded the EPA drinking-water advisory taste threshold of 60 mg/L (table 8). The concentration of chloride in one sample from a sand-and-gravel well (J1736, 304 mg/L) and one sample from a bedrock well (ST2065, 1,160 mg/L) exceeded the EPA SDWS and the NYSDOH MCL of 250 mg/L. The concentration of sulfate in one sample from a bedrock well (ST2065, 783 mg/L) exceeded the EPA SDWS and the NYSDOH MCL of 250 mg/L. The concentrations of fluoride did not exceed established MCLs or SDWS in any sample (table 8 and appendix table 1.3).

For samples in the St. Lawrence River Basin, 3 samples were classified as "soft," 4 samples as "moderately hard," 3 as "hard," and 11 samples as "very hard." The median hardness was 111 mg/L as $CaCO_3$ for sand-and-gravel wells and 280 mg/L as $CaCO_3$ for bedrock wells; and the maximum hardness was 1,380 mg/L as $CaCO_3$. Alkalinity ranged from 30 to 383 mg/L as $CaCO_3$; the median was 98 mg/L as $CaCO_3$ for sand-and-gravel wells and 183 mg/L as $CaCO_3$ for bedrock wells. Dissolved solids concentrations ranged from 71 to 3,210 mg/L with a median of 132 mg/L for sand-and-gravel wells and 388 mg/L for bedrock wells. Dissolved solids concentration in one sample from a sand-and-gravel well (J1736, 899 mg/L) and four samples from bedrock wells

Table 7. Summary statistics for concentrations of major ions, hardness, alkalinity, and dissolved solids in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations are in milligrams per liter in filtered water representing dissolved concentrations. **Bold** values exceed one or more drinking-water or safety standards. °C, degree Celsius; $CaCO_3$, calcium carbonate]

Constituent		Delaware River Basin						Genesee River Basin						St. Lawrence River Basin					
		Sand-and-gravel aquifers (3 samples)			Bedrock aquifers (7 samples)			Sand-and-gravel aquifers (6 samples)			Bedrock aquifers (9 samples)			Sand-and-gravel aquifers (7 samples)			Bedrock aquifers (14 samples)		
		Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Cations	Calcium	12.5	16.0	18.5	3.88	12.3	23.6	21.9	56.9	88.8	22.9	67.6	94.2	10.1	28.0	114	12.8	71.8	312
	Magnesium	2.27	2.63	6.9	1.34	3.46	6.94	6.5	14.1	18	7.06	15.6	63.6	3.2	9.33	32.2	2.7	22.7	145
	Potassium	0.72	1.68	2.17	0.48	0.97	8.05	0.77	1.50	2.2	1.84	2.66	4.04	0.67	0.82	4.15	0.46	3.6	13.6
	Sodium	10.8	21.4	26.4	2.65	8.22	22	7.27	19.9	**104**	11.6	**72.4**	**446**	2.58	4.17	**168**	1.45	23.4	**514**
Anions	Bicarbonate	15	36	37	8	50	80	57	199	386	178	317	706	37	118	355	43	224	467
	Chloride	18.1	54.6	65.2	0.56	9.21	35.2	16.8	38.7	82.6	2.56	63.4	**323**	0.48	5.82	**304**	0.5	22.4	**1,160**
	Fluoride	0.03	0.04	0.06	0.01	0.06	0.11	0.05	0.085	0.2	0.09	0.2	0.32	0.04	0.08	0.4	0.06	0.39	0.91
	Silica	3.59	3.79	6.85	5.32	6.39	12.8	6.11	7.225	14.9	5.91	11.6	16.9	8.78	11.4	22.6	7.61	10.6	28.6
	Sulfate	5.57	5.64	9.05	4.31	6.17	9.68	0.05	15.45	26.2	<0.20	11.9	51.6	2.73	7.74	49.9	4.29	37.8	**783**
Hardness as $CaCO_3$		40.6	50.7	74.6	23.9	41.2	87.4	81.5	206	292	86.2	221	493	38.5	111	417	46	280	1,380
Alkalinity as $CaCO_3$		10.8	21.4	26.4	2.65	8.22	22	59	165	317	147	244	580	30	98	292	36	183	383
Dissolved solids, dried at 180 °C		89	165	173	62	89	134	159	244	467	265	456	**1,280**	71	132	**899**	86	388	**3,210**

Table 8. Drinking-water standards for concentrations of major ions and dissolved solids and number of groundwater samples exceeding those standards collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations are in milligrams per liter in filtered water representing dissolved concentrations; °C, degree Celsius]

Constituent		Drinking-water standard	Number of samples exceeding drinking-water standards			
			All samples (46 samples)	Delaware River Basin (10 samples)	Genesee River Basin (15 samples)	St. Lawrence River Basin (21 samples)
Cations	Sodium	[4]60	10	0	7	3
Anions	Chloride	[2,3]250	3	0	1	2
	Fluoride	[1]4.0	0	0	0	0
		[2]2.2	0	0	0	0
		[3]2	0	0	0	0
	Sulfate	[2,3]250	1	0	0	1
Dissolved solids, dried at 180 °C		[3]500	8	0	3	5

[1]U.S. Environmental Protection Agency (2012) maximum contaminant level.

[2]New York State Department of Health (2011) maximum contaminant level.

[3]U.S. Environmental Protection Agency (2012) secondary drinking water standard.

[4]U.S. Environmental Protection Agency (2012) drinking water advisory taste threshold.

(J1628, 750 mg/L; J2146, 561 mg/L; ST2065, 3,210 mg/L; ST3358, 727 mg/L) exceeded the EPA SDWS for total dissolved solids of 500 mg/L (table 8 and appendix table 1.3).

Nutrients and Total Organic Carbon

Groundwater samples were analyzed for several nutrients, including ammonia plus organic nitrogen, ammonia, nitrate plus nitrite, nitrite, and orthophosphate, as well as for total organic carbon (unfiltered). Nitrate was calculated by subtracting the nitrite from the nitrate plus nitrite measured values. Results are reported in table 9 and in appendix table 1.4. The numbers of samples that exceeded drinking-water standards for nitrate, nitrite, and nitrate plus nitrite are reported in table 10. No drinking-water standards exist for ammonia, orthophosphate, and total organic carbon.

The dominant nutrient detected in the Delaware River Basin was nitrate (table 9 and appendix table 1.4). The concentrations of nitrate ranged from <0.040 to 2.15 mg/L as nitrogen (N) and were generally greater in samples from sand-and-gravel wells (median 1.76 mg/L as N) than in samples from bedrock wells (median 0.312 mg/L as N). The concentrations of nitrate and nitrate plus nitrite did not exceed the EPA and NYSDOH MCL of 10 mg/L as N (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011) in any sample (table 10 and appendix table 1.4). The concentrations of ammonia ranged from <0.010 to V0.06 mg/L as nitrogen (N) and were similar in samples from sand-and-gravel wells and bedrock wells. Nitrite was detected in only 1 of 10 samples and did not exceed the EPA and NYSDOH MCL of 1 mg/L as N (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011) in any sample. Orthophosphate concentrations ranged from <0.004 to 0.032 mg/L as phosphorus (P). Total organic carbon was not detected in any of the 10 samples.

The dominant nutrient detected in the Genesee River Basin was ammonia (table 9 and appendix table 1.4). The concentration of ammonia ranged from <0.01 to V7.49 mg/L as N and was generally greater in samples from bedrock wells (median V0.65 mg/L as N) than in samples from sand-and-gravel wells (median V0.075 mg/L as N). The concentration of nitrate and nitrate plus nitrite did not exceed the EPA and NYSDOH MCL of 10 mg/L as N in any sample (table 10 and appendix table 1.4); however, a sample from one bedrock well (MO1855) had a concentration of 9.68 mg/L of N for both the nitrate and the nitrate plus nitrite analyses. Nitrite was detected in 3 of the 15 samples and did not exceed the NYSDOH and EPA MCL of 1 mg/L as N in any sample. Orthophosphate concentrations ranged from <0.004 to 1.29 mg/L as P. Total organic carbon was detected in 8 of the 15 samples; the maximum concentration was 5.2 mg/L.

The dominant nutrient detected in the St. Lawrence River Basin was nitrate (table 9 and appendix table 1.4). The concentrations of nitrate ranged from <0.040 to 15.6 mg/L as N and were generally greater in samples from sand-and-gravel wells (median 0.103 mg/L as N) than in samples from bedrock wells (median <0.040 mg/L as N). The concentrations of nitrate and nitrate plus nitrite exceeded the EPA and NYSDOH MCL of 10 mg/L as N in one sample from a bedrock well (ST3358; 15.6 mg/L as N) (table 10 and appendix table 1.4). The concentrations of ammonia ranged from <0.01 to V0.44 mg/L as N and were similar in samples from

Table 9. Summary statistics for concentrations of nutrients in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations are in milligrams per liter and are in filtered water unless otherwise indicated as unfiltered. "V" remark codes indicate that a value may be affected by contamination. N, nitrogen; P, phosphorus; <, less than]

Constituent	Delaware River Basin						Genesee River Basin						St. Lawrence River Basin					
	Sand-and-gravel aquifers (3 samples)			Bedrock aquifers (7 samples)			Sand-and-gravel aquifers (6 samples)			Bedrock aquifers (9 samples)			Sand-and-gravel aquifers (7 samples)			Bedrock aquifers (14 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia plus organic N, as N	<0.07	<0.07	V0.07	<0.07	<0.07	<0.07	<0.07	V0.17	V1.8	<0.07	V0.62	V8.4	<0.07	<0.07	V0.52	<0.07	V0.1	V0.53
Ammonia (NH_3 + NH_4^+), as N	<0.01	<0.01	V0.01	<0.01	<0.01	V0.06	<0.01	V0.075	V1.81	<0.01	V0.65	V7.49	<0.01	<0.01	V0.42	<0.01	V0.06	V0.44
Nitrate plus nitrite (NO_3 + NO_2), as N	0.301	1.76	2.15	<0.040	0.312	0.672	<0.040	<0.040	1.66	<0.040	<0.040	9.68	<0.040	0.103	1.59	<0.040	<0.040	15.6
Nitrate (NO_3), as N	0.301	1.76	2.15	<0.04	0.312	0.672	<0.039	<0.040	1.66	<0.040	<0.040	9.68	<0.040	0.103	1.59	<0.039	<0.040	15.6
Nitrite (NO_2), as N	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.043	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Orthophosphate (PO_4), as P	0.008	0.01	0.018	<0.004	0.008	0.032	<0.004	0.0235	0.161	<0.004	0.01	1.29	<0.004	0.006	0.471	<0.004	0.007	0.026
Total organic carbon, unfiltered	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	1.7	<0.7	1.1	5.2	<0.7	<0.7	2.3	<0.7	<0.7	1.8

Table 10. Drinking-water standards for concentrations of nutrients and number of groundwater samples exceeding those standards collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations in milligrams per liter in filtered water. N, nitrogen]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (46 samples)	Delaware River Basin (10 samples)	Genesee River Basin (15 samples)	St. Lawrence River Basin (20 samples)
Nitrate (NO_3), as N	[1,2]10	1	0	0	1
Nitrite (NO_2), as N	[1,2]1	0	0	0	0

[1]U.S. Environmental Protection Agency (2012) maximum contaminant level.

[2]New York State Department of Health (2011) maximum contaminant level.

sand-and-gravel wells and bedrock wells. Nitrite was detected in only 4 of 21 samples and did not exceed the EPA and NYSDOH MCL of 1 mg/L as N in any sample. Orthophosphate concentrations ranged from <0.004 to 0.471 mg/L as P. Total organic carbon was detected in 5 of the 21 samples; the maximum concentration was 2.3 mg/L.

Trace Elements

Twenty-five trace elements were analyzed for in filtered and (or) unfiltered groundwater samples. Mercury was not detected in groundwater samples from any of the basins (appendix table 1.1). Results are reported in table 11 and in appendix table 1.5. The numbers of samples that exceeded drinking-water standards for trace elements are reported in table 12. No drinking-water standards exist for cobalt and lithium.

In the Delaware River Basin, the trace elements present in the highest median concentrations in the samples were strontium (median of 78.4 micrograms per liter [µg/L] in sand-and-gravel wells, 111 µg/L in bedrock wells), iron (median of 47.1 µg/L in unfiltered water from bedrock wells, 20.5 µg/L in filtered water from bedrock wells), and boron (median of 11 µg/L in filtered water from bedrock wells, 11 µg/L in filtered water from sand-and-gravel wells) (table 11 and appendix table 1.5).

In the Delaware River Basin, the concentrations of iron in one sample from a bedrock well (O10369) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L (New York State Department of Health, 2011; U.S. Environmental Protection Agency, 2012) in the filtered and unfiltered samples (8,190 µg/L in the filtered sample; 7,760 µg/L in the unfiltered sample) (table 12 and appendix table 1.5). Another sample from a bedrock well (D2321) exceeded the NYSDOH MCL and EPA SDWS for iron in only the unfiltered sample (412 µg/L). Samples from two bedrock wells (D2321 and O10369) and one sand-and-gravel well (SV 39) had concentrations of manganese that exceeded the EPA SDWS of 50 µg/L (U.S. Environmental Protection Agency, 2012) in unfiltered and filtered samples. However, samples from these wells did not exceed the NYSDOH MCL of 300 µg/L (New York State Department of Health, 2011). The maximum concentration of manganese was 225 µg/L in a filtered sample from bedrock well O10369. A sample from one bedrock well (SV1689) had a concentration of aluminum that exceeded the EPA SDWS of 50–200 µg/L (U.S. Environmental Protection Agency, 2012). Drinking-water standards for antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, zinc, and uranium were not exceeded (table 12 and appendix table 1.5). Antimony, chromium, mercury, silver, and thallium were not detected in any of the 10 Delaware River Basin samples collected (tables 11 and 12; appendix tables 1.1 and 1.5).

In the Genesee River Basin, the trace elements present in the highest median concentrations in the samples were strontium (median of 516 µg/L in bedrock wells, 170 µg/L in sand-and-gravel wells), iron (median of 522 µg/L in unfiltered water from bedrock wells, 454 µg/L in filtered water from sand-and-gravel wells), barium (median of 260 µg/L in bedrock wells, 240 µg/L in sand-and-gravel wells), manganese (median of 77.8 µg/L in unfiltered water from bedrock wells, 62.1 µg/L in unfiltered water from sand-and-gravel wells), and boron (median of 243 µg/L in filtered water from bedrock wells, 24 µg/L in filtered water from sand-and-gravel wells) (table 11 and appendix table 1.5).

In the Genesee River Basin, the concentration of aluminum in three samples from bedrock wells (AG2300, 207 µg/L; OT2282, 365 µg/L; WO1483, 461 µg/L) exceeded the EPA SDWS of 50–200 µg/L (table 12 and appendix table 1.5) in the Genesee River Basin. The concentration of arsenic in two samples—one from bedrock well (LV1351, 44.0 µg/L), and one from sand-and-gravel well (AG1129, 161 µg/L)—exceeded the EPA MCL and NYSDOH MCL of 10 µg/L (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011). The concentration of iron in nine samples (five bedrock wells and four sand-and-gravel) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L in unfiltered samples; the maximum iron concentration was 2,200 µg/L (OT2282). Seven of the nine samples also had concentrations of iron that exceeded the MCL and SDWS when filtered. The concentration of manganese in 9 of 15 samples from the Genesee River Basin (5 from bedrock wells, 4 from

Table 11. Summary statistics for concentrations of trace elements in groundwater collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations in micrograms per liter in unfiltered water unless otherwise indicated as filtered water. **Bold** values exceed one or more drinking-water or safety standard. <, less than.]

Constituent	Delaware River Basin						Genesee River Basin						St. Lawrence River Basin					
	Sand-and-gravel aquifers (3 samples)			Bedrock aquifers (7 samples)			Sand-and-gravel aquifers (6 samples)			Bedrock aquifers (9 samples)			Sand-and-gravel aquifers (7 samples)			Bedrock aquifers (14 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Aluminum	<3.8	<3.8	17.9	3.8	15.4	**55.8**	<3.8	4.1	9.7	<3.8	10	**461**	<3.8	5.8	20.6	<3.8	<3.8	7.3
Antimony	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	0.75	<0.18	<0.18	<0.18	<0.18	<0.18	0.72
Arsenic	<0.02	0.22	0.37	0.38	1.2	6.2	0.26	2.2	**161**	<0.20	0.28	**44**	<0.20	0.51	0.62	<0.20	0.76	3
Barium	<0.02	0.22	0.37	0.38	1.2	6.2	62.1	240	733	23	260	454	4.81	40.5	189	<0.25	48.2	372
Beryllium	<0.02	<0.02	0.04	<0.02	<0.02	1.1	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.03	<0.02	<0.02	0.03
Boron, filtered	6	11	11	5.8	11	35	15	24	90	33	243	1,170	3.4	7.3	129	4.6	124	1,430
Cadmium	<0.030	<0.030	0.036	<0.030	<0.030	0.107	<0.030	<0.030	0.039	<0.030	<0.030	0.194	<0.030	<0.030	0.067	<0.030	<0.030	0.055
Chromium	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	8.6	<0.40	<0.40	1.7	<0.40	<0.40	0.74
Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	6.3	<0.05	<0.05	0.1	<0.05	0.06	0.57	<0.05	0.1	0.37	<0.05	<0.05	0.25
Copper	<0.80	0.96	101	<0.80	4.7	33	<0.80	2.1	3.8	<0.80	<0.80	32.9	<0.80	1.7	178	<0.80	<1.0	7.8
Iron, filtered	11.8	12.7	37.5	<4.0	20.5	**8,190**	9.3	**454**	**1,720**	<4.0	153	**1,500**	<4.0	13.1	167	<4.0	52	**568**
Iron	17.2	21.6	68.5	34.6	47.1	**7,760**	7.9	**448**	**1,680**	6	**522**	**2,200**	<4.6	91.7	253	<4.6	92.6	**563**
Lead	0.06	0.24	1.78	0.15	0.25	0.79	<0.04	0.45	1.88	0.05	0.28	2.87	<0.04	0.24	0.68	<0.04	0.06	1.29
Lithium	0.36	0.41	4.07	0.83	8.38	70.2	2.95	4.115	7.56	0.87	36.7	656	0.7	0.88	20.5	0.62	8.08	442
Manganese, filtered	4.99	6.3	**85.6**	<0.20	3.18	**225**	<0.20	**57.1**	**257**	0.95	37.9	**171**	<0.20	2.48	**225**	<0.20	8.12	**83.8**
Manganese	V5.2	V7	**90.4**	V0.5	V9.2	**213**	<0.4	**62.1**	**270**	1	**77.8**	**449**	<0.4	7.1	**225**	<0.4	8.5	**225**
Molybdenum	<0.05	<0.05	<0.05	<0.05	0.15	0.3	<0.05	0.92	13.8	0.11	0.32	3.56	0.13	0.55	2.27	0.13	1.44	7.86
Nickel	<0.20	<0.20	2.1	<0.20	<0.20	6.8	<0.20	0.72	1.9	<0.20	0.97	4.5	<0.20	<0.20	1.3	<0.20	<0.20	1.1
Selenium	<0.100	<0.100	0.17	<0.100	<0.100	0.126	<0.100	<0.100	0.147	<0.100	<0.100	0.224	<0.100	<0.100	0.137	<0.100	<0.100	0.292
Silver	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.060	<0.030	<0.030	0.035	<0.030	<0.030	<0.030
Strontium	47.7	78.4	93.4	19.2	111	689	109	170	519	188	516	3,570	28.5	62.9	**4,990**	96.5	1,030	**22,600**
Thallium	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	0.07	<0.06	<0.06	0.1	<0.06	<0.06	<0.12
Zinc	<2.0	2.2	11.7	2.1	8.5	17	<2.0	6.8	64.8	<2.0	6.6	118	<2.0	4.1	15.8	<2.0	4.6	13.9
Uranium	<0.014	<0.014	0.031	0.063	0.511	1.16	<0.014	0.052	0.339	<0.014	0.033	0.726	0.045	0.249	0.689	<0.028	0.608	3.06

Table 12. Drinking-water standards for concentrations of trace elements and number of groundwater samples exceeding those standards collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All concentrations in micrograms per liter in unfiltered water representing unless otherwise indicated as filtered water]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (46 samples)	Delaware River Basin (10 samples)	Genesee River Basin (15 samples)	St. Lawrence River Basin (21 samples)
Aluminum	[3]50–200	4	1	3	0
Antimony	[1,2]6	0	0	0	0
Arsenic	[1,2]10	2	0	2	0
Barium	[1,2]2,000	0	0	0	0
Beryllium	[1,2]4	0	0	0	0
Boron	[5]6,000	0	0	0	0
	[6]3,000	0	0	0	0
Cadmium	[1,2]5	0	0	0	0
Chromium	[1,2]100	0	0	0	0
Copper	[3]1,000	0	0	0	0
Iron, filtered	[2,3]300	10	1	7	2
Iron	[2,3]300	13	2	9	2
Lead	[4]15	0	0	0	0
Manganese, filtered	[2]300	0	0	0	0
	[3]50	14	3	7	4
Manganese	[2]300	1	0	1	0
	[3]50	16	3	9	4
Molybdenum	[5]40	0	0	0	0
	[6]80	0	0	0	0
Nickel	[5]100	0	0	0	0
	[6]1,000	0	0	0	0
Selenium	[1,2]50	0	0	0	0
Silver	[2,3]100	0	0	0	0
Strontium	[5]4,000	4	0	0	4
	[6]25,000	0	0	0	0
Thallium	[1,2]2	0	0	0	0
Zinc	[2,3]5,000	0	0	0	0
Uranium	[1,2]30	0	0	0	0

[1]U.S. Environmental Protection Agency (2012) maximum contaminant level.

[2]New York State Department of Health (2011) maximum contaminant level.

[3]U.S. Environmental Protection Agency (2012) secondary drinking water standard.

[4]U.S. Environmental Protection Agency (2012) treatment technique.

[5]U.S. Environmental Protection Agency (2012) lifetime health advisory.

[6]U.S. Environmental Protection Agency (2012) single-day health advisory.

sand-and-gravel wells) exceeded the EPA SDWS of 50 µg/L in unfiltered samples; only 3 of the samples from those 9 wells did not have an exceedance in the associated filtered sample. The concentration of manganese in one of these samples further exceeded the NYSDOH MCL of 300 µg/L. The maximum manganese concentration was 449 µg/L (AG2300). Drinking-water standards for antimony, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not exceeded. Silver was not detected in any of the 15 Genesee River Basin samples collected (tables 11 and 12; appendix tables 1.1 and 1.5).

In the St. Lawrence River Basin, the trace elements present in the highest median concentrations in the samples were strontium (median of 62.9 µg/L in sand-and-gravel wells, 1,030 µg/L in bedrock wells), iron (median of 92.6 µg/L in unfiltered water from bedrock wells, 91.7 µg/L in unfiltered water from sand-and-gravel wells), and boron (median of 124 µg/L in filtered water from bedrock wells, 7.3 µg/L in filtered water from sand-and-gravel wells) (table 11 and appendix table 1.5).

In the St. Lawrence River Basin, the concentration of iron in samples from two bedrock wells (ST2227 and ST3674) exceeded the NYSDOH MCL and EPA SDWS of 300 µg/L in filtered and unfiltered samples (table 12); the maximum iron concentration was 568 µg/L (ST3674). The concentration of manganese in samples from two sand-and-gravel wells (F1544 and J1736) and two bedrock wells (J2146 and ST2227) exceeded the EPA SDWS of 50 µg/L in unfiltered samples. None of the samples from these four wells further exceeded the NYSDOH MCL of 300 µg/L for manganese. The maximum manganese concentration was 225 µg/L (F1544). The EPA does currently have a lifetime health advisory of 4,000 µg/L and a single-day health advisory of 25,000 µg/L for strontium (U.S. Environmental Protection Agency, 2012). One sand-and-gravel well (J1736, 4,990 µg/L) and three bedrock wells in the St. Lawrence River Basin exceeded the lifetime health advisory for strontium (J1628, 14,200 µg/L; J2146, 7,020 µg/L; ST2065, 22,600 µg/L). Drinking-water standards for aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not exceeded (tables 11 and 12; appendix tables 1.1 and 1.5).

Pesticides

Groundwater samples were analyzed for 52 pesticides and pesticide degradates. Of the 52 pesticides and pesticide degradates analyzed for, 48 were not detected in any samples from any of the basins (table 1.1). For the four pesticides and pesticide degradates detected in groundwater samples (table 1.6), no concentrations exceeded established drinking-water standards set for pesticides and pesticide degradates.

In the Delaware River Basin, two pesticides and one pesticide degradate were detected at trace concentrations among three samples (appendix table 1.6). All of the pesticides detected were broadleaf herbicides or their degradates. Two of the wells with pesticide detections were sand-and-gravel production wells (D 276 and SV 534), and one well was a bedrock production well (D 199). The pesticide atrazine was detected in two samples (D 276 and SV 534). The pesticide prometon was detected in one sample (D 199). The pesticide degradate 2-chloro-4-isopropylamino-6-amino-*S*-triazine (deethylatrazine [CIAT], a degradation product of atrazine) was detected at the highest concentration (E0.040 µg/L).

In the Genesee River Basin, three broadleaf herbicides and a degradate were detected at trace concentrations among three samples. CIAT was detected in a sand-and-gravel production well (AG 266). Two domestic bedrock wells (LV1423 and MO1855) had trace concentrations of CIAT, atrazine, metolachlor, and prometon. The pesticide degradate CIAT was detected at the highest concentration (E0.039 µg/L).

In the St. Lawrence River Basin, two broadleaf herbicides and a degradate were detected at trace concentrations in two samples. CIAT was detected in one sand-and-gravel production well (ST 366). Metolachlor and prometon were detected in one sand-and-gravel well (F 543). Both metolachlor and prometon were detected at the highest concentration (both at 0.036 µg/L).

Volatile Organic Compounds

Groundwater samples were analyzed for 34 VOCs. Of the 34 VOCs analyzed, 29 were not detected in any samples from any of the basins (table 1.1). For the five VOCs detected in samples, drinking-water standards only exist for two of these VOCs, and no concentrations exceeded established drinking-water standards set for VOCs. Results are reported in appendix table 1.7.

In the Delaware River Basin, one VOC, a trihalomethane (THM) or byproduct formed when chlorine or bromine are used as disinfectants, was detected in a sample from one sand-and-gravel production well (D 276) (appendix table 1.7). The VOC detected was the THM trichloromethane, or chloroform (0.6 µg/L).

In the Genesee River Basin, four VOCs were detected among samples from two bedrock wells (LV1351 and MO1855) (appendix table 1.7). The VOCs detected included two THMs—trichloromethane and bromodichloromethane—and two solvents—1,1,1-trichloroethane and toluene. The sample from bedrock well MO1855 contained detectable concentrations of three VOCs: 1,1,1-trichloroethane, bromodichloromethane, and trichloromethane. The VOC detected at the highest concentration, 0.8 µg/L was trichloromethane, in a sample from a bedrock well (MO1855).

In the St. Lawrence River Basin, three VOCs were detected in one sample from a sand-and-gravel production well (ST 378) (appendix table 1.7). The VOCs detected were three THMs—bromodichloromethane, dibromochloromethane, and trichloromethane. Trichloromethane was detected at the highest concentration (0.7 µg/L).

Radionuclides

Groundwater samples were analyzed for radon-222, gross-α activity and gross-β activity. Radon is currently (2019) not regulated in drinking water; however, the EPA has proposed a two-part standard for radon-222 in drinking water: (1) a 300-picocuries per liter (pCi/L) MCL for areas that do not implement an indoor-air radon-222 mitigation program and (2) an alternative MCL (AMCL) of 4,000 pCi/L for areas that do implement an indoor-air radon-222 mitigation program (U.S. Environmental Protection Agency, 1999). The EPA and NYSDOH MCLs for gross-α activity are 15 pCi/L (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011). The EPA and NYSDOH MCLs for gross-β are 4 millirems per year (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011), a dosage determination that requires knowledge of the specific radionuclide sources. The activity units (picocuries per liter) that were used to measure gross-β radioactivity in this study are not comparable to dosage units (millirems per year) without determination of the nuclide sources; therefore, it is not possible to determine whether any of the samples exceeded the MCL for gross-β radioactivity. Results are reported in appendix table 1.8.

In the Delaware River Basin, gross-α activity ranged from nondetectable levels to 4.0 pCi/L (table 13 and appendix table 1.8). No samples exceeded the NYSDOH and EPA MCLs of 15 pCi/L for gross-α activity (table 14 and appendix table 1.8). Gross-β activities ranged from nondetectable levels to 13.0 pCi/L. Radon-222 activities in the water samples ranged from 310 to 2,190 pCi/L; the median activity was 750 pCi/L for sand-and-gravel wells and 980 pCi/L for bedrock wells. The highest radon-222 activities were in a sample from one bedrock well, SV 132 (2,190 pCi/L), that is completed in shale and sandstone bedrock. Radon-222 activities in all 10 of the Delaware River Basin samples exceeded the proposed MCL of 300 pCi/L; no samples exceeded the proposed AMCL of 4,000 pCi/L (table 14).

In the Genesee River Basin, gross-α activity ranged from nondetectable levels to 4.9 pCi/L (table 13 and appendix table 1.8). No samples exceeded the NYSDOH and EPA MCLs of 15 pCi/L for gross-α activity. Gross-β activities ranged from nondetectable levels to 10.6 pCi/L. Radon-222 activities in the groundwater samples ranged from 260 to 1,440 pCi/L; the medians were 515 pCi/L in sand-and-gravel wells and 330 pCi/L in bedrock wells. The two highest radon-222 activities were in samples from bedrock wells completed in shale and sandstone (AG2300, 1,440 pCi/L; LV1423, 1,010 pCi/L). Radon-222 activities in 12 of the 15 Genesee River Basin samples exceeded the proposed MCL of 300 pCi/L with one additional sample with an activity equal to the proposed MCL; no samples exceeded the proposed AMCL of 4,000 pCi/L (table 14 and appendix table 1.8).

In the St. Lawrence River Basin, gross-α activity ranged from nondetectable levels to 8.9 pCi/L (table 13 and appendix table 1.8). No samples exceeded the NYSDOH and EPA MCLs of 15 pCi/L for gross-α activity. Gross-β activities ranged from nondetectable levels to 7.7 pCi/L. Radon-222 activities in the groundwater samples ranged from nondetectable levels to 1,280 pCi/L; the medians were 400 pCi/L in sand-and-gravel wells and 410 in bedrock wells. The highest radon-222 activity was in a sample from a bedrock well (J1451, 1,280 pCi/L). Radon-222 activities in 14 of the 21 St. Lawrence River Basin samples exceeded the proposed MCL of 300 pCi/L; no samples exceeded the proposed AMCL of 4,000 pCi/L (table 14 and appendix table 1.8).

Bacteria

Groundwater samples were analyzed for fecal indicator bacteria, including *E. coli* bacteria, fecal coliform bacteria, and total coliform bacteria. Heterotrophic plate count was also determined. Heterotrophic plate count is used to assess the overall bacterial load in the sample, which in conjunction with fecal indicator bacteria allows for inferring potential sources of contamination. The NYSDOH and EPA MCLs for total coliform bacteria are exceeded when 5 percent of samples of finished water collected in 1 month test positive for total coliforms (if 40 or more samples are collected per month) or when two samples of finished water test positive for total coliforms (if fewer than 40 samples are collected per month) (U.S. Environmental Protection Agency, 2012; New York State Department of Health, 2011). In this report, where conditions are based on one sample per well, any detection of total coliform bacteria, fecal coliform bacteria, or *E. coli* bacteria is described as an exceedance. Units for total coliform bacteria, fecal coliform bacteria, and *E. coli* bacteria results are in colony-forming units per 100 milliliters (CFU/100 mL); units for heterotrophic plate count are in colony-forming units per milliliter (CFU/mL). Results are reported in appendix table 1.9.

In the Delaware River Basin, total coliform bacteria were detected in two samples from bedrock wells (D1584, 11 CFU/100 mL; D1997, 1 CFU/100 mL) (appendix table 1.9), therefore exceeding the EPA and NYSDOH MCLs. Fecal coliform bacteria and *E. coli* bacteria were not detected in samples from any wells. The heterotrophic plate count ranged from <1 to 24 CFU/mL; no Delaware River Basin samples exceeded the EPA MCL for heterotrophic plate count (EPA MCL is 500 CFU/mL; U.S. Environmental Protection Agency, 2012).

In the Genesee River Basin, total coliform bacteria were detected in six samples from bedrock wells (AG 275, GS 289, LV1423, MO1855, OT2282, and WO1483), all exceeding the EPA and NYSDOH MCLs for total coliform bacteria (appendix table 1.9). The maximum detection of total coliform bacteria was >200 CFU/100 mL (LV1423). Fecal coliforms (130 CFU/100 mL) and *E. coli* bacteria (178 CFU/100 mL) were also detected in well LV1423. Well LV1423 exceeded the EPA and NYSDOH MCLs for fecal coliform bacteria and

Table 13. Summary statistics for activities of radionuclides in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All activities in picocuries per liter and are in unfiltered water. ***Bold and italicized*** values exceed one or more proposed drinking-water or safety standard. gross-α, gross-alpha; gross-β, gross-beta <, less than]

Constituent	Delaware River Basin						Genesee River Basin						St. Lawrence River Basin					
	Sand-and-gravel aquifers (3 samples)			Bedrock aquifers (7 samples)			Sand-and-gravel aquifers (6 samples)			Bedrock aquifers (9 samples)			Sand-and-gravel aquifers (7 samples)			Bedrock aquifers (14 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Gross-α radioactivity	<0.83	<1.2	0.7	<0.63	1.0	4.0	<0.58	1	2.6	<1.3	1.7	4.9	<0.65	<1.0	0.8	<0.65	1.2	8.9
Gross-β radioactivity	<1.3	<1.4	2.8	<0.75	1.5	13.0	<1.1	2.6	5.8	2.7	4.6	10.6	<0.87	1.4	4	<0.89	3.6	7.7
Radon-222	***410***	***750***	***1,260***	***310***	***980***	***2,190***	270	***515***	***880***	260	***330***	***1,440***	65	***400***	***870***	<11.2	***410***	***1,280***

Table 14. Drinking-water standards for activities of radionuclides and number of groundwater samples exceeding those standards collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

[All activities in picocuries per liter in unfiltered water. Activity units (picocuries per liter) used to measure gross-beta (gross-β) radioactivity in this study are not comparable to dosage units (millirems per year). gross-α, gross-alpha; mrem/yr, millirem per year; --, not applicable]

Constituent	Drinking-water standard	Number of samples exceeding drinking-water standards			
		All samples (46 samples)	Delaware River Basin (10 samples)	Genesee River Basin (15 samples)	St. Lawrence River Basin (21 samples)
Gross-α radioactivity	[1,2]15	0	0	0	0
Gross-β radioactivity	[1,2,4]mrem/yr	--	--	--	--
Radon-222	[3]300	36	10	12	14
	[4]4,000	0	0	0	0

[1]U.S. Environmental Protection Agency (2012) maximum contaminant level.

[2]New York State Department of Health (2011) maximum contaminant level.

[3]U.S. Environmental Protection Agency (1999) proposed maximum contaminant level.

[4]U.S. Environmental Protection Agency (1999) proposed alternative maximum contaminant level.

E. coli bacteria. The heterotrophic plate count ranged from <1 to 319 CFU/mL; no samples exceeded the EPA MCL for heterotrophic plate count.

In the St. Lawrence River Basin, total coliform bacteria were detected in one sample from a bedrock well (ST3358, 52 CFU/100 mL), therefore exceeding the EPA and NYSDOH MCLs for total coliform bacteria (appendix table 1.9). Fecal coliforms (2 CFU/100 mL) and *E. coli* bacteria (detected but not quantified) were also detected in well ST3358, therefore exceeding the EPA and NYSDOH MCLs for fecal coliform bacteria and *E. coli* bacteria. The heterotrophic plate count ranged from <1 to 227 CFU/mL; no samples exceeded the EPA MCL for heterotrophic plate count.

Comparison of Results From Wells Sampled in 2005–6, 2010, and 2015

A subset of 10 wells sampled in 2015 were previously sampled in 2010 and (or) 2005–6. Of the 148 physical properties, organic compounds, and inorganic compounds analyzed for in 2015 and 2010, 140 were also analyzed for in 2005–6. Note that the NWQL annually updates the LRLs for all analytes based on method performance during the previous year of analysis. Therefore, reporting levels and the determination of whether a concentration is considered "estimated" changes annually, and concentrations of compounds could differ for this reason between 2005–6, 2010, and 2015. The rules for determining and adjusting LRLs and long-term method detection levels are outlined by the USGS Branch of Quality Systems (U.S. Geological Survey, 1999a,b). Results are reported in appendix tables 2.1 through 2.8.

Two of the Delaware River Basin wells sampled in 2015 (wells SV 534 and SV1689) were sampled previously in 2010; SV1689 was sampled in 2005–6 as well. Overall, physiochemical properties exhibited little to no change for these wells (appendix table 2.1); however, for SV1689, color was substantially lower in 2015 and 2010 (<1 Pt-Co units) than in 2005–6 (8 Pt-Co units). Concentrations of nutrients, major ions, dissolved gases (2010 and 2015 only), and most trace elements exhibited little to no change in both wells (appendix tables 2.1 to 2.4, 2.7). The concentrations of aluminum, iron (unfiltered), lead, manganese (unfiltered), nickel, strontium, and zinc differed substantially in the SV1689 sample from 2015, compared to previous samples from that well (appendix table 2.4). The concentration of aluminum in the sample from SV1689 in 2015 was 55.8 µg/L, which is higher than the EPA SDWS of 50–200 µg/L but considerably lower than in 2005–6, when the concentration was 1,100 µg/L. The concentrations of iron, lead, manganese, nickel, and zinc also decreased substantially from 2005–6 (appendix table 2.4). The concentration of strontium, alternatively, increased since 2005–6 and 2010 (220 µg/L in 2005–6; 276 µg/L in 2010; and 489 µg/L in 2015). For well SV 534, atrazine and CIAT were detected in both the 2010 sample (CIAT—E0.077 µg/L; atrazine—E0.059 µg/L) and the 2015 sample (CIAT—E0.040 µg/L; atrazine—0.031 µg/L) (appendix table 2.5). No VOCs were detected in samples from either of the wells that were resampled (appendix table 2.6). Gross-α, gross-β, and radon-222 activities exhibited little to no change for these wells (appendix table 2.7). Total coliform bacteria were detected in the 2010 sample from SV 534 but not in the 2015 sample (appendix table 2.8). Total coliform bacteria were detected in the 2005–6 and 2010 samples from SV1689 but were not detected in 2015. In 2010, 70 CFU/100 mL of total coliform was detected in SV1689, up from 3 CFU/100 mL in 2005–6. Fecal coliform bacteria and *E. coli* bacteria were not detected in any samples from either well. The heterotrophic plate count for SV 534 was slightly higher in 2015 compared to 2010; however, for SV1689, the heterotrophic plate count decreased from 86 CFU/mL in 2005–6 to 6 CFU/mL in 2010, to <1 CFU/mL in 2015 (appendix table 2.8).

Three of the Genesee River Basin wells sampled in 2015 (AG 266, AG1129, and WO 352) were sampled previously in 2010. Overall, physiochemical properties exhibited little to no change for these wells (appendix table 2.1); however, for AG1129, color was substantially lower in 2015 (2 Pt-Co units) than in 2010 (10 Pt-Co units). Concentrations of nutrients, some dissolved gases (2010 and 2015 only), major ions, and trace elements showed little change for each of the three wells (appendix tables 2.1 to 2–4, and 2–7). Concentrations of carbon dioxide in samples from AG 266 and WO 352 were substantially higher in samples from 2010 (26.1 and 24.6 mg/L, respectively) than in samples from 2015 (mean of 8.0 and 10.1 mg/L, respectively). For wells AG1129 and WO 352, no pesticides were detected in any of the samples from 2010 or 2015 (appendix table 2.5). For well AG 266, CIAT was detected in the sample from 2015 (E0.003 µg/L), but it was not detected in the sample from 2010 (appendix table 2.5). No VOCs were detected in samples from either of the wells that were resampled (appendix table 2.6). Gross-α, gross-β and radon-222 activities exhibited little to no change for these wells (appendix table 2.7). Total coliform bacteria, fecal coliform bacteria, and *E. coli* bacteria were not detected in any samples from AG 266, AG1129, or WO 352 (appendix table 2.8). Heterotrophic plate counts in these three wells were consistent across the two rounds of sampling (appendix table 2.8).

Four of the St. Lawrence River Basin wells sampled in 2015 (F 543, F 573, J1736, and ST 378) were sampled previously in 2010; three of those wells (F 543, F 573, and ST 378) and one additional well (ST 366) were sampled in the 2005–6 round as well. Overall, physiochemical properties exhibited little to no change for these wells (appendix table 2.1); however, for F 543, color decreased over time; color was 5 Pt-Co units in 2005–6, 2 Pt-Co units in 2010, and <1 Pt-Co units in 2015. For well ST 378, dissolved oxygen was measured lower in 2010 (3.0 mg/L) and 2015 (3.6 mg/L) than in 2005–6 (9.2 mg/L). Concentrations of nutrients, dissolved gases (2010 and 2015 only), most major ions, and trace elements showed little change for each of the five wells (appendix tables 2.1 to 2.4, and 2.7). Concentrations of sodium and chloride in samples from well J1736 increased from 2010 (105 and 206 mg/L, respectively) to 2015 (168 and 304 mg/L, respectively). The concentration of chloride in the 2015 sample from J1736 exceeded the EPA SDWS and NYSDOH MCL of 250 mg/L. For wells F 573 and ST 378, no pesticides were detected in any of the samples from 2005–6, 2010, or 2015. For well F 543, the pesticide prometon was only detected in the 2015 sample (0.036 µg/L). For well J1736, the pesticide degradate CIAT was only detected in the 2010 sample (E0.001 µg/L). For the well ST 366, CIAT was detected in both the 2005–6 sample (E0.011 µg/L) and the 2015 sample (E0.015 µg/L) (appendix table 2.5). VOCs were not detected in any samples from F 543, F 573, J1736, or ST 366. For well ST 378, three VOCs—three THMs (trichloromethane, bromodichloromethane, and dibromochloromethane) were detected in the 2015 sample (appendix table 2.6). Gross-α, gross-β, and radon-222 activities exhibited little to no change for these wells (appendix table 2.7). Total coliform bacteria were not detected in samples from F 573, J1736, ST 366, or ST 378 (appendix table 2.8). For well F 543, 3 CFU/100 mL were detected in the 2010 sample only; samples from 2005–6 and 2015 were negative. Fecal coliform bacteria and *E. coli* bacteria were not detected in any samples from the five resampled wells. Heterotrophic plate counts in these five wells were relatively unchanged across the three rounds of sampling (appendix table 2.8).

Summary

In a study conducted by the U.S. Geological Survey (USGS), in cooperation with the New York Department of Environmental Conservation, groundwater samples were collected during May through November 2015 from 10 wells in the Delaware River Basin, 15 wells in the Genesee River Basin, and 21 wells in the St. Lawrence River Basin to characterize the overall groundwater quality in each of these basins. Sample collection and analysis followed standard U.S. Geological Survey procedures and other documented procedures. Samples were measured for physical properties and concentrations of dissolved gases, major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radionuclides, and bacteria. About 53 percent (78 of 148) of constituents analyzed for were not detected at concentrations greater than laboratory reporting levels in any of the samples.

Five of the 10 wells sampled in the Delaware River Basin are production wells, and the remaining 5 are domestic wells. Samples from these wells generally had few exceedances of State and (or) Federal drinking-water standards, although concentrations of some constituents—pH, color, aluminum, iron, manganese, radon-222, and total coliform bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. Every well sampled in the Delaware River Basin had at least one constituent equal to or greater than a primary, secondary, or proposed drinking-water standard. The constituents most frequently detected in concentrations exceeding drinking-water standards were manganese (filtered and unfiltered; 3 out of 10 samples) and pH (3 out of 10 samples). Additionally all 10 samples collected in the Delaware River Basin had radon-222 activities equal to or greater than the U.S. Environmental Protection Agency [EPA] proposed maximum contaminant level (MCL) of 300 picocuries per liter [pCi/L]). The highest radon-222 activities were in samples from wells completed in bedrock.

In the Delaware River Basin, pH was typically slightly below neutral. The groundwater was typically soft, although some wells were moderately hard. The median dissolved solids concentration was 165 milligrams per liter (mg/L) in sand-and-gravel wells and 89 mg/L in bedrock wells. The ions detected in the highest median concentrations were bicarbonate, chloride, calcium, and sodium. The dominant nutrient was nitrate; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Strontium, manganese, iron, and boron were the trace elements with the highest median concentrations. Iron concentrations exceeded drinking-water standards in samples from two wells; the maximum concentration was 8,190 micrograms per liter. Manganese concentrations in three samples exceeded drinking-water standards. Two pesticides and a pesticide degradate were detected among three samples. One sample had a detection of a VOC (trichloromethane). Radon-222 activities in all 10 samples exceeded a proposed MCL; no samples exceeded the proposed alternative maximum contaminant level. Total coliform bacteria were detected in two samples.

In the Genesee River Basin, 8 of the 15 wells sampled are production wells, and 7 are domestic wells. The samples had several exceedances of State and (or) Federal drinking-water standards, and properties and concentrations of some constituents—color, sodium, dissolved solids, chloride, iron, manganese, arsenic, aluminum, radon-222, methane, total coliform bacteria, fecal coliform bacteria, and *Escherichia coli* (*E. coli*) bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. All of the 15 wells sampled had at least one constituent equal to or greater than a primary, secondary, or proposed standard. The constituents most frequently detected in concentrations exceeding drinking-water standards were iron and manganese (unfiltered; 9 out of 15 samples). Radon-222 activities were equal to or greater than the proposed EPA MCL of 300 pCi/L in 12 out of 15 samples. The highest radon-222 activities were in samples from wells completed in bedrock.

In the Genesee River Basin, sample pH was typically near neutral. Methane was detected in 14 of the 15 samples; the action level was exceeded in samples from 3 wells. The groundwater was moderately hard to very hard, and the median dissolved solids concentration was 244 mg/L in sand-and-gravel wells and 456 mg/L in bedrock wells. The ions detected in the highest median concentrations were bicarbonate, calcium, sodium, and chloride. The dominant nutrient was ammonia; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Strontium, iron, barium, manganese, and boron were the trace elements with the highest median concentrations. Color, chloride, sodium, aluminum, arsenic, iron, and manganese concentrations exceeded drinking-water standards in samples. Three pesticides and one pesticide degradate were detected among three samples; all were trace-level detections. Four VOCs were detected in two samples. Radon-222 activities in 12 of 15 samples exceeded a proposed MCL. Total coliform bacteria were detected in six samples, and fecal coliform bacteria and *E. coli* bacteria were detected in one of those samples.

In the St. Lawrence River Basin, 7 of the 21 wells sampled are production wells, 1 is a municipal well, and 13 are domestic wells. The samples had several exceedances of State and (or) Federal drinking-water standards, and properties and concentrations of some constituents—pH, sodium, dissolved solids, chloride, iron, manganese, sulfate, radon-222, nitrate, total coliform bacteria, fecal coliform bacteria, and *E. coli* bacteria—equaled or exceeded primary, secondary, or proposed drinking-water standards. Nineteen of the 21 wells sampled had at least one constituent equal to or greater than primary, secondary, or proposed standards. The constituent most frequently detected in concentrations exceeding drinking-water standards was dissolved solids (5 out of 12 samples). Radon-222 activities were equal to or greater than the proposed EPA MCL of 300 pCi/L for 14 out of 21 samples. The highest radon-222 activities were in samples from wells completed in sand and gravel.

In the St. Lawrence River Basin, sample pH was typically near neutral. The groundwater tended toward moderately hard to very hard, and the median dissolved solids concentration was 132 mg/L in sand-and-gravel wells and 388 mg/L in bedrock wells. The ions detected in the highest median concentrations were bicarbonate, sulfate, calcium, magnesium, and sodium. The dominant nutrient was nitrate; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Strontium, iron, and boron were the trace elements with the highest median concentrations. Iron and manganese concentrations exceeded drinking-water standards in two and four samples, respectively. Two pesticides and one pesticide degradate were detected in two samples; all were trace-level detections. Three VOCs were detected in one sample. Radon-222 activities in 14 of 21 samples exceeded a proposed MCL. Total coliform bacteria, fecal coliform bacteria, and *E. coli* bacteria were detected in one sample.

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Appendixes 1–2

Appendix 1. Results of Water-Sample Analyses, 2015

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Table 1.1. Constituents that were not detected in groundwater samples collected from 46 wells in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Table 1.2. Physiochemical properties of and concentrations of dissolved gases in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Table 1.3. Concentrations of major ions and dissolved solids in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Table 1.4. Concentrations of nutrients and organic carbon in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

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Table 1.7. Concentrations of volatile organic compounds detected in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Table 1.8. Activities of radionuclides in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Table 1.9. Bacteria in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2015.

Appendix 2. Results of Water-Sample Analyses, 2005–6, 2010, and 2015

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Table 2.1. Physiochemical properties of and concentrations of dissolved gases in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.2. Concentrations of major ions and dissolved solids in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.3. Concentrations of nutrients and organic carbon in groundwater samples collected in the Delaware, Genesee and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.4. Concentrations of trace elements and radon in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.5. Concentrations of pesticides and pesticide degradates detected in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.6. Concentrations of volatile organic compounds detected in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.7. Activities of radionuclides in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

Table 2.8. Bacteria in groundwater samples collected in the Delaware, Genesee, and St. Lawrence River Basins, New York, 2005–6, 2010, and 2015.

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