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

Groundwater Quality in the Lower Hudson River Basin, New York, 2008

Open-File Report 2010–1197

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

Cover. View of the Hudson River from near the Bear Mountain bridge

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By Elizabeth A. Nystrom

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KEN SALAZAR, Secretary

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Conversion Factors, Datums, and Acronyms

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
liter (L)	0.2642	gallon (gal)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
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.
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).
Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).
Radon-222 activities are given in picocuries per liter (pCi/L).

Acronyms used in this report

AMCL	Alternative maximum contaminant level
CFU	Colony-forming units
CIAT	2-Chloro-4-isopropylamino-6-amino-*s*-triazine
cICP-MS	Collision/reaction cell inductively coupled plasma-mass spectrometry
ESA	Ethanesulfonic acid
GC-MS	Gas chromatography-mass spectrometry
GPS	Global positioning system
HPLC-MS	High-performance liquid chromatography-mass spectrometry
ICP-AES	Inductively coupled plasma-atomic emission spectrometry
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectrometry
LC-MS	Liquid chromatography-mass spectrometry
LRL	Laboratory reporting level
MCL	Maximum contaminant level
MTBE	Methyl *tert*-butyl ether
NWQL	USGS National Water Quality Laboratory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OA	Oxanilic acid
OGRL	USGS Organic Geochemistry Research Laboratory
OIET	2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine
PERC	Tetrachloroethene
PVC	Polyvinyl chloride
SDWS	Secondary drinking-water standards
TCE	Trichloroethene
THM	Trihalomethane
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

Groundwater Quality in the Lower Hudson River Basin, New York, 2008

By Elizabeth A. Nystrom

Abstract

Water samples were collected from 32 production and domestic wells in the study area from August through November 2008 to characterize the groundwater quality. The study area, which covers 5,607 square miles, encompasses the part of the Lower Hudson River Basin that lies within New York plus the parts of the Housatonic, Hackensack, Bronx, and Saugatuck River Basins that are in New York. The study area is underlain by mainly clastic bedrock, predominantly shale, with carbonate and crystalline rock present locally. The bedrock is generally overlain by till, but surficial deposits of saturated sand and gravel are present in some areas. Of the 32 wells sampled, 16 were finished in sand and gravel deposits and 16 were finished in bedrock. The samples were collected and processed by standard U.S. Geological Survey procedures and were analyzed for 225 physiochemical properties and constituents, including major ions, nutrients, trace elements, radon-222, pesticides, and volatile organic compounds (VOCs); indicator bacteria were collected and analyzed by New York State Department of Health procedures.

Water quality in the study area is generally good, but concentrations of some constituents exceeded current or proposed Federal or New York State primary or secondary drinking-water standards; the standards exceeded were color (2 samples), pH (6 samples), sodium (8 samples), fluoride (1 sample), aluminum (3 samples), arsenic (1 sample), iron (7 samples), manganese (14 samples), radon-222 (17 samples), tetrachloroethene (1 sample), and bacteria (7 samples). The pH of all samples was typically neutral or slightly basic (median 7.2); the median water temperature was 11.8°C. The ions with the highest concentrations were bicarbonate [median 167 milligrams per liter (mg/L)] and calcium (median 38.2 mg/L). Groundwater in the study area ranged from very soft to very hard, but more samples were classified as very hard (181 mg/L as $CaCO_3$ or more) than soft (60 mg/L as $CaCO_3$ or less); the median hardness was 140 mg/L as $CaCO_3$. The maximum concentration of nitrate plus nitrite was 2.38 mg/L as nitrogen, which did not exceed established drinking-water standards for nitrate plus nitrite (10 mg/L as nitrogen). The trace elements with the highest concentrations were strontium [median 189 micrograms per liter (µg/L)] and barium (median 50.6 µg/L). The highest radon-222 activities were in samples from crystalline bedrock wells [maximum 13,800 picocuries per liter (pCi/L)]. Seventeen samples had radon-222 activities that exceeded a proposed U.S. Environmental Protection Agency (USEPA) drinking-water standard of 300 pCi/L; activities in two samples exceeded a proposed alternative drinking-water standard of 4,000 pCi/L. Ten pesticides and pesticide degradates were detected among 14 samples at concentrations of 0.183 µg/L or less; most were herbicides or their degradates. Eight VOCs were detected among six samples; these included solvents, gasoline components, and a trihalomethane. Total coliform bacteria were detected in seven samples; fecal coliform bacteria, including *Escherichia coli*, were detected in one sample.

Introduction

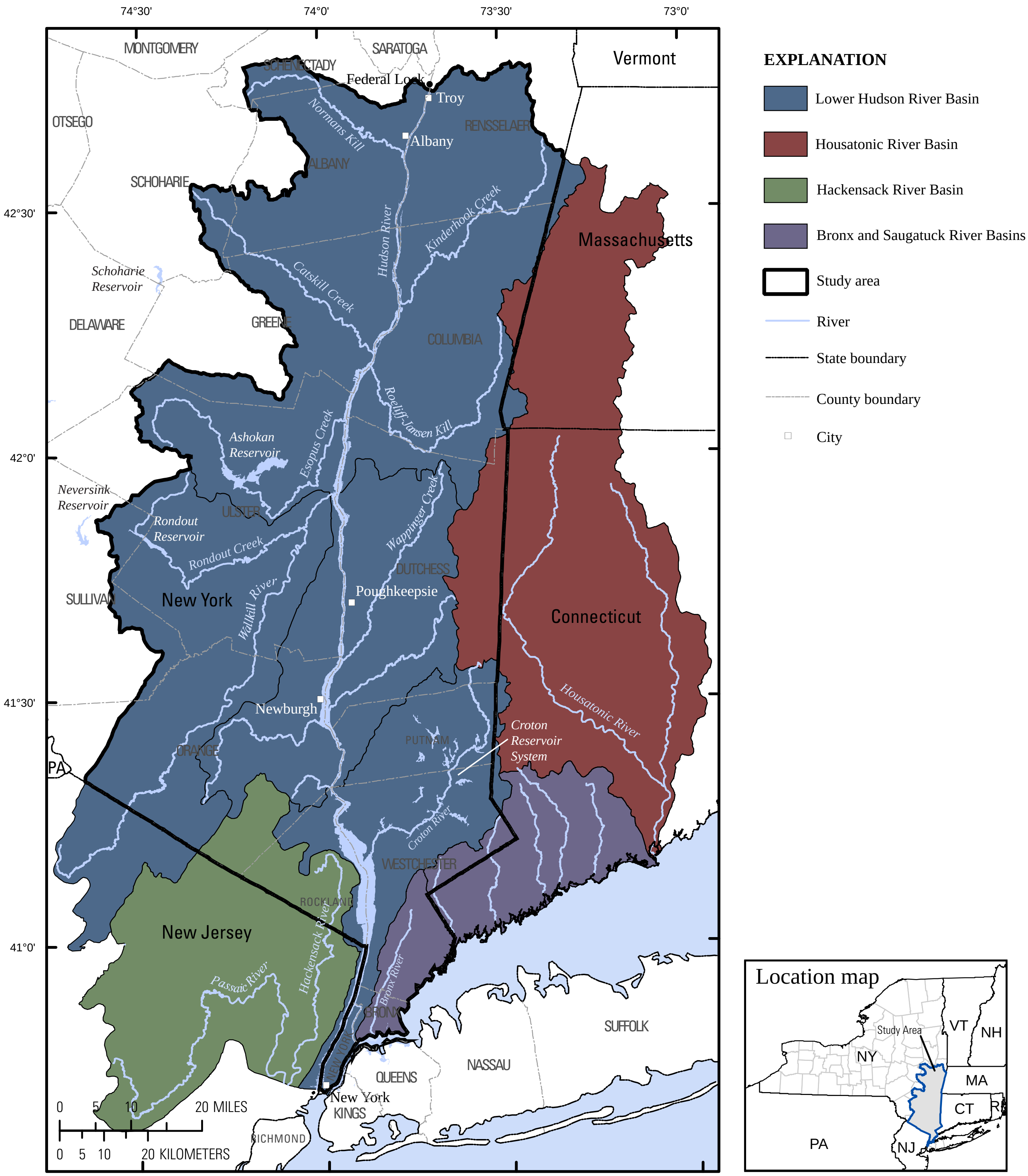
The Federal Clean Water Act Amendments of 1977 require biennial reports from states on the chemical quality of surface water and groundwater within their boundaries (U.S. Environmental Protection Agency, 1997). In 2002, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), developed a program to evaluate groundwater quality throughout the major river basins in New York on a rotating basis. The work parallels the NYSDEC Rotating Intensive Basin Study program, which evaluates surface-water quality in 2 or 3 of the 14 major river basins in the State each year. The USGS groundwater-quality program began in 2002 with a pilot study in the Mohawk River Basin (Butch and others, 2003). Sampling was completed in the Chemung River Basin in 2003 (Hetcher-Aguila, 2005); the Lake Champlain (Nystrom, 2006) and Susquehanna River Basins in 2004 (Hetcher-Aguila and Eckhardt, 2006); the St. Lawrence (Nystrom, 2007a), Delaware (Nystrom, 2007b), and Genesee River Basins (Eckhardt and others, 2007) in 2005; the Mohawk River Basin (Nystrom, 2008) and western New York (Niagara and Allegheny River Basins and tributaries to Lake Erie and western Lake Ontario) (Eckhardt and others, 2008) in 2006; and the Upper Hudson River Basin (Nystrom, 2009) and central New York (Oswego, Seneca, and Oneida River Basins and tributaries to Lake Ontario) (Eckhardt and others, 2009) in 2007. Studies in the Lower Hudson River Basin, the Black River Basin, and the Chemung River Basin were completed in 2008.

Purpose and Scope

This report presents the findings of the 2008 study in the Lower Hudson River Basin and surrounding areas, in which 32 groundwater-quality samples were collected from August through November 2008. This report (1) describes the hydrogeologic setting and the methods of site selection, sample collection, and chemical analysis, and (2) discusses the analytical results for physiochemical properties and concentrations of major ions, nutrients, trace elements and radon-222, pesticides, volatile organic compounds (VOCs), and indicator bacteria. Information about the sampled wells and results of the analyses are presented in tables in the text and Appendix 1.

Hydrogeologic Setting

The Lower Hudson River Basin encompasses 5,313 mi^2 in New York, Massachusetts, Connecticut, and New Jersey and is defined as the part of the Hudson River Basin that lies below the Federal Lock and Dam at Troy, N.Y. (fig. 1). This study included the 5,001-mi^2 part of the Lower Hudson River Basin that lies within New York as well as 606 mi^2 of the Housatonic, Hackensack, Bronx, and Saugatuck River Basins that lie within New York along the southern and eastern border of New York State (hereafter referred to as the “study area,” fig. 1). The study area contains all or part of 16 counties, including all of Columbia, Dutchess, Putnam, Westchester, Bronx, New York, and Rockland Counties, much of Albany, Ulster, Orange, Green, and Rensselaer Counties, and parts of Schenectady, Schoharie, Sullivan, and Delaware Counties (fig. 1). Major tributaries to the Lower Hudson River include the Wallkill River, Rondout Creek, Esopus Creek, Croton River, Catskill Creek, Kinderhook Creek, and Wappinger Creek. New York City maintains a system of several reservoirs for drinking-water supply; several of these reservoirs are in the Lower Hudson River Basin, including the Ashokan Reservoir, Rondout Reservoir, and the Croton Reservoir system. Aqueducts conduct water from these reservoirs and additional reservoirs outside of the Lower Hudson River Basin to New York City for use.



Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
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Hydrology from National Hydrography Dataset

Figure 1. Principal hydrologic and geographic features of the Lower Hudson River Basin in New York.

The highest elevations in the study area are more than 4,000 ft above NAVD 88 along the western edge of the Hudson River Basin, in the Catskill Mountains (fig. 2). The area of greatest precipitation in the study area is in the Catskill Mountains, where more than 60 in. of precipitation fall per year; the lowest amount of precipitation in the study area occurs along the Hudson Valley, where approximately 40 in. of precipitation fall per year (Randall, 1996). The lowest elevations in the study area are along the Hudson River, which is tidal for more than 150 mi from its mouth at New York City to the Federal Lock and Dam at Troy, N.Y. (fig. 1).

The largest urban center in the study area is New York City (fig. 1); other urban centers in the study area include Albany, Poughkeepsie, and Newburgh. Land use in the study area (fig. 3) reflects these urban areas and the terrain of the land. The upland areas of the study area are predominantly forested (Vogelmann and others, 2001) (fig. 3); urban development and agriculture occur mainly along the Hudson Valley and other low-lying areas. Many fruit orchards are found in the Hudson Valley; numerous vegetable farms, especially onions, are located in the organic-rich "black dirt" region of Orange County.

Bedrock in the study area (fig. 4) mainly consists of sedimentary and metamorphic clastic rock (Isachsen and others, 2000). The western part of the study area is underlain by shale and sandstone, with a band of carbonate rock running from north to south. The southeastern part of the study area is predominantly underlain by crystalline rock. The eastern part of the study area is underlain by a mix of clastic bedrock, including shale and graywacke, with some carbonate and crystalline rock. Yields from bedrock wells in the study area vary greatly, but the carbonate units produce the highest average yields (Hammond and others, 1978).

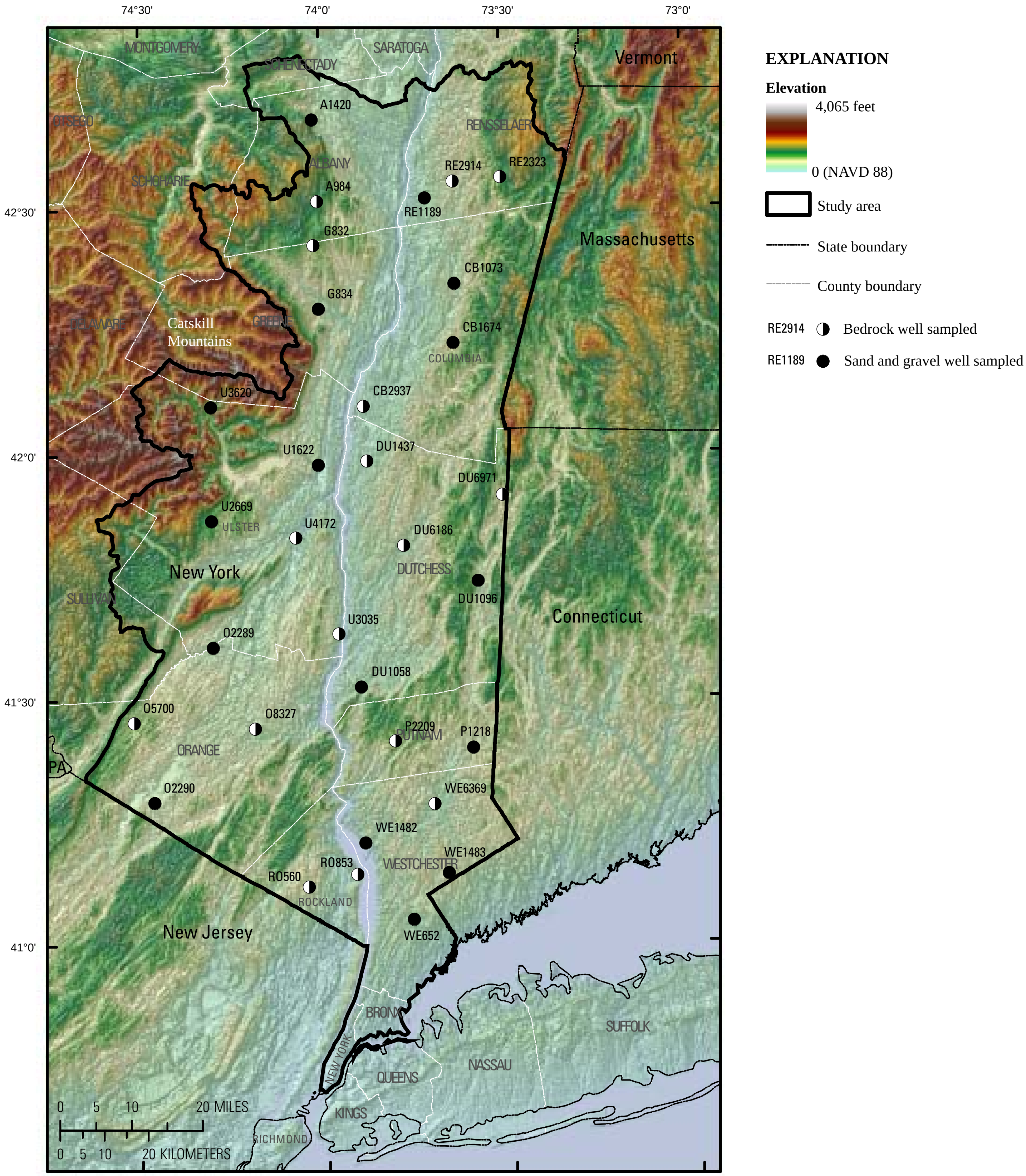
The surficial material throughout the study area was deposited primarily during the Pleistocene epoch when glaciers covered most of the Northeast. Till was directly deposited by the glaciers and mantles bedrock in the uplands (fig. 5). Ice-contact and lacustrine sediments, outwash, and alluvium were deposited mainly in valleys during and following glacial retreat. Ice-contact and outwash sand and gravel form the most productive aquifers in the study area. Wells screened in these deposits may yield 2,000 gal/min or more (Hammond and others, 1978, Phillips and Hanchar, 1996).

Methods of Investigation

The methods used in this study, including (1) well-selection criteria, (2) sampling methods, and (3) analytical methods, were designed to maximize data precision, accuracy, and comparability. The collection and processing of groundwater samples followed standard USGS procedures documented in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Samples were analyzed by documented methods at the USGS National Water Quality Laboratory (NWQL) in Denver, Colo., the USGS Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kans., and New York State Department of Health (NYSDOH)-certified laboratories.

Well Selection

Wells were selected to provide adequate spatial coverage of the study area; areas of greatest groundwater use were emphasized. The final selection was based on the availability of well-construction data and hydrogeologic information for each well and its surrounding area. The study did not target specific municipalities, industries, or agricultural practices. The 32 wells selected for sampling represented rural, residential, and developed, forested, and agricultural areas (fig. 3). The characteristics of the wells sampled, including well and casing depths, well type, aquifer type, and the type of land cover surrounding each well are listed in table 1. The depths of the wells, the geologic units from which samples were collected, and the numbers of production and domestic wells are summarized in table 2.



Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
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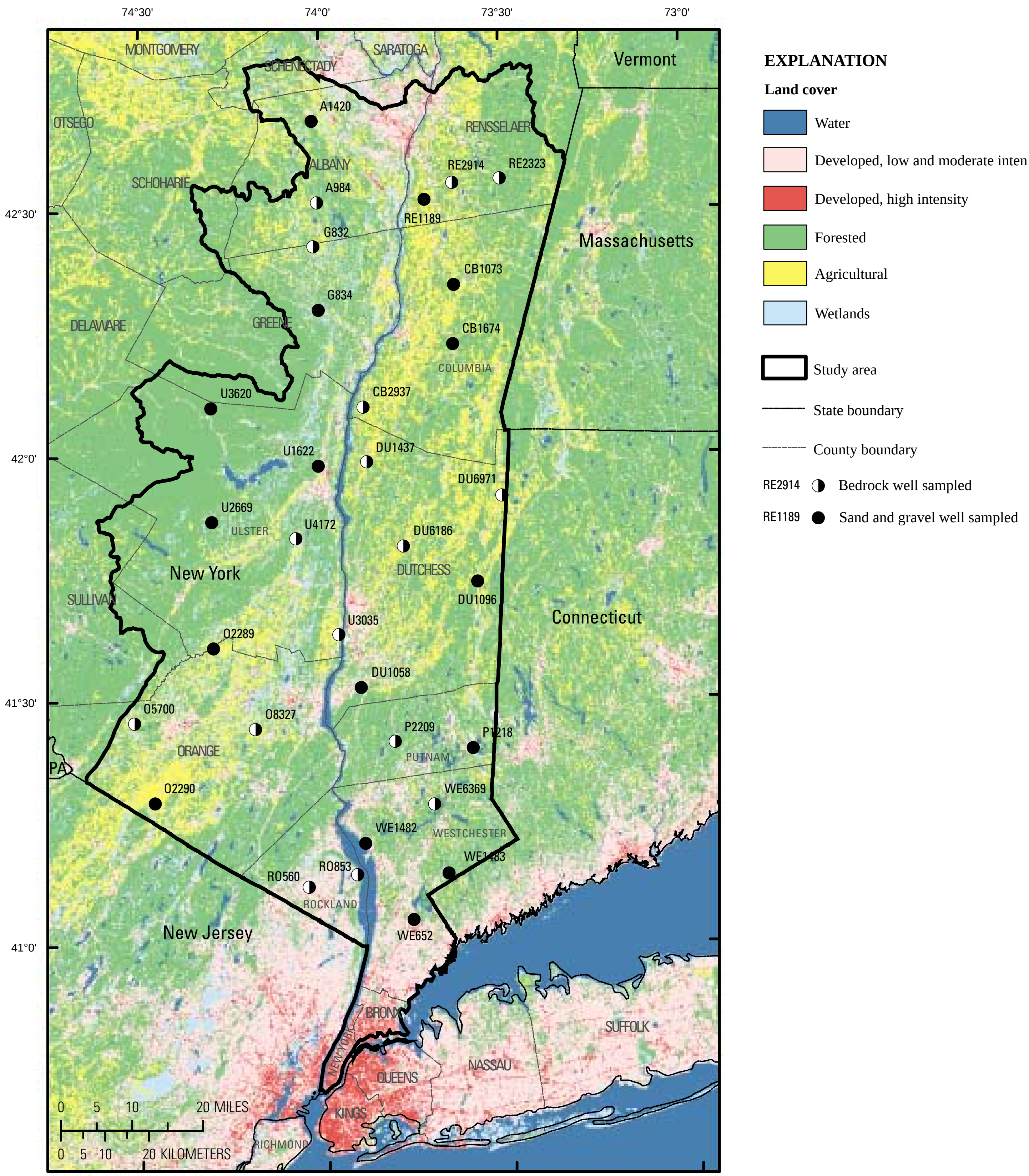
Elevations from National Elevation Dataset, 2005

Figure 2. Topography of the Lower Hudson River Basin in New York, and locations of wells sampled in 2008.



Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
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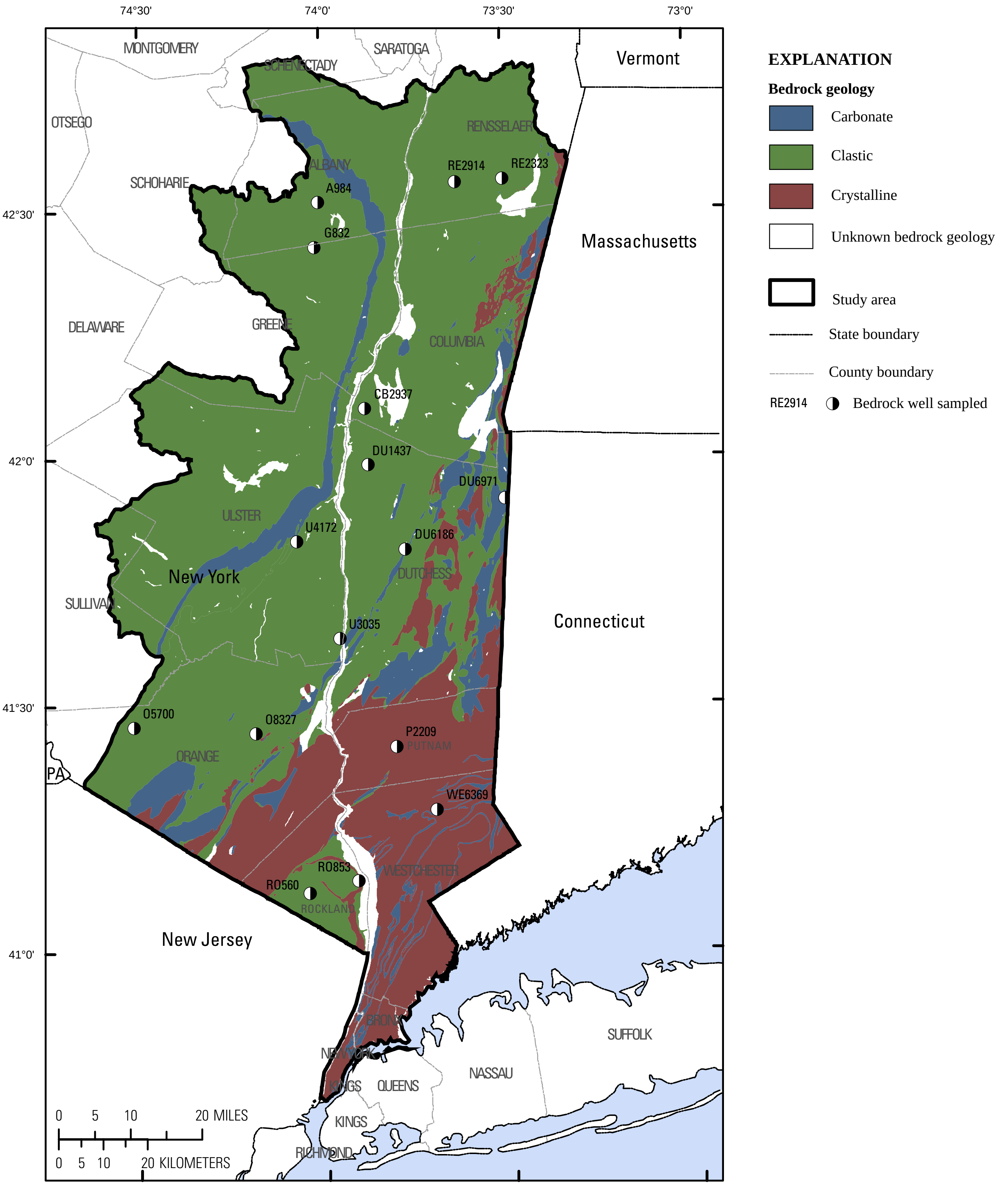
Land cover from Vogelmann and others, 2001

Figure 3. Land cover of the Lower Hudson River Basin in New York, and locations of wells sampled in 2008.



Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
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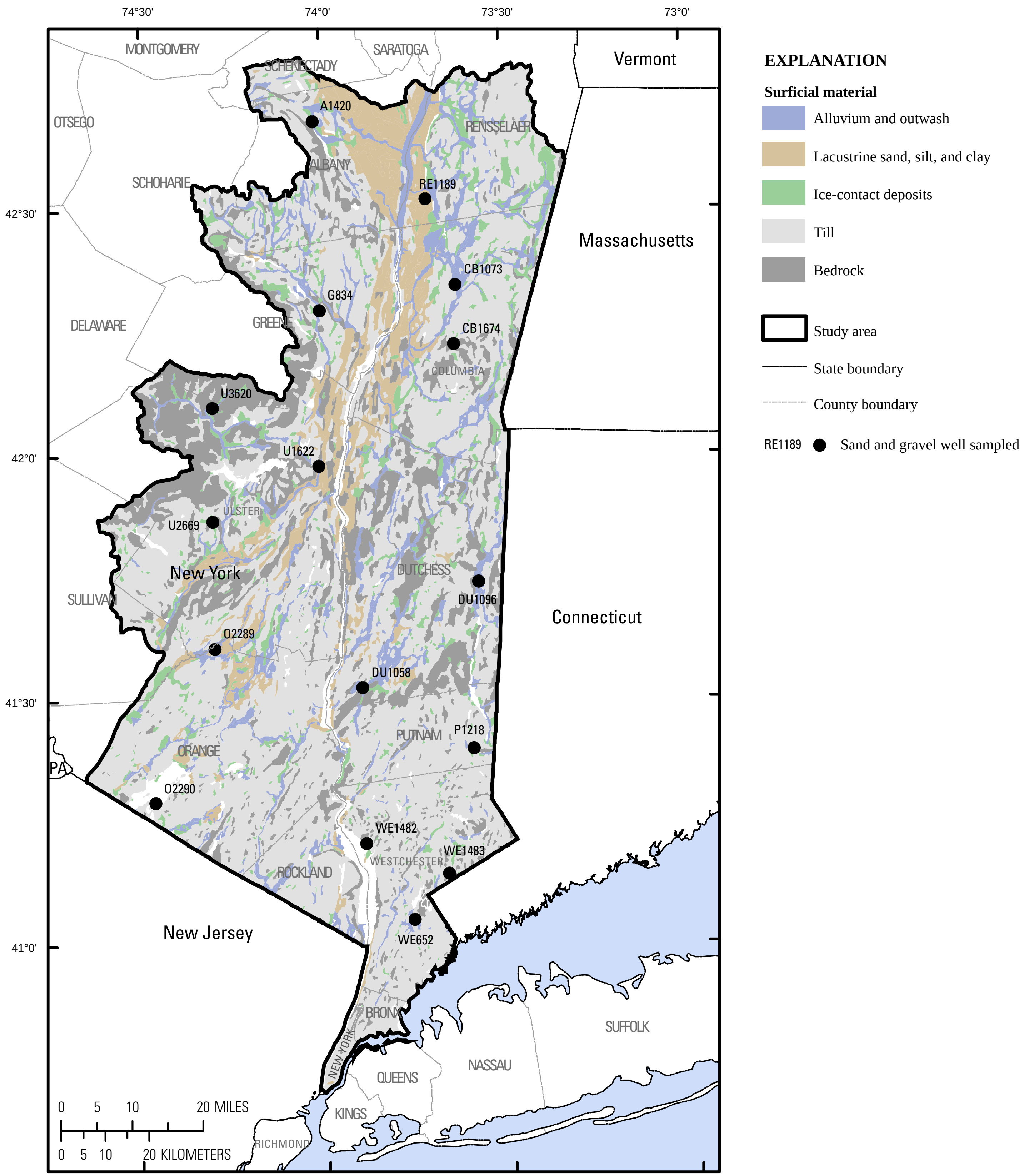
Geology modified from Fisher and others, 1970

Figure 4. Generalized bedrock geology of the Lower Hudson River Basin in New York, and locations of bedrock wells sampled in 2008.



Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
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Geology modified from Fisher and others, 1970

Figure 5. Generalized surficial geology of the Lower Hudson River Basin in New York, and locations of sand and gravel wells sampled in 2008.

Table 1. Information on wells from which water samples were collected in the Lower Hudson River Basin, New York, 2008.

[--, unknown; well types: P, production; D, domestic. Land-cover categories: D, developed; F, forested; A, agricultural; W, wetlands and open water. Well locations are shown in fig. 2.]

Well number[1]	Date sampled	Well depth, feet below land surface	Casing depth, feet below land surface	Well type	Bedrock type	Land cover[2], percentage by category: D	F	A	W
Sand and gravel wells									
A1420	8/5/2008	42	30	P		7	16	41	36
CB1073	9/9/2008	15	--	P		6	56	33	5
CB1674	8/6/2008	58	43	P		27	62	4	7
DU1058	9/30/2008	120	98	P		13	76	4	7
DU1096	8/26/2008	50	--	P		28	48	23	1
G834	11/20/2008	20	--	P		38	41	8	13
O2289	8/19/2008	91	82	P		22	11	54	13
O2290	8/19/2008	66	28	P		19		78	2
P1218	9/22/2008	50	--	P		53	37	1	9
RE1189	9/16/2008	90	--	P		14	53	32	1
U1622	8/13/2008	60	50	P		54	20	2	24
U2669	9/8/2008	100	100	D		4	52	1	43
U3620	8/11/2008	202	202	D		9	87		4
WE652	8/12/2008	23	--	P		80	14		6
WE1482	10/1/2008	75	--	P		19	74	5	2
WE1483	8/14/2008	40	25	P		25	67	4	4
Bedrock wells									
A984	8/18/2008	215	78	D	Sandstone and shale	4	81	13	2
CB2937	8/11/2008	265	32	D	Shale and other clastic	5	58	34	3
DU1437	8/27/2008	300	--	P	Shale and other clastic	41	28	31	0
DU6186	8/26/2008	303	20	D	Shale	5	18	76	1
DU6971	8/6/2008	460	80	D	Carbonate	4	30	53	13
G832	8/27/2008	353	60	P	Sandstone and shale	9	37	34	20
O5700	8/7/2008	505	20	D	Shale and other clastic	5	59	16	20
O8327	8/7/2008	403	160	D	Shale	3	32	52	13
P2209	8/28/2008	265	32	D	Crystalline	5	91	1	3
RE2323	8/5/2008	270	40	D	Shale and other clastic	5	92	3	
RE2914	11/17/2008	51	50	D	Shale and other clastic	12	38	40	10
RO560	9/3/2008	363	65	P	Sandstone	87	6		7
RO853	9/3/2008	575	80	D	Crystalline	20	38	5	37
U3035	8/20/2008	143	20	D	Shale and other clastic	17	21	32	30
U4172	8/13/2008	540	212	D	Carbonate	50	25	5	20
WE6369	8/14/2008	405	52	D	Crystalline	22	70	5	3

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

[2] Land cover by category within a 0.5-mile radius of the well, determined from the National Land Cover Data set, 2001.

Table 2. Summary of information on wells from which water samples were collected in the Lower Hudson River Basin, New York, 2008.

[--, no wells]

Type of well		Number of wells		
		Production	Domestic	Total
Wells finished in sand and gravel	(15 to 202 feet deep)	14	2	16
Wells finished in bedrock	(51 to 575 feet deep)	3	13	16
Carbonate bedrock		--	2	2
Shale bedrock		--	2	2
Sandstone bedrock		1	--	1
Sandstone and shale bedrock		1	1	2
Shale and other clastic bedrock		1	5	6
Crystalline bedrock		--	3	3
Total number of wells		17	15	32

The 15 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 and diameter, yield, and a hydrogeologic log. Inspection of well-completion reports identified about 400 wells as potential sampling sites. A letter that included a request for permission to sample the well and a questionnaire about the well was sent to the well owners. Well owners who granted permission and whose wells were selected for sampling were contacted later by phone to verify well information and to arrange a convenient time for sampling.

Production wells considered for sampling were identified through the U.S. Environmental Protection Agency (USEPA) Safe Drinking Water Information System 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 evaluated through review of the hydrogeologic logs and inspection of published geologic maps including Fisher and others (1970) and Cadwell (1991).

Sampling Methods

The 32 wells were sampled from August through November 2008, and samples, except bacteria, were collected and processed in accordance with documented USGS protocols (U.S. Geological Survey, variously dated). Bacteria samples were collected in accordance with documented NYSDEC and NYSDOH protocols. The samples were collected from a spigot between the well and the pressure tank, where possible, and before any water-treatment system, to be as representative of the aquifer water quality as possible. Most 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.

One or two wells were sampled per day. Typically, samples were collected from one or more 10-ft lengths of Teflon tubing attached to a “garden-hose” type spigot located as close to the well as possible. Domestic wells were purged after the tubing was connected by running to waste for at least 20 minutes, or until at least one well-casing volume of water had passed the sampling point. Many of the production wells were pumped for at least 1 hour prior to sampling, typically at rates of about 100 gal/min. Domestic wells were purged at pumping rates ranging from about 2 to 5 gal/min. Collection of representative samples from wells that had been pumped recently may not require the commonly prescribed removal of less than three well-casing volumes (U.S. Geological Survey, 2006). During well purging, information about the well and surrounding land and land use were noted, and a global positioning system (GPS) measurement of latitude and longitude was made. After the well was purged, field measurements of water temperature, pH, specific conductance, and dissolved-oxygen concentration were recorded at regular intervals until these values had stabilized, after which the sample was collected (U.S. Geological Survey, variously dated).

The flow rate for sample collection was adjusted to less than 0.5 gal/min when possible. The Teflon sampling tube was connected to a sample-collection chamber constructed of a polyvinyl chloride (PVC) frame and a clear plastic chamber bag. The sampling chamber was placed on a plastic-box table with a built-in drain. Before each day of sampling, the Teflon tubing and spigot-attachment equipment were cleaned in the laboratory with a dilute phosphate-free detergent solution, followed by rinses with tap water and deionized water. Equipment for filtration of pesticide samples was rinsed with methanol as described in Wilde (2004). A new sampling-chamber bag was used at each site. Samples were collected and preserved in the sampling chamber according to standard USGS procedures (Wilde and others, 2004). Sample bottles for nutrient, major-ion, and some trace-element analyses were filled with water filtered through disposable (one-time use) 0.45-µm-pore-size polyether sulfone capsule filters that were preconditioned in the laboratory with 1 L of deionized water the day of sample collection. Sample bottles for pesticide analyses were filled with water filtered through baked 0.7-µm-pore-size glass fiber filters. Acid preservation was required for trace element, VOC, and some major-ion analyses. Acid preservative was added after the collection of other samples to avoid 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. Bacterial samples were collected in accordance with NYSDEC and NYSDOH protocols, except that the tap from which each water sample was collected was not flame sterilized. Samples for radon analyses were collected through a septum chamber with a glass syringe to avoid exposure to the atmosphere according to standard USGS procedures. Water samples analyzed by NYSDOH-certified laboratories were collected in bottles provided by the analyzing laboratory. After collection, all samples except those for radiochemical analyses were chilled to 4°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.

Most sampling sites had easy access to a garden-hose spigot; however, some wells did not. Wells P1218, RO560, U1622, WE652, and WE1482 (fig. 2 and table 1) were sampled from valves at which water-system personnel routinely collect raw-water samples. Wells DU1437 and RE2914 were sampled at sinks. Well U3620 was a flowing artesian well; the sample was collected at the overflow outlet. The syringe for collecting a radon-222 sample at these sites was inserted directly into the flowing water in the throat of the valve, tap, or outlet to minimize sample exposure to the atmosphere.

Analytical Methods

Samples were analyzed for 225 physiochemical properties and constituents, including major ions, nutrients, trace elements, radon-222, pesticides and pesticide degradates, VOCs, and bacteria. Physiochemical properties such as water temperature, pH, dissolved-oxygen concentration, and specific conductance were measured at the sampling site. Sample color was measured at the USGS NWQL by visual comparison using a color comparator. Major ions, nutrients, trace elements, radon-222, pesticides and pesticide degradates, and VOCs were analyzed at the USGS NWQL in Denver, Colo.; additional pesticide and pesticide degradates were analyzed at the USGS OGRL in Lawrence, Kans. Total organic carbon and phenolic compounds were analyzed at H2M Labs in Melville, N.Y., and indicator bacteria were analyzed at St. Peter's Bender Laboratory in Albany, N.Y.; both of these laboratories are certified by NYSDOH.

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). Nutrients were analyzed by colorimetry, as described by Fishman (1993), and Kjeldahl digestion with photometric finish, as described by Patton and Truitt (2000). Mercury concentrations were measured through cold vapor–atomic fluorescence spectrometry according to methods described by Garbarino and Damrau (2001). Arsenic, chromium, and nickel analyses used collision/reaction cell inductively coupled plasma-mass spectrometry (cICP-MS) 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 (ICP-OES), and inductively coupled plasma-mass spectrometry (ICP-MS) (Garbarino and Struzeski, 1998). In-bottle digestions for trace-element analyses described by Hoffman and others (1996) were followed. Radon-222 was measured through liquid-scintillation counting (ASTM International, 2006).

Samples for pesticide analyses were processed as described by Wilde and others (2004). Pesticides and pesticide-degradates were analyzed at the NWQL through gas chromatography-mass spectrometry (GC-MS) and high-performance liquid chromatography-mass spectrometry (HPLC-MS), as described by Zaugg and others (1995), Sandstrom and others (2001), and Furlong and others (2001). Acetamide parent compounds and degradation-product analyses were done by liquid chromatography-mass spectrometry (LC-MS) at the USGS OGRL according to methods described by Lee and Strahan (2003). VOCs were analyzed by GC-MS using methods described by Connor and others (1998).

Concentrations of total organic carbon were measured by method SW-846 9060 (U.S. Environmental Protection Agency, 2004); total phenolic compounds were analyzed by USEPA method 420.2 (U.S. Environmental Protection Agency, 1983). Indicator bacteria samples were tested for total coliform, fecal coliform, and *Escherichia coli (E. coli)* through Standard Method 9222 (American Public Health Association, 2005). A heterotrophic plate count test (SM 9215 B) also was done.

In addition to the 32 groundwater samples, 1 equipment blank sample and 2 sequential replicate samples were collected for quality assurance. Nitrogen-purged VOC/pesticide-grade blank water and inorganic-grade blank water supplied by the USGS-NWQL were used for a laboratory equipment blank. The water for unfiltered constituents was run through a piece of the Teflon tubing used for sampling; water for filtered-water constituents was pumped through the Teflon tubing into cleaned, preconditioned filters. Samples were acidified in the same manner as environmental well-water samples. The only constituents that exceeded laboratory reporting levels (LRLs) in the blank were sample color, which was measured at 2 platinum-cobalt (Pt-Co) units (LRL 1 Pt-Co unit), and boron, which was measured at 1.3 µg/L (LRL 1.2 µg/L). The concentration differences in the first of the sequential replicate samples were less than 5 percent for all constituents detected above the LRL in the sample except for color, iron, lead, manganese, zinc, and heterotrophic plate count, which were detected at levels close to the LRL, where small differences in concentration make large relative percent-concentration differences. Concentrations of trace elements in the second sequential replicate, at well WE652, were markedly different than the environmental sample, with the replicate concentrations being generally 30 to 50 percent higher. This result is not typical of replicate samples collected previously as part of this study and likely reflects unusual sampling conditions at the site. Well WE652 is a production well that was not in general use at the time of sampling; when pumped, the water level in the well quickly reached the maximum operational drawdown level and the pump was automatically shut off. Concentrations of constituents in the sample from well WE652 should be interpreted as having substantially higher than usual variability.

Groundwater Quality

The 32 samples were analyzed for 225 constituents and physiochemical properties. Most (153) of these were not detected above the LRLs in any sample (appendix table 1-1). Results for the remaining 72 constituents and properties that were detected are presented in the appendix (tables 1-2 through 1-8). Some concentrations were reported as "estimated." Estimated concentrations are typically reported where 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). Concentrations of some constituents exceeded maximum contaminant levels (MCLs) or secondary drinking-water standards (SDWS) set by the USEPA (U.S. Environmental Protection Agency, 2009b) or NYSDOH (New York State Department of Health, 2007). MCLs are enforceable standards for finished water at public water supplies; they are not enforceable for private homeowner wells but are presented here as a standard for evaluation of the water-quality results. SDWS are nonenforceable drinking-water standards that typically relate to aesthetic concerns such as taste, odor, or staining of plumbing fixtures.

Physiochemical Properties

The color of samples ranged from less than (<) 1 to 30 Pt-Co units; the median sample color was 2 Pt-Co units (appendix table 1-2). The color of two samples, 20 and 30 Pt-Co units, exceeded the NYSDOH MCL and USEPA SDWS of 15 Pt-Co units; both these samples were from sand and gravel wells. Dissolved-oxygen concentrations ranged from < 0.1 to more than 10 mg/L and were generally greater in samples from sand and gravel wells (median 4.6 mg/L) than in samples from bedrock wells (median 1.4 mg/L). Sample pH was typically near neutral or slightly basic (median 7.2 in all wells) and ranged from 6.2 to 9.4. The pH of six samples exceeded the USEPA SDWS range for pH (6.5 to 8.5); two samples had a pH less than the SDWS range and four samples had a pH greater than the SDWS range; all six samples were from bedrock wells. Specific conductance ranged from 108 to 1,500 µS/cm at 25°C. Water temperature ranged from 9.7 to 19.8°C; the median temperature was 11.8°C. Hydrogen sulfide gas was detected in approximately one-third of the bedrock wells sampled; it was not detected in any of the sand and gravel wells sampled.

Major Ions

The anions detected from all wells in the highest concentrations were bicarbonate (median concentration 167 mg/L) and chloride (median concentration 42.4 mg/L) (table 3 and appendix table 1-3). The cation from all wells with the greatest median concentration (38.2 mg/L) was calcium. The concentration of sodium in eight samples exceeded the USEPA nonregulatory drinking-water advisory taste threshold of 60 mg/L; the maximum concentration of sodium was 178 mg/L. The concentration of fluoride in one sample, 3.46 mg/L, exceeded the NYSDOH MCL of 2.2 mg/L and the USEPA SDWS of 2.0 mg/L. Concentrations of chloride and sulfate did not exceed established MCLs in any sample.

Water hardness ranged from very soft to very hard – 2 to 440 mg/L as $CaCO_3$ – with a median of 140 mg/L as $CaCO_3$. More samples (11) were very hard (181 mg/L as $CaCO_3$ or more) than were soft (5 samples, 60 mg/L as $CaCO_3$ or less; Hem, 1985). Alkalinity ranged from 47 to 397 mg/L as $CaCO_3$; the median was 138 mg/L of $CaCO_3$. Residue on evaporation at 180°C, a measurement of total dissolved solids, ranged from 68 to 822 mg/L, and the median was 286 mg/L.

Table 3. Drinking-water standards and summary statistics for concentrations of major ions in groundwater samples from the Lower Hudson River Basin, New York, 2008.

[All concentrations are in milligrams per liter in filtered water; --, no standard; <, less than; E, estimated value]

	Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (16 samples) Minimum	Sand and gravel aquifers (16 samples) Median	Sand and gravel aquifers (16 samples) Maximum	Bedrock aquifers (16 samples) Minimum	Bedrock aquifers (16 samples) Median	Bedrock aquifers (16 samples) Maximum
Cations	Calcium	--		38.2	12.6	36.4	116	0.68	40.3	97.6
	Magnesium	--		8.25	2.02	8.39	38.3	.123	7.31	30.2
	Potassium	--		1.08	.29	1.32	4.60	.54	1.01	4.55
	Sodium	[1]60	8	28.2	5.51	23.9	126	1.61	35.7	178
Anions	Bicarbonate	--		167	57	138	483	58	197	372
	Chloride	[2,3]250	0	42.4	.76	42.4	232	2.05	42.2	155
	Fluoride	[2]2.2 [3]2.0	1 1	E .04	< .08	< .12	.17	< .08	E .10	3.46
	Silica	--		10.8	4.14	9.19	13.8	5.19	11.5	40.7
	Sulfate	[2,3]250	0	23.8	5.35	16.0	70.8	2.04	24.2	56.1
Hardness as $CaCO_3$				140	42	125	440	2	140	300
Alkalinity as $CaCO_3$				138	47	114	397	48	162	330
Residue on evaporation				286	68	214	822	181	322	524

[1] U.S. Environmental Protection Agency Drinking Water Advisory Taste Threshold.

[2] New York State Department of Health Maximum Contaminant Level.

[3] U.S. Environmental Protection Agency Secondary Drinking Water Standard.

Nutrients and Organic Carbon

The dominant nutrient in the groundwater samples was nitrate. Concentrations of nitrate plus nitrite ranged from < 0.04 to 2.38 mg/L as nitrogen (N) (table 4 and appendix table 1-4); the median concentration was 0.17 mg/L as N. The concentration of nitrate plus nitrite did not exceed the USEPA and NYSDOH MCL of 10 mg/L as N in any sample. Nitrite was detected in less than one fifth of the samples and had a maximum concentration of 0.015 mg/L as N; the concentration of nitrite did not exceed the MCL (1 mg/L as N) in any sample. The concentrations of ammonia ranged from < 0.020 to 0.487 mg/L as N. Orthophosphate concentrations ranged from < 0.006 to 0.099 mg/L as phosphorus (P). Organic carbon was detected in 18 samples; the maximum concentration was 3.0 mg/L.

Table 4. Drinking-water standards and summary statistics for concentrations of nutrients in groundwater samples from the Lower Hudson River Basin, New York, 2008.

[All concentrations in milligrams per liter in filtered water except as noted. N, nitrogen; P, phosphorus; --, no standard; <, less than; E, estimated.]

Summary statistics and concentrations									
Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (16 samples)			Bedrock aquifers (16 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia plus organic N, as N	--		< 0.14	< 0.1	< 0.14	0.44	< 0.14	< 0.14	0.51
Ammonia, as N	--		< .020	< .020	< .020	.408	< .020	.036	.487
Nitrite plus nitrate, as N	[1,2]10	0	.17	< .04	.22	2.38	< .04	.14	1.86
Nitrite, as N	[1,2]1	0	< .002	< .002	< .002	.015	< .002	< .002	.015
Orthophosphate, as P	--		.008	< .006	.008	.039	E .006	.009	.099
Total organic carbon, unfiltered	--		1.0	< 1.0	1.2	2.0	< 1.0	< 1.0	3.0

[1] U.S. Environmental Protection Agency Maximum Contaminant Level.

[2] New York State Department of Health Maximum Contaminant Level.

Trace Elements and Radon-222

The trace elements present in the highest median concentrations in the samples were strontium (median 189 µg/L), barium (median 50.6 µg/L), iron (median 26 µg/L in unfiltered water; E5 µg/L in filtered water), boron (median 16 µg/L), and manganese (median 15.6 µg/L in unfiltered water; 4.8 µg/L in filtered water) (table 5 and appendix table 1-5). The highest detected concentration of a trace element, 8,860 µg/L, was iron in an unfiltered sample from a bedrock well. The concentration of aluminum in three samples exceeded the USEPA SDWS range of 50 to 200 µg/L. The concentration of arsenic in one sample, 13.3 µg/L, exceeded the USEPA and NYSDOH MCLs of 10 µg/L. The concentration of iron in seven unfiltered samples and in three filtered samples exceeded the USEPA SDWS and NYSDOH MCL for iron of 300 µg/L. The concentration of manganese in 14 unfiltered and 13 filtered samples exceeded the USEPA SDWS of 50 µg/L; the concentration in 5 unfiltered and 4 filtered samples exceeded the NYSDOH MCL of 300 µg/L. Drinking-water standards for antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, zinc, and uranium were not exceeded; thallium was not detected in any sample (appendix table 1-1).

Radon-222 activities in the water samples ranged from 28 to 13,800 pCi/L; the median was 355 pCi/L. Radon is currently not regulated in drinking water; however, the USEPA has proposed a two-part standard for radon in drinking water: (1) a 300 pCi/L MCL for areas that do not implement an indoor-air radon mitigation program, and (2) an alternative MCL (AMCL) of 4,000 pCi/L for areas that do (U.S. Environmental Protection Agency, 1999). Activities in 17 (53 percent) of the samples exceeded the proposed MCL; 10 of these samples were from wells finished in sand and gravel, and 7 were from wells finished in bedrock. Activities in two samples, 5,600 and 13,800 pCi/L, exceeded the proposed AMCL; both of these samples were from wells finished in crystalline bedrock.

Table 5. Drinking-water standards and summary statistics for concentrations of trace elements and radon-222 in groundwater samples from the Lower Hudson River Basin, New York, 2008.

[µg/L, micrograms per liter; <, less than; E, estimated value; M, presence verified but not quantified; --, no standard; pCi/L, picocuries per liter]

Constituent	Drinking-water standard	Number of samples exceeding standard	Median (all samples)	Sand and gravel aquifers (16 samples)			Bedrock aquifers (16 samples)		
				Minimum	Median	Maximum	Minimum	Median	Maximum
Aluminum, unfiltered, µg/L	[3]50-200	3	E 2	< 4	< 4	305	< 4	6	114
Antimony, unfiltered, µg/L	[1,2]6	0	< .1	< .1	< .1	< .4	< .1	< .1	1.0
Arsenic, unfiltered, µg/L	[1,2]10	1	E .38	< .60	E .46	6.4	< .60	< .60	13.3
Barium, unfiltered, µg/L	[1,2]2000	0	50.6	1.1	49.8	238	6.0	57.2	904
Beryllium, unfiltered, µg/L	[1,2]4	0	< .04	< .02	< .04	< .04	< .02	< .04	E .04
Boron, filtered, µg/L	--		16	5.9	16	32	2.8	34	1,060
Cadmium, unfiltered, µg/L	[1,2]5	0	< .01	< .01	< .01	.13	< .01	< .01	.02
Chromium, unfiltered, µg/L	[1,2]100	0	< .40	< .40	< .40	.94	< .40	< .40	2.4
Cobalt, unfiltered, µg/L	--		E .02	< .04	E .02	.88	< .04	E .02	1.9
Copper, unfiltered, µg/L	[3]1000	0	2.3	< 1.2	1.8	17.4	E .60	3.0	17.1
Iron, filtered, µg/L	[2,3]300	3	E 5	< 8	E 5	2,290	< 8	E 4	584
Iron, unfiltered, µg/L	[2,3]300	7	26	< 6	20	3,330	E 3	30	8,860
Lead, unfiltered, µg/L	[4]15	0	.24	< .06	.20	2.16	< .06	.28	2.81
Lithium, unfiltered, µg/L	--		5.0	.5	2.6	18.5	.7	9.6	448
Manganese, filtered, µg/L	[3]50 [2]300	13 4	4.8	< .4	60.2	572	< .4	3.4	739
Manganese, unfiltered, µg/L	[3]50 [2]300	14 5	15.6	< .4	63.2	717	< .4	7.2	806
Mercury, unfiltered, µg/L	[1,2]2	0	< .010	< .010	< .010	< .010	< .010	< .010	.016
Molybdenum, unfiltered, µg/L	--		.6	M	.5	1.8	< .1	.8	10.9
Nickel, unfiltered, µg/L	--		.26	< .12	.30	1.5	< .12	.22	2.2
Selenium, unfiltered, µg/L	[1,2]50	0	E .06	< .08	E .06	.27	< .08	E .06	.40
Silver, unfiltered, µg/L	[2,3]100	0	< .02	< .02	< .02	.04	< .02	< .02	E .01
Strontium, unfiltered, µg/L	--		189	29.3	157	579	44.3	308	1,950
Zinc, unfiltered, µg/L	[2,3]5000	0	3.1	< 2.0	3.2	25.1	< 2.0	3.1	76.6
Radon-222, unfiltered, pCi/L	[5]300 [6]4,000	17 2	355	28	495	1,370	29	260	13,800
Uranium, unfiltered, µg/L	[1]30	0	.346	.037	.346	1.74	< .020	.355	26.3

[1] U.S. Environmental Protection Agency Maximum Contaminant Level.
[2] New York State Department of Health Maximum Contaminant Level.
[3] U.S. Environmental Protection Agency Secondary Drinking Water Standard.
[4] U.S. Environmental Protection Agency Treatment Technique.
[5] U.S. Environmental Protection Agency Proposed Maximum Contaminant Level.
[6] U.S. Environmental Protection Agency Proposed Alternative Maximum Contaminant Level.

Pesticides

Ten pesticides were detected in 14 samples. Most of the pesticides detected were broadleaf herbicides or their degradates; an insecticide (dieldrin) was also detected (appendix table 1-6). Pesticides were detected in 10 samples from sand and gravel wells and in 4 samples from bedrock wells. Most detections were in hundredths or thousandths of micrograms per liter; the constituent with the highest concentration (maximum 0.183 µg/L) was the atrazine degradate, CIAT (2-chloro-4-isopropylamino-6-amino-*s*-triazine). The most frequently detected pesticides were CIAT (eight samples), simazine (seven samples), atrazine (six samples), and prometon (five samples). More than one pesticide was detected in several samples; four samples had detections of five pesticides and five additional samples had detections of three pesticides. No pesticide concentrations exceeded established drinking-water standards; pesticide degradates are not currently regulated.

Volatile Organic Compounds

Eight VOCs were detected in samples from six wells—two finished in sand and gravel and four finished in bedrock (appendix table 1-7). Six VOCs were detected in one sample each: 1,1,1-trichloroethane, a solvent; c*is*-1,2-dichloroethene, a solvent; methyl *tert*-butyl ether (MTBE), a gasoline additive; toluene, a gasoline component; *trans*-1,2-dichloroethene, a solvent; and trichloroethene (TCE), a solvent; concentrations of these compounds did not exceed MCLs in any sample (table 6). Tetrachloroethene (PERC), a solvent sometimes used for dry cleaning, was detected in three samples with a maximum concentration of 5.7 µg/L; the concentration in one sample exceeded NYSDOH and USEPA MCLs of 5 µg/L (table 6). Trichloromethane, a trihalomethane (THM), was detected in four samples with a maximum concentration of 1.0 µg/L. THMs are byproducts that form when chlorine or chloramine is used as a disinfectant (U.S. Environmental Protection Agency, 2005); THMs are also used as solvents. Trichloromethane was the only THM detected; the USEPA and NYSDOH MCLs for total THMs, 80 µg/L, was not exceeded.

The sample from well P1218 contained detectable concentrations of five VOCs: c*is*-1,2-dichloroethene (2.8 µg/L), PERC (5.7 µg/L), *trans*-1,2-dichloroethene (0.1 µg/L), TCE (1.6 µg/L), and trichloromethane (0.7 µg/L). This well is affected by historic (1978 and earlier) contamination originating at a drywell adjacent to a dry cleaner; soils on site have been remediated and a packed-column air-stripping unit is used to remove VOCs from the water (U.S. Environmental Protection Agency, 2009a).

Bacteria

Total coliform bacteria were detected in seven samples (appendix table 1-8). The NYSDOH and USEPA MCL for total coliform bacteria is exceeded when 5 percent of samples of finished water collected in 1 month test positive for total coliform (if 40 or more samples are collected per month) or when 2 samples are positive for total coliform (if fewer than 40 samples are collected per month). The owners of the wells were notified of the detection upon receipt of the results from the laboratory. Fecal coliform and *E. coli* were detected in one sample from a sand and gravel well. The heterotrophic plate count ranged from < 1 colony-forming unit per milliliter (CFU/mL) to 106 CFU/mL. The USEPA MCL for the heterotrophic plate count is 500 CFU/mL; this limit was not exceeded in any sample.

Table 6. Drinking-water standards for volatile organic compounds detected in groundwater samples from the Lower Hudson River Basin, New York, 2008.

[NYSDOH, New York State Department of Health; USEPA, United States Environmental Protection Agency; MCL, Maximum Contaminant Level; µg/L, micrograms per liter]

Constituent	NYSDOH MCL, µg/L	USEPA MCL, µg/L	Maximum detected concentration, µg/L	Number of samples exceeding standards
1,1,1-Trichloroethane	5	200	0.3	0
cis-1,2-Dichloroethene	5	70	2.8	0
Methyl *tert*-butyl ether	10	--	.2	0
Tetrachloroethene	5	5	5.7	1
Toluene	5	1,000	.1	0
trans-1,2-Dichloroethene	5	100	.1	0
Trichloroethene	5	5	1.6	0
Trichloromethane	[1]80	[1]80	1.0	0

[1] 80 µg/L MCL applies to total trihalomethane concentration; trichloromethane is one of the four compounds included in this total concentration.

Summary

Groundwater samples were collected from August through November 2008 from 16 wells finished in sand and gravel and 16 wells finished in bedrock to characterize the groundwater quality in the Lower Hudson River Basin in New York State. The wells finished in sand and gravel ranged from 15 to 202 ft deep; those finished in bedrock ranged from 51 to 575 ft deep. Seventeen of the 32 wells sampled were production wells; 15 were domestic wells. Sample collection and analyses followed standard USGS procedures, except bacteria samples, which were collected by NYSDEC and NYSDOH procedures. Samples were analyzed for physiochemical properties and concentrations of major ions, nutrients, trace elements, radon-222, pesticides, VOCs, and bacteria. Of the 225 constituents, 153 were not detected in any of the samples.

The samples generally indicated good water quality, although concentrations of some constituents—color, pH, sodium, fluoride, aluminum, arsenic, iron, manganese, radon-222, PERC, and bacteria—exceeded primary, secondary, or proposed drinking-water standards. The constituents most frequently detected in concentrations exceeding drinking-water standards were radon-222 (17 samples with concentrations greater than the USEPA proposed MCL of 300 pCi/L), manganese (14 unfiltered samples with concentrations greater than the USEPA SDWS of 50 µg/L), and sodium (8 samples with concentrations greater than the USEPA drinking-water advisory taste threshold of 60 mg/L).

Sample pH was typically near neutral or slightly basic. Water hardness ranged from very soft to very hard; more samples were classified as hard than were classified as soft. The ions detected in the highest concentrations were bicarbonate, chloride, and calcium. The dominant nutrient was nitrate; concentrations of nitrate and nitrite did not exceed established drinking-water standards. Iron was the trace element with the highest concentration detected; strontium had the highest median concentrations. The highest radon-222 activities were in samples from bedrock wells finished in crystalline rock (maximum 13,800 pCi/L). Ten pesticides and pesticide degradates were detected in 14 samples; 10 samples were from sand and gravel wells and 4 were from bedrock wells; most were trace-level detections of broadleaf herbicides or their degradates. Eight VOCs were detected in six samples, including two components of gasoline (MTBE and toluene), a disinfection byproduct, and six solvents. One sample had detectable concentrations of five VOCs, including 5.7 µg/L of PERC, which exceeded the NYSDOH and USEPA MCLs of 5 µg/L. Coliform bacteria were detected in seven samples; fecal coliform and *E. coli* were detected in one sample.

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Appendix 1: Results of Water-Sample Analyses

The following tables summarize results of the chemical analyses of the 32 samples collected in the Lower Hudson River Basin of eastern New York from August through November 2008.

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey parameter code	Compound	Laboratory reporting level	
		WY08	WY09
Trace Elements in unfiltered water, micrograms per liter			
01059	Thallium	0.08	0.12
Pesticides in filtered water, micrograms per liter			
50470	2,4-D methyl ester	.040	.200
39732	2,4-D	.02	.06
38746	2,4-DB	.02	.02
82660	2,6-Diethylaniline	.002	.006
62850	2-[(2-Ethyl-6-methylphenyl)amino]-2-oxoethanesulfonic acid	.02	.02
04038	2-Chloro-6-ethylamino-4-amino-*s*-triazine	.08	.06
63781	2-Chloro-*N*-(2,6-diethylphenyl)acetamide	.02	.02
63782	2-Chloro-*N*-(2-ethyl-6-methylphenyl)acetamide	.02	.02
49308	3-Hydroxy carbofuran	.040	.040
61029	Acetochlor ethanesulfonic acid	.02	.02
61030	Acetochlor oxanilic acid	.02	.02
62847	Acetochlor sulfynilacetic acid	.02	.02
49260	Acetochlor	.006	.010
49315	Acifluorfen	.040	.040
62849	Alachlor ethanesulfonic acid secondary amide	.02	.02
61031	Alachlor oxanilic acid	.02	.02
62848	Alachlor sulfynilacetic acid	.02	.02
46342	Alachlor	.006	.008
49313	Aldicarb sulfone	.08	.08
49314	Aldicarb sulfoxide	.060	.060
49312	Aldicarb	.12	.12
34253	*alpha*-HCH	.002	.008
82686	Azinphos-methyl	.120	.120
50299	Bendiocarb	.04	.04
82673	Benfluralin	.004	.014
50300	Benomyl	.040	.060
61693	Bensulfuron	.06	.06
38711	Bentazon	.04	.06
04029	Bromacil	.02	.06
49311	Bromoxynil	.12	.12
04028	Butylate	.002	.002
50305	Caffeine	.060	.080
49310	Carbaryl	.04	.04
82680	Carbaryl	.060	.200
49309	Carbofuran	.020	.040
82674	Carbofuran	.020	.060
61188	Chloramben methyl ester	.10	.10

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey parameter code	Compound	Laboratory reporting level	
		WY08	WY09
Pesticides in filtered water, micrograms per liter (continued)			
50306	Chlorimuron	0.080	0.080
38933	Chlorpyrifos	.005	.010
82687	*cis*-Permethrin	.010	.014
49305	Clopyralid	.06	.06
04041	Cyanazine	.020	.040
04031	Cycloate	.02	.04
49304	Dacthal monoacid	.02	.04
82682	DCPA	.003	.006
63778	Dechloroacetochlor	.02	.02
63777	Dechloroalachlor	.02	.02
63779	Dechlorodimethenamid	.02	.02
63780	Dechlorometolachlor	.02	.02
62170	Desulfinyl fipronil	.012	.012
39572	Diazinon	.005	.005
38442	Dicamba	.04	.04
49302	Dichlorprop	.02	.04
61951	Dimethenamid ethanesulfonic acid	.02	.02
62482	Dimethenamid oxanilic acid	.02	.02
61588	Dimethenamid	.02	.02
49301	Dinoseb	.04	.04
04033	Diphenamid	.04	.04
82677	Disulfoton	.04	.04
49300	Diuron	.04	.04
82668	EPTC	.002	.002
82663	Ethalfluralin	.009	.009
82672	Ethoprop	.012	.016
49297	Fenuron	.04	.06
62169	Desulfinylfipronil amide	.029	.029
62167	Fipronil sulfide	.013	.013
62168	Fipronil sulfone	.024	.024
62166	Fipronil	.020	.040
61952	Flufenacet ethanesulfonic acid	.02	.02
62483	Flufenacet oxanilic acid	.02	.02
62481	Flufenacet	.02	.02
61694	Flumetsulam	.06	.06
38811	Fluometuron	.04	.04
04095	Fonofos	.010	.010
63784	Hydroxyacetochlor	.02	.02
63783	Hydroxyalachlor	.02	.02
64045	Hydroxydimethenamid	.02	.02

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey parameter code	Compound	Laboratory reporting level	
		WY08	WY09
Pesticides in filtered water, micrograms per liter (continued)			
63785	Hydroxymetolachlor	0.02	0.02
50356	Imazaquin	.04	.06
50407	Imazethapyr	.04	.06
61695	Imidacloprid	.060	.060
39341	Lindane	.006	.014
38478	Linuron	.02	.04
82666	Linuron	.060	.060
39532	Malathion	.016	.020
38482	MCPA	.06	.04
38487	MCPB	.06	.20
50359	Metalaxyl	.02	.04
38501	Methiocarb	.040	.040
49296	Methomyl	.120	.120
82667	Methyl parathion	.008	.008
39415	Metolachlor	.010	.014
82630	Metribuzin	.012	.016
82671	Molinate	.002	.002
61692	*N*-(4-Chlorophenyl)-*N*'-methylurea	.12	.06
82684	Napropamide	.018	.018
49294	Neburon	.02	.02
50364	Nicosulfuron	.10	.10
49293	Norflurazon	.02	.04
49292	Oryzalin	.04	.04
38866	Oxamyl	.12	.12
34653	*p,p*'-DDE	.003	.003
39542	Parathion	.010	.020
82669	Pebulate	.004	.016
82683	Pendimethalin	.012	.012
82664	Phorate	.040	.020
49291	Picloram	.12	.12
82676	Propyzamide	.004	.004
62766	Propachlor ethanesulfonic acid	.05	.05
62767	Propachlor oxanilic acid	.02	.02
04024	Propachlor	.006	.012
82679	Propanil	.006	.014
82685	Propargite	.04	.02
49236	Propham	.040	.040
50471	Propiconazole	.04	.04
38538	Propoxur	.040	.060
38548	Siduron	.02	.04

Table 1-1. Constituents that were not detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[WY, water year, the 12-month period from October 1 through September 30 of the following year. The water year is designated by the calendar year in which it ends.]

U.S. Geological Survey parameter code	Compound	Laboratory reporting level	
		WY08	WY09
Pesticides in filtered water, micrograms per liter (continued)			
50337	Sulfometuron	0.060	0.060
82665	Terbacil	.018	.040
04032	Terbacil	.040	.040
82675	Terbufos	.02	.02
82681	Thiobencarb	.010	.016
82678	Triallate	.006	.006
49235	Triclopyr	.08	.08
82661	Trifluralin	.006	.012
Volatile organic compounds in unfiltered water, micrograms per liter			
32730	Total Phenolic Compounds	4.0	4.0
77652	1,1,2-Trichloro-1,2,2-trifluoroethane	.1	.1
34496	1,1-Dichloroethane	.1	.1
34501	1,1-Dichloroethene	.1	.1
34536	1,2-Dichlorobenzene	.1	.1
32103	1,2-Dichloroethane	.2	.2
34541	1,2-Dichloropropane	.1	.1
34566	1,3-Dichlorobenzene	.1	.1
34571	1,4-Dichlorobenzene	.1	.1
34030	Benzene	.1	.1
32101	Bromodichloromethane	.1	.1
34301	Chlorobenzene	.1	.1
32105	Dibromochloromethane	.2	.2
34668	Dichlorodifluoromethane	.2	.2
34423	Dichloromethane	.2	.2
81576	Diethyl ether	.2	.2
81577	Diisopropyl ether	.2	.2
34371	Ethylbenzene	.1	.1
50005	Methyl *tert*-pentyl ether	.2	.2
85795	*m*-Xylene plus *p*-xylene	.2	.2
77135	*o*-Xylene	.1	.1
77128	Styrene	.1	.1
50004	*tert*-Butyl ethyl ether	.1	.1
32102	Tetrachloromethane	.2	.2
32104	Tribromomethane	.2	.2
34488	Trichlorofluoromethane	.2	.2
39175	Vinyl chloride	.2	.2

Table 1-2. Physiochemical properties of groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; (00080), U.S. Geological Survey National Water Information System parameter code; >, greater than; <, less than. **Bold** values exceed one or more drinking-water standards. Well locations are shown in fig. 2.]

Well number[1]	Color, platinum-cobalt units (00080)	Dissolved oxygen, mg/L (00300)	pH, standard units (00400)	Specific conductance, µS/cm (00095)	Water temperature, degrees Celsius (00010)	Hydrogen sulfide (71875)
Sand and gravel wells						
A1420	5	0.3	7.2	577	10.6	Absent
CB1073	2	3.7	6.5	387	13.5	Absent
CB1674	2	5.2	7.4	[2]253	11.8	Absent
DU1058	2	.4	7.3	378	13.9	Absent
DU1096	2	> 10.0	7.8	295	10.7	Absent
G834	2	8.8	6.8	183	11.2	Absent
O2289	5	.2	7.0	944	11.6	Absent
O2290	5	.9	6.9	1,500	11.8	Absent
P1218	2	1.6	6.7	1,090	11.5	Absent
RE1189	< 1	8.3	7.7	269	10.7	Absent
U1622	**30**	10.6	7.2	[2]611	13.0	Absent
U2669	**20**	3.9	7.1	243	13.2	Absent
U3620	2	11.4	7.3	108	9.7	Absent
WE652	2	> 10.0	7.0	778	14.6	Absent
WE1482	2	1.3	7.3	450	19.8	Absent
WE1483	5	13.0	6.8	389	13.9	Absent
Bedrock wells						
A984	2	.3	**8.8**	[2]642	10.8	Present
CB2937	< 1	< .1	**8.9**	747	13.4	Present
DU1437	2	> 10.0	7.0	631	10.7	Absent
DU6186	5	5.2	7.5	442	12.4	Absent
DU6971	8	7.4	7.3	523	10.7	Absent
G832	2	< .1	7.9	727	10.6	Present
O5700	2	4.4	**6.4**	361	12.1	Absent
O8327	5	.1	7.6	411	14.4	Present
P2209	2	7.8	**6.2**	316	10.6	Absent
RE2323	2	.1	6.7	400	10.7	Absent
RE2914	12	1.4	7.4	505	11.8	Absent
RO560	2	5.9	6.5	568	11.8	Absent
RO853	2	1.3	**8.8**	416	14.3	Absent
U3035	< 1	.6	7.3	794	11.9	Present
U4172	5	< .1	**9.4**	[2]761	13.3	Present
WE6369	< 1	1.5	7.2	379	12.8	Absent

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

[2] Specific conductance measured in the laboratory due to a malfunction of the field instrument.

Table 1-3. Concentrations of major ions in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; (00900), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value. **Bold** values exceed one or more drinking-water standards. Well locations are shown in fig. 2.]

Well number[1]	Hardness, filtered, mg/L as $CaCO_3$ (00900)	Calcium, filtered, mg/L (00915)	Magnesium, filtered, mg/L (00925)	Potassium, filtered, mg/L (00935)	Sodium, filtered, mg/L (00930)	Acid neutralizing capacity, unfiltered, mg/L as $CaCO_3$ (90410)	Alkalinity, filtered, incremental titration,field, mg/L as $CaCO_3$ (39086)
Sand and gravel wells							
A1420	210	66.0	11.7	1.08	26.6	181	175
CB1073	100	33.0	4.36	1.40	33.0	94	90
CB1674	100	37.1	2.82	.71	8.60	100	94
DU1058	150	40.9	12.6	.91	14.9	121	119
DU1096	100	28.3	8.16	1.41	13.1	88	82
G834	65	22.5	2.02	.72	10.2	63	59
O2289	380	116	22.1	1.31	28.2	251	243
O2290	440	115	38.3	1.44	**126**	401	397
P1218	340	85.5	30.4	4.60	**80.9**	196	205
RE1189	96	26.9	7.04	1.08	20.2	115	114
U1622	210	68.5	8.34	1.33	36.9	181	174
U2669	110	33.2	5.85	.92	5.51	117	113
U3620	42	12.6	2.64	.29	6.28	50	47
WE652	200	51.5	16.1	3.48	**66.3**	151	150
WE1482	130	34.6	10.0	2.64	34.7	103	100
WE1483	120	35.8	8.44	2.69	21.2	106	100
Bedrock wells							
A984	37	9.78	3.16	.58	**139**	332	320
CB2937	4	1.11	.247	.82	**178**	345	328
DU1437	240	87.3	6.46	.94	28.4	210	218
DU6186	150	42.1	11.2	1.76	28.3	144	164
DU6971	270	57.9	30.2	.81	1.61	253	[2]252
G832	140	39.3	11.2	.74	**109**	265	257
O5700	130	41.3	6.30	1.00	21.0	113	104
O8327	110	30.9	8.16	.54	49.1	160	[2]161
P2209	74	24.0	3.44	4.55	28.1	51	48
RE2323	150	52.5	4.69	.82	12.3	87	81
RE2914	300	97.6	14.2	1.08	47.9	157	151
RO560	220	65.8	12.7	1.46	26.3	128	125
RO853	53	12.9	4.97	1.02	**74.4**	120	116
U3035	260	78.8	15.0	1.65	43.0	170	169
U4172	2	.68	.123	1.80	**169**	339	330
WE6369	140	33.3	13.1	3.01	8.35	86	84

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

[2] Laboratory value, fixed endpoint titration.

Table 1-3. Concentrations of major ions in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; (00453), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value. **Bold** values exceed one or more drinking-water standards. Well locations are shown in fig. 2.]

Well number[1]	Bicarbonate, filtered, incremental titration,field, mg/L (00453)	Chloride, filtered, mg/L (00940)	Fluoride, filtered, mg/L (00950)	Silica, filtered, mg/L (00955)	Sulfate, filtered, mg/L (00945)	Residue on evaporation, filtered, mg/L (70300)
Sand and gravel wells						
A1420	212	42.6	E 0.11	9.81	43.6	335
CB1073	109	49.1	< .12	6.55	12.4	205
CB1674	114	13.7	< .12	7.21	9.05	155
DU1058	144	27.7	< .12	8.57	25.4	220
DU1096	99	24.7	< .12	6.58	14.0	149
G834	71	13.1	< .08	4.14	7.20	97
O2289	296	99.5	E .09	10.8	70.8	562
O2290	483	232	< .12	12.8	36.0	822
P1218	250	212	< .12	12.6	25.6	648
RE1189	138	3.80	.17	11.9	24.3	163
U1622	212	69.2	E .08	7.83	27.0	350
U2669	137	.76	.15	10.7	7.59	137
U3620	57	2.33	< .12	6.46	5.35	68
WE652	182	130	.15	13.8	18.0	414
WE1482	122	63.9	E .04	7.14	11.1	238
WE1483	122	42.1	< .12	13.0	12.9	209
Bedrock wells						
A984	368	5.65	.67	8.19	22.6	399
CB2937	372	35.9	.50	10.2	7.31	425
DU1437	265	54.6	< .12	8.40	24.1	357
DU6186	198	23.0	.16	11.8	33.7	239
DU6971	[2]307	2.83	< .12	5.19	25.4	290
G832	309	62.4	.60	9.14	30.1	420
O5700	127	26.1	E .08	11.5	28.0	221
O8327	[2]196	2.05	.18	11.5	56.1	270
P2209	58	52.7	< .12	11.1	13.2	181
RE2323	98	55.4	E .11	12.5	14.8	310
RE2914	183	155	< .08	14.9	28.3	524
RO560	152	81.8	< .12	12.3	24.2	335
RO853	133	45.9	E .09	40.7	22.6	281
U3035	203	109	E .07	11.6	49.9	466
U4172	312	31.6	**3.46**	9.79	2.04	436
WE6369	102	38.5	.12	16.8	23.4	207

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

[2] Laboratory value, fixed endpoint titration.

Table 1-4. Concentrations of nutrients and organic carbon in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[N, nitrogen; P, phosphorus; mg/L, milligrams per liter; (00623), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value. Well locations are shown in fig. 2.]

Well number[1]	Ammonia plus organic-N, filtered, mg/L as N (00623)	Ammonia, filtered, mg/L as N (00608)	Nitrate plus nitrite, filtered, mg/L as N (00631)	Nitrite, filtered, mg/L as N (00613)	Ortho-phosphate, filtered, mg/L as P (00671)	Organic carbon, unfiltered, mg/L (00680)
Sand and gravel wells						
A1420	E 0.07	0.020	< 0.04	< 0.002	0.008	1.1
CB1073	< .14	< .020	.69	< .002	E .005	< 1.0
CB1674	< .14	< .020	.19	< .002	.007	< 1.0
DU1058	< .14	< .020	.15	.015	.008	1.5
DU1096	< .14	< .020	.29	< .002	E .005	1.0
G834	< .10	< .020	.22	< .002	.011	1.5
O2289	< .14	E .016	< .04	< .002	.007	1.1
O2290	.15	< .020	2.38	< .002	.008	2.0
P1218	.17	.064	.91	E .002	.007	1.9
RE1189	.22	.192	< .04	< .002	.019	< 1.0
U1622	.44	.408	< .04	< .002	.036	1.7
U2669	< .14	.023	< .04	< .002	< .006	< 1.0
U3620	< .14	< .020	.45	< .002	.015	< 1.0
WE652	E .09	< .020	1.25	.002	.039	1.6
WE1482	E .12	.026	.22	< .002	E .007	1.8
WE1483	< .14	< .020	.74	< .002	.012	1.2
Bedrock wells						
A984	.33	.290	< .04	< .002	.099	< 1.0
CB2937	.34	.298	< .04	< .002	.026	2.0
DU1437	< .14	< .020	1.86	< .002	E .006	1.6
DU6186	E .12	.092	.14	.015	.007	3.0
DU6971	< .14	< .020	.82	< .002	E .006	< 1.0
G832	.22	.170	< .04	< .002	.058	2.4
O5700	< .14	< .020	.14	< .002	.007	< 1.0
O8327	E .08	.051	< .04	< .002	.009	< 1.0
P2209	< .14	< .020	.48	< .002	E .006	1.5
RE2323	< .14	< .020	< .04	< .002	.009	< 1.0
RE2914	.14	.121	< .04	< .002	.012	1.0
RO560	< .14	< .020	1.44	< .002	.062	< 1.0
RO853	< .14	< .020	1.09	< .002	E .006	< 1.0
U3035	.24	.184	.14	.003	.007	< 1.0
U4172	.51	.487	< .04	< .002	.079	1.9
WE6369	< .14	< .020	.37	.002	.023	< 1.0

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-5. Concentrations of trace elements and radionuclide activities in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[µg/L, micrograms per liter; (01105), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. **Bold** values exceed one or more drinking-water standards. Well locations are shown in fig. 2.]

Well number[1]	Aluminum, unfiltered, µg/L (01105)	Antimony, unfiltered, µg/L (01097)	Arsenic, unfiltered, µg/L (01002)	Barium, unfiltered, µg/L (01007)	Beryllium, unfiltered, µg/L (01012)	Boron, filtered, µg/L (01020)
Sand and gravel wells						
A1420	< 4	< 0.1	1.6	30.6	< 0.04	15
CB1073	18	< .1	< .60	54.2	< .04	15
CB1674	< 4	< .1	E .41	45.7	< .04	7.5
DU1058	< 4	< .1	E .54	33.8	< .04	8.6
DU1096	< 4	< .1	E .43	3.5	< .04	5.9
G834	E 3	< .4	.23	12.1	< .02	9.8
O2289	< 4	< .1	E .56	71.8	< .04	16
O2290	12	< .1	< .60	71.4	< .04	31
P1218	< 4	< .1	< .60	118	< .04	16
RE1189	10	< .1	6.4	152	< .04	32
U1622	< 4	< .1	< .60	238	< .04	19
U2669	13	< .1	.61	34.5	< .04	11
U3620	E 2	< .1	E .48	1.1	< .04	6.3
WE652	**305**	< .1	E .57	75.8	< .04	21
WE1482	14	< .4	E .17	28.9	< .02	16
WE1483	< 4	< .1	< .60	53.9	< .04	22
Bedrock wells						
A984	23	< .1	< .60	27.0	< .04	611
CB2937	12	< .1	< .60	67.0	< .04	202
DU1437	< 4	E .1	< .60	47.4	< .04	16
DU6186	**114**	1.0	2.3	110	E .04	56
DU6971	17	.2	< .60	7.4	< .04	2.8
G832	4	< .1	< .60	164	< .04	329
O5700	E 2	< .1	< .60	38.1	< .04	21
O8327	7	< .1	.75	34.0	< .04	93
P2209	21	< .1	< .60	120	< .04	9.7
RE2323	< 4	< .1	.76	69.8	< .04	9.7
RE2914	< 6	< .4	**13.3**	904	< .02	6.5
RO560	< 4	< .1	E .39	87.1	E .03	18
RO853	15	< .1	.61	6.0	< .04	1,060
U3035	< 4	.2	< .60	145	E .02	46
U4172	**51**	< .1	< .60	29.4	< .04	752
WE6369	< 4	< .1	E .37	19.8	< .04	11

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-5. Concentrations of trace elements and radionuclide activities in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[µg/L, micrograms per liter; (01027), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. **Bold** values exceed one or more drinking water standards. Well locations are shown in fig. 2.]

Well number[1]	Cadmium, unfiltered, µg/L (01027)	Chromium, unfiltered, µg/L (01034)	Cobalt, unfiltered, µg/L (01037)	Copper, unfiltered, µg/L (01042)	Iron, filtered, µg/L (01046)	Iron, unfiltered, µg/L (01045)
Sand and gravel wells						
A1420	< 0.01	< 0.40	< 0.04	< 1.2	85	85
CB1073	< .01	< .40	< .04	3.2	< 8	23
CB1674	< .01	< .40	< .04	E .72	< 8	< 6
DU1058	< .01	< .40	E .02	< 1.2	< 8	E 4
DU1096	< .01	< .40	< .04	< 1.2	< 8	< 6
G834	< .06	< .40	< .10	14.9	5	< 14
O2289	< .01	< .40	.42	2.5	213	224
O2290	< .01	.56	.07	16.9	28	91
P1218	.04	< .40	.09	1.3	12	18
RE1189	< .01	< .40	E .03	2.3	34	54
U1622	E .01	< .40	E .04	< 1.2	**2,290**	**3,020**
U2669	< .01	< .40	.11	2.4	**834**	**1,220**
U3620	< .01	< .40	< .04	< 1.2	< 8	E 3
WE652	.13	.94	.88	17.4	< 8	**3,330**
WE1482	< .06	< .40	< .10	E 3.2	E 2	< 14
WE1483	< .01	< .40	E .03	2.2	E 5	< 6
Bedrock wells						
A984	< .01	< .40	< .04	E .75	51	82
CB2937	< .01	< .40	< .04	E .60	< 8	28
DU1437	< .01	E .25	E .02	3.9	E 4	E 3
DU6186	.02	2.4	1.9	3.5	< 8	**8,860**
DU6971	< .01	E .32	E .03	10.8	13	**4,740**
G832	< .01	< .40	< .04	E 1.0	E 5	22
O5700	< .01	< .40	.06	17.1	< 8	18
O8327	.02	< .40	< .04	E .64	28	31
P2209	E .01	.44	.06	13.3	13	142
RE2323	< .01	< .40	< .04	3.3	E 5	22
RE2914	< .06	< .40	< .10	E 3.9	**584**	**1,000**
RO560	< .01	.44	E .02	2.3	< 8	9
RO853	< .01	< .40	< .04	1.6	< 8	12
U3035	< .01	< .40	.18	3.8	15	22
U4172	< .01	< .40	.04	2.7	< 8	**487**
WE6369	E .01	E .31	E .03	5.4	< 8	40

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-5. Concentrations of trace elements and radionuclide activities in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[µg/L, micrograms per liter; (01051), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. **Bold** values exceed one or more drinking water standards. Well locations are shown in fig. 2.]

Well number[1]	Lead, unfiltered, µg/L (01051)	Lithium, unfiltered, µg/L (01132)	Manganese, filtered, µg/L (01056)	Manganese, unfiltered, µg/L (01055)	Mercury, unfiltered, µg/L (71900)	Molybdenum, unfiltered, µg/L (01062)
Sand and gravel wells						
A1420	0.35	6.3	**263**	**271**	< 0.010	0.6
CB1073	.28	.5	.5	E .7	< .010	.1
CB1674	.52	3.0	< .4	< .4	< .010	M
DU1058	E .04	2.9	**119**	**121**	< .010	.8
DU1096	.21	1.2	E .2	< .4	< .010	.3
G834	.73	.8	.5	.5	< .010	E .1
O2289	.08	14.5	**519**	**546**	< .010	.6
O2290	1.82	8.2	1.7	2.0	< .010	.3
P1218	.20	2.1	**286**	**283**	< .010	.6
RE1189	.15	18.5	**61.8**	**64.9**	< .010	1.1
U1622	E .04	4.5	**532**	**569**	< .010	1.8
U2669	.08	2.9	**572**	**584**	< .010	1.3
U3620	< .06	.6	.6	1.7	< .010	.1
WE652	2.16	2.3	**134**	**717**	< .010	.3
WE1482	.13	1.0	**58.5**	**61.6**	< .010	.6
WE1483	.35	1.8	2.6	2.3	< .010	.4
Bedrock wells						
A984	< .06	448	5.5	5.6	< .010	1.1
CB2937	< .06	370	1.5	1.4	< .010	< .1
DU1437	.12	6.5	< .4	< .4	< .010	.1
DU6186	2.81	27.2	47.6	**256**	< .010	4.4
DU6971	1.52	.7	2.3	32.7	< .010	1.7
G832	.21	242	**81.0**	**80.0**	< .010	.8
O5700	1.08	13.1	.4	7.9	< .010	E .1
O8327	< .06	6.7	**79.7**	**81.6**	< .010	10.9
P2209	.54	1.7	4.0	5.9	< .010	.7
RE2323	.11	9.2	**51.5**	**51.5**	< .010	2.2
RE2914	.29	10.1	**739**	**806**	< .010	.2
RO560	.08	4.5	E .2	< .8	.016	.1
RO853	.44	5.4	< .4	< .8	< .010	.5
U3035	1.36	14.9	22.4	23.3	< .010	.5
U4172	.27	430	2.1	6.6	< .010	3.6
WE6369	1.01	3.5	2.8	3.2	< .010	3.8

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-5. Concentrations of trace elements and radionuclide activities in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[µg/L, micrograms per liter; (01067), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. **Bold** values exceed one or more drinking water standards. Well locations are shown in fig. 2.]

Well number[1]	Nickel, unfiltered, µg/L (01067)	Selenium, unfiltered, µg/L (01147)	Silver, unfiltered, µg/L (01077)	Strontium, unfiltered, µg/L (01082)	Zinc, unfiltered, µg/L (01092)	Radon-222, unfiltered, picoCuries per liter (82303)	Uranium, unfiltered, µg/L (28011)
Sand and gravel wells							
A1420	1.1	< 0.08	< 0.02	259	4.3	52	0.582
CB1073	.51	.14	< .02	192	5.5	**600**	.092
CB1674	< .12	E .06	< .02	171	9.1	**510**	.100
DU1058	E .10	.25	< .02	104	< 2.0	185	.361
DU1096	< .12	.18	< .02	98.9	E 1.1	**770**	.167
G834	.40	< .12	< .06	45.4	14.0	**500**	.037
O2289	.59	< .08	< .02	267	E 1.2	76	1.50
O2290	.70	E .07	.04	219	25.1	**500**	.733
P1218	.35	.08	< .02	209	13.1	**650**	1.74
RE1189	E .06	< .08	E .01	579	E 1.2	113	.047
U1622	.16	< .08	< .02	200	E 1.8	28	.330
U2669	.19	< .08	< .02	90.0	4.4	**340**	1.09
U3620	< .12	.18	< .02	29.3	< 2.0	**1,370**	.090
WE652	1.5	.27	E .01	143	13.5	145	.554
WE1482	.48	< .12	< .06	94.6	2.0	**540**	.109
WE1483	.26	E .07	< .02	111	< 2.0	**490**	.513
Bedrock wells							
A984	< .12	< .08	< .02	520	< 2.0	56	< .020
CB2937	< .12	< .08	< .02	88.2	< 2.0	37	< .020
DU1437	.25	.22	< .02	489	22.6	277	.143
DU6186	2.0	.14	< .02	586	6.2	29	1.51
DU6971	.46	.40	E .01	45.2	11.3	**480**	1.49
G832	.19	< .08	< .02	587	< 2.0	153	.104
O5700	.83	E .05	< .02	234	20.9	140	.061
O8327	< .12	< .08	< .02	1,080	2.2	**420**	1.93
P2209	.46	E .07	< .02	73.1	76.6	**13,800**	26.3
RE2323	.20	< .08	< .02	383	12.7	**1,920**	1.40
RE2914	< .20	< .12	< .06	532	E 1.3	243	.294
RO560	2.2	.10	< .02	104	E 1.1	**370**	2.27
RO853	E .07	.21	< .02	112	< 2.0	110	.219
U3035	1.2	.23	< .02	1,950	4.0	**400**	.416
U4172	E .11	< .08	< .02	44.3	E 1.2	33	< .020
WE6369	.93	.29	< .02	186	22.8	**5,600**	2.33

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-6. Concentrations of pesticides detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-*s*-triazine; OIET, 2-hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine; ESA, ethanesulfonic acid; OA, oxanilic acid; (04040), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. Well locations are shown in fig. 2.]

Well number[1]	CIAT, filtered, µg/L (04040)	OIET, filtered, µg/L (50355)	Alachlor ESA, filtered, µg/L (50009)	Atrazine, filtered, µg/L (39632)	Dieldrin, filtered, µg/L (39381)
Sand and gravel wells					
A1420	< 0.014	< 0.040	< 0.02	< 0.007	< 0.009
CB1073	E .007	< .040	< .02	E .006	< .009
CB1674	E .003	< .040	< .02	E .002	< .009
DU1058	< .014	< .040	< .02	< .007	< .009
DU1096	E .003	< .040	< .02	< .007	< .009
G834	< .014	< .060	< .02	< .007	< .009
O2289	< .014	< .040	< .02	< .007	< .009
O2290	< .014	< .040	< .02	E .001	< .009
P1218	E .003	< .040	< .02	< .007	< .009
RE1189	< .014	< .040	< .02	< .007	< .009
U1622	< .014	< .040	.10	< .007	< .009
U2669	< .014	< .040	< .02	< .007	< .009
U3620	< .014	< .040	< .02	< .007	< .009
WE652	< .014	< .040	< .02	E .003	.025
WE1482	E .002	E .005	< .02	E .002	< .009
WE1483	< .014	< .040	< .02	< .007	< .009
Bedrock wells					
A984	< .014	< .040	< .02	< .007	< .009
CB2937	< .014	< .040	< .02	< .007	< .009
DU1437	< .014	< .040	< .02	< .007	< .009
DU6186	E .002	< .040	< .02	< .007	< .009
DU6971	E .183	E .010	< .02	.092	< .009
G832	< .014	< .040	< .02	< .007	< .009
O5700	< .014	< .040	< .02	< .007	< .009
O8327	< .014	< .040	< .02	< .007	< .009
P2209	< .014	< .040	< .02	< .007	< .009
RE2323	< .014	< .040	< .02	< .007	< .009
RE2914	< .014	< .060	.03	< .007	< .009
RO560	E .002	< .040	< .02	< .007	< .009
RO853	< .014	< .040	< .02	< .007	< .009
U3035	< .014	< .040	< .02	< .007	< .009
U4172	< .014	< .040	< .02	< .007	< .009
WE6369	< .014	< .040	< .02	< .007	< .009

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-6. Concentrations of pesticides detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.—Continued

[µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-*s*-triazine; OIET, 2-hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine; ESA, ethanesulfonic acid; OA, oxanilic acid; (61043), U.S. Geological Survey National Water Information System parameter code; <, less than; E, estimated value; M, presence verified but not quantified. Well locations are shown in fig. 2.]

Well number[1]	Metolachlor ESA, filtered, µg/L (61043)	Metolachlor OA, filtered, µg/L (61044)	Prometon, filtered, µg/L (04037)	Simazine, filtered, µg/L (04035)	Tebuthiuron, filtered, µg/L (82670)
Sand and gravel wells					
A1420	< 0.02	< 0.02	< 0.01	< 0.006	< 0.02
CB1073	< .02	< .02	< .01	.006	< .02
CB1674	< .02	< .02	< .01	.007	< .02
DU1058	< .02	< .02	< .01	< .006	< .02
DU1096	< .02	< .02	< .01	< .006	< .02
G834	< .02	< .02	< .01	E .007	< .02
O2289	< .02	< .02	< .01	< .006	< .02
O2290	.04	.02	< .01	E .002	M
P1218	< .02	< .02	< .01	< .006	< .02
RE1189	< .02	< .02	< .01	< .006	< .02
U1622	.05	.02	< .01	< .006	< .02
U2669	< .02	< .02	< .01	< .006	< .02
U3620	< .02	< .02	< .01	< .006	< .02
WE652	< .02	< .02	E .01	E .001	E .03
WE1482	< .02	< .02	E .01	.029	< .02
WE1483	< .02	< .02	M	< .006	< .02
Bedrock wells					
A984	< .02	< .02	< .01	< .006	< .02
CB2937	< .02	< .02	< .01	< .006	< .02
DU1437	< .02	< .02	< .01	< .006	< .02
DU6186	.06	.04	< .01	< .006	< .02
DU6971	.07	< .02	.01	< .006	< .02
G832	< .02	< .02	< .01	< .006	< .02
O5700	< .02	< .02	< .01	< .006	< .02
O8327	< .02	< .02	< .01	< .006	< .02
P2209	< .02	< .02	< .01	< .006	< .02
RE2323	< .02	< .02	< .01	< .006	< .02
RE2914	< .02	< .02	< .01	< .010	< .02
RO560	< .02	< .02	M	E .005	< .02
RO853	< .02	< .02	< .01	< .006	< .02
U3035	< .02	< .02	< .01	< .006	< .02
U4172	< .02	< .02	< .01	< .006	< .02
WE6369	< .02	< .02	< .01	< .006	< .02

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

Table 1-7. Concentrations of volatile organic compounds detected in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[µg/L, micrograms per liter; (34506), U.S. Geological Survey National Water Information System parameter code; <, less than. **Bold** values exceed one or more drinking-water standards. Well locations are shown in fig. 2.]

Well number[1]	1,1,1-Trichloro-ethane, unfiltered, µg/L (34506)	*cis*-1,2-Dichloro-ethene, unfiltered, µg/L (77093)	Methyl *tert*-butyl ether, unfiltered, µg/L (78032)	Tetrachloro-ethene, unfiltered, µg/L (34475)	Toluene, unfiltered, µg/L (34010)	*trans*-1,2-Dichloro-ethene, unfiltered, µg/L (34546)	Trichloro-ethene, unfiltered, µg/L (39180)	Trichloro-methane, unfiltered, µg/L (32106)
Sand and gravel wells								
A1420	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
CB1073	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
CB1674	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
DU1058	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
DU1096	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
G834	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
O2289	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
O2290	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
P1218	< .1	2.8	< .2	**5.7**	< .1	.1	1.6	.7
RE1189	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
U1622	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
U2669	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
U3620	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
WE652	< .1	< .1	< .2	< .1	< .1	< .1	< .1	.2
WE1482	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
WE1483	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
Bedrock wells								
A984	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
CB2937	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
DU1437	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
DU6186	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
DU6971	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
G832	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
O5700	.3	< .1	< .2	< .1	< .1	< .1	< .1	< .1
O8327	< .1	< .1	< .2	.1	< .1	< .1	< .1	< .1
P2209	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
RE2323	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
RE2914	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
RO560	< .1	< .1	.2	.2	< .1	< .1	< .1	.2
RO853	< .1	< .1	< .2	< .1	.1	< .1	< .1	1.0
U3035	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
U4172	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1
WE6369	< .1	< .1	< .2	< .1	< .1	< .1	< .1	< .1

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Table 1-8. Bacteria in groundwater samples collected in the Lower Hudson River Basin, New York, 2008.

[CFU, colony-forming unit; mL, milliliter; (31691), U.S. Geological Survey National Water Information System parameter code; <, less than. **Bold** values indicate detections of coliform bacteria. Well locations are shown in fig. 2]

Well number[1]	*Escherichia coli,* unfiltered, CFU/100mL (31691)	Fecal coliform, unfiltered, CFU/100mL (61215)	Heterotrophic plate count, unfiltered, CFU/mL (31692)	Total coliform, unfiltered, CFU/100mL (61213)
Sand and gravel wells				
A1420	< 1	< 1	< 1	**7**
CB1073	< 1	< 1	106	**88**
CB1674	< 1	< 1	< 1	< 1
DU1058	< 1	< 1	1	< 1
DU1096	< 1	< 1	< 1	< 1
G834	< 1	< 1	4	**16**
O2289	< 1	< 1	< 1	< 1
O2290	< 1	< 1	14	< 1
P1218	< 1	< 1	< 1	< 1
RE1189	< 1	< 1	16	< 1
U1622	< 1	< 1	< 1	< 1
U2669	< 1	< 1	< 1	< 1
U3620	< 1	< 1	< 1	< 1
WE652	**1**	**1**	44	**26**
WE1482	< 1	< 1	6	< 1
WE1483	< 1	< 1	< 1	< 1
Bedrock wells				
A984	< 1	< 1	6	< 1
CB2937	< 1	< 1	100	< 1
DU1437	< 1	< 1	< 1	< 1
DU6186	< 1	< 1	40	**20**
DU6971	< 1	< 1	20	**5**
G832	< 1	< 1	< 1	< 1
O5700	< 1	< 1	18	< 1
O8327	< 1	< 1	11	**1**
P2209	< 1	< 1	< 1	< 1
RE2323	< 1	< 1	2	< 1
RE2914	< 1	< 1	1	< 1
RO560	< 1	< 1	< 1	< 1
RO853	< 1	< 1	11	< 1
U3035	< 1	< 1	< 1	< 1
U4172	< 1	< 1	4	< 1
WE6369	< 1	< 1	< 1	< 1

[1] A, Albany County; CB, Columbia County; DU, Dutchess County; G, Greene County; O, Orange County; P, Putnam County; RE, Rensselaer County; RO, Rockland County; U, Ulster County; WE, Westchester County.

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For more information concerning this report, contact

Director
U.S. Geological Survey
New York Water Science Center
425 Jordan Road
Troy, NY 12180-8349
dc_ny@usgs.gov

or visit our Web site at:
http://ny.water.usgs.gov

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