National Water-Quality Assessment Program
Toxic Substances Hydrology Program

Environmental Settings of Streams Sampled for Mercury in New York and South Carolina, 2005–09

Open-File Report 2011–1318

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

Cover: Sixmile Brook near Long Lake, New York,
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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Foreword

The U.S. Geological Survey (USGS) is committed to providing the Nation with reliable scientific information that helps to enhance and protect the overall quality of life and that facilitates effective management of water, biological, energy, and mineral resources *(http://www.usgs.gov/)*. Information on the Nation's water resources is critical to ensuring long-term availability of water that is safe for drinking and recreation and is suitable for industry, irrigation, and fish and wildlife. Population growth and increasing demands for water make the availability of that water, measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to support national, regional, State, and local information needs and decisions related to water-quality management and policy *(http://water.usgs.gov/nawqa).* The NAWQA Program is designed to answer: What is the quality of our Nation's streams and groundwater? How are conditions changing over time? How do natural features and human activities affect the quality of streams and groundwater, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. From 1991 to 2001, the NAWQA Program completed interdisciplinary assessments and established a baseline understanding of water-quality conditions in 51 of the Nation's river basins and aquifers, referred to as Study Units *(http://water.usgs.gov/nawqa/studies/study_units.html)*.

National and regional assessments are ongoing in the second decade (2001–2012) of the NAWQA Program as 42 of the 51 Study Units are selectively reassessed. These assessments extend the findings in the Study Units by determining water-quality status and trends at sites that have been consistently monitored for more than a decade, and filling critical gaps in characterizing the quality of surface water and groundwater. For example, increased emphasis has been placed on assessing the quality of source water and finished water associated with many of the Nation's largest community water systems. During the second decade, NAWQA is addressing five national priority topics that build an understanding of how natural features and human activities affect water quality, and establish links between sources of contaminants, the transport of those contaminants through the hydrologic system, and the potential effects of contaminants on humans and aquatic ecosystems. Included are studies on the fate of agricultural chemicals, effects of urbanization on stream ecosystems, bioaccumulation of mercury in stream ecosystems, effects of nutrient enrichment on aquatic ecosystems, and transport of contaminants to public-supply wells. In addition, national syntheses of information on pesticides, volatile organic compounds (VOCs), nutrients, trace elements, and aquatic ecology are continuing.

The USGS aims to disseminate credible, timely, and relevant science information to address practical and effective water-resource management and strategies that protect and restore water quality. We hope this NAWQA publication will provide you with insights and information to meet your needs, and will foster increased citizen awareness and involvement in the protection and restoration of our Nation's waters.

The USGS recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for cost-effective management, regulation, and conservation of our Nation's water resources. The NAWQA Program, therefore, depends on advice and information from other agencies—Federal, State, regional, interstate, Tribal, and local—as well as nongovernmental organizations, industry, academia, and other stakeholder groups. Your assistance and suggestions are greatly appreciated.

William H. Werkheiser
USGS Associate Director for Water

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Conversion Factors, Datums, and Abbreviations and Acronyms

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Flow rate	
cubic meters per second (m^3/s)	35.31	cubic feet per second (ft^3/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

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 North American Datum of 1983 (NAD 83) unless otherwise noted.

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

Latitude and longitude listed in table 1 and the appendixes are referenced to the North American Datum of 1927 (NAD 27).

Water year: The 12-month period, October 1–September 30. The water year is designated by the calendar year in which it ends.

Abbreviations and Acronyms

APA	New York State Adirondack Park Agency
CY	calendar year
ESRI	Environmental Systems Research Institute
GIS	geographic information system
Hg	mercury
KSAT	areal-weighted saturated hydraulic conductivity
MDN	Mercury Deposition Network of the National Atmospheric Deposition Program
MeHg	methylmercury
NADP	National Atmospheric Deposition Program
NAIP	National Agriculture Imagery Program
NAWQA	National Water-Quality Assessment Program
NCDC	National Climatic Data Center
NLCD	National Land Cover Dataset
NLCD01	National Land Cover Dataset for 2001
NTN	National Trends Network of NADP
NWI	U.S. Fish and Wildlife Service National Wetlands Inventory
PRISM	Parameter-elevation Regressions on Independent Slopes Model
SAGA	System for Automated Geoscientific Analysis
SSURGO	U.S. Department of Agriculture Soil Survey Geographic database
USGS	U.S. Geological Survey
WY	water year

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Abstract

This report summarizes the environmental settings of streams in New York and South Carolina, where the U.S. Geological Survey completed detailed investigations during 2005–09 into factors contributing to mercury bioaccumulation in top-predator fish and other stream organisms. Descriptions of location, land use/land cover, climate, precipitation, atmospheric deposition, hydrology, water temperature, and other characteristics are provided. Atmospheric deposition is the dominant mercury source in the studied basins where biota, sediment, soil, and water were sampled for mercury and for physical and chemical characteristics believed to be important in mercury methylation and transport.

Introduction

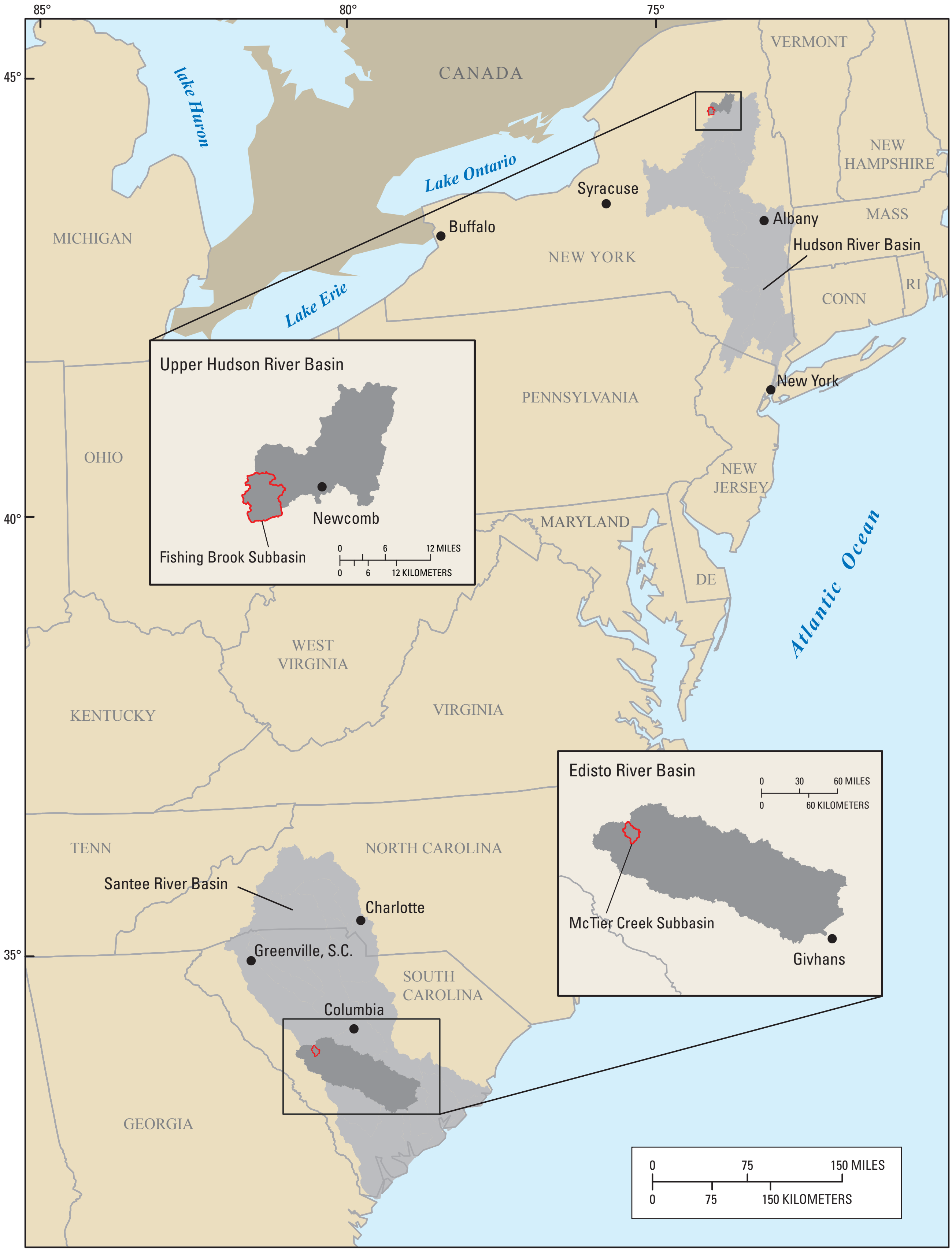
In 2002, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) program began studies of mercury (Hg) in stream and river ecosystems (henceforth referred to as ‘streams’) across the United States. These streams spanned a large range in Hg source strength and environmental settings. Initial studies focused on environmental factors contributing to bioavailability and bioaccumulation of Hg in stream ecosystems from single locations in each of eight study basins—two in Oregon, three in Wisconsin, and three in Florida (Bell and Lutz, 2008; Brigham and others, 2003, 2009; Chasar and others, 2009; Marvin-DiPasquale and others, 2009). Subsequent studies conducted during 2005–09 examined mercury cycling, transport, and bioaccumulation at multiple sites across two stream basins in New York and South Carolina. The purpose of this report is to describe the environmental settings of study basins in New York and South Carolina (fig. 1) and to serve as a reference document for other reports associated with the 2005–09 Hg studies.

Environmental Setting and Mercury Cycling

Both the New York and South Carolina study basins are in areas that are considered to be biologically sensitive to Hg from atmospheric sources, in that conditions are favorable for efficient conversion of inorganic Hg from atmospheric deposition to methylmercury (MeHg, the organic and bioavailable form of Hg) and its transport to adjacent streams (Evers and others, 2007; Bradley and others, 2011). MeHg is a potent neurotoxin that enters the base of aquatic food webs and is concentrated to increasingly higher levels by consumers. Thus, conversion of inorganic Hg to MeHg (a process known as methylation) is a critical step because it greatly increases the bioavailability of Hg.

Hg transported by the atmosphere and deposited on the landscape is thought to be the dominant source of Hg to the study basins (New York State Department of Environmental Conservation, 2008; South Carolina Department of Health and Environmental Control, 2010); Hg in wet atmospheric deposition (rain and snow) is moderate to high in the two basins relative to the rest of the Nation (National Atmospheric Deposition Program, 2010).

Land use/land cover in the New York and South Carolina basins is mostly forested and woody wetland (“swamp”), and these types of land cover are known to be important in methylation of Hg (Driscoll and others, 1994; Hurley and others, 1995; St. Louis and others, 1994, 1996; U.S. Environmental Protection Agency, 1997; Kolka and others, 1999; Krabbenhoft and others, 1999; Chumchal and others, 2008; Brigham and others, 2009; Scudder and others, 2009).



Base from USGS Watershed Boundaries Dataset. Albers Conical Equal Area Projection, North American Datum of 1983.

Figure 1. Locations of New York and South Carolina study basins.

Indeed, fish from the New York and South Carolina basins are known to have Hg concentrations of concern for consumption by humans and wildlife (Yeardley and others, 1998; U.S. Environmental Protection Agency, 2001a, 2001b; Evers and others, 2007; New York State Department of Environmental Conservation, 2008; Simonin and others, 2009; Glover and others, 2010; South Carolina Department of Health and Environmental Control, 2010; National Oceanic and Atmospheric Administration and South Carolina Department of Natural Resources, 2011; New York State Department of Health, 2011; South Carolina Department of Health and Environmental Control, 2011). Hg in top-predator fish is particularly high in the Edisto River of the Santee River Basin, South Carolina. In a study of top-predator fish from streams across the Nation, concentrations of Hg in a composite sample of largemouth bass (*Micropterus salmoides*) from the Edisto River ranked above the 95th percentile, and a composite sample of largemouth bass from the North Fork Edisto River near Fairview Crossroads, S.C., contained 1.80 micrograms per gram (µg/g) wet weight Hg, a concentration that was exceeded only by a composite sample of fish from a stream in a mined basin (Bauch and others, 2009; Scudder and others, 2009).

Several candidate basins were explored for inclusion at the outset of this study, and the Upper Hudson River Basin and Edisto River Basin were selected because each included regions, such as the Adirondacks in the Hudson and Coastal Plain in the Edisto, where high MeHg concentrations had been identified previously in surface waters and biota. Once these basins were identified for study, a smaller subbasin within each was selected for intensive study based on the premise that subbasins in the range of 50 to 100 km^2 would be most appropriate for investigations focused on biogeochemical processes and bioaccumulation. Factors such as the presence of an existing streamgage or an appropriate streamgaging location, accessibility throughout the year, and landscape representativeness of the larger basin also were considered in subbasin selection. The two selected subbasins, Fishing Brook in New York and McTier Creek in South Carolina, are similar in size but differ in climate, atmospheric Hg loading, land use/land cover, aquatic species composition and community structure, and hydrology. The numerous synoptic sites sampled during the study were selected primarily based on representing a range of influence of landscape elements such as riparian wetlands, forested uplands, and lakes/ponds that were assumed likely to affect MeHg concentrations in surface water and biota. Reconnaissance included a total of 54 sites, 28 in New York and 26 in South Carolina; although most of the subsequent sampling was done at a subset of these sites. All sites are listed in table 1.

Sources of Environmental Setting Data

Environmental setting data for the sites described in this report were compiled from a variety of sources, which are listed in table 2. Total Hg concentrations and deposition were monitored at two National Atmospheric Deposition Program Mercury Deposition Network (NADP–MDN) monitoring locations near each study basin: Huntington Wildlife Forest (NY20) and Congaree Swamp (SC19) (National Atmospheric Deposition Program, 2010a; table 3). As part of NADP–MDN monitoring, precipitation samples were collected weekly and analyzed for total Hg using established protocols to quantify weekly precipitation and wet deposition loads of Hg at both sites (National Atmospheric Deposition Program, 2006, 2010b; Latysch and Wetherbee, 2007). The Parameter-elevation Regressions on Independent Slopes Model (PRISM) was used for this investigation to determine basin-wide mean annual precipitation for the Edisto and Hudson River Basins. The PRISM is a system that uses point measurements of precipitation, temperature, and other climatic factors from across the United States to produce continuous, regularly spaced, digital-grid estimates of monthly, annual, and event-based climatic parameters (Daly and others, 1994, 2002; Daly, 2006; National Water and Climate Center, 2010; PRISM Climate Group, 2010). In a method modified from Latysch and Wetherbee (2011), PRISM grid estimates of mean annual precipitation were applied to mean annual Hg concentrations at the two NADP–MDN monitoring locations to produce mean annual wet-deposition estimates for total Hg in both basins (table 4). Data for atmospheric dry deposition of Hg are not available but dry deposition can be significant (Miller and others, 2005; Sakata and others, 2006; Choi and others, 2008; Risch and others, 2011). Mean air temperatures for summer and winter near the primary USGS sampling sites were estimated using data from the National Climatic Data Center (NCDC) (National Climatic Data Center, 2011a) for nearby NCDC sites (table 4).

Table 1. Map numbers and complete site names with basic basin characteristics for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.

[USGS, U.S. Geological Survey; km^2, square kilometer; m, meter; km, kilometer; nd, no data; latitude and longitude are in decimal degrees, referenced to the North American Datum of 1927; elevation at basin outlet is from the National Elevation Dataset, referenced to the North American Vertical Datum of 1988; NADP–MDN, National Atmospheric Deposition Program–Mercury Deposition Network; NADP–MDN site NY20: latitude and longitude are 43.9731 and -74.2231, respectively; NADP–MDN site SC19: latitude and longitude are 33.8145 and -80.7809, respectively; primary sampling sites are shown in **bold**]

Map number (fig. 3)	USGS station number	USGS station name	Latitude (decimal degrees)	Longitude (decimal degrees)	County	Drainage basin area[1] (km^2)	Elevation at basin outlet (m)	Distance from NADP–MDN site NY20 to stream-water sampling location (km)
		New York						
1	01311985	Fishing Brook near Windfall Mountain near Long Lake, N.Y.	43.963833	-74.326528	Hamilton	15.9	560	8.3
2	01311989	Fishing Brook near Long Lake, N.Y.	43.972972	-74.328417	Hamilton	25.0	544	8.4
3	01311990	Fishing Brook at 28N near Long Lake, N.Y.	43.978056	-74.336667	Hamilton	27.1	540	9.1
4	0131199010	Sixmile Brook at 28N near Long Lake, N.Y.	43.975667	-74.361306	Hamilton	4.56	546	11.1
5	0131199020	Sixmile Brook Tributary near Long Lake, N.Y.	43.991278	-74.351194	Hamilton	6.89	527	10.5
6	0131199021	Sixmile Brook below Sixmile Brook Tributary near Long Lake, N.Y.	43.987778	-74.345556	Hamilton	17.0	520	9.9
7	**0131199022**	**Sixmile Brook near Long Lake, N.Y.**	43.988194	-74.341000	Hamilton	17.7	522	9.6
8	0131199029	Pickwacket Pond Inlet near Long Lake, N.Y.	44.008250	-74.311722	Hamilton	1.32	549	8.1
9	0131199035	Pickwacket Pond Outlet at mouth near Long Lake, N.Y.	43.992841	-74.309047	Hamilton	8.42	505	7.2
10	0131199040	Fishing Brook above County Line Flow near Long Lake, N.Y.	43.987583	-74.291333	Hamilton	60.6	509	5.7
11	0131199045	Unnamed tributary to County Line Flow near Long Lake, N.Y.	43.979000	-74.285889	Hamilton	0.96	540	5.1
12	**0131199050**	**Fishing Brook (County Line Flow outlet) near Newcomb, N.Y.**	43.977389	-74.270417	Hamilton	65.6	504	3.8
13	435937074144301	Archer Creek near Newcomb, N.Y.	43.993611	-74.245278	Essex	1.32	516	2.9
14	01311992	Arbutus Pond Outlet near Newcomb, N.Y.	43.982286	-74.235433	Essex	3.50	513	1.4

Table 1. Map numbers and complete site names with basic basin characteristics for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.—Continued

[USGS, U.S. Geological Survey; km², square kilometer; m, meter; km, kilometer; nd, no data; latitude and longitude are in decimal degrees, referenced to the North American Datum of 1927; elevation at basin outlet is from the National Elevation Dataset, referenced to the North American Vertical Datum of 1988; NADP–MDN, National Atmospheric Deposition Program–Mercury Deposition Network; NADP–MDN site NY20: latitude and longitude are 43.9731 and -74.2231, respectively; NADP–MDN site SC19: latitude and longitude are 33.8145 and -80.7809, respectively; primary sampling sites are shown in **bold**]

Map number (fig. 3)	USGS station number	USGS station name	Latitude (decimal degrees)	Longitude (decimal degrees)	County	Drainage basin area[1] (km²)	Elevation at basin outlet (m)	Distance from NADP–MDN site NY20 to stream-water sampling location (km)
		New York						
15	0131199405	Flat Brook at mouth near Newcomb, N.Y.	43.973953	-74.230154	Essex	8.99	477	0.6
16	435840074141001	Fishing Brook downstream of Lilypad Pond near Newcomb, N.Y.	43.977842	-74.235710	Essex	131	478	1.1
17	0131199710	Fishing Brook (Rich Lake at dam) at Newcomb, N.Y.	43.973119	-74.180985	Essex	168	475	3.4
18	01311830	Hudson River at Tahawus, N.Y.	44.043670	-74.057925	Essex	74.4	521	15.4
19	0131184703	Henderson Lake Outlet above Calamity Brook near Tahawus, N.Y.	44.091168	-74.056260	Essex	44.8	557	18.7
20	0131185005	Calamity Brook at mouth near Tahawus, N.Y.	44.091168	-74.055704	Essex	13.4	537	18.8
21	0131185008	Hudson River (proper) below Calamity Brook near Tahawus, N.Y.	44.090890	-74.056260	Essex	58.3	531	18.7
22	01311940	Hudson River near Tahawus, N.Y.	44.016172	-74.053758	Essex	163	521	14.4
23	435757074030101	Hudson River at Tahawus Road crossing near Newcomb, N.Y.	43.965833	-74.050278	Essex	197	516	13.9
24	01311951	Hudson River near Winebrook Hills, N.Y.	43.958417	-74.093750	Essex	223	481	10.5
25	01311998	Woodruff Pond Outlet at Newcomb, N.Y.	43.969507	-74.163762	Essex	8.60	475	4.8
26	435808074065801	Hudson River below Newcomb River near Newcomb, N.Y.	43.968889	-74.116111	Essex	300	474	8.6
27	**01312000**	**Hudson River near Newcomb, N.Y.**	43.966174	-74.130704	Essex	493	468	7.4
28	01312005	Hudson River Tributary Number Nine at Newcomb, N.Y.	43.957285	-74.124315	Essex	3.37	483	8.1

Table 1. Map numbers and complete site names with basic basin characteristics for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.—Continued

[USGS, U.S. Geological Survey; km^2, square kilometer; m, meter; km, kilometer; nd, no data; latitude and longitude are in decimal degrees, referenced to the North American Datum of 1927; elevation at basin outlet is from the National Elevation Dataset, referenced to the North American Vertical Datum of 1988; NADP–MDN, National Atmospheric Deposition Program–Mercury Deposition Network; NADP–MDN site NY20: latitude and longitude are 43.9731 and -74.2231, respectively; NADP–MDN site SC19: latitude and longitude are 33.8145 and -80.7809, respectively; primary sampling sites are shown in **bold**]

Map number (fig. 10)	USGS station number	USGS station name	Latitude (decimal degrees)	Longitude (decimal degrees)	County	Drainage basin area[1] (km^2)	Elevation at basin outlet (m)	Distance from NADP–MDN site SC19 to stream-water sampling location (km)
				South Carolina				
29	334658081264400	North Fork Edisto River at Steedman, S.C.	33.782926	-81.445380	Aiken	213	95.8	61.5
30	**02172300**	**McTier Creek (State Highway 209) near Monetta, S.C**	33.753477	-81.601771	Aiken	40.5	106	76.2
31	3345100813509	Gully Creek at Bridge on Shoals Road near Monetta, S.C.	33.752778	-81.585833	Aiken	25.9	108	74.7
32	02172304	McTier Creek above Hunt Shed near New Holland, S.C.[2]	33.745833	-81.597222	Aiken	79.1	98.6	75.8
33	3344280813547	McTier Creek above Gully Creek near New Holland, S.C.	33.741111	-81.596389	Aiken	42.9	102	75.8
34	3344250813538	Gully Creek at McTier Creek near New Holland, S.C.	33.740278	-81.593889	Aiken	29.9	102	75.6
35	**02172305**	**McTier Creek near New Holland, S.C.**	33.717500	-81.607500	Aiken	79.4	96.5	77.2
36	334230081185600	North Fork Edisto River near Wagner, S.C.	33.708483	-81.315380	Aiken	401	78.4	50.8
37	334108081361300	South Fork Edisto River near Foxtown, S.C.	33.685699	-81.603439	Aiken	340	90.3	77.4
38	333901081110700	North Fork Edisto River near Woodford, S.C.	33.650429	-81.185100	Orangeburg	889	69.2	41.6
39	333547081321900	South Fork Edisto River near Kitchings Mill, S.C.	33.596534	-81.538439	Aiken	500	80.5	74.2
40	333455081021400	Bull Swamp Creek near North, S.C.	33.582098	-81.037039	Orangeburg	250	58.8	35.1
41	333434081021900	North Fork Edisto River near North, S.C.	33.576265	-81.038428	Orangeburg	1091	58.4	35.6
42	333315081290100	South Fork Edisto River at Aiken State Park, S.C.	33.554313	-81.483439	Aiken	917	74.8	71.2

Table 1. Map numbers and complete site names with basic basin characteristics for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.—Continued

[USGS, U.S. Geological Survey; km^2, square kilometer; m, meter; km, kilometer; nd, no data; latitude and longitude are in decimal degrees, referenced to the North American Datum of 1927; elevation at basin outlet is from the National Elevation Dataset, referenced to the North American Vertical Datum of 1988; NADP–MDN, National Atmospheric Deposition Program–Mercury Deposition Network; NADP–MDN site NY20: latitude and longitude are 43.9731 and -74.2231, respectively; NADP–MDN site SC19: latitude and longitude are 33.8145 and -80.7809, respectively; primary sampling sites are shown in **bold**]

Map number (fig. 10)	USGS station number	USGS station name	Latitude (decimal degrees)	Longitude (decimal degrees)	County	Drainage basin area[1] (km^2)	Elevation at basin outlet (m)	Distance from NADP–MDN site SC19 to stream-water sampling location (km)
				South Carolina				
43	333130080565000	North Fork Edisto River above Orangeburg, S.C.	33.525154	-80.947037	Orangeburg	1507	52.0	35.7
44	333015080531900	Caw Caw Swamp Creek near Orangeburg, S.C.	33.504320	-80.888426	Orangeburg	207	49.2	35.9
45	332935081191800	Dean Swamp Creek near Springfield, S.C.	33.493204	-81.321494	Orangeburg	163	63.6	61.5
46	332931081144400	Tampa Creek near Springfield, S.C.	33.492095	-81.245382	Orangeburg	97.5	62.4	56.0
47	332743081163400	South Fork Edisto River near Springfield, S.C.	33.462095	-81.275938	Orangeburg	1493	59.1	60.3
48	332406080520900	North Fork Edisto River near Rowesville, S.C.	33.401822	-80.868983	Orangeburg	1830	41.6	46.6
49	332337081160000	Windy Hill Creek near Blackville, S.C.	33.393763	-81.266494	Barnwell	16.6	66.8	64.9
50	331849080575200	South Fork Edisto River near Bamberg, S.C.	33.313768	-80.964263	Bamberg	2195	37.6	58.2
51	331625080530300	North Fork Edisto River near Branchville, S.C.	33.273770	-80.883985	Orangeburg	127	32.2	60.9
52	330319080241600	Four Hole Swamp near Ridgeville, S.C.	33.055446	-80.404265	Dorchester	3485	9.92	91.4
53	02174175	Edisto River near Cottageville, S.C.	33.054612	-80.449266	Colleton	5341	10.8	89.9
54	**02175000**	**Edisto River near Givhans, S.C.**	33.027946	-80.391488	Dorchester	7071	6.24	94.6

[1]Drainage basin areas for gaged sites were derived from delineations made as part of the process of determining land cover area in this study. In some cases, the drainage basin areas differed from those shown for these sites in the USGS National Water Information System (NWIS) and published in annual streamflow reports. Some of the papers and reports written as part of this study have used the NWIS values of 65.3 km^2 for Site 12 and 497.3 km^2 for Site 27, 40.4 km^2 for Site 30, 79.5 km^2 for Site 35, and 7070.7 km^2 for Site 54.

[2]Site 32 is about 800 meters upstream of site 35.

Table 2. Sources of environmental-setting data for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.

Data	Data source	Reference
Atmospheric mercury deposition	Mercury Deposition Network–National Atmospheric Deposition Program (MDN–NADP)	National Atmospheric Deposition Program, 2010b *(http://nadp.sws.uiuc.edu/mdn)*
Drainage basin areas	Watershed Boundary Dataset	Natural Resources Conservation Service, 2010 *(http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/)*
Elevation, 10 meter resolution	National Elevation Dataset (NED)–Digital Elevation Model (DEM)	U.S. Geological Survey, 2010a *(http://ned.usgs.gov/)*
Flow-path length, flow distance to channel network	System for Automated Geoscientific Analysis–Geographic Information System software (SAGA–GIS)	System for Automated Geoscientific Analysis Geographic Information System, 2007 *(http://www.saga-gis.org/en/index.html)*
Frost-free period	Freeze/frost maps	National Climatic Data Center, 2011b *(http://www.ncdc.noaa.gov/img/climate/freezefrost/Freezefree32F.pdf)*
Hydric soils, organic-matter content, KSAT[1]	U.S. Department of Agriculture Soil Survey (SSURGO)	Natural Resources Conservation Service, 2011 *(http://soils.usda.gov/survey/geography/ssurgo/)*
Land use/land cover	National Land Cover Data for 2001 (NLCD01)	Yang and others, 2002; Homer and others, 2004; *http://www.mrlc.gov/nlcd2001.php*
Precipitation (basin-wide means)	Parameter-elevation Regressions on Independent Slopes Model (PRISM)	PRISM Climate Group, 2010 (http://prism.oregonstate.edu; National Water and Climate Center, 2010 *(http://www.wcc.nrcs.usda.gov/climate/prism.html)*
Satellite images	U.S. Department of Agriculture–Farm Service Agency, National Agriculture Imagery Program (New York only), provided by Environmental Systems Research Institute	Environmental Systems Research Institute, 2008 *(http://www.arcgis.com/home/item.html?id=5f5f6b9ee5b4483f9767b118b7b99323)*
Satellite images	AEX Aerials Maps & Data (South Carolina only), provided by Environmental Systems Research Institute	Environmental Systems Research Institute, 2007 *(http://www.aerials-gis.com/AEX_Site/GIS_System.html)*
Stream network base maps	National Hydrography Dataset	U.S. Geological Survey, 2010b *(http://nhd.usgs.gov/)*
Streamflow	National Water Information System (NWIS)	U.S. Geological Survey, 2010c (*http://waterdata.usgs.gov/nwis/measurements*)
Temperature, air (seasonal means)	National Climatic Data Center (NCDC)	National Climatic Data Center, 2011a (*http://www.ncdc.noaa.gov/oa/climate/stationlocator.html*)
Temperature, water	Water-Data Reports, National Water Information System (NWIS)	U.S. Geological Survey, 2010c (*http://wdr.water.usgs.gov/*; *http://waterdata.usgs.gov/nwis/measurements*)
Wetness index, topographic	System for Automated Geoscientific Analysis–Geographic Information System software (SAGA–GIS)	System for Automated Geoscientific Analysis Geographic Information System, 2007 (*http://www.saga-gis.org/en/index.html*)
Wetland cover, detailed	Wetlands in the Greater Upper Hudson River Watershed Dataset (New York only)	New York State Adirondack Park Agency, 2007 *(http://www.apa.state.ny.us/gis/index.html)*
Wetland cover, detailed	National Wetlands Inventory Dataset (South Carolina only)	U.S. Fish and Wildlife Service, 2010 *(http://www.fws.gov/wetlands/)*

[1]KSAT, areal-weighted saturated hydraulic conductivity.

Table 3. Selected locations in the National Atmospheric Deposition Program–Mercury Deposition Network (NADP–MDN) used to estimate atmospheric wet deposition of total mercury in the Hudson River Basin, New York, and the Edisto River Basin, South Carolina.

Study area	NADP–MDN monitoring location	Location name	Period of record	Latitude (decimal degrees)	Longitude (decimal degrees)	Elevation at location (meters)
Hudson River	NY20	Huntington Wildlife Forest	12/10/1999–present	43.9731	-74.2231	500
Edisto River	SC19	Congaree Swamp	3/5/1996–present	33.8145	-80.7809	34

Table 4. Mean air temperature, precipitation, and atmospheric mercury data for primary stream basins sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.

[°C, degrees Celsius; mm, millimeter; µg/m²/yr, microgram per square meter per year; nd, no data; data in this table were obtained from several sources: air temperature data were summarized from National Climatic Data Center (NCDC) datasets for nearest sites; NCDC site 305714 at Newcomb, N.Y.: latitude and longitude are 43.97 and -74.22, respectively; NCDC site 380074 at Aiken, S.C.: latitude and longitude are 33.50 and -81.70, respectively; National Climatic Data Center, 2011a); atmospheric mercury values are from the National Atmospheric Deposition Program–Mercury Deposition Network (NADP–MDN, National Atmospheric Deposition Program, 2010) and are precipitation-weighted values; precipitation values used for weighting were basin-wide means derived from Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate mapping system (PRISM Climate Group, 2010); location information for NADP–MDN sites NY20 and SC19 is provided in table 1.]

Year	Fishing Brook (County Line Flow) near Newcomb, New York site 12, figs 3 and 10	McTier Creek near New Holland, South Carolina site 35, figs 3 and 10
	Mean winter-air temperature (Dec.–Feb.) (°C)	
2005	-8.8	9.1
2006	-4.6	9.7
2007	-9.0	9.2
2008	-7.4	8.3
2009	-9.5	nd
Mean (2005–09)	**-7.9**	**9.1**
	Mean summer-air temperature (June–Aug.) (°C)	
2005	20.0	26.4
2006	18.1	26.9
2007	16.9	27.0
2008	16.7	26.8
2009	16.1	nd
Mean (2005–09)	**17.6**	**26.8**
	Mean annual precipitation, in mm	
2005	1267	1226
2006	1320	1094
2007	1214	845
2008	1360	1147
2009	1183	1360
Mean (2005–09)	**1269**	**1134**
	Mean total mercury in wet atmospheric deposition, in µg/m²/yr	
2005	6.68	11.0
2006	6.96	9.85
2007	6.40	7.60
2008	7.17	10.3
2009	6.24	12.2
Mean (2005–09)	**6.69**	**10.21**

Drainage basin areas were determined using the Watershed Boundary Dataset (Natural Resources Conservation Service, 2010), field checked, and adjusted when necessary. Drainage area and site elevations are shown in table 1. Elevations were obtained from the 10 m USGS National Elevation Dataset (U.S. Geological Survey, 2010a). Several elevation-derived descriptive parameters were derived using System for Automated Geoscientific Analysis (SAGA) geographic information system (GIS), and these parameters included topographic wetness index, flow-path length, overland flow distance and horizontal flow distance to channel network, altitude above channel network, and riparian area and width (System for Automated Geoscientific Analysis Geographic Information System, 2007). Topographic wetness index is a ratio of natural upslope contributing area to slope and is used as a measure of soil wetness. Flow-path length is an average of flow lengths, or distances, from points in the basin along the direction of flow to the basin outlet; the flow path is defined using a multi-flow direction algorithm. Overland flow distance is an average value that represents overland and shallow subsurface flow distances to the nearest point on the stream channel network, and it is also referred to as 'Hydrologic Transport Distance' in Riva-Murray and others (2011). Horizontal flow distance is the Euclidean distance from each point in the basin to the nearest point on the stream. Riparian area is the area within 0.65 m elevation of each stream point, excluding open water. The Natural Resources Conservation Service Soil Survey Geographic (SSURGO) database was used for estimating areas of hydric soils, organic-matter content, and areal-weighted saturated hydraulic conductivity as shown in appendix 1 for New York and appendix 2 for South Carolina (Natural Resources Conservation Service, 2011). Land use/land cover data for all basins, provided in table 5, were based on the National Land Cover Dataset (NLCD) for 2001 (NLCD01) (Homer and others, 2004; Yang and others, 2002). Additional detailed wetland coverage, using a different method of delineation and based on aerial photogrammetry, was from the New York State Adirondack Park Agency (APA) for New York basins and from the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) for South Carolina; these data are summarized in table 5, and details are provided in appendixes 1 and 2 (New York State Adirondack Park Agency, 2007; U.S. Fish and Wildlife Service, 2010). Wetland percentages for sites may differ between NLCD01 and either APA or NWI due to methodological differences.

Stream network base maps were created using the USGS National Hydrography Dataset (U.S. Geological Survey, 2010b). Streamflow (discharge) and water temperature data at USGS streamflow-gaging stations are summarized in tables 6 and 7, and all data are available in the USGS National Water Information System (U.S. Geological Survey, 2010c) and (or) as water-data reports, available at *http://wdr.water.usgs.gov/*.

Figures provided in this report include photographs and maps (at several scales) of the study areas. Photographs show conditions at or near sampling sites during spring or summer when most biological samples were collected. Location of stream-basin boundaries, USGS streamflow-gaging stations, and sampling sites are shown within the context of their respective larger stream basins and their location in the United States. Maps showing detailed wetland coverage for New York streams are from the Wetlands in the Greater Upper Hudson River Watershed dataset (New York State Adirondack Park Agency, 2007), and those for South Carolina streams are from the NWI dataset (U.S. Fish and Wildlife Service, 2010). Satellite images for figures 7 and 13 were provided by the Environmental Systems Research Institute (ESRI); images for the Fishing Brook/Upper Hudson River were taken by the U.S. Department of Agriculture–Farm Service Agency, National Agriculture Imagery Program (NAIP) at 1-m resolution on October 11, 2008 (Environmental Systems Research Institute, 2008); and images for the McTier Creek/Edisto River were taken by Aerials Express at 0.5-m resolution on March 15, 2007 (Environmental Systems Research Institute, 2007).

Environmental Setting of New York Streams

The New York streams sampled for the 2005–09 NAWQA Hg studies are in the Upper Hudson River Basin (fig. 1, table 1), which is defined here as the portion of the basin upstream of Hudson River near Newcomb, N.Y. (*Site 27*). Reconnaissance sampling was conducted throughout the Upper Hudson River Basin during 2005 (one of these sites, *Site 28*, was slightly downstream of the defined basin boundary at *Site 27*), after which more intensive sampling (2007–09) focused in the Fishing Brook Subbasin, in the western-most headwaters of the Upper Hudson River Basin. Seventeen sites were located throughout the Fishing Brook Subbasin and include locations on Fishing Brook, Sixmile Brook, several pond/lake inlets and outlets, and an un-named tributary. Elevations in the Upper Hudson Basin range from 468 m above sea level near Newcomb (*Site 27*) to 1,624 m above sea level at Mount Marcy, the highest point in New York State. The Fishing Brook sites range in elevation from 475 to 560 m above sea level (table 1). Topography is highly heterogeneous, across both the entire Upper Hudson River Basin and the Fishing Brook Subbasin, with relatively flat to steep slopes. Median basin slope ranges from 3.6 percent slope at Hudson River Tributary Number Nine at Newcomb, N.Y. (*Site 28*) to 31.8 percent slope at Calamity Brook (*Site 20*) (appendix 1). With the exception of Hudson River Tributary Number Nine at Newcomb, N.Y. (*Site 28*), sample sites in the Upper Hudson River Basin have predominantly (>70 percent) forested upland land cover. There is a wide range of wetland amount across sites (0 to 14 percent). For *Site 28* only, ground truthing showed erroneously high NLCD01 wetland values that may be incorrectly categorized forested land in this small basin (3.37 km^2), so NLCD01 wetland and forested values are not included in table 5. The amount of open water (lakes and ponds, both natural and man-made) also varies among the subbasins studied in the Upper Hudson River Basin, from 0 to 15 percent.

Table 5. Land use/land cover data for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.

[Land use/land cover data are based on the National Land Cover Dataset for 2001 (NLCD01; Yang and others, 2002; Homer and others, 2004) for basins that were delineated using a geographic information system. More detailed wetland data, using a separate method of delineation, are included: APA wetland values for New York streams are from the Wetlands in the Greater Upper Hudson River Watershed dataset (New York State Adirondack Park Agency, 2007) and National Wetlands Inventory (NWI) wetland values for South Carolina streams are from the NWI dataset (U.S. Fish and Wildlife Service, 2010); nd, no data. Additional detailed land-use data are provided in appendixes 1 and 2. Primary sampling sites shown in bold]

Map number (fig. 3)	Land use/land cover (percent of basin area)														
	Forest				Wetland				NLCD01 Open water	APA Open water	NLCD01 Shrubland	NLCD01 Herbaceous upland	NLCD01 Agriculture	NLCD01 Developed*	NLCD01 Barren
	NLCD01 Deciduous forest	NLCD01 Evergreen forest	NLCD01 Mixed forest	NLCD01 Total forest	NLCD01 Woody wetland	NLCD01 Herbaceous wetland	NLCD01 Total wetland	APA Total wetland							
New York															
1	52.12	31.21	10.62	93.95	4.74	0.82	5.56	4.41	0.16	0.49	0.16	0	0	0	0
2	48.08	35.54	10.26	93.89	4.87	0.62	5.49	5.18	0.10	0.41	0.21	0	0	0.10	0
3	47.46	34.74	9.86	92.06	5.55	0.86	6.41	5.84	1.05	1.15	0.29	0	0	0.19	0
4	40.34	41.48	11.36	93.18	5.11	0.57	5.68	6.82	1.14	0.57	0	0	0	0.57	0
5	72.56	11.28	6.39	90.23	7.14	1.13	8.27	6.77	0.75	1.13	0.75	0	0	0	0
6	51.22	25.99	6.99	84.19	11.85	1.82	13.68	13.22	0.91	0.61	0.46	0	0	0.76	0
7	51.39	25.40	7.15	83.94	11.82	2.04	13.87	12.99	1.02	0.58	0.44	0	0	0.73	0
8	76.47	13.73	5.88	96.08	1.96	0	1.96	0	0	0	1.96	0	0	0	0
9	73.23	5.54	4.31	83.08	4.62	0.62	5.23	4.62	11.4	10.5	0.62	0	0	0	0
10	53.03	26.37	7.48	86.88	8.29	1.20	9.49	8.63	2.35	2.18	0.51	0.21	0	0.64	0
11	64.86	21.62	13.51	100.00	0	0	0	0	0	0	0	0	0	0	0
12	53.75	25.30	7.26	86.31	8.17	1.14	9.31	8.25	3.00	2.68	0.47	0.20	0	0.71	0
13	56.86	13.73	21.57	92.16	5.88	0.00	5.88	9.80	0	0	0.00	0	0	0	0
14	43.70	14.81	16.30	74.81	10.37	0.00	10.37	4.44	14.8	14.1	0.00	0	0	0	0
15	65.13	16.71	6.63	88.47	8.93	1.44	10.37	7.20	0.00	0.58	0.29	0	0	0.86	0
16	55.61	18.78	7.22	81.61	10.32	1.20	11.52	7.61	5.90	5.35	0.47	0.10	0	0.41	0
17	56.29	18.07	7.50	81.87	9.81	1.14	10.95	7.29	6.18	5.70	0.37	0.08	0.03	0.52	0
18	21.84	48.38	17.49	87.70	3.97	1.11	5.09	2.61	3.38	3.20	3.17	0.24	0	0.45	0.07
19	23.64	56.47	13.82	93.93	2.25	0.06	2.31	2.89	3.24	2.95	0.35	0.12	0	0	0
20	4.05	56.76	34.56	95.37	2.32	0	2.32	2.12	0.19	0.00	2.12	0	0	0	0
21	19.11	56.62	18.58	94.31	2.27	0.04	2.31	2.71	2.53	2.27	0.80	0.09	0	0	0
22	22.07	49.35	16.63	88.06	4.52	0.78	5.30	2.93	2.68	2.11	3.17	0.25	0	0.38	0.17
23	26.83	44.68	15.75	87.26	5.62	0.80	6.42	4.28	2.88	2.27	2.64	0.21	0	0.46	0.14
24	27.52	42.99	15.02	85.54	7.36	1.10	8.46	5.11	2.67	2.15	2.33	0.19	0.01	0.67	0.13
25	52.71	16.57	3.31	72.59	14.46	1.20	15.7	9.9	4.82	4.52	0.00	0.30	0.30	3.61	2.41
26	34.18	37.68	13.61	85.47	7.83	1.00	8.83	6.29	3.08	2.59	1.77	0.15	0.01	0.59	0.09
27	42.49	30.09	11.15	83.73	8.73	1.04	9.77	6.71	4.38	3.90	1.21	0.12	0.02	0.66	0.11
28	nd	nd	nd	nd	nd	nd	nd	13.8	0	0	0	0	0	6.15	0

Table 5. Land use/land cover data for streams sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.—Continued

[Land use/land cover data are based on the National Land Cover Dataset for 2001 (NLCD01; Yang and others, 2002; Homer and others, 2004) for basins that were delineated using a geographic information system. More detailed wetland data, using a separate method of delineation, are included: APA wetland values for New York streams are from the Wetlands in the Greater Upper Hudson River Watershed dataset (New York State Adirondack Park Agency, 2007) and National Wetlands Inventory (NWI) wetland values for South Carolina streams are from the NWI dataset (U.S. Fish and Wildlife Service, 2010); nd, no data. Additional detailed land-use data are provided in appendixes 1 and 2. Primary sampling sites shown in bold]

Map number (fig. 3)	Land use/land cover (percent of basin area)														
	Forest				Wetland										
	NLCD01 Deciduous forest	NLCD01 Evergreen forest	NLCD01 Mixed forest	NLCD01 Total forest	NLCD01 Woody wetland	NLCD01 Herbaceous wetland	NLCD01 Total wetland	NWI Total wetland	NLCD01 Open water	NWI Open water	NLCD01 Shrubland	NLCD01 Herbaceous upland	NLCD01 Agriculture	NLCD01 Developed*	NLCD01 Barren
South Carolina															
29	15.50	24.61	3.49	43.60	9.01	0.32	9.33	nd	1.09	nd	2.56	15.04	19.27	8.96	0.17
30	15.40	31.78	6.37	53.54	6.94	0.29	7.24	5.06	0.99	1.15	0.45	19.63	12.87	5.24	0.04
31	10.89	39.36	7.29	57.54	6.29	0.10	6.39	5.29	1.30	1.60	0.60	16.78	12.59	4.80	0.00
32	13.08	30.10	6.39	49.58	7.96	0.23	8.19	6.35	1.04	1.24	0.49	21.07	14.87	4.73	0.00
33	15.35	27.55	6.71	49.61	7.73	0.30	8.04	5.74	0.91	1.09	0.36	20.60	15.35	5.20	0.00
34	10.30	36.19	6.75	53.25	6.93	0.09	7.01	6.06	1.21	1.39	0.61	18.87	14.72	4.50	0.00
35	13.08	30.10	6.39	49.58	7.96	0.23	8.19	6.43	1.04	1.24	0.49	21.07	14.87	4.73	0.00
36	11.33	26.62	4.55	42.50	10.05	0.41	10.45	nd	0.93	nd	8.26	12.65	17.84	7.06	0.31
37	12.98	24.88	3.48	41.34	8.87	0.29	9.16	nd	1.21	nd	2.77	18.68	20.66	5.98	0.19
38	8.34	26.09	4.53	38.96	10.18	0.40	10.58	nd	0.90	nd	10.3	11.34	21.34	6.25	0.30
39	11.08	25.84	3.41	40.33	10.15	0.40	10.54	nd	1.13	nd	6.50	16.89	18.47	5.66	0.50
40	3.11	26.31	2.10	31.52	15.41	0.57	15.98	nd	0.73	nd	14.4	4.80	25.54	6.94	0.06
41	7.42	26.77	4.04	38.23	12.06	0.48	12.54	nd	0.88	nd	10.4	9.88	21.33	6.51	0.27
42	10.10	25.38	3.23	38.72	10.27	0.39	10.67	nd	1.05	nd	6.91	15.75	20.35	6.20	0.36
43	6.20	26.84	3.28	36.33	13.91	0.51	14.42	nd	0.88	nd	11.8	8.58	21.50	6.33	0.21
44	3.29	23.37	0.27	26.93	17.97	0.44	18.42	nd	1.37	nd	16.3	5.12	21.64	10.11	0.09
45	4.38	27.82	4.46	36.66	13.95	0.63	14.57	nd	0.50	nd	17.0	4.31	21.64	4.92	0.43
46	2.95	29.00	1.09	33.03	19.00	0.70	19.70	nd	0.55	nd	10.0	2.94	28.84	4.89	0.09
47	7.63	25.83	3.53	37.00	12.61	0.53	13.14	nd	0.81	nd	11.2	11.41	20.72	5.40	0.33
48	5.60	25.51	2.74	33.85	15.22	0.54	15.77	nd	0.95	nd	12.4	7.95	20.98	7.95	0.18
49	1.62	24.74	0.97	27.34	24.33	0.47	24.81	nd	0.34	nd	13.6	1.31	20.70	11.91	0.00
50	5.78	25.16	2.57	33.51	16.91	0.69	17.60	nd	0.80	nd	10.7	8.53	23.46	5.14	0.25
51	2.23	19.11	0.03	21.37	29.44	0.59	30.04	nd	0.82	nd	11.3	4.31	26.87	5.24	0.00
52	3.73	22.92	1.98	28.63	20.32	0.62	20.94	nd	0.67	nd	10.9	5.31	26.10	7.19	0.30
53	10.70	24.21	2.95	37.86	15.79	0.22	16.01	nd	0.62	nd	1.45	15.23	22.85	5.93	0.06
54	9.50	23.61	2.75	35.86	17.90	0.24	18.13	nd	0.54	nd	2.06	13.01	24.28	5.98	0.14

* In Riva-Murray and others (2011), urban and agricultural land cover/land use was combined under "developed."

Table 6. Hydrologic data for primary stream sites sampled in New York and South Carolina for U.S. Geological Survey mercury studies for period of record and study period of 2005–09.

[ft^3/s, cubic foot per second; WY, water year, the 12-month period, October 1–September 30. The water year is designated by the calendar year in which it ends; nd, no data; partial, only partial record available; values in range are minimum and maximum daily mean for period of record; data available at *http://wdr.water.usgs.gov/*]

Map number (figs. 3, 10)	Period of record (WY)	Mean annual streamflow (ft^3/s)					
		Period of record	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009
		New York					
12	2007–09	58.8 (5.2–508)	nd	nd	partial	61.8	55.9
27	1926–2010	411 (11–6,780)	413	604	532	603	498
		South Carolina					
30	1996–2010	16.4 (1.4–248)	18.2	14.2	12.5	9.94	12.7
35	2007–09	22.8 (2.6–163)	nd	nd	partial	19.2	26.4
54	1939–2010	2,478 (150–24,100)	1,765	1,193	1,306	929	1,579

Table 7. Mean annual water temperature and range for primary stream sites sampled in New York and South Carolina for U.S. Geological Survey mercury studies, 2005–09.

[°C, degrees Celsius; CY, calendar year; nd, no data]

Map number (figs. 3, 10)	Period of record (CY)	Mean annual water temperature (°C)					
		Period of record	CY 2005	CY 2006	CY 2007	CY 2008	CY 2009
		New York					
7	2007–09	12.7 (-0.1–23.2)	nd	nd	10.3	12.7	15.1
12	2007–09	10.4 (-0.1–23.8)	nd	nd	11.0	10.1	10.2
27	2005–09	12.1 (0.0–23.0)	9.6	9.0	15.5	11.7	14.9
		South Carolina					
30	2005–09	18.0 (5.2–25.9)	17.8	19.1	17.4	16.4	19.5
35	2007–09	17.5 (3.0–25.7)	nd	nd	18.7	17.8	15.8
54	2005–09	21.1 (7.1–28.9)	18.9	18.9	19.8	26.9	21.1

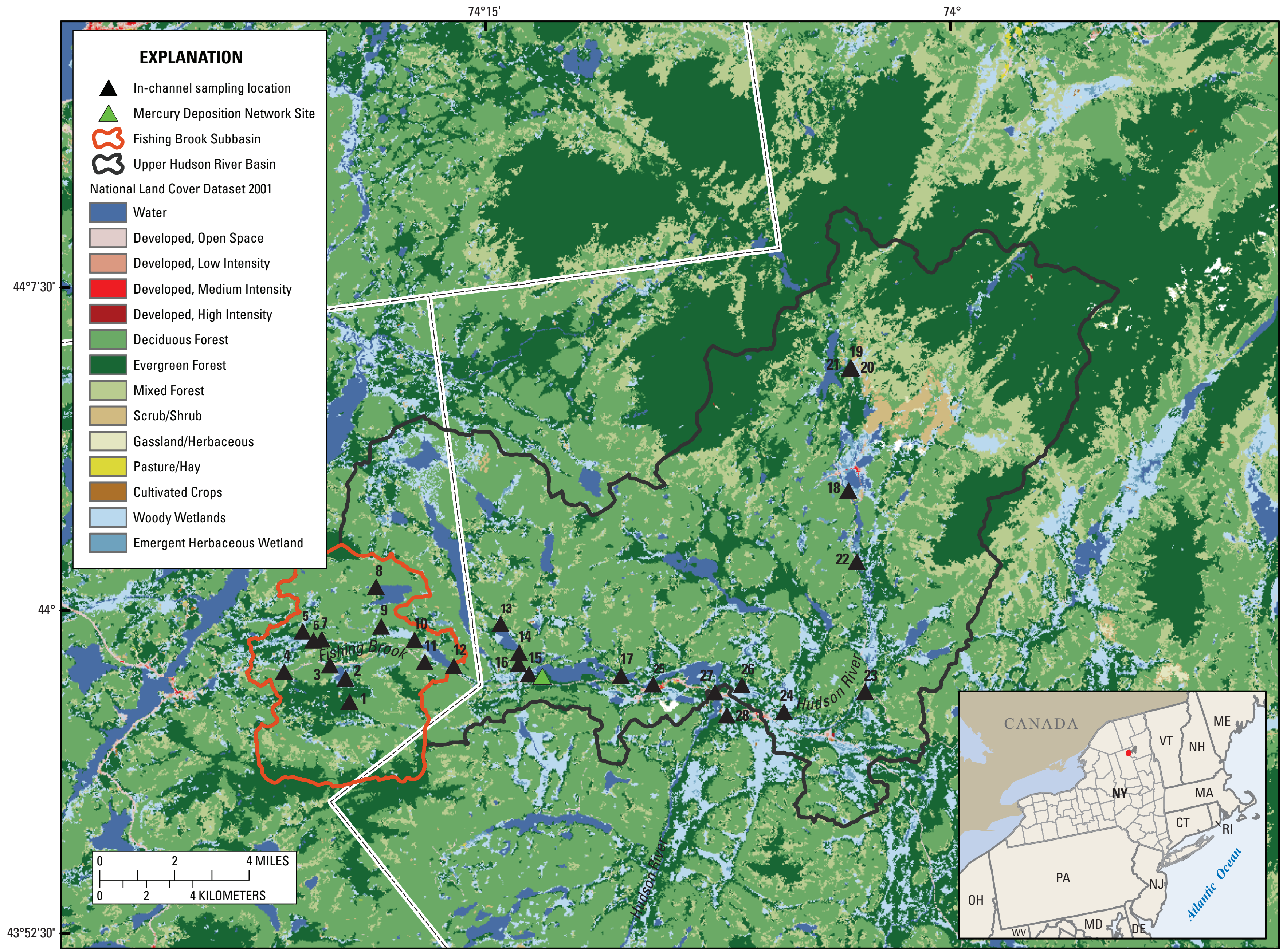
The climate of this area in New York is temperate continental with relatively long, cold winters and a lengthy dormant season. Summers are cool and wet, and the growing season is fairly short with a frost-free period of less than 150 days (National Climatic Data Center, 2011b). Cold, dry air masses from the northern continental interior and warm, humid air masses from south and southwest drive most of the climate characteristics. Cool, damp air masses from the North Atlantic Ocean during storms can also affect the inland climate of New York. Moisture for precipitation originates generally from the Gulf of Mexico and the Atlantic Ocean; however, Lakes Erie and Ontario contribute to the generally abundant snowfall of the study area (Pack, 1960).

After reconnaissance sampling in 2006, sampling efforts focused in the Fishing Brook Subbasin, which is defined here as that portion upstream of the County Line Flow outlet (*Site 12*) as well as the Hudson River at Newcomb (*Site 27*). The following sections provide additional detail on the environmental settings of these stream sites.

Upper Hudson River Basin

The Hudson River near Newcomb (*Site 27*), in Essex County, drains about 493 km^2 and lies at an elevation of 468 m above sea level (table 1). This site and others in the Upper Hudson River Basin are in the mountainous Adirondack region, which also is part of the Northeastern Highlands ecoregion (Omernik, 1987; U.S. Environmental Protection Agency, 2005). The Upper Hudson River Basin is entirely in the Adirondack Park, and is mostly undeveloped, with large portions of protected wilderness (fig. 2, Jenkins, 2004). Land use/land cover (fig. 3, table 5) is primarily forested, predominantly deciduous trees (sugar maple [*Acer saccharum*], yellow birch [*Betula alleghaniensis*], and American beech [*Fagus grandifolia*]) with evergreen trees (red spruce [*Picea rubens*] and balsam fir [*Abies balsamea*]) dominant at elevations above 1,000 m and adjacent to surface waters and wetlands (State University of New York—College of Environmental Science and Forestry, 2011). Part of the forested

Figure 2. Hudson River near Newcomb, New York (Site 27 in table 1 and figure 3) (summer). Photograph by Dennis A. Wentz, U.S. Geological Survey.



Base from US Geological Survey National Land Cover Dataset 2001. Universe Transverse Mercator projection, Zone 18N, North American Datum of 1983.

Figure 3. Land use/land cover of Upper Hudson River Basin near Newcomb, New York, with nested outline of Fishing Brook Subbasin in headwaters. Map numbers refer to sites listed in table 1.

land is used for silviculture. There is a relatively high amount (about 10 percent) of wetlands, and woody wetland (including forest and shrub/scrub) is the dominant wetland type (fig. 3, table 5). Lakes, ponds, and low-head dams are prevalent. A small (5 km^2) northeastern section of the basin was the site of mining for iron during 1827–57 and titanium during 1940–89 (New York State Adirondack Park Agency, 2011); this area now appears as shrub-scrub on land use/land cover maps (fig. 3). The river flows south from the Adirondack region, eventually reaching the City of New York metropolitan area and New York Harbor before flowing into the Atlantic Ocean.

Data for mean air temperatures, precipitation, and mean total Hg in wet atmospheric deposition for the Hudson River at Newcomb, N.Y. (*Site 27*), are assumed to be similar to those measured or derived for the headwaters site at Fishing Brook (County Line Flow outlet) near Newcomb, N.Y. (*Site 12*) based on data from nearby NCDC and NADP–MDN sites (table 4). Mean annual streamflow for the period of record (water years (WYs) 1979–2010) at Site 27 was 411 cubic feet per second (ft^3/s); mean annual streamflow ranged from 413 ft^3/s in 2005 to 604 ft^3/s in 2006 (table 6). Daily mean streamflow was weighted by area to compute estimated runoff (millimeters per day) for a common metric of comparison between the New York and South Carolina study areas. During the period of study, mean water temperatures for the Hudson River near Newcomb, N.Y. (*Site 27*), ranged from 0 to 23.0°C with a mean annual water temperature of 12.1°C (table 7).

Fishing Brook Subbasin

Fishing Brook lies in a small western subbasin of the Upper Hudson River Basin and is in Hamilton and Essex Counties near Newcomb, N.Y. (figs. 3 and 4, table 1). The most-downstream site studied within this subbasin, Fishing Brook near Newcomb (*Site 12*), drains 65.6 km^2 and is at the downstream end of County Line Flow, an impoundment (fig. 5). The study area is upstream of Rich Lake and is just west of the 60-km^2 Huntington Wildlife Forest (*http://www.esf.edu/aec/facilities/hwf.htm*) in the central Adirondack Mountains. *Site 12* is about 4 km west of the NADP–MDN site NY20, which is at the Huntington Wildlife Forest. Land use/land cover for the Fishing Brook Subbasin upstream of *Site 12*

Figure 4. Fishing Brook above County Line Flow near Long Lake, New York (Site 10 in table 1 and figure 3) (summer). Photograph by Dennis A. Wentz, U.S. Geological Survey.

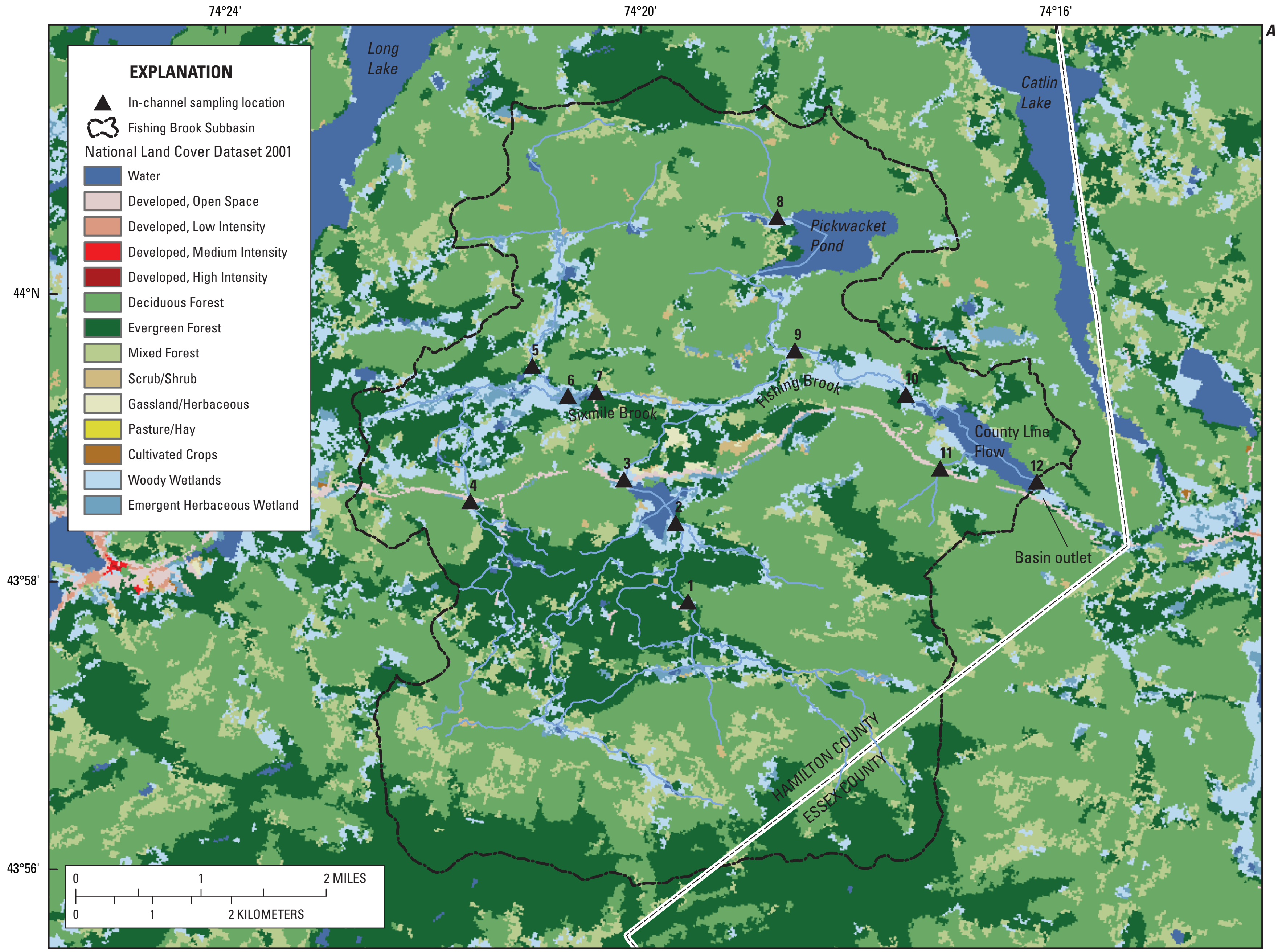
consists primarily (86 percent) of upland forests, with slightly over one-half of the land area as deciduous forest (dominated by northern hardwoods such as sugar maple, American beech, and yellow birch), about one-quarter of the land area as evergreen forest (dominated by red spruce and balsam fir), and the remaining forest area with a mix of evergreen and deciduous trees (figs. 6 and 7, table 5); logging is common. Wetland area is about 9 percent and is largely comprised of a combination of woody vegetation (evergreens, such as spruce, are dominant but with areas of deciduous shrubs, such as speckled alder, *Alnus incana*) and emergent herbaceous vegetation.

During the study period, the mean winter-air temperature was -7.9°C, and the mean summer-air temperature was 17.6°C at the primary Fishing Brook site (*Site 12*; table 4). Annual precipitation at the site during 2005–2009 averaged 1,269 mm/yr, partly as snow. Based on 30-year averages (1971–2000) for the NCDC station at Newcomb, N.Y., conditions were slightly warmer and wetter than average during 2007–09. For the NCDC station data, about 28 percent of the 30-year average annual precipitation (1,077 mm) was snowfall, based on 30-year average precipitation amounts for the winter months (December through March).

Three NADP monitoring sites are located near the Fishing Brook Subbasin, including National Trends Network (NTN) site NY20 (table 3). Major ions and solutes are sampled on a weekly basis at these NTN sites. Site NY20 also has provided data on Hg in precipitation since 1999 as part of the NADP–MDN; it is located at the Huntington Wildlife Forest. During 2005–09, mean total Hg in wet atmospheric deposition was 6.69 $\mu g/m^2/yr$ based on computed values when PRISM-modeled precipitation values were combined with Hg values from NADP–MDN (table 4).

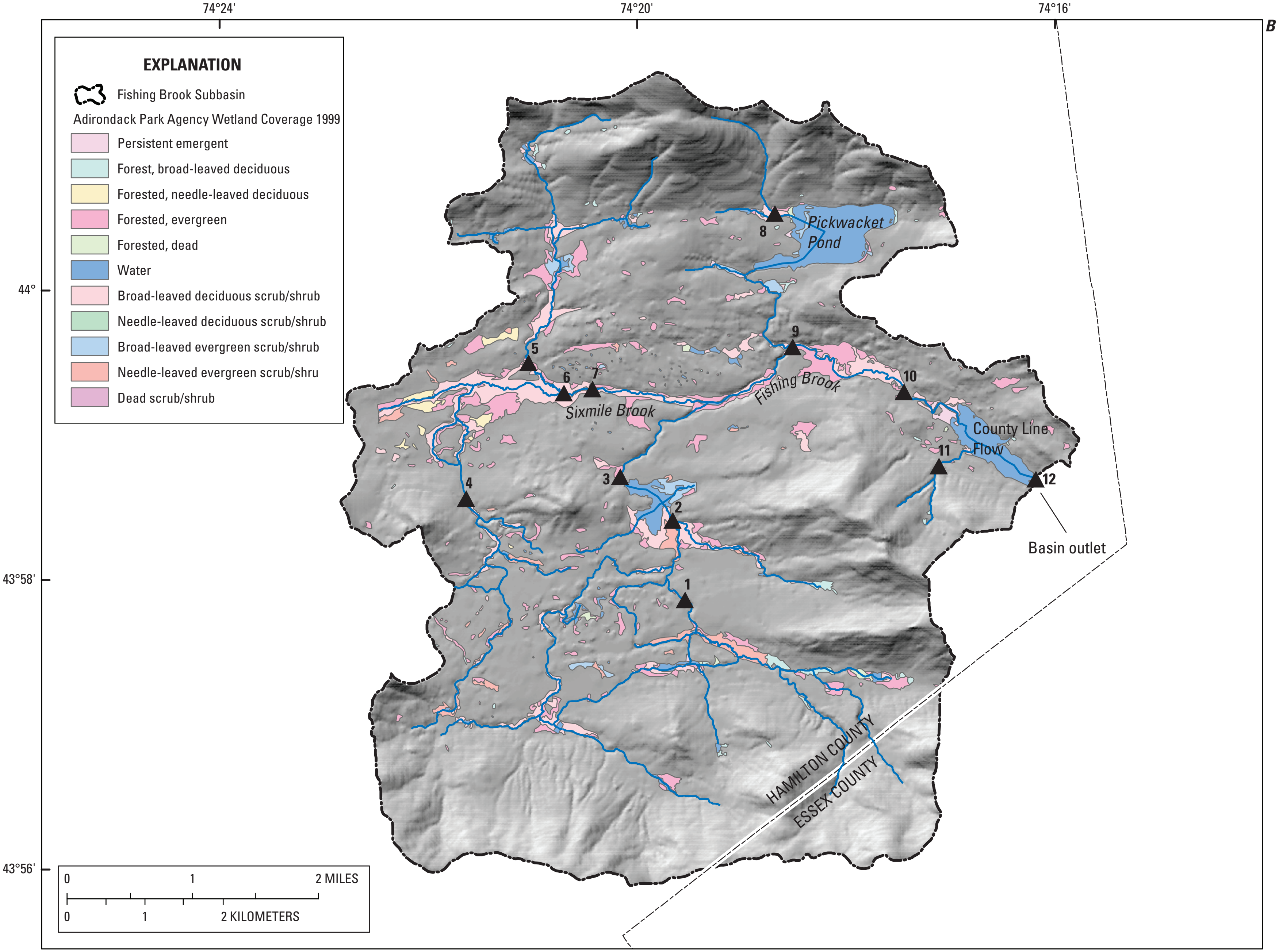
Mean annual streamflow for Fishing Brook (County Line Flow outlet) near Newcomb, N.Y. (*Site 12*) was 58.8 ft^3/s (WYs 2008 and 2009) and ranged from 55.9 ft^3/s in WY 2009 to 61.8 ft^3/s in WY 2008; only a partial streamflow record existed for WY 2007 at this site, so no annual statistics were computed for that year (table 6). Water temperatures ranged from −0.1 to 23.8°C, with a mean annual water temperature of 10.4°C during 2007–2009 (table 7).

Figure 5. Fishing Brook (County Line Flow outlet) near Newcomb, New York (Site 12 in table 1 and figure 3) (summer). Photograph by Dennis A. Wentz, U.S. Geological Survey.



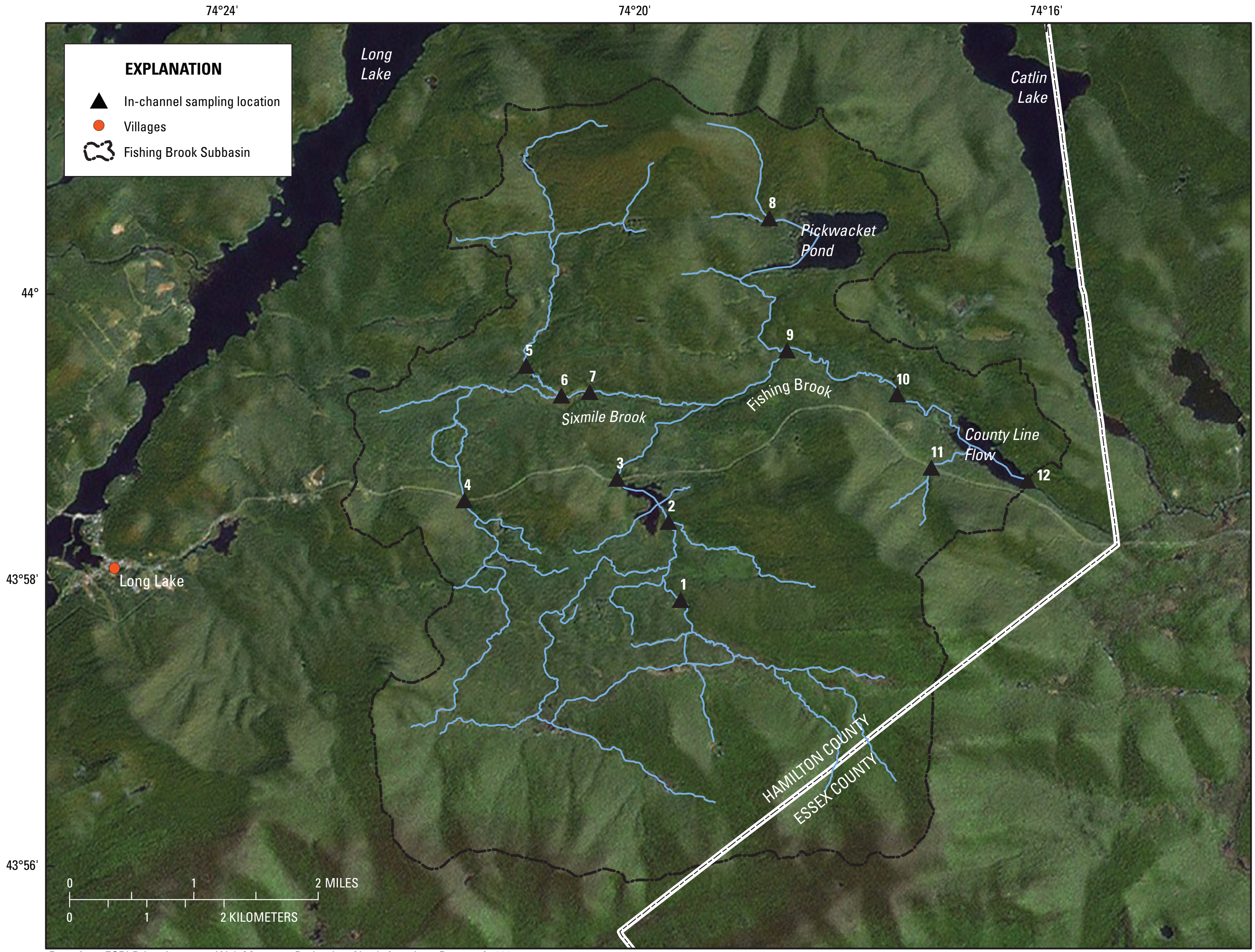
Base from US Geological Survey National Land Cover Dataset 2001. Universe Transverse Mercator projection, Zone 18N, North American Datum of 1983.

Figure 6*A*. Detailed land use/land cover and wetland cover for Fishing Brook Subbasin, New York: land use/land cover, based on National Land Cover Dataset for 2001 (NLCD01) .



Base from US Geological Survey National Elevation Dataset. Universe Transverse Mercator projection, Zone 18N, North American Datum of 1983.

Figure 6*B*. Detailed land use/land cover and wetland cover for Fishing Brook Subbasin, New York: wetland cover, based on New York State Adirondack Park Agency data. Map numbers refer to sites listed in table 1.



Base from ESRI Prime Imagery. Web Mercator Projection, North American Datum of 1983.

Figure 7. Fishing Brook Subbasin, New York, showing sampling locations. Map numbers refer to sites listed in table 1.

The major tributary to Fishing Brook—Sixmile Brook—drains a basin of about 18 km^2 and joins Fishing Brook between *Sites 3* and *10* (figs. 3 and 8*A*). Based on NLCD01 data, wetland percentages for downstream reaches of Sixmile Brook (*Sites 6* and *7*) are about 14 percent, slightly higher than for downstream reaches of Fishing Brook Subbasin near *Site 12* (table 5). The Pickwacket Pond outlet (*Site 9*) is at 505 m elevation and, although it drains a small basin of only 8.4 km^2, more than 11 percent of the basin area is open water and about 5.2 percent is wetland (figs. 3 and 8*B*, Pickwacket Pond Inlet). Its confluence with Fishing Brook is downstream from that of Sixmile Brook. Wetlands of the Sixmile Brook and Pickwacket Pond Subbasins are primarily wooded (evergreen forest and deciduous shrub/scrub dominant (table 5). County Line Flow, Sixmile wetland (formerly a flow), and Fishing Brook Flow were all a result of constructed features for transporting logs during historical logging activity (Jenkins, 2004).

A

B

Figure 8. (*A*) Sixmile Brook near Long Lake, New York (Site 7) (summer), major tributary to Fishing Brook and (*B*) Pickwacket Pond Inlet near Long Lake, N.Y. (Site 9) (summer). Photographs by Douglas A. Burns and Dennis A. Wentz, respectively, U.S. Geological Survey.

Environmental Setting of South Carolina Streams

The South Carolina streams sampled for the 2005–09 NAWQA Hg studies are in the Edisto River Basin, which is part of the larger Santee River Basin (fig. 1, table 1). Reconnaissance sampling (2005–06) was conducted throughout the Edisto River Basin, and intensive sampling (2007–09) focused in the McTier Creek Subbasin. Elevations in the Edisto study basin range from 8.5 m at the most-downstream site on the Edisto River near Givhans (*Site 54*) to 207 m near the town of Ward, S.C. (appendix 2). The McTier Creek sites range in elevation from 96 to 106 m. In contrast with the New York study area, the South Carolina streams are characterized by generally low slopes; the median basin slope is about 5.5 percent.

Land use/land cover for the sample sites ranges from about 21 to 58 percent forested land cover (dominated by evergreens), and about 1 to 21 percent herbaceous upland (table 5, appendix 2). Wetland area (NLCD01) ranges from 6 to 8 percent in the McTier Creek Subbasin (*Site 35*), up to 30 percent at North Fork Edisto River near Branchville, S.C. (*Site 51*), and to about 18 percent at the most-downstream site on the Edisto River near Givhans (*Site 54*). The amount of open water (lakes and ponds, both natural and man-made) is less than 1 or 2 percent and varies little among the subbasins studied in the Edisto River Basin. About 13 to 29 percent of the land in some subbasins is agricultural (row crops of corn, soybeans, and cotton; pasture for hay and cattle), and 4 to 12 percent of the land is developed (urban).

The climate of this area in South Carolina is sub-tropical with relatively mild winters and distinct wet and dry seasons. The wet and dry seasons result in seasonally fluctuating water levels in riparian pools, wetlands, and streams of the area (Bradley and others, 2011). However, it should be noted that a drought of historical significance occurred in South Carolina in 2007 (Feaster and others, 2010). With a frost-free period of about 210 days, the growing season in South Carolina is long relative to the growing season in New York (National Climatic Data Center, 2011b). Warm, humid air masses from the Atlantic Ocean drive most of the climate characteristics. In addition, the Appalachian mountain range has an important influence on the climate because it serves as a barrier to many cold air masses from the northwest, moderating temperatures and affecting the prevailing wind direction. Prevailing winds are generally from the southwest and south in the spring/summer and from the northeast and southwest during the fall/winter (South Carolina State Climatology Office, 2011).

After reconnaissance sampling in 2006, sampling efforts focused in the McTier Creek Subbasin, defined here as that portion upstream of New Holland (*Site 35*) and on the main stem Edisto River near Givhans (*Site 54*; biological sampling for the Edisto River was done upstream of Givhans near Cottageville, *Site 53*). The following sections provide additional detail on the environmental settings of these stream sites.

Edisto River Basin

The Edisto River is one of the longest free-flowing (no dams or levees) blackwater rivers in the United States. It flows over 300 km from its headwaters to its mouth at the Atlantic Ocean and lies within the Southeastern Plains and Middle Atlantic Coastal Plain Level III ecoregions (Omernik, 1987; Griffith and others, 2002; U.S. Environmental Protection Agency, 2005). The Edisto is called a “blackwater” stream because of its clear and dark, amber-colored water resulting from plant tannins leaching out of abundant cypress forests or wetlands (fig. 9). Although the Edisto River Basin lies mainly within the Coastal Plain physiographic province of South Carolina, the uppermost portion of the basin lies in the Piedmont physiographic province.

The Edisto River has a North Fork and a South Fork, and the McTier Creek Basin is the headwaters tributary to the South Fork of the Edisto River. The Edisto River near Givhans (*Site 54*), in Dorchester County, is downstream of the confluence of the two river forks. At this point, it drains 7,071 km^2 and lies at an elevation of only 8.5 m above sea level (table 1). Land use/land cover (table 5, fig. 10) for *Site 54* is about 36 percent forested, mostly as evergreen forest that is used partly for silviculture in the McTier Creek Subbasin, and about 18 percent wetland (based on NLCD01), mostly as woody wetland dominated by bald cypress (*Taxodium distichum*) and swamp tupelo (*Nyssa biflora*). Four Holes Swamp (*Site 52*) is a major tributary of the Edisto River.

Data for mean air temperatures, precipitation, and mean total Hg in wet atmospheric deposition were not measured directly but are assumed to be similar to those measured or derived for the headwaters site at McTier Creek near New Holland (*Site 35*) using data from the nearby NCDC and NADP–MDN sites (table 4).

The hydrology of the Edisto River Basin is characterized by groundwater-flood events, which tend to promote upward transport of MeHg from wetland and floodplain sediment to the water column, thereby enhancing the bioavailability of Hg to stream organisms (Bradley and others, 2009, 2010; Feaster and others, 2010). Mean annual streamflow for the period of record (WYs 1939–2010) at the Edisto River near Givhans (*Site 54*) was 2,478 ft^3/s; mean annual streamflow during water years 2005–2007 ranged from a low of 929 ft^3/s in WY 2007 to a high of 1,765 ft^3/s in WY 2005 (table 6). During the study period, mean water temperatures for *Site 54* ranged from 7.1 to 28.9°C, with an annual mean of 21.1°C (table 7).

Figure 9. Photograph of Edisto River Basin near Givhans, South Carolina (Site 54 in table 1 and figure 10) (winter). Photograph by Celeste A. Journey, U.S. Geological Survey.

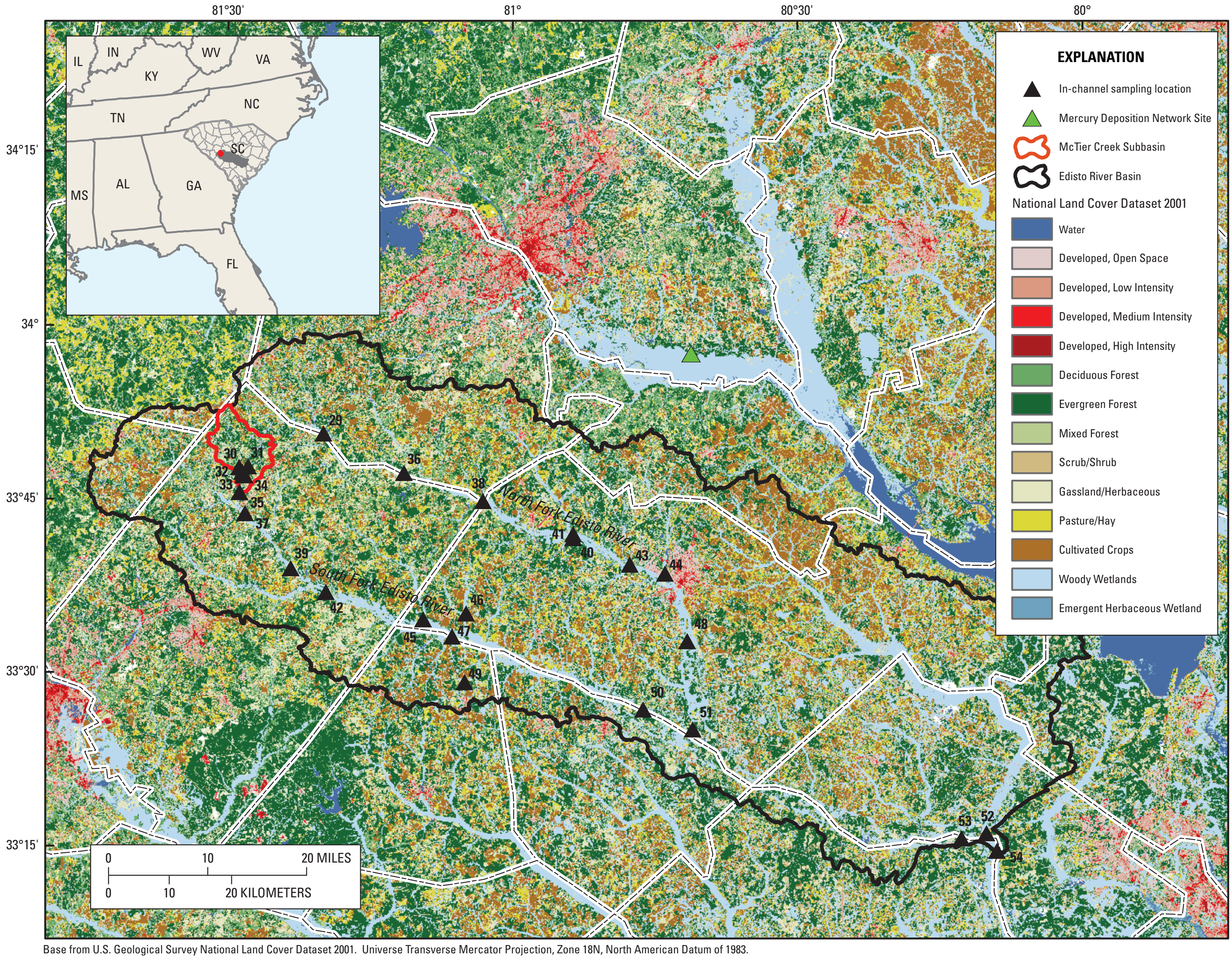
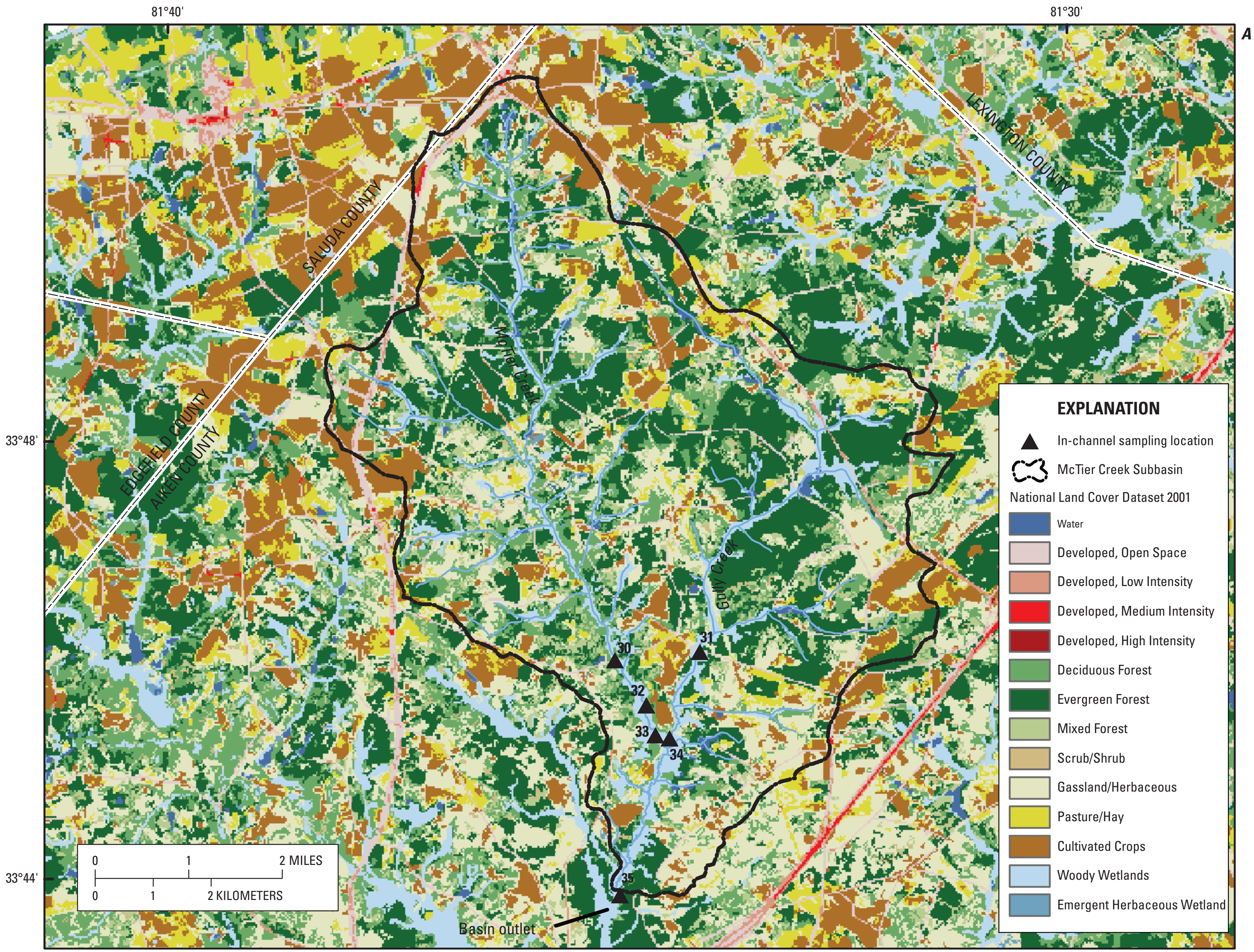


Figure 10. Map of detailed land use/land cover for Edisto River Basin near Givhans, South Carolina, with nested outline of McTier Creek Subbasin. Map numbers refer to sites listed in table 1.

McTier Creek Subbasin

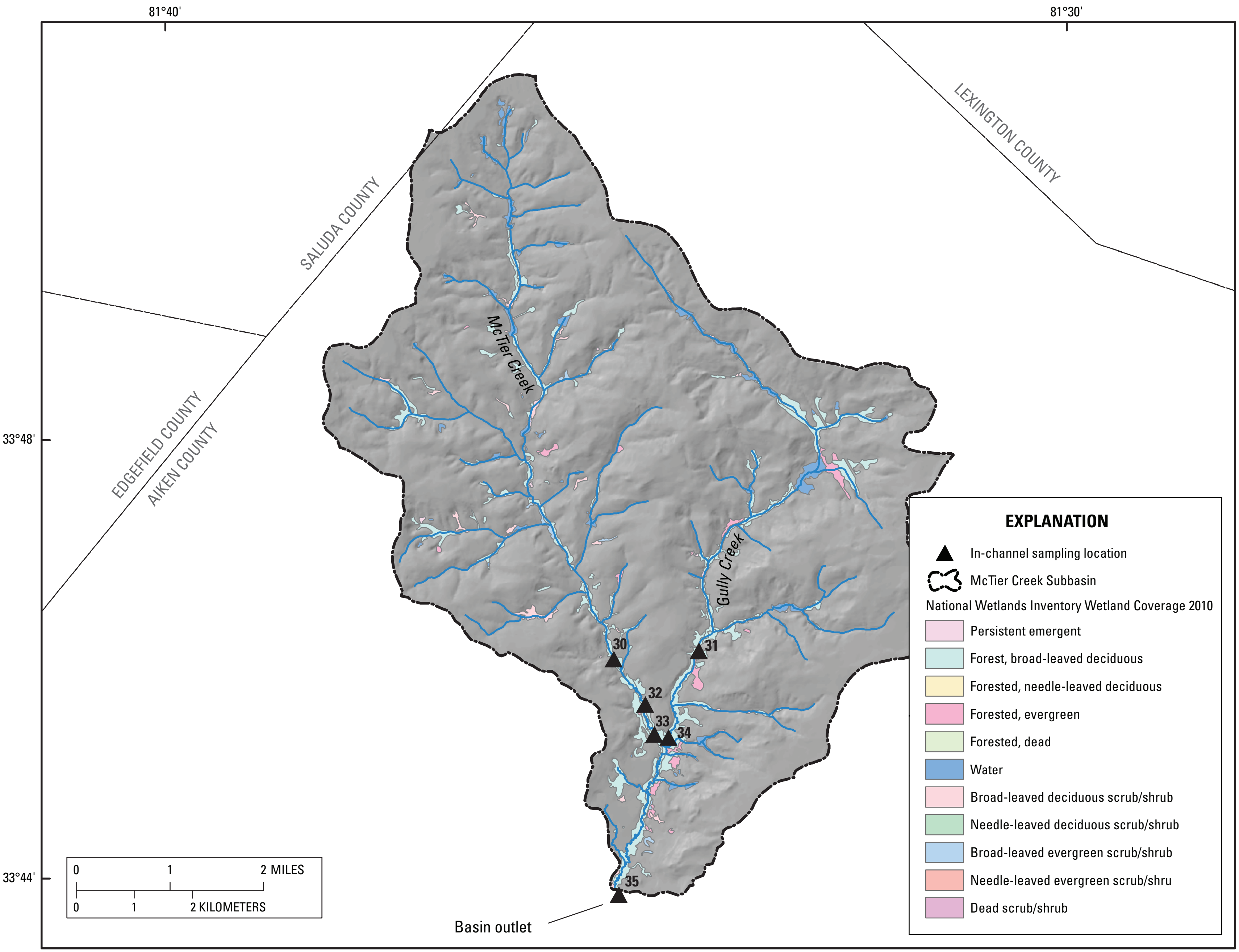
McTier Creek lies in a small subbasin of the Edisto River Basin and is in Aiken County, S.C. (figs. 3 and 11, table 1). The most-downstream site studied drains 79.4 km^2 and is near New Holland (*Site 35*), close to its confluence with the South Fork of the Edisto River. *Site 35* is about 77 km from NADP–MDN site SC19. The creek lies within the Sand Hills area of the Coastal Plain (Griffith and others, 2002). The upper reaches of the McTier Creek Subbasin near Monetta (*Site 30*) are near the Fall Line, the boundary between the Piedmont and Southeastern Plains ecoregions (also Piedmont and Coastal Plain Physiographic Provinces), and the stream transitions from characteristics similar to Piedmont streams (high gradient with rock substrate) in the headwaters to characteristics similar to Coastal Plain streams (low gradient with sandy substrate) (Feaster and others, 2010; Omernik, 1987; U.S. Environmental Protection Agency, 2005). The lower reaches of the McTier Creek Subbasin near New Holland (*Site 35*) exhibit lowland characteristics of the Southeastern Plains ecoregion (Feaster and others, 2010; Omernik, 1987; U.S. Environmental Protection Agency, 2005). Land use/land cover (NLCD01) for the McTier Creek drainage is about 50 percent upland forests, mostly evergreens such as loblolly pine (*Pinus taeda,* as silviculture) or longleaf pine (*Pinus palustris*) with some deciduous trees (turkey oak [*Quercus cerris*]), and 21 percent herbaceous upland (figs. 12 and 13, table 5). Agricultural land accounts for about 15 percent of the basin area. Wetland makes up about 7 percent of the total basin area at *Site 30* and about 8 percent at *Site 35*, which is slightly less than that for Fishing Brook near Newcomb, N.Y. (*Site 12*), with about 9 percent. Similar to the NY study basins, wetlands in the South Carolina basins are dominated by woody vegetation. Woody vegetation in the McTier Creek Subbasin is dominated by broad-leaved deciduous trees, such as red maple (*Acer rubrum*), mixed oaks (*Quercus* spp.), holly (*Ilex opaca and I. vomitoria*), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), black or sour gum (*Nyssa sylvatica*), and swamp tupelo (*Nyssa biflora*).

Figure 11. McTier Creek near Monetta, South Carolina (Site 30 in table 1 and figure 10) (summer). Photograph by Paul M. Bradley, U.S. Geological Survey.



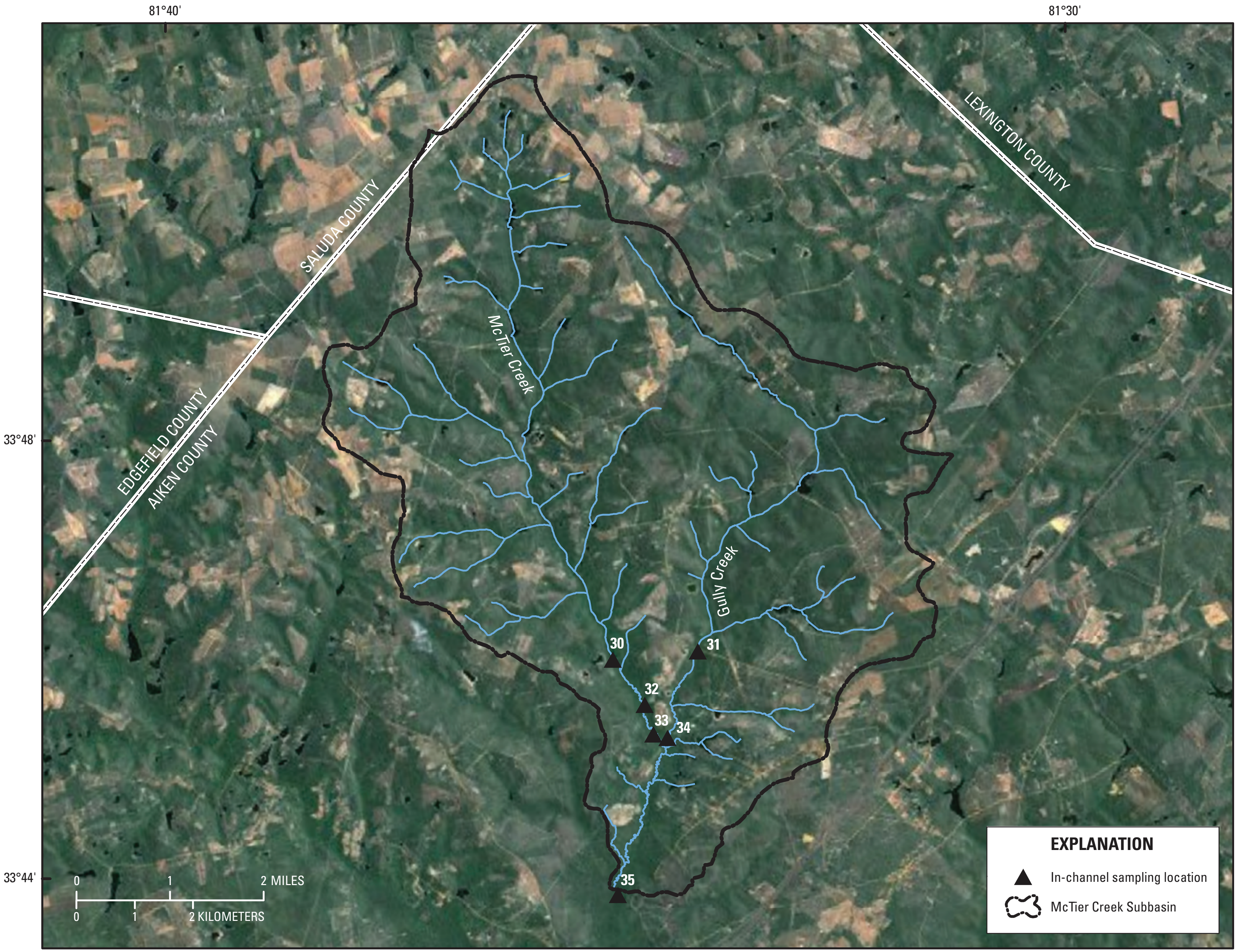
Base from U.S. Geological Survey National Land Cover Dataset for 2001. Universe Transverse Mercator Projection, Zone 18N, North American Datum of 1983.

Figure 12*A*. Detailed land use/land cover and wetland cover for McTier Creek Subbasin: land use/land cover, based on National Land Cover Dataset for 2001. Map numbers refer to sites listed in table 1.



Base from U.S. Geological Survey National Elevation Dataset. Universe Transverse Mercator Projection, Zone 18N, North American Datum of 1983.

Figure 12*B*. Detailed land use/land cover and wetland cover for McTier Creek Subbasin: wetland cover, based on U.S. Fish and Wildlife Service National Wetlands Inventory. Map numbers refer to sites listed in table 1.



Base from ESRI Prime Imagery. Web Mercator Projection, North American Datum of 1983.

Figure 13. McTier Creek Subbasin, South Carolina, showing sampling locations. Map numbers refer to sites listed in table 1.

During the study period for the primary sampling site at McTier Creek near New Holland (*Site 35*), the mean winter-air temperature was 9.1°C and the mean summer-air temperature was 26.8°C. Mean annual precipitation during 2005–2009 averaged 1,134 mm/yr, with no snow (table 4); however, as mentioned earlier, 2007 was an historic drought year for the area.

For estimating atmospheric Hg deposition, NADP–MDN site SC19 is in the nearby Congaree National Park and is the closest NADP–MDN site to the McTier Creek Subbasin; the other nearest NADP site is NTN site SC06, which monitors concentrations of acids, base cations, and nutrients but not Hg, and is in the Santee National Wildlife Refuge (tables 2 and 4). Mean total Hg, precipitation-weighted, in wet atmospheric deposition was 10.2 µg/m^2/yr, which is larger than the value of 6.69 µg/m^2/yr for Fishing Brook in New York. This does not consider dry atmospheric deposition, which can be significant in both study areas (Miller and others, 2005; Sakata and others, 2006; Choi and others, 2008; Risch and others, 2011).

In contrast with the free-flowing Edisto River, there are at least a dozen small (less than 2 ha), man-made impoundments along McTier Creek upstream of the Monetta site. Mean annual streamflow was 16.4 ft^3/s (WYs 2007–09) for McTier Creek near New Holland (table 6). McTier Creek near New Holland, S.C. (*Site 35*), had mean annual streamflows of 19.2 ft^3/s in WY 2008 and 26.4 ft^3/s in WY 2009. As with Fishing Brook, only partial streamflow record existed for 2007, so no annual statistics were computed for that year. During 2007–09, daily mean water temperatures ranged from 3.0 to 25.7°C, with a mean annual water temperature of 17.5°C (table 7). Mean annual water temperature and range were similar at McTier Creek near Monetta, S.C. (*Site 30*, table 7).

The major tributary to McTier Creek is Gully Creek, which has shallow ponds from beaver activity (fig. 14). Gully Creek drains a basin of about 30 km^2 and joins McTier Creek about 2 km downstream of the Monetta site.

Figure 14. Gully Creek at Bridge on Shoals Road near Monetta, South Carolina, major tributary to McTier Creek (Site 31) (fall). Photograph by Celeste A. Journey, U.S. Geological Survey.

Summary

Mercury (Hg) bioaccumulation in streams draining contrasting environmental settings across the United States is the focus of studies by the U.S. Geological Survey (USGS). This report describes environmental settings of stream sites that were investigated with regard to Hg cycling and bioaccumulation: Upper Hudson River Basin in New York and its headwater subbasin, Fishing Brook; and Edisto River Basin in South Carolina and its headwater subbasin, McTier Creek. Atmospheric deposition is the dominant Hg source. Biota, sediment, and water were sampled for Hg and additional physical and chemical characteristics thought to be important to Hg cycling and bioaccumulation. The primary sampling areas were Fishing Brook and McTier Creek Subbasins. The Fishing Brook sites are in the mountainous Adirondack region of New York where the climate is temperate continental, and the McTier Creek sites are in the lowland Coastal Plain region of South Carolina where the climate is sub-tropical. Land use/land cover in both is mostly rural, with higher percentages of forested upland in Fishing Brook Subbasin when compared to McTier Creek Subbasin. The percentage of wetland in Fishing Brook Subbasin was fairly similar to that of McTier Creek Subbasin; most wetland in both basins was wooded wetland. An important difference in the environmental settings of the two basins is the heterogeneity of Fishing Brook Subbasin in terms of landscape characteristics, such as slope and amounts of wetland and open water, in contrast to the much more homogeneous landscape characteristics of McTier Creek Subbasin. The USGS studies are designed to evaluate environmental characteristics that affect Hg bioaccumulation in these two Hg-sensitive ecosystems.

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Appendix 1. Detailed Geographic Information System data for selected streams sampled in New York for U.S. Geological Survey mercury studies, 2005–09.

Appendix1.xlsx (Excel 68KB) is available on the HTML page in Excel format.

Appendix 2. Detailed Geographic Information System Data for Selected Streams Sampled in South Carolina for U.S. Geological Survey Mercury Studies, 2005–09.

Appendix2.xlsx (Excel 48KB) is available on the HTML page in Excel format.

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