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Prepared in cooperation with the U.S. Marine Corps, Quantico, Virginia

The Quality of Water and Bottom Material in Lunga Reservoir, Virginia, September 2004 through August 2005

Open-File Report 2007–1053

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

Cover. **Lunga Reservoir, Quantico, Virginia**.

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Contents

Illustrations

Tables

Appendixes

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

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

$$°C = (°F - 32) / 1.8$$

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

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).

Concentrations of chemical constituents in sediment are given either in micrograms per gram (µg/g) or micrograms per kilogram (µg/kg).

Acronyms and Abbreviations:

DEQ	Department of Environmental Quality
DOC	dissolved organic carbon
MRL	method reporting limit
N	normality
NAVD 88	North American Vertical Datum of 1988
NREA	Natural Resources and Environmental Affairs Branch, USMC
NTU	nephelometric turbidity units
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
SWCB	State Water Control Board
TOC	total organic carbon
TSI	trophic state index
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
VA WSC	Virginia Water Science Center

col/100 mL	colonies per 100 milliliters
L	liter
mg/L	milligram per liter
mL	milliliter
mm	millimeter
µg/g	microgram per gram
µg/kg	microgram per kilogram
µg/L	microgram per liter
µm	micrometer
<	less than

The Quality of Water and Bottom Material in Lunga Reservoir, Virginia, September 2004 through August 2005

By R. Russell Lotspeich

Abstract

Lunga Reservoir is on the U.S. Marine Corps Base in Quantico, which is in the Potomac River basin and the Piedmont Physiographic Province of northern Virginia. Because of the potential use of the reservoir for scuba-diver training and public water supply in addition to current recreational activities, the U.S. Marine Corps wanted to know more about the water quality of Lunga Reservoir and how it compared to Virginia Department of Environmental Quality and Virginia State Water Control Board ambient water-quality standards.

Water samples and physical properties were collected by the U.S. Geological Survey at 6 locations throughout Lunga Reservoir, and physical properties were collected at 11 additional locations in the reservoir from September 2004 through August 2005. Water samples for analysis of pesticides and bottom-material trace elements were collected once during the study at four of the sampling locations.

Water temperature, dissolved-oxygen concentration, specific conductance, pH, and total chlorophyll concentration in Lunga Reservoir all had similar seasonal and spatial variations as in other lakes and reservoirs in this geographic region—thermal gradient in the summer and fall and isothermal conditions in the winter and early spring. Concentrations of water-quality indicators in Lunga Reservoir were within comparable levels of those in other reservoirs and did not violate the Virginia State Water Control Board standards for public water supplies.

Water temperatures throughout Lunga Reservoir during the study period ranged from 4.4 to 30.1 degrees Celsius, well below the State Water Control Board maximum water temperature criteria of 32 degrees Celsius. Dissolved-oxygen concentrations ranged from 0.05 to 14.1 milligrams per liter throughout the reservoir during the study period, but never fell below the State Water Control Board minimum dissolved-oxygen criterion of 4.0 milligrams per liter at the surface of Lunga Reservoir. Specific conductance throughout Lunga Reservoir ranged from 29 to 173 microsiemens per centimeter at 25 degrees Celsius during the study period, with a mean specific conductance of 68 microsiemens per centimeter at 25 degrees Celsius. Measurements of pH throughout the reservoir ranged from 4.8 to 7.6 standard units.

Concentrations of chemical constituents analyzed in Lunga Reservoir samples were below any State Water Control Board criteria and generally were similar in concentration to the same chemical constituents in other reservoirs in the State. Four water samples were analyzed for 54 pesticides, and none of these pesticides were above the laboratory minimum reporting level.

Introduction

Lunga Reservoir is located on the U.S. Marine Corps (USMC) Base at Quantico in the Potomac River basin and the Piedmont Physiographic Province of northern Virginia (fig. 1). The reservoir is formed by an earthen dam with a spillway elevation of 288 feet (ft) above North American Vertical Datum of 1988 (NAVD 88) at the confluence of Flat Run and Beaverdam Run.

Lunga Reservoir was built in the mid-1950s to serve Camp Barrett on the USMC Base, Quantico, and is used mainly for recreational purposes, such as fishing, swimming, and canoeing. The Virginia Department of Game and Inland Fisheries and the USMC Natural Resources and Environmental Affairs (NREA) Branch cooperatively manage Lunga Reservoir. Infrastructure is present that allows Lunga Reservoir to serve as an emergency water supply for Breckenridge Reservoir, which provides water to the Base. Because of the potential for the reservoir to be used for scuba-diver training and public water supply as well as the current recreational activities, the USMC requested that the U.S. Geological Survey (USGS) monitor the water quality of Lunga Reservoir and compare the observed water quality with the ambient water-quality standards of the Virginia Department of Environmental Quality (DEQ) and Virginia State Water Control Board (SWCB). The USGS Virginia Water Science Center (VA WSC) conducted the 12-month study from September 2004 through August 2005.

Lunga Reservoir is listed as a Class III waterway (Commonwealth of Virginia State Water Control Board,

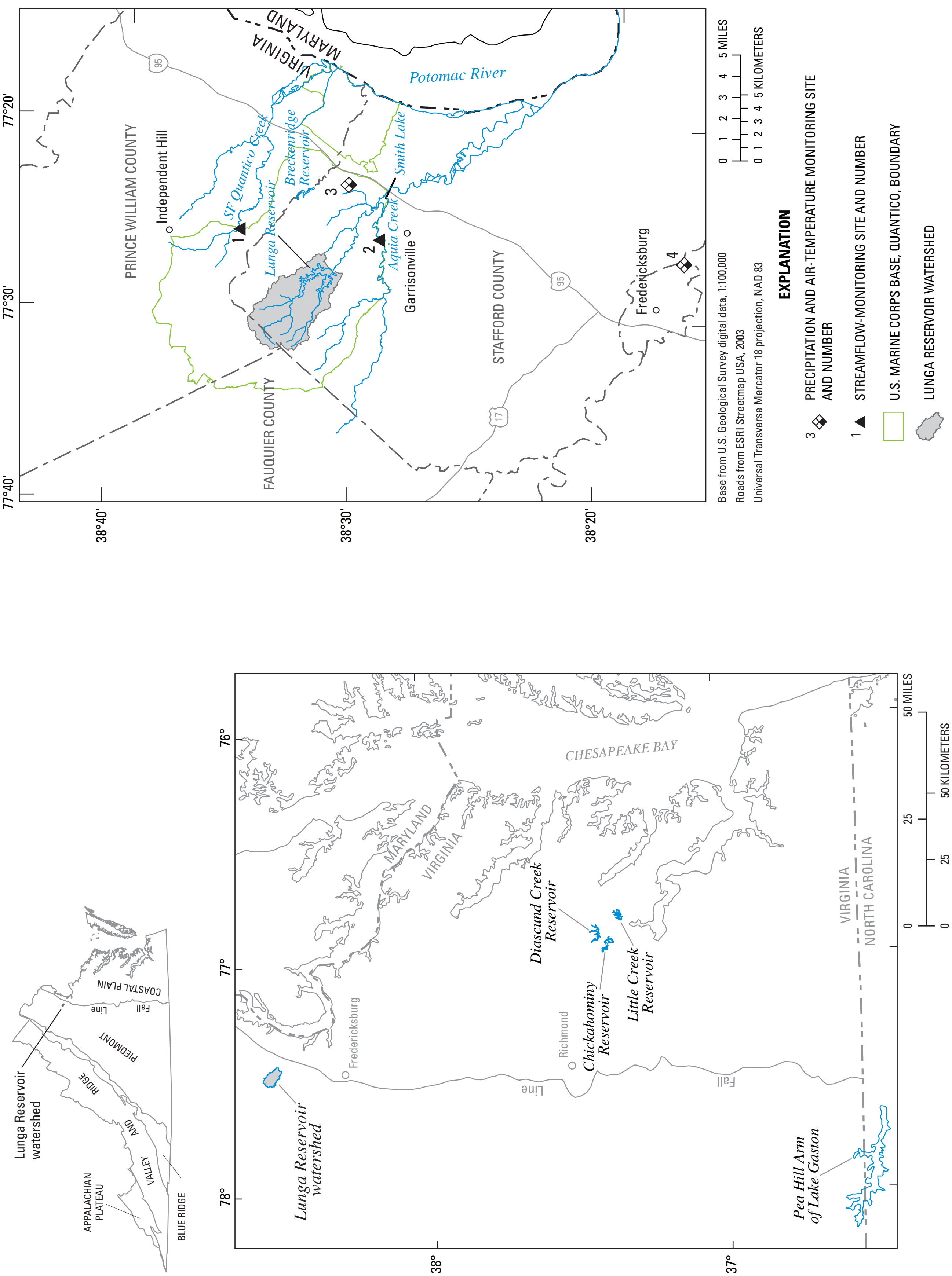


Figure 1. Location of study area, reference locations, and streamflow and climatological sites near Lunga Reservoir, Virginia.

2006a). Although the Virginia SWCB has published criteria for dissolved-oxygen concentrations, pH, and maximum temperature for Class III waterways, criteria specific to waters with naturally low dissolved-oxygen concentrations resulting from temperature gradient and depth have not been published. In addition, many of the published criteria for public water supplies do not directly apply to Lunga Reservoir because the SWCB criteria are for streams that have constantly moving water and transport greater suspended material than a reservoir or lake. The SWCB is developing criteria for lake and reservoir environments that will address the regular seasonal transitions that occur in these systems, and the data contained in this report can be compared to the new standards when they are published.

When no SWCB standards were available, data were compared with data collected from four other manmade reservoirs in the State (fig. 1). The Pea Hill Arm of Lake Gaston in the Piedmont Physiographic Province was monitored by the USGS between 1988 and 1990 (Woodside, 1994). Chickahominy, Diascund Creek, and Little Creek Reservoirs, located mainly in the Coastal Plain Physiographic Province with some of the Chickahominy Reservoir lying in the Piedmont, were monitored between 1983 and 1986 (Lynch, 1992). These reservoirs serve the residents of southeastern Virginia as water-supply sources. While three of the reservoirs are located in a different physiographic province and the Chickahominy Reservoir encompasses a much larger drainage area than Lunga Reservoir, these four reservoirs are similar to Lunga Reservoir in other physical characteristics (table 1).

Table 1. Physical characteristics of Lunga, Pea Hill Arm of Lake Gaston, Chickahominy, Diascund Creek, and Little Creek Reservoirs. (Location of reservoirs are shown in figure 1)

Reservoir	Total drainage area, in square miles	Reservoir surface area, in square miles	Maximum depth, in feet	Volume, in millions of gallons
Lunga Reservoir	10.8	0.66	40	1,700
Pea Hill Arm of Lake Gaston[a]	27.1	2.2	50	8,400
Chickahominy Reservoir[b]	305	1.70	18	1,900
Diascund Creek Reservoir[b]	43.6	2.01	24	3,900
Little Creek Reservoir[b]	4.50	1.48	58	7,480

[a] Woodside, 1994. [b] Lynch, 1992.

Purpose and Scope

This report documents water-quality data collected at 11 sites throughout Lunga Reservoir from September 2004 through August 2005. The sampling sites were selected to generate a broad picture of the overall quality of water and health of the reservoir. The water-quality results are compared to concentrations that affect human, biological, and aquatic species and to available SWCB standards. No samples were collected during January 2005 because the surface of the reservoir was frozen for most of the month. The analytical results of monthly sampling for physical, chemical, and biological constituents as well as bottom-material trace elements are summarized herein.

Description of Study Area

Lunga Reservoir is formed by an earthen dam, has a volume of 1.7 billion gallons, and covers approximately 420 acres. Inundated sections of Beaverdam Run to the north and Flat Run to the southwest form the two arms of Lunga Reservoir (fig. 1). Water from the reservoir spills into Beaverdam Run and continues downstream for 3.4 miles (mi) where it enters Smith Lake in Stafford County (fig. 1). The maximum depth of Lunga Reservoir is approximately 40 ft, although much of the reservoir has depths greater than 20 ft. The upper portions of both arms of Lunga Reservoir are much shallower, with maximum depths ranging from 4 to 6 ft. The hydraulic retention time of Lunga Reservoir averages 285 days based on an average runoff rate of 12 inches per year (in/yr) from the watershed.

The watershed has a drainage area of 10.8 square miles (mi^2; tables 1, 2). The area surrounding Lunga Reservoir is about 85 percent forested and less than 3 percent urbanized (fig. 2; table 2). A visitors' center near the dam rents canoes and small powered boats. The USMC conducts military operations that include the use of heavy artillery on a regular basis in the upper part of the watershed.

Table 2. Watershed land use in the Lunga Reservoir, Virginia.

[mi^2, square mile. Land-use data from Goetz and others, 2004]

Land-use classification	Total area (mi^2)	Percentage of watershed
Forest	9.2	84.6
Wetlands	.7	6.3
Open water	.4	4.1
Urban/developed	.3	2.8
Barren land	.1	1.1
Grassland	.1	1.1
Total	10.8	100

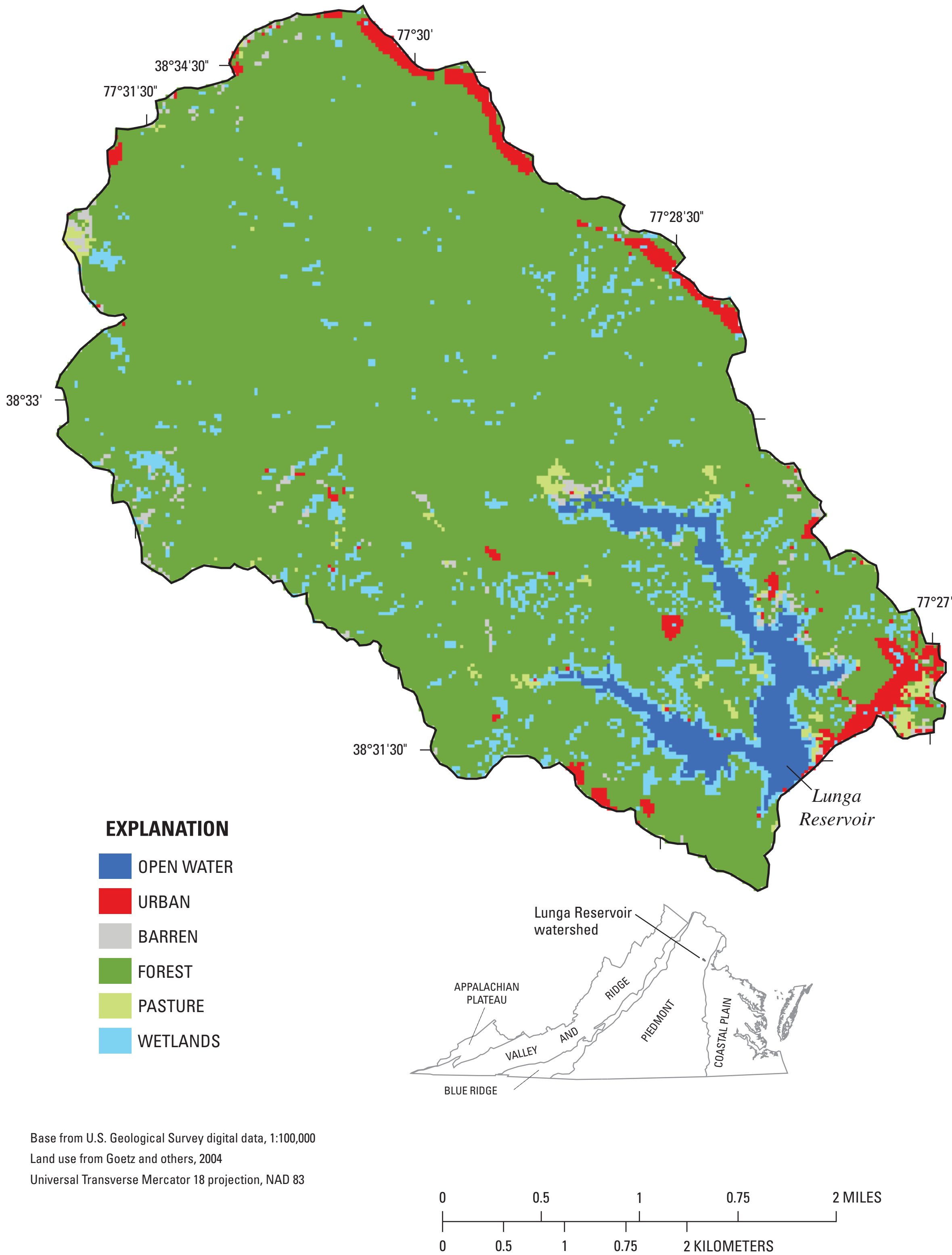


Figure 2. Land use in the Lunga Reservoir watershed, Virginia, 2000.

Historical Climatological and Streamflow Data in the Study Area

Based on historical climatological data provided by the USMC Quantico (Jeff Gardner, U.S. Marine Corps Quantico, written commun., 2005), the climatic year was divided into four seasons: fall (October–November), winter (December–March), spring (April–May), and summer (June–September, fig. 3). This seasonal division was determined by using average monthly mean air temperatures from 1998 to 2005 recorded at the meteorological station on the Base (fig. 1).

Historical streamflow data from two nearby USGS streamflow gages (fig. 1) on South Fork Quantico Creek near Independent Hill, VA (01668500), and on Aquia Creek near Garrisonville, VA (01660400), were used to compare streamflow during the study period to streamflow for the period of record (fig. 4). The time period shown in figure 4 is referred to as a "water year," which for water year 2005 was from October 1, 2004, to September 30, 2005. No streamflow data were collected on the two inflows into the reservoir, but these two sites are indicative of streamflow within the Lunga Reservoir drainage basin. Streamflows for these sites were near the mean monthly discharge throughout the study. Precipitation data collected at two locations near Lunga Reservoir (fig. 1) during the study indicate that annual precipitation in 2005 was less than in 2004 and was below the long-term average at both sites (table 3).

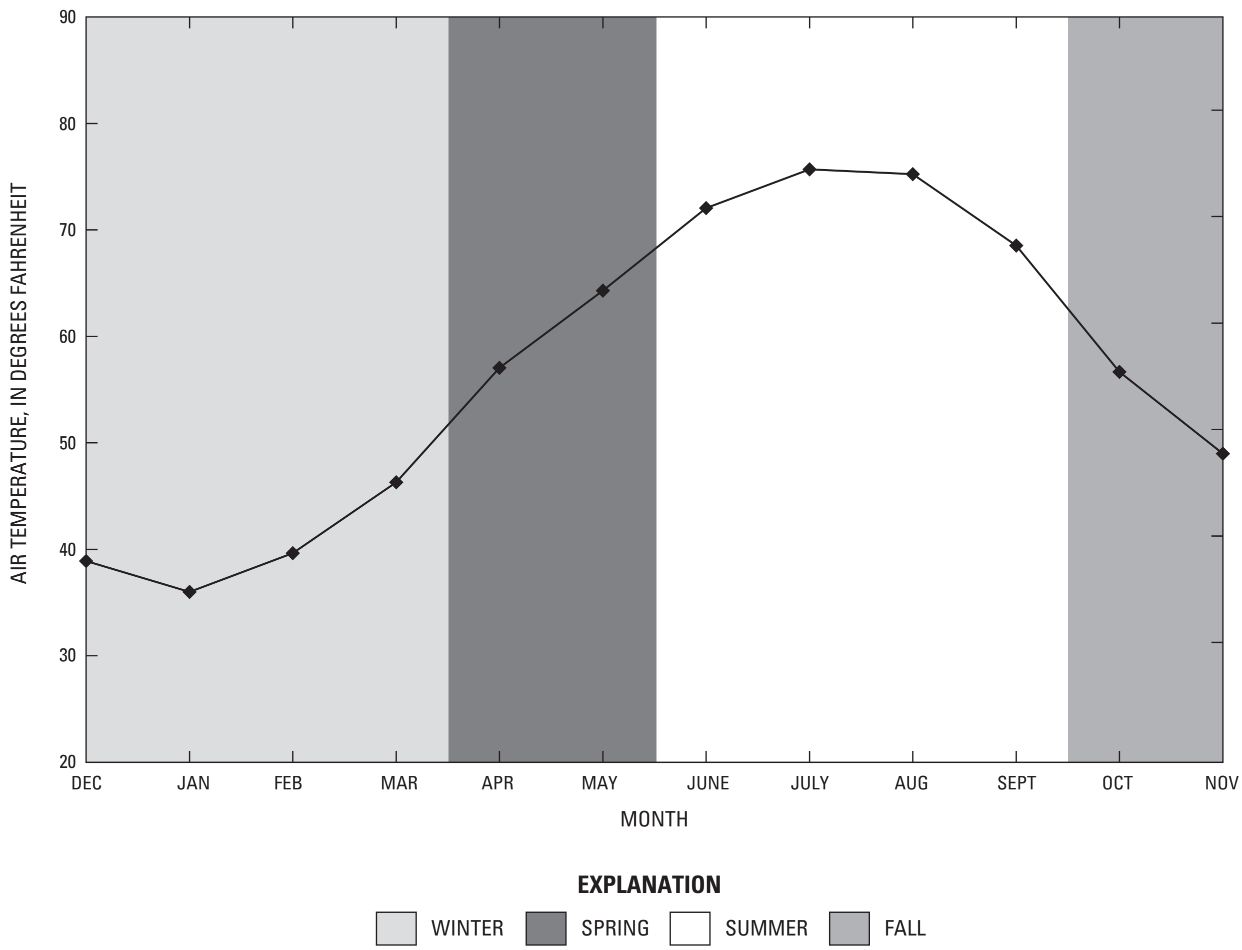


Figure 3. Seasonal changes in mean monthly air temperature near Lunga Reservoir, Virginia, 1998–2005. (Air temperature data were provided by the U.S. Marine Corps, Quantico, Virginia.)

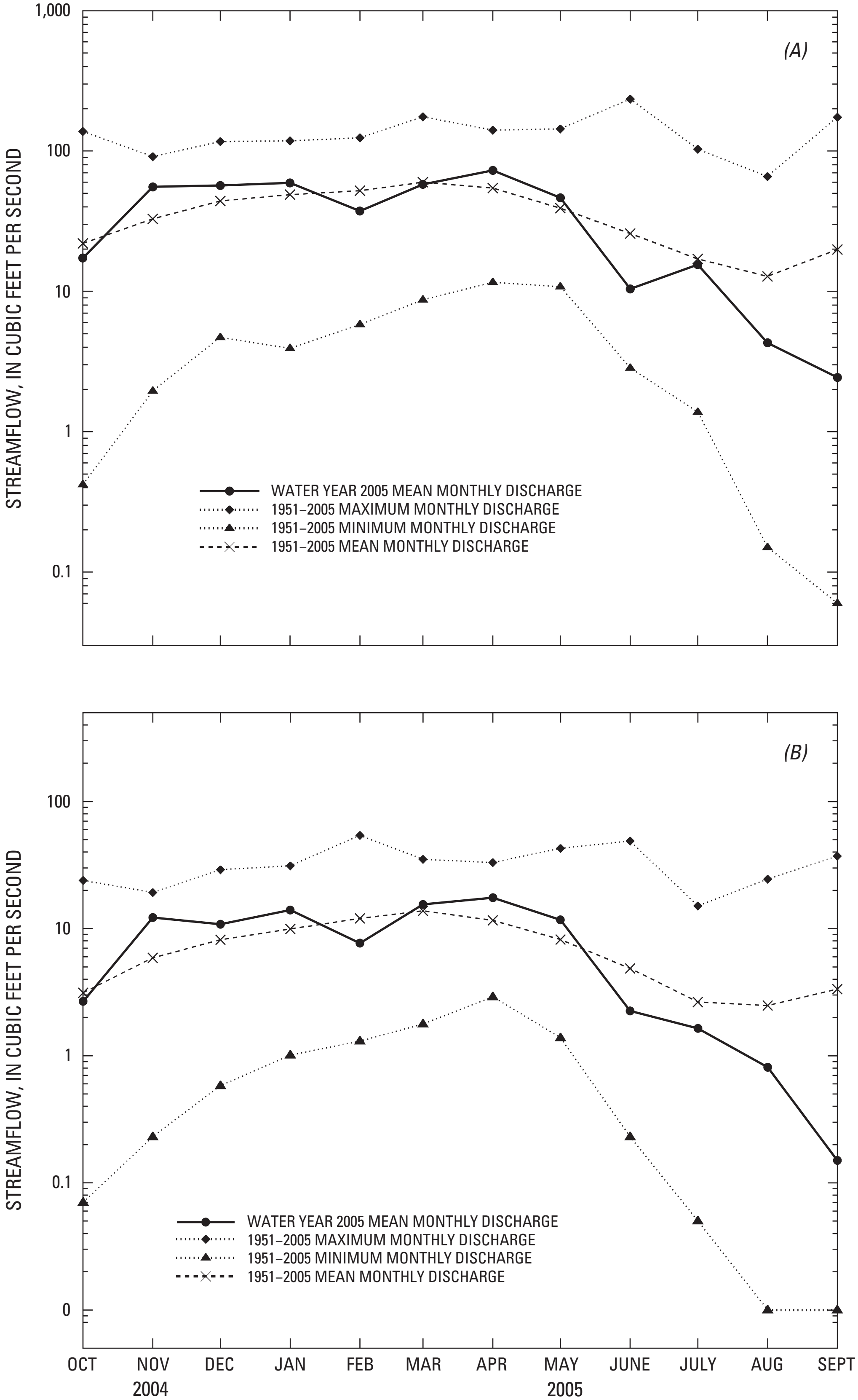


Figure 4. Mean monthly discharge in water year 2005 and minimum, maximum, and mean monthly discharges for the period of record at *(A)* Aquia Creek near Garrisonville, Virginia, and *(B)* South Fork Quantico Creek near Independent Hill, Virginia.

Table 3. Precipitation summary for selected sites near Lunga Reservoir, Virginia.

[USMC, U.S. Marine Corps; NREA, Natural Resources and Environmental Affairs Branch]

Site number (fig. 1)	Site name and identification number	Annual precipitation, in inches		Average annual precipitation, in inches (period of record)
		2004	2005	
3	USMC Quantico NREA Office	39.47	34.02	42.27 (1998–2005)
4	Fredericksburg Sewage at Fredericksburg, VA (443204)	41.80	37.64	41.07 (1995–2005)

Sample Collection and Analysis

Site selection and sample collection were accomplished through a cooperative effort between the USMC and USGS. Laboratory analyses were conducted at the USGS National Water Quality Laboratory (NWQL) in Denver, CO, and the USGS Kentucky Sediment Laboratory in Louisville, KY. Bacteria sample processing and analysis were conducted by the USGS Virginia Water Science Center. Water samples were collected at a depth of 1.0 ft, which is consistent with sampling protocols of the Virginia DEQ.

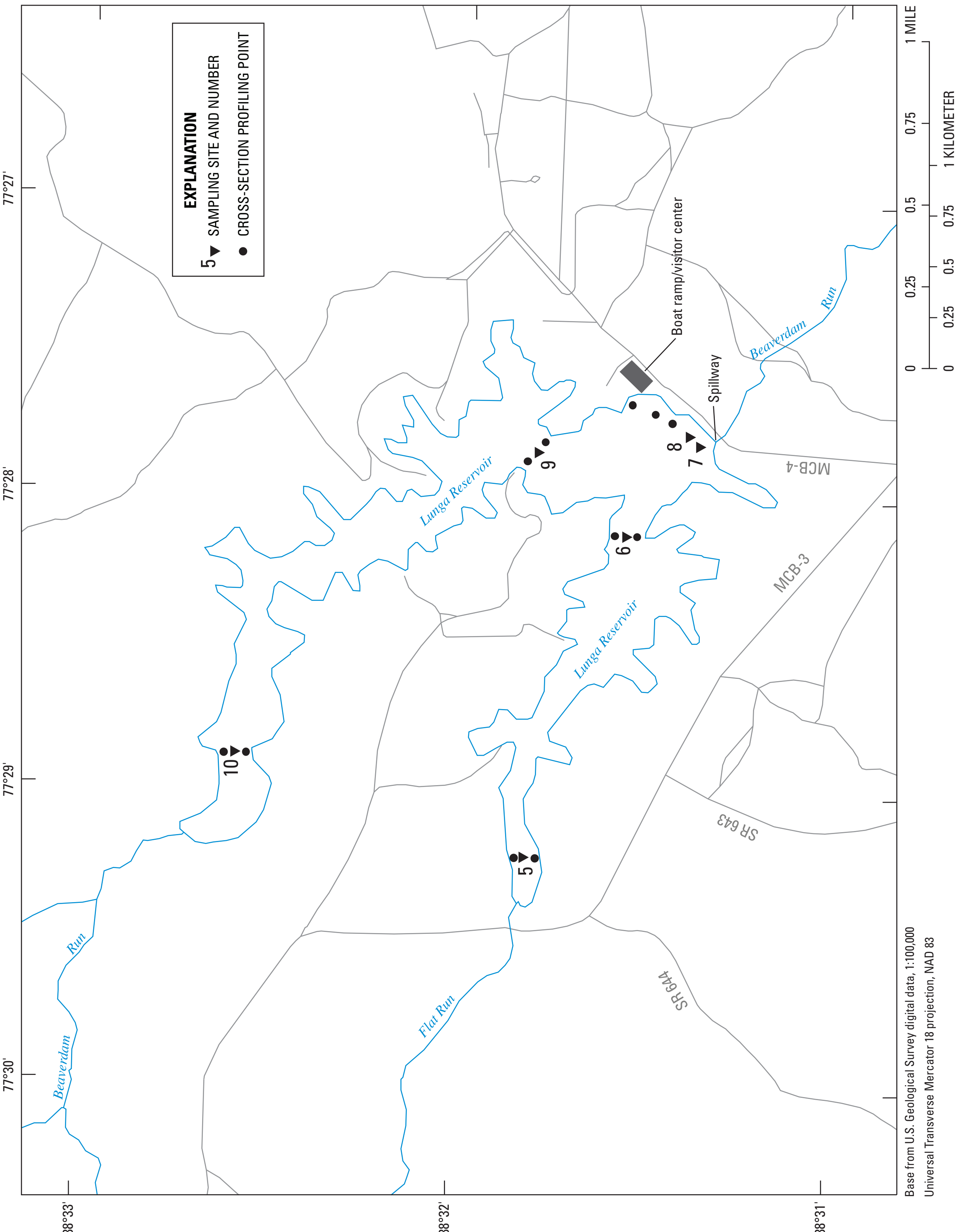
Six sampling sites were selected in Lunga Reservoir (fig. 5; table 4), and 11 additional sites were located throughout the reservoir as cross-section profiling points for physical properties at each sampling site. To assess the effects of the two streams (Beaverdam Run and Flat Run) flowing into the reservoir, one sampling site was selected in the upper part of each arm of the reservoir just downstream from the uppermost inundation caused by the dam (fig. 5, sites 5 and 10). One sampling site was selected in the lower part of each arm just above the confluence of Flat Run and Beaverdam Run (fig. 5, sites 6 and 9). These four sites were located near the middle of the channel where the reservoir depth was greatest. Two cross-section profiling points were located near each of the four sampling sites to obtain additional measurements of physical properties to evaluate variability in the water chemistry across the channel. The cross-section profiling points were located halfway between the sampling sites and the shore in both directions. A fifth sampling site was located at the spillway, and a sixth sampling site was located northeast of the spillway (fig. 5, sites 7 and 8). Three cross-section profiling points were selected between these sampling sites and the recreational boat ramp northeast of the intake. Physical properties were measured at these sites to evaluate variability in water chemistry across the spillway of the reservoir.

Water temperature, dissolved-oxygen concentration, specific conductance, pH, total chlorophyll concentration, turbidity, and Secchi-disk depth were measured monthly in the field at all locations, including the cross-section profiling points. Concentrations of major ions, nutrients, suspended sediment, silica, petroleum hydrocarbons, organic carbon, chlorophyll *a*, alkalinity, and *Escherichia coliform* bacteria (*E. coli*) were determined monthly for the six sampling sites. In addition, four bottom-material and water samples were collected in November 2004 for analysis of trace elements and pesticides, respectively.

Water temperature, dissolved-oxygen concentration, specific conductance, pH, and total chlorophyll concentration were measured using a multiparameter water-quality meter. The meter was calibrated before each sampling event according to published USGS guidelines (Wilde and others, 1999). Turbidity was determined at each site using a turbidimeter, which was checked with turbidity standards before each sampling event. Alkalinity was determined by incremental titration using a digital titrator with 0.16-normality (N) sulfuric acid, filtered sample water, and a calibrated pH meter. Secchi-disk depth was measured by lowering a white disk into the water until it was no longer visible. The depth at which the disk was no longer visible is referred to as the Secchi-disk depth.

Water samples were collected as grab samples. A grab sample is collected by lowering the sample bottle below the water surface, 1.0 ft for this study, and holding it in place until the bottle is full. Water samples were shipped overnight on ice to the NWQL for analysis. Periodic quality-assurance samples were collected and analyzed to ensure field and laboratory accuracy. Field blanks were sent to the NWQL for analysis in February and August 2005. Replicate samples were sent to the NWQL for analysis in November 2004 and April 2005. Results from the quality-assurance samples were satisfactory. The USGS sediment laboratory conducts its own quality assurance; therefore, no additional samples were sent for analysis. Field and analytical results were recorded and stored in the USGS National Water Information System (NWIS) database.

Whole, unfiltered water samples were analyzed for concentrations of total nitrogen, total phosphorus, suspended sediment, bacteria, total organic carbon (TOC), and petroleum hydrocarbons (app. 1). Total nitrogen and total phosphorus samples were collected in clean, 125-milliliter (mL) polyethylene bottles that were rinsed with native water three times before sample collection. Samples were preserved with 2 mL of 4.5-N sulfuric acid. Suspended-sediment samples were collected in clean, unrinsed glass bottles. Bacteria samples were collected in unrinsed 500-mL borosilicate bottles that had been sterilized in an autoclave. TOC and petroleum hydrocarbon samples were collected in unrinsed 125-mL and 1 liter (L), respectively, amber glass bottles that had been baked



Base from U.S. Geological Survey digital data, 1:100,000
Universal Transverse Mercator 18 projection, NAD 83

Figure 5. Sampling and cross-section profiling locations in Lunga Reservoir, Virginia.

Table 4. Data-collection and reference sites in Lunga Reservoir, Virginia, September 2004 through August 2005.

[USGS, U.S. Geological Survey; ft, feet; na, not applicable; USMC, U.S. Marine Corps; NREA, Natural Resources and Environmental Affairs; NOAA, National Oceanic and Atmospheric Administration; na, not applicable. Data type: D, discharge; P, periodic water quality; R, rainfall. Site numbers are shown in figures 1 and 5]

Site number	Site name and USGS identification number	Latitude	Longitude	Mean depth (ft)	Data type	Data source
1	South Fork Quantico Creek near Independent Hill, VA (01658500)	38°35'14"	77°25'43"	na	D,P	USGS
2	Aquia Creek near Garrisonville, VA (01660400)	38°29'25"	77°26'01"	na	D	USGS
3	USMC Quantico NREA Office	38°30'45"	77°23'19"	na	R	USMC
4	Fredericksburg Sewage (443204)	38°17'	77°27'	na	R	NOAA
5	Upper South Branch Lunga Reservoir near Garrisonville, VA (01660470)	38°31'49"	77°29'13"	4.3	P	USGS
6	Lower South Branch Lunga Reservoir near Garrisonville, VA (01660480)	38°31'34"	77°28'08"	23.2	P	USGS
7	Lunga Reservoir at spillway near Garrisonville, VA (01660490)	38°31'22"	77°27'49"	5.1	P	USGS
8	Lunga Reservoir at water intake near Garrisonville, VA (01660489)	38°31'24"	77°27'47"	39.8	P	USGS
9	Lower North Branch Lunga Reservoir near Garrisonville, VA (01660450)	38°31'49"	77°27'52"	27.3	P	USGS
10	Upper North Branch Lunga Reservoir near Garrisonville, VA (01660440)	38°32'37"	77°28'53"	6.9	P	USGS

at 450 degrees Celsius (°C). Petroleum hydrocarbon samples were preserved with 8 mL of 1:1 sulfuric acid.

Water for filtered samples was collected in 3-L Teflon® bottles. Before each sampling event, bottles were cleaned according to published USGS guidelines (Wilde and others, 1999). Water was pumped from the sample bottle through clean Teflon® tubing using a peristaltic pump and then filtered through a clean 0.45 micrometer (µm) capsule filter into bottles ready to be shipped to the NWQL. Filtrate to be analyzed for concentrations of calcium, magnesium, potassium, silica, and sodium was bottled in clean, acid-rinsed, 250-mL polyethylene bottles and preserved with 2 mL of nitric acid. Filtrate to be analyzed for concentrations of bromide, chloride, fluoride, and sulfate was bottled in clean, filtrate-rinsed, 500-mL polyethylene bottles. Filtrate to be analyzed for concentrations of ammonia, nitrite, nitrite plus nitrate, total dissolved nitrogen, dissolved phosphorus, and dissolved orthophosphate was bottled in clean, filtrate-rinsed, 125-mL polyethylene bottles. Dissolved organic carbon (DOC) filtrate was collected in 125-mL baked, unrinsed, amber glass bottles and preserved with 2 mL of 4.5-N sulfuric acid.

Bacteria samples were processed onsite within the 6-hour holding time and placed in pre-heated incubators for 20–24 hours (Myers and Wilde, 2003). Prepared *E. coli* media was poured into sterile petri dishes where the 47-millimeter (mm), 0.45-µm filters were placed. *E. coli* colonies were counted after the plates were removed.

Water and bottom-material samples were collected at four sampling sites in the reservoir on November 29, 2004 (fig. 5, sites 5, 7, 9, and 10). Water samples were collected at 1.0-ft depth for analysis of concentrations of 54 pesticides (app. 2) and stored in 1-L, unrinsed, amber glass bottles that had been baked at 450 °C. Bottom-material samples were collected using a dredge-style sampler and sent to the NWQL where they were analyzed for concentrations of 13 trace elements—arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, phosphorus, selenium, and zinc.

Water Quality

Water-quality samples were collected at six sampling sites during the study of Lunga Reservoir. Physical properties of Lunga Reservoir, including water temperature, dissolved-oxygen, specific conductance, pH, and water clarity, were analyzed. Chemical constituents—nutrients, organic carbon, major ions, alkalinity, silica, pesticides, and petroleum hydrocarbons were analyzed from water samples taken at sampling sites. Biological constituents—*E. coli* and chlorophyll were also analyzed. The trophic status was evaluated, and suspended-sediment concentrations were analyzed during the study.

Physical Properties

Measurements of water temperature, dissolved-oxygen concentrations, specific conductance, pH, and total chlorophyll concentrations were essential in understanding the water-quality of Lunga Reservoir. Measured values of these properties followed distinct and predictable seasonal vertical trends throughout the water column.

Water Temperature

Water temperature is a measure of heat in the water column and directly affects many physical, chemical, and biological processes. Water temperature at 1.0-ft depth in Lunga Reservoir ranged from 4.6 to 30.1 °C (table 5) and throughout the water column ranged from 4.4 to 30.1 °C (app. 3–8). All water temperatures measured during the study were below the maximum water temperature criteria (32 °C) for Class III waterways (Commonwealth of Virginia State Water Control Board, 2006a). A thermal gradient was observed in Lunga Reservoir during the spring and summer months (fig. 6). During the fall and winter months, the water temperature in the reservoir was nearly isothermal with depth.

This thermal gradient in Lunga Reservoir was similar for the three deep sites (fig. 5, sites 6, 8, and 9). The two sites in the upper part of each reservoir arm and the spillway site had isothermal conditions throughout the year (fig. 5, sites 5, 7, and 10). The depths of these sites ranged from 4 to 6 ft and are shallower than the depth of the top of the thermal gradient observed in the deeper portions of Lunga Reservoir.

Dissolved Oxygen

Dissolved oxygen is a measurement of the available oxygen molecules in water, which directly affect the ability of aquatic organisms to survive. Dissolved-oxygen concentrations also affect numerous chemical reactions.

Dissolved-oxygen concentrations at 1.0-ft depth in Lunga Reservoir ranged from 5.28 to 13.9 milligrams per liter (mg/L; table 5) and throughout the water column ranged from 0.05 to 14.1 mg/L (app. 3–8). The Virginia SWCB lists the minimum dissolved-oxygen concentration for Class III waterways as 4.0 mg/L (Commonwealth of Virginia State Water Control Board, 2006a). Dissolved-oxygen concentrations measured in Lunga Reservoir during the study met the SWCB criteria for dissolved-oxygen concentrations measured according to Virginia DEQ sampling protocols. Low dissolved-oxygen concentrations occurred during the thermal gradient. The Virginia SWCB currently (2006) is establishing criteria for lakes and reservoirs with low dissolved-oxygen concentrations below the surface as a result of natural thermal and chemical gradients.

Dissolved-oxygen concentrations generally were higher during the colder months and lower during warmer months (fig. 7). During the colder months, (1) the water column is well mixed and is in contact with oxygen from the atmosphere, (2) the rate of consumption of oxygen in the reservoir by decomposition and respiration is relatively low because of colder water temperatures, and (3) the solubility of oxygen increases as water temperature decreases.

Specific Conductance

Specific conductance is a measure of how well a solution at 25 °C conducts an electrical current. As ionic concentrations in an aqueous solution increase, the conductance of an electrical current by the solution increases. Therefore, water with the least electrical conductance has the lowest specific conductance, which indicates low ionic concentration as well. Additionally, because electrical conductance is affected by water temperature, conductance measurements are normalized to 25 °C to enable comparisons of different values. Such normalized measurements are referred to as specific conductance.

Specific conductance at 1.0-ft depth in Lunga Reservoir ranged from 29 to 37 microsiemens per centimeter (µS/cm) at 25 °C (table 5), which indicates a low ionic strength (Wetzel, 2001). The specific conductance in the shallow part of the reservoir varied little with depth, ranging from 28 to 41 µS/cm throughout the year. Vertical specific conductance profiles in Lunga Reservoir indicate a sharp gradient during the summer and fall at the deeper sites (fig. 5, sites 6, 8, and 9; fig. 8). Specific conductance throughout the deeper part of the reservoir ranged from 32 to 173 µS/cm; specific conductance values were greater during the thermal gradient (app. 3–8).

Although the SWCB has no criteria for specific conductance, the mean specific conductance in Lunga Reservoir during the study (68 µS/cm) was lower than the mean specific conductance in similar reservoirs in the State, indicating relatively low ionic concentrations in Lunga Reservoir. The Pea Hill Arm of Lake Gaston Reservoir had a mean specific conductance of 90 µS/cm from 1988 to 1990 (Woodside, 1994). Chickahominy, Diascund Creek, and Little Creek Reservoirs had mean specific conductance values of 118, 81, and 117 µS/cm, respectively, from 1983 to 1986 (Lynch, 1992).

Variation in specific conductance throughout Lunga Reservoir mainly is due to seasonal changes in atmospheric conditions that cause the formation of the thermal gradient. The low specific conductance indicates an environment devoid of sources that introduce highly saline or alkaline constituents. In general, specific conductance remained stable, between 32 and 35 µS/cm, in the upper 12 ft of Lunga Reservoir during the year. While differences were observed, changes in specific conductance were minimal in the upper part of the water column. The three shallow sites had very little change in specific conductance during the study, and values generally were constant with depth (fig. 5, sites 5, 7, and 10). Noticeable

Table 5. Summary of physical properties at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005.

[USGS, U.S. Geological Survey; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 degrees Celsius; units, standard pH units; NTU, nephelometric turbidity units; ft, feet; >, greater than]

Site number (fig. 5)	Site name and USGS identification number	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)		
		Median	Minimum	Maximum	Median	Minimum	Maximum	Median	Minimum	Maximum
5	Upper South Branch Lunga Reservoir near Garrisonville, VA (01660470)	15.7	6.67	29.2	9.97	6.57	13.9	33	29	37
6	Lower South Branch Lunga Reservoir near Garrisonville, VA (01660480)	15.5	4.94	29.8	10.1	5.51	13.3	34	32	37
7	Lunga Reservoir at spillway near Garrisonville, VA (01660490)	15.3	4.61	29.7	9.90	6.01	13.4	34	32	37
8	Lunga Reservoir at water intake near Garrisonville, VA (01660489)	15.4	4.59	29.8	10.0	5.28	13.3	34	32	37
9	Lower North Branch Lunga Reservoir near Garrisonville, VA (01660450)	15.3	4.94	30.1	9.80	6.84	13.3	34	32	37
10	Upper North Branch Lunga Reservoir near Garrisonville, VA (01660440)	15.4	6.23	30.0	9.62	6.84	13.6	34	31	37

Site number (fig. 5)	Site name and USGS identification number	pH (units)			Turbidity (NTU)[a]			Secchi-disk depth (ft)[a]		
		Median	Minimum	Maximum	Median	Minimum	Maximum	Median	Minimum	Maximum
5	Upper South Branch Lunga Reservoir near Garrisonville, VA (01660470)	6.8	4.8	7.5	6	3	13	4.0	2.4	4.5
6	Lower South Branch Lunga Reservoir near Garrisonville, VA (01660480)	7.2	5.4	7.4	4	3	8	5.4	3.7	7.8
7	Lunga Reservoir at spillway near Garrisonville, VA (01660490)	7.1	5.7	7.3	4	3	7	4.4	> 3.5	7.5
8	Lunga Reservoir at water intake near Garrisonville, VA (01660489)	7.1	5.8	7.3	4	3	7	5.2	3.5	7.7
9	Lower North Branch Lunga Reservoir near Garrisonville, VA (01660450)	7.2	5.6	7.3	4	3	8	5.3	3.9	6.6
10	Upper North Branch Lunga Reservoir near Garrisonville, VA (01660440)	7.0	5.4	7.6	6	4	8	4.2	2.7	6.4

[a] Turbidity and Secchi-disk depth readings were taken 11 times at all locations.

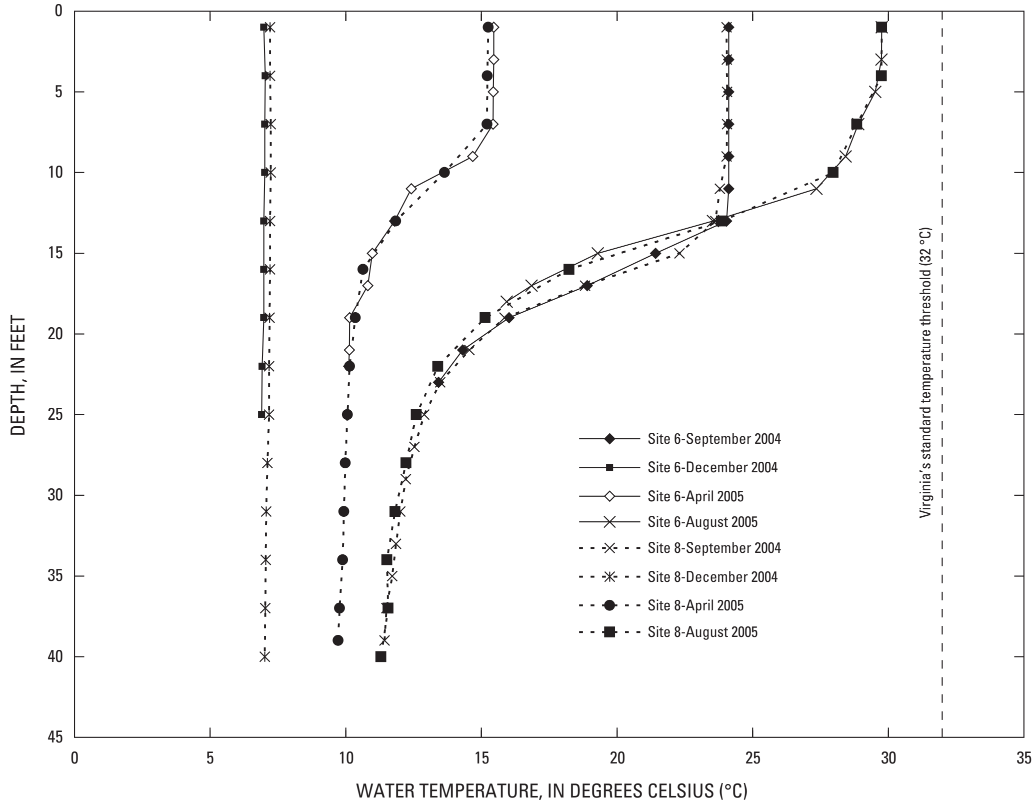


Figure 6. Water temperatures in the Lower South Branch of Lunga Reservoir (site 6) and in Lunga Reservoir at spillway (site 8) near Garrisonville, Virginia, for selected months. (Site locations are shown in figure 5.)

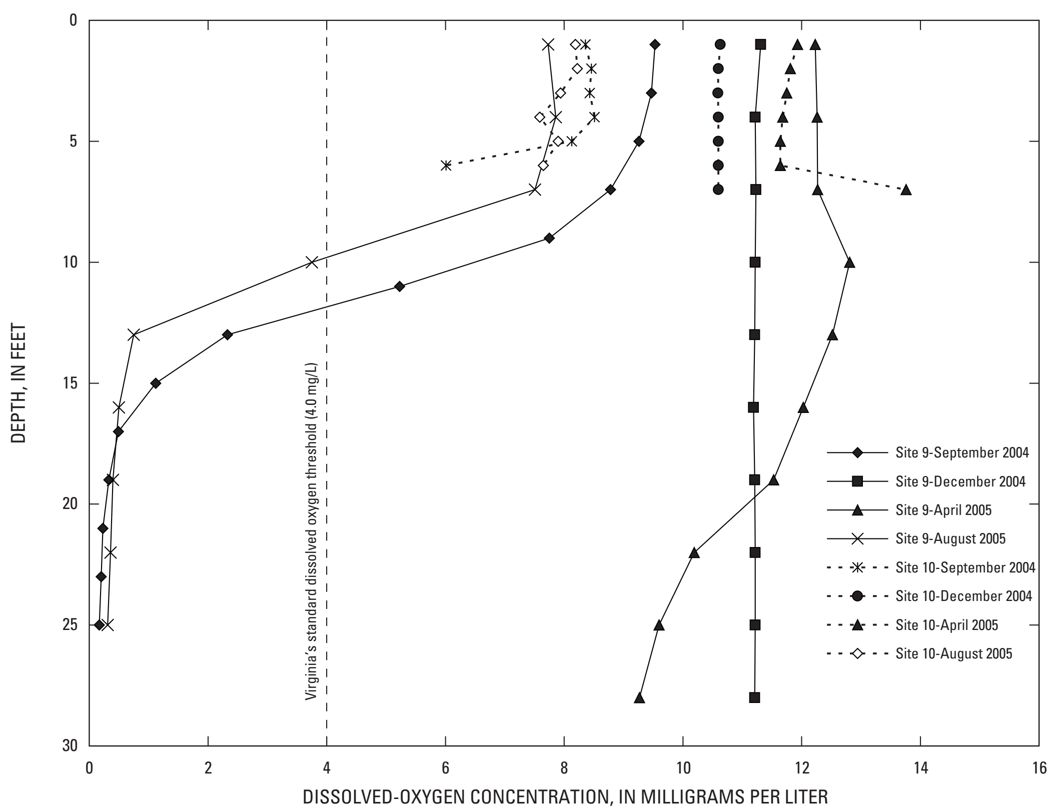


Figure 7. Dissolved-oxygen concentrations in Lower North Branch Lunga Reservoir (site 9) and Upper North Branch Lunga Reservoir (site 10) near Garrisonville, Virginia, for selected months. (Site locations are shown in figure 5.)

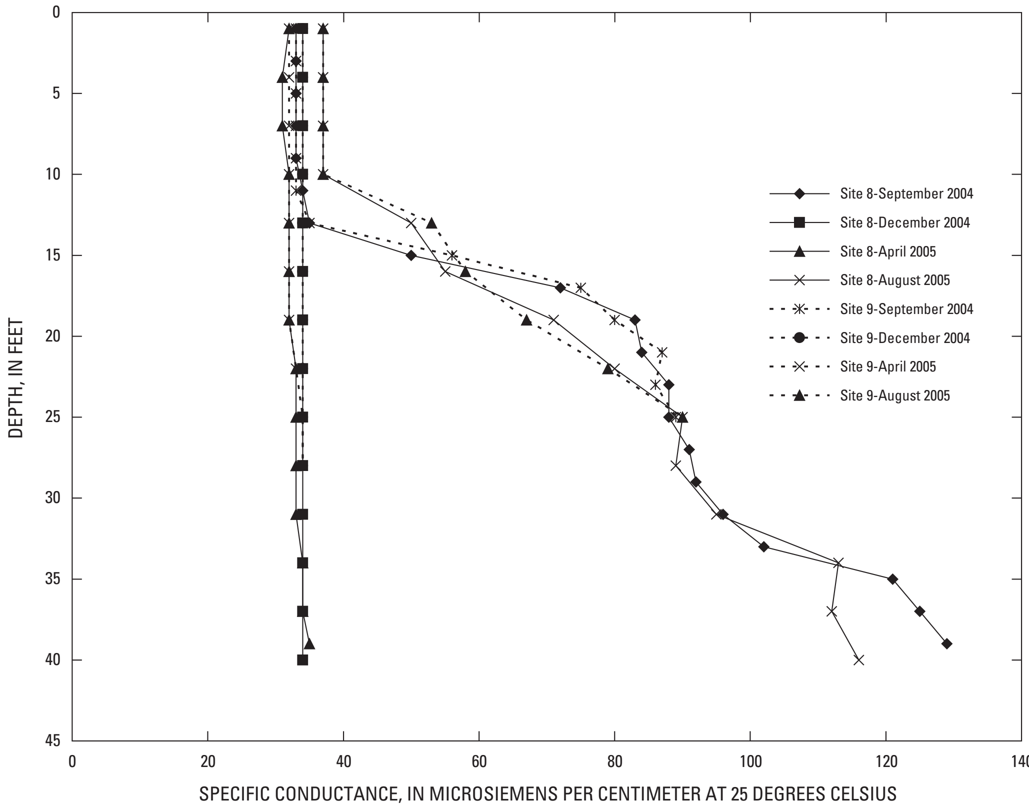


Figure 8. Specific conductance in Lunga Reservoir at water intake (site 8) and in Lower North Branch Lunga Reservoir (site 9) near Garrisonville, Virginia, for selected months. (Site locations are shown in figure 5.)

gradients in specific conductance were observed through the water column at the three deeper sampling sites (fig. 5, sites 6, 8, and 9) during the summer and fall as ions were being released from anaerobic bottom sediments but were not being transported through the water column to the surface.

pH

pH is a measure of the activity of the hydrogen ion (H^+). Natural lake waters that have low pH usually are rich in dissolved organic material; high pH waters usually contain high concentrations of salts (Wetzel, 2001). According to Wetzel (2001), the pH of most open lakes ranges from 6.0 to 9.0, which is consistent with the pH of other reservoirs in Virginia. In the Pea Hill Arm of Lake Gaston Reservoir, pH ranged from 6.8 to 8.2 from 1988 to 1990 (Woodside, 1994). The Chickahominy, Diascund Creek, and Little Creek Reservoirs had ranges of 6.0 to 7.0, 6.5 to 7.0, and 6.5 to 7.5, respectively, from 1983 to 1986 (Lynch, 1992).

The pH at 1.0-ft depth in Lunga Reservoir ranged from 4.8 to 7.6 during the year (table 5). The pH in the shallow part of Lunga Reservoir ranged from 4.8 to 8.2, while the pH in the deeper part of the reservoir ranged from 5.6 to 7.4 and was generally lower during the late summer through winter and showed little spatial variability (fig. 9; app. 3–8). The pH at 1.0-ft depth varied seasonally as well (fig. 10). The Virginia SWCB pH criterion for Class III waterways is a range of 6.0 to 9.0 standard units (Commonwealth of Virginia State Water Control Board, 2006a). The pH in Lunga Reservoir was below the maximum SWCB standard during the entire study period, and the pH fell below the minimum SWCB standard during the late summer and early winter when the reservoir was isothermal.

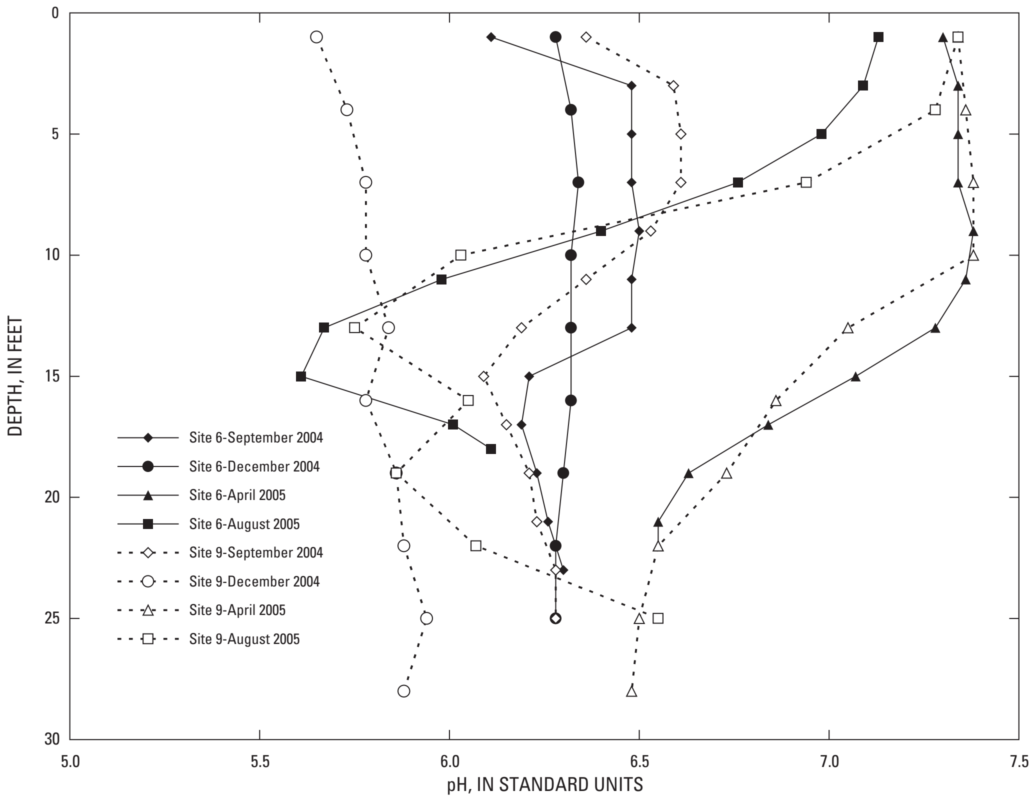


Figure 9. pH at Lower South Branch Lunga Reservoir (site 6) and Lower North Branch Lunga Reservoir (site 9) near Garrisonville, Virginia, for selected months. (Site locations are shown in figure 5.)

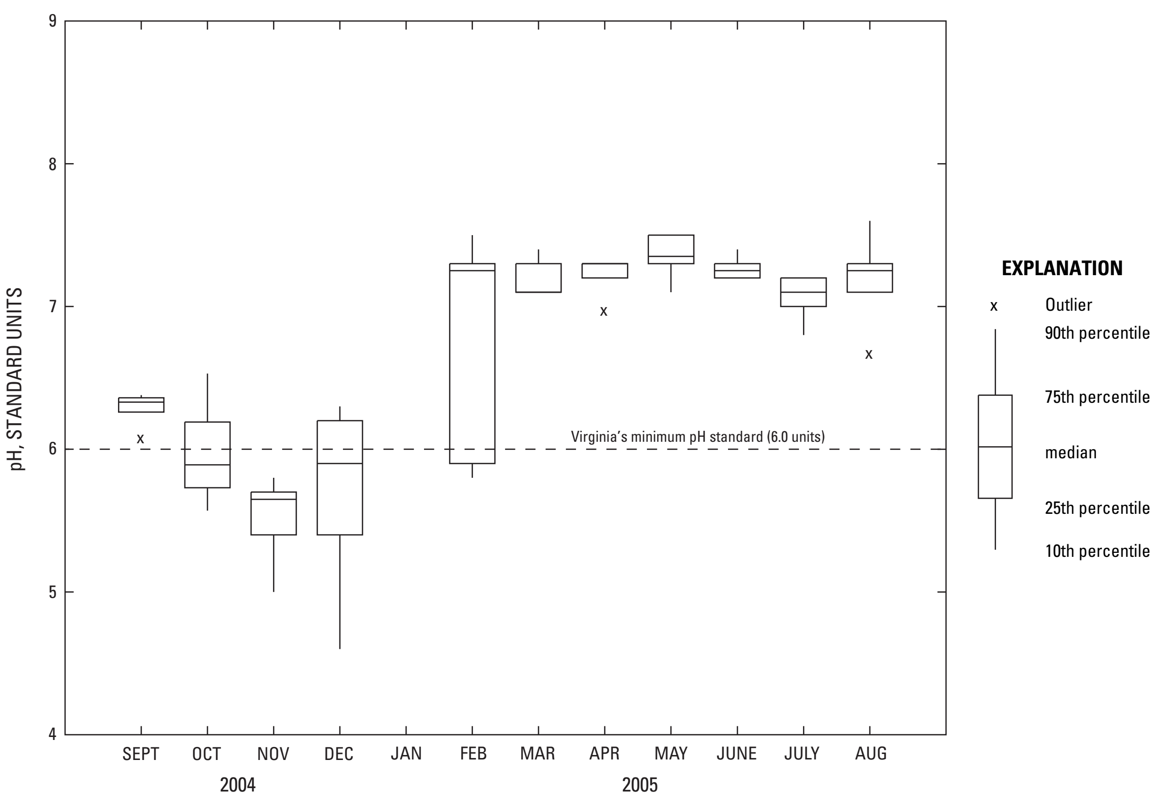


Figure 10. Monthly pH readings at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005.

Water Clarity

The water clarity in Lunga Reservoir was analyzed during the study period by measuring two different indicators—turbidity and Secchi-disk depth. Turbidity is a visual property of water that implies a reduction in clarity resulting from the presence of increased suspended particles (Wetzel, 2001). The Secchi-disk depth is a measure of the vertical extinction of light in natural waters (Wetzel, 2001). Factors that limit the ability to accurately measure Secchi-disk depth include the time of day, water color, physical condition of the Secchi disk, and the visual acuity of the person taking the reading.

Turbidity at 1.0-ft depth in Lunga Reservoir ranged from 3 to 13 nephelometric turbidity units (NTU; table 5; app. 9). Turbidity generally was low throughout the reservoir and was highest in the upper arms of the reservoir (fig. 11).

Secchi-disk depths in Lunga Reservoir ranged from 2.4 to 7.8 ft, and the greatest depths occurred at the deep sampling sites in the lower part of the reservoir (fig. 11; table 5; app. 9). Although the lowest Secchi-disk depths were in the upper part of each arm and at the spillway, many of the readings represent the total depths at these sites. The sampling site in the upper part of Beaverdam Run (fig. 5, site 10) had Secchi-disk depths that all were less than the total depth at the site during the study period. The sampling sites in the upper part of the Flat Run arm (fig. 5, site 5) and at the spillway (fig. 5, site 7) had Secchi-disk depths that were greater than the total depth at each site 36 percent and 45 percent of the time, respectively, during the study period (app. 9). These values are labeled as “greater than” (>) in table 5 and appendix 9.

Chemical Constituents

The following sections include discussions related to the results of the chemical analysis of water samples collected in Lunga Reservoir during the study period. Water samples were collected and analyzed for nutrients, organic carbon, major ions, alkalinity, silica, pesticides, and petroleum hydrocarbons.

Nutrients

Nitrogen and phosphorus are essential nutrients for primary productivity in aquatic systems. For aquatic systems to be healthy and productive environments, a balance of these two nutrients must be maintained. The relative concentrations of nitrogen and phosphorus necessary to maintain a healthy environment are unique to each aquatic system.

Samples were analyzed for the species of nitrogen commonly present in water—nitrite, nitrate, ammonia, and organic nitrogen. Dissolved nitrite-nitrogen concentrations in Lunga Reservoir during the study period were at or below the laboratory minimum reporting level (MRL) of 0.002 mg/L except for two samples that had concentrations of 0.003 mg/L. Dissolved nitrite-plus-nitrate nitrogen and dissolved ammonia-nitrogen concentrations ranged from less than the MRLs of 0.016 and 0.010 mg/L, respectively, to 0.084 and 0.162 mg/L, respectively. Total dissolved nitrogen concentrations ranged from 0.16 to 0.56 mg/L, and total nitrogen (the sum of the nitrogen species) concentrations ranged from 0.22 to 0.47 mg/L (app. 10).

Although the SWCB currently has no criterion for nitrogen, the concentrations in Lunga Reservoir were relatively low compared to nitrogen concentrations in other reservoirs in Virginia. The mean nitrite-plus-nitrate concentration at 1.0-ft depth in Lunga Reservoir (0.026 mg/L) was lower than the mean nitrite-plus-nitrate concentration in the Pea Hill Arm of Lake Gaston Reservoir (0.066 mg/L) from 1988 to 1990 (Woodside, 1994). The Chickahominy, Diascund, and Little Creek Reservoirs all had mean nitrite-plus-nitrate nitrogen concentrations less than (<) 0.1 mg/L from 1983 to 1986 (Lynch, 1992). The Pea Hill Arm of Lake Gaston, Chickahominy, Diascund Creek, and Little Creek Reservoirs had mean dissolved ammonia-nitrogen concentrations of 0.40, 0.80, 0.60, and 0.65 mg/L, respectively, (Lynch, 1992; Woodside, 1994) compared to the mean dissolved ammonia-nitrogen concentration of 0.039 mg/L at 1.0-ft depth in Lunga Reservoir. The mean total nitrogen concentration at 1.0-ft depth in Lunga Reservoir during the study (0.35 mg/L) also was less than the mean total nitrogen concentrations in the Chickahominy, Diascund Creek, Little Creek, and Pea Hill Arm of Lake Gaston Reservoirs, which were 0.8, 0.7, 0.7, and 0.5 mg/L, respectively (Lynch, 1992; Woodside, 1994).

Water samples were analyzed for total phosphorus, dissolved phosphorus, and dissolved orthophosphorus. Total phosphorus concentrations at 1.0-ft depth ranged from 0.004 to 0.034 mg/L, and dissolved orthophosphorus concentrations in all samples collected were below the MRL of 0.006 mg/L (app. 10). Concentrations of dissolved phosphorus at 1.0-ft depth in Lunga Reservoir ranged from 0.002 to 0.011 mg/L (app. 10). The maximum total phosphorus concentration in Lunga Reservoir of 0.034 mg/L is below the SWCB criteria of 40 micrograms per liter (μg/L), or 0.040 mg/L (Commonwealth of Virginia State Water Control Board, 2006a). The mean total phosphorus concentration in Lunga Reservoir, 0.016 mg/L, generally is low compared to the mean concentrations in the Chickahominy, Diascund Creek, and Little Creek Reservoirs, which were 0.049, 0.028, and 0.014 mg/L, respectively (Lynch, 1992).

Concentrations of dissolved ammonia-nitrogen and total nitrogen had inverse seasonal variations compared to concentrations of total phosphorus (fig. 12). Dissolved ammonia-nitrogen concentrations were generally at or below the MRL during the spring and summer months and were higher during the fall and winter. Total phosphorus concentrations were higher during the spring and summer than during the fall and winter.

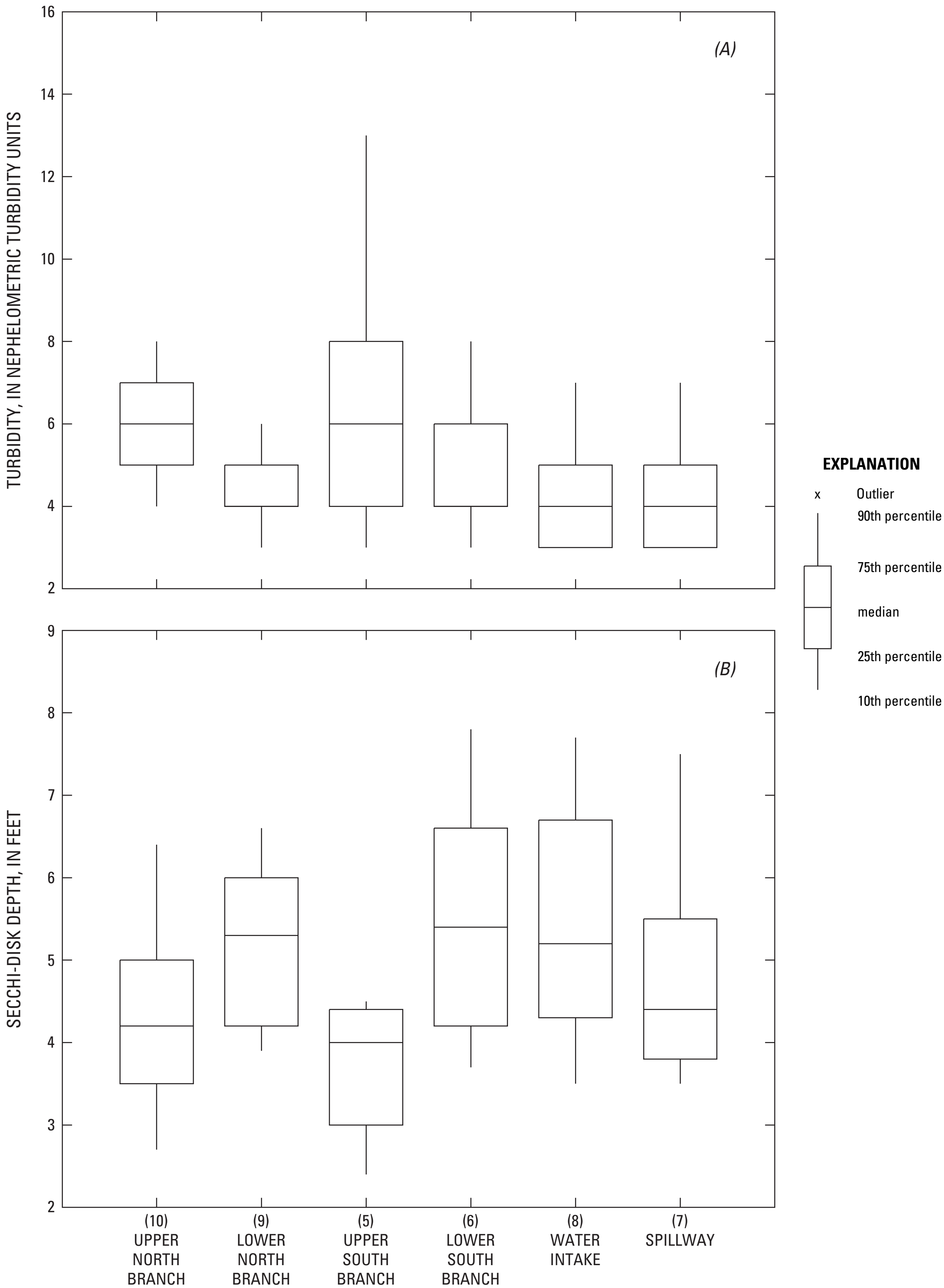


Figure 11. *(A)* Turbidity measurements and *(B)* Secchi-disk depths at sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005. (Site numbers are in parentheses, and locations are shown in figure 5.)

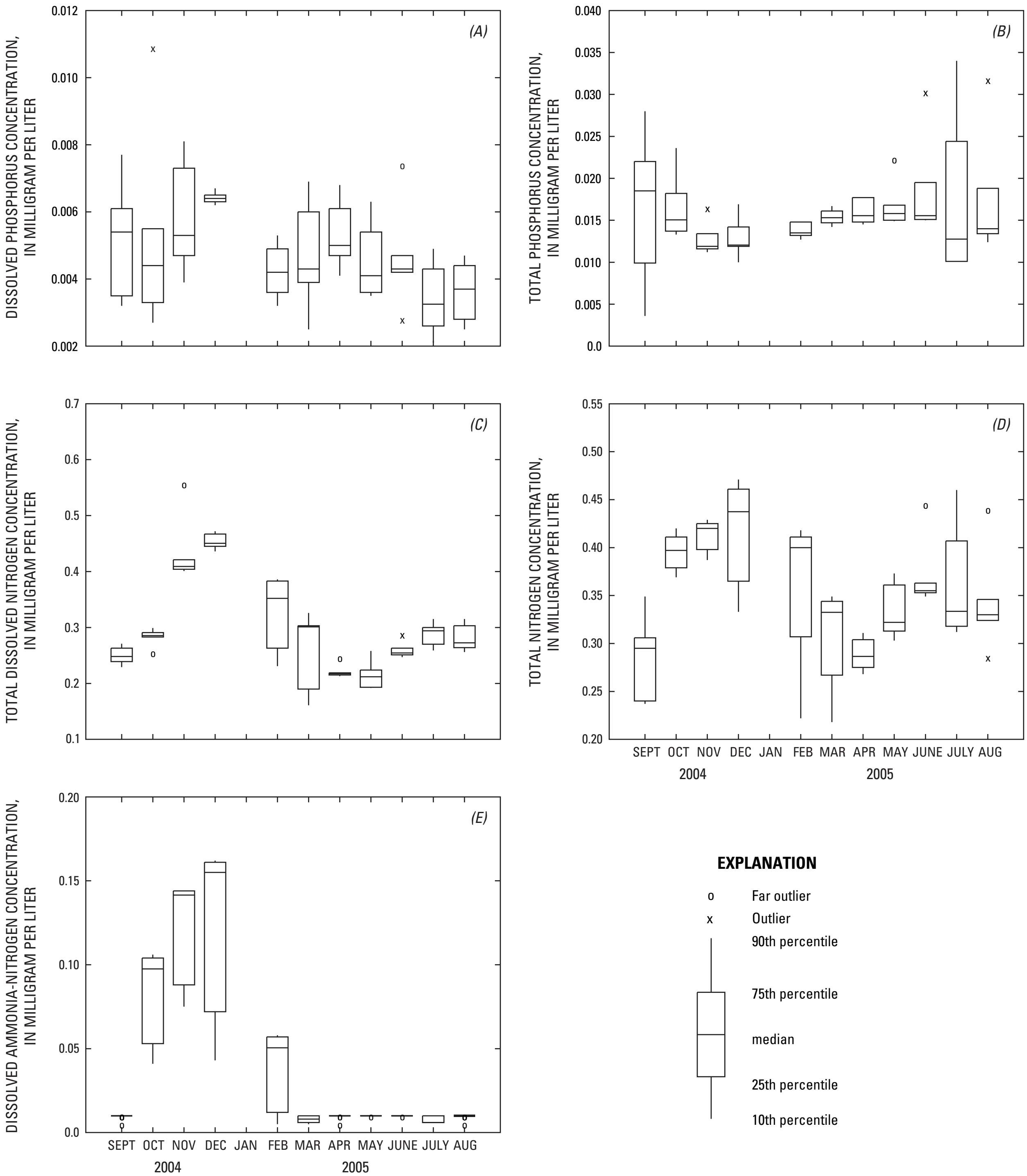


Figure 12. Concentrations of *(A)* dissolved phosphorus, *(B)* total phosphorus, *(C)* dissolved nitrogen, *(D)* total nitrogen, and *(E)* dissolved ammonia-nitrogen, Lunga Reservoir, Virginia, September 2004 through August 2005.

Organic Carbon

Water samples were analyzed for both total and dissolved organic carbon concentrations. Concentrations of total organic carbon (TOC) at 1.0-ft depth in Lunga Reservoir ranged from 3.54 to 7.48 mg/L (app. 10). The mean TOC concentration of 5.82 mg/L is between the mean TOC concentrations in the Pea Hill Arm of Lake Gaston and Chickahominy Reservoirs, which were 5.2 and 9.5 mg/L, respectively (Lynch, 1992; Woodside, 1994). Concentrations of TOC in the Diascund Creek and Little Creek Reservoirs could not be obtained. Concentrations of dissolved organic carbon (DOC) at 1.0-ft depth in Lunga Reservoir ranged from 2.70 to 5.68 mg/L, with a mean concentration of 4.38 mg/L (app. 10). There was little spatial variability in organic carbon concentrations throughout Lunga Reservoir during the study (app. 10), and concentrations were higher during spring and summer months than during the fall and winter months (fig. 13).

Major Ions

Concentrations of cations (calcium, magnesium, potassium, and sodium) and anions (chloride, fluoride, sulfate, and bromide) in Lunga Reservoir followed the same trend as specific conductance. Concentrations generally were low, varied seasonally, and varied little spatially.

Of the eight major ions, all except sulfate concentrations generally increased during the thermal gradient and subsequently decreased during the breakdown of the thermal gradient (fig. 14; app. 11). Sulfate (SO_4) is an oxygen-heavy ion that is dependent on the availability of dissolved oxygen in the water. During periods when dissolved-oxygen concentrations decrease in deep parts of the reservoir, reducing conditions convert sulfate to sulfide. Increased concentrations of calcium, chloride, magnesium, potassium, and sodium increase the specific conductance of water; as a result, when

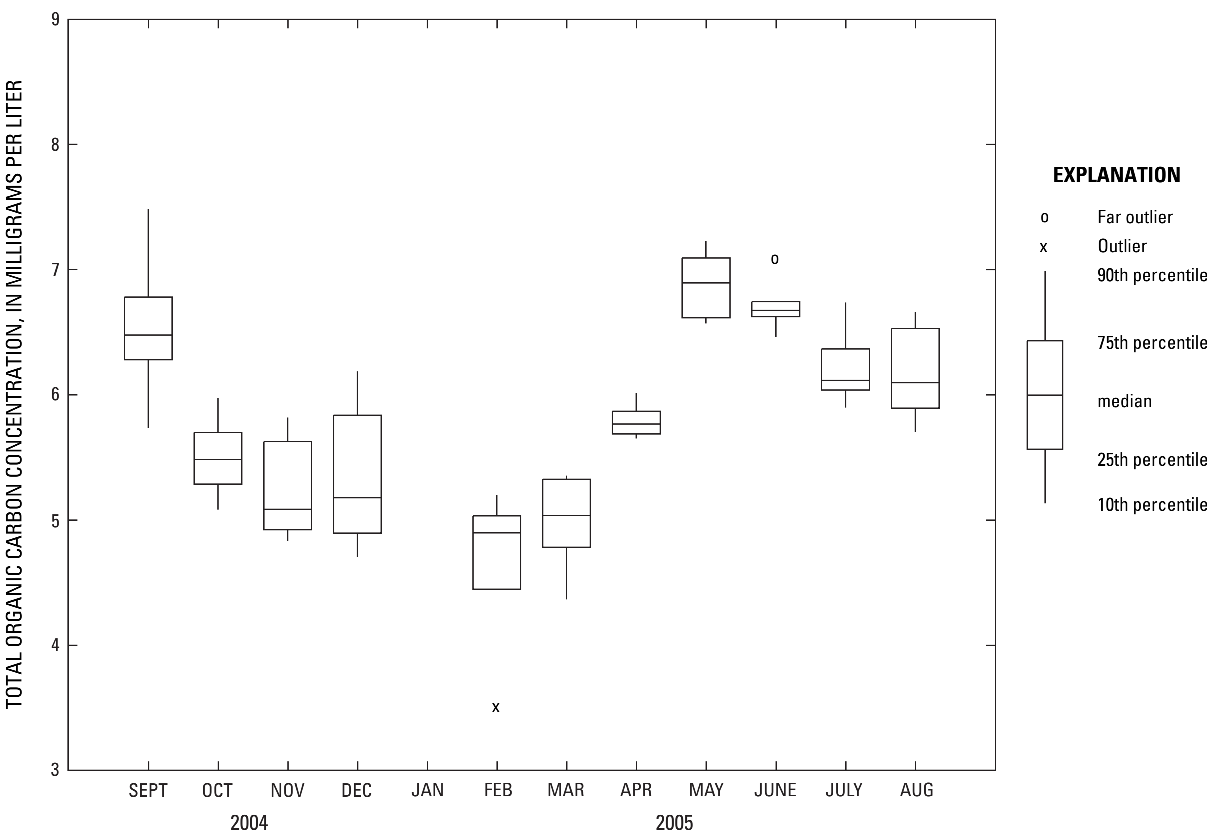


Figure 13. Monthly concentrations of total organic carbon at sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005.

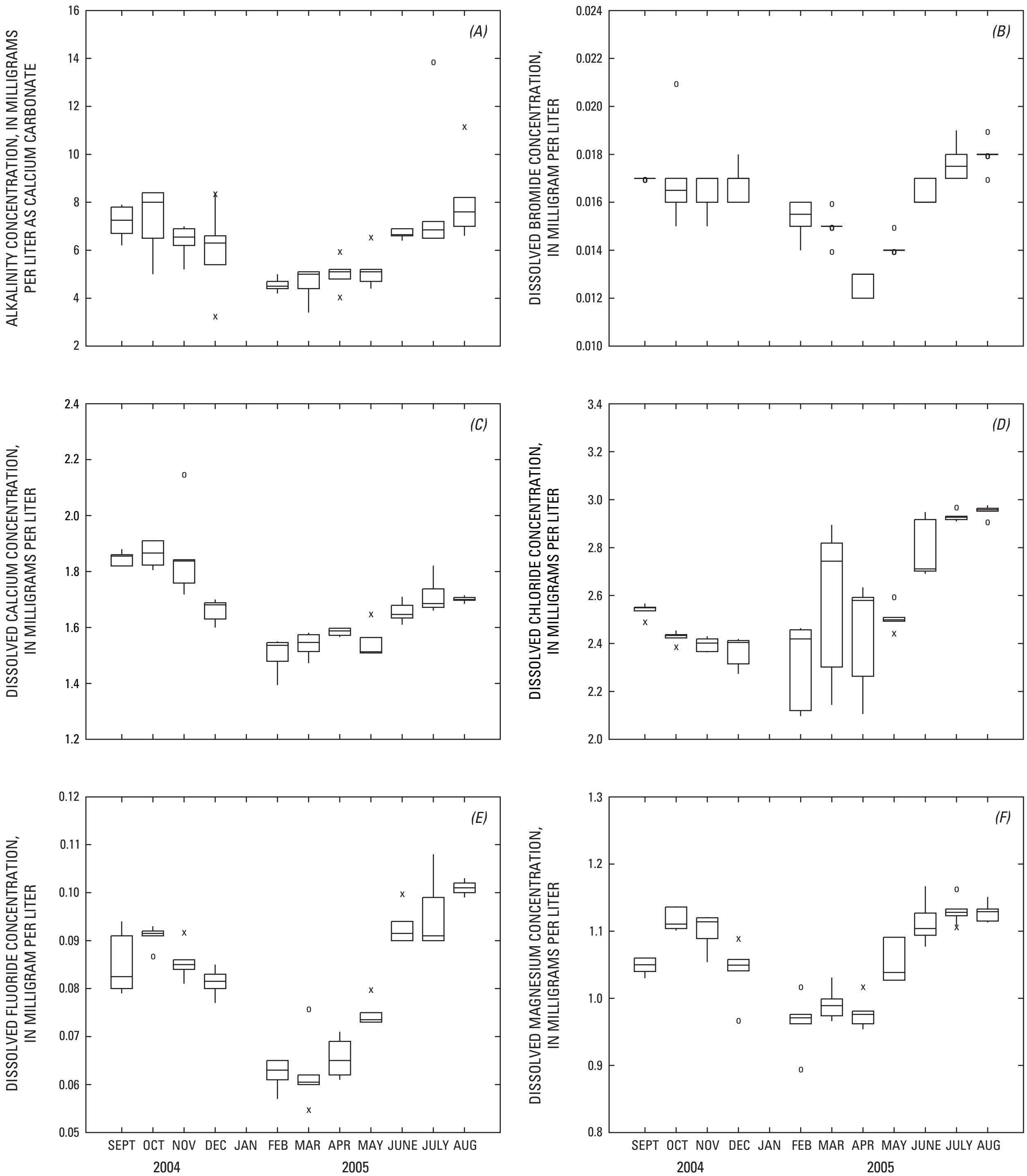


Figure 14. Concentrations of *(A)* alkalinity, *(B)* dissolved bromide, *(C)* dissolved calcium, *(D)* dissolved chloride, *(E)* dissolved fluoride, *(F)* dissolved magnesium, *(G)* dissolved potassium, *(H)* dissolved silica, *(I)* dissolved sodium, *(J)* dissolved sulfate, and *(K)* specific conductance at 1.0-foot depth for sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005. (Continued on p. 20)

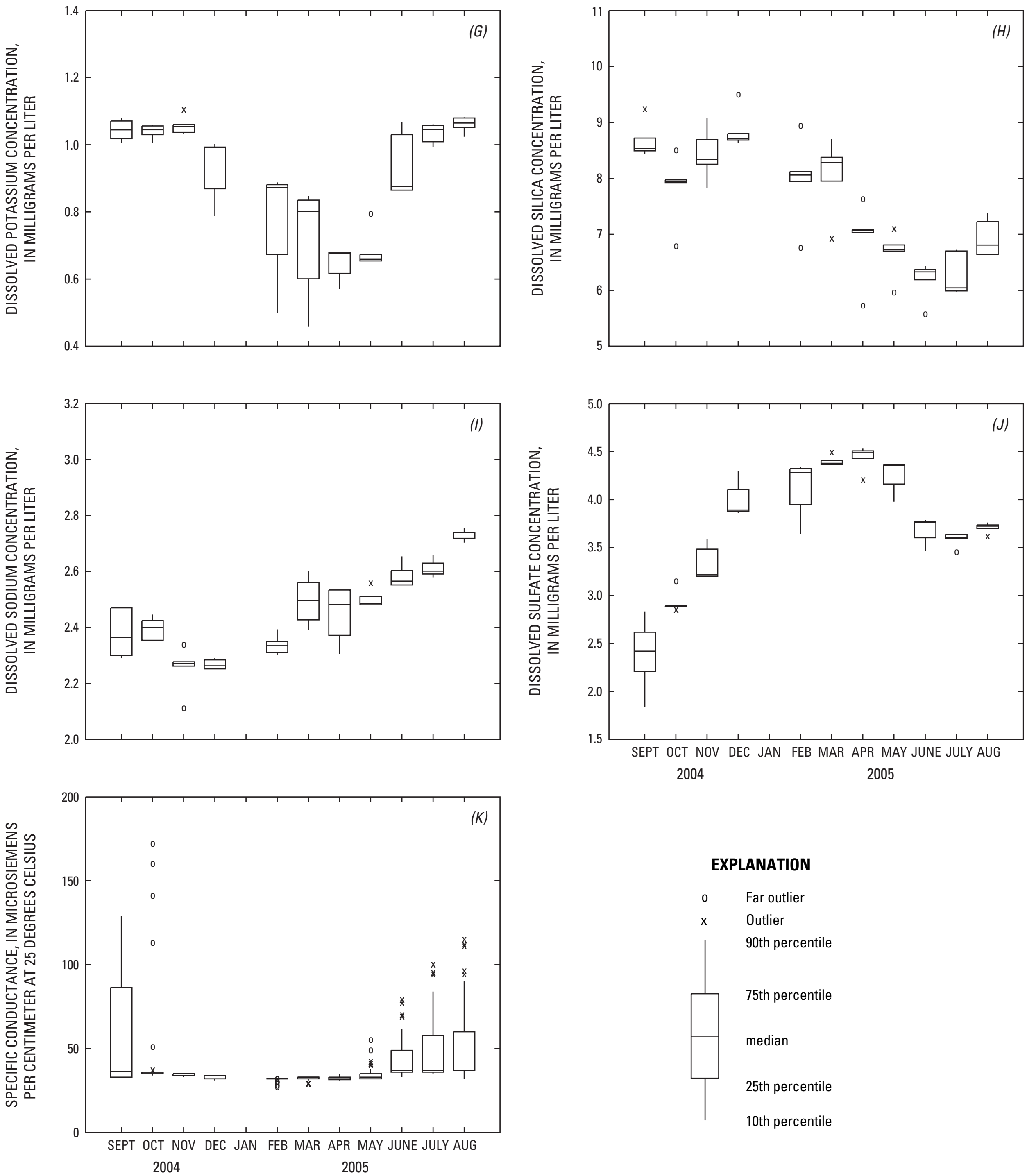


Figure 14. (Continued) Concentrations of *(A)* alkalinity, *(B)* dissolved bromide, *(C)* dissolved calcium, *(D)* dissolved chloride, *(E)* dissolved fluoride, *(F)* dissolved magnesium, *(G)* dissolved potassium, *(H)* dissolved silica, *(I)* dissolved sodium, *(J)* dissolved sulfate, and *(K)* specific conductance at 1.0-foot depth for sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005.

concentrations of these ions increased during the thermal gradient, the specific conductance increased as well.

The maximum dissolved sulfate concentration in Lunga Reservoir, 4.54 mg/L (app. 11; 4,540 µg/L), is below the SWCB criterion of 250,000 µg/L for sulfate concentrations in public water supply. While the SWCB has no criteria for the other major ions analyzed during this study, mean concentrations of other dissolved major ions in Lunga Reservoir were similar to or less than those in the Chickahominy, Diascund Creek, and Little Creek reservoirs (Lynch, 1992; table 6).

Table 6. Mean dissolved major-ion concentrations at 1.0-foot depths at sampling sites in Lunga Reservoir, Virginia, during September 2004 through August 2005 in relation to mean dissolved major ion concentrations in other reservoirs.

[Concentrations in milligrams per liter; <, less than]

Constituent	Lunga Reservoir	Chickahominy Reservoir[a]	Diascund Creek Reservoir[a]	Little Creek Reservoir[a]
Calcium	1.68	7.1	10	9.5
Chloride	2.57	18	6.4	11
Fluoride	.08	< .1	< .1	< .1
Magnesium	1.06	1.9	.89	1.6
Potassium	.90	1.6	1.1	1.7
Sodium	2.45	12	3.2	6.8
Sulfate	3.72	9.6	6.6	9.0

[a]Lynch, 1992.

Alkalinity

Alkalinity is the capacity of a solution to react with and buffer changes in pH. Alkalinity concentrations in Lunga Reservoir ranged from 3.3 to 13.9 mg/L (app. 9). Concentrations were relatively low and indicated little variation among sites. As the thermal gradient formed in the reservoir, alkalinity concentrations increased (fig. 14). Alkalinity is closely related to specific conductance in much the same way as many of the major ions.

The mean alkalinity concentration in Lunga Reservoir during the study was 6.3 mg/L. Mean alkalinity concentrations in the Chickahominy, Diascund Creek, and Little Creek reservoirs from 1983 to 1986 were 18, 22, and 24 mg/L, respectively (Lynch, 1992). The lower alkalinity concentration in Lunga Reservoir also is reflected in the lower specific conductance in Lunga Reservoir relative to the other reservoirs.

Silica

Silica (SiO_2) usually is present in moderately abundant concentrations in freshwater lakes and reservoirs, ranging from 5 to 25 mg/L (Langmuir, 1997). Silicon is an element that influences algal production in many reservoirs, because diatoms use silica in developing their skeletons, thereby greatly affecting dissolved silica concentrations. As a result, silica concentrations in lakes and reservoirs typically have spatial and seasonal variations.

Dissolved silica concentrations in Lunga Reservoir ranged from 5.60 to 9.52 mg/L (app. 11). During the study, silica concentrations varied seasonally and were smaller during the spring and summer months (fig. 14). The sampling site located in the upper part of the Beaverdam Run arm of Lunga Reservoir (fig. 5, site 10) had a lower median concentration of dissolved silica compared to the median concentrations at the other sampling sites.

The mean dissolved silica concentration in Lunga Reservoir was 7.53 mg/L. Mean dissolved silica concentrations in the Chickahominy, Diascund Creek, and Little Creek reservoirs from 1983 to 1986 were 5.1, 3.6, and 1.8 mg/L, respectively (Lynch, 1992).

Pesticides and Petroleum Hydrocarbons

Concentrations of all pesticides analyzed in water samples collected from Lunga Reservoir were below the minimum laboratory detection level (app. 2). Similarly, concentrations of petroleum hydrocarbons in all except one sample were below the minimum laboratory detection level of 7.00 mg/L. One sample collected July 25, 2005, in the lower part of the Flat Run arm had a concentration of 8.73 mg/L.

Biological Constituents

Water samples were collected in Lunga Reservoir during the study period and analyzed for concentrations of biological constituents—bacteria and chlorophyll. The following sections discuss the analytical results of these samples.

Bacteria

Water samples from Lunga Reservoir were analyzed for *Escherichia coliform* bacteria (*E. coli*) because it is an indicator of contamination from warm-blooded animals. *E. coli* concentrations generally were low, ranging from 1 to 78 colonies per 100 mL of sample (col/100 mL; app. 9). None of the *E. coli* analytical results exceeded the SWCB standard of 126 col/100 mL, which is based on a geometric mean of two or more samples collected during any calendar month (Commonwealth of Virginia State Water Control Board, 2006a). The maximum monthly mean *E. coli* concentration for Lunga Reservoir during the study was 36 col/100 mL, and the second highest concentration was 24 col/100 mL. These concentrations occurred during November and December 2004, respectively. *E. coli* concentrations in the Flat Run arm (fig. 5, sites 5 and 6) and across the spillway area of Lunga Reservoir (fig. 5, sites 7 and 8) were higher than those in the Beaverdam Run arm (fig. 5, sites 9 and 10; fig. 15). The highest concentrations, 78 and 54 col/100 mL, were recorded during the November 2004 sampling at the upper Beaverdam Run and upper Flat Run sites, respectively (fig. 5; sites 10 and 5).

Chlorophyll

Chlorophyll *a* is present in all algae and is the primary photosynthetic pigment of all oxygen-evolving photosynthetic organisms. Eight chlorophyll-*a* samples were collected at the six sampling sites in Lunga Reservoir for laboratory analysis as quality assurance for the field-meter readings. Samples were not collected for chlorophyll-*a* analysis from May through July 2005. Chlorophyll-*a* concentrations in Lunga Reservoir ranged from 0.10 to 11.6 µg/L (app. 9). These values are below the SWCB criteria of 35 µg/L for chlorophyll *a* in public water supplies (Commonwealth of Virginia State Water Control Board (DRAFT), 2006b).

Total chlorophyll concentrations throughout the reservoir ranged from 0.10 to 119.4 µg/L (app. 3–8). Field measurements of total chlorophyll were not recorded during the May 2005 sampling because of a malfunctioning chlorophyll probe.

Trophic Status

The trophic status of a reservoir is an indicator of the physical, chemical, and biological condition of the reservoir. The general trophic condition of a reservoir is classified typically in one of four categories—oligotrophic (the most pristine water-quality condition), mesotrophic, eutrophic, or hypereutrophic (the poorest water-quality condition). As a reservoir matures, its trophic condition evolves from oligotrophic to hypereutrophic. This evolution is natural but can be accelerated by human activities.

The trophic state index (TSI) is a method used to classify the trophic status of a reservoir. It can be computed using near-surface total phosphorus or chlorophyll-*a* concentrations (Carlson, 1977). TSI values based on total phosphorus concentrations (TSI_p) and chlorophyll-*a* concentrations (TSI_c) for a reservoir are computed using the following equations:

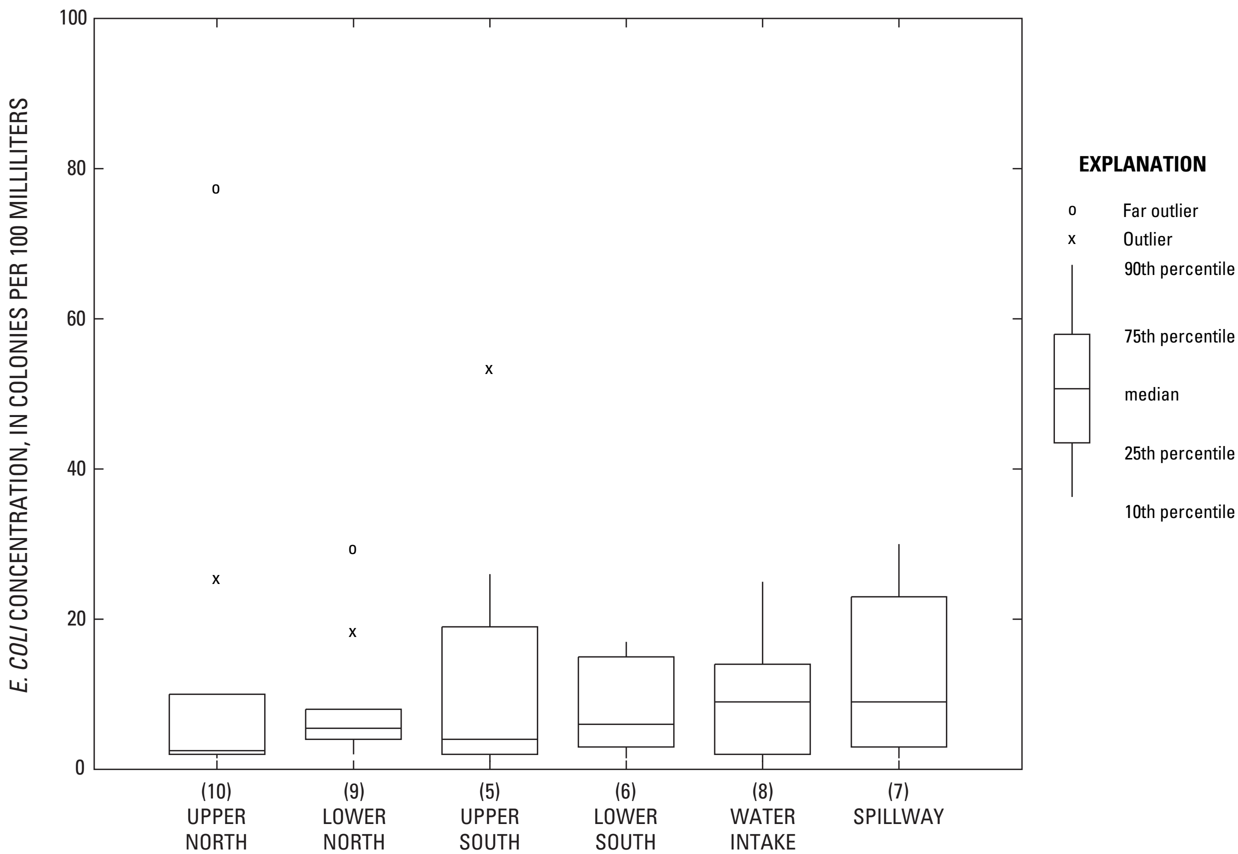


Figure 15. *E. coli* concentrations at sampling sites in Lunga Reservoir, Virginia, September 2004 through August 2005. (Site locations are shown in figure 5.)

$$TSI_p = 14.42 \ln(TP) + 4.15 \quad (1)$$

where TP = total phosphorus concentration (µg/L)

$$TSI_c = 9.81 \ln(CHL) + 30.6 \quad (2)$$

where CHL = chlorophyll-*a* concentration (µg/L)

Trophic state classifications based on the Carlson (1977) TSI are oligotrophic (0–30), mesotrophic (31–50), eutrophic (51–69), and hypereutrophic (> 69) for both the chlorophyll-*a* and total phosphorus indices. Both the TSI_p and the TSI_c ranged from oligotrophic to mesotrophic for all sites in Lunga Reservoir. Surface TSI values for all sampling sites in Lunga Reservoir indicate the reservoir is generally mesotrophic with some fluctuation between mesotrophic and eutrophic during the summer.

Suspended Sediment

Inflows to reservoirs that include large amounts of surface runoff can contribute an influx of sediment that may be detrimental to the life span of a reservoir. Even if a reservoir has high sediment loads, concentrations of suspended sediment typically are not large and decrease toward the lower end of the reservoir because the sediment tends to settle as the water flows through the reservoir. The two main inflows into Lunga Reservoir drain small watersheds that contain greater than 90 percent wooded and wetland areas. Because of the watershed size and land-use types, suspended sediment concentrations in Lunga Reservoir ranged from 1 to 12 mg/L (app. 9). Larger concentrations of suspended sediment were observed in the upper part of both arms of the reservoir and at the spillway. The highest concentration (12 mg/L) was observed in the upper part of the south arm (fig. 5, site 5).

Bottom-Material Quality

Concentrations of most trace elements increased between the sampling sites in the upper and lower parts of the Beaverdam Run arm and generally were greater in the Beaverdam Run arm than in the Flat Run arm (table 7). Concentrations of all trace elements except chromium and manganese were lowest at the spillway site (table 7).

Currently (2006), the SWCB has no criteria for concentrations of trace elements in bottom material in lakes and reservoirs. Bottom material collected from Cross Lake, Caddo Parish, in Louisiana in 1997 was analyzed for many of the same trace elements (McGee, 2004) that were analyzed in the Lunga Reservoir samples. Concentrations of most trace elements in Lunga Reservoir bottom material were lower than

Table 7. Concentrations of trace elements in bottom-material samples from Lunga Reservoir, November 29, 2004.

[µg/g, micrograms per gram; <, less than; mg/kg, milligrams per kilogram; %, percent. Site locations are shown in figure 5]

Arsenic (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)
Upper North Branch Lunga Reservoir near Garrisonville, VA (site 10)						
1.54	0.34	11.6	16.5	9.21	14,600	18.3
Lower North Branch Lunga Reservoir near Garrisonville, VA (site 9)						
2.23	0.38	14.3	14.1	19.8	33,100	29.7
Upper South Branch Lunga Reservoir near Garrisonville, VA (site 5)						
< 1.00	0.20	9.63	14.5	8.68	12,300	12.2
Lunga Reservoir at spillway near Garrisonville, VA (site 7)						
< 1.00	0.02	11.3	5.42	6.23	9,730	5.28
Manganese (µg/g)	**Mercury (µg/g)**	**Nickel (µg/g)**	**Phosphorus (mg/kg)**	**Selenium (µg/g)**	**Zinc (µg/g)**	**Moisture content (%)**
Upper North Branch Lunga Reservoir near Garrisonville, VA (site 10)						
334	0.06	9.25	507	< 1.00	48.8	97.4
Lower North Branch Lunga Reservoir near Garrisonville, VA (site 9)						
311	0.10	12.6	896	< 1.00	65.5	97.0
Upper South Branch Lunga Reservoir near Garrisonville, VA (site 5)						
415	0.05	7.61	402	< 1.00	35.0	98.3
Lunga Reservoir at spillway near Garrisonville, VA (site 7)						
669	0.02	7.21	203	< 1.00	15.6	99.2

those in Cross Lake (table 8). No bottom-material contamination was evident in Cross Lake, which indicates that the concentrations of minor elements in Lunga Reservoir bottom material are within acceptable ranges.

Table 8. Mean trace-element concentrations in bottom material from Lunga Reservoir, Virginia, and Cross Lake, Caddo Parish, Louisiana.

[Concentrations are in micrograms per gram; <, less than]

Constituent	Lunga Reservoir	Cross Lake[a]
Arsenic	1.44	4.7
Cadmium	.24	< 1.0
Chromium	11.7	20.8
Copper	11.0	30.2
Iron	17,400	21,900
Lead	16.4	27.2
Manganese	432	640
Mercury	.06	.06
Zinc	41.2	70

[a]McGee, 2004.

Summary

Lunga Reservoir is located on the U.S. Marine Corps (USMC) Base in Quantico, Virginia, in the Potomac River basin and the Piedmont Physiographic Province of northern Virginia. Because of the potential for the reservoir to be used for scuba-diver training and public water supply in addition to the current recreational activities, the USMC requested that the U.S. Geological Survey (USGS) monitor the water-quality of Lunga Reservoir and compare the observed water quality with the ambient water-quality standards of the Virginia Department of Environmental Quality (DEQ) and Virginia State Water Control Board (SWCB). The USGS conducted a 12-month study of water quality in Lunga Reservoir from September 2004 through August 2005.

Water samples for this study were collected at 6 locations throughout the reservoir, and physical properties were collected at 11 additional locations in the reservoir. Pesticide and bottom-material samples were collected once during the study at four of the sampling sites. The seasonal and spatial variations of water temperature, dissolved oxygen, specific conductance, pH, and total chlorophyll in Lunga Reservoir were similar to the variations in other lakes and reservoirs in this geographic region—a thermal gradient in the summer and fall, and isothermal conditions in the winter and early spring. Concentrations of nutrients and major ions generally were low in Lunga Reservoir, and concentrations of *E. coli*, suspended sediment, alkalinity, and bottom-material trace elements throughout the reservoir were similar to concentrations of these constituents in other reservoirs with similar physical characteristics.

Water temperatures throughout Lunga Reservoir ranged from 4.4 to 30.1 °C, which is below the SWCB maximum water temperature criteria of 32 °C. Dissolved-oxygen concentrations ranged from 0.05 to 14.1 mg/L throughout the reservoir and were never below the SWCB minimum dissolved-oxygen criterion of 4.0 mg/L near the surface of Lunga Reservoir. Specific conductance throughout Lunga Reservoir ranged from 28 to 173 µS/cm, with a mean of 68 µS/cm. This is lower than the mean specific conductance in similar reservoirs in the State, which indicates relatively low ionic concentrations in Lunga Reservoir. The pH throughout the reservoir ranged from 4.8 to 7.6 units.

Chemical constituents analyzed in water samples from Lunga Reservoir were below the SWCB criteria when applicable. When no criteria existed, constituent concentrations generally were similar to those in other reservoirs in the State. Fifty-four pesticides were analyzed in four water samples from Lunga Reservoir. None of the pesticides were detected in any of the samples.

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Appendixes

Appendix 1. Laboratory reporting levels for major ions and nutrients analyzed in water samples collected from Lunga Reservoir, Virginia.

[mg/L, milligrams per liter]

Constituent name	Method reporting limit (mg/L)
Bromide	0.010
Calcium	.010
Chloride	.010
Chlorophyll-a	.1[a]
Fluoride	.010
Magnesium	.008
Nitrogen, ammonia, dissolved	.010
Nitrogen, nitrite, dissolved	.002
Nitrogen, nitrite plus nitrate, dissolved	.016
Nitrogen, total, dissolved	.03
Nitrogen, total	.03
Organic carbon, total	.40
Organic carbon, dissolved	.33
pH	.1[b]
Petroleum hydrocarbons	7
Phosphorus, dissolved	.004
Phosphorus, phosphate, ortho, dissolved	.006
Phosphorus, total	.004
Potassium	.008
Silica	.04
Sodium	.10
Specific conductance	1[c]
Sulfate	.010

[a]Micrograms per liter.

[b]Standard units.

[c]Microsiemens per centimeter at 25 degrees Celsius.

Appendix 2. Laboratory reporting levels for pesticides analyzed in water samples collected from Lunga Reservoir, Virginia.

[µg/L, micrograms per liter; pct, percentage]

Constituent name	Method reporting level (µg/L)	Constituent name	Method reporting level (µg/L)
2,6-Diethylaniline	0.006	Fipronil sulfone	0.024
2-Chloro-4-isopropylamino-6-amino-s-triazine	.006	Fonofos	.003
alpha-HCH-d6	pct	Lindane	.004
alpha-HCH	.005	Linuron	.035
Acetochlor	.006	Malathion	.027
Alachlor	.005	Metolachlor	.006
Atrazine	.007	Metribuzin	.006
Azinphos-methyl	.05	Molinate	.003
Benfluralin	.010	Napropamide	.007
Butylate	.004	p,p'-DDE	.003
Carbaryl	.041	Parathion	.010
Carbofuran	.02	Parathion-methyl	.015
Chlorpyrifos	.005	Pebulate	.004
cis-Permethrin	.006	Pendimethalin	.022
Cyanazine	.018	Phorate	.011
Dacthal	.003	Prometon	.010
Desulfinylfipronil	.012	Propyzamide	.004
Desulfinylfipronil amide	.029	Propachlor	.025
Diazinon	.005	Propanil	.011
Diazinon-d10	pct	Propargite	.023
Dieldrin	.009	Simazine	.005
Disulfoton	.021	Tebuthiuron	.016
EPTC	.004	Terbacil	.034
Ethalfluralin	.009	Terbufos	.017
Ethoprophos	.005	Thiobencarb	.010
Fipronil	.016	Tri-allate	.006
Fipronil sulfide	.013	Trifluralin	.009

Appendix 3. Summary of physical properties at various depths for Upper North Branch Lunga Reservoir near Garrisonville, Virginia (01660440), and cross-section profiling points (fig. 5, site 10).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; F-1 and F-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2
Sep-04	1	25.2	25.3	25.2	8.4	8.3	9.0	33	34	33	6.4	6.3	6.4	6.9	7.5	6.1
Sep-04	2	25.1	25.2	25.2	8.5	8.3	8.8	33	34	33	6.4	6.4	6.4	6.8	7.3	6.5
Sep-04	3	25.1	25.1	25.2	8.4	8.3	8.8	33	33	33	6.4	6.4	6.5	6.6	6.0	6.8
Sep-04	4	25.1	25.0	25.2	8.5	8.4	8.8	33	33	33	6.4	6.4	6.5	5.6	6.5	6.5
Sep-04	5	25.0	24.9	25.1	8.1	8.0	8.7	33	34	33	6.4	6.4	6.5	5.4	4.8	6.6
Sep-04	6	24.8	24.8		6.0	6.6		35	34		6.3	6.3		3.7	3.9	
Oct-04	1	14.5	14.5	14.5	8.4	8.8	8.5	34	34	34	5.6	6.0	5.9	10.5	10.6	9.8
Oct-04	2	14.5	14.5	14.5	8.4	8.8	8.3	34	34	34	5.7	6.0	6.0	11.1	11.8	9.5
Oct-04	3	14.5	14.5	14.5	8.3	8.9	8.3	34	34	34	5.8	6.1	6.0	10.6	11.6	9.3
Oct-04	4	14.5	14.5	14.4	8.2	8.9	8.3	34	34	34	5.8	6.1	6.0	10.3	11.8	9.1
Oct-04	5	14.5	14.4	14.4	8.3	9.2	8.3	34	34	34	5.9	6.1	6.1	11.1	11.3	9.8
Oct-04	6	14.4	14.4		8.4	9.3		34	34		5.9	6.1		11.3	10.8	
Oct-04	7		14.4						34			6.1			11.0	
Nov-04	1	10.4	10.4	10.6	9.6	9.9	9.8	34	34	34	5.8	5.8	5.8	5.8	5.3	5.4
Nov-04	2	10.4	10.3	10.5	9.6	9.8	9.7	34	34	34	5.8	5.8	5.9	6.5	5.3	6.3
Nov-04	3	10.3	10.1	10.3	9.6	9.8	9.6	34	34	34	5.8	5.8	6.0	6.0	5.4	5.6
Nov-04	4	10.2	9.9	10.3	9.6	9.7	9.6	34	34	34	5.8	5.8	5.9	5.9	4.9	5.8
Nov-04	5	10.0	9.7	10.3	9.5	9.7	9.6	34	33	34	5.8	5.8	5.9	4.9	5.3	4.6
Nov-04	6	9.6	9.5		9.6	9.8		34	33		5.8	5.8		3.4	4.3	
Dec-04	1	7.3	7.3	6.5	10.6	11.0	10.8	32	32	32	5.4	5.7	5.6	3.0	2.9	2.9
Dec-04	2	7.3	7.3	6.4	10.6	10.8	10.9	32	32	32	5.5	5.6	5.6	3.5	3.5	2.9
Dec-04	3	7.3	7.3	6.4	10.6	10.7	10.9	32	32	32	5.5	5.6	5.6	3.5	3.2	3.0
Dec-04	4	7.3	7.3	6.4	10.6	10.7	10.9	32	32	32	5.5	5.6	5.6	4.1	3.5	2.7
Dec-04	5	7.3	7.3	6.3	10.6	10.7	10.9	32	32	32	5.5	5.5	5.6	3.5	3.7	3.0
Dec-04	6	7.3	7.3	6.4	10.6	10.6	10.9	32	32	32	5.5	5.5	5.6	4.0	3.5	3.4
Dec-04	7	7.3	7.3		10.6	10.7		32	32		5.5	5.5		3.4	3.5	
Feb-05	1	6.2	6.5	6.6	12.2	12.1	12.3	31	31	31	7.5	7.2	7.3	4.0	2.9	3.2
Feb-05	2	6.2	6.6	6.6	12.2	12.1	12.3	31	31	31	7.3	7.0	7.2	3.4	2.9	3.9
Feb-05	3	6.2	6.2	6.6	12.2	12.2	12.4	31	31	31	7.3	7.0	7.1	3.4	3.2	4.0
Feb-05	4	6.3	5.8	6.6	12.2	12.2	12.4	31	31	31	7.3	7.0	7.0	4.3	3.2	5.0
Feb-05	5	6.1	5.6		12.2	12.1		31	31		7.3	7.0		5.0	3.7	
Feb-05	6	6.1	5.6		12.2	12.1		31	31		7.3	7.0		6.5	4.4	
Feb-05	7		5.5			12.1			31			6.9			5.0	
Mar-05	1	6.5	6.6	6.7	13.6	13.4	13.4	31	31	31	7.1	7.2	7.2	3.0	3.2	3.4
Mar-05	2			6.6			13.4			31			7.2			5.0
Mar-05	3	6.5	6.6	6.6	13.5	13.4	13.4	31	31	31	7.1	7.2	7.2	3.7	3.5	5.6
Mar-05	4			6.6			13.4			31			7.2			4.9
Mar-05	5	6.5	6.6	6.6	13.5	13.4	13.5	31	31	31	7.1	7.2	7.2	4.8	4.1	5.0
Mar-05	6															
Mar-05	7	6.5	6.6		13.5	13.4		31	31		7.1	7.2		5.9	5.5	

Appendix 3. Summary of physical properties at various depths for Upper North Branch Lunga Reservoir near Garrisonville, Virginia (01660440) and cross-section profiling points (fig. 5, site 10).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; F-1 and F-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2	01660440	F-1	F-2
Apr-05	1	16.4	16.3	16.4	11.9	11.5	11.5	31	31	31	7.2	7.1	7.4	6.6	4.9	5.8
Apr-05	2	16.4	16.4	16.4	11.8	11.3	11.5	31	31	31	7.2	7.1	7.4	6.8	6.9	6.5
Apr-05	3	16.3	16.3	16.4	11.8	11.3	11.4	31	31	31	7.2	7.1	7.4	7.1	6.6	6.5
Apr-05	4	16.3	16.3	16.4	11.7	11.2	11.4	31	31	31	7.2	7.1	7.3	7.6	7.0	6.6
Apr-05	5	16.4	16.3	16.4	11.6	11.2	11.8	31	31	31	7.2	7.1	7.9	7.5	7.3	12.3
Apr-05	6	16.3	16.3		11.6	11.2		31	31		7.3	7.1		7.5	7.4	
Apr-05	7	15.0	16.2		13.8	11.3		30	31		8.2	7.1		21.1	9.1	
May-05	1	20.3	20.3	20.4	9.9	8.4	9.5	33	33	33	7.5	7.6	7.4			
May-05	2	20.3	20.3	20.4	9.9	9.5	9.9	33	33	33	7.5	7.6	7.4			
May-05	3	20.3	20.2	20.2	9.9	9.9	10.0	33	33	33	7.5	7.6	7.5			
May-05	4	20.1	20.1	19.9	9.9	9.9	10.2	33	33	33	7.6	7.6	7.7	NO MAY CHLOROPHYLL VALUES		
May-05	5	19.9	20.0	19.8	9.8	9.8	10.3	33	33	33	7.5	7.6	7.9			
May-05	6	19.0	19.6		9.8	10.0		33	33		7.4	7.5				
May-05	7	17.1	17.9		4.7	9.8			33		7.0	7.3				
May-05	8		17.7			9.5			33			7.2				
Jun-05	1	25.4	25.6	25.8	8.6	8.6	8.6	37	37	37	7.2	7.1	7.2	6.8	5.5	5.5
Jun-05	2	25.2	25.4	25.4	8.7	8.6	8.7	37	37	37	7.2	7.2	7.2	7.5	7.0	7.0
Jun-05	3	25.0	25.1	25.2	8.8	8.5	8.8	37	37	37	7.2	7.2	7.2	8.1	8.3	8.8
Jun-05	4	24.9	24.7	25.0	8.6	7.5	8.9	37	38	37	7.2	7.1	7.2	8.6	9.0	8.3
Jun-05	5	24.6	24.6		8.1	7.0		38	38		7.2	7.0		8.6	8.6	
Jun-05	6	24.6	24.5		7.6	6.7		38	39		7.1	6.9		8.3	9.8	
Jun-05	6.5	23.9			2.6			41			6.9			12.8		
Jul-05	1	29.4	29.4	29.4	6.8	6.8	7.2	37	37	37	7.0	6.9	7.0	6.5	7.8	7.0
Jul-05	2	29.4	29.4	29.3	6.9	6.8	7.1	37	37	37	7.0	6.9	6.9	6.1	7.6	6.5
Jul-05	3	29.4	29.4	29.2	6.9	6.8	7.0	37	37	37	7.0	6.9	6.9	5.8	8.8	7.0
Jul-05	4	29.4	29.4		6.9	6.5		37	38		7.0	6.7		6.0	10.3	
Jul-05	5	29.4	29.3		6.9	6.3		37	38		7.0	6.7		5.9	9.1	
Jul-05	6	29.4	29.2		6.9	5.7		37	39		6.9	6.6		6.3	8.0	
Aug-05	1	30.0			8.2			37			7.6			6.0		
Aug-05	2	30.0			8.2			37			7.6			5.3		
Aug-05	3	29.7			7.9			37			7.3			9.6		
Aug-05	4	29.4			7.6			37			6.9			10.8		
Aug-05	5	29.3			7.9			37			6.8			11.8		
Aug-05	6	29.3			7.7			37			6.7			11.3		

Appendix 4. Summary of physical properties at various depths for Lower North Branch Lunga Reservoir near Garrisonville, Virginia (01660450) and cross-section profiling points (fig. 5, site 9).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; E-1 and E-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2
Sep-04	1	25.3	25.3	25.3	9.5	9.4	8.5	33	33	33	6.4	6.3	6.7	4.5	4.1	4.6
Sep-04	3	25.3	25.3	25.2	9.5	9.5	9.2	33	33	33	6.6	6.6	6.8	4.3	4.5	5.3
Sep-04	5	25.1	25.2	25.1	9.3	9.4	9.2	33	33	33	6.6	6.7	6.8	4.4	4.5	4.5
Sep-04	7	24.9	24.9	25.0	8.8	8.8	8.9	33	33	32	6.6	6.8	6.8	4.9	4.9	5.8
Sep-04	9	24.4	24.4	24.4	7.8	8.0	7.7	33	33	33	6.5	6.7	6.6	3.0	3.0	2.9
Sep-04	11	24.0	24.0	23.9	5.2	6.2	5.0	33	33	34	6.4	6.6	6.4	2.0	2.4	2.2
Sep-04	13	23.5	23.4	23.4	2.3	3.1	1.7	35	35	36	6.2	6.3	6.1	3.4	3.7	3.2
Sep-04	15	21.3	21.1	21.2	1.1	1.0	0.4	56	64	62	6.1	6.3	6.2	20.7	22.2	24.2
Sep-04	16			19.7			0.2			70			6.2			36.0
Sep-04	17	18.5	18.8	18.4	0.5	0.5	0.1	75	75	76	6.2	6.3	6.2	37.0	37.2	37.7
Sep-04	19	16.4	16.4		0.3	0.3		80	80		6.2	6.3		25.2	24.2	
Sep-04	21	14.8	14.9		0.2	0.2		87	85		6.2	6.3		12.5	13.3	
Sep-04	23	13.7	13.6		0.2	0.2		86	87		6.3	6.4		7.8	8.1	
Sep-04	25	13.1	13.1		0.2	0.1		89	91		6.3	6.4		6.4	6.6	
Oct-04	1	15.3	15.6	15.9	10.0	10.6	10.7	36	36	36	6.5	6.1	6.2	6.0	5.0	4.5
Oct-04	3	15.3		15.3	10.1		10.4	36		36	6.5		6.3	6.0		6.0
Oct-04	4		15.5			10.4			36			6.2			6.5	
Oct-04	5	15.2		15.2	10.0		10.0	36		36	6.5		6.3	6.4		5.0
Oct-04	7	15.2	15.2	15.2	9.9	10.1	9.9	36	36	36	6.5	6.3	6.3	6.0	6.5	4.6
Oct-04	9	15.1		15.2	9.3		9.6	36		36	6.5		6.3	5.0		4.8
Oct-04	10		15.1			9.9			36			6.3			5.1	
Oct-04	11	15.1		15.1	9.2		9.0	36		36	6.5		6.2	4.5		4.3
Oct-04	12			15.1			8.8			36			6.2			4.0
Oct-04	13	15.0	15.0		9.1	9.3		36	36		6.5	6.2		5.1	4.9	
Oct-04	15	15.0			9.1			36			6.4			5.0		
Oct-04	16		14.9			9.1			36			6.2			4.6	
Oct-04	17	15.0			9.1			36			6.4			4.4		
Oct-04	19	14.9	14.9		8.9	8.9		36	36		6.4	6.2		4.3	4.5	
Oct-04	21	14.9			8.9			36			6.4			4.9		
Oct-04	22		14.9			8.8			36			6.2			4.3	
Oct-04	23	14.9			8.8			36			6.4			4.9		
Oct-04	25	14.8	14.8		8.8	8.6		36	36		6.4	6.2		4.6	4.4	
Oct-04	27	14.8	14.7		8.6	8.2		37	37		6.3	6.2		4.3	4.5	
Nov-04	1	10.8	10.8	10.8	10.0	10.1	11.1	35	35	35	5.9	5.9	6.4	3.4	3.7	2.9
Nov-04	3		10.7	10.8		10.0	10.6		35	35		5.9	6.4		4.5	4.0
Nov-04	4	10.7			10.0			35			6.0			4.8		
Nov-04	5		10.7	10.8		9.9	10.4		35	35		6.0	6.3		4.4	3.9
Nov-04	7	10.7	10.7	10.8	9.8	9.8	10.2	35	35	35	6.0	6.0	6.3	4.8	4.0	4.6
Nov-04	9		10.7	10.8		10.4	10.1		35	35		6.3	6.3		4.5	4.1
Nov-04	10	10.7			9.8			35			6.1			4.5		
Nov-04	11			10.8			10.0			35			6.2			4.4
Nov-04	12		10.6			10.1			35			6.2			5.3	
Nov-04	13	10.7			9.7			35			6.0			4.1		
Nov-04	15		10.6			9.9			35			6.1			3.7	
Nov-04	16	10.6			9.6			35			6.0			3.9		
Nov-04	18		10.5			9.7			35			6.1			3.4	
Nov-04	19	10.6			9.5			35			6.0			3.5		
Nov-04	21		10.5			9.5			35			6.1			3.0	
Nov-04	22	10.4			9.3			35			6.0			3.5		
Nov-04	24		10.4			9.3			35			6.1			3.4	
Nov-04	25	10.3			9.2			35			6.0			3.5		
Nov-04	28	10.2			9.0			35			6.0			3.5		
Nov-04	30	10.3			8.9			35			6.0			4.4		

Appendix 4. Summary of physical properties at various depths for Lower North Branch Lunga Reservoir near Garrisonville, Virginia (01660450) and cross-section profiling points (fig. 5, site 9).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; E-1 and E-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2
Dec-04	1	7.1	7.1	7.2	11.3	11.2	11.0	34	34	34	5.7	6.1	6.2	4.0	3.9	3.2
Dec-04	3			7.2			11.0			34			6.2			3.5
Dec-04	4	7.2	7.2		11.2	11.1		34	34		5.7	6.1		4.1	3.5	
Dec-04	5			7.2			11.0			34			6.2			3.9
Dec-04	7	7.2	7.2	7.2	11.2	11.1	11.0	34	34	34	5.8	6.1	6.2	4.1	3.5	3.7
Dec-04	9			7.2			10.9			34			6.2			3.5
Dec-04	10	7.2	7.1		11.2	11.1		34	34		5.8	6.1		3.7	4.1	
Dec-04	11			7.2			10.9			34			6.2			3.2
Dec-04	13	7.2	7.2	7.1	11.2	11.1	10.9	34	34	34	5.8	6.1	6.2	4.5	3.7	4.0
Dec-04	15			7.1			10.9			34			6.2			3.7
Dec-04	16	7.2	7.2		11.2	11.1		34	34		5.8	6.1		4.1	3.7	
Dec-04	19	7.2	7.1		11.2	11.1		34	34		5.9	6.1		4.3	3.9	
Dec-04	22	7.1	7.1		11.2	11.1		34	34		5.9	6.1		3.7	4.3	
Dec-04	25	7.0	7.0		11.2	11.1		34	34		5.9	6.1		3.9	3.7	
Dec-04	28	7.0			11.2			34			5.9			4.5		
Feb-05	1	4.9	5.1	5.1	11.6	11.6	11.7	32	32	32	7.3	7.2	7.2	5.4	3.7	3.7
Feb-05	3			5.0			11.7			32			7.2			4.9
Feb-05	4	4.9	5.1		11.6	11.6		32	32		7.2	7.2		4.8	4.5	
Feb-05	5			5.1			11.7			32			7.1			5.9
Feb-05	7	4.9	5.1	5.1	11.6	11.6	11.7	32	32	32	7.2	7.1	7.0	6.6	6.8	6.4
Feb-05	9			5.0			11.6			32			7.0			7.5
Feb-05	10	4.8	5.1		11.6	11.6		32	32		7.2	7.0		8.3	7.5	
Feb-05	11			5.0			11.6			32			7.0			7.9
Feb-05	13	4.8	5.1	5.0	11.5	11.6	11.6	32	32	32	7.2	7.0	6.9	8.8	7.9	7.5
Feb-05	15			4.9			11.6			32			6.9			8.1
Feb-05	16	4.8	5.0		11.5	11.6		32	32		7.0	7.0		8.3	8.0	
Feb-05	19	4.9	5.0		11.5	11.6		32	32		7.0	7.0		8.1	8.3	
Feb-05	22	4.8	4.6		11.3	11.6		32	32		7.1	7.0		8.8	8.1	
Feb-05	25	4.6			11.3			32			7.1			9.0		
Feb-05	28	4.6			11.2			33			7.1			9.1		
Mar-05	1	6.3			13.3			33			7.1			4.3		
Mar-05	4	6.3			13.3			33			7.1			5.5		
Mar-05	7	6.3			13.2			33			7.1			8.1		
Mar-05	10	6.3			13.2			33			7.1			10.5		
Mar-05	13	6.3			13.2			33			7.1			10.0		
Mar-05	15	6.3			13.2			33			7.1			9.8		
Apr-05	1	15.4	15.6	15.4	12.2	11.9	12.1	32	32	32	7.3	7.3	7.3	6.6	5.3	5.1
Apr-05	3			15.4			12.0			32			7.3			6.9
Apr-05	4	15.4	15.6		12.3	11.9		32	32		7.4	7.3		8.3	7.5	
Apr-05	5			15.3			12.0			32			7.3			9.1
Apr-05	7	15.3	15.4	15.1	12.3	11.9	11.9	32	32	32	7.4	7.3	7.4	9.8	9.1	9.3
Apr-05	9			14.9			11.9			32			7.3			11.3
Apr-05	10	13.4	12.7		12.8	12.7		32	32		7.4	7.3		12.3	15.1	
Apr-05	11			11.6			12.6			32			7.2			17.1
Apr-05	13	11.1	11.4		12.5	12.6		32	32		7.1	7.2		18.8	17.7	
Apr-05	16	10.8	10.5		12.0	11.4		32	32		6.9	6.8		18.2	16.1	
Apr-05	19	10.5	10.4		11.5	11.0		32	32		6.7	6.7		16.1	15.3	
Apr-05	22	10.1	10.3		10.2	10.8		33	32		6.6	6.7		11.6	14.3	
Apr-05	25	10.0	10.1		9.6	10.4		34	33		6.5	6.6		12.0	11.8	
Apr-05	28	10.0			9.3			34			6.5			10.8		

Appendix 4. Summary of physical properties at various depths for Lower North Branch Lunga Reservoir near Garrisonville, Virginia (01660450) and cross-section profiling points (fig. 5, site 9).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; E-1 and E-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2	01660450	E-1	E-2
May-05	1	20.3	20.5	20.7	9.4	9.6	9.7	32	32	32	7.3	7.1	7.3			
May-05	3			20.5			9.8			32			7.3			
May-05	4	20.3	20.4		9.6	9.9		32	32		7.4	7.3				
May-05	5			20.4			9.8			32			7.4			
May-05	7	20.3	20.3	20.3	9.7	9.8	9.8	32	32	32	7.4	7.4	7.4			
May-05	9			20.2			9.8			32			7.4			
May-05	10	19.2	18.9		9.7	9.8		32	32		7.3	7.2			NO MAY CHLOROPHYLL VALUES	
May-05	11			17.2			9.5			32			7.1			
May-05	12			16.9			8.2			33			6.7			
May-05	13	16.7	16.8		9.1	9.2		33	32		7.0	6.8				
May-05	16	15.6	15.3		8.1	6.7		33	33		6.7	6.3				
May-05	19	14.3	14.4		5.7	5.6		35	34		6.3	6.2				
May-05	22	13.1	12.9		3.3	3.3		37	37		6.2	6.1				
May-05	25	11.4	11.6		2.0	1.7		41	40		6.1	6.1				
May-05	28	11.2			0.8			50			6.4					
Jun-05	1	25.9	27.1	27.2	8.9	9.0	8.9	35	35	35	7.3	7.2	7.1	7.0	5.9	5.5
Jun-05	3			26.1			9.2			35			7.3			8.5
Jun-05	4	25.7	25.9		9.1	9.2		35	35		7.4	7.3		9.0	8.6	
Jun-05	5			25.9			9.2			35			7.3			9.1
Jun-05	7	25.6	25.6	25.7	8.9	8.9	9.2	35	35	35	7.4	7.3	7.3	9.6	10.8	9.8
Jun-05	9			22.9			5.3			35			6.7			13.1
Jun-05	10	22.5	22.6		6.5	5.2		36	35		7.1	6.7		10.8	11.8	
Jun-05	11			21.4			3.7			35			6.5			7.5
Jun-05	13	18.9	19.1	19.1	2.4	1.3	1.3	37	36	37	6.8	6.4	6.4	5.9	4.8	5.9
Jun-05	15			17.4			0.7			40			6.4			4.1
Jun-05	16	16.1	16.4		0.8	0.6		43	42		6.7	6.5		4.5	3.5	
Jun-05	19	14.3	14.4		0.5	0.5		49	50		6.7	6.5		3.7	3.7	
Jun-05	22	13.1	13.4		0.4	0.5		55	54		6.7	6.6		3.2	3.5	
Jun-05	25	13.1			0.4			55			6.7			3.0		
Jun-05	28	12.3			0.4			62			6.8			2.5		
Jun-05	30	12.1			0.4			71			6.8			2.5		
Jul-05	1	29.3	29.5	29.6	6.8	7.6	7.7	36	36	36	7.2	7.1	7.2	3.7	3.5	3.5
Jul-05	3			29.4			7.7			36			7.1			4.0
Jul-05	4	29.3	29.3		7.1	7.7		36	36		7.2	7.1		4.0	4.0	
Jul-05	5			29.3			7.7			36			7.1			3.9
Jul-05	7	29.2	29.2	29.2	7.1	7.6	7.8	36	36	36	7.2	7.0	7.2	4.0	4.3	3.7
Jul-05	9			26.7			3.8			38			6.3			9.5
Jul-05	10	26.4	26.2	25.6	1.7	2.8	1.2	38	37	39	6.3	6.1	6.2	10.3	10.3	11.6
Jul-05	12			22.4			0.6			48			6.3			11.6
Jul-05	13	20.4	19.4		0.6	1.2		50	51		6.4	6.1		13.8	16.3	
Jul-05	16	16.0	16.0		0.4	0.7		56	56		6.4	6.0		33.7	30.7	
Jul-05	19	14.5	14.4		0.3	0.6		63	64		6.5	6.1		31.3	29.7	
Jul-05	22	13.4	13.0		0.3	0.6		70	74		6.6	6.2		11.8	8.1	
Jul-05	25	12.5	12.4		0.3	0.6		81	83		6.7	6.3		5.4	5.4	
Aug-05	1	30.1			7.7			37			7.3			3.5		
Aug-05	4	29.9			7.9			37			7.3			4.9		
Aug-05	7	28.9			7.5			37			6.9			5.4		
Aug-05	10	27.8			3.8			37			6.0			9.3		
Aug-05	13	23.4			0.8			53			5.8			23.1		
Aug-05	16	17.7			0.5			58			6.1			37.2		
Aug-05	19	14.9			0.4			67			5.9			50.0		
Aug-05	22	13.4			0.4			79			6.1			16.8		
Aug-05	25	12.6			0.3			90			6.6			9.1		

Appendix 5. Summary of physical properties at various depths for Upper South Branch Lunga Reservoir near Garrisonville, Virginia (01660470) and cross-section profiling points (fig. 5, site 5).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; A-1 and A-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660470	A-1	A-2	01660470	A-1	A-2	01660470	A-1	A-2	01660470	A-1	A-2	01660470	A-1	A-2
Sep-04	1	25.1	25.2	25.2	7.8	8.4	8.4	32	32	32	6.4	6.4	6.4	6.5	6.5	6.8
Sep-04	2	25.1	25.2	25.2	7.8	8.2	8.1	33	32	33	6.4	6.4	6.4	6.0	6.5	8.1
Sep-04	3	25.0	25.1	25.1	7.5	7.7	7.6	33	32	33	6.4	6.4	6.4	5.3	6.0	6.9
Sep-04	4	24.8	24.9	24.9	6.4	7.5	6.8	32	32	33	6.3	6.4	6.3	5.5	5.6	6.1
Oct-04	1	14.7	14.7	14.8	9.4	9.5	9.4	34	34	34	6.2	6.1	6.1	4.8	5.0	7.0
Oct-04	2	14.7	14.7	14.8	9.3	9.5	9.3	34	34	34	6.3	6.2	6.2	4.8	5.5	6.4
Oct-04	3	14.7	14.6	14.7	9.3	9.4	9.1	34	35	34	6.3	6.2	6.3	5.0	4.5	4.6
Oct-04	4	14.6	14.6	14.6	9.2	9.1	9.0	34	34	34	6.3	6.2	6.2	4.5	4.3	5.1
Nov-04	1	10.3	10.2	10.5	9.8	10.1	10.1	34	34	34	5.1	5.4	5.5	4.0	4.6	3.7
Nov-04	2	10.2	10.0	10.4	9.8	10.0	9.9	34	34	34	5.2	5.4	5.6	3.7	4.4	4.1
Nov-04	3	10.1	9.9	10.2	9.8	10.0	9.9	34	34	34	5.2	5.4	5.6	3.9	3.4	4.1
Nov-04	4	9.7	9.8	9.7	9.7	10.0	9.8	33	33	33	5.3	5.4	5.5	2.9	4.0	2.7
Dec-04	1	6.7	6.4	6.7	10.8	11.3	10.9	31	31	31	4.8	5.0	5.2	2.7	2.9	2.5
Dec-04	2	6.7	6.4	6.7	10.8	11.0	10.8	31	31	31	4.8	5.0	5.2	2.7	2.4	2.5
Dec-04	3	6.6	6.5	6.7	10.8	10.9	10.7	31	31	32	4.9	5.1	5.2	2.7	2.4	2.7
Dec-04	4	6.6		6.7	10.8		10.7	31		31	4.9		5.3	3.0		3.7
Feb-05	1	7.1	7.1	7.4	13.0	12.7	12.6	29	29	29	7.3	7.0	6.9	2.0	3.4	4.5
Feb-05	2	7.1	6.9	7.5	13.0	12.8	12.6	29	29	29	7.2	7.0	6.9	2.2	3.0	3.2
Feb-05	3	6.7	6.5	7.3	13.1	13.0	12.6	29	29	29	7.1	6.9	7.0	3.4	3.7	4.0
Feb-05	4	6.7	6.6	6.6	13.9	13.4	13.0	28	28	29	7.1	6.9	6.9	19.6	27.3	7.0
Mar-05	1	7.0	7.1	6.6	13.9	13.6	13.6	30	30	30	7.4	7.5	7.8	0.5	-0.4	3.2
Mar-05	2	7.0	7.1	6.6	13.9	13.8	13.8	30	30	30	7.4	7.5	7.7	3.2	2.0	3.4
Mar-05	3	6.9	7.1	6.6	13.9	13.9	13.8	30	30	30	7.4	7.5	7.6	2.7	14.5	3.2
Mar-05	4	6.9	7.2	6.7	14.1	14.2	13.9	30	30	30	7.7	8.4	7.9	43.0	57.5	28.3
Apr-05	1	16.8	16.7	16.8	12.6	10.9	10.9	30	30	30	7.1	7.1	7.3	4.4	4.8	4.4
Apr-05	2	16.8	16.7	16.8	12.4	10.9	10.8	30	30	30	7.1	7.1	7.3	4.6	11.6	5.5
Apr-05	3	16.7	16.5	16.8	12.5	11.2	10.8	30	29	30	7.1	7.2	7.3	6.8	119.4	4.6
Apr-05	4	16.5		16.7	12.6		10.9	29		30	7.2		7.6	46.0		71.3
Apr-05	5			16.7			11.0			31			7.8			84.4
May-05	1	19.8	19.9	19.9	10.1	9.9	9.4	33	34	33	7.5	7.5	7.5			
May-05	2	19.9	19.9	19.9	10.3	10.1	10.0	33	34	33	7.5	7.5	7.5		NO MAY CHLOROPHYLL VALUES	
May-05	3	19.8	19.9	19.9	10.4	10.3	10.0	33	34	33	7.7	7.5	7.5			
May-05	4	19.8	20.0	19.9	10.4	10.4	10.1	34	33	33	7.8	7.7	7.5			
May-05	5			19.6			9.6			34			7.4			
Jun-05	1	24.4	25.7	26.0	7.6	7.8	8.5	37	37	36	7.3	7.2	7.1	8.0	5.3	4.4
Jun-05	2	24.4	25.7	26.0	7.6	7.8	8.4	37	37	36	7.3	7.1	7.1	8.6	5.4	5.1
Jun-05	3	24.2	24.6	25.0	7.5	7.7	7.6	37	37	37	7.2	7.0	7.0	9.1	6.9	7.8
Jun-05	4	24.2		24.4	7.0		7.2	37		37	7.2		6.9	11.6		9.5
Jun-05	4.5			24.3			7.2			37			6.9			10.3
Jul-05	1	29.2	29.3	29.3	6.8	7.3	7.4	37	37	37	6.8	6.8	6.8	8.0	8.0	10.1
Jul-05	2	29.2	29.2	29.2	6.9	7.1	7.4	37	37	37	6.8	6.8	6.8	7.3	10.6	11.8
Jul-05	3	29.2	29.1	29.0	6.9	7.0	7.1	37	37	37	6.8	6.7	6.7	7.5	10.1	11.8
Jul-05	3.5	29.1	29.0	28.9	6.8	6.8	7.1	37	37	37	6.8	6.6	6.7	8.0	8.0	10.3
Aug-05	1	28.8			6.6			37			6.7			8.3		
Aug-05	2	28.8			6.6			37			6.6			8.6		
Aug-05	3	28.9			6.6			37			6.5			8.3		
Aug-05	3.5	28.8			6.6			37			6.4			8.1		

Appendix 6. Summary of physical properties at various depths for Lower South Branch Lunga Reservoir near Garrisonville, Virginia (01660480) and cross-section profiling points (fig. 5, site 6).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; B-1 and B-2, cross-section profiling points; <, less than]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2
Sep-04	1	24.1	24.2	24.1	5.5	5.7	5.7	33	32	33	6.1	6.2	6.3	<1.0	<1.0	<1.0
Sep-04	3	24.1	24.2	24.2	6.0	5.8	5.7	33	32	32	6.5	6.3	6.3	<1.0	<1.0	<1.0
Sep-04	5	24.1	24.2	24.1	5.8	5.8	5.7	33	32	32	6.5	6.5	6.4	<1.0	<1.0	<1.0
Sep-04	7	24.1	24.1	24.1	5.7	5.8	5.7	33	32	33	6.5	6.6	6.5	<1.0	<1.0	<1.0
Sep-04	9	24.1	24.1	24.1	5.7	5.8	5.7	33	32	33	6.5	6.5	6.5	<1.0	<1.0	<1.0
Sep-04	11	24.1	24.1	24.1	5.7	5.8	5.7	33	32	33	6.5	6.6	6.5	<1.0	<1.0	<1.0
Sep-04	13	24.0	23.9	24.1	5.6	5.5	5.5	33	33	33	6.5	6.6	6.5	<1.0	<1.0	<1.0
Sep-04	15	21.4	21.6	21.5	0.3	0.6	1.1	62	60	61	6.2	6.3	6.3	17.7	16.3	16.2
Sep-04	17	18.9	18.5	18.8	0.3	0.3	0.4	76	77	76	6.2	6.3	6.3	34.2	34.7	35.0
Sep-04	19	16.0	16.2		0.2	0.2		82	82		6.2	6.3		18.0	21.7	
Sep-04	21	14.3			0.1			88			6.3			7.4		
Sep-04	23	13.4			0.1			97			6.3			3.0		
Oct-04	1	15.4	15.5	15.6	10.2	11.2	11.3	35	35	35	6.0	6.4	6.2	8.3	8.8	9.8
Oct-04	3	15.4	15.4	15.4	10.2	10.8	10.7	35	35	35	6.0	6.5	6.4	8.1	9.3	9.3
Oct-04	5	15.4	15.4	15.4	10.2	10.6	10.4	35	35	36	6.0	6.5	6.4	8.6	8.6	7.3
Oct-04	7	15.4	15.2	15.2	10.2	10.1	9.6	35	35	36	6.0	6.4	6.4	8.1	5.8	5.1
Oct-04	9	15.3	15.1	15.1	10.0	9.7	9.3	35	35	36	6.0	6.4	6.4	6.8	5.0	4.8
Oct-04	11	15.1	15.1	15.1	9.5	9.5	9.3	36	35	35	6.0	6.4	6.3	5.4	5.5	4.8
Oct-04	13	15.1	15.1	15.1	9.4	9.4	9.3	35	35	35	6.0	6.4	6.3	5.6	5.8	4.5
Oct-04	15	15.1	15.0		9.4	9.4		35	35		6.0	6.4		5.5	5.0	
Oct-04	17	15.0	15.0		9.4	9.3		35	35		5.9	6.3		5.5	5.5	
Oct-04	19	15.0	14.9		9.2	9.2		35	35		5.9	6.3		5.3	5.1	
Oct-04	21	15.0	14.9		9.1	9.1		35	35		5.9	6.3		5.3	4.9	
Oct-04	23	14.9	14.9		9.1	8.9		35	36		5.9	6.3		5.5	5.0	
Oct-04	25	14.9	14.8		8.8	8.3		36	38		5.9	6.2		6.0	4.8	
Oct-04	27	14.8			8.3			37			5.9			4.9		
Nov-04	1	10.8	11.1	11.1	10.1	10.3	10.0	35	35	35	5.4	6.3	6.1	4.3	2.9	3.0
Nov-04	3	10.8			9.9			35			5.5			5.1		
Nov-04	4		10.9	10.8		10.2	9.9		35	35		6.3	6.2		5.9	4.5
Nov-04	5	10.8			9.8			35			5.6			5.1		
Nov-04	7	10.8	10.8	10.8	9.8	10.1	9.8	35	35	35	5.6	6.3	6.2	4.9	5.1	4.8
Nov-04	9	10.8			9.8			35			5.6			5.0		
Nov-04	10		10.7	10.7		10.1	9.7		35	35		6.3	6.2		4.5	4.5
Nov-04	11	10.7			9.7			35			5.6			5.1		
Nov-04	13	10.7	10.6	10.6	9.6	10.0	9.7	35	35	35	5.7	6.3	6.2	4.3	4.5	4.5
Nov-04	15	10.6			9.6			35			5.7			4.6		
Nov-04	16		10.5	10.6		9.9	9.6		35	35		6.3	6.2		4.1	4.5
Nov-04	17	10.6			9.7			35			5.7			4.8		
Nov-04	19	10.4	10.5	10.5	9.7	9.7	9.5	35	35	35	5.7	6.2	6.2	4.3	4.6	3.7
Nov-04	21	10.4			9.7			35			5.7			4.5		
Nov-04	22		10.4			9.6			35			6.2			4.5	
Nov-04	23	10.2			9.6			35			5.7			4.8		
Nov-04	25	10.1	9.9		9.3	9.6		34	35		5.7	6.2		4.0	3.7	
Nov-04	26	10.0			9.1			34			5.7			4.1		

Appendix 6. Summary of physical properties at various depths for Lower South Branch Lunga Reservoir near Garrisonville, Virginia (01660480) and cross-section profiling points (fig. 5, site 6).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; B-1 and B-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2
Dec-04	1	7.0	7.0	7.1	11.3	10.9	10.3	34	34	34	6.3	6.1	6.3	3.0	2.5	3.0
Dec-04	4	7.0	7.0	7.1	11.2	10.7	10.3	34	34	34	6.3	6.0	6.3	4.0	3.2	2.5
Dec-04	7	7.0	7.0	7.1	11.1	10.6	10.3	34	34	34	6.3	6.1	6.4	3.5	3.9	4.1
Dec-04	10	7.0	7.0	7.1	11.1	10.6	10.2	34	34	34	6.3	6.2	6.3	4.5	3.5	3.7
Dec-04	13	7.0	7.0	7.1	11.1	10.6	10.2	34	34	34	6.3	6.2	6.3	4.1	3.5	4.0
Dec-04	16	7.0	7.0	7.1	11.1	10.5	10.2	34	34	34	6.3	6.3	6.3	4.0	3.5	3.5
Dec-04	19	7.0	7.0	7.1	11.1	10.5	10.2	34	34	34	6.3	6.4	6.3	3.7	3.4	3.7
Dec-04	22	6.9			11.1			34			6.3			4.0		
Dec-04	25	6.9			11.0			34			6.3			3.5		
Feb-05	1	4.9	5.2	5.3	11.8	11.9	11.9	32	32	32	7.4	6.9	6.8	4.0	7.0	6.3
Feb-05	3	4.9			11.7			32			7.3			6.9		
Feb-05	4		5.2	5.2		12.0	11.9		32	32		6.8	6.8		7.4	8.0
Feb-05	5	4.9			11.7			32			7.4			7.0		
Feb-05	7	4.8	5.2	5.3	11.7	12.0	11.9	32	32	32	7.4	6.8	6.8	9.1	8.1	8.1
Feb-05	9	4.8			11.7			32			7.3			8.8		
Feb-05	10		5.2	5.3		12.0	11.9		32	32		6.8	6.8		8.1	7.5
Feb-05	11	4.7			11.7			32			7.3			8.8		
Feb-05	13	4.7	4.8	5.3	11.6	12.0	11.9	32	32	32	7.4	6.8	6.8	8.5	8.3	8.1
Feb-05	15	4.6		5.3	11.6		11.9	32		32	7.3		6.8	9.1		7.9
Feb-05	16		4.7			11.9			32			6.8			8.1	
Feb-05	17	4.5			11.6			32			7.3			8.5		
Feb-05	19	4.5	4.6		11.5	11.8		32	32		7.3	6.8		8.5	8.8	
Feb-05	21	4.4			11.5			32			7.3			8.3		
Feb-05	22		4.7			11.8			32			6.8			8.8	
Feb-05	25		4.6			11.8			32			6.8			8.3	
Mar-05	1	6.7			13.3			32			7.3			5.3		
Mar-05	4	6.7			13.4			32			7.2			7.3		
Mar-05	7	6.6			13.4			32			7.2			7.5		
Mar-05	10	6.6			13.4			32			7.2			9.3		
Mar-05	13	6.5			13.4			32			7.2			11.1		
Mar-05	16	6.5			13.4			32			7.2			11.3		
Mar-05	19	6.4			13.4			32			7.1			10.5		
Mar-05	22	6.4			13.3			32			7.1			10.0		
Mar-05	24	6.3			13.3			33			7.1			10.5		
Apr-05	1	15.5	15.6	15.5	12.4	11.4	11.4	32	32	32	7.3	7.2	7.3	6.1	5.9	4.8
Apr-05	3	15.5			12.4			32			7.3			7.8		
Apr-05	4		15.7	15.5		11.2	11.3		32	32		7.4	7.3		6.5	7.0
Apr-05	5	15.4			12.3			32			7.3			8.1		
Apr-05	7	15.4	15.5	15.4	12.3	11.1	11.3	32	32	32	7.3	7.4	7.4	8.3	7.0	8.1
Apr-05	9	14.7			12.8			32			7.4			10.6		
Apr-05	10		14.4	15.2		11.4	11.3		32	32		7.4	7.4		10.3	9.6
Apr-05	11	12.4			13.4			32			7.4			15.0		
Apr-05	13	11.8	12.1	11.7	13.4	11.9	11.9	32	32	32	7.3	7.3	7.3	16.1	15.6	16.0
Apr-05	14			11.3			11.5			32			7.1			16.5
Apr-05	15	11.0			13.0			32			7.1			18.2		
Apr-05	16		10.8			11.3			32			7.0			16.2	
Apr-05	17	10.8			12.2			32			6.8			17.1		
Apr-05	19	10.1	10.6		11.6	10.8		33	32		6.6	6.8		11.6	14.8	
Apr-05	21	10.1			10.6			33			6.6			11.6		
Apr-05	22	10.1	10.5		10.4	10.5		33	32		6.6	6.7		13.1	14.6	
Apr-05	25		10.2			10.2			33			6.6			13.1	

Appendix 6. Summary of physical properties at various depths for Lower South Branch Lunga Reservoir near Garrisonville, Virginia (01660480) and cross-section profiling points (fig. 5, site 6).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; B-1 and B-2, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)			Dissolved oxygen (mg/L)			Specific conductance (µS/cm)			pH (units)			Total chlorophyll (µg/L)		
		01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2	01660480	B-1	B-2
May-05	1	20.9	21.0	21.4	9.7	9.7	9.7	32	32	32	7.4	7.3	7.3			
May-05	3			20.9			9.9			32			7.5			
May-05	4	20.6	20.7		9.8	9.9		32	32		7.5	7.4				
May-05	5			20.6			9.9			32			7.5			
May-05	7	20.5	20.5	20.4	9.8	9.9	9.8	32	32	32	7.5	7.4	7.5			
May-05	9			20.3			9.7			32			7.4		NO MAY CHLOROPHYLL VALUES	
May-05	10	19.5	19.8		10.3	10.0		32	32		7.5	7.4				
May-05	11			19.1			10.2			32			7.4			
May-05	13	16.6	16.4	16.6	9.8	9.3	9.9	32	32	32	7.3	6.9	7.2			
May-05	16	15.5	15.5		7.8	7.2		33	33		6.8	6.4				
May-05	19	14.4	14.8		6.1	5.4		34	34		6.4	6.2				
May-05	22	13.6			3.8			36			6.2					
Jun-05	1	26.0	27.2	27.3	8.9	8.7	8.9	35	35	35	7.3	7.2	7.1	5.6	4.5	5.5
Jun-05	3	25.8	25.9	26.1	8.9	8.9	9.0	35	35	35	7.3	7.3	7.2	8.8	8.0	7.8
Jun-05	5	25.8	25.6	25.7	8.9	9.0	9.1	35	35	35	7.3	7.3	7.2	8.3	8.3	8.5
Jun-05	7	25.5	25.5	25.5	8.9	8.8	9.0	35	35	35	7.4	7.3	7.3	9.0	9.1	9.6
Jun-05	9	25.1	25.0	25.0	8.2	7.6	8.0	35	35	35	7.3	7.1	7.1	13.0	11.1	13.5
Jun-05	11	21.1	20.9	21.2	4.2	3.0	3.1	36	36	37	6.9	6.6	6.6	8.5	7.4	8.0
Jun-05	12			19.6			1.7			36			6.5			5.4
Jun-05	13	18.6	18.7		1.6	1.0		36	36		6.7	6.5		4.6	5.1	
Jun-05	15	17.2	16.9		0.8	0.6		40	41		6.7	6.5		4.6	4.5	
Jun-05	17	16.0	16.1		0.6	0.4		44	44		6.7	6.5		4.1	4.5	
Jun-05	19	14.8			0.5			49			6.6			4.5		
Jun-05	21	13.9			0.5			55			6.6			3.7		
Jun-05	22	13.5			0.5			56			6.6			3.4		
Jul-05	1	29.4	29.5	29.4	7.3	7.7	7.6	36	36	36	7.2	7.1	7.2	3.7	3.5	3.2
Jul-05	3	29.4		29.4	7.3		7.6	36		36	7.1		7.2	4.4		3.4
Jul-05	4		29.4			7.6			36			7.1			3.2	
Jul-05	5	29.4		29.3	7.3		7.6	36		36	7.1		7.2	4.4		3.9
Jul-05	7	28.8	29.1	29.1	5.7	7.4	7.1	36	36	36	6.6	6.9	6.9	6.6	4.8	6.0
Jul-05	9	27.3		27.0	3.5		2.8	36		36	6.3		6.2	13.5		15.6
Jul-05	10		25.1			1.7			38			6.1			9.5	
Jul-05	11	24.2		23.7	1.3		1.4	41		43	6.2		6.2	8.8		9.6
Jul-05	13	20.6	20.8		0.5	0.9		51	51		6.3	6.2		15.5	13.3	
Jul-05	15	17.9			0.4			53			6.2			24.5		
Jul-05	16		17.1			0.8			54			6.1			28.0	
Jul-05	17	15.7			0.4			58			6.2			36.5		
Jul-05	19	15.2	14.9		0.3	0.7		62	64		6.3	6.2		38.2	36.4	
Jul-05	22		13.4			0.7			77			6.3			19.0	
Aug-05	1	29.8			7.6			37			7.1			3.7		
Aug-05	3	29.8			7.6			37			7.1			5.4		
Aug-05	5	29.5			7.8			37			7.0			5.4		
Aug-05	7	28.9			7.4			37			6.8			5.5		
Aug-05	9	28.4			6.6			37			6.4			5.8		
Aug-05	11	27.4			3.6			38			6.0			7.9		
Aug-05	13	23.5			0.8			54			5.7			24.7		
Aug-05	15	19.3			0.5			55			5.6			31.5		
Aug-05	17	16.9			0.4			60			6.0			38.5		
Aug-05	18	15.9			0.3			64			6.1			48.5		

Appendix 7. Summary of physical properties at various depths for Lunga Reservoir at water intake near Garrisonville, Virginia (01660489) and cross-section profiling points (fig. 5, site 8).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; D-1, D-2, and D-3, cross-section profiling points; <, less than]

Sample date	Depth (ft)	Water temperature (°C)				Dissolved oxygen (mg/L)				Specific conductance (µS/cm)				pH (units)				Total chlorophyll (µg/L)			
		01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3
Sep-04	1	24.0	24.0	24.0	24.0	5.3	5.5	5.2	5.6	33	33	33	33	6.3	6.7	6.6	6.5	<1.0	<1.0	<1.0	<1.0
Sep-04	3	24.1	24.0	24.0	24.0	5.4	5.6	5.3	5.5	33	33	33	33	6.3	6.7	6.5	6.5	<1.0	<1.0	<1.0	<1.0
Sep-04	5	24.1	24.0	24.0	23.9	5.3	5.5	5.3	5.1	33	33	33	33	6.3	6.7	6.5	6.4	<1.0	<1.0	<1.0	<1.0
Sep-04	7	24.1	24.0	24.0	23.9	5.6	5.5	5.2	5.0	33	33	33	33	6.3	6.6	6.5	6.4	<1.0	<1.0	<1.0	<1.0
Sep-04	9	24.0	24.0	24.0	23.9	5.2	4.9	5.2	4.8	33	33	33	33	6.3	6.5	6.5	6.4	<1.0	<1.0	<1.0	<1.0
Sep-04	11	23.8	23.8	24.0	23.8	2.4	2.6	5.0	4.9	34	34	33	33	6.2	6.3	6.5	6.4	<1.0	<1.0	<1.0	<1.0
Sep-04	13	23.6	23.7	23.8		1.0	1.3	3.8		35	34	33		6.1	6.3	6.4		<1.0	<1.0	<1.0	
Sep-04	15	22.3	22.0	23.6		0.3	0.5	2.2		50	52	35		6.2	6.3	6.3		<1.0	<1.0	<1.0	
Sep-04	17	18.8	19.3	22.0		0.2	0.3	0.5		72	72	54		6.2	6.4	6.3		31.7	32.7	6.9	
Sep-04	19	15.9				0.1				83				6.2				18.2			
Sep-04	21	14.6				0.1				84				6.3				7.0			
Sep-04	23	13.5				0.1				88				6.3				2.4			
Sep-04	25	12.9				0.1				88				6.3				0.1			
Sep-04	27	12.5				0.1				91				6.3				0.1			
Sep-04	29	12.2				0.1				92				6.3				0.1			
Sep-04	31	12.0				0.1				96				6.3				0.1			
Sep-04	33	11.9				0.1				102				6.3				0.1			
Sep-04	35	11.7				0.1				121				6.3				1.7			
Sep-04	37	11.5				0.1				125				6.3				2.4			
Sep-04	39	11.4				0.1				129				6.4				3.0			
Oct-04	1	15.4	15.5	15.6	15.8	10.2	11.0	10.6	10.7	36	36	36	36	6.0	6.3	6.3	6.3	6.6	8.3	5.9	5.8
Oct-04	2		15.5				10.7				36				6.4				7.8		
Oct-04	3		15.5	15.5	15.5		10.6	10.5	10.4		36	36	36		6.4	6.3	6.3		7.5	7.1	6.4
Oct-04	4	15.4	15.4			10.2	10.5			36	36			6.3	6.4			6.1	8.3		
Oct-04	5		15.4	15.4	15.4		10.4	10.4	10.0		36	36	36		6.4	6.3	6.3		8.3	6.9	5.5
Oct-04	6		15.4				10.4				36				6.4				7.9		
Oct-04	7	15.4	15.4	15.3	15.4	10.2	10.4	9.7	9.8	36	36	36	36	6.3	6.4	6.3	6.3	6.5	7.9	5.5	5.0
Oct-04	8		15.4				10.4				36				6.4				6.0		
Oct-04	9		15.4	15.1	15.2		10.2	8.4	9.2		36	37	36		6.4	6.3	6.3		5.4	4.1	4.9
Oct-04	10	15.3				9.7				36				6.4				5.8			
Oct-04	11			15.1	15.1			8.3	8.6			37	36			6.2	6.3			4.0	4.4
Oct-04	13	15.1				9.4				36				6.3				5.1			
Oct-04	16	15.0				8.9				36				6.3				4.8			
Oct-04	19	15.0				8.4				37				6.2				4.5			
Oct-04	22	14.9				8.1				38				6.2				4.4			
Oct-04	25	14.9				7.7				38				6.1				4.5			
Oct-04	28	14.3				6.3				52				6.0				4.0			
Oct-04	31	12.6				3.6				114				5.9				5.5			
Oct-04	34	11.9				2.4				142				5.9				7.0			
Oct-04	37	11.7				1.6				161				5.9				6.8			
Oct-04	40	11.6				1.1				173				6.0				7.5			

Appendix 7. Summary of physical properties at various depths for Lunga Reservoir at water intake near Garrisonville, Virginia (01660489) and cross-section profiling points (fig. 5, site 8).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; D-1, D-2, and D-3, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)				Dissolved oxygen (mg/L)				Specific conductance (µS/cm)				pH (units)				Total chlorophyll (µg/L)			
		01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3
Nov-04	1	10.9	11.2	11.2	11.3	10.0	10.0	10.1	9.9	35	35	35	35	5.9	6.6	6.4	6.3	5.0	2.5	3.5	3.7
Nov-04	3		11.2	11.1	11.2		9.9	10.0	9.8		35	35	35		6.6	6.4	6.3		4.0	4.3	4.1
Nov-04	4	10.9				10.2				35				6.0				5.1			
Nov-04	5		11.1	11.1	11.2		9.8	9.9	9.8		35	35	35		6.5	6.4	6.3		4.5	5.0	4.5
Nov-04	7	10.9	11.1	11.1	11.0	10.1	9.8	9.9	9.8	35	35	35	35	6.0	6.5	6.4	6.3	5.3	5.0	4.5	4.5
Nov-04	9		11.1	11.0	10.8		9.7	9.8	9.6		35	35	35		6.5	6.3	6.3		4.8	5.3	3.5
Nov-04	10	10.9				10.0				35				6.0				4.8			
Nov-04	11		11.0	11.0	10.7		9.7	9.8	9.4		35	35	35		6.4	6.3	6.2		4.5	5.5	3.0
Nov-04	12		11.0				9.7				35				6.4				4.9		
Nov-04	13	10.9				9.9				35				6.0				5.3			
Nov-04	16	10.9				9.9				35				6.0				5.0			
Nov-04	19	10.7				9.7				35				6.0				4.0			
Nov-04	22	10.6				9.4				35				6.0				3.4			
Nov-04	25	10.4				9.2				35				6.0				4.5			
Nov-04	28	10.3				9.1				35				6.0				3.9			
Nov-04	31	10.3				9.0				35				6.0				3.5			
Nov-04	34	10.3				9.0				35				5.9				3.5			
Nov-04	36	10.3				8.9				35				5.9				3.9			
Dec-04	1	7.2	7.3	7.1	7.3	11.0	10.3	9.9	9.7	34	34	34	34	6.2	6.1	6.4	6.3	4.0	3.0	3.0	3.0
Dec-04	3		7.2	7.2	7.3		10.2	9.9	9.7		34	34	34		6.4	6.3	6.3		4.8	3.5	3.7
Dec-04	4	7.2				10.9				34				6.3				4.3			
Dec-04	5		7.2	7.2	7.2		10.1	9.9	9.6		34	34	34		6.5	6.3	6.2		3.5	3.5	3.7
Dec-04	7	7.2	7.2	7.2	7.2	10.9	10.0	9.9	9.6	34	34	34	34	6.3	6.4	6.3	6.3	3.4	4.4	4.3	3.5
Dec-04	9		7.2	7.2	6.9		10.0	9.9	9.6		34	34	34		6.4	6.3	6.3		4.0	3.5	4.0
Dec-04	10	7.2				10.8				34				6.3				3.9			
Dec-04	11		7.2	7.1	6.7		10.0	9.8	9.6		34	34	34		6.3	6.3	6.3		3.7	4.0	4.1
Dec-04	12		7.2				9.9				34				6.3				4.0		
Dec-04	13	7.2		6.9		10.8		9.8		34		34		6.3		6.3		4.0		4.1	
Dec-04	16	7.2				10.8				34				6.3				3.5			
Dec-04	19	7.2				10.8				34				6.2				4.0			
Dec-04	22	7.2				10.7				34				6.3				4.1			
Dec-04	25	7.2				10.7				34				6.3				4.3			
Dec-04	28	7.1				10.7				34				6.2				3.9			
Dec-04	31	7.1				10.7				34				6.2				3.7			
Dec-04	34	7.1				10.7				34				6.2				3.2			
Dec-04	37	7.0				10.7				34				6.2				3.5			
Dec-04	40	7.0				10.7				34				6.2				3.2			
Feb-05	1	4.6	4.7	4.7	4.8	11.4	11.5	11.6	11.7	32	32	32	32	7.2	7.3	7.2	7.3	7.5	3.7	5.0	6.0
Feb-05	3		4.6	4.6	4.8		11.6	11.6	11.6		32	32	32		7.2	7.2	7.3		5.5	4.9	7.3
Feb-05	4	4.5				11.4				32				7.2				9.6			
Feb-05	5		4.6	4.6	4.8		11.5	11.6	11.6		32	32	32		7.2	7.2	7.2		5.9	5.5	7.8
Feb-05	7	4.4	4.6	4.6	4.8	11.4	11.5	11.6	11.6	32	32	32	32	7.2	7.2	7.2	7.2	9.1	7.5	7.1	8.3
Feb-05	9		4.5	4.6	4.8		11.5	11.6	11.6		32	32	32		7.0	7.1	7.2		7.8	7.4	7.9
Feb-05	10	4.4		4.6		11.4		11.6		32		32		7.2		7.1		9.5		7.8	
Feb-05	11		4.5		4.8		11.5		11.6		32		32		7.1		7.2		8.1		8.3
Feb-05	13	4.4	4.5			11.3	11.5			32	32			7.3	7.1			8.5	8.3		
Feb-05	15		4.5				11.5				32				7.1				9.3		
Feb-05	16	4.4				11.3				32				7.2				8.6			
Feb-05	19	4.4				11.3				32				7.2				9.6			
Feb-05	22	4.4				11.3				32				7.2				9.6			
Feb-05	25	4.4				11.3				32				7.2				8.3			
Feb-05	28	4.4				11.3				32				7.2				9.3			
Feb-05	31	4.4				11.2				32				7.2				9.1			
Feb-05	34	4.4				11.2				32				7.2				8.5			
Feb-05	37	4.4				11.2				32				7.2				8.6			
Feb-05	40	4.4				11.1				33				7.2				9.5			

Appendix 7. Summary of physical properties at various depths for Lunga Reservoir at water intake near Garrisonville, Virginia (01660489) and cross-section profiling points (fig. 5, site 8).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; D-1, D-2, and D-3, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)				Dissolved oxygen (mg/L)				Specific conductance (µS/cm)				pH (units)				Total chlorophyll (µg/L)			
		01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3
03/15/05	1	6.6	6.4	6.1	6.0	13.3	13.3	13.3	13.3	33	33	33	33	7.1	7.1	7.1	7.1	9.0	6.0	4.1	6.0
03/15/05	2		6.4				13.3				33				7.1				5.0		
03/15/05	3		6.4	6.1	6.0		13.3	13.3	13.3		33	33	33		7.1	7.1	7.1		4.8	4.4	7.6
03/15/05	4	6.6	6.4			13.3	13.3			33	33			7.1	7.1			9.3	4.3		
03/15/05	5		6.4	6.1	6.0		13.3	13.3	13.3		33	33	33		7.1	7.1	7.1		5.0	6.1	9.1
03/15/05	7	6.6		6.0	6.0	13.3		13.3	13.3	33		33	33	7.1		7.1	7.1	10.6		7.0	10.0
03/15/05	8			6.1				13.3				33				7.1				9.6	
03/15/05	9				6.1				13.3				33				7.1				10.8
03/15/05	10	6.6				13.2				33				7.1				10.8			
03/15/05	11				6.0				13.3				33				7.1				10.3
03/15/05	13	6.6				13.2				33				7.1				10.6			
03/15/05	16	6.6				13.3				33				7.1				10.6			
03/15/05	19	6.6				13.2				33				7.1				10.0			
03/15/05	22	6.6				13.3				33				7.1				10.3			
03/15/05	25	6.6				13.3				33				7.1				9.6			
03/15/05	28	6.6				13.3				33				7.1				10.5			
03/15/05	31	6.6				13.3				33				7.1				10.3			
03/15/05	34	6.6				13.3				33				7.1				10.0			
03/15/05	37	6.5				13.3				33				7.1				11.0			
03/15/05	39	6.5				13.2				33				7.1				11.0			
04/12/05	1	15.3	15.4	15.3	15.3	12.3	11.3	11.6	11.9	32	32	32	32	7.3	7.4	7.4	7.4	7.6	4.5	5.5	6.0
04/12/05	3			15.3	15.2			11.6	11.8			32	32			7.4	7.4			7.5	6.8
04/12/05	4	15.2	15.3			12.3	11.3			31	32			7.4	7.4			8.3	6.0		
04/12/05	5			15.2	14.6			11.5	11.9			32	32			7.4	7.4			9.6	9.6
04/12/05	7	15.2	15.2	14.2	14.0	12.2	11.3	11.8	12.1	31	32	32	31	7.3	7.4	7.4	7.4	8.8	8.5	11.6	11.3
04/12/05	9			13.6	13.7			11.9	12.2			31	31			7.4	7.4			13.1	13.0
04/12/05	10	13.6	12.9			12.7	11.9			32	32			7.3	7.4			13.6	13.5		
04/12/05	11			12.6	12.5			12.2	12.4			32	31			7.4	7.4			16.2	15.8
04/12/05	13	11.8	11.3			13.2	11.7			32	32			7.3	7.2			17.3	16.7		
04/12/05	16	10.6	10.6			12.2	10.8			32	32			6.9	6.8			17.8	16.2		
04/12/05	18		10.5				10.6				32				6.8				15.0		
04/12/05	19	10.4				11.7				32				6.8				15.6			
04/12/05	22	10.1				11.1				33				6.7				12.1			
04/12/05	25	10.1				10.6				33				6.6				11.8			
04/12/05	28	10.0				10.2				33				6.6				11.8			
04/12/05	31	9.9				10.0				33				6.5				11.8			
04/12/05	34	9.9				9.7				34				6.5				11.1			
04/12/05	37	9.8				9.3				34				6.5				11.0			
04/12/05	39	9.7				8.5				35				6.5				12.1			
05/17/05	1	20.4	20.9	20.8	20.9	9.6	9.8	9.7	9.5	32	32	32	32	7.2	7.6	7.6	7.5				
05/17/05	3		20.9	20.8	20.8		9.8	9.8	9.7		32	32	32		7.6	7.7	7.6				
05/17/05	4	20.4				9.6				32				7.3							
05/17/05	5		20.5	20.6	20.5		9.8	9.8	9.8		32	32	32		7.6	7.7	7.6				
05/17/05	7	20.4	20.5	20.5	20.4	9.7	9.8	9.8	9.8	32	32	32	32	7.3	7.6	7.7	7.6				
05/17/05	9		20.4	20.4	20.4		9.7	9.8	9.8		32	32	32		7.6	7.7	7.6				
05/17/05	10	17.1				9.9				32				7.2							
05/17/05	11			19.7	19.8			9.8	9.4			32	33			7.6	7.5				
05/17/05	12			18.8				10.1				32				7.4					
05/17/05	13	17.0				9.6				32				7.1							
05/17/05	16	15.4				8.3				33				6.7							
05/17/05	19	14.6				5.9				34				6.3							
05/17/05	22	14.5				5.4				34				6.2							
05/17/05	25	12.9				3.7				36				6.1							
05/17/05	28	11.9				2.5				38				6.1							
05/17/05	31	11.5				1.9				38				6.1							
05/17/05	34	11.2				1.7				38				6.1							
05/17/05	37	10.7				1.0				42				6.1							
05/17/05	39	10.6				0.6				43				6.2							

NO MAY CHLOROPHYLL VALUES

Appendix 7. Summary of physical properties at various depths for Lunga Reservoir at water intake near Garrisonville, Virginia (01660489) and cross-section profiling points (fig. 5, site 8).—Continued

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; D-1, D-2, and D-3, cross-section profiling points]

Sample date	Depth (ft)	Water temperature (°C)				Dissolved oxygen (mg/L)				Specific conductance (µS/cm)				pH (units)				Total chlorophyll (µg/L)			
		01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3	01660489	D-1	D-2	D-3
Jun-05	1	25.8	27.4	27.5	27.3	8.5	9.0	8.9	8.8	35	35	35	35	7.2	7.1	7.1	7.1	8.8	3.9	4.5	5.4
Jun-05	3		26.4	26.2	26.1		9.3	9.4	9.2		35	35	35		7.2	7.3	7.2		7.5	6.5	8.8
Jun-05	4	25.8				9.1				35				7.3				9.5			
Jun-05	5		26.1	26.0	25.9		9.4	9.4	9.3		35	35	35		7.3	7.3	7.3		8.3	8.1	9.0
Jun-05	7	22.8	25.8	25.8	25.7	5.9	9.2	9.2	9.2	36	35	35	35	7.0	7.3	7.4	7.3	11.3	9.0	9.8	10.5
Jun-05	9		24.0	25.1	25.5		7.1	8.3	8.8		35	35	35		7.0	7.2	7.2		13.8	12.6	10.8
Jun-05	10	19.5				3.0				36				6.8				6.4			
Jun-05	11		21.0	20.7	20.3		3.2	2.8	2.9		37	37	38		6.6	6.6	6.6		7.0	7.0	7.1
Jun-05	13	16.6	18.3	18.4		1.3	0.7	0.7		41	37	38		6.7	6.4	6.5		4.0	4.8	5.6	
Jun-05	15		16.5				0.6				42				6.4				3.7		
Jun-05	16	15.3				0.6				46				6.7				4.5			
Jun-05	19	13.6				0.5				53				6.7				3.0			
Jun-05	22	12.8				0.5				56				6.7				3.0			
Jun-05	25	12.7				0.5				56				6.7				3.0			
Jun-05	28	12.2				0.4				59				6.8				2.4			
Jun-05	31	11.7				0.4				62				6.8				2.2			
Jun-05	34	11.1				0.4				78				6.8				2.7			
Jun-05	37	10.9				0.4				80				6.9				2.5			
Jul-05	1	29.2	29.4	29.4	29.4	6.8	7.5	7.4	7.5	36	36	36	36	7.1	7.1	7.1	7.2	4.0	3.2	2.9	3.7
Jul-05	3		29.3	29.4	29.4		7.6	7.7	7.7		36	36	36		7.1	7.2	7.2		3.5	3.9	3.5
Jul-05	4	29.3				7.2				36				7.2				3.5			
Jul-05	5		29.3	29.3	29.3		7.5	7.7	7.7		36	36	36		7.1	7.1	7.2		4.0	4.1	4.0
Jul-05	7	29.2	28.8	28.8	29.2	7.2	6.3	7.2	7.7	36	36	37	36	7.1	6.6	6.9	7.2	4.6	5.6	4.9	3.2
Jul-05	9		27.1	26.9	27.0		3.5	4.1	4.6		36	36	36		6.2	6.2	6.3		14.3	15.6	16.1
Jul-05	10	26.9			25.6	4.1			2.2	36			38	6.3			6.2	11.6			14.8
Jul-05	11		22.8	23.9			1.2	1.1			46	43			6.3	6.2			10.6	8.8	
Jul-05	13	20.7	20.8			1.1	0.8			50	50			6.3	6.2			12.3	12.3		
Jul-05	16	16.4				0.5				53				6.2				27.6			
Jul-05	19	15.0				0.4				62				6.3				32.5			
Jul-05	22	13.4				0.3				70				6.4				13.6			
Jul-05	25	12.5				0.3				75				6.5				4.6			
Jul-05	28	12.1				0.3				78				6.6				3.0			
Jul-05	31	11.7				0.3				84				6.6				2.7			
Jul-05	34	11.4				0.2				95				6.8				2.7			
Jul-05	37	11.4				0.2				96				6.9				2.9			
Jul-05	40	11.2				0.2				101				7.0				5.6			
Aug-05	1	29.8				7.6				37				7.3				4.0			
Aug-05	4	29.8				7.6				37				7.1				4.6			
Aug-05	7	28.8				7.5				37				7.3				4.8			
Aug-05	10	28.0				5.5				37				6.4				6.6			
Aug-05	13	23.9				2.7				50				5.9				22.0			
Aug-05	16	18.2				1.0				55				5.7				33.7			
Aug-05	19	15.1				0.6				71				5.8				47.7			
Aug-05	22	13.4				0.5				80				6.4				17.7			
Aug-05	25	12.6				0.3				90				6.2				7.3			
Aug-05	28	12.2				0.3				89				6.3				6.3			
Aug-05	31	11.8				0.3				95				6.7				6.0			
Aug-05	34	11.5				0.3				113				6.8				5.9			
Aug-05	37	11.6				0.3				112				6.6				6.4			
Aug-05	40	11.3				0.3				116				6.9				6.0			

Appendix 8. Summary of physical properties at various depths for Lunga Reservoir at spillway near Garrisonville, Virginia (01660490; fig. 5, site 7).

[ft, feet; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microseimens per centimeter at 25 °C; units, standard pH units; µg/L, micrograms per liter; <, less than]

Sample date	Depth (ft)	Water tempera-ture (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (units)	Total chlorophyll (µg/L)
		01660490	01660490	01660490	01660490	01660490
Sep-04	1	24.1	6.0	33	6.3	<1.0
Sep-04	2	24.1	6.0	33	6.5	<1.0
Sep-04	3	24.1	6.0	33	6.3	<1.0
Sep-04	4	24.1	6.0	33	6.5	<1.0
Sep-04	5	24.0	5.9	33	6.5	<1.0
Oct-04	1	15.5	10.1	36	5.9	6.3
Oct-04	2	15.5	10.1	36	6.1	6.0
Oct-04	3	15.5	10.0	36	6.1	6.5
Oct-04	4	15.5	10.0	36	6.1	6.0
Nov-04	1	10.9	10.1	35	5.8	4.8
Nov-04	2	10.9	10.1	35	5.8	5.0
Nov-04	3	10.9	10.0	35	5.9	5.3
Nov-04	4	10.9	9.9	35	5.9	5.1
Nov-04	5	10.9	9.9	35	6.0	5.6
Dec-04	1	7.3	11.1	34	6.2	3.4
Dec-04	2	7.2	11.0	34	6.3	2.9
Dec-04	3	7.3	11.0	34	6.3	3.5
Dec-04	4	7.3	11.0	34	6.3	3.5
Dec-04	5	7.3	11.0	34	6.3	3.7
Dec-04	6	7.3	11.0	34	6.3	3.9
Feb-05	1	4.6	11.5	32	7.3	4.9
Feb-05	2	4.6	11.4	32	7.3	5.0
Feb-05	3	4.6	11.4	32	7.3	5.0
Feb-05	4	4.5	11.4	32	7.2	5.5
Feb-05	5	4.5	11.4	32	7.3	7.5
Feb-05	6	4.5	11.4	32	7.2	7.6
Mar-05	1	6.6	13.4	33	7.1	4.9
Mar-05	2	6.6	13.4	33	7.1	5.4
Mar-05	3	6.6	13.4	33	7.1	5.6
Mar-05	4	6.6	13.3	33	7.1	7.5

Sample date	Depth (ft)	Water tempera-ture (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (units)	Total chlorophyll (µg/L)
		01660490	01660490	01660490	01660490	01660490
Apr-05	1	15.3	12.3	32	7.3	6.8
Apr-05	2	15.3	12.4	31	7.4	7.1
Apr-05	3	15.3	12.3	31	7.4	7.4
Apr-05	4	15.3	12.3	31	7.4	8.1
Apr-05	5	15.3	12.3	31	7.4	7.9
Apr-05	6	15.3	12.2	31	7.4	8.5
Apr-05	7	15.3	12.2	31	7.4	7.8
May-05	1	20.6	9.7	32	7.3	NO MAY CHLORO-PHYLL VALUES
May-05	2	20.6	9.7	32	7.4	
May-05	3	20.6	9.7	32	7.4	
May-05	4	20.6	9.7	32	7.4	
May-05	5	20.6	9.7	32	7.4	
Jun-05	1	25.9	8.9	35	7.3	7.3
Jun-05	2	25.9	8.9	35	7.4	7.9
Jun-05	3	25.9	8.9	35	7.4	7.6
Jun-05	3.5	25.9	8.9	35	7.4	8.6
Jul-05	1	29.2	7.0	36	7.1	3.2
Jul-05	2	29.2	7.0	36	7.1	3.5
Jul-05	3	29.2	7.0	36	7.1	3.5
Jul-05	4	29.2	7.1	36	7.1	3.7
Aug-05	1	29.7	7.5	37	7.3	3.9
Aug-05	2	29.7	7.5	37	7.2	4.4
Aug-05	2.5	29.7	7.5	37	7.1	4.5
Aug-05	3	29.7	7.4	37	6.9	4.6

Appendix 9. Summary of various constituents at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.

[NTU, nephelometric turbidity units; mg/L, milligrams per liter; E. coli, Escherichia coliform bacteria; col/100mL, colonies per 100 milliliters; CaCO3, calcium carbonate; µg/L, micrograms per liter; e, estimated; <, less than; >, greater than; –, no sample collected]

Constituent	Upper North Branch Lunga Reservoir near Garrisonville, Virginia (site 10, 01660440)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	8	7	5	6	–	8	5	7	5	4	6	4
Secchi -disk depth, in feet	2.7	4.2	4.8	5.0	–	6.4	5.6	5.0	3.9	3.8	3.5	3.5
Suspended sediment, in mg/L	5	3	3	2	–	2	3	5	3	3	5	3
E. coli, in col/100 mL	e6	e10	78	26	–	e2	e2	e2	e4	e2	e2	e3
Alkalinity, in mg/L as CaCO3	7.1	6.5	6.7	5.4	–	5.0	4.9	5.0	4.7	6.9	6.5	7.5
Pheophytin A, phytoplankton, in µg/L	3.7	6.3	e3.0	1.9	–	1.0	e1.9	1.5	–	–	–	2.7
Chlorophyll *a*, laboratory, in µg/L	11.6	4.5	e3.8	1.2	–	3.3	e2.5	1.8	–	–	–	4.7

Constituent	Lower North Branch Lunga Reservoir near Garrisonville, Virginia (site 9, 01660450)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	6	5	5	4	–	8	4	4	4	4	4	3
Secchi -disk depth, in feet	3.9	4.3	6.0	6.6	–	6.5	5.8	5.3	4.1	4.2	5.2	5.5
Suspended sediment, in mg/L	3	2	2	1	–	2	2	4	2	3	3	1
E. coli, in col/100 mL	e8	e5	19	30	–	e4	e2	e2	e8	e4	e6	e7
Alkalinity, in mg/L as CaCO3	7.8	7.8	6.4	6.5	–	4.2	5.1	4.8	5.1	6.9	6.5	7.7
Pheophytin A, phytoplankton, in µg/L	2.2	6.0	e2.4	2.7	–	2.0	e2.8	1.4	–	–	–	1.8
Chlorophyll *a*, laboratory, in µg/L	6.5	4.9	e1.8	0.9	–	4.4	e4.2	2.3	–	–	–	3.6

Appendix 9. Summary of various constituents at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[NTU, nephelometric turbidity units; mg/L, milligrams per liter; E. coli, Escherichia coliform bacteria; col/100mL, colonies per 100 milliliters; CaCO3, calcium carbonate; µg/L, micrograms per liter; e, estimated; <, less than; >, greater than; –, no sample collected]

Constituent	Upper South Branch Lunga Reservoir near Garrisonville, Virginia (site 5, 01660470)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	13	6	4	8	–	8	5	6	6	4	8	3
Secchi -disk depth, in feet	2.4	>4.4	>4.4	4.0	–	>4.4	4.5	3.3	>4.0	3.2	3.0	2.8
Suspended sediment, in mg/L	12	4	1	3	–	1	2	4	5	5	6	5
E. coli, in col/100 mL	e12	19	54	26	–	e4	<1	e2	e2	e4	e2	e2
Alkalinity, in mg/L as CaCO3	7.9	8.4	5.2	3.3	–	4.4	3.4	6.0	6.6	6.7	13.9	7.0
Pheophytin A, phytoplankton, in µg/L	6.2	3.5	e3.8	2.0	–	2.1	e2.1	8.2	–	–	–	3.8
Chlorophyll *a*, laboratory, in µg/L	8.4	2.4	e4.7	1.1	–	1.4	e2.1	<0.1	–	–	–	5.5

Constituent	Lower South Branch Lunga Reservoir near Garrisonville, Virginia (site 6, 01660480)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	8	6	4	6	–	4	3	4	3	4	4	5
Secchi -disk depth, in feet	4.2	3.7	5.2	7.8	–	6.0	7.5	5.6	5.0	3.8	5.4	6.6
Suspended sediment, in mg/L	3	4	3	2	–	1	2	3	2	2	2	2
E. coli, in col/100 mL	e8	e6	17	15	–	e2	e4	e3	e2	e6	e8	17
Alkalinity, in mg/L as CaCO3	7.4	5.0	6.9	8.4	–	4.6	5.1	5.2	4.4	6.4	7.2	6.6
Pheophytin A, phytoplankton, in µg/L	4.0	5.0	e2.8	2.0	–	1.4	e5.1	8.4	–	–	–	1.5
Chlorophyll *a*, laboratory, in µg/L	5.8	3.5	e1.9	0.8	–	4.2	e4.0	<0.1	–	–	–	3.3

Appendix 9. Summary of various constituents at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[NTU, nephelometric turbidity units; mg/L, milligrams per liter; E. coli, Escherichia coliform bacteria; col/100mL, colonies per 100 milliliters; CaCO3, calcium carbonate; µg/L, micrograms per liter; e, estimated; <, less than; >, greater than; –, no sample collected]

Constituent	Lunga Reservoir at water intake near Garrisonville, Virginia (site 8, 01660489)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	7	5	5	4	–	4	3	4	3	4	3	3
Secchi -disk depth, in feet	4.3	3.5	4.8	7.7	–	7.0	6.4	5.5	4.1	4.8	5.2	6.7
Suspended sediment, in mg/L	3	3	2	1	–	2	2	3	1	3	2	1
E. coli, in col/100 mL	e11	e1	25	14	–	16	e6	e2	e9	e2	14	e3
Alkalinity, in mg/L as CaCO3	6.2	8.4	6.2	6.1	–	4.7	5.1	4.1	5.2	6.6	6.5	8.2
Pheophytin A, phytoplankton, in µg/L	5.0	7.6	e3.6	2.3	–	1.5	e2.7	1.9	–	–	–	1.2
Chlorophyll *a*, laboratory, in µg/L	7.1	6.2	e2.6	0.9	–	4.3	e3.9	3.2	–	–	–	2.3

Constituent	Lunga Reservoir at spillway near Garrisonville, Virginia (site 7, 01660490)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Turbidity, in NTU	7	4	5	6	–	4	3	4	3	4	3	5
Secchi -disk depth, in feet	4.2	3.7	4.4	5.8	–	7.5	>4.2	5.5	>5.2	>3.8	>4.5	>3.5
Suspended sediment, in mg/L	3	3	3	1	–	2	4	3	2	3	6	1
E. coli, in col/100 mL	e15	e4	23	30	–	e9	9	e2	e8	e3	23	e2
Alkalinity, in mg/L as CaCO3	6.7	8.2	7.0	6.6	–	4.4	4.4	5.2	5.1	6.6	7.2	11.2
Pheophytin A, phytoplankton, in µg/L	3.5	4.9	e3.1	2.5	–	1.8	e2.8	1.6	–	–	–	1.4
Chlorophyll *a*, laboratory, in µg/L	5.4	4.2	e1.8	0.9	–	4.1	e4.9	2.5	–	–	–	2.2

Appendix 10. Summary of organic carbon and nutrient concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.

[mg/L, milligrams per liter; e, estimated; –, no sample collected; <, less than]

Constituent, in mg/L	Upper North Branch Lunga Reservoir near Garrisonville, Virginia (site 10, 01660440)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	6.78	5.97	5.82	6.19	–	4.45	4.78	6.01	7.09	6.62	6.74	6.53
Organic carbon, dissolved	4.50	4.13	4.53	4.71	–	3.42	3.36	4.42	4.93	5.12	4.68	4.32
Nitrogen, total, unfiltered	0.349	0.379	0.425	0.365	–	0.307	0.267	0.268	0.317	0.363	0.407	0.332
Nitrogen, total, filtered	0.271	0.255	0.413	0.445	–	0.263	0.161	0.219	0.224	0.247	0.300	0.278
Nitrogen, ammonia, dissolved	<0.010	0.041	0.088	0.072	–	0.012	<0.010	<0.010	<0.010	<0.010	0.006	<0.010
Nitrogen, nitrite, dissolved	e0.001	e0.001	0.002	0.002	–	0.002	e0.001	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	e0.011	0.019	0.043	–	0.053	0.018	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	0.008	0.006	0.008	0.006	–	0.005	e0.003	e0.007	0.005	0.005	0.005	0.004
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	0.028	0.024	0.017	0.014	–	0.015	0.016	0.018	0.017	0.020	0.024	0.019

Constituent, in mg/L	Lower North Branch Lunga Reservoir near Garrisonville, Virginia (site 9, 01660450)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	6.50	5.29	5.10	5.20	–	4.81	5.04	5.85	6.94	6.63	6.12	6.03
Organic carbon, dissolved	4.85	4.19	4.09	3.90	–	4.47	3.87	4.10	4.65	5.17	4.62	4.21
Nitrogen, total, unfiltered	0.306	0.411	0.398	0.471	–	0.405	0.344	0.275	0.373	0.354	0.312	0.328
Nitrogen, total, filtered	0.251	0.288	0.404	0.472	–	0.383	0.303	0.217	0.193	0.251	0.315	0.267
Nitrogen, ammonia, dissolved	e0.005	0.106	0.141	0.158	–	0.058	e0.006	<0.010	<0.010	<0.010	e0.006	<0.010
Nitrogen, nitrite, dissolved	e0.001	<0.002	e0.001	0.003	–	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	<0.016	0.017	0.042	–	0.084	0.071	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	0.006	e0.003	e0.004	0.007	–	e0.004	0.006	e0.005	e0.004	e0.003	e0.003	e0.003
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	0.022	0.013	0.012	0.012	–	0.014	0.015	0.015	0.016	0.015	0.013	0.014

Appendix 10. Summary of organic carbon and nutrient concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[mg/L, milligrams per liter; e, estimated; –, no sample collected; <, less than]

Constituent, in mg/L	Upper South Branch Lunga Reservoir near Garrisonville, Virginia (site 5, 01660470)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	7.48	5.70	5.63	5.84	–	3.54	4.37	5.69	7.23	6.74	6.04	6.66
Organic carbon, dissolved	5.14	4.28	4.54	4.95	–	2.70	3.37	4.44	5.07	5.16	4.58	4.48
Nitrogen, total, unfiltered	0.291	0.369	0.387	0.333	–	0.222	0.218	0.311	0.361	0.445	0.460	0.440
Nitrogen, total, filtered	0.263	0.291	0.557	0.453	–	0.231	0.190	0.246	0.258	0.288	0.296	0.315
Nitrogen, ammonia, dissolved	<0.010	0.053	0.075	0.043	–	e0.005	<0.010	e0.005	<0.010	<0.010	<0.010	<0.010
Nitrogen, nitrite, dissolved	e0.001	e0.001	e0.001	0.002	–	e0.001	e0.001	<0.002	e0.001	<0.002	<0.002	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	e0.015	0.016	0.035	–	0.024	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	e0.004	0.005	0.007	0.007	–	e0.003	0.004	0.006	0.005	0.007	0.004	0.005
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	0.010	0.018	0.013	0.017	–	0.013	0.014	0.015	0.022	0.030	0.034	0.032

Constituent, in mg/L	Lower South Branch Lunga Reservoir near Garrisonville, Virginia (site 6, 01660480)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	6.28	5.65	5.08	4.70	–	5.03	5.35	5.69	e6.62	6.46	6.11	5.89
Organic carbon, dissolved	4.77	4.16	3.80	4.09	–	3.89	3.80	4.03	4.76	5.40	4.66	4.63
Nitrogen, total, unfiltered	0.240	0.404	0.424	0.427	–	0.395	0.330	0.280	0.313	0.349	0.341	0.346
Nitrogen, total, filtered	0.229	0.299	0.401	0.448	–	0.335	0.326	0.213	0.192	0.257	0.292	0.264
Nitrogen, ammonia, dissolved	<0.010	0.092	0.144	0.152	–	0.045	e0.006	<0.010	<0.010	<0.010	e0.006	<0.010
Nitrogen, nitrite, dissolved	e0.001	e0.001	e0.001	0.002	–	0.002	0.002	e0.001	<0.002	<0.002	<0.002	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	e0.014	e0.013	0.040	–	0.083	0.064	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	e0.003	e0.004	0.005	0.006	–	0.005	0.004	0.004	e0.004	0.004	e0.003	e0.003
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	0.018	0.016	0.012	0.012	–	0.015	0.015	0.018	0.015	0.016	0.012	0.014

Appendix 10. Summary of organic carbon and nutrient concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[mg/L, milligrams per liter; e, estimated; –, no sample collected; <, less than]

Constituent, in mg/L	Lunga Reservoir at water intake near Garrisonville, Virginia (site 8, 01660489)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	6.45	5.32	4.83	5.16	–	5.20	5.33	5.87	6.84	6.71	6.37	6.16
Organic carbon, dissolved	4.67	4.15	4.01	3.96	–	3.99	3.81	4.11	4.75	5.68	4.53	4.55
Nitrogen, total, unfiltered	0.299	0.390	0.416	0.461	–	0.418	0.335	0.293	0.303	0.353	0.318	0.286
Nitrogen, total, filtered	0.239	0.283	0.405	0.436	–	0.369	0.302	0.217	0.208	0.252	0.270	0.303
Nitrogen, ammonia, dissolved	<0.010	0.103	0.144	0.162	–	0.056	e0.005	<0.010	<0.010	<0.010	e0.006	e0.005
Nitrogen, nitrite, dissolved	e0.001	e0.001	e0.001	0.002	–	0.002	0.003	<0.002	<0.002	<0.002	e0.001	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	e0.012	0.017	0.041	–	0.084	0.070	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	0.006	e0.003	0.005	0.006	–	e0.004	0.007	e0.005	e0.004	0.004	e0.004	e0.004
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	0.019	0.014	0.012	0.012	–	0.013	0.015	0.016	0.015	0.015	0.010	0.013

Constituent, in mg/L	Lunga Reservoir at spillway near Garrisonville, Virginia (site 7, 01660490)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Organic carbon, total	5.74	5.08	4.92	4.90	–	4.98	5.03	5.65	6.57	7.13	5.90	5.70
Organic carbon, dissolved	4.63	4.24	4.01	3.94	–	4.05	3.86	4.13	4.84	5.44	4.54	4.50
Nitrogen, total, unfiltered	0.237	0.420	0.429	0.448	–	0.411	0.349	0.304	0.327	0.356	0.326	0.324
Nitrogen, total, filtered	0.245	0.283	0.421	0.467	–	0.386	0.300	0.215	0.216	0.263	0.259	0.256
Nitrogen, ammonia, dissolved	<0.010	0.104	0.142	0.161	–	0.057	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen, nitrite, dissolved	e0.001	e0.001	e0.001	0.002	–	0.002	0.002	e0.001	<0.002	<0.002	<0.002	<0.002
Nitrogen, nitrite + nitrate, dissolved	<0.016	e0.010	e0.012	0.039	–	0.082	0.071	<0.016	<0.016	<0.016	<0.016	<0.016
Phosphorus, dissolved	0.005	0.011	0.006	0.006	–	0.005	e0.004	0.005	0.006	0.004	e0.002	e0.003
Phosphorus, orthophosphate, dissolved	<0.006	<0.006	<0.006	<0.006	–	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Phosphorus, total	e0.004	0.014	0.011	0.010	–	0.013	0.017	0.015	0.016	0.015	0.010	0.012

Appendix 11. Summary of dissolved major-ion concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.

[mg/L, milligrams per liter; –, no sample collected]

Major ions, in mg/L	Upper North Branch Lunga Reservoir near Garrisonville, Virginia (site 10, 01660440)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.017	0.015	0.016	–	0.014	0.014	0.012	0.015	0.016	0.019	0.018
Calcium, dissolved	1.820	1.805	1.759	1.630	–	1.479	1.472	1.566	1.564	1.710	1.738	1.707
Chloride, dissolved	2.496	2.391	2.366	2.273	–	2.120	2.302	2.263	2.447	2.917	2.973	2.964
Fluoride, dissolved	0.080	0.087	0.086	0.085	–	0.061	0.060	0.071	0.073	0.094	0.099	0.102
Magnesium, dissolved	1.030	1.105	1.089	1.091	–	1.019	1.031	1.019	1.091	1.167	1.165	1.127
Potassium, dissolved	1.080	1.030	1.057	0.869	–	0.673	0.601	0.617	0.673	1.030	0.994	1.080
Silica, dissolved	9.26	8.53	8.70	9.52	–	8.97	8.70	7.65	7.12	6.43	6.72	7.23
Sodium, dissolved	2.29	2.45	2.26	2.29	–	2.39	2.43	2.37	2.51	2.65	2.66	2.72
Sulfate, dissolved	2.617	3.164	3.483	4.104	–	3.947	4.407	4.430	4.162	3.468	3.470	3.633

Major ions, in mg/L	Lower North Branch Lunga Reservoir near Garrisonville, Virginia (site 9, 01660450)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.016	0.017	0.017	–	0.015	0.015	0.012	0.014	0.016	0.018	0.018
Calcium, dissolved	1.850	1.877	2.152	1.700	–	1.546	1.574	1.598	1.517	1.634	1.685	1.684
Chloride, dissolved	2.549	2.437	2.430	2.419	–	2.464	2.895	2.634	2.493	2.691	2.931	2.952
Fluoride, dissolved	0.094	0.092	0.092	0.080	–	0.065	0.060	0.069	0.073	0.090	0.108	0.101
Magnesium, dissolved	1.050	1.116	1.121	1.058	–	0.974	0.997	0.978	1.042	1.094	1.132	1.113
Potassium, dissolved	1.006	1.043	1.060	0.991	–	0.877	0.807	0.681	0.654	0.865	1.048	1.066
Silica, dissolved	8.57	7.95	9.08	8.80	–	8.09	8.38	7.08	6.81	6.34	6.00	6.63
Sodium, dissolved	2.47	2.35	2.34	2.28	–	2.35	2.60	2.53	2.49	2.55	2.63	2.70
Sulfate, dissolved	2.588	2.883	3.229	3.901	–	4.341	4.384	4.508	4.347	3.772	3.615	3.702

Appendix 11. Summary of dissolved major-ion concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[mg/L, milligrams per liter; –, no sample collected]

Major ions, in mg/L	Upper South Branch Lunga Reservoir near Garrisonville, Virginia (site 5, 01660470)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.017	0.016	0.018	–	0.016	0.015	0.013	0.014	0.017	0.018	0.019
Calcium, dissolved	1.860	1.823	1.718	1.600	–	1.394	1.514	1.581	1.653	1.679	1.821	1.697
Chloride, dissolved	2.536	2.423	2.363	2.315	–	2.097	2.144	2.106	2.600	2.948	2.909	2.962
Fluoride, dissolved	0.083	0.093	0.081	0.077	–	0.057	0.062	0.061	0.080	0.100	0.090	0.100
Magnesium, dissolved	1.050	1.101	1.054	0.969	–	0.896	0.966	0.954	1.091	1.127	1.133	1.115
Potassium, dissolved	1.071	1.006	1.109	0.788	–	0.499	0.458	0.570	0.799	1.067	1.058	1.024
Silica, dissolved	8.72	6.81	7.82	8.68	–	6.78	6.94	5.76	5.99	5.60	6.70	7.38
Sodium, dissolved	2.36	2.42	2.12	2.27	–	2.31	2.39	2.31	2.56	2.60	2.60	2.72
Sulfate, dissolved	1.834	2.888	3.590	4.294	–	3.641	4.506	4.222	3.979	3.602	3.597	3.761

Major ions, in mg/L	Lower South Branch Lunga Reservoir near Garrisonville, Virginia (site 6, 01660480)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.015	0.017	0.017	–	0.016	0.016	0.013	0.014	0.016	0.017	0.017
Calcium, dissolved	1.880	1.855	1.842	1.675	–	1.530	1.536	1.597	1.507	1.647	1.686	1.701
Chloride, dissolved	2.551	2.433	2.404	2.401	–	2.392	2.670	2.592	2.501	2.713	2.931	2.913
Fluoride, dissolved	0.082	0.092	0.085	0.083	–	0.063	0.076	0.062	0.075	0.092	0.090	0.101
Magnesium, dissolved	1.060	1.104	1.120	1.041	–	0.962	0.974	0.981	1.027	1.107	1.124	1.133
Potassium, dissolved	1.026	1.059	1.037	0.993	–	0.869	0.795	0.679	0.664	0.864	1.061	1.052
Silica, dissolved	8.49	7.92	8.33	8.63	–	7.94	7.95	7.07	6.70	6.19	6.08	6.77
Sodium, dissolved	2.37	2.35	2.27	2.26	–	2.30	2.46	2.53	2.48	2.56	2.58	2.74
Sulfate, dissolved	2.250	2.892	3.203	3.862	–	4.250	4.366	4.481	4.366	3.755	3.637	3.736

Appendix 11. Summary of dissolved major-ion concentrations at 1.0-foot depth at sampling sites in Lunga Reservoir, Virginia.—Continued

[mg/L, milligrams per liter; –, no sample collected]

Major ions, in mg/L	Lunga Reservoir at water intake near Garrisonville, Virginia (site 8, 01660489)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.021	0.017	0.017	–	0.016	0.015	0.013	0.014	0.016	0.017	0.018
Calcium, dissolved	1.860	1.912	1.836	1.687	–	1.542	1.557	1.594	1.509	1.646	1.660	1.699
Chloride, dissolved	2.567	2.454	2.419	2.412	–	2.446	2.819	2.569	2.497	2.709	2.922	2.976
Fluoride, dissolved	0.091	0.091	0.085	0.082	–	0.065	0.061	0.068	0.073	0.090	0.092	0.103
Magnesium, dissolved	1.060	1.137	1.115	1.046	–	0.968	0.981	0.974	1.035	1.101	1.108	1.131
Potassium, dissolved	1.018	1.056	1.053	1.002	–	0.881	0.835	0.674	0.653	0.872	1.009	1.082
Silica, dissolved	8.50	7.97	8.35	8.73	–	8.03	8.32	7.03	6.72	6.37	5.99	6.64
Sodium, dissolved	2.47	2.40	2.28	2.25	–	2.33	2.53	2.49	2.48	2.55	2.59	2.72
Sulfate, dissolved	2.207	2.887	3.199	3.880	–	4.317	4.362	4.495	4.374	3.771	3.643	3.726

Major ions, in mg/L	Lunga Reservoir at spillway near Garrisonville, Virginia (site 7, 01660490)											
	2004				2005							
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Bromide, dissolved	0.017	0.016	0.017	0.016	–	0.015	0.015	0.013	0.014	0.017	0.017	0.018
Calcium, dissolved	1.820	1.910	1.839	1.688	–	1.550	1.581	1.572	1.509	1.610	1.672	1.715
Chloride, dissolved	2.549	2.433	2.399	2.407	–	2.457	2.817	2.590	2.509	2.702	2.917	2.954
Fluoride, dissolved	0.079	0.091	0.084	0.081	–	0.063	0.055	0.062	0.074	0.091	0.090	0.099
Magnesium, dissolved	1.040	1.136	1.113	1.053	–	0.976	0.999	0.962	1.027	1.077	1.123	1.151
Potassium, dissolved	1.063	1.047	1.033	0.992	–	0.888	0.847	0.680	0.654	0.880	1.044	1.064
Silica, dissolved	8.43	7.93	8.25	8.68	–	8.12	8.25	7.08	6.72	6.31	5.98	6.84
Sodium, dissolved	2.30	2.40	2.27	2.25	–	2.34	2.56	2.47	2.48	2.57	2.60	2.75
Sulfate, dissolved	2.834	2.867	3.192	3.881	–	4.323	4.373	4.536	4.367	3.788	3.596	3.721

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