NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: WATER-QUALITY CONDITIONS AND MASS TRANSPORT IN THE FLINT RIVER, SOUTHWESTERN GEORGIA, RELATED TO THE FLOOD OF JULY 1994, CAUSED BY TROPICAL STORM ALBERTO

Daniel J. Hippe and Jerry W. Garrett

AUTHORS: U.S. Geological Survey Peachtree Business Center, 3039 Amwiler Road, Suite 130, Atlanta, GA 30360-2824.
REFERENCE: *Proceedings of the 1995 Georgia Water Resources Conference*, held April 11 and 12, 1995, at The University of Georgia, Kathryn J. Hatcher, Editor, Carl Vinson Institute of Government, The University of Georgia, Athens, Georgia.

ABSTRACT

Nineteen water samples were collected from July 6-26 in the Flint River at Newton, Ga., to assess water quality and mass transport related to flooding caused by tropical storm Alberto. Water-quality and stream-discharge data indicate that the large quantity of runoff caused substantial changes in sediment and chemical-constituent concentrations because of dilution, or mobilization of constituents. Nutrient loads were a substantial part of the mean annual loads based on historic data. Nutrient and pesticide loads were from 0.07 to 4.5 percent of the estimated annual inputs to the basin from point and nonpoint sources.

INTRODUCTION

Rainfall from tropical storm Alberto on July 3-7, 1994, caused record flooding in central and southwestern Georgia and adjacent areas of Florida and Alabama. As part of the National Water-Quality Assessment Program of the U.S. Geological Survey (USGS), water samples were collected from July 6 to 26 in the Flint River at Newton, Georgia (fig. 1), to assess water quality and mass transport related to flooding caused by Tropical Storm Alberto. Data collected at this site illustrate the effects of the unprecedented large stream discharges and extensive inundation of flood plains on the chemical quality and mass transport of the Flint River. This paper presents a brief summary of the changes in water-quality conditions, and estimates of sediment and chemical mass transport relative to known inputs and historical loads in the Flint River at Newton, Georgia, related to the flood caused by Tropical Storm Alberto.

BACKGROUND AND METHODS

The 5,740-mi^2 area drained by the Flint River at Newton (76 percent of the total basin area) includes part of the Atlanta Metropolitan area and the cities of Montezuma, Americus, and Albany (fig. 1). However, much of the drainage area is either forested or agricultural land (fig. 2). Most agricultural land is in the lower one-third of the basin and is used primarily for production of peanuts, small grains, cotton, corn, soybeans, and pecans.

Within the Flint River basin, Americus received 28 in. of precipitation from July 3 to 7, 1994; while much of the basin received between 5 and 15 in. of precipitation (Hippe and others, 1994). During the resulting flood, the Flint River at Newton was above bankfull stage for about 13 days from July 8 through 20, 1994; the peak stream discharge was 100,000 ft^3/s on July 13. The peak stream discharge exceeded a 200-year recurrence interval based on 53 years of record (Stamey and Hess, 1993). The volume of floodwaters was about 700 billion gallons, or about 45 percent of the average annual runoff (15.5 in.).

Intensive data collection was performed at the USGS streamflow gage on the Flint River at Newton, the furthest downstream location on the river that was accessible during the flood. Nineteen discharge-weighted water samples were collected and processed according to methods of Shelton (1994) using a D-77 sampler fitted with a 3-L teflon bottle and nozzle that was lowered from the stream surface to the stream bed (or to about 15 ft—the maximum operational depth of the sampler) at 3 to 11 locations in the channel and flood plain.

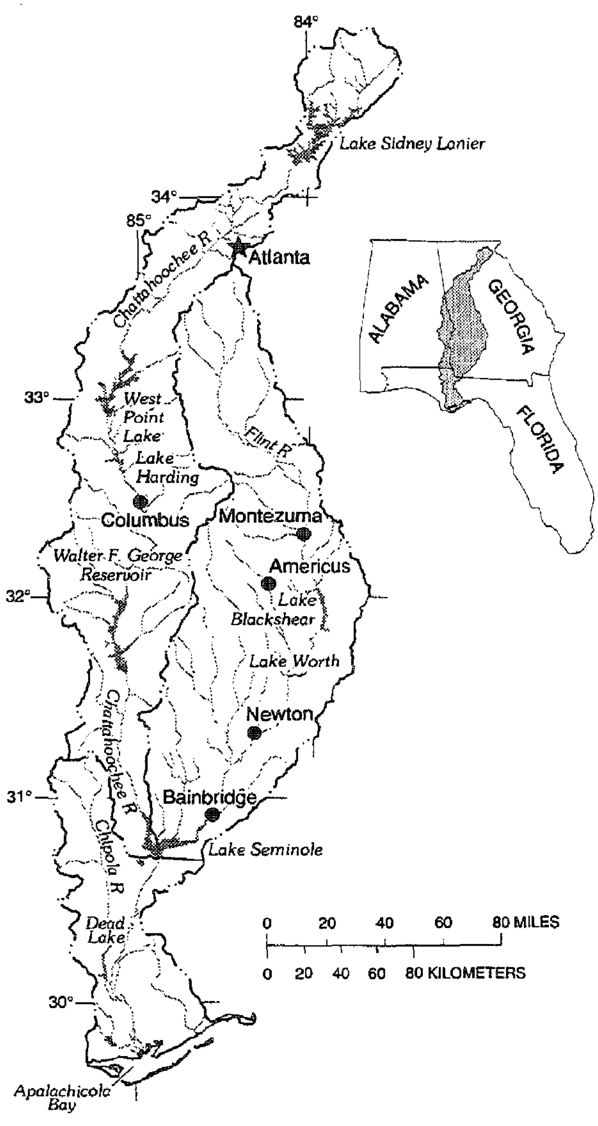

Figure 1. Location of Apalachicola-Chattahoochee-Flint River basin in parts of Georgia, Alabama, and Florida.

Samples were analyzed for concentrations of suspended sediment, turbidity, major ions, nitrogen and phosphorus species, dissolved and suspended organic carbon, and volatile organic compounds using methods of Guy (1969), Wershaw and others (1987), and Fishman and Friedman (1989). Samples were analyzed for 88 pesticide residues using two multi-analyte methods (S.D. Zaugg and M.R. Burkhardt, USGS, written commun., 1993). Stream temperature, specific conductance, pH, dissolved oxygen, and alkalinity were determined on site.

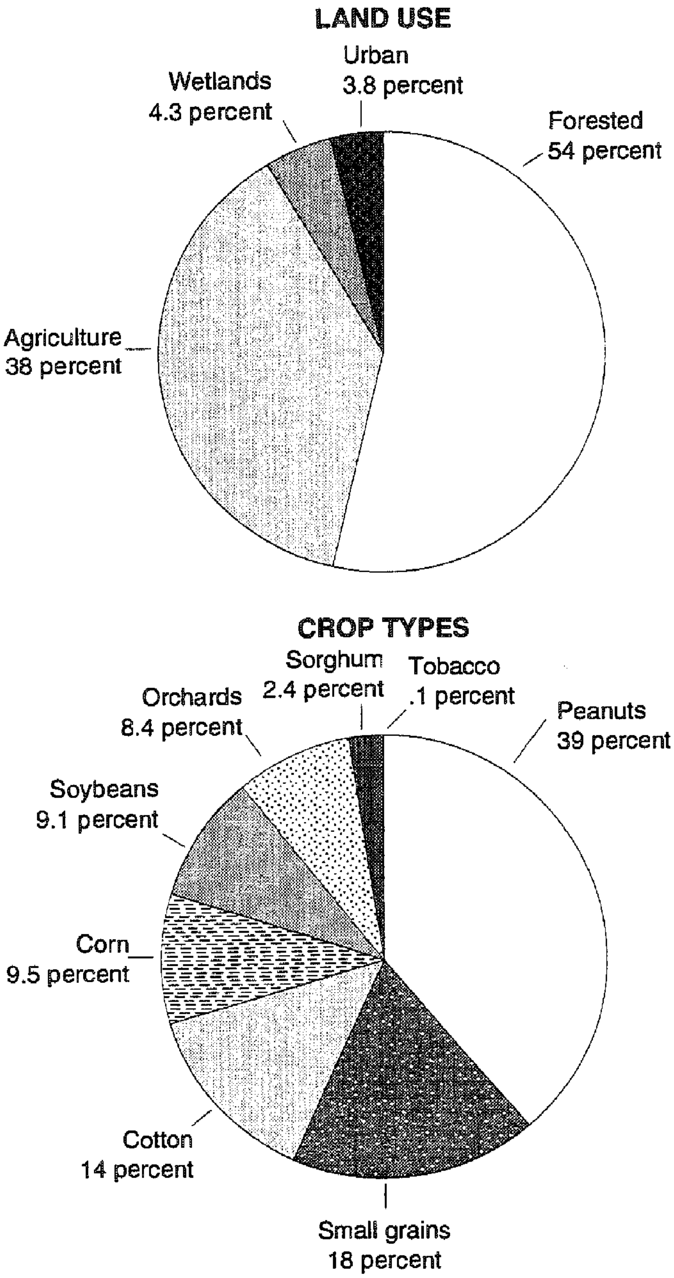

Figure 2. Land use and crop types in the Flint River basin, upstream of Newton, Georgia.

Daily and cumulative flood loads of selected constituents were computed using the mean-interval method of Porterfield (1972). Estimates of pesticide use on agricultural land were based on county-level crop and orchard data for the latest available years, and State-level pesticide-use data. County-level crop and orchard data (Georgia Agricultural Statistics Service, 1994; Hubbard and others, 1988; Hubbard and others, 1990) were adjusted for the percentage of each county in the basin and multiplied by State-level coefficients for the percentage of each crop-acre receiving applications, and the annual rate-per-acre application of the particular pesticide (Gianessi and Puffer, 1990, 1992; Brown and Brown, 1992; National Agricultural Statistics Service, 1991, 1992, 1994). Finally, the total pesticide use on agricultural land was determined from summing the crop- specific estimates.

Estimates of point and nonpoint-source nutrient inputs in the drainage basin upstream of Newton and mean annual loads of total ammonia plus organic nitrogen, dissolved nitrate plus nitrite, and total phosphorus for the period of record are from E.A. Frick and G.R. Buell (USGS, written commun., 1994).

WATER-QUALITY CONDITIONS

Large streamflows and extensive inundation of the flood plains had a marked effect on the water-quality conditions of the Flint River and below the mouth of the river system in Apalachicola Bay in Florida. Floodwaters contained unprecedented low concentrations of dissolved solids (based on measured and historical specific conductance data). The large streamflow volume of freshwater resulted in near zero salinity in the Apalachicola Bay for about 10 days and caused widespread mortality to fish and shellfish populations in the bay (L. Edmiston, Florida Dept. of Natural Resources, oral commun., 1994).

Depletion of dissolved oxygen (fig. 3) in floodwaters—in combination with factors such as high suspended-sediment concentrations and high stream velocities—could have caused appreciable stress on fish. Dissolved-oxygen concentrations decreased with increasing stream discharge, and decreased to 2.3 mg/L (lowest measured concentration) as the river returned to bankfull conditions. Oxygen probably was depleted by biological processes occurring in floodwaters having an abundance of oxidizable organic material.

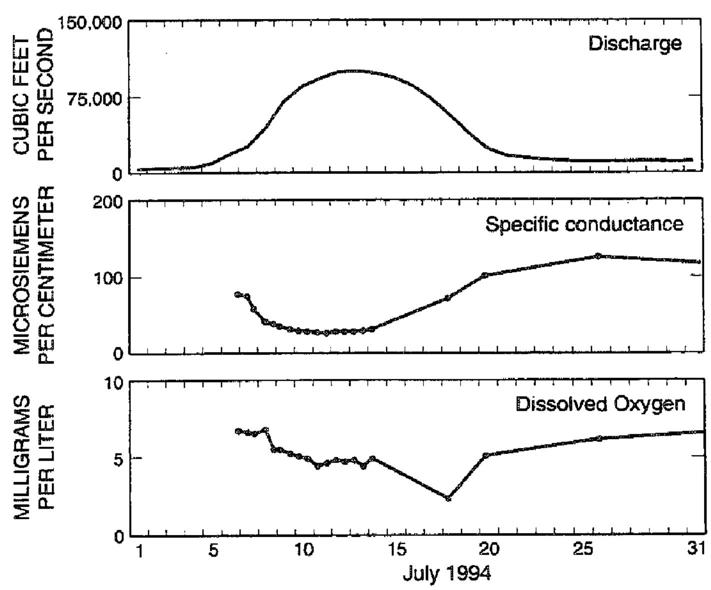

Figure 3. Stream discharge, specific conductance, and dissolved oxygen in the Flint River at Newton, Georgia, during flooding caused by Tropical Storm Alberto, July 1994.

The large quantity of runoff caused substantial changes in sediment and chemical-constituent concentrations because of dilution, or mobilization of constituents during the flood. Concentrations of calcium, magnesium, sulfate, and silica varied directly with specific conductance; the stream discharge-concentration relation (fig. 4) for these constituents was indicative of dilution of instream concentrations from runoff during the early part of the flood and enrichment in the latter part of the flood, probably from increased ground-water discharge. However, stream discharge-concentration relations of nitrate, chloride, and sodium were indicative of simple dilution of instream concentrations by runoff. Stream discharge-concentration relations of potassium and organic carbon were indicative of their widespread mobilization for the duration of the flood. Phosphorus, organic nitrogen, and sediment concentrations were highest at near bankfull conditions as floodwaters were rising, and decreased until return to bankfull conditions. This response indicates appreciable mobilization of these constituents followed by dilution from additional runoff at above bankfull conditions. Stream discharge-pesticide concentration relations were indicative of mobilization from nearby upland areas during the early part of the flood followed by dilution to much lower concen- trations for the remainder of the flood (Hippe and others, 1994).

Silt and clay were major components and sand was a minor component of the suspended sediment transported in floodwaters. The highest suspended-sediment concentrations and the highest percentage of sand were measured at near bankfull conditions (fig. 5). The decrease in concentration and percent sand at higher stages could be the result of sediment trapping in densely vegetated flood plains and deposition of coarser sediment in the mouths of tributary streams that were subject to backwater from the Flint River.

Nitrogen and phosphorus concentrations and speciation changed appreciably during the flood. Total nitrogen concentrations in floodwaters averaged slightly less than the median concentration (0.95 mg/L as N) of historical data (fig. 5). However, much of the nitrogen present in floodwaters was in the form of dissolved and suspended organic nitrogen, with much lower nitrate concentrations than the median concentration of 0.55 mg/L as N, from historical data. Floodwaters contained increased phosphorus concentrations relative to median concentrations (0.07 mg/L as P) of historical data (fig. 5). Much of the phosphorus mobilized during the flood was associated with suspended rather than dissolved forms.

Organic-carbon concentrations in floodwaters were higher than previous measurements at baseflow conditions. Much of the organic carbon was in dissolved forms (fig. 5). The highest organic-carbon concentrations were at near bankfull conditions during the rise and fall of floodwaters.

Twelve herbicides, five insecticides, the fungicide chlorothalonil, and the pesticide soil metabolite deethylatrazine were detected in one or more filtered-water samples from the Flint River at Newton (table 1). Pesticide-concentration data presented by Hippe and others (1994) indicated an early flush of most pesticides in initial runoff; for example, the highest measured concentrations of most pesticides was from 4 to 6 days before the peak stream discharge. The herbicides atrazine, metolachlor, simazine, cyanazine, and fluometuron, and the insecticide diazinon were present for much of the flood. Herbicide concentrations in floodwaters were well below existing U.S. Environmental Protection Agency maximum-contaminant levels and lifetime health advisory levels for drinking water (U.S. Environmental Protection Agency, 1994), as well as guidelines for protecting aquatic life (Nowell and Resek, 1994). Insecticide concentrations were below applicable drinking-water standards and guidelines. However, concentrations of chlorpyrifos, carbaryl, and diazinon in the Flint River approached or exceeded guidelines intended for protecting aquatic life (Nowell and Resek, 1994). During the flood, carbaryl and diazinon also were detected in the Apalachicola River near Apalachicola Bay.

Table 1. Pesticide residues analyzed for, and detected in the Flint River at Newton, Georgia, during flooding caused by Tropical Storm Alberto, July 1994.

(Pesticide residues shown in bold text were detected in one or more samples)[h, herbicide; i, insecticide; m, metabolite; f, fungicide]

Chemical class	Pesticide residues determined by gas chromatography-mass spectrometry	Pesticide residues determined by liquid chromatography
Amides	**alachlor (h)**, **metolachlor (h)**, napropamide (h), pronamide (h), propachlor (h), and propanil (h)	
Carbamates	butylate (h), **carbaryl (i)**, carbofuran (i), EPTC (h), molinate (h), pebulate (h), thiobencarb (h), triallate (h)	aldicarb (i), aldicarb sulfone (m), aldicarb sulfoxide (m), carbaryl (i), 3-hydroxy -carbofuran (i), methiocarb (i), methomyl (i), oxamyl (i), propham (h), propoxur (i)
Chlorophenoxys		**2,4-D (h)**, 2,4-DB (h), 2,4-DP (h), MCPA (h), 2,4,5-T (h), 2,4,5-TP (h), trichlopyr (h)
Dinitroanalines	benfluralin (h), ethafluralin (h), pendimethalin (h), **trifluralin (h)**	oryzalin (h)
Organochlorines	DCPA (h), *p,p'*-DDE (m), dieldrin (i), alpha-HCH (i), lindane (i)	**chlorothalonil (f)**, DCPA (h), dichlobenil (h),
Organophosphates	Azinphos-methyl (i), **chlorpyrifos (i)**, **diazinon (i)**, dimethoate (i), disulfoton (i), ethoprop (i), **fonofos (i)**, **malathion (i)**, methyl-parathion (i), parathion (i), phorate (i), terbufos (i)	
Pyrethroids	*cis*-permethrin *(i)*	
Triazines	**atrazine (h)**, **deethylatrazine (m)**, **cyanazine (h)**, **metribuzin (h)**, **prometon (h)**, **simazine (h)**	
Uracils	terbacil (h)	bromacil (h)
Ureas	linuron (h), **tebuthiuron (h)**	fenuron (h), diuron (h), **fluometuron (h)**, linuron (h), neburon (h)
Unclassified	2,6-diethylanaline (m), propargite (i)	acifluorfen (h), **bentazon (h)**, bromoxynil (h), chloramben (h), chlopyralid (h), dicamba (h), dinoseb (h), DNOC (h,i), esfenvalerate (i), 1-napthol (m), norflurazon (h), picloram (h)

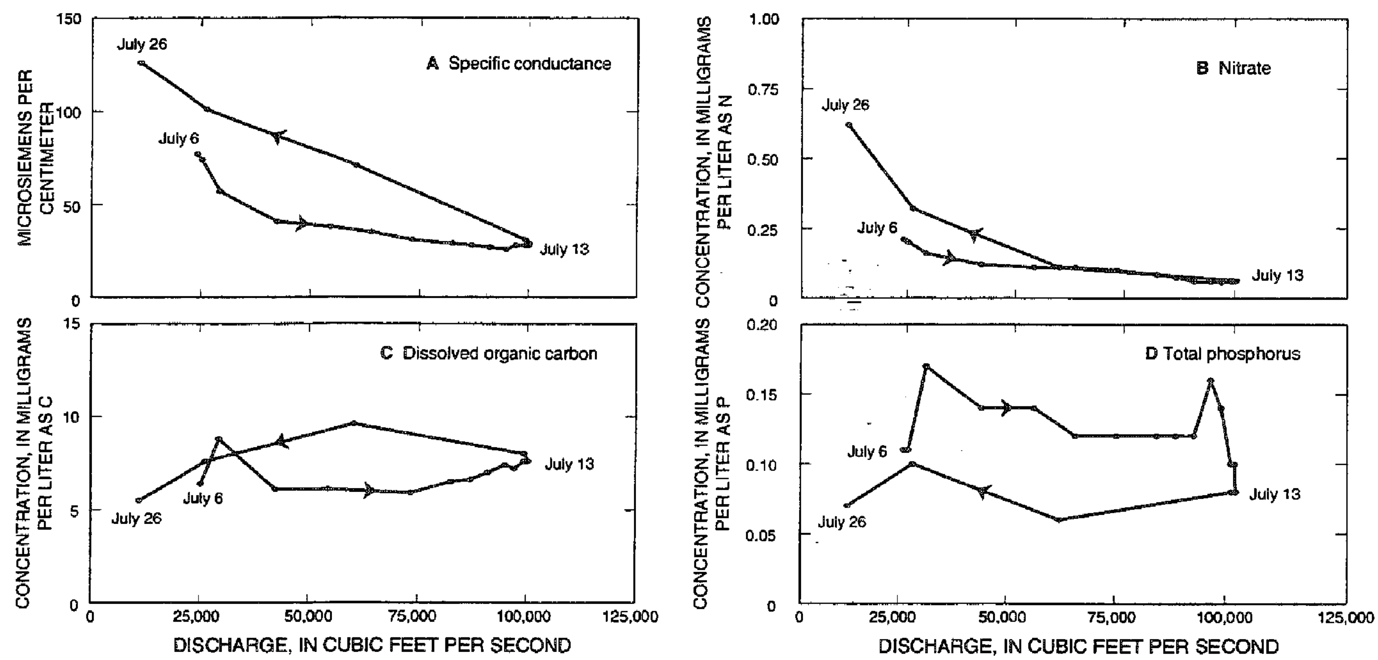

Figure 4. Stream-discharge concentration relations for (A) specific conductance, (B) nitrae, (C) dissolved organic carbon, and (D) total phosphorus in the Flint River at Newton, Georgia, during flooding caused by Tropical Storm Alberto, July 1994.

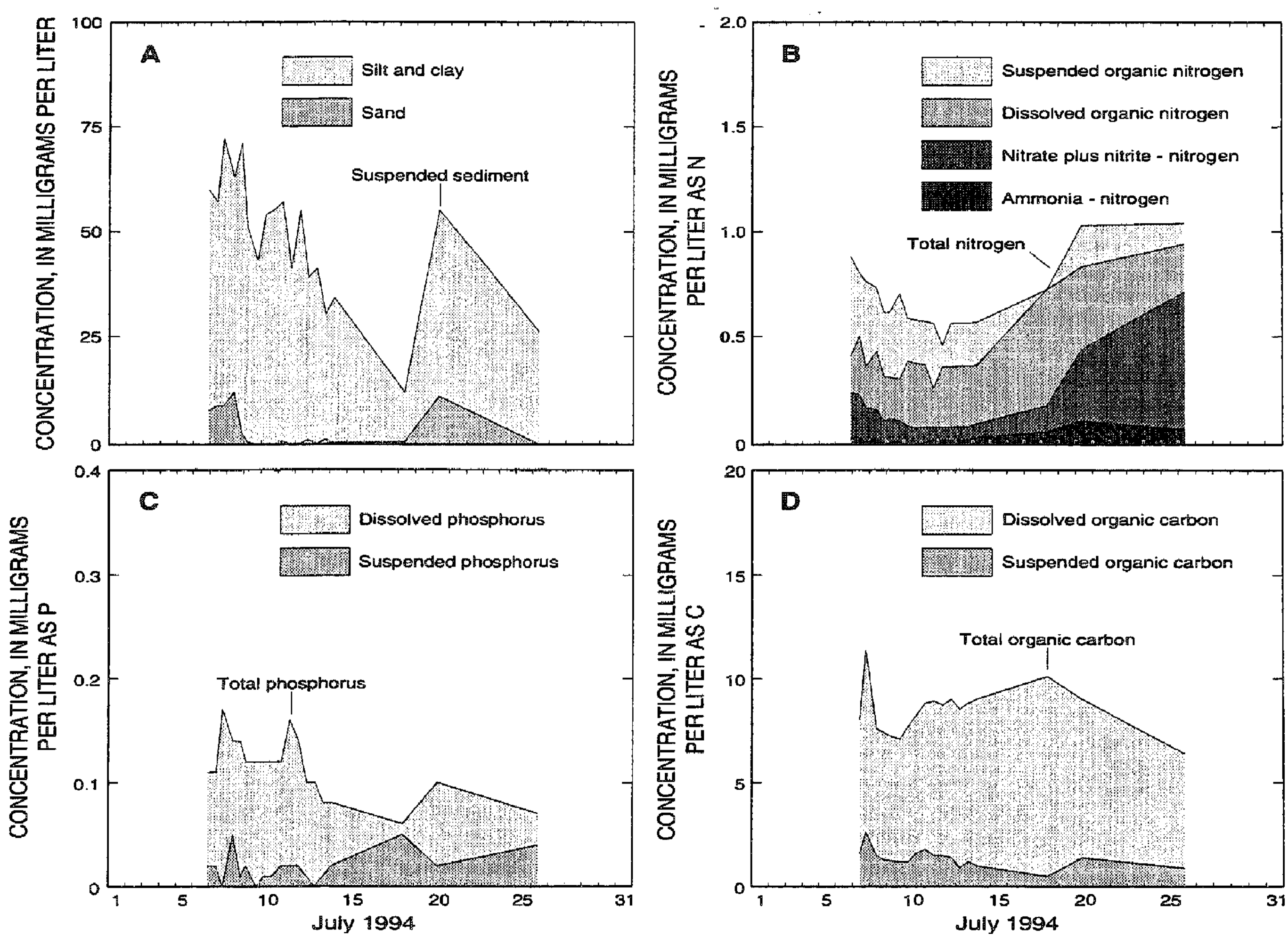

Figure 5. Concentrations of (A) suspended sediment, (B) nitrogen, (C) phosphorus, and (D) organic carbon in the Flint River at Newton, Georgia, during flooding caused by Tropical Storm Alberto, July 1994.

Twelve samples collected during the peak of the flooding from July 9 to 14, 1994, were analyzed for 60 volatile organic compounds. Many of these compounds are solvents or components of gasoline or other fuels. However, no volatile organic compounds were detected in floodwaters at or above the minimum detection limit of 0.2 µg/L.

MASS TRANSPORT

Loads in the Flint River at Newton from July 6-21, 1994, were estimated for suspended sediment, organic carbon, nitrate plus nitrite, total phosphorus, and six pesticides.

The cumulative suspended-sediment load was 110,000 tons, or about 60 pounds per acre, of the basin upstream of Newton. Suspended-sediment data are not sufficient for estimates of historical annual sediment loads at this location. Floodwaters transported 25,000 tons of organic carbon. The source of much of the organic carbon probably was detritus (mostly plant debris) in floodplains and upland areas.

Floodwaters transported about 50 percent of the mean annual load of ammonia plus organic nitrogen (E.A. Frick and G.R. Buell, written commun., 1994) and 13 percent of the mean annual load of nitrate plus nitrite (table 2). The source of much of the nitrogen probably was detritus in flood plains and upland areas. Additional contributions of organic nitrogen also may have come from sewage and manure. The total nitrogen flood load is about 4.5 percent of annual point and nonpoint sources of nitrogen in the basin from a combination of wastewater- treatment plant discharges and applications of manure and fertilizer to agricultural land in the basin. Total phosphorus flood load was about 59 percent of the mean annual load of phosphorus (table 2). Sources of phosphorus include detritus in floodplains and upland areas, as well as sewage effluent, fertilizers, and manure. The total phosphorus flood load is about 2.8 percent of the annual point and nonpoint sources of phosphorus in the basin from a combination of wastewater discharges and applications of manure and fertilizer to agricultural land in the basin. Cumulative loads of the six pesticides present throughout much of the flood were from 0.07 to 2.5 percent of their estimated annual use on major row crops and orchards in the basin (table 3). The actual use of the herbicides simazine and atrazine, and the insecticide diazinon may be higher because of extensive, but undocumented, use in urban and suburban areas in the basin.

Table 2. Cumulative loads of nutrients and organic carbon in the Flint River at Newton, Georgia, during flooding caused by tropical storm Alberto, July 1994 [--, not determined]

Nutrient	Cumulative load	
	Tons	Percentage of mean annual load[1]
Total nitrogen	1,880	--
Total ammonia plus organic nitrogen	1,500	50
Dissolved nitrate plus nitrite	380	13
Total phosphorus	280	59
Total organic carbon	25,000	--

[1]Data from E.A. Frick and G.R. Buell, USGS, written commun., 1994

Table 3. Cumulative loads of selected pesticides in the Flint River at Newton, Georgia, during flooding caused by Tropical Storm Alberto, July 1994.

Pesticide	Cumulative load	
	Pounds	Percentage of use[1]
Atrazine	140	0.09
Cyanazine	310	1.4
Fluometuron	220	.28
Metolachlor	95	.07
Simazine	50	.39
Diazinon	43	2.5

[1]Estimated pesticide use on crop and orchard land for the latest available years

LITERATURE CITED

Brown, S.L., and Brown, S.M., 1992, Assessment of Pesticides Used on Peanuts: Univ. of Georgia, Coop. Extension Service, Rural Development Center, 13 p.

Fishman, M.J., and Friedman, L.C., 1989, Methods for the Determination of Inorganic Substances in Water and Fluvial Sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Georgia Agricultural Statistics Service, 1994, Georgia Agricultural Facts-1994 Edition: Athens, Georgia, 104 p.

Gianessi, L.P., and Puffer, C., 1990, Herbicide use in the United States: Washington, D.C., Resources For The Future, December 1990 (*revised* April 1991), 128 p.

____1992, Insecticide Use in U.S. Crop Production: Washington, D.C., *Resources For The Future,* November 1992.

Guy, H.P., 1969, Laboratory Theory and Methods for Sediment Analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. C1, 58 p.

Hippe, D.J., Wangsness, D.J., Frick, E.A., and Garrett, J.W., 1994, Water Quality of the Apalachicola-Chattahoochee-Flint and Ocmulgee River Basins Related to Flooding from Tropical Storm Alberto; Pesticides in Urban and Agricultural Watershed; and Nitrate and Pesticides in Ground Water, Georgia, Alabama, and Florida: U.S. Geological Survey Water-Resources Investigations Report 94-4183, 36 p.

Hubbard, E.E., Purcell, J.C., and Crocker, T.F., 1988, Commercial Pecan Tree Inventory and Prospectus, Georgia, 1987: University of Georgia, College of Agriculture, Agricultural Experiment Station, Research Report 554, 40 p.

Hubbard, E.E., Purcell, J.C., and Myers, S.C., 1990, Commercial Peach Tree Survey, Georgia 1989: University of Georgia, College of Agriculture. Agricultural Experi- ment Station, Research Report 587, 27 p.

National Agricultural Statistics Service, 1991, Agricultural Chemical Usage 1990 Field Crops Summary: U.S. Department of Agriculture (March 20, 1991), 154 p.

____1992, Agricultural Chemical Usage 1991 Fruits and Nuts Summary: U.S. Department of Agriculture (June 1992), 167 p.

____1994, Agricultural Chemical Usage 1993 Field Crops Summary: U.S. Department of Agriculture (March 1994), 161 p.

LITERATURE CITED--Continued

Nowell, L.H., and Resek, E.A., 1994, National Standards and Guidelines for Pesticides in Water, Sediment, and Aquatic Organisms, Application to Water-Quality Assessments: *Reviews in Environmental Contamination and Toxicology*, v. 140, New York, Springer-Verlag, 164 p.

Porterfield, G., 1972, Computation of Fluvial-Sediment Discharge: U.S. Geological Survey Techniques of Water- Resources Investigations book 3, chap. C2, 66 p.

Shelton, L.P., 1994, Field Guide for Collecting and Processing Stream-Water Samples for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-455, 42 p.

Stamey, T.C., and Hess, G.W., 1993, Techniques for Estimating Magnitude and Frequency of Floods in Rural Basins of Georgia: U.S. Geological Survey Water-Resources Investigations Report 93-4016, p. 74.

U.S. Environmental Protection Agency, 1994, Drinking-Water Regulations and Health Advisories: Washington, D.C., U.S. Environmental Protection Agency, Office of Water, 11 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the Determination of Organic Substances in Water and Fluvial Sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.