Water Quality in the Georgia-Florida Coastal Plain

Georgia and Florida, 1992–96

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

Circular 1151

A COORDINATED EFFORT

Coordination among agencies and organizations is an integral part of the NAWQA Program. We thank the following agencies and organizations who contributed data used in this report or participated in the study unit liaison committee.

Federal Organizations
- National Park Service
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture-Natural Resources Conservation Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

State Agencies
- Florida Department of Agriculture and Consumer Services
- Florida Department of Environmental Protection
- Florida Game and Fresh Water Fish Commission
- Florida Geological Survey
- Florida Health and Rehabilitative Services
- Georgia Department of Environmental Protection
- Georgia Department of Natural Resources
- Georgia Geologic Survey
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- South Florida Water Management District
- Southwest Florida Water Management District
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- Suwannee River Water Management District

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- Florida State University
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Local Agencies
- Alachua County Environmental Protection Department
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- Volusia County Environmental Management

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- Florida Defenders of the Environment
- Georgia Water and Pollution Control Association, Inc.
- Karst Environmental Services
- The Nature Conservancy

This report is dedicated to the memory of Clyde E. Asbury, our colleague responsible for the ecological and surface-water sampling design.

Much appreciation is extended to U.S. Geological Survey employees for their contributions:

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Information on the NAWQA Program is also available on the Internet via the World Wide Web. You may connect to the NAWQA Home Page using the Universal Resources Locator (URL):
http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

The Georgia-Florida Coastal Plain study unit's Home Page is at URL:
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Front Cover: Santa Fe River, a tributary to the Suwannee River, 1992.
(Photograph by Marian P. Berndt, U.S. Geological Survey.)
Pages 2 and 12: Cotton field in southwest Georgia. *(Photograph by D.N. Skofronick, Tallahassee, Fla.)*

Water Quality in the Georgia-Florida Coastal Plain, Georgia and Florida, 1992-96

By Marian P. Berndt, Hilda H. Hatzell, Christy A. Crandall, Michael Turtora, John R. Pittman, *and* Edward T. Oaksford

U. S. GEOLOGICAL SURVEY CIRCULAR 1151

A contribution of the National Water-Quality Assessment (NAWQA) Program

CONTENTS

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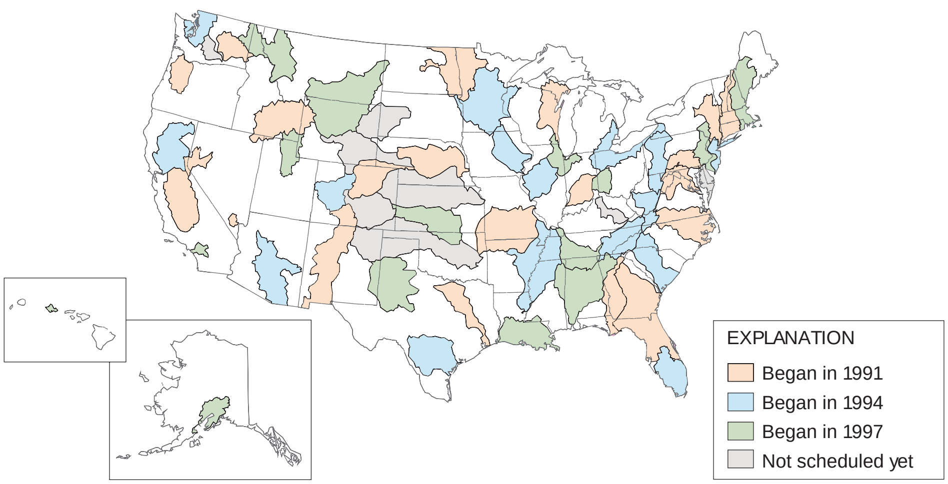
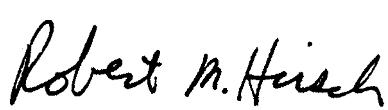


Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

This report is intended to summarize major findings that emerged between 1992 and 1995 from the water-quality assessment of the Georgia-Florida Coastal Plain Study Unit and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.



Robert M. Hirsch, Chief Hydrologist

A healthy environment is critical to Florida's economic success. That's why it is important we protect our fragile ecological systems. The National Water-Quality Assessment Program will help Florida make more informed decisions on the overall conservation of our valuable water and natural resources so we can preserve them for the benefit of future generations.

Lawton Chiles, Governor of Florida

SUMMARY OF MAJOR ISSUES AND FINDINGS

NUTRIENTS IN GROUND WATER AND STREAMS

Nitrate concentrations (as nitrogen) exceeded the U.S. Environmental Protection Agency (USEPA) drinking-water standard of 10 milligrams per liter (mg/L) in more than 20 percent of ground-water samples from surficial aquifers in agricultural areas **(page 6)**. In the 23 ground-water samples from the row-crop agricultural area in the upper Suwannee River Basin, 33 percent exceeded the drinking-water standard. These samples were from aquifers that overlie the Upper Floridan aquifer, the major source of drinking water for the study area.

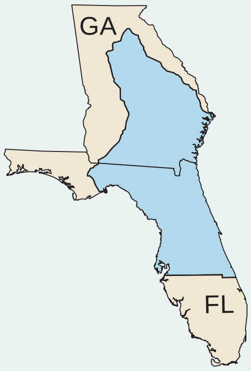
Nitrate concentrations in streams did not exceed drinking-water standards or guidelines, but were higher in streams draining basins with agricultural and mixed land uses **(pages 7-9)**. Phosphorus concentrations in nearly 30 percent of stream samples were greater than 0.1 mg/L, the USEPA guideline for the prevention of nuisance algal growth.

GROUND-WATER/SURFACE-WATER INTERACTIONS

Nitrate concentrations (as nitrogen) in the lower Suwannee River are affected by a cycle of water exchange between the river and the adjoining aquifer (**pages 10-11**). During low flow in the river, ground water containing nitrate enters the river, increasing river nitrate concentrations. During high flow, river water enters the aquifer, resulting in a decrease in nitrate concentrations. As the exchange cycle reverses, ground water flows into the river.

PESTICIDES IN GROUND WATER AND STREAMS

Of 85 pesticides and degradation products analyzed, 21 were detected in ground water and 32 were detected in streams **(pages 12-14)**. Pesticide concentrations did not exceed any USEPA drinking-water standards, but criteria for protection of aquatic life were exceeded in some streams. The most frequently detected pesticides in ground water and streams were three herbicides—atrazine, metolachlor, and prometon. No insecticides were detected in ground water. The kinds and frequency of pesticides detected differed in agricultural and urban areas.



VOLATILE ORGANIC COMPOUNDS (VOCs) AND RADON IN GROUND WATER

Eleven different volatile organic compounds (VOCs) were detected in ground water, with one VOC usually detected in each sample **(page 15)**. Most concentrations were less than 1 microgram per liter (µg/L). VOCs were detected in ground water in all land-use areas; however, samples from wells in urban and agricultural areas contained VOCs more often than samples from rangeland and forest areas.

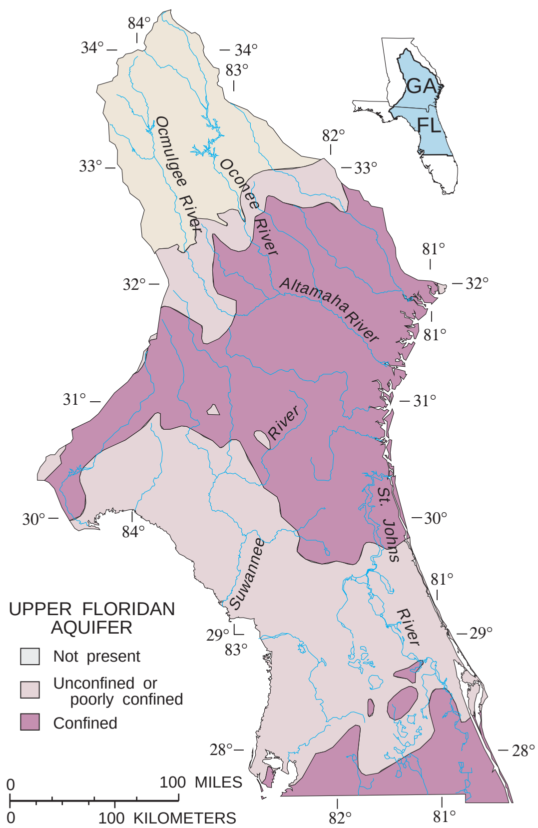
Radon concentrations in ground water were among the highest in the Nation and are related to the minerals naturally present in aquifer sediments **(pages 15, 20)**. Elevated radon concentrations were present in the Upper Floridan aquifer in central Florida, the primary drinking-water aquifer for that area.

ORGANIC COMPOUNDS AND TRACE ELEMENTS IN STREAMBED SEDIMENTS

Concentrations of organochlorine pesticides in 22 percent of streambed-sediment samples exceeded aquatic-life criteria **(page 16)**. Most exceedances were for chlordane and DDT and their degradation products, which were also the organochlorine pesticides most frequently detected in streambed sediments. Semivolatile organic compounds (SVOCs) were detected in nearly all streambed sediments. Polychlorinated biphenyls (PCBs) detected were at only one site (in an urban basin) at a concentration below the aquatic-life criterion.

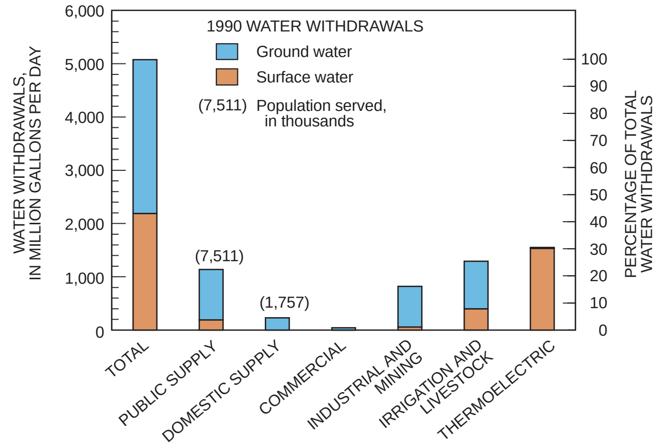
The Georgia-Florida Coastal Plain study area encompasses nearly 62,000 square miles and contains several major rivers. Most water used in the study area is ground water.

The Altamaha River in Georgia and the Suwannee River in Georgia and Florida were the major rivers sampled regularly for this study. The Altamaha is an alluvial river and the Suwannee has blackwater and springfed features, as do many rivers in the study area (Berndt and others, 1996). About 80 percent of the 9 million people residing in the study area obtain drinking water from ground water (Marella and Fanning, 1996). Nearly 94 percent of this ground water is from the limestone and dolomite rocks that comprise the Upper Floridan aquifer. In much of the area, the Upper Floridan aquifer is unconfined, contains many karst features (sinkholes, sinking streams, and springs) and is vulnerable to the same land-use effects as the sandy surficial aquifers.



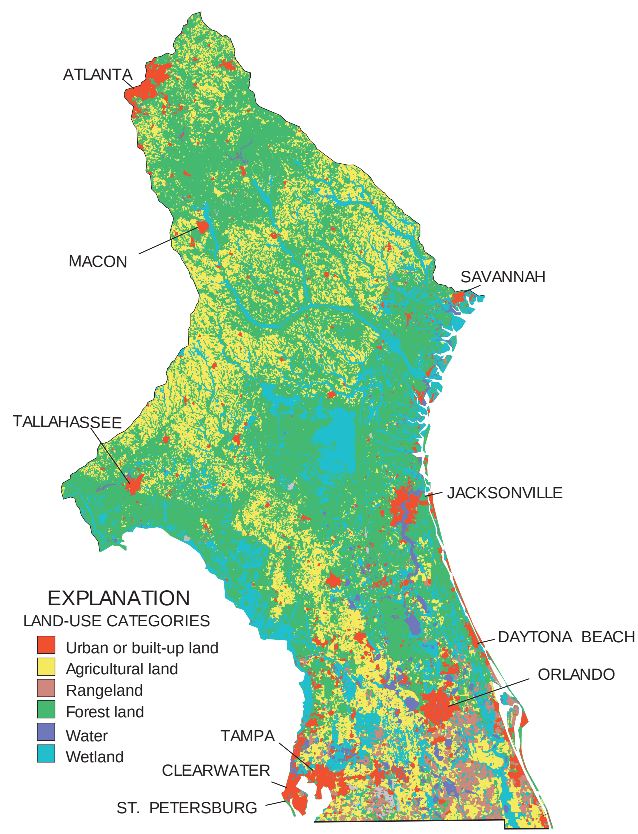
The Upper Floridan aquifer, the primary drinking-water aquifer, is poorly confined and vulnerable to contamination from the surface in much of the study area.

Ground-water/surface-water interaction is an important factor affecting water quality in much of the study area, particularly in the Suwannee River Basin. This area contains numerous springs and other ground-water inputs that supply base flow to the Suwannee River during low flow. The quality of spring water also reflects the drinking-water quality in the Upper Floridan aquifer in areas where it is most vulnerable to contamination from land uses.



More than one-half of the water used in the study area is ground water; most is used for public supply and irrigation.

More than one-half of the study area is forest land used for the production of paper products and lumber (Berndt and others, 1996). Agricultural land covers about 25 percent of the study area. Field crops (including cotton, peanuts, corn, soybeans, and wheat) are grown in the central part of the study area, vegetables are grown throughout, and citrus crops are grown in the southern part of the study area. Dairy and poultry farms are present in northern and central parts of the study area.

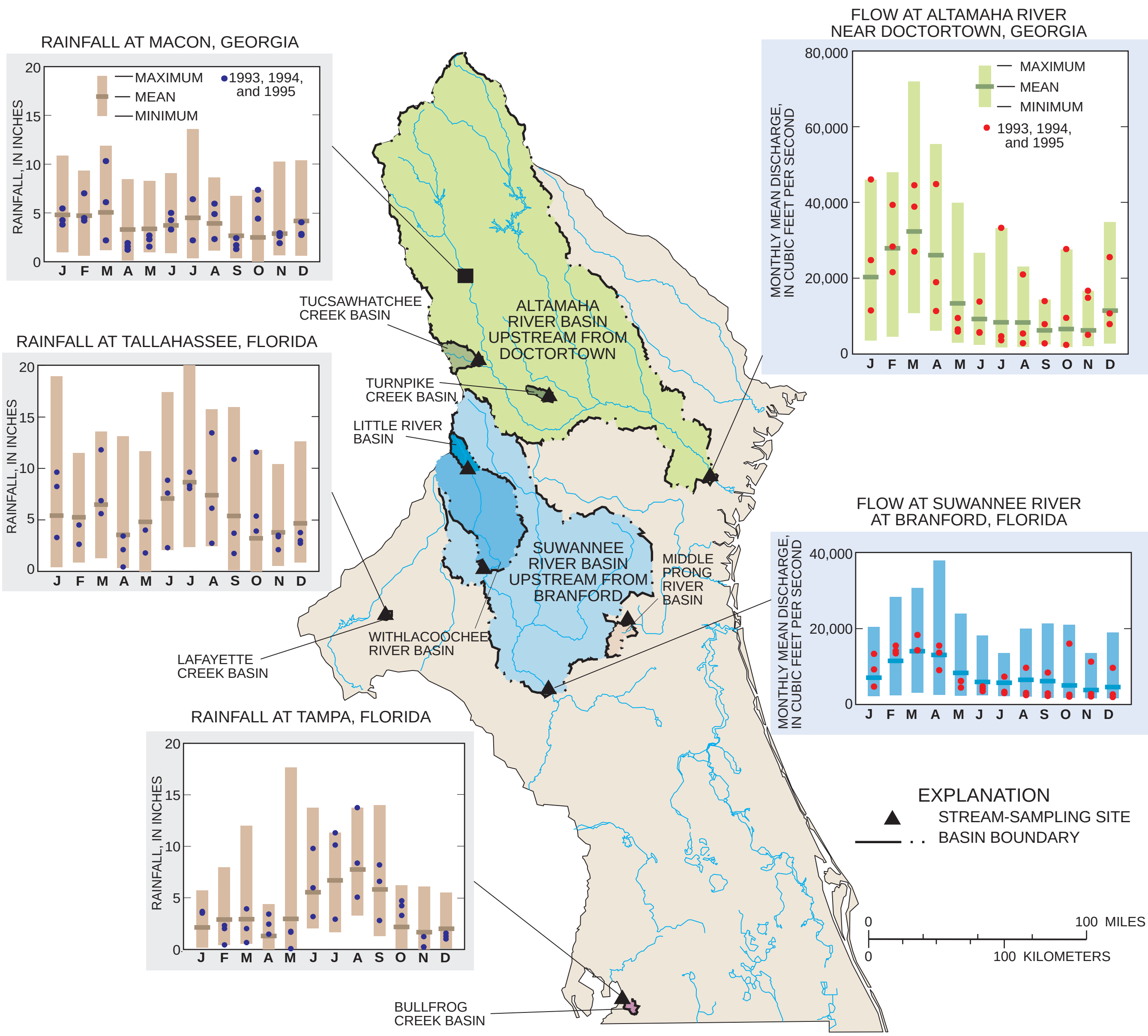


The study area contains large agricultural areas and numerous large urban areas.

The climate in the study area varies from temperate in the north to subtropical in the south.

Winter frontal systems that move across the continent affect northern and central parts of the study area. The central and southern parts are subject to subtropical air masses from the Gulf of Mexico and the Atlantic Ocean. Northern Florida receives the most rainfall. The long-term average is about 65 inches per year (in/yr) in Tallahassee, Fla. North-central Georgia (45 in/yr in Macon) and west-central Florida (44 in/yr in Tampa) receive less rain. Rainfall amounts in 1993 and 1995 throughout the study area were below or near the long-term average.

Numerous tropical storms and hurricanes in the summer and fall of 1994 caused very high rainfall in central and southwestern Georgia and northern Florida. These high rainfall amounts were reflected in the river flows in 1994. Flows in the Altamaha and Suwannee Rivers were higher in 1994 than the 30-year mean. In 1994 in the Altamaha River, the highest monthly mean discharge in 30 years was observed for five months (January, July, September, October, and November).



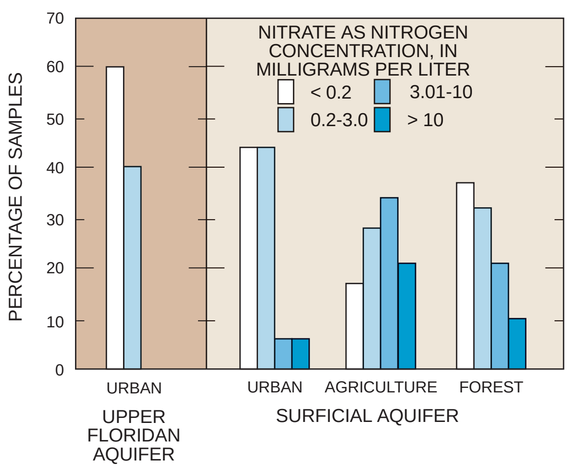
Rainfall amounts vary from north to south. Tropical storms and hurricanes caused high rainfall in 1994, during the 3 years of the most intensive data collection, 1993-95. Flows in the Altamaha and Suwannee Rivers reflect the varying rainfall amounts in these 3 years.

NITRATE IN GROUND WATER

More than 20 percent of samples from agricultural areas throughout the study area had nitrate concentrations greater than the USEPA drinking-water standard of 10 mg/L as nitrogen.

Nitrate concentrations in ground water were analyzed by grouping samples from all ground-water surveys and special studies into three land-use categories: agriculture, forest, and urban. Most samples were from shallow monitoring wells or domestic wells in the surficial aquifer. The median nitrate concentration in ground water for wells in agricultural areas was 4.2 mg/L. Many of these samples were from the row-crop agricultural area in south-central Georgia, but some samples were from a ground-water seepage study in a citrus-grove area (p. 22). In the row-crop agricultural study area, nitrate concentrations in 33 percent of samples were greater than the drinking-water standard.

To assess the effect of human activities on ground-water quality in the study area, samples were analyzed on the basis of four ranges of nitrate concentrations: less than or equal to 0.2 mg/L (natural background concentrations); 0.21 to 3.0 mg/L (concentrations may or may not represent human influence); 3.01 to 10 mg/L (elevated concentrations resulting from human activities); greater than 10 mg/L (exceeds drinking-water standard for nitrate as a result of human activities) (Madison and Brunett, 1985).

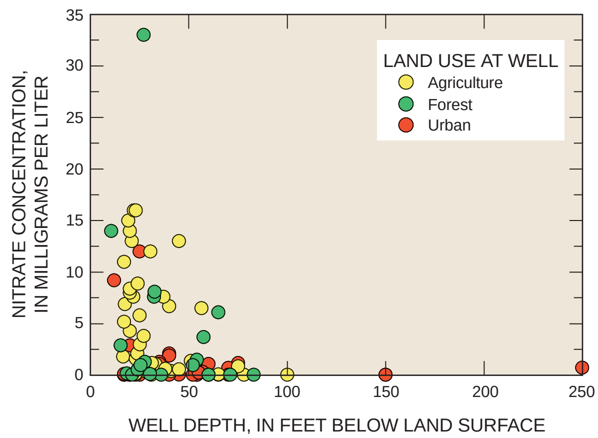


Samples with nitrate concentrations greater than the drinking-water standard of 10 mg/L were predominantly from agricultural areas.

Nitrate concentrations were related to land use at the well and tended to decrease with depth of well sampled.

In the Upper Floridan aquifer, the primary drinking-water aquifer for most of the study area, the median nitrate concentration was less than 0.05 mg/L in urban areas. In contrast, the median nitrate concentration was 0.95 mg/L in the surficial aquifer in urban areas. Nitrate concentrations in 60 percent of samples from Upper Floridan aquifer wells were less than 0.2 mg/L, whereas concentrations in 40 percent of samples from surficial wells were less than 0.2 mg/L. The highest concentration of nitrate in urban areas was 12 mg/L in a sample from a surficial well in Ocala, Fla. (Berndt and others, in press).

Nitrate concentrations commonly are highest in shallow wells due to sources of nitrogen at the land surface. Nitrate concentrations were higher in water from shallow wells in agricultural areas, but even samples from the most shallow wells in the urban areas had fairly low nitrate concentrations. The highest nitrate concentration (33 mg/L) was in a sample from a well located in a forest area with confined animal feedlots located nearby.



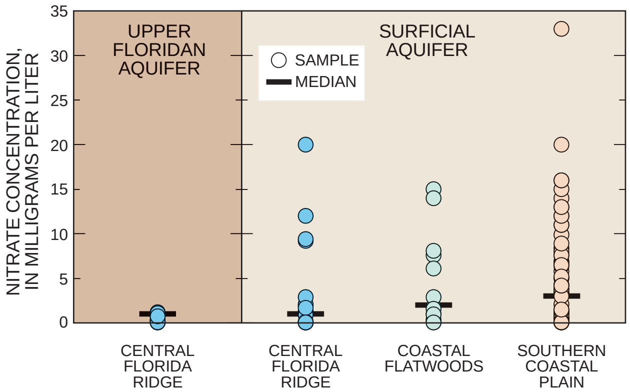
Nitrate concentrations were generally higher in samples from agricultural areas and shallower wells.

Fertilizers and animal waste contribute nitrate to shallow ground water in the row-crop agricultural area.

Nitrogen isotope ratios were analyzed in ground-water samples from the row-crop agricultural study area (p. 22) to determine probable sources of nitrate. Nitrogen isotope ratios indicated that both inorganic fertilizer and animal wastes were the predominant sources of nitrate in ground water (Crandall, 1996).

Nitrate concentrations in ground water are generally influenced by land use, geology, soils, and topography.

Ground water in agricultural areas in most of the study area is at risk for elevated nitrate concentrations because of the relatively large amounts of fertilizer applications (Berndt and others, 1996), high mean annual recharge, sandy soils, and karst features. The central part of the study area is a karst region with well-drained sandy soils that have a low water-nutrient holding capacity; therefore, nitrogen not taken up by plants has a high probability of leaching to ground water. Nitrate was the nutrient detected most frequently in ground water.



High nitrate concentrations were more common in the Southern Coastal Plain, which contains most of the row-crop agriculture in the study area.

To evaluate the effects of various factors such as soils, geology, topography, climate, and land use on nitrate concentrations in ground water, concentrations were compared by land resource provinces (Berndt and others, 1996). These provinces are shown on page 9. Nitrate concentrations in the surficial aquifer differed little among land resource provinces, but higher concentrations were generally measured in the Southern Coastal Plain. Surprisingly, nitrate concentrations were lowest in the Central Florida Ridge, despite the fact that most of the samples in this area were from the urban land-use study and the ground-water seepage study in a citrus-growing area.

Concentrations of other nutrients in ground water were lower than nitrate concentrations.

Other nitrogen and phosphorus compounds analyzed in ground water include ammonia, orthophosphate, and total phosphorus. Concentrations for these constituents were low and did not differ by land resource province or by land use. The highest concentration of ammonia as nitrogen was 0.81 mg/L in samples from surficial wells in urban and rangeland areas. Total phosphorus was less than 0.05 mg/L in about 50 percent of ground-water samples. The maximum phosphorus concentration, 1.3 mg/L, was measured in samples from surficial wells in urban and forest areas.

NUTRIENTS IN STREAMS

Nitrate concentrations (as nitrogen) in streams did not exceed the USEPA drinking-water standard.

Among streams that were sampled intensively (p. 22), the highest nitrate concentration was 2.5 mg/L in the Withlacoochee River in southwestern Georgia (Ham, 1997). This concentration is one-fourth of the USEPA 10-mg/L drinking-water standard. Nitrate concentrations in 95 percent of all stream samples were less than 1 mg/L; the median was 0.14 mg/L. Nitrogen concentrations greater than 1 mg/L could promote algal blooms in estuaries—areas where streams drain into coastal waters (National Oceanic and Atmospheric Administration/U.S. Environmental Protection Agency Team on Near Coastal Waters, 1988). Sources of nitrate include fertilizer, human and animal wastes, and atmospheric deposition (Asbury and Oaksford, 1997).

Nearly 30 percent of the dissolved phosphorus concentrations in streams were greater than the aquatic criteria for total phosphorus.

Although there are no aquatic criteria for dissolved phosphorus, the USEPA (1986) recommended a maximum concentration of total phosphorus equal to 0.1 mg/L to discourage excessive growth of aquatic plants. Dissolved phosphorus concentrations in 28 percent of the samples were greater than 0.1 mg/L. The highest dissolved phosphorus concentration among intensively sampled streams was 0.78 mg/L in the Withlacoochee River. The median concentration for intensively sampled streams was 0.04 mg/L.

Higher nitrate concentrations were associated with streams draining agricultural and mixed basins.

Sources of nutrients are commonly associated with specific land uses, such as the use of fertilizer in agriculture. However, no direct relation was found when nutrient concentrations were compared to land-use percentages because land use tends to be a patchwork. For example, nitrate concentrations did not increase as the percentage of agricultural land in basins increased.

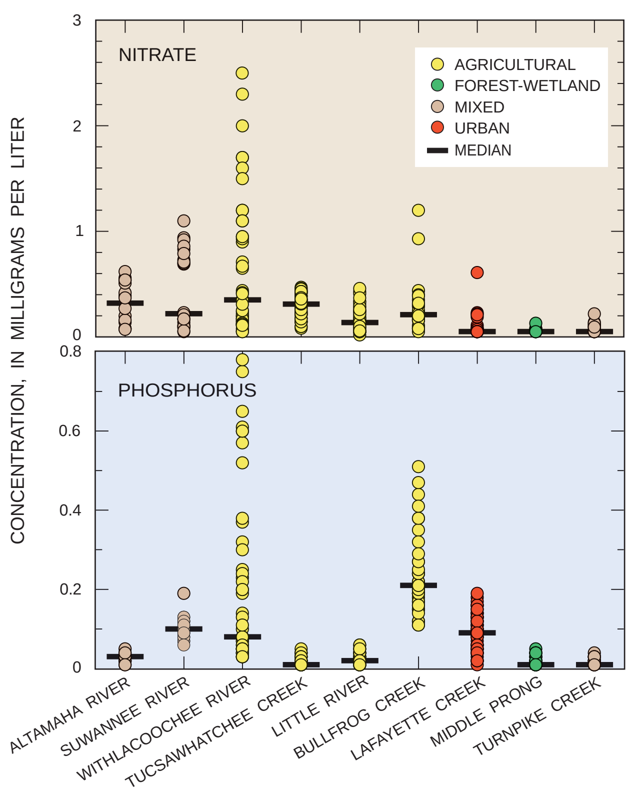
The lack of a direct relation between nitrate and phosphorus concentrations and land-use percentage could be caused partly by the intermingling of land uses within basins. Agricultural land in south-central Georgia commonly is located in upland areas and is interspersed among forests and wetlands that tend to occupy lowland areas. Small towns are scattered throughout the landscape. This pattern is less distinct in Florida. As a consequence of the intermingled land uses, basins with one dominant land use are generally small—less than about 50 mi^2.

To circumvent this problem, the effects of land use on nutrient concentrations were evaluated by assigning all stream basins to one of four empirical categories based on land-use percentages. Comparisons were then made among the categories listed in the table on page 8.

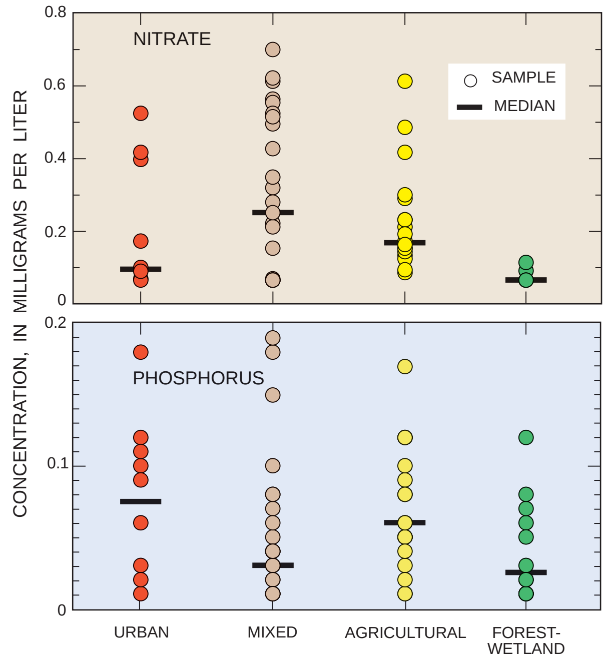
Basin category	Land use		
	Agriculture	Forest-Wetland	Urban
Agricultural	> 50%	Variable	< 10%
Urban	< 10%	Variable	> 10%
Forest-Wetland	< 10%	> 90%	< 10%
Mixed	All other sites		

Most of the intensively sampled stream sites were located in south-central Georgia and north Florida. An additional 36 stream sites, called synoptic sites, were sampled twice to provide greater spatial coverage throughout the study area.

Among the synoptic sites, the highest median nitrate concentration was 0.24 mg/L in streams draining basins in the mixed category, followed by 0.16 mg/L in streams draining agricultural basins. The relation between nitrate concentrations and basin categories was similar but less distinct for the intensively sampled sites. Median nitrate concentrations tended to be higher in the streams draining basins categorized as agricultural or mixed, whereas the medians tended to be lower for Lafayette Creek (urban basin) and Middle Prong (forest-wetland basin). Low nitrate concentrations in Lafayette Creek reflect the fact that the basin is a sewered suburban area with no wastewater discharges.



Nitrate and phosphorus concentrations in the stream draining a forest-wetland basin were generally lower than in other intensively sampled streams.



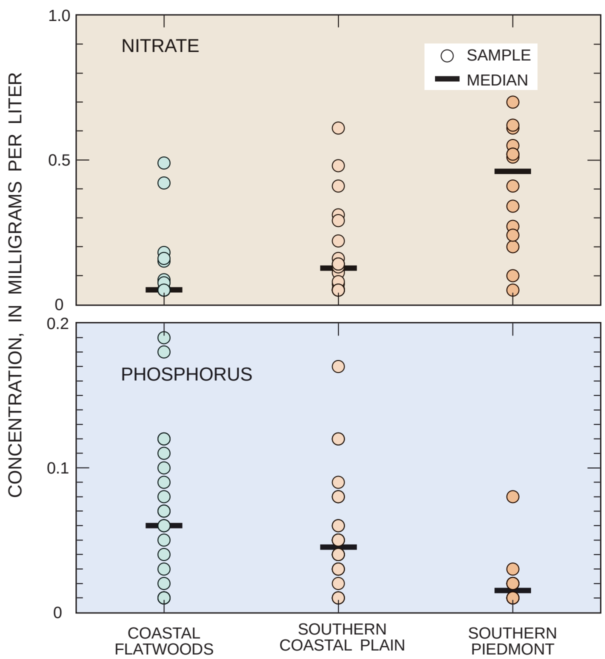
Nitrate and phosphorus concentrations at synoptic sites differed among four basin land-use categories.

Higher phosphorus concentrations were associated with streams draining agricultural and urban basins.

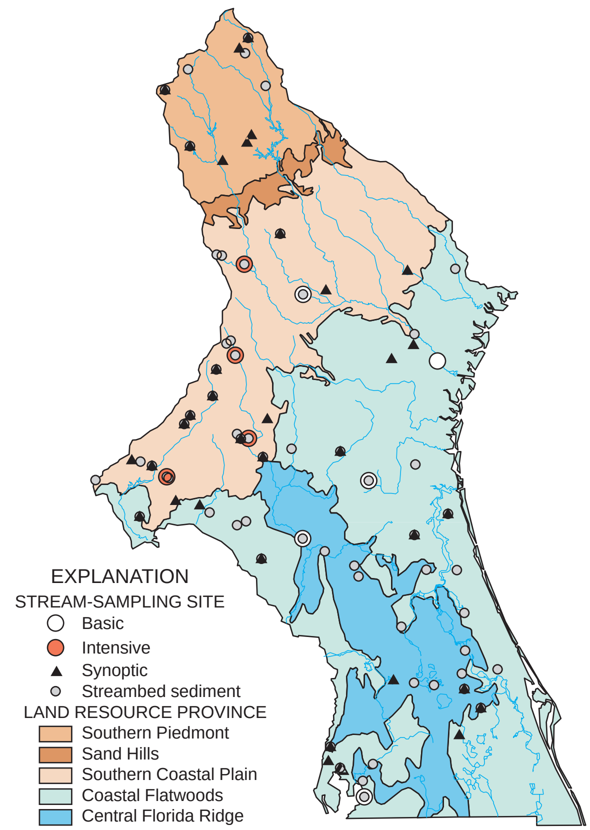
Among the synoptic basins, the median dissolved phosphorus concentration was 0.08 mg/L for urban streams and 0.06 mg/L for agricultural streams. The highest median phosphorus concentration among the intensively sampled streams was in Bullfrog Creek, which drains an agricultural basin along the coast of west-central Florida. The high phosphorus concentrations at Bullfrog Creek may be partly derived from phosphate deposits in the area. The lowest median phosphorus concentrations were in Middle Prong (forest-wetland basin), in Tucsawhatchee Creek (agricultural basins), and in Turnpike Creek (mixed basin).

Nitrate and phosphorus concentrations in streams draining agricultural basins were more related to stream discharge than to agricultural season.

Increases in nitrate and phosphorus concentrations would be expected in the planting season when fertilizers are most frequently applied. Durations of the planting, harvesting, and fallow seasons were based on the growth of major crops in south-central Georgia. Minor crops, such as wheat, are grown in the fallow season. Concentrations did not consistently increase in the planting season for three intensively sampled streams that drain agricultural basins. Nitrate concentrations in the Little River tended to increase during high streamflow (Hatzell, 1997) as shown in February 1994 (see graph at right). This increase could be related to the transport of nitrate downslope by subsurface flow from agricultural fields through wetlands to the Little River channel (Lowrance and others, 1985).



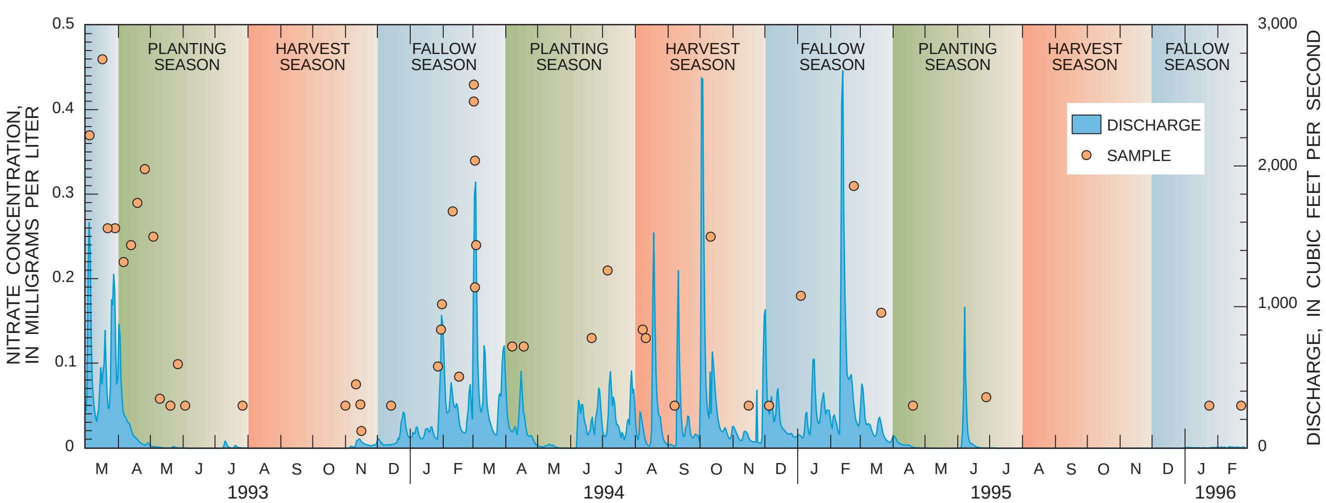
Nitrate concentrations at synoptic stream sites were highest in the Southern Piedmont, whereas phosphorus concentrations were highest in the Coastal Flatwoods.



Sites were distributed among basins located in five land resource provinces.

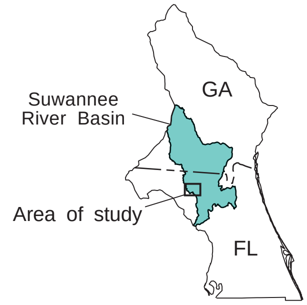
Median concentrations of nitrate and phosphorus were different for stream basins in different land resource provinces.

Land resource provinces represent various combinations of environmental factors—such as climate, geology, soils, and topography—expressed over large regions (Berndt and others, 1996). The highest median nitrate concentration and the lowest median phosphorus concentration were present in streams draining basins in the Southern Piedmont. These differences in median concentrations among the land resource provinces indicate that environmental factors could affect the nitrate and phosphorus concentrations in streams. Environmental factors also affect which land use is dominant in a province. For example, forest-wetland basins and urban basins tend to be located in the Coastal Flatwoods whereas agricultural basins tend to be located in the Southern Coastal Plain.



Nitrate concentrations increased during periods of high flow in the Little River, a stream that drains an agricultural basin.

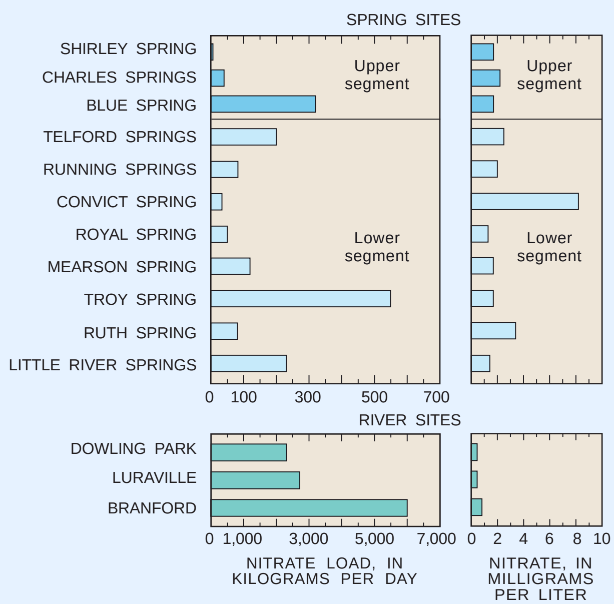
Ground-water/surface-water interactions affect water quality in the Suwannee River.



Resource managers are concerned that nitrate in ground water increases nitrate concentrations and loads in the lower Suwannee River (Ceryak and Hornsby, 1996), a stream reach that is highly valued for ecological and recreational reasons. Nitrate concentrations in the lower Suwannee River are affected by a cycle of water exchange between the river and the Upper Floridan aquifer.

The greatest amount of ground-water inflow to the Suwannee River occurs during low flow when ground-water discharges to the river through springs and upward movement of ground water through the riverbed (riverbed leakage). The greatest amount of river-water inflow to the Upper Floridan aquifer occurs during high flow when water from the Suwannee River recharges portions of the aquifer.

During low flow, ground-water discharge increases nitrate concentrations and loads in the Suwannee River.



Nitrate concentrations were higher in the measured springs than in the river. Nitrate loads in the river reach increased twice as much in the lower segment than the upper segment.

Several springs are present along the river reach from Dowling Park to Branford, Fla. This 33-mile reach, which was divided into an upper and lower segment, was selected because all the inflow to the river is from ground water. During low flow in July 1995, the river and 11 springs were measured and sampled (Pittman and others, 1997).

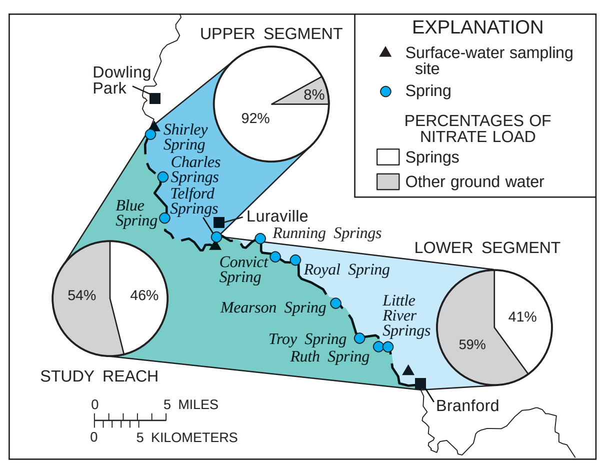
River discharge increased by 950 cubic feet per second (ft^3/s) along the entire study reach. Inflow from springs that were measured accounted for about 40 percent of the increase, and inflow from other ground water such as unmeasured springs and riverbed leakage accounted for about 60 percent.

Nitrate concentrations in the measured springs ranged from 1.3 to 8.2 mg/L; the median concentration was 1.7 mg/L. Nitrate concentrations at the three river sites were less than 1.0 mg/L and almost doubled in the lower segment. Except for Convict Spring, a spring with a small discharge (1.7 ft^3/s), the nitrate concentrations of springs in the upper and lower segments were similar.

In the upper segment, the estimated nitrate concentration for other ground water (unmeasured springs and riverbed leakage) was 0.05 mg/L, which is much lower than the concentration in measured springs. In contrast, in the lower segment, the estimated nitrate concentration for other ground-water inflow was 2.7 mg/L, which is similar to concentrations for measured springs.

The nitrate load increased 3,700 kilograms per day (kg/d) in the river reach. Eleven percent of the increase occurred in the upper segment; the remaining 89 percent occurred in the lower segment. Measured springs were the major contributor to the nitrate load in the upper reach and other ground-water inflow was the major contributor in the lower reach. The spring contributing the largest load was Troy Spring, the spring with the largest discharge (132 ft^3/s).

Possible sources of nitrate in the ground water in the vicinity of the river reach include fertilizer, animal wastes from dairy and poultry operations, and septic-tank effluent. The differences between the two river segments indicate that increases in nitrate loads in the river reach are controlled by factors that interact with the effects of land use on ground water. These factors include magnitude of spring discharges, the size and location of the spring basins, and ground-water hydrology.



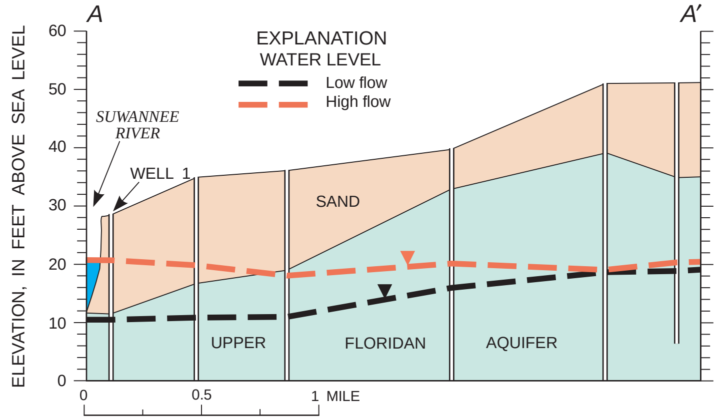
Measured springs accounted for nearly half of the increase in nitrate load in the river reach.

High Flow Conditions

During high flow, stream water infiltrated the aquifer and caused a decrease in nitrate concentrations. Field observations indicated that the Suwannee River flooded the Little River Springs. During this flooding, river water levels rose about 10 ft above the base-flow level of the spring; thus, river water was likely inflowing to the spring during this period. The Little River Springs, ground water in the vicinity of the spring, and the Suwannee River (upstream and downstream from the spring) were sampled four times from July 1995 through April, 1996 (C.A. Crandall, U.S. Geological Survey, written commun., 1997).

High flow on the Suwannee River near Little River Springs peaked at 12,700 ft^3/s in April 1996. Water levels in the river and the aquifer gained 10 feet in elevation, and a low in the water table formed in the Upper Floridan aquifer, approximately 1 mile from the river. This low area indicates that surface water may have moved laterally into the aquifer, causing ground-water flow to be slowed and redirected. Thus the necessary time and chemical conditions [high dissolved organic carbon (DOC) and low dissolved oxygen concentrations] were favorable for denitrification to occur.

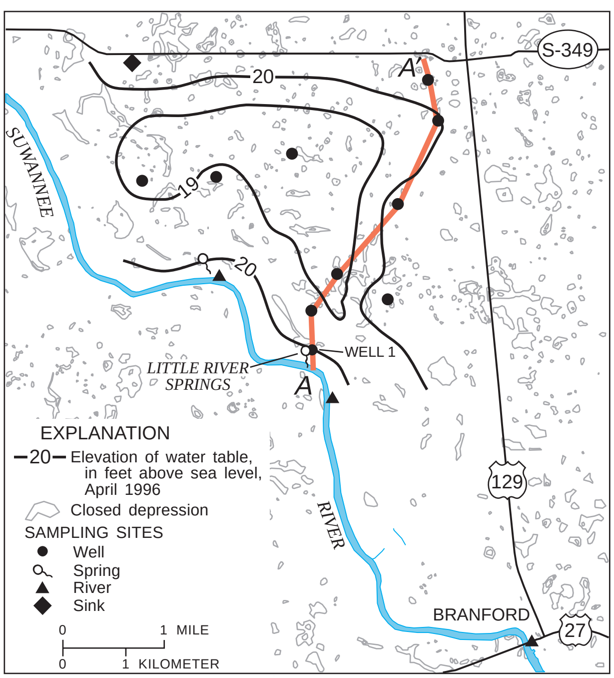
Denitrification can occur when river water containing DOC flows into the Upper Floridan aquifer (Katz and Dehan, 1996). Denitrification is a naturally occurring microbial process that decreases nitrate concentrations in water.



Water levels in wells were 10 feet higher during high flow conditions on the river (April 10, 1996).

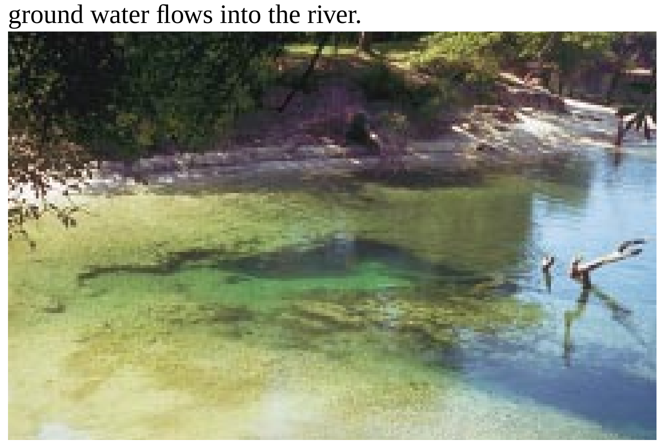
When river water infiltrated the aquifer during high flow, nitrate concentrations decreased in ground water.

Water sampled	Nitrate as N, mg/L		DOC, mg/L	
	Low flow	High flow	Low flow	High flow
Well 1	0.18	0.05	1.0	28
Little River Springs	1.25	0.08	0.55	31
Suwannee River	0.77	0.10	12	30



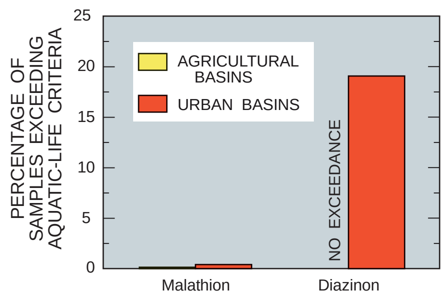
A low formed in the water table north of the Little River Springs during high flow conditions in 1996.

The chemical effects of stream water recharging ground water during high flow were noted in water from well 1, located about 300 feet from the river channel. A geochemical mixing model (Parkhurst, 1995) gave an estimate of 88 percent river water in this well. The DOC concentration increased from 1.0 mg/L during low flow to 28 mg/L during high flow. Over the same period, the nitrate concentration decreased from 0.18 to 0.05 mg/L. Denitrification is a likely explanation for the decrease in nitrate concentrations in this well. If denitrification occurs in the aquifer during high flow, then nitrate loads from ground water will be decreased when ground water flows into the river.



Concentrations of two pesticides exceeded aquatic-life criteria in surface water.

Pesticide concentrations in streams and ground water did not exceed USEPA drinking-water standards; however, concentrations of two insecticides—diazinon and malathion—sometimes exceeded aquatic-life criteria (Gilliom and others, in press). The exceedances for these insecticides occurred more frequently in samples from an urban stream in Tallahassee than in samples from three streams draining agricultural basins in central Georgia. Not all of the pesticides analyzed in samples have been assigned drinking-water standards or aquatic-life criteria (p. 24-25).



About 20 percent of diazinon concentrations in a stream draining an urban basin exceeded the aquatic-life criteria.

Although more pesticides were detected in surface water than in ground water, the median concentration for all pesticides was higher for ground water than for surface water.

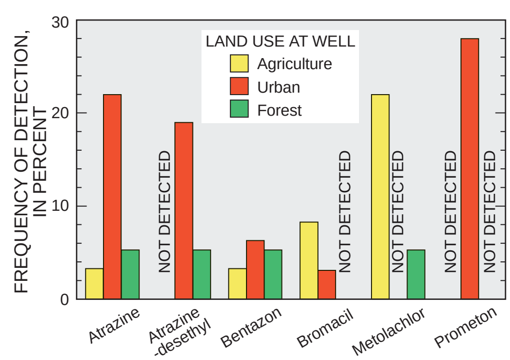
Of 85 pesticides (including herbicides, insecticides, and degradation products) analyzed, 20 herbicides and two insecticide degradation products were detected in 114 ground water samples. The median concentration for all herbicide analyses combined was 0.03 microgram per liter (µg/L), 95 percent of the concentrations were less than 1.04 µg/L. Pesticides with the highest concentrations were bromacil and bentazon. Bromacil concentrations of 57 and 14 µg/L were detected in a ground-water seepage study in a citrus-growing area in central Florida (p. 22). Bromacil is used for weed control in citrus and noncropland areas. Bentazon (maximum concentration of 6.4 µg/L) controls broadleaf weeds in corn, peanuts, and beans.

Twenty-two herbicides, 7 insecticides, and 3 degradation products were detected in 209 water samples collected from three streams draining agricultural basins (Hatzell, 1997) and one stream draining an urban basin. The median concentration for all pesticide analyses combined was 0.012 µg/L, which is about one-third of the ground-water median. Ninety-five percent of all pesticide detections in surface water were less than 0.12 µg/L. The highest pesticide concentrations were 2.62 µg/L of propargite and 0.86 µg/L of atrazine. Propargite, which is used to control mites in orchards, was only detected twice. Atrazine, a herbicide used to control a variety of weeds in corn and sorghum, was the most frequently detected pesticide in surface water.

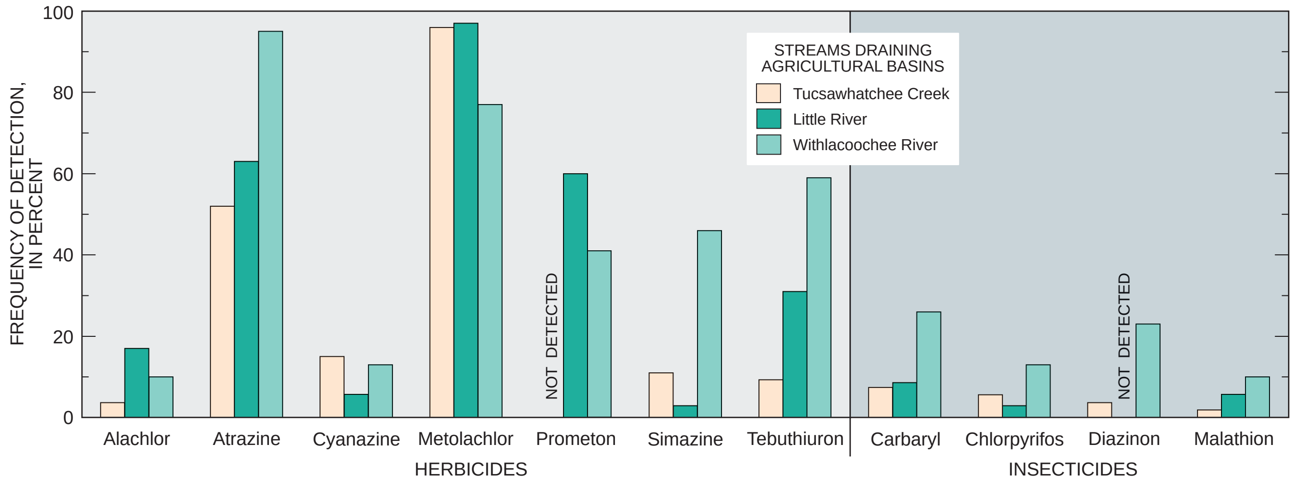
When comparing pesticides in ground water with those in surface water, it should be noted that different sampling strategies were used (p. 22-23). Ground water was sampled at many wells over a large area, with usually one or two samples from each well. Surface water was usually intensively sampled at a few sites for 3 years. Thus, ground-water samples generally provided more spatial information about the distribution of pesticides, whereas surface-water samples generally provided more temporal information.

Fourteen herbicides were detected in ground water in agricultural areas.

Metolachlor, used to control weeds in a wide variety of crops, was the most frequently detected herbicide. Atrazine, bentazon, and 11 other herbicides were also detected in ground water within agricultural areas; however, each of these pesticides was detected in less than 5 percent of the samples. Samples from seven wells contained three or more herbicides per sample.



Atrazine, metolachlor, and prometon were the herbicides detected most frequently in ground water.

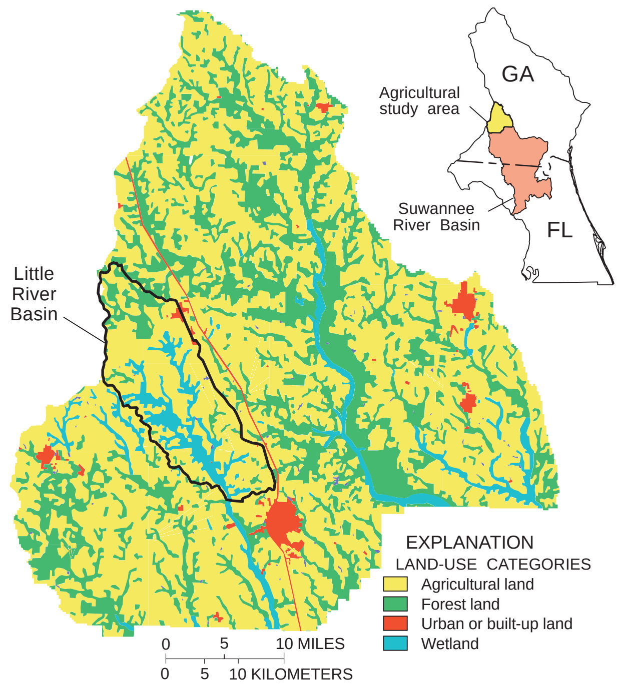


Atrazine and metolachlor were among the most frequently detected pesticides in streams draining agricultural basins.

Herbicides were detected more frequently than insecticides in streams draining agricultural basins.

Insecticides were detected in less than 30 percent of the samples from three streams draining agricultural basins. In contrast, five herbicides were detected in more than 30 percent of the samples from at least one of the streams.

Comparisons among the three streams indicate that several streams would need to be intensively sampled to provide an overview of the pesticides detected in streams draining agricultural basins. For example, although most pesticides were detected in all three streams, prometon would not have been detected if Tucsawhatchee Creek had been the only agricultural stream sampled. Herbicides applied to cotton, such as diuron, fluometuron, and norflurazon, were detected only in Tucsawhatchee Creek which has about one-third of the basin planted in cotton compared to about one-fifth for the other two basins. Generally, the largest number of different pesticides detected was in Tucsawhatchee Creek, and the highest percentage of detections for insecticides was in the Withlacoochee River.



Pesticide detections from the ground water row-crop agricultural study were compared to pesticide detections from stream samples from the Little River Basin.

Metolachlor was the most frequently detected herbicide in ground-water and stream samples within the same agricultural area.

A ground-water study in a row-crop agricultural area was done in the northernmost part of the Suwannee River Basin, which contains the Little River, an intensively sampled stream. This overlap provided an opportunity to examine pesticides present in ground water and stream water in one area over the same time periods (March-April and August, 1994). During the two sampling periods, nine herbicides and one insecticide degradation product were detected in ground water whereas five herbicides, one herbicide degradation product, and one insecticide were detected in stream water.

Only metolachlor and atrazine were present in both ground water and stream samples. Metolachlor was detected in nearly 40 percent of the wells sampled in March-April and about 20 percent of the wells sampled in August, whereas atrazine was detected once in March-April. Metolachlor and atrazine were detected in all of the stream samples.

More pesticides were detected in ground water and stream water in March-April than in August. The March-April period occurs at the beginning of the planting season when herbicides are frequently applied before or shortly after planting. Three herbicides used to control weeds in cotton—diuron, fluometuron, and norflurazon—were detected in ground-water samples. Two of the herbicides detected in stream water—prometon and tebuthiuron—are used to control weeds in noncropland areas. Ethoprop, which is used to control nematodes, was detected in a stream sample taken in March-April.

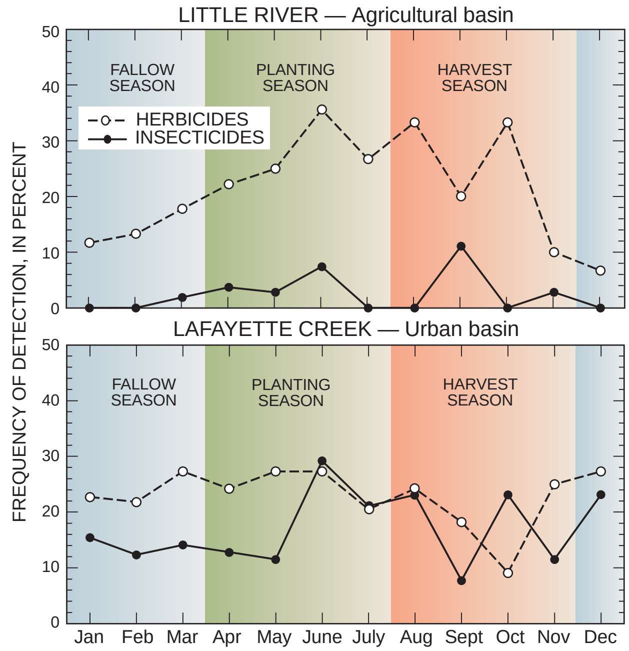
Herbicides detected in ground water in urban areas differed from those detected in agricultural areas.

Herbicides that were detected in urban areas but not agricultural areas included cyanazine, fenuron, and prometon. The occurrence of cyanazine in an urban area was not expected because cyanazine is usually applied to control weeds in field corn. Fenuron is used to control woody plants and perennial weeds. Prometon is a nonselective herbicide used to control many grasses and broadleaf weeds. Five herbicides—atrazine, bromacil, bentazon, simazine, and tebuthiuron—were detected in ground water in both urban and agricultural areas.

Differences in herbicide detections in ground water were also present when two urban areas, Ocala and Tampa, Fla., were compared. These results are somewhat surprising because these two cities are only about 150 miles apart, and landscaping and pest management practices are likely similar. Most of the detections for prometon and atrazine in urban areas were in Ocala. Six additional herbicides were detected in one of the two cities. Some of the differences could be attributed to the type of urban land use adjacent to the wells. The wells in Ocala were in downtown parks and near schools, whereas the wells in Tampa were in a residential section.

Insecticides were detected more frequently in a stream draining an urban basin than a stream draining an agricultural basin.

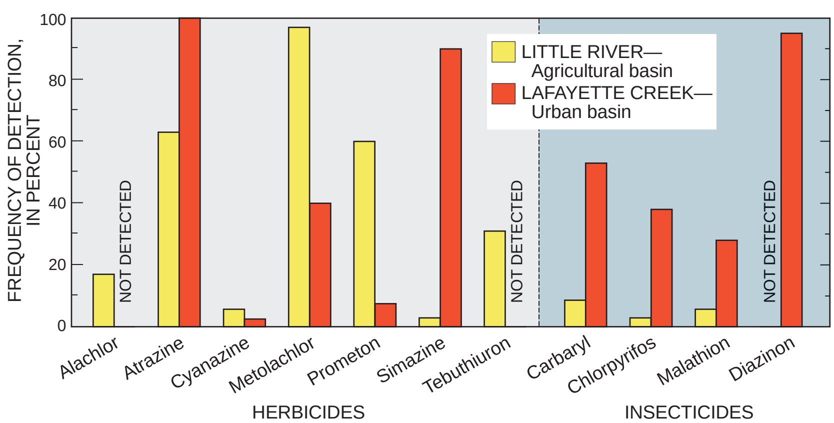
The primary difference between Lafayette Creek, which drains an urban basin, and the Little River, which drains an agricultural basin, was the greater frequency of insecticide detections in Lafayette Creek. Other differences included greater frequencies of atrazine and simazine detections, as well as an absence of alachlor and tebuthiuron detections in Lafayette Creek.



The frequency of pesticide detections in a stream draining an agricultural basin was related to the agricultural cycle.

When all detections for each month were counted regardless of the year of occurrence, an interesting contrast became apparent between Lafayette Creek (urban basin) and the Little River (agricultural basin). In the Little River, the frequency of detections for herbicides and insecticides generally followed the planting and harvesting seasons for the major crops. The frequency decreased in the fallow season, when agricultural activity is at a minimum and many fields are unplanted. Also, the frequency of detections of herbicides was always higher than that for insecticides.

In contrast, herbicide and insecticide detections in Lafayette Creek did not follow the cyclic pattern of agriculture. From June through August, the frequency of insecticide detections in Lafayette Creek was about equal to the frequency of herbicide detections.



Four insecticides were detected in more than 25 percent of the samples from a stream draining an urban basin.

Herbicides were detected in 4 of 19 ground-water samples in forest areas.

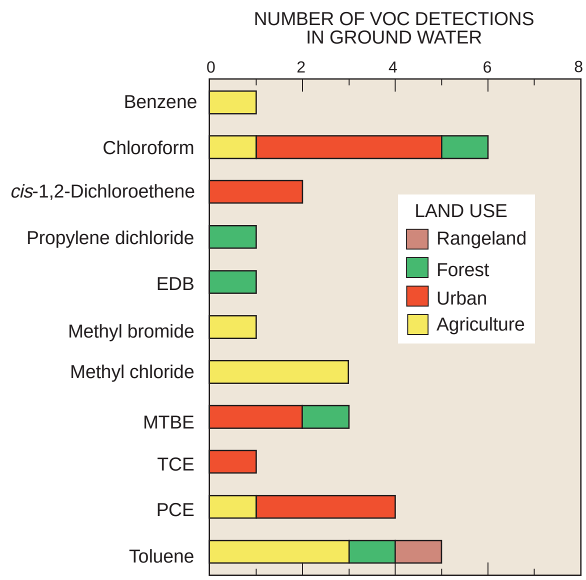
Atrazine, bentazon, metolachlor, or p,p′-DDE (a degradation product of DDT) were detected at least once in samples from four wells in forest areas. These detections were unexpected and could be related to several conditions: pesticide applications during previous land uses of the currently forested area, land uses upgradient from the wells, or improper disposal of pesticides.

The number of VOC detections was low, and most concentrations were less than 1 µg/L.

Only 11 of 60 volatile organic compounds (VOCs) analyzed were detected in ground-water samples (p. 25-26). VOCs were not analyzed in all ground-water samples (VOCs were analyzed in 104 samples). The drinking-water standard was exceeded in one sample for methyl chloride and one sample for ethylene dibromide (EDB). The highest VOC concentrations were 23 µg/L for toluene and 20 µg/L for methyl chloride. Concentrations of all other VOCs were equal to or less than 1 µg/L. Generally, one VOC was detected per sample, thus causing the percentage of samples with VOC detections to be higher than in other NAWQA studies (p. 21). Four VOCs were detected in one sample.

VOCs were detected in ground water from all land-use areas.

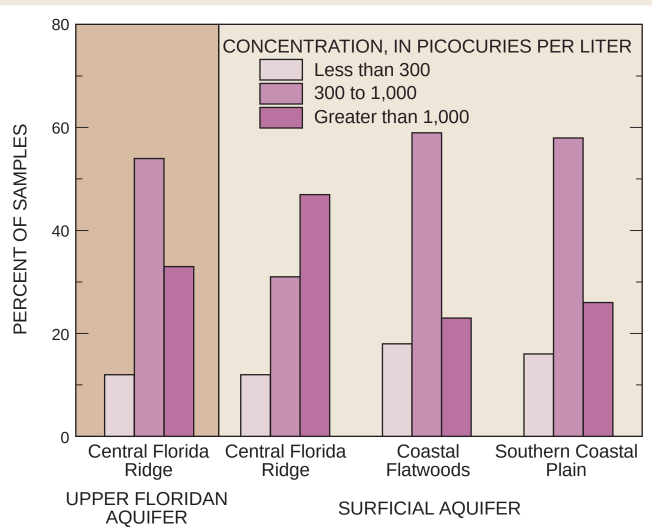
Benzene, methyl bromide, methyl chloride, and toluene were most frequently detected in samples from agricultural areas, whereas chloroform, methyl *tert*-butyl ether (MTBE), tetrachloroethene (PCE), trichloroethene (TCE), and *cis*-1,2-Dichloroethene were most frequently detected in samples from urban areas. The occurrence of some VOCs in more than one land-use area is expected because several of the VOCs have multiple uses. Many VOCs are components of gasoline or are used as solvents (including inert ingredients in pesticides). The detection of VOCs in samples from forested areas was not expected, just as pesticides were not expected. The presence of VOCs in forested areas could be related to the presence of nearby roads, rights-of-way, or agricultural activities upgradient from the sampled wells.



Eleven volatile organic compounds were detected in 104 ground-water samples.

Radon concentrations in ground water are among the highest in the Nation.

Radon concentrations ranged from 50 to 40,000 picocuries per liter (pCi/L) in the study area and were among the highest in the Nation (p. 20, 26). Radon is a naturally occurring daughter product of the decay of uranium-238. Generally, the concentration of radon in ground water is elevated when the ground water is directly in contact with rocks or sediments containing uranium. High concentrations of radon are usually detected in iron-rich and phosphatic materials (Gundersen and Peake, 1992), such as some of the soils and aquifers in the study area. Radon in water may present health problems primarily when radon is inhaled (Gundersen and Szabo, 1995), such as during bathing or showering. Generally, 10,000 pCi/L of radon in household water contributes about 1 pCi/L to the level of radon in indoor air (Otton and others, 1993). There is currently no drinking-water standard for radon.



Radon concentrations were high in both the surficial aquifer and the Upper Floridan aquifer.

The median concentration was 1,150 pCi/L for water samples from the surficial aquifer in the Central Florida Ridge. Radon concentrations in this area were higher in areas where phosphate deposits are generally present; the median was 770 pCi/L in the Southern Coastal Plain and 458 pCi/L in the Coastal Flatwoods area.

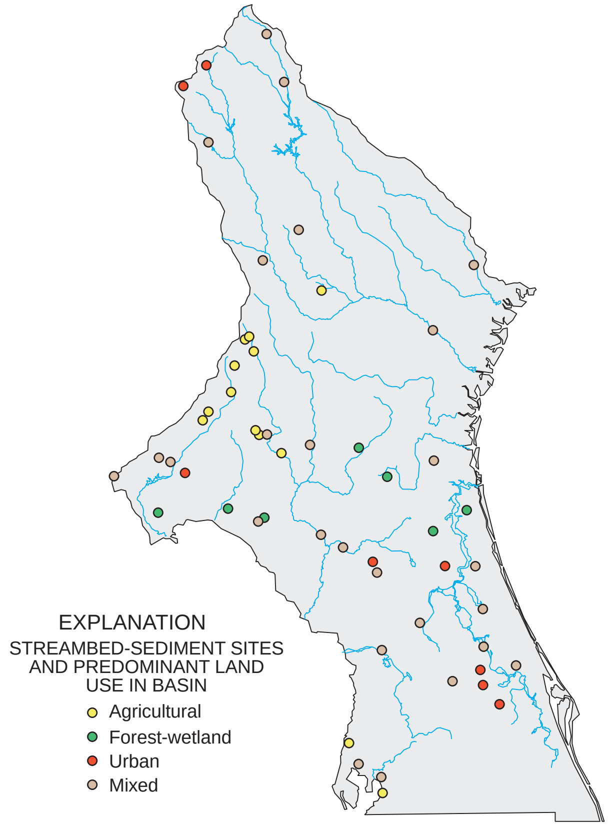
In the limestone and dolomite of the Upper Floridan aquifer, the median radon concentration was 720 pCi/L. Water samples from this aquifer were collected in Ocala and Tampa, Fla. In the Ocala area, the Upper Floridan aquifer is the primary source of drinking water.

Organic compounds, including organochlorine pesticides and semivolatile organic compounds, were detected in all streambed-sediment samples.

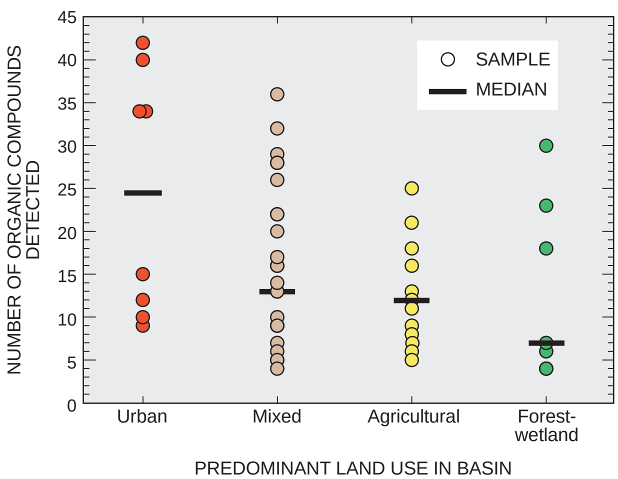
Organic compounds and trace elements sorb onto streambed sediments and can persist in the environment for many years. Streambed sediments provide habitat for a wide variety of aquatic organisms. Excessive levels of these organic compounds and trace elements can be detrimental to aquatic organisms, causing tumors, suppression of growth, and changes in behavior, blood chemistry, and reproduction (U.S. Environmental Protection Agency, 1996).

Forty or more organic compounds were detected in streambed-sediment samples from two urban basins.

Of the 24 organochlorine pesticides and 74 semivolatile organic compounds (SVOCs) analyzed in streambed-sediment samples from 54 sites, 12 organochlorine pesticides and 50 SVOCs were detected. The median number of organic compounds detected was considerably higher for samples from urban basins than for samples from any other land-use setting (see land-use classification of basins, p. 8). Most sampling sites were in basins of mixed land use, so assessing the source of the compounds was extremely difficult.



Streambed-sediment samples were collected in basins with a variety of land uses.



The median number of organic compounds detected was highest in streambed-sediment samples from urban basins.

Organochlorine pesticides detected most often were p,p′-DDE, p,p′-DDT, mirex, and chlordane.

Although most organochlorine pesticides are no longer used, they persist in streambed sediments and are potentially available for biological uptake. The DDT degradation product p,p′-DDE was detected in 45 percent of the samples, whereas p,p′-DDT was detected in 28 percent. Mirex was detected at 22 percent of sites and chlordane was detected at 26 percent of sites. Concentrations of one or more compounds exceeded aquatic-life criteria (Gilliom and others, in press) at 22 percent of sites, including chlordane at 11 sites; p,p′-DDE at 6 sites; and total DDT at 2 sites. None of the exceedances occurred in forest-wetland basins. Before chlordane was banned in 1987, it was widely used to kill termites and ants in dwellings and as an insecticide in agricultural areas (Barbash and Resek, 1996). DDT, a widely used pesticide for 30 years, was banned in the United States in 1972.

The two most frequently detected SVOCs were phthalates.

The most frequently detected SVOCs were chrysene, di-*n*-butyl-phthalate, bis (2-ethylhexyl) phthalate, phenol, fluoranthene, *p*-cresol, pyrene, benzo[*b*] fluoranthene, benzo[*k*] fluoranthene, benz[*a*] anthracene, and 2,6-dimethylnaphthalene. These compounds were detected in 52 to 94 percent of the streambed-sediment samples (p. 27-28). Phthalates are present in many plastic materials. Although a naturally occurring substance, phenol is used as a disinfectant and for making dyes and resins (Windholz and others, 1976). PCBs were detected in only one sample from an urban site near Atlanta, Ga., at concentrations that did not exceed aquatic-life criteria.

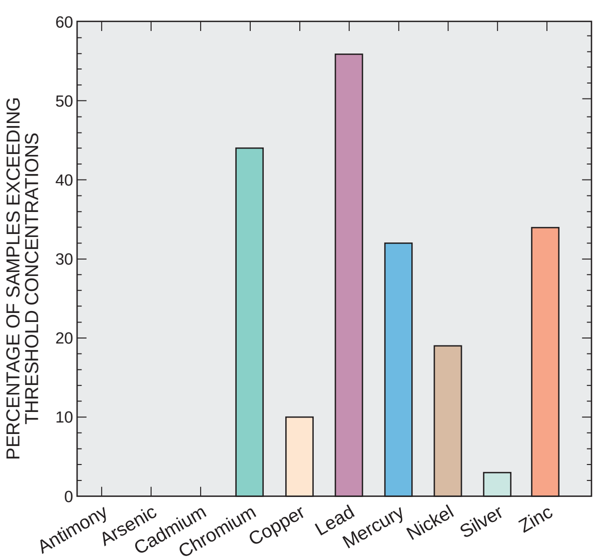
Trace element concentrations in streambed sediments are related to natural and human influences.

The trace elements antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc are included in the USEPA list of priority pollutants which may have adverse effects on aquatic life. Trace elements in streambed sediments are derived from a variety of sources. Natural sources include the weathering of soils and bedrock. Anthropogenic sources include atmospheric deposition, stormwater runoff, wastewater discharges, landfills, automobile exhaust, fertilizer, inorganic pesticides, and industrial emissions.

Long and Morgan (1991) developed criteria called "effects-range thresholds" for use in assessing the effects of differing concentrations of trace elements on aquatic organisms. They computed threshold concentrations for each element. When a trace element concentration exceeds the threshold, some aquatic organisms could be adversely affected.

One or more trace elements exceeded threshold concentrations in streambed sediments from most sites.

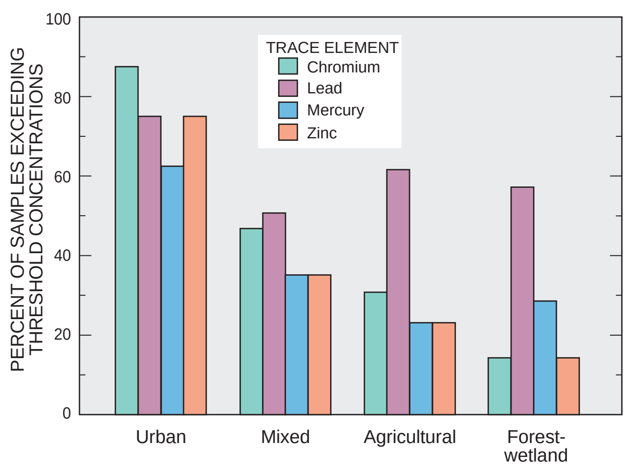
In the study area, the threshold concentration of one or more trace elements was exceeded at 83 percent of all sites. Lead, chromium, mercury, and zinc exceeded threshold concentrations most often. Lead concentrations exceeded thresholds at 57 percent of all sites. Concentrations of antimony, arsenic, and cadmium did not exceed threshold concentrations.



Lead concentrations were the most frequently detected at levels likely to adversely affect aquatic organisms.

Streambed sediments from sites in urban basins exceeded threshold concentrations more frequently than those from other land uses.

The percentage of trace elements exceeding threshold concentrations in streambed sediments was related to land use. Threshold concentrations of lead, chromium, mercury and zinc were exceeded in at least 60 percent of sites in urban areas. Threshold concentrations were exceeded less frequently in mixed, agricultural, and forest-wetland areas, with the exception of lead. Lead exceeded the threshold concentration in more than 50 percent of the sites in all land-use categories.



Chromium, lead, mercury, and zinc exceeded threshold concentrations most frequently in streambed sediment samples from urban basins.

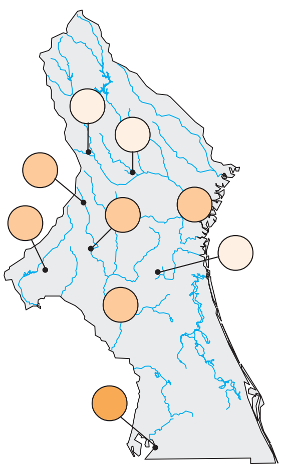
The percentage of sites with lead and mercury exceeding threshold concentrations in forest-wetland basins is of concern because these basins are relatively pristine. The sources of these two elements in concentrations of concern could be due to (1) the natural weathering of bedrock and soils in the basin, (2) atmospheric deposition from the burning of fossil fuels, or (3) other previous activities in the basin.

Comparison of Stream Quality in the Georgia-Florida Coastal Plain with Nationwide NAWQA Findings

White areas indicate other NAWQA Study Units sampled during 1992-95.

Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the Georgia-Florida Coastal Plain were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described by Gilliom and others, in press.)

NUTRIENTS in water



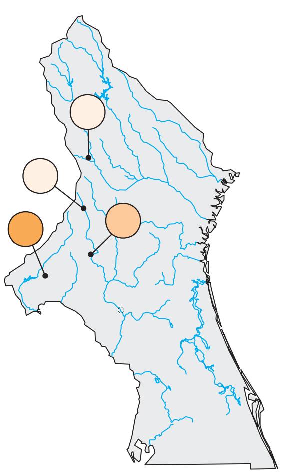
Nutrient concentrations are less than the national median at all but one of nine sites intensively sampled. Three sites had nutrient concentrations in the lowest 25 percent of NAWQA sites. The only site with nutrient levels greater than the median of NAWQA sites nationally was in an agricultural area where the land use is gradually changing to urban.

EXPLANATION

Ranking of stream quality relative to all NAWQA stream sites—Darker colored circles generally indicate poorer quality. Bold outline indicates one or more aquatic-life criteria were exceeded.

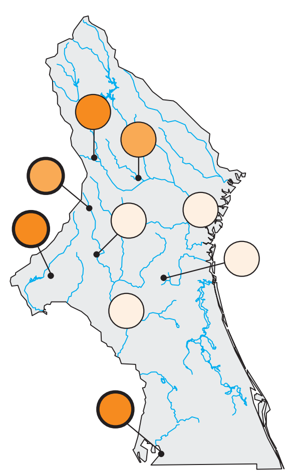
- **Greater than the 75th percentile** (Among the highest 25 percent of NAWQA stream sites)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (Among the lowest 25 percent of NAWQA stream sites)

PESTICIDES in water



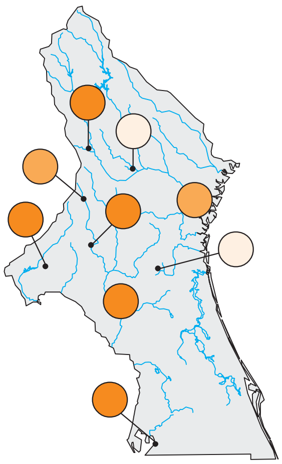
At three of the four stream sites intensively sampled for pesticides, the number of pesticide detections was less than the median for NAWQA sites nationwide. The only site where pesticide detections were greater than the median for NAWQA sites nationwide was in a highly urbanized area. Most of the measured concentrations were very low and did not exceed any drinking-water standards.

PCBs and ORGANOCHLORINES in bed sediment



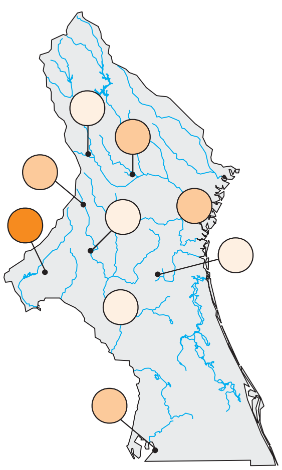
PCBs were not detected at any of the nine sites sampled. Organochlorine pesticides in streambed sediments at five of nine sites sampled were higher than the median for NAWQA sites nationwide. Three of the nine sites were in the highest 25 percent of NAWQA sites. Concentrations of chlordane exceeded guidelines for protection of aquatic life at two of these sites, one located in a highly urbanized basin and one in an agricultural basin. Concentration of p,p′-DDE exceeded guidelines for protection of aquatic life at one agricultural site.

TRACE ELEMENTS
in bed sediment



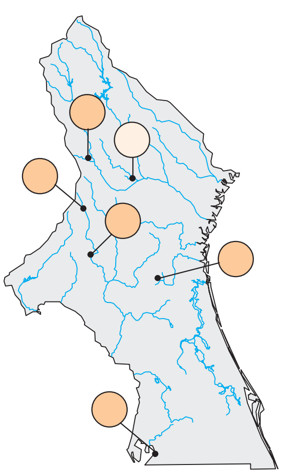
At five of the nine sites sampled trace element concentrations in streambed sediments were in the highest 25 percent of NAWQA sites nationwide. Concentrations of lead were highest in a highly urbanized basin and in a mixed land-use basin. Although some trace elements occur naturally in soils and stream sediments in the study area, the higher concentrations are probably related to urban and agricultural land-use activities.

SEMIVOLATILE ORGANIC COMPOUNDS
in bed sediment



At eight of nine sites sampled, SVOCs concentrations in streambed sediments were lower than the median for NAWQA sites nationwide. Four of the nine sites had levels in the lowest 25 percent of NAWQA sites. Concentrations at one site located in a highly urbanized basin, however, were in the highest 25 percent of NAWQA sites.

FISH COMMUNITY DEGRADATION



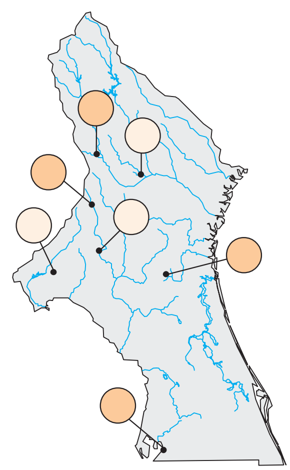
Fish communities at the six sites sampled in the study area were less affected by pollution and other effects on their ecosystems than in other NAWQA Study Units nationwide. At these sites, the number of diseased, pollution-tolerant, and non-native fish in the streams in the study area was less than the median for NAWQA sites around the country.

CONCLUSIONS

In the Georgia-Florida Coastal Plain, compared to other NAWQA Study Units:

- Concentrations of nutrients and pesticides in streams and semivolatile organic compounds in streambed sediments were low.
- PCBs were not detected in sediments.
- Organochlorine pesticides and trace element concentrations in streambed sediments were high.
- Stream habitats and fish communities were less degraded.

STREAM HABITAT DEGRADATION



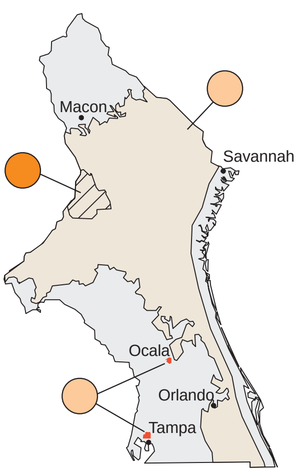
Stream habitats at the seven sites studied were ranked below the median for NAWQA sites nationwide, that is, they are providing better conditions to sustain aquatic organisms than many other streams around the country. Stream habitat, which includes the physical characteristics of streams and their banks (such as amount of bank vegetation, stability of bank soils, and stream depth and shape), strongly influences the capacity of streams to support biological communities.

Comparison of Ground-Water Quality in the Georgia-Florida Coastal Plain with Nationwide NAWQA Findings

White areas indicate other NAWQA Study Units sampled during 1992–95.

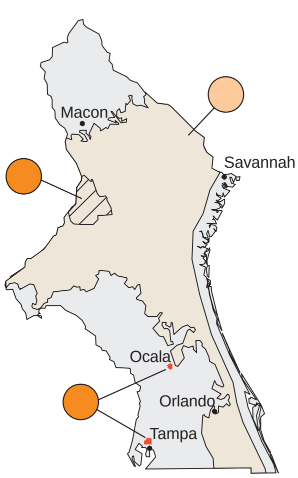
Five major water-quality characteristics were evaluated for ground-water studies in each NAWQA Study Unit. Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the Georgia-Florida Coastal Plain were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer also are compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described by Gilliom and others, in press.)

NITRATE



Nitrate concentrations in the row-crop agricultural area were among the highest 25 percent of NAWQA studies nationwide. One-third of the ground-water samples collected in this area contained nitrate concentrations greater than the drinking-water standard of 10 milligrams per liter. However, the aquifer sampled is not a major source of drinking water. Nitrate concentrations in two urban areas and in domestic wells in rural areas were lower than the median of NAWQA studies.

RADON



Radon concentrations in ground water in the row-crop agricultural and urban study areas were in the highest 25 percent of NAWQA studies nationwide. Radon, a decay product of uranium-238, naturally occurs in the phosphate rocks and other sediments in the study area accounting for the high radon concentrations. There is currently no drinking-water standard or guideline for radon.

EXPLANATION

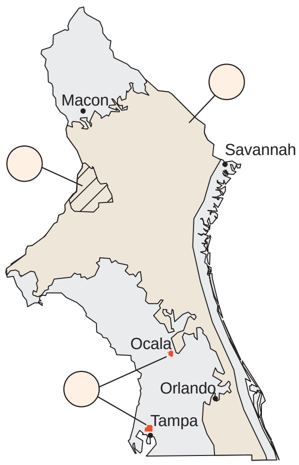
Shallow ground-water study areas

- Surficial aquifer survey
- Row-crop agricultural survey
- Tampa and Ocala urban studies

Ranking of ground-water quality relative to all NAWQA ground-water studies—Darker colored circles generally indicate poorer quality.

- **Greater than the 75th percentile** (Among the highest 25 percent of NAWQA ground-water studies)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (Among the lowest 25 percent of NAWQA ground-water studies)

DISSOLVED SOLIDS



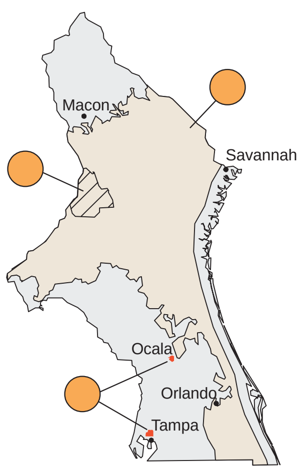
Concentrations of dissolved solids in the study area were in the lowest 25 percent of NAWQA studies nationwide. Dissolved solids are derived from the minerals present in the aquifer materials. The sandy sediments in the surficial aquifers sampled in the study area are less readily dissolved than sediments in other study areas.

CONCLUSIONS

In the Georgia-Florida Coastal Plain, Compared to other NAWQA Study Units:

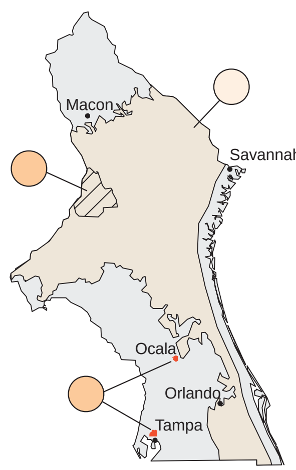
- Nitrate concentrations exceeding the drinking-water standard in the row-crop agricultural area were the greatest ground-water quality problem in the study area. This area does not rely on the sampled aquifer for drinking water. The same area had very few pesticide detections and concentrations of detected compounds were quite low.
- Radon levels were elevated. Radon is naturally present in the aquifer sediments in the study area. There is currently no drinking-water standard or guideline for radon.
- Dissolved solids were low.
- Urban areas showed little contamination from volatile organic compounds. The percent of samples with VOC detections in urban areas was greater than the median of NAWQA studies nationwide, but most samples had only one VOC detection and concentrations were very low.
- Pesticide detections and concentrations were low.

VOLATILE ORGANIC COMPOUNDS



The percentage of samples containing one or more VOCs was greater than the median of NAWQA studies nationwide. However, concentrations of individual compounds were quite low and few drinking-water standards were exceeded. No drinking-water supplies contained elevated VOC concentrations. Usually no more than one VOC was detected per sample. VOCs detected were at low levels. Only 11 of the 60 VOCs analyzed were detected in samples in the study area.

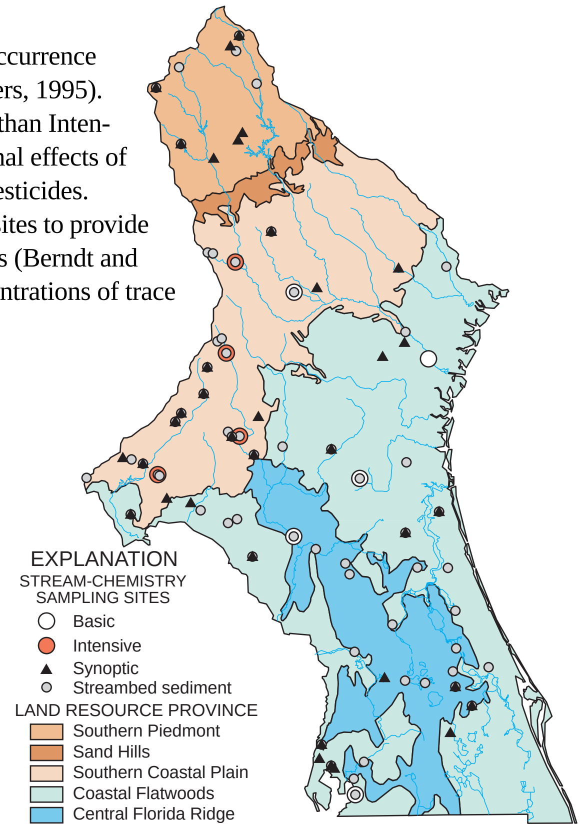
PESTICIDES



Pesticides were detected in ground water less frequently than in most other NAWQA studies nationwide. Detection frequencies in agricultural and urban samples were about equal, and concentrations were generally low. Prometon in the Ocala urban area and metolachlor in the row-crop agricultural area accounted for most of the pesticide detections.

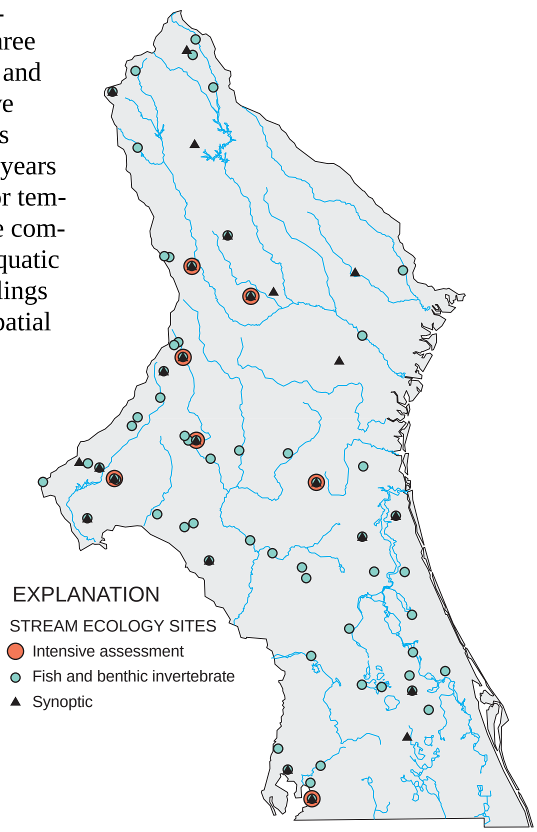
Stream Chemistry

Basic and Intensive Fixed Sites were selected primarily to assess the occurrence and distribution of dissolved compounds in streamwater (Gilliom and others, 1995). Basic Fixed Sites were sampled less frequently and for fewer compounds than Intensive Fixed Sites. Intensive Fixed Sites were sampled to evaluate the seasonal effects of land uses on water quality and to determine the occurrence of dissolved pesticides. Stream synoptic studies extended the range of sampling beyond the fixed sites to provide an overview of dissolved compounds in relation to land resource provinces (Berndt and others, 1996). Sampling of streambed sediments was done to assess concentrations of trace elements and the occurrence and distribution of organic compounds.



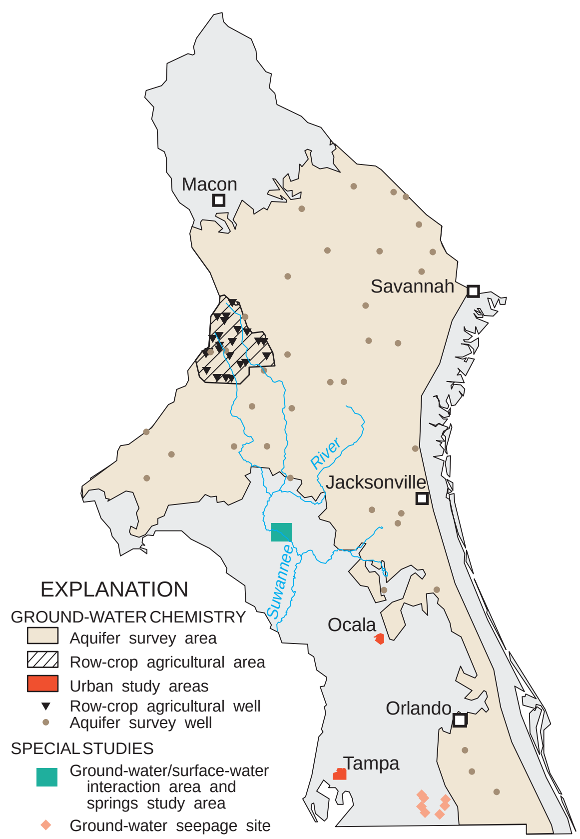
Stream Ecology

Ecological assessments were done at three of the four basic sites and all five of the intensive sites. The assessments were repeated over 2 years to determine spatial or temporal variations in the community structure of aquatic biota. Synoptic samplings were done to define spatial variability in stream ecology by sampling clam or other macroinvertebrate communities at a number of sites in a short period of time.



Ground-Water Chemistry and Special Studies

Surveys of background water quality and effects of agricultural land use were done in the surficial aquifer in the Southern Coastal Plain and the eastern parts of the Coastal Flatwoods. Urban water-quality studies were done in Ocala and Tampa, Fla. A ground-water/surface-water interaction study was done in a karst area where ground water from the Upper Floridan aquifer interacts with water from the Suwannee River. Pesticides and nutrients were evaluated in a ground-water seepage study in the surficial aquifer downgradient from citrus groves in central Florida.



SUMMARY OF DATA COLLECTION IN THE GEORGIA-FLORIDA COASTAL PLAIN, 1992-96

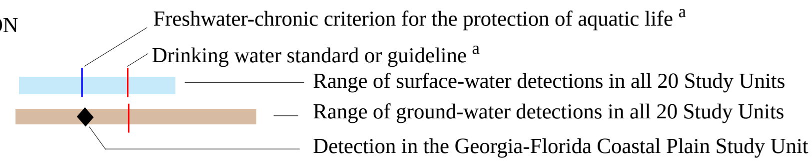
Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream chemistry				
Basic Fixed Sites — general water chemistry	Streamflow, nutrients, major ions, suspended sediment, water temperature, specific conductance, organic carbon, alkalinity, dissolved oxygen, and pH; to describe concentrations, loads, and seasonal variations.	Large rivers with prior long-term nutrient sampling and continuous streamflow measurements. Streams with continuous streamflow measurements, that drain forested, and agricultural basins.	2 3	Quarterly, 3/93-6/96 Monthly, 3/93-6/96
Intensive Fixed Sites — pesticides	In addition to the above constituents, 85 pesticides; to describe concentrations and seasonal variations.	Streams with continuous streamflow measurements, that drain urban and agricultural basins.	3 1	Weekly, 3/93-10/93 Monthly, 11/93-6/96 Biweekly, 3/93-10/93 Monthly, 11/93-6/96
Synoptic studies — water chemistry	Nutrients, pesticides, suspended sediment, organic carbon, and streamflow; to describe spatial distribution.	Tributaries draining subbasins in two intensive sites. Streams draining forested, agricultural, and urban basins.	36 36	Twice in 1993 Twice in 1994
Contaminants in bed sediments	Total PCBs, 32 organochlorine pesticides, 63 semivolatile organic compounds, and 44 trace elements to determine presence of potentially toxic compounds attached to sediments in major streams.	Sites representing depositional zones of basic and intensive sites and selected tributaries.	59	Once
Contaminants in benthic invertebrates	Total PCBs, 30 organochlorine pesticides, and 24 trace elements in *Corbicula fluminea* (a clam) to determine presence of contaminants that can accumulate in *Corbicula fluminea* tissues.	Streams with continuous streamflow measurements.	30	Once
Stream ecology				
Intensive assessments	Fish, macroinvertebrates, and algae; to assess biological communities and habitat in streams representing primary ecological regions.	Sites at or near a stream-chemistry station.	7	Once per year, 2 years
Synoptic studies	Fish, macroinvertebrates and algae; to determine spatial distribution and community structure of aquatic species and habitat.	Sites at or near stream-chemistry stations and in representative streams across the study area.	17	Once
Ground-water chemistry				
Aquifer survey — surficial	Major ions, nutrients, pesticides, volatile organic compounds, and radon; to describe the overall water quality and natural chemistry in surficial aquifers.	Domestic wells in selected subregions across the study area.	38	Once in 1993
Land-use effects — row crop agriculture	Major ions, nutrients, pesticides, volatile organic compounds and radon; to determine the effects of land use on the quality of shallow ground water.	Newly drilled monitoring wells completed near water table in surficial aquifer beneath cropland.	23	Once in 1994 (14 wells sampled twice)
Land-use effects —urban	Major ions, nutrients, pesticides, volatile organic compounds, radon, and trace elements; to determine the effects of land use on shallow ground water.	Existing monitoring wells in surficial and Upper Floridan aquifers beneath urban areas.	32	Once in 1995
Special studies				
Suwannee River ground-water/ surface-water interaction and springs study	Ground water samples collected and analyzed for major ions, nutrients, trace elements, and age-dating constituents to describe chemistry and hydrology of ground-water interaction with the river. Springs sampled for nutrients and major ions.	Clusters of wells of various depths (in the Upper Floridan aquifer), springs and the river. Springs discharging to Suwannee River.	15 11	Quarterly, 1995-96 Once in July 1995
Ground-water seepage — citrus grove area in central Florida	Pesticides, nutrients and tritium; to determine the effects of citrus agriculture on the quality of ground water discharging to streams.	Drive-point wells to sample ground water discharging to small creeks and lakes downgradient from citrus groves. Wells were approximately 1 to 4 ft deep.	8	Once in June 1994

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

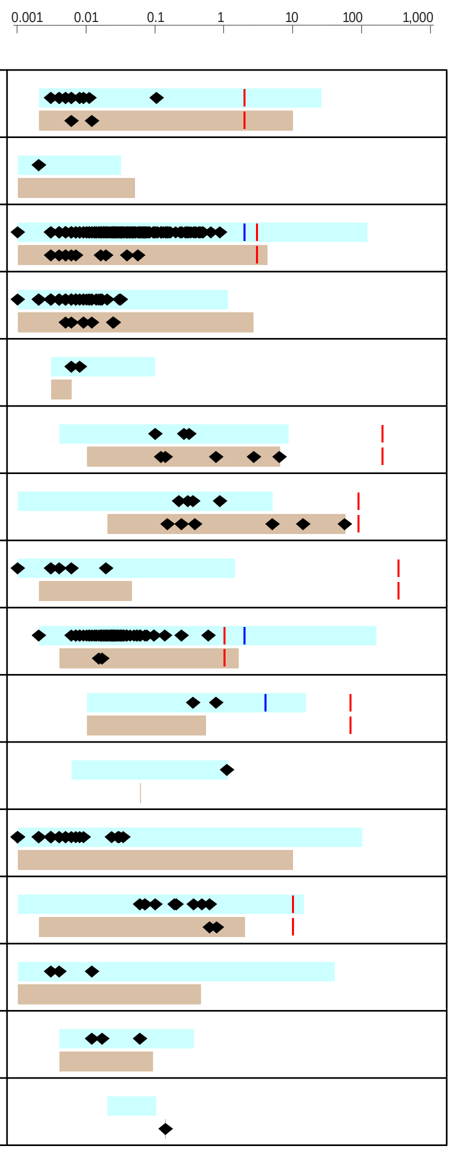
The following tables summarize data collected for NAWQA studies from 1992-1995 by showing results for the Georgia-Florida Coastal Plain Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of places and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1000), rather than the precise number. The complete dataset used to construct these tables is available upon request.

Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Georgia-Florida Coastal Plain Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured; trade names may vary]

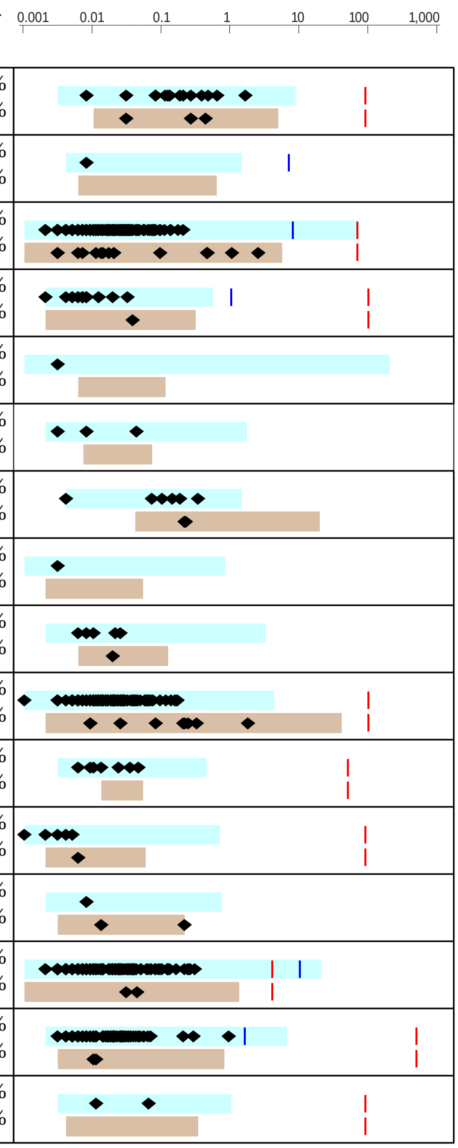
EXPLANATION



Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Alachlor (Lasso)	1% 1%	
2,6-Diethylaniline (Alachlor metabolite)	<1% 0%	
Atrazine (AAtrex, Gesaprim)	53% 3%	
Deethylatrazine[c] (Atrazine metabolite)	4% 3%	
Benfluralin (Balan, Benefin, Bonalan)	<1% 0%	
Bentazon (Basagran, bentazone)	1% 4%	
Bromacil (Hyvar X, Urox B, Bromax)	2% 5%	
Butylate (Sutan, Genate Plus, butilate)	<1% 0%	
Cyanazine (Bladex, Fortrol)	19% 2%	
2,4-D (2,4-PA)	1% 0%	
2,4-DB (Butyrac, Embutox)	<1% 0%	
DCPA (Dacthal, chlorthal-dimethyl)	1% 0%	
Diuron (Karmex, Direx, DCMU)	4% 2%	
EPTC (Eptam)	<1% 0%	
Ethalfluralin (Sonalan, Sonalen)	1% 0%	
Fenuron (Beet-Kleen, Dybar; Vrab)	0% 1%	



Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Fluometuron (Flo-Met, Cotoran)	6% 3%	
Linuron (Lorox, Linex, Sarclex)	<1% 0%	
Metolachlor (Dual, Pennant)	42% 9%	
Metribuzin (Lexone, Sencor)	1% 1%	
Molinate (Ordram)	<1% 0%	
Napropamide (Devrinol)	<1% 0%	
Norflurazon (Evital, Solicam, Telok)	2% 2%	
Pebulate (Tillam)	<1% 0%	
Pendimethalin (Prowl, Stomp)	1% 1%	
Prometon (Gesagram, prometone)	31% 6%	
Pronamide (Kerb, propyzamid)	1% 0%	
Propachlor (Ramrod, propachlore)	<1% <1%	
Propanil (Stampede, Surcopur)	<1% 2%	
Simazine (Aquazine, Princep)	25% 2%	
Tebuthiuron (Spike, Perflan)	19% 2%	
Terbacil[c] (Sinbar)	1% 0%	



Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Thiobencarb (Bolero, Saturn)	<1% 0%	
Triallate (Far-Go)	<1% 0%	
Trifluralin (Treflan, Trinin, Elancolan)	1% 0%	

Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Phorate (Thimet, Rampart)	<1% 0%	
Propargite (Comite, Omite, BPPS)	<1% 0%	
Terbufos (Counter)	<1% 0%	

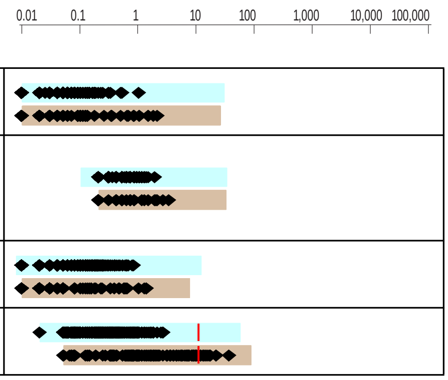
Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Aldicarb sulfoxide[c] (Aldicarb metabolite)	<1% 1%	
Azinphos-methyl[c] (Guthion, Gusathion)	1% 0%	
Carbaryl[c] (Sevin, Savit)	11% 0%	
Carbofuran[c] (Furadan, Curaterr)	1% 0%	
Chlorpyrifos (Dursban, Lorsban)	7% 0%	
p,p'-DDE (*p,p'*-DDT metabolite)	<1% <1%	
Diazinon	20% 0%	
Dieldrin (Panoram D-31, Octalox)	<1% 0%	
Disulfoton[c] (Disyston, Dithiosystox)	<1% 0%	
Ethoprop (Mocap, Prophos)	1% 0%	
Fonofos (Dyfonate)	<1% 0%	
alpha-HCH (*alpha*-BHC, *alpha*-lindane)	<1% 0%	
gamma-HCH	1% 0%	
Malathion (maldison, malathon, Cythion)	6% 0%	
Parathion (Thiophos, Bladan, Folidol)	<1% 0%	
cis-Permethrin[c] (Ambush, Pounce)	<1% 0%	

Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000)
1,2-Dibromoethane (EDB, ethylene dibromide)	-- 1%	
1,2-Dichloropropane (Propylene dichloride)	-- 1%	
Benzene	-- 1%	
Bromomethane (Methyl bromide)	-- 1%	
Chloromethane (Methyl chloride)	-- 3%	
Methylbenzene (Toluene)	-- 5%	
total Trihalomethanes	-- 6%	
Trichloroethene (TCE)	-- 1%	
cis-1,2-Dichloroethene	-- 2%	

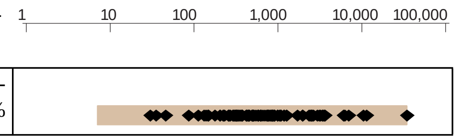
Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Methyl *tert*-butyl[d] ether (MTBE)	-- 3%	
Tetrachloroethene (Perchloroethene)	-- 4%	

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

Nutrient (Trade or common name)	Rate of detection [b]	Concentration, in mg/L
Dissolved ammonia	87% 58%	
Dissolved ammonia plus organic nitrogen as nitrogen	82% 14%	
Dissolved phosphorus as phosphorus	83% 59%	
Dissolved nitrite plus nitrate	72% 81%	



Other	Rate of detection [b]	Concentration, in pCi/L
Radon 222	-- 100%	



Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Georgia-Florida Coastal Plain Study Unit.

Herbicides

2,4,5-T

2,4,5-TP (Silvex, Fenoprop)

Acetochlor (Harness Plus, Surpass)

Acifluorfen (Blazer, Tackle 2S)

Bromoxynil (Buctril, Brominal)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dacthal mono-acid (Dacthal metabolite)

Dicamba (Banvel, Dianat, Scotts Proturf)

Dichlorprop (2,4-DP, Seritox 50, Kildip, Lentemul)

Dinoseb (Dinosebe)

MCPA (Rhomene, Rhonox, Chiptox)

MCPB (Thistrol)

Neburon (Neburea, Neburyl, Noruben)

Oryzalin (Surflan, Dirimal)

Picloram (Grazon, Tordon)

Propham (Tuberite)

Triclopyr (Garlon, Grandstand, Redeem, Remedy)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb (Temik, Ambush, Pounce)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Acinate)

Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M)

Oxamyl (Vydate L, Pratt)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

Volatile organic compounds

1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)

1,1,1-Trichloroethane (Methylchloroform)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113)

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethane (Ethylidene dichloride)

1,1-Dichloroethene (Vinylidene chloride)

1,1-Dichloropropene

1,2,3-Trichlorobenzene (1,2,3-TCB)

1,2,3-Trichloropropane (Allyl trichloride)

1,2,4-Trichlorobenzene

1,2,4-Trimethylbenzene (Pseudocumene)

1,2-Dibromo-3-chloropropane (DBCP, Nemagon)

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dichloroethane (Ethylene dichloride)

1,3,5-Trimethylbenzene (Mesitylene)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,3-Dichloropropane (Trimethylene dichloride)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Chloro-2-methylbenzene (*o*-Chlorotoluene)

1-Chloro-4-methylbenzene (*p*-Chlorotoluene)

2,2-Dichloropropane

Bromobenzene (Phenyl bromide)

Bromochloromethane (Methylene chlorobromide)

Chlorobenzene (Monochlorobenzene)

Chloroethane (Ethyl chloride)

Chloroethene (Vinyl Chloride)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dichloromethane (Methylene chloride)

Dimethylbenzenes (Xylenes (total))

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Naphthalene

Tetrachloromethane (Carbon tetrachloride)

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

p-Isopropyltoluene (*p*-Cymene)

sec-Butylbenzene

tert-Butylbenzene

trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)

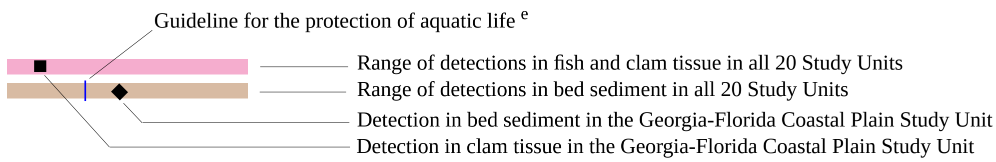
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)

Nutrients

No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in clam tissue and bed sediment of the Georgia-Florida Coastal Plain Study Unit. Clam tissue compared to fish and clam tissue in other Study Units.
[µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; - -, not measured; trade names may vary]

EXPLANATION

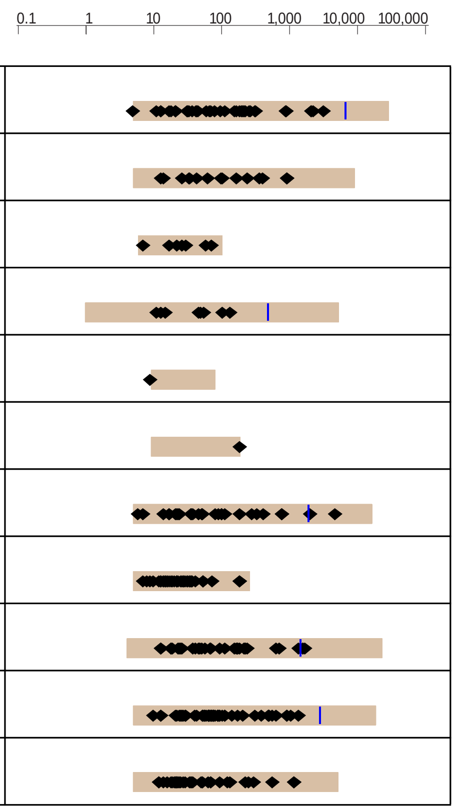


Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
1,2-Dimethylnaphthalene	-- 7%	
1,6-Dimethylnaphthalene	-- 19%	
1-Methyl-9H-fluorene	-- 5%	
1-Methylphenanthrene	-- 26%	
1-Methylpyrene	-- 24%	
2,2-Biquinoline	-- 3%	
2,3,6-Trimethylnaphthalene	-- 9%	
2,6-Dimethylnaphthalene	-- 52%	
2-Ethylnaphthalene	-- 7%	
2-Methylanthracene	-- 19%	
3,5-Dimethylphenol	-- 2%	
4,5-Methylenephenanthrene	-- 28%	
4-Chlorophenyl-phenylether	-- 2%	
9H-Carbazole	-- 21%	
9H-Fluorene	-- 24%	
Acenaphthene	-- 28%	
Acenaphthylene	-- 43%	

Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Acridine	-- 12%	
Anthracene	-- 45%	
Anthraquinone	-- 22%	
Benz[*a*]anthracene	-- 55%	
Benzo[*a*]pyrene	-- 40%	
Benzo[*b*]fluoranthene	-- 57%	
Benzo[*c*]cinnoline	-- 5%	
Benzo[*ghi*]perylene	-- 19%	
Benzo[*k*]fluoranthene	-- 57%	
Butylbenzylphthalate	-- 34%	
Chrysene	-- 57%	
Di- *n* -butylphthalate	-- 91%	
Di- *n* -octylphthalate	-- 24%	
Dibenz[*a,h*] anthracene	-- 12%	
Dibenzothiophene	-- 12%	
Diethylphthalate	-- 47%	
Dimethylphthalate	-- 12%	

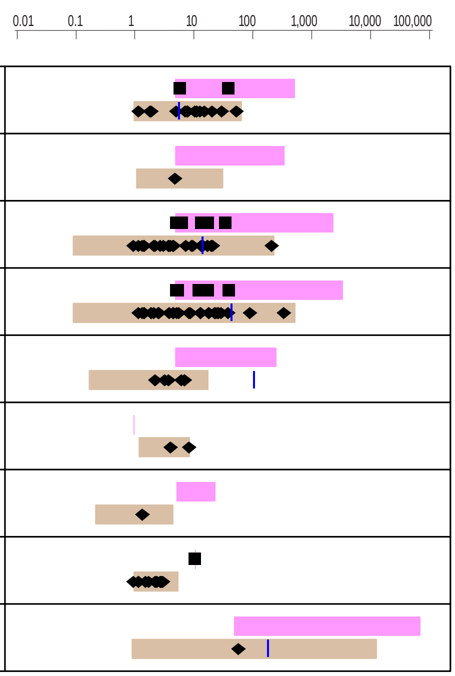
SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

Semivolatile organic compound	Rate of detection [b]
Fluoranthene	-- 67%
Indeno[1,2,3- *cd*] pyrene	-- 26%
Isoquinoline	-- 12%
Naphthalene	-- 14%
N-Nitrosodi-phenylamine	-- 2%
Pentachloronitroben-zene	-- 2%
Phenanthrene	-- 48%
Phenol	-- 72%
Pyrene	-- 59%
bis(2-Ethyl-hexyl)phthalate	-- 90%
p-Cresol	-- 62%



Trace element	Rate of detection [b]
Arsenic	97% 100%
Cadmium	75% 100%
Chromium	100% 100%
Copper	100% 100%
Lead	53% 100%
Mercury	81% 100%
Nickel	75% 100%
Selenium	62% 100%
Zinc	100% 100%

Organochlorine compound (Trade name)	Rate of detection [b]
total-Chlordane	7% 26%
DCPA (dacthal, chlo-rthal-dimethyl)	0% 2%
p,p'-DDE	21% 45%
total-DDT	21% 49%
Dieldrin (Panoram D-31, Octalox)	0% 10%
Endosulfan I (*alpha*-endosulfan, Thiodan)	-- 3%
Heptachlor epoxide	0% 3%
Mirex (Dechlorane)	3% 22%
PCB, total	0% 2%



Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in clam tissue and bed sediment of the Georgia-Florida Coastal Plain Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

2,4-Dinitrotoluene

2,6-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

Azobenzene

C8-Alkylphenol

Isophorone

N-Nitrosodi-*n*-propylamine

Nitrobenzene

Phenanthridine

Quinoline

bis (2-Chloroethoxy)methane

Organochlorine compounds

Aldrin (HHDN, Octalene)

Chloroneb (chloronebe, Demosan, Soil Fungicide 1823)

Endrin (Endrine)

Heptachlor (Heptachlore, Velsicol 104)

Hexachlorobenzene (HCB)

Isodrin (Isodrine, Compound 711)

Pentachloroanisole (PCA, pentachlorophenol metabolite)

Toxaphene (Camphechlor, Hercules 3956)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

beta-HCH (*beta*-BHC, *beta*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

delta-HCH (*delta*-BHC, *delta*-hexachlorocyclohexane, *delta*-benzene hexachloride)

gamma-HCH (Lindane, *gamma*-BHC, Gammexane, Gexane, Soprocide, *gamma*-hexachlorocyclohexane, *gamma*-benzene hexachloride, *gamma*-benzene)

o,p'-Methoxychlor

p,p'-Methoxychlor (Marlate, methoxychlore)

trans-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

Trace elements

No non-detects

[a] Selected water-quality standards and guidelines [Gilliom and others, in press].

[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L in order to facilitate equal comparisons among compounds, which had widely varying detection limits. For herbicides and insecticides, a detection rate of "<1%" means that all detections are less than 0.01 µg/L, or the detection rate rounds to less than one percent. For other compound groups, all detections were counted and minimum detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in these tables are summarized [Gilliom and others, in press].

[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values [Zaugg and others, 1995].

[d] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L [Gilliom and others, in press].

[e] Selected sediment-quality guidelines [Gilliom and others, in press].

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GLOSSARY

The terms in this glossary were compiled and modified from numerous sources. Definitions given here may not be the only valid ones for these terms.

Aquatic-life criteria - Water-quality guidelines for protection of aquatic life. Often refers to U.S. Environmental Protection Agency water-quality criteria for protection of aquatic organisms. *See also* Water-quality guidelines, Water-quality criteria, and Freshwater chronic criteria.

Aquifer - A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Base flow - Sustained, low flow in a stream; ground-water discharge is the source of base flow in most places.

Basic Fixed Sites - Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and metals, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of streamwater in relation to hydrologic conditions and environmental settings.

Basin - *See* Drainage basin.

Bed sediment - The material that temporarily is stationary in the bottom of a stream or other watercourse.

Bioavailability - The capacity of a chemical constituent to be taken up by living organisms either through physical contact or by ingestion.

Carbonate rocks - Rocks (such as limestone or dolostone) that are composed primarily of minerals (such as calcite and dolomite) containing the carbonate ion (CO_3^{2-}).

Chlordane - Octachloro-4,7-methanotetrahydroindane. An organochlorine insecticide no longer registered for use in the U.S. Technical chlordane is a mixture in which the primary components are *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and heptachlor.

Community - In ecology, the species that interact in a common area.

Concentration - The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as microgram per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Confined aquifer (artesian aquifer) - An aquifer that is completely filled with water under pressure and that is overlain by material that restricts the movement of water.

Contamination - Degradation of water quality compared to original or natural conditions due to human activity.

Cubic foot per second (ft^3/s, or cfs) - Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second.

Degradation products - Compounds resulting from transformation of an organic substance through chemical, photochemical, and/or biochemical reactions.

Denitrification - A process by which oxidized forms of nitrogen such as nitrate (NO_3^-) are reduced to form nitrites, nitrogen oxides, ammonia, or free nitrogen: commonly brought about by the action of denitrifying bacteria and usually resulting in the escape of nitrogen to the air.

DDT - Dichloro-diphenyl-trichloroethane. An organochlorine insecticide no longer registered for use in the United States.

Discharge - Rate of fluid flow passing a given point at a given moment in time, expressed as volume per unit of time.

Dissolved constituent - Operationally defined as a constituent that passes through a 0.45-micrometer filter.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity or hardness.

Drainage basin - The portion of the surface of the Earth that contributes water to a stream through overland run-off, including tributaries and impoundments.

Drinking-water standard or guideline - A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Fertilizer - Any of a large number of natural or synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.

Fish community - *See* Community.

Fixed Sites - NAWQA's most comprehensive monitoring sites. *See also* Basic Fixed Sites and Intensive Fixed Sites.

Freshwater chronic criteria - The highest concentration of a contaminant that freshwater aquatic organisms can be exposed to for an extended period of time (4 days) without adverse effects. *See also* Water-quality criteria.

Gaging station - A particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Ground water - In general, any water that exists beneath the land surface, but more commonly applied to water in fully saturated soils and geologic formations.

Habitat - The part of the physical environment where plants and animals live.

Health advisory - Nonregulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Herbicide - A chemical or other agent applied for the purpose of killing undesirable plants. *See also* Pesticide.

Hydrograph - Graph showing variation of water elevation, velocity, streamflow, or other property of water with respect to time.

Indicator sites - Stream sampling sites located at outlets of drainage basins with relatively homogeneous land use and physiographic conditions; most indicator-site basins have drainage areas ranging from 20 to 200 square miles.

Insecticide - A substance or mixture of substances intended to destroy or repel insects.

Instantaneous discharge - The volume of water that passes a point at a particular instant of time.

Integrator or Mixed-use site - Stream sampling site located at an outlet of a drainage basin that contains multiple environmental settings. Most integrator sites are on major streams with relatively large drainage areas.

Intensive Fixed Sites - Basic Fixed Sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year. Most NAWQA Study Units have one to two integrator Intensive Fixed Sites and one to four indicator Intensive Fixed Sites.

Karst - A type of topography that results from dissolution and collapse of carbonate rocks such as limestone and dolomite, and characterized by closed depressions or sinkholes, caves, and underground drainage.

Load - General term that refers to a material or constituent in solution, in suspension, or in transport; usually expressed in terms of mass or volume.

Maximum contaminant level (MCL) - Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCL's are enforceable standards established by the U.S. Environmental Protection Agency.

Median - The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Milligrams per liter (mg/L) - A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Nitrate - An ion consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nutrient - Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Organochlorine insecticide - A class of organic insecticides containing a high percentage of chlorine. Includes dichlorodiphenylethanes (such as DDT), chlorinated cyclodienes (such as chlordane), and chlorinated benzenes (such as lindane). Most organochlorine insecticides were banned because of their carcinogenicity, tendency to bioaccumulate, and toxicity to wildlife.

Organochlorine pesticide - *See* Organochlorine insecticide.

Pesticide - A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents or other "pests".

Phosphorus - A nutrient essential for growth that can play a key role in stimulating aquatic growth in lakes and streams.

Picocurie (pCi) - One trillionth (10^{-12}) of the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7×10^{10} radioactive disintegrations per second (dps). A picocurie yields 2.22 disintegrations per minute (dpm) or 0.037 dps.

Polychlorinated biphenyls (PCBs) - A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Radon - A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and Polycyclic aromatic hydrocarbons (PAHs).

GLOSSARY

Stream reach - A continuous part of a stream between two specified points.

Study Unit - A major hydrologic system of the United States in which NAWQA studies are focused. Study Units are geographically defined by a combination of ground- and surface-water features and generally encompass more than 4,000 square miles of land area.

Synoptic sites - Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Total concentration - Refers to the concentration of a constituent regardless of its form (dissolved or bound) in a sample.

Total DDT - The sum of DDT and its metabolites (breakdown products), including DDD and DDE.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Uranium - A heavy silvery-white metallic element, highly radioactive and easily oxidized. Of the 14 known isotopes of uranium, U238 is the most abundant in nature.

Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water-quality criteria - Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water-quality guidelines - Specific levels of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Water-quality standards - State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. Standards include the use of the water body and the water-quality criteria that must be met to protect the designated use or uses.

Water table - The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table varies widely across the country.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Georgia-Florida Coastal Plain

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