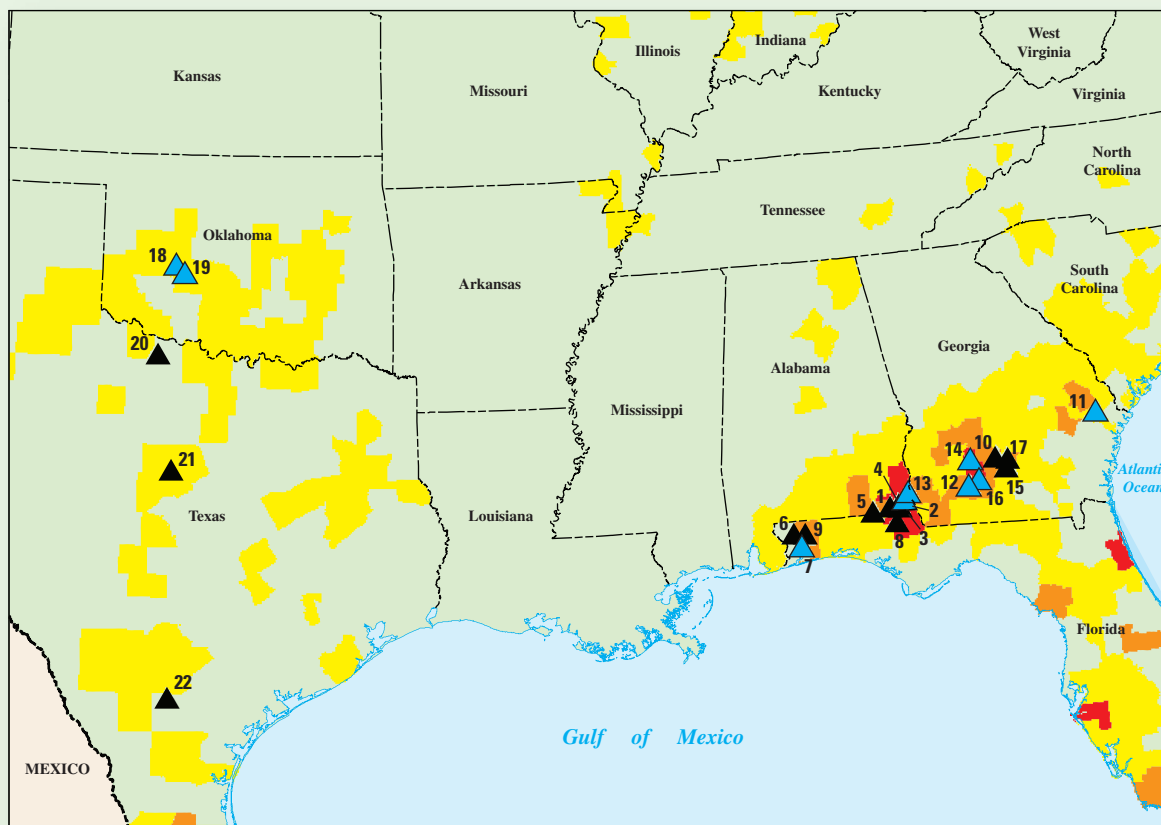


U.S. Geological Survey Toxic Substances Hydrology Program

# Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides at 22 Surface-Water Sites in Five Southern States, 2003–04



Open-File Report 2006–1207

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By Elisabeth A. Scribner, James L. Orlando, William A. Battaglin,  
Mark W. Sandstrom, Kathryn M. Kuivila, and Michael T. Meyer

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*Back cover:*

Spraying of chlorothalonil on a peanut field in the Southern United States.

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## Conversion Factors, Abbreviated Water-Quality Units, and Datum

Multiply	By	To obtain
acre	4,047	square meter (m <sup>2</sup> )
cubic centimeter (cm <sup>3</sup> )	0.6102	cubic inch (in <sup>3</sup> )
cubic foot per second (ft <sup>3</sup> /s)	0.02832	cubic meter per second (m <sup>3</sup> /s)
foot (ft)	0.3048	meter (m)
liter (L)	0.2642	gallon (gal)
microgram (µg)	3.527 x 10 <sup>-8</sup>	ounce (oz)
microliter (µL)	2.642 x 10 <sup>-7</sup>	gallon (gal)
micrometer (µm)	3.937 x 10 <sup>-5</sup>	inch (in.)
mile (mi)	1.609	kilometer (km)
milligram (mg)	3.53 x 10 <sup>-5</sup>	ounce (oz)
milliliter (mL)	0.0338	ounce (oz)
millimeter (mm)	0.03937	inch (in.)
nanogram (ng)	3.527 x 10 <sup>-11</sup>	ounce (oz)
ounce, fluid (oz)	0.02957	liter (L)
pound (lb)	453.6	gram (g)
pound per square inch (lb/in <sup>2</sup> )	0.07031	kilogram per square centimeter (kg/cm <sup>2</sup> )
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )

Temperature can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by the equations:

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

$$^{\circ}\text{F} = 9/5 (^{\circ}\text{C}) + 32.$$

## **Abbreviated Water-Quality Units**

microgram per liter ( $\mu\text{g/L}$ )

microgram per milliliter ( $\mu\text{g/mL}$ )

microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S/cm}$ )

milligram per liter ( $\text{mg/L}$ )

milliliter ( $\text{mL}$ )

milliliter per minute ( $\text{mL/min}$ )

## **Datum**

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

# Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides at 22 Surface-Water Sites in Five Southern States, 2003–04

By Elisabeth A. Scribner, James L. Orlando, William A. Battaglin, Mark W. Sandstrom, Kathryn M. Kuivila, and Michael T. Meyer

## Abstract

In accordance with the mission of the U.S. Geological Survey (USGS) Toxic Substances Hydrology Program, a pesticide study was conducted during 2003–04 to determine the occurrence of the fungicide chlorothalonil and its degradation products at 22 surface-water sites in five Southern States. Water-quality samples were collected during the peanut-growing season (June–September) in 2003. During the peanut-growing season in 2004, samples were collected after large storms.

An analytical method was developed at the USGS Organic Geochemistry Research Laboratory in Lawrence, Kansas, to measure chlorothalonil and its degradation products by liquid chromatography/mass spectrometry (LC/MS). Chlorothalonil was detected in 4 of the 113 surface-water samples. The primary degradation product of chlorothalonil, 4-hydroxy-chlorothalonil, was detected in 26 of the 113 samples with concentrations ranging from 0.002 to 0.930 microgram per liter. The chlorothalonil degradation products, 1-amide-4-hydroxy-chlorothalonil and 1,3-diamide-chlorothalonil, were detected in one water sample each at 0.020 and 0.161 microgram per liter, respectively.

The USGS Methods and Research Development Group, Lakewood, Colorado, developed a custom method for chlorothalonil using gas chromatography/mass spectrometry (GC/MS) in an effort to achieve a lower laboratory reporting level (LRL) than the USGS National Water-Quality Laboratory (NWQL) schedule 2060, which analyzes the compound chlorothalonil at a LRL of 0.035  $\mu\text{g/L}$ . The group succeeded in achieving a lower GC/MS reporting level of 0.01  $\mu\text{g/L}$ . Chlorothalonil was detected in 5 of 68 water samples analyzed using the custom GC/MS method, whereas chlorothalonil was detected in 2 of 21 water samples analyzed using NWQL schedule 2060.

In addition to analysis of chlorothalonil and its degradation products, samples were analyzed using the USGS NWQL schedules 2001 and 2060 for about 114 pesticides and their

degradation products. Samples also were analyzed for dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles.

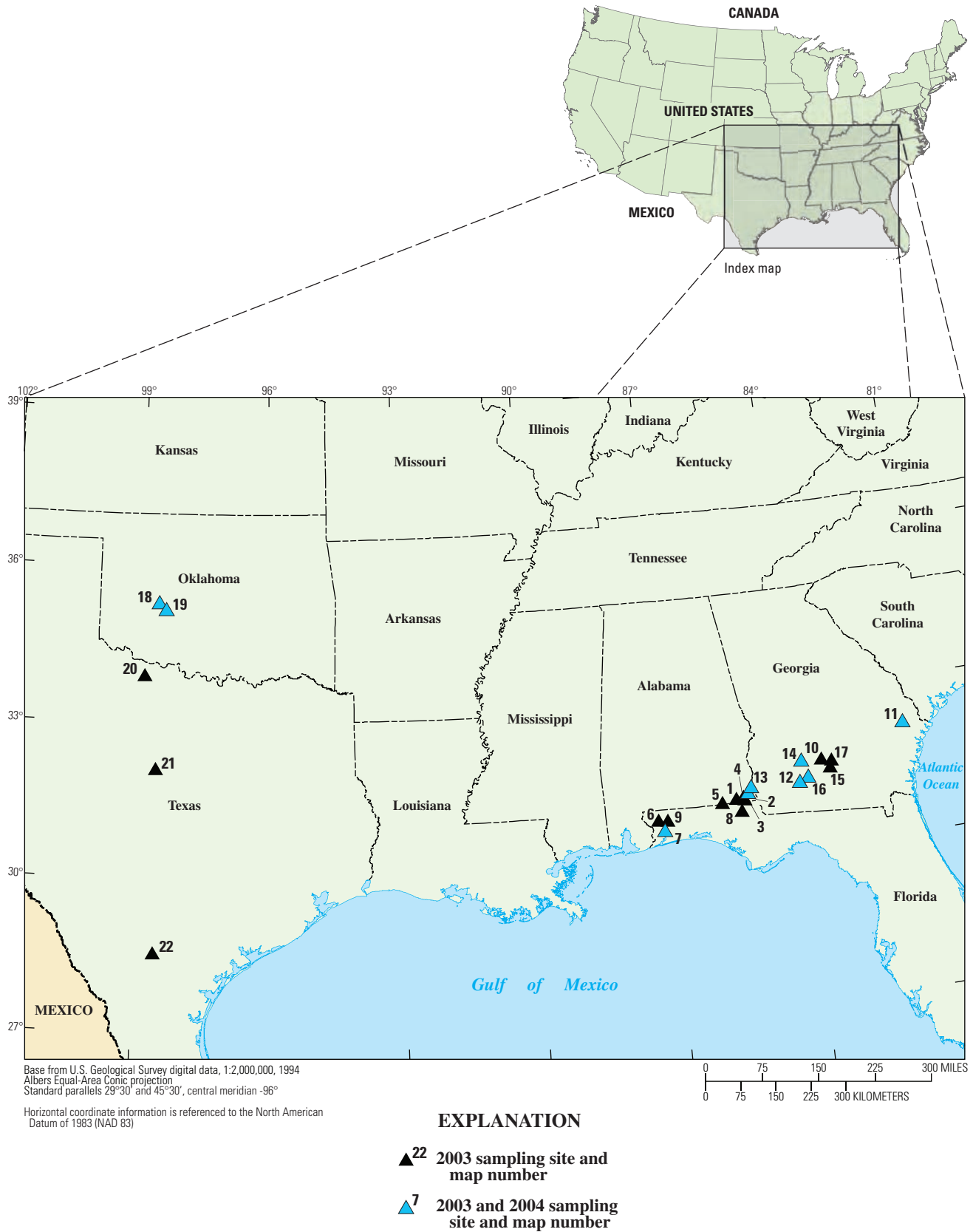
Overall, it was found that chlorothalonil was detected only infrequently and at relatively low concentrations. Chlorothalonil's major degradation product, 4-hydroxy-chlorothalonil, was detected most frequently, occurred generally at higher concentrations in water samples than did the parent fungicide, and the data from this study reaffirmed that it is the dominant degradation product of chlorothalonil in the peanut-growing environment.

## Introduction

### Background

The primary objective of Pesticide Studies (PEST) in the U.S. Geological Survey's (USGS) Toxic Substances Hydrology Program is to conduct research on the occurrence, fate, and ecotoxicity of new or understudied pesticides and pesticide degradation products in the environment. In line with this objective, PEST conducted a study during 2003–04 to improve understanding of these processes with regard to the extensively used fungicide, chlorothalonil, and its degradation products. Chlorothalonil has a wide variety of beneficial uses, including agricultural, home and garden, industrial, and vector control of fungi, and it is used extensively for disease control in peanuts, potatoes, turf, and many fruit and vegetable crops (Cox, 1997). However, the transport of chlorothalonil and its degradation products through natural and human processes from the point of application could result in potentially harmful concentrations in the environment. During the study, water samples were collected from 22 surface-water sampling sites in five Southern States—Alabama, Florida, Georgia, Oklahoma, and Texas (fig. 1).

**2 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides**



**Figure 1.** Location of 22 surface-water sampling sites in five Southern States, 2003–04.

Chlorothalonil (1,3-dicyano-2,4,5,6-tetrachlorobenzene) is a broad spectrum, non-systemic fungicide used as a preventative treatment to control foliar diseases of vegetable, field, and ornamental crops. It was first registered for use on food crops in the United States in 1970 by the U.S. Environmental Protection Agency. Chlorothalonil frequently is applied multiple times per growing season and can be used exclusively or in rotation with other fungicides. Chlorothalonil is one of the most extensively used fungicides in the United States. During 1992, it was the second-most extensively used fungicide behind only sulfur, and in 1997 ranked third behind sulfur and copper. Pesticide use data show that chlorothalonil applications nationwide exceeded 10 million lb annually during both 1992 and 1997 (National Center for Food and Agricultural Policy, 1997). Chlorothalonil application data by county for 1997 show that areas of highest use occurred in Alabama, Florida, and Georgia, with less amounts in Oklahoma and Texas (fig. 2). Peanuts are the primary crops treated with chlorothalonil in these five States.

Chlorothalonil has the potential to be transported away from the point of application either through spray drift, field runoff, or on sediment mobilized by runoff (Cox, 1997). The field half-life for chlorothalonil ranges from 10 to 60 days (Syngenta Crop Protection, 2005), and this coupled with large application amounts and the practice of frequent, repeated applications would tend to promote the offsite movement of this fungicide. It has been detected in surface water (Scott and others, 2002), rainfall (Sakai, 2002), and chlorothalonil degradation products have been detected in ground-water samples (Harris and Andreoli, 1988). Chlorothalonil also has been detected in air samples at great distances from areas where it is applied, such as the Bering Sea (Chernyak and others, 1996) and Sequoia National Park, California (McConnell and others, 1998). The U.S. Environmental Protection Agency (1999) has classified chlorothalonil as a probable carcinogen because tests have shown very high toxicity to both terrestrial and aquatic vertebrates (Cox, 1997).

Chlorothalonil has three principle degradation products, 4-hydroxy-chlorothalonil (1,3-dicyano-4-hydroxy-2,5,6-trichlorobenzene), 1,3-diamide-chlorothalonil (1,3-dicarbamoyl-2,4,5,6-tetrachlorobenzene), and 1-amide-4-hydroxy-chlorothalonil (1-carbamoyl-3-cyano-4-hydroxy-2,5,6-trichlorobenzene) (Sato and Tanaka, 1987; Rouchaud and others, 1988; Katayama and others, 1992). Two additional degradation products have been tentatively identified, 1-amide-2-hydroxy-chlorothalonil (1-carbamoyl-2-hydroxy-5-cyano-3,4,6-trichlorobenzene) and 4-hydroxy-1,3-diamide-chlorothalonil (1,3-dicarbamoyl-2,4,5-trichloro-6-hydroxybenzene) (fig. 3).

Research was undertaken by the USGS Organic Geochemistry Research Laboratory (OGRL), Lawrence, Kansas, to develop a reliable, sensitive analytical method using liquid chromatography/mass spectrometry (LC/MS) to look for chlorothalonil and its primary degradation product 4-hydroxy-chlorothalonil in water. The 4-hydroxy-chlorothalonil has been reported to have greater stability and toxicity than the

parent compound (Potter and others, 2001). Two degradation products, 1-amide-2-hydroxy-chlorothalonil and 4-hydroxy-1,3-diamide-chlorothalonil, were identified in initial method development due to their formation while synthesizing the 4-hydroxy-chlorothalonil for use as a primary standard (Rouchaud and others, 1988). Studies have indicated that chlorothalonil is degraded by ultraviolet light (Sakkas and others, 2002).

The USGS Methods and Research Development Group, Lakewood, Colorado, developed a method for chlorothalonil using gas chromatography/mass spectrometry (GC/MS) endeavoring to reach a lower LRL (0.01 µg/L) than the USGS National Water-Quality Laboratory (NWQL) schedule 2060, which analyzes the compound chlorothalonil at a LRL of 0.035 µg/L.

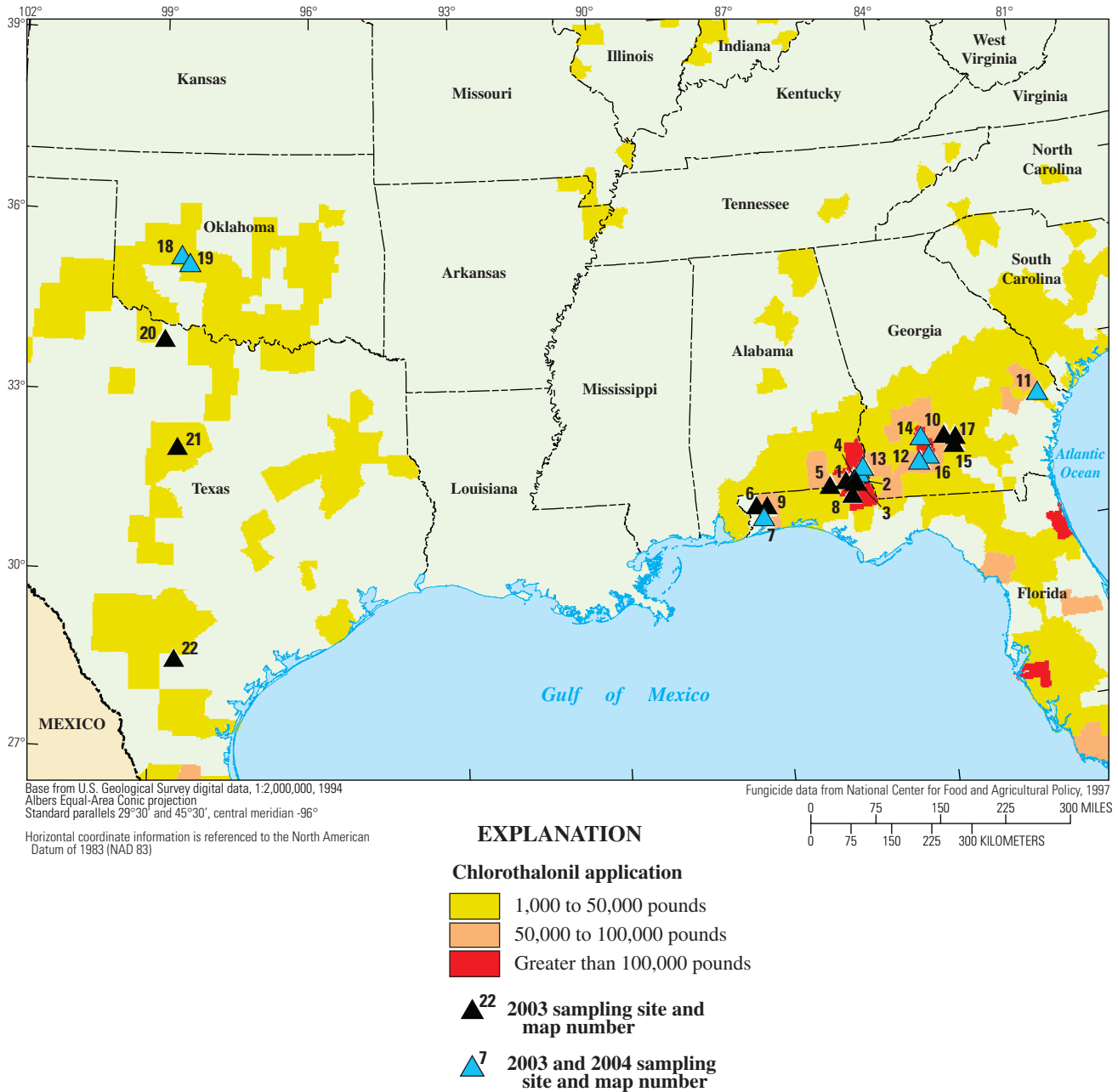
In addition to analysis of chlorothalonil and its degradation products, samples were analyzed by the USGS National Water-Quality Laboratory schedules 2001 and 2060 for about 114 pesticides and their degradation products. Samples also were analyzed for dissolved organic carbon by the USGS National Research Program, Boulder, Colorado, and concentrations of suspended sediment and percentage of silt- and clay-sized particles were determined by the Marine Sediment Laboratory, Marina, California.

## Purpose and Scope

The primary purpose of this report is to document the results of analyses of the fungicide chlorothalonil and its degradation products in samples from 22 surface-water sampling sites in Alabama, Florida, Georgia, Oklahoma, and Texas during 2003–04. As part of quantifying chlorothalonil and its degradation products in surface water, the report describes an analytical method, using solid-phase extraction (SPE) and liquid chromatography/mass spectrometry (LC/MS), developed by the USGS Organic Geochemistry Research Laboratory (OGRL), Lawrence, Kansas, and a limited test of a gas chromatography/mass spectrometry (GC/MS) method for determination of a lower LRL for chlorothalonil developed by the USGS Methods and Research Development Group, Lakewood, Colorado. The report also describes chlorothalonil usage, selection of sampling sites, sample-collection and processing methods, and quality-assurance procedures.

This report also includes the results of analysis of water-quality samples collected at the 22 surface-water sampling sites for the occurrence of selected pesticides and their degradation products by laboratory schedules 2001 and 2060 at the USGS National Water-Quality Laboratory (NWQL), Lakewood, Colorado, analysis of dissolved organic carbon (DOC) by the USGS National Research Program, Boulder, Colorado, and analysis of suspended sediment in environmental water samples by the USGS Marine Sediment Laboratory, Marina, California. Streamflow discharge measurements, gage heights, and physical properties of the water associated with each surface-water sample also are presented.

**4 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides**



**Figure 2.** Geographic distribution of chlorothalonil applications at 22 surface-water sampling sites in five Southern States (fungicide data from National Center for Food and Agricultural Policy, 1997).

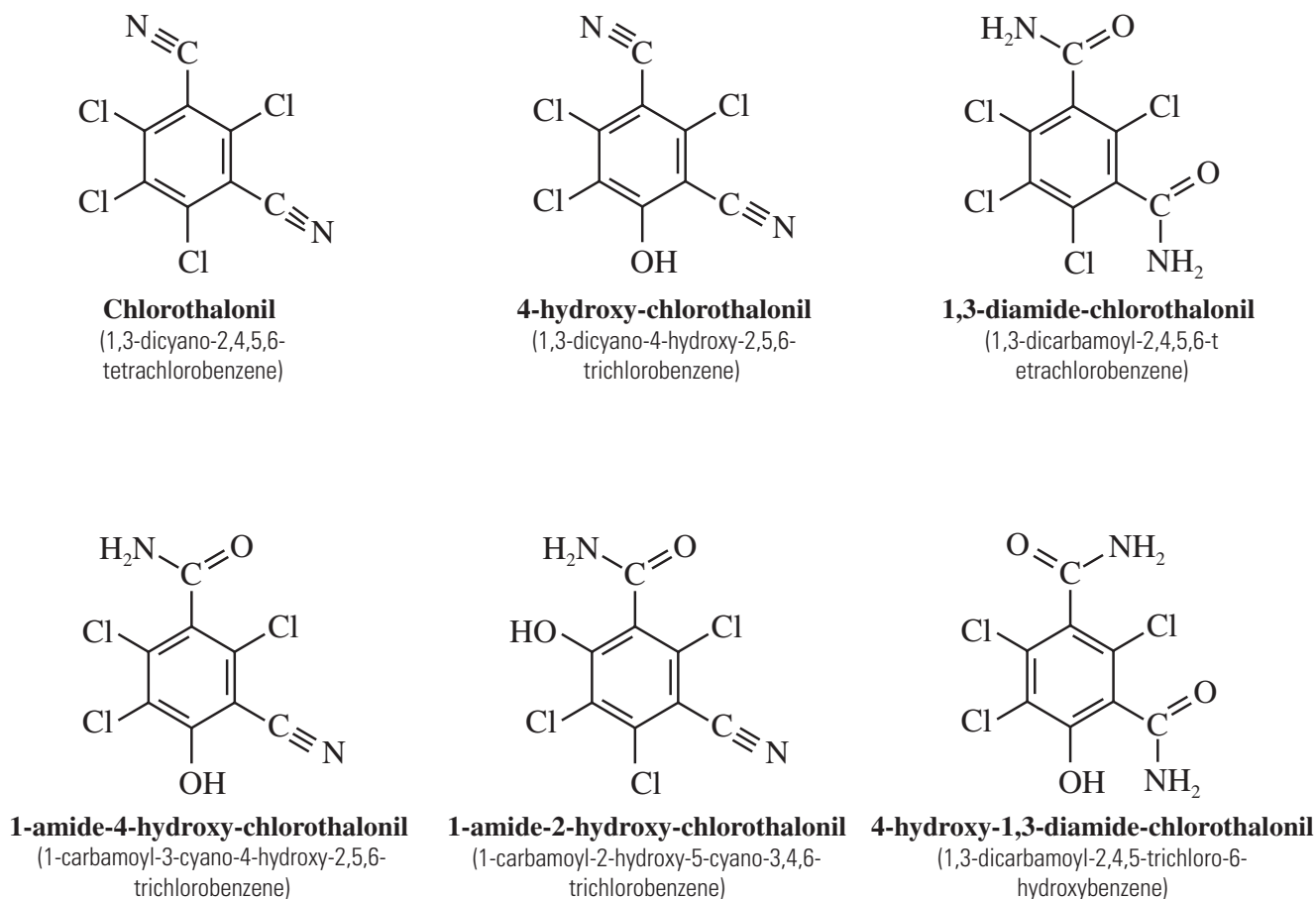
**Acknowledgments**

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**Sampling Methods and Procedures**

**Sampling-Site Selection Method**

A geographic information system (GIS) database was created to evaluate relevant spatial and pesticide application data on a nationwide scale. Data types in the GIS database included land-use/land-cover data, detailed hydrology, watershed boundaries, and chlorothalonil application data circa



**Figure 3.** Chemical structures of chlorothalonil and five degradation products

1997, as well as other ancillary data sources. The GIS database then was manipulated using the site-selection criteria to identify watershed-scale regions in which to locate sampling sites.

During May 2003, USGS personnel evaluated selected areas in Alabama, Florida, and Georgia to locate specific sites for sampling. During this process, focus was on the prevalence of peanut crops in the potential sampling-site watersheds, as well as associated logistical and safety concerns. Sites in Oklahoma and Texas were selected primarily on the basis of onsite reconnaissance by local USGS personnel with the additional criteria that the sites be collocated with existing USGS streamflow-gaging stations.

During 2003, 22 surface-water sites in Alabama, Florida, Georgia, Oklahoma, and Texas (fig. 1) were sampled, and 9 of the 22 sites were sampled again in 2004 (table 1). The selection of sampling sites in 2004 was based largely upon chlorothalonil detections during the previous year. The selected sampling sites for 2003–04 represented areas of varying climate, vegetation, topography, geology, and cropping practices. Watershed basin areas for the surface-water sampling sites varied from 13 to 783 mi<sup>2</sup> (table 1). All the sites represented watersheds with abundant peanut acreage and were located in counties with substantial amounts of chlorothalonil applica-

tion (table 1). Chlorothalonil application data circa 1997 are shown by county for the watersheds of each site sampled in 2003–04 (table 1).

## Sample Collection

During 2003, each surface-water site was sampled three times during the peanut-growing season (June through September) with the exception of one site each in Oklahoma and Texas, which were sampled twice. The timing of each sampling was intended to correspond with the timing of chlorothalonil applications in each study area as determined through contacts with local county agricultural extension agents. In 2004, nine surface-water sites were sampled twice, once early in the growing season and once just prior to harvest. These samples were collected within 48 hours after storms in the respective watersheds.

Water samples were collected either by wading or from bridges depending upon streamflow conditions and safety considerations (Wilde and others, 1999). Wading samples were collected during low flows using a USGS DH-81 sampler and 1-L Teflon bottle, whereas samples collected during high-flow conditions, or where water at the site was too deep to be

## 6 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides

**Table 1.** Site name, location, year sampled, watershed basin size, and amount of chlorothalonil application during 1997 in counties adjacent to 22 surface-water sampling sites in five Southern States, 2003–04.

[mi<sup>2</sup>, square mile]

Map number (fig. 1)	Site name	Site identification number	Latitude (degree/minute/second)	Longitude (degree/minute/second)	Year sampled	Watershed basin size (mi <sup>2</sup> )	Chlorothalonil application counties	Chlorothalonil application <sup>1</sup> (pounds)
Alabama								
1	Big Creek at State Highway 203 near Rehobeth	02358765	31° 04' 49"	85° 25' 53"	2003	26	Geneva, Houston	210,051
2	Cedar Creek at East Cook Road near Pansey	02343848	31° 11' 07"	85° 09' 00"	2003–04	22	Houston	126,862
3	Cowarts Creek above Cottonwood	235878075	31° 06' 19"	85° 15' 17"	2003	44	Houston	126,862
4	Cowarts Creek near Love Hill	235878055	31° 07' 20"	85° 17' 32"	2003	19	Houston	126,862
5	Spring Creek at County Road 55 near Geneva	02365100	31° 02' 35"	85° 45' 11"	2003	15	Geneva	83,189
Florida								
6	Moore Creek near Chumuckla	02375800	30° 48' 35"	87° 15' 14"	2003	22	Santa Rosa	63,189
7	Pond Creek near Milton	02370700	30° 40' 50"	87° 07' 55"	2003–04	59	Santa Rosa	63,189
8	Russ Mill Creek at Union Road near Cottondale	02358778	30° 51' 09"	85° 20' 30"	2003	18	Jackson	127,828
9	West Fork Big Coldwater Creek near Allentown	02370400	30° 47' 22"	87° 02' 29"	2003	70	Santa Rosa	63,189
Georgia								
10	Big Creek at Crystal Lake Road near Irwinville	02315919	31° 40' 19"	83° 25' 12"	2003	34	56,310	2003
11	Black Creek near Blitchton	02202600	32° 10' 04"	81° 29' 18"	2003–04	232	70,158	2003–04
12	Bridge Creek at James King Road near Doerun	02327314	31° 17' 15"	85° 57' 19"	2003–04	13	185,465	2003–04
13	Coheelee Creek at River Road near Hilton	02343410	31° 18' 22"	85° 04' 43"	2003–04	21	83,897	2003–04
14	Little Abrams Creek at GA Highway 313 near Doles	02350522	31° 41' 13"	--	2003–04	19	168,166	2003–04
15	Reedy Creek at U.S. Highway 129 near Ocilla	02316217	31° 29' 59"	83° 14' 19"	2003	49	56,310	2003
16	Warrior Creek near Sumner	02317870	31° 21' 45"	83° 46' 11"	2003–04	109	106,401	2003–04
17	Willacoochee Creek at Frank Road near Ocilla	02316134	31° 37' 21"	83° 12' 58"	2003	54	79,893	2003
Oklahoma								
18	Cobb Creek near Eakly	07325800	35° 17' 26"	98° 35' 38"	2003–04	132	Caddo, Washita	51,712
19	Cobb Creek near Fort Cobb	07326000	35° 08' 37"	98° 26' 33"	2003–04	307	Caddo, Washita	51,712

**Table 1.** Site name, location, year sampled, watershed basin size, and amount of chlorothalonil application during 1997 in counties adjacent to 22 surface-water sampling sites in five Southern States, 2003–04.—Continued[mi<sup>2</sup>, square mile]

Map number (fig. 1)	Site name	Site identification number	Latitude (degree/minute/second)	Longitude (degree/minute/second)	Year sampled	Watershed basin size (mi <sup>2</sup> )	Chlorothalonil application counties	Chlorothalonil application <sup>1</sup> (pounds)
Texas								
20	Beaver Creek near Electra	07312200	33° 54' 21"	98° 54' 17"	2003	652	Foard, Wichita, Willbarger	2,965
21	Sabana River near DeLeon	08099300	32° 06' 50"	98° 36' 19"	2003	264	Comanche, Eastland	20,592
22	San Miguel Creek near Tilden	08206700	28° 35' 14"	98° 32' 44"	2003	783	Atascosa, Frio, McMullen, Medina	44,778

<sup>1</sup>Chlorothalonil application data from National Center for Food and Agricultural Policy (1997).

waded safely, used a USGS D-95 weighted sampler with a 1-L Teflon bottle and bridgeboard cable-reel device. Sampling was conducted using the equal-width-increment method as described in Shelton (1994). During sampling, in-situ measurements were made of water physical properties (specific conductance, pH, temperature, and dissolved oxygen concentrations) using a hand-held multiparameter meter. Stream stage and discharge measurements also were collected each time water-quality samples were collected, following standard USGS procedures (Buchanan and Somers, 1969). Samples for analysis of suspended-sediment concentration and percentage of silt- and clay-sized particles (less than 0.062 mm in diameter) were collected by submerging a 500-mL glass bottle in the center of flow and were not processed prior to shipment.

In addition to the standard sampling conducted at all sites in both years, samples were collected at one site (Black Creek near Blitchton, Georgia, map number 11, fig. 1) using an ISCO Model 3700 portable automatic sampler (Teledyne ISCO, Los Angeles, California). This sampling method was used so that samples could be collected automatically every 30 to 60 minutes without the need for personnel onsite and in response to rising stage associated with storms near the site. The sampler was mounted in a specially designed aluminum housing attached to the side of a road bridge spanning Black Creek. The sampler used a Teflon inlet hose that was attached to a bridge pile near the center of flow and immediately adjacent to a USGS gaging station located at the site. Sampling was triggered either by a rise in stream stage as detected by the sampler or manually. During a sampled storm, the instrument first purged the sampling line to reduce the chances of contamination between samples and then pumped a preset volume of sample water into an open-mouthed, pre-cleaned, 1-L glass or polypropylene bottle contained within the sealed sampler housing. During this study, the autosampler typically was programmed to collect 2 L of water every hour for 6 consecutive hours during the initial period of rising stream stage. Samples were removed from the autosampler by USGS

personnel within 6 to 12 hours of collection and processed for shipment.

## Sample Processing

Onsite sample processing was conducted after collection of the samples using USGS procedures (Shelton, 1994; Shelton and Capel, 1994). Upon collection, water from the equal-discharge increment profile or autosampler was poured into a 14-L Teflon churn where it was composited and homogenized. All samples for pesticide analysis were filtered through 0.7- $\mu$ m baked, glass-fiber filters. These samples then were filtered directly into 1-L or 125-mL baked, amber glass bottles in accordance with the laboratory schedule as listed in table 2. Water samples collected using the autosampler were processed in the same manner and analyzed only for pesticides and pesticide degradation products.

Quality-assurance samples included pesticide field spike, field replicate, and blank samples that were processed in an identical manner to environmental samples. Certified-grade blank water for pesticide spike solution and blank samples were obtained from the USGS NWQL. Additional information about quality-assurance samples is provided in the 'Quality Assurance' section of this report.

Water samples collected for dissolved organic carbon analysis were filtered separately using single 47-mm glass-fiber filters and 0.7- $\mu$ m, pre-combusted glass microfiber filters. The dissolved organic carbon samples then were filtered into 125-mL baked, amber glass bottles. Water samples for suspended sediment were collected in 500-mL baked, amber glass bottles. All samples were shipped on ice within 24 hours to the appropriate laboratories (table 2).

**Table 2.** Type of analysis, number of bottles, sample volume, and year collected for surface-water samples collected from five Southern States, 2003–04.

[MSL, Marine Sediment Laboratory, Marina, California; NRP, U.S. Geological Survey National Research Program, Boulder, Colorado; NWQL, U.S. Geological Survey National Water-Quality Laboratory, Lakewood, Colorado; OGRL, U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas; mL, milliliter; L, liter]

Laboratory	Type of analysis	Number of bottles and sample volume	Year collected
MSL	Suspended-sediment concentration and percentage of silt- and clay-sized particles	1 x 500 mL	2003–04
NRP	Dissolved organic carbon (DOC)	2 x 125 mL	2003–04
NWQL	Schedule 2001 pesticides and degradation products	1 x 1 L	2003–04
NWQL	Schedule 2060 pesticides and degradation products	1 x 1 L	2003–04
OGRL	Acetamide herbicides and acetamide degradation products (laboratory code LCPD)	2 x 125 mL	2004
OGRL	Chlorothalonil and degradation products	4 x 125 mL	2003–04
OGRL	Chlorothalonil and degradation products (field spike)	1 x 125 mL	2003–04

## Analytical Methods and Procedures

### Analysis of Chlorothalonil and Its Degradation Products by Liquid Chromatography/Mass Spectrometry

Analytical methods for chlorothalonil and its three principle degradation products were developed by the USGS OGRL in Lawrence, Kansas, and are described in this section. The methods include SPE LC/MS using atmospheric pressure chemical ionization (APCI) or electrospray ionization (ESI) in negative-ion mode. The APCI method was used to analyze chlorothalonil and three degradation products during 2003 at an LRL of 0.050  $\mu\text{g/L}$ . To improve sensitivity and minimize background matrix interferences, water-quality samples collected during 2004 were analyzed by two separate LC/MS methods with the same sample extract. Although LRLs ranged from 0.020 to 0.050  $\mu\text{g/L}$ , compounds were detected at estimated concentrations as low as 0.002  $\mu\text{g/L}$  depending on the sample matrix. As a research method, LRLs were established on the basis of reagent spikes at levels five times above the background. The APCI method measured chlorothalonil and 1,3-diamide-chlorothalonil, and the ESI method measured 4-hydroxy-chlorothalonil and 1-amide-4-hydroxy-chlorothalonil. All four compounds could be determined using the APCI method, but the ESI method was approximately 10 to 20 times more sensitive to the presence of the 4-hydroxy-chlorothalonil degradation product. Chlorothalonil and 1,3-diamide-chlorothalonil did not ionize efficiently using the ESI method.

### Materials

Chlorothalonil was obtained from Chem Service, Inc. (Westchester, Pennsylvania). The chlorothalonil degradation

product 4-hydroxy-chlorothalonil was obtained from the U.S. Environmental Protection Agency (USEPA) repository (Fort Meade, Maryland). 1,3-diamide-chlorothalonil and 1-amide-4-hydroxy-chlorothalonil were synthesized using the method of Rouchaud and others (1988) with added purification using flash chromatography and concentrated by lyophilization. The surrogate standard, 2,4-dichlorophenoxyacetic acid- $\text{D}_3$ , and internal standard (ISTD), pentachlorophenol- $^{13}\text{C}_6$ , were obtained from Cambridge Isotope Laboratory (Andover, Massachusetts). All solvents were high-performance liquid chromatography (HPLC) grade, and the acetic acid was American Chemical Society (ACS) certified.

### Atmospheric Pressure Chemical Ionization Method Used in 2003

A 1.23-ng/mL working standard mix of chlorothalonil, 4-hydroxy-chlorothalonil, 1,3-diamide-chlorothalonil, and 1-amide-4-hydroxy-chlorothalonil was prepared in acetonitrile. A 2-ng/mL working standard of 2,4-dichlorophenoxyacetic acid- $\text{D}_3$  was prepared in methanol. The working standard of pentachlorophenol- $^{13}\text{C}_6$  was prepared by diluting the stock to 0.5  $\mu\text{g/mL}$  in 96/4 acetonitrile/isopropanol.

Blank samples and calibration standards were prepared in buffered reagent water, pH 7.0, at 0.05-, 0.10-, 0.20-, 0.50-, 1.00-, and 2.00- $\mu\text{g/L}$  concentrations by diluting directly into baked 123-mL amber bottles. Buffered reagent water was prepared by adding 2 mL of 0.1 M phosphate buffer (adjusted to pH 7.0 standard units with phosphoric acid) to the bottle prior to filling with deionized water. All blank samples, calibration standards, and unknown samples were spiked with 50  $\mu\text{L}$  of the surrogate standard, 2,4-dichlorophenoxyacetic acid- $\text{D}_3$ .

Solid-phase extraction (SPE) was performed on a Zymark Autotrace (Zymark, Palo Alto, California) using Waters Oasis hydrophilic-lipophilic-balanced (HLB) 500-mg/6- $\text{cm}^3$  cartridges (Waters, Milford, Massachusetts) to analyze water

samples collected in 2003. Cartridges were rinsed with 3 mL acetonitrile at a flow rate of 1 mL/min and equilibrated with 3 mL reagent water at a flow rate of 1 mL/min. The 123-mL sample was loaded onto the cartridge at a flow rate of 10 mL/min and kept under vacuum for 30 seconds after loading. Compounds then were eluted from the column with 3 mL acetonitrile at a flow rate of 1 mL/min. One hundred microliters (100  $\mu$ L) of the ISTD solution, pentachlorophenol- $^{13}\text{C}_6$  (0.5  $\mu\text{g}/\text{mL}$ ), were added to the sample tubes. Sample eluates were reduced to a volume of 100  $\mu$ L using a Zymark turbopap with nitrogen evaporation at 15 lb/in $^2$  with a water bath at 35  $^{\circ}\text{C}$ . Sample extracts were not allowed to go to dryness. The extracts then were transferred to 0.10-mL amber

vials, capped, labeled, and stored in a freezer at  $-10^{\circ}\text{C}$  until analysis.

Samples were analyzed on an Agilent 1100 model D series LC/MS using the APCI spray chamber in negative-ion mode with selected-ion monitoring. The compounds were separated using a Luna 3- $\mu\text{m}$ , 150- x 2-mm C-18 (2) LC column (Phenomenex, Torrance, California). The LC injection volume was 25  $\mu\text{L}$ , which was mixed with 10  $\mu\text{L}$  of 2.5-percent acetic acid using the programming function of the autosampler.

The APCI spray chamber was operated using the conditions as shown in table 3. The mobile-phase composition (which is the solvent that carries the analyte through the column) was used with the APCI negative-ion mode. Mobile-

**Table 3.** Operating conditions of liquid chromatograph/mass spectrometer using atmospheric pressure chemical ionization and electrospray ionization for analysis of samples from 22 surface-water sampling sites in five Southern States, 2003–04.

[APCI, atmospheric pressure chemical ionization; ESI, electrospray ionization;  $^{\circ}\text{C}$ , degrees Celsius; L/min, liter per minute; lb/in $^2$ , pounds per square inch; kV, kilovolt;  $\mu\text{A}$ , microamp; V, volt; v, volume; min, minute; mM, millimolar; DI, deionized; H $_2$ O, water; %, percent; --, not applicable]

Measurement	APCI 2003 negative ion	ESI negative ion
Gas temperature	300 $^{\circ}\text{C}$	--
Vaporizer temperature	350 $^{\circ}\text{C}$	--
Drying gas flow	9.0 L/min	--
Nebulizer pressure	30 lb/in $^2$	--
Capillary voltage	2.0 kV	--
Corona current	15 $\mu\text{A}$	--
Fragmentation	100 V	--
Gain	1.0	--
Dwell	35 milliseconds	--
Peak width	0.15 min	--
Mobile-phase A	5 mM ammonium acetate	--
Mobile-phase B	acetonitrile	--
Measurement	APCI 2004 negative ion	ESI negative ion
Gas temperature	300 $^{\circ}\text{C}$	300 $^{\circ}\text{C}$
Vaporizer temperature	350 $^{\circ}\text{C}$	350 $^{\circ}\text{C}$
Drying gas flow	9.0 L/min	9.0 L/min
Nebulizer pressure	30 lb/in $^2$	30 lb/in $^2$
Capillary voltage	3,000 V	3,000 V
Corona current	2.5 $\mu\text{A}$	--
Fragmentation	100 V	100 V
Gain	1.0	1.0
Dwell	35 milliseconds	27 milliseconds
Peak width	0.15 min	0.15 min
Mobile-phase A negative	5 mM ammonium acetate in DI water	2.5 mM ammonium acetate in DI water adjusted using acetic acid to pH 3.7 standard units
Mobile-phase B negative	Isopropanol/acetonitrile/H $_2$ O 49.75%/49.75%/0.5% v/v/v	Acetonitrile

phase A consisted of ammonium acetate in deionized water, and mobile-phase B consisted of acetonitrile. The mass spectrometer was turned on at 3 min and turned off at 25 min (table 3).

## Atmospheric Pressure Chemical Ionization and Electrospay Ionization Methods Used in 2004

A standard mix solution was prepared from individual 1-mg/mL stock solutions of chlorothalonil, 4-hydroxy-chlorothalonil, 1-amide-4-hydroxy-chlorothalonil, and 1,3-diamide-chlorothalonil at 2.46 ng/ $\mu$ L, and 2,4-dichlorophenoxyacetic acid-D<sub>3</sub> and pentachlorophenol-<sup>13</sup>C<sub>6</sub> at 4.92 ng/ $\mu$ L. In a 2-mL autosampler vial, 100  $\mu$ L of the standard mix were added to 700  $\mu$ L deionized water. Blank solution for the standard addition was prepared in a 2-mL autosampler vial by adding 100  $\mu$ L acetonitrile to 700  $\mu$ L deionized water. Extracts were transferred to 0.1-mL amber vials, capped, labeled, and stored in freezer at -10 °C until analysis.

The 123-mL blank sample was prepared using deionized water with 2 mL buffer solution. Then 50  $\mu$ L of 1.23- $\mu$ g/mL surrogate standard solution and 100  $\mu$ L glacial acetic acid were added to all environmental and blank samples. Each SPE cartridge was rinsed by mounting the cartridges on the vacuum manifold and passing 5 mL acetonitrile and 5 mL deionized water through each cartridge. The samples then were loaded onto the SPE cartridges.

SPE was performed on a Zymark Autotrace using Waters HLB 500-mg/6-cm<sup>3</sup> cartridges to elute compound with 8 mL of 0.75-percent ammonium hydroxide in acetonitrile. One hundred microliters (100  $\mu$ L) of the ISTD solution, pentachlorophenol-<sup>13</sup>C<sub>6</sub>, and 15  $\mu$ L of glacial acetic acid then were added to each sample tube. A second test tube was placed in the vacuum rack, and the cartridges were eluted with another 8 mL of 0.75-percent ammonium hydroxide in acetonitrile. Sample eluates then were reduced in each of the two test tubes to a volume of 2 to 4 mL, and the eluate of the two test tubes was combined. Sample eluates then were reduced to a volume of 200  $\mu$ L using a Zymark turbovap. Sample extracts were transferred to 250- $\mu$ L autosampler vials, capped, and labeled.

Compounds then were eluted from the cartridge with 8 mL of 0.75-percent ammonium hydroxide in acetonitrile. One hundred microliters (100  $\mu$ L) of the ISTD solution, pentachlorophenol-<sup>13</sup>C<sub>6</sub>, and 15  $\mu$ L of glacial acetic acid then were added to each sample tube. A second test tube was placed in the vacuum rack, and the cartridges were eluted with another 8 mL of 0.75-percent ammonium hydroxide in acetonitrile. Sample eluates then were reduced in each of the two test tubes to a volume of 2 to 4 mL, and the eluate of the two test tubes was combined. Sample eluates then were reduced to a volume of 200  $\mu$ L using a Zymark turbovap. Sample extracts were transferred to 250- $\mu$ L autosampler vials, capped, labeled, and stored in a freezer at -10 °C until analysis.

An Agilent 1100 model D series liquid chromatography/mass spectrometry (LC/MS) using APCI and ESI was used to

analyze chlorothalonil and its diamide degradation product. The compounds were measured using the APCI negative-ion mode, and 4-hydroxy-chlorothalonil and 1-amide-4-hydroxy-chlorothalonil were measured using ESI negative-ion mode, which is more sensitive than APCI for these two compounds. Mobile-phase A and B compositions used for the APCI and ESI methods and MS conditions are listed in table 3. The LC autosampler was programmed to inject 25  $\mu$ L of environmental sample and 25  $\mu$ L of blank solution onto the column. The LC autosampler then took up 25  $\mu$ L of environmental sample and 25  $\mu$ L of standard addition mix and injected them onto the column. The difference in the ratio of the detected analyte to the internal standard in the unspiked and spiked samples then was used to calculate the concentration in the unspiked sample.

## Identification and Quantitation

All compounds in this method, including the internal and surrogate standards, contained from two to five chlorine atoms (fig. 3). The low molecular weight and chemical structure of the compounds with their benzene ring, where the chlorine atoms were attached, were not easy to fragment in the mass spectrometer. However, the signature of the chlorine atoms, along with retention times relative to the standards, made identification accurate.

## Analysis of Chlorothalonil by Gas Chromatography/Mass Spectrometry

The USGS Methods and Research Development Group, Lakewood, Colorado, developed a custom method for analysis of chlorothalonil by gas chromatography/mass spectrometry (GC/MS) in an effort to achieve a lower LRL than the USGS National Water-Quality Laboratory (NWQL) schedule 2060, which analyzes the compound chlorothalonil at a LRL of 0.035  $\mu$ g/L (table 4). Chlorothalonil was determined in filtered water samples by C-18 SPE and GC/MS.

## Solid-Phase Extraction

The extraction and analysis procedures for SPE are described in Zaugg and others (1995) and Sandstrom and others (2001). Briefly, a 1-L water sample was filtered through a 0.7- $\mu$ m glass-fiber filter onsite. The sample then was shipped to the laboratory. At the laboratory, after addition of surrogate standards, diazinon-d<sub>10</sub> and alpha HCH-d<sub>6</sub>, and methanol conditioner, the sample was pumped through a C-18 SPE column at about 25 mL/min. The SPE column then was dried with nitrogen and eluted with about 3 mL ethyl acetate into a test tube containing a 100- $\mu$ L aliquot of toluene containing the polycyclic aromatic hydrocarbons (PAH) internal standards. After evaporation of the ethyl acetate, the sample extract in

**Table 4.** Compounds analyzed in samples from 22 surface-water sampling sites in five Southern States using U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedules 2001 and 2060, 2003–04.

[µg/L, micrograms per liter]

<b>Pesticide compound schedule 2001</b>	<b>Laboratory reporting level (µg/L)</b>	<b>Pesticide compound schedule 2060</b>	<b>Laboratory reporting level (µg/L)</b>
2,6-diethylaniline	0.006	2,4-D	0.038
acetochlor	.006	2,4-D methyl ester	.016
alachlor	.005	2,4-DB	.020
alpha-HCH	.005	2-hydroxyatrazine	.032
atrazine	.007	3-(4-chlorophenyl)-1-methyl urea	.036
azinphos-methyl	.050	3-hydroxycarbofuran	.008
benfluralin	.010	3-ketocarbofuran	.020
butylate	.004	acifluorfen	.028
carbaryl	.041	aldicarb	.040
carbofuran	.020	aldicarb sulfone	.018
chlorpyrifos	.005	aldicarb sulfoxide	.022
cis-permethrin	.006	atrazine	.008
cyanazine	.018	bendiocarb	.020
dacthal (DCPA)	.003	benomyl	.022
deethylatrazine (DEA)	.006	bensulfuron-methyl	.018
desulfinylfipronil	.012	bentazon	.012
desulfinylfipronil amide	.029	bromacil	.018
diazinon	.005	bromoxynil	.028
dieldrin	.009	caffeine	.018
disulfoton	.021	carbaryl	.018
EPTC (s-ethyl dipropylthiocarbamate)	.004	carbofuran	.016
ethalfluralin	.009	chloramben, methyl ester	.024
ethoprophos	.005	chlordiamino-s-triazine	.022
fipronil	.016	chlorimuron-ethyl	.032
fipronil sulfide	.013	chlorothalonil	.035
fipronil sulfone	.024	clopyralid	.024
fonofos	.003	cycloate	.014
lindane	.004	dacthal monoacid	.028
linuron	.035	deethylatrazine (DEA)	.028
malathion	.027	deisopropylatrazine (DIA)	.080

**12 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides**

**Table 4.** Compounds analyzed in samples from 22 surface-water sampling sites in five Southern States using U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedules 2001 and 2060, 2003–04.—Continued

[µg/L, micrograms per liter]

<b>Pesticide compound schedule 2001</b>	<b>Laboratory reporting level (µg/L)</b>	<b>Pesticide compound schedule 2060</b>	<b>Laboratory reporting level (µg/L)</b>
metolachlor	0.006	dicamba	0.038
metribuzin	.006	dichlorprop	.028
molinate	.003	dinoseb	.038
napropamide	.007	diphenamid	.010
p,p'-DDE	.003	diuron	.015
parathion	.010	fenuron	.032
parathion-methyl	.015	flumetsulam	.040
pebulate	.004	fluometuron	.016
pendimethalin	.022	imazaquin	.036
phorate	.011	imazethapyr	.038
prometon	.010	imidacloprid	.020
propachlor	.025	linuron	.014
propanil	.011	MCPA	.030
propargite	.023	MCPB	.010
propyzamide	.004	metalaxyl	.012
simazine	.005	methiocarb	.010
tebuthiuron	.016	methomyl	.020
terbacil	.034	metsulfuron methyl	.025
terbufos	.017	neburon	.012
thiobencarb	.010	nicosulfuron	.040
tri-allate	.006	norflurazon	.020
trifluralin	.009	oryzalin	.012
		oxamyl	.030
		picloram	.032
		propham	.030
		propiconazole	.010
		propoxur	.008
		siduron	.020
		sulfometuron-methyl	.038
		tebuthiuron	.032
		terbacil	.016
		triclopyr	.026

toluene was transferred to a GC vial, followed by one rinse with about 100  $\mu\text{L}$  toluene.

## Gas Chromatography/Mass Spectrometry

The water-sample extracts were analyzed for pesticides by GC/MS operated in the selected-ion monitoring (SIM) mode. The approximate retention time for chlorothalonil was 21.26 minutes. The 264 and 266 mass-to-charge ( $m/z$ ) ions with 100- and 129- percent abundance, respectively, were used for quantitation. The 124 and 229  $m/z$  ions, with 17- and 13-percent abundance, respectively, were used as confirming quantitation ions.

## Analysis of Other Pesticides and Their Degradation Products

Water samples shipped to the NWQL were analyzed for 52 pesticides and degradation products using laboratory schedule 2001 and 62 pesticides and degradation products using laboratory schedule 2060. Analytes for these laboratory schedules are listed in table 4. Details of the analytical methods for NWQL schedules 2001 and 2060 can be found in Zaugg and others (1995), Furlong and others (2001), Sandstrom and others (2001), and Madsen and others (2003).

## Determination of Dissolved Organic Carbon

Water samples were analyzed for dissolved organic carbon concentrations by the National Research Program, Branch of Regional Research, Boulder, Colorado (Aiken, 1992; Aiken and others, 1992). Dissolved organic carbon measurements using the catalyzed persulfate wet oxidation method were made on an O.I. Analytical Model 700 TOC Analyzer (O.I. Corporation, College Station, Texas). The instrument was warmed up for 24 hours before analyzing samples. Samples and calibration standards were loaded onto an autosampler for analysis and introduced into the reaction vessel by means of a fixed-volume sample loop. The volume of the sample loop was constrained by the desire to maintain linear instrument response (0 to 50  $\mu\text{g}$  of carbon). The standard automated analytical conditions called for 0.5 mL of 5-percent-by-volume phosphoric acid to be added to the sample. The sample then was purged for 2.0 minutes with nitrogen to remove inorganic carbon after which 0.5 mL of 0.42-m sodium persulfate solution was added. The standard reaction time of 5 minutes was employed for the persulfate oxidation step. The instrument was calibrated with solutions of reagent-grade potassium hydrogen phthalate (KHP) in distilled water. The standard curve, consisting of a minimum of five standards over the range of interest, was repeated for every eight water samples analyzed in duplicate. Reported values are the averages of duplicate analyses. The standard deviation for dissolved

organic carbon measurements was determined to be  $\pm 0.2$  mg (Aiken, 1992).

## Analysis of Suspended Sediment

Unfiltered water samples were analyzed for suspended-sediment concentrations and percentage of silt- and clay-sized particles (less than 0.062 mm in diameter) at the USGS Marine Sediment Laboratory in Marina, California. Details of the analytical method can be found in Guy (1969). Analytical results of single-blind quality-control samples provided by the USGS Sediment Laboratory Quality Assurance Project show that laboratory performance during the period of this study was satisfactory (U.S. Geological Survey, 2005).

## Quality Assurance

All water-quality measurements and water samples for this study were collected by USGS personnel in accordance with a written work plan for the study (on file with the USGS, Sacramento, California). Onsite quality assurance required all bottles and sampling equipment to be cleaned by washing the glass containers, filter units, and tubing with a phosphate-free laboratory detergent and rinsing with tapwater, then rinsing with organic-free, deionized, or distilled water, rinsing with methanol, and rinsing again with organic-free water to remove traces of methanol. Bottles were inverted to drain and dry.

## Analysis of Chlorothalonil and Its Degradation Products by Liquid Chromatography/Mass Spectrometry

Quality-assurance samples for chlorothalonil and its three degradation products collected during 2003–04 and analyzed by LC/MS at the OGRL consisted of 10 field blanks, 11 field replicates, and 13 chlorothalonil spikes as shown in table 5. Chlorothalonil or its degradation products were not detected in any of the 11 field blanks. The field replicates were analyzed to estimate method precision at ambient chlorothalonil concentrations in the presence of sample-collection and sample-matrix interferences. The chlorothalonil field-spiked samples were prepared by the collector and submitted with the environmental sample for analysis at a concentration of 0.25  $\mu\text{g/L}$ . Spikes of environmental samples are useful in determining the effect of a particular matrix on analyte recovery. Laboratory-spiked samples (LS) were fortified at 1.0  $\mu\text{g/L}$  for chlorothalonil, 1-3, diamide chlorothalonil, 1 amide-4-hydroxy-chlorothalonil, and 4-hydroxy-chlorothalonil. The concentration of these compounds varied from less than the LRL to 1.6  $\mu\text{g/L}$ . The field replicates (FR) all agreed, and neither chlorothalonil nor its degradation products were detected in any of the field blanks.

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**Table 5.** Concentrations of chlorothalonil and three chlorothalonil degradation products in quality-assurance samples from surface-water sampling sites in five Southern States as determined by U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, 2003–04.

[Sample type: FB, field blank; FCS, field chlorothalonil spike; FR, field replicate; LD, laboratory duplicate; LS, laboratory spike; R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site location	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chloro-thalonil	1-3, diamide-chloro-thalonil	1 amide-4-hydroxy-chloro-thalonil	4-hydroxy-chloro-thalonil
Alabama								
1	Big Creek at State Highway 203 near Rehobeth	09/17/03	1220	R	<0.050	<0.050	<0.050	<0.050
		09/17/03	1221	FR	<.050	<.050	<.050	<.050
2	Cedar Creek at East Cook Road near Pansey	08/04/03	1105	R	<.050	<.050	<.050	.110
		08/04/03	1106	FR	<.050	<.050	<.050	.050
		06/15/04	1250	R	<.020	<.050	.020	.066
		06/15/04	1255	FCS	.160	<.050	.016	.076
		06/15/04	1240	FB	<.020	<.050	<.020	<.020
3	Cowarts Creek above Cottonwood	08/05/03	0900	R	<.050	<.050	<.050	<.050
		08/05/03	0900	LS	1.04	<.050	1.36	1.29
4	Cowarts Creek near Love Hill	08/05/03	1300	R	<.050	<.050	<.050	<.050
		08/05/03	1300	LD	<.050	<.050	<.050	<.050
5	Spring Creek at County Road 55 near Geneva	06/25/03	0810	R	<.050	<.050	<.050	<.050
		06/25/03	0810	LD	<.050	<.050	<.050	<.050
		09/17/03	0900	R	<.050	<.050	<.050	<.050
		09/17/03	0800	FB	<.050	<.050	<.050	<.050
Florida								
6	Moore Creek near Chumuckla	07/29/03	1225	R	<.050	<.050	<.050	<.050
		07/29/03	1145	LD	<.050	<.050	<.050	<.050
		07/29/03	1145	FB	<.050	<.050	<.050	<.050
		09/25/03	1200	R	<.050	<.050	<.050	<.050
		09/25/03	1200	LD	<.050	<.050	<.050	<.050
		09/25/03	1202	FCS	.080	<.050	<.050	<.050

**Table 5.** Concentrations of chlorothalonil and three chlorothalonil degradation products in quality-assurance samples from surface-water sampling sites in five Southern States as determined by U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, 2003–04.—Continued

[Sample type: FB, field blank; FCS, field chlorothalonil spike; FR, field replicate; LD, laboratory duplicate; LS, laboratory spike; R, regular environmental; &lt;, less than; --, no data]

Map number (fig. 1)	Site location	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chloro-thalonil	1-3, diamide-chloro-thalonil	1 amide-4-hydroxy-chloro-thalonil	4-hydroxy-chloro-thalonil
Florida—Continued								
7	Pond Creek near Milton	06/14/04	1310	R	<0.020	<0.050	<0.020	<0.020
		06/14/04	1315	FCS	.123	<.050	<.020	.005
		09/23/04	0830	R	<.020	<.050	<.020	.007
		09/23/04	0830	LS	.072	<.050	<.020	.006
		09/23/04	0835	FR	<.020	<.050	<.020	.005
9	West Fork Big Coldwater Creek near Allentown	06/24/03	0900	R	<.050	<.050	<.050	<.050
		06/24/03	0745	FB	<.050	<.050	<.050	<.050
		09/25/03	0845	R	<.050	<.050	<.050	<.050
		09/25/03	0845	LS	1.19	1.50	1.56	.960
Georgia								
10	Big Creek at Crystal Lake Road near Irwinville	09/24/03	0715	R	<.050	<.050	<.050	<.050
		09/24/03	0716	FR	<.050	<.050	<.050	<.050
11	Black Creek near Blynton	09/08/03	0930	R	<.050	<.050	<.050	<.050
		09/08/03	0930	LS	1.08	<.050	.920	.940
		09/08/03	0945	R	<.050	<.050	<.050	<.050
		09/08/03	0945	LD	<.050	<.050	<.050	<.050
		09/22/03	1230	R	<.050	<.050	<.050	<.050
		09/22/03	1232	FCS	.240	<.050	<.050	<.050
		09/22/03	1232	LS	.730	<.050	<.050	1.18
		10/18/03	2030	R	<.050	<.050	<.050	<.050
		10/18/03	2030	LS	.260	<.050	1.23	1.62
		06/23/04	0430	R	<.020	<.050	<.020	.009
		06/23/04	0432	FCS	.252	<.050	<.020	.021
		06/23/04	0930	R	<.020	<.050	<.020	.008
		06/23/04	0932	FCS	.048	<.050	<.020	.015
06/24/04	0915	R	<.020	<.050	<.020	.013		
06/24/04	0915	LS	.456	<.050	<.020	.013		
06/24/04	0916	FCS	.248	<.050	<.020	.009		

16 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides

**Table 5.** Concentrations of chlorothalonil and three chlorothalonil degradation products in quality-assurance samples from surface-water sampling sites in five Southern States as determined by U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, 2003–04.—Continued

[Sample type: FB, field blank; FCS, field chlorothalonil spike; FR, field replicate; LD, laboratory duplicate; LS, laboratory spike; R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site location	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	1-3, diamide-chlorothalonil	1 amide-4-hydroxy-chlorothalonil	4-hydroxy-chlorothalonil
Georgia—Continued								
11	Black Creek near Blythe—Continued	09/07/04	1540	R	<0.020	<0.050	<0.020	<0.020
		09/07/04	1540	LS	.055	<.050	<.020	.011
12	Bridge Creek at James King Road near Doerun	07/15/03	1150	R	<.050	<.050	<.050	<.050
		07/15/03	1150	LS	.990	1.21	.950	1.51
		09/23/03	0800	R	<.050	<.050	<.050	<.050
		09/23/03	0800	LD	<.050	<.050	<.050	<.050
		09/23/03	0801	FB	<.050	<.050	<.050	<.050
		07/08/04	1900	R	<.020	<.050	<.020	.019
		07/08/04	1900	LS	.114	<.050	<.020	.025
13	Coheelee Creek at River Road near Hilton	09/15/03	1220	R	<.050	<.050	<.050	<.050
		09/15/03	1220	LD	<.050	<.050	<.050	<.050
		09/15/03	1221	FR	<.050	<.050	<.050	<.050
		06/15/04	1510	R	<.020	<.050	<.020	.031
		06/15/04	1515	FCS	.109	<.050	<.020	.032
14	Little Abrams Creek at GA Highway 313 near Doles	08/12/03	1300	R	<.050	<.050	<.050	<.050
		08/12/03	1301	FR	<.050	<.050	<.050	<.050
		08/12/03	1301	LS	.890	<.050	<.050	1.61
		07/08/04	1030	R	.433	<.050	<.020	.930
		07/08/04	1030	FCS	.369	<.050	<.020	.754
		07/08/04	0955	FB	<.020	<.050	<.020	<.020
		07/08/04	1215	R	.150	<.050	<.020	.350
		07/08/04	1215	LD	.150	<.050	<.020	.350
15	Reedy Creek at U.S. Highway 129 near Ocilla	08/13/03	1345	R	<.050	<.050	<.050	<.050
		08/13/03	1345	LD	<.050	<.050	<.050	<.050
16	Warrior Creek near Sumner	07/15/03	750	R	<.050	<.050	<.050	<.050
		07/15/03	0751	FR	<.050	<.050	<.050	<.050

**Table 5.** Concentrations of chlorothalonil and three chlorothalonil degradation products in quality-assurance samples from surface-water sampling sites in five Southern States as determined by U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, 2003–04.—Continued

[Sample type: FB, field blank; FCS, field chlorothalonil spike; FR, field replicate; LD, laboratory duplicate; LS, laboratory spike; R, regular environmental; &lt;, less than; --, no data]

Map number (fig. 1)	Site location	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter					
					Chloro-thalonil	1-3, diamide-chloro-thalonil	1 amide-4-hydroxy-chloro-thalonil	4-hydroxy-chloro-thalonil		
Oklahoma										
18	Cobb Creek near Eakly	07/15/03	1030	R	<0.050	<0.050	<0.050	<0.050		
		07/15/03	1033	FR	<.050	<.050	<.050	<.050		
		07/30/03	1200	R	<.050	<.050	<.050	<.050		
		07/30/03	1202	FR	<.050	<.050	<.050	<.050		
		08/15/04	1630	R	<.020	<.050	<.020	.002		
		08/15/04	1630	LD	<.020	<.050	<.020	.002		
		08/15/04	1630	LS	<.020	<.050	<.020	.002		
		08/15/04	1632	FCS	.189	<.050	<.020	.009		
		08/15/04	1636	FB	<.020	<.050	<.020	<.020		
		08/28/04	1700	R	<.020	<.050	<.020	.018		
		08/28/04	1700	LD	<.020	<.050	<.020	.012		
		10/07/04	2130	R	<.020	<.050	<.020	<.020		
		10/07/04	2132	FCS	.109	<.050	<.020	.007		
		19	Cobb Creek near Fort Cobb	07/17/03	1430	R	<.050	<.050	<.050	<.050
				07/15/03	1430	LD	<.050	<.050	<.050	<.050
				12/03/03	1400	R	<.050	<.050	<.050	<.050
				12/03/03	1401	FR	<.050	<.050	<.050	<.050
				12/03/03	1402	FB	<.050	<.050	<.050	<.050
08/15/04	1930			R	<.020	<.050	<.020	.002		
08/15/04	1932			FCS	.171	<.050	<.020	.012		
08/30/04	1300			R	<.020	<.050	<.020	<.020		
08/30/04	1306			FB	<.020	<.050	<.020	<.020		
10/12/04	1230			R	<.020	<.050	<.020	<.020		
10/12/04	1232	FCS	.112	<.050	<.020	.007				
Texas										
20	Beaver Creek near Electra	08/30/03	1305	R	<.050	<.050	<.050	<.050		
		08/30/03	1306	FR	<.050	<.050	<.050	<.050		

**Table 5.** Concentrations of chlorothalonil and three chlorothalonil degradation products in quality-assurance samples from surface-water sampling sites in five Southern States as determined by U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, 2003–04.—Continued

[Sample type: FB, field blank; FCS, field chlorothalonil spike; FR, field replicate; LD, laboratory duplicate; LS, laboratory spike; R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site location	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	1-3, diamide-chlorothalonil	1 amide-4-hydroxy-chlorothalonil	4-hydroxy-chlorothalonil
Texas—Continued								
21	Sabana River near DeLeon	07/09/03	1240	R	<0.050	<0.050	<0.050	<0.050
		07/09/03	1240	LS	1.02	.950	1.48	--
		09/03/03	1030	R	<.050	<.050	<.050	<.050
		09/03/03	1030	FB	<.050	<.050	<.050	<.050
		12/11/03	1130	R	<.050	<.050	<.050	<.050
		12/11/03	1130	LS	.050	.810	.200	.560

Quality-assurance laboratory samples for the OGRL LC/MS chlorothalonil method consisted of 16 blank, 12 duplicate, and 14 spiked samples. The results for the laboratory-duplicate and field- and laboratory-spiked samples are shown in table 5. Chlorothalonil and its degradation products were not detected in any of the laboratory blank samples. The laboratory-duplicate samples were analyzed to estimate precision at ambient chlorothalonil concentrations in natural matrices. Field-spiked samples (FCS) were fortified at 0.25 µg/L with chlorothalonil. The concentration of chlorothalonil in these FCS varied from 0.11 to 0.25 µg/L.

### Analysis of Chlorothalonil by Gas Chromatography/Mass Spectrometry

Analysis of chlorothalonil using GC/MS selected-ion monitoring demonstrated stable retention times, quantitation and confirming ions, and abundance percentage response as previously discussed. Samples fortified with a spike mixture containing chlorothalonil, which had been extracted in September 2003, were analyzed by the GC/MS method in March 2004. Results in table 6 show that the recoveries of several samples spiked at 0.025 µg/L varied from 78 and 116 percent indicating good performance.

### Analysis of Other Pesticides and Their Degradation Products

Surrogate compounds were added to all environmental and blank samples analyzed for pesticides by the USGS NWQL. Surrogate compounds in samples analyzed using

laboratory schedule 2001 were diazinon-d<sub>10</sub> and alpha HCH-d<sub>6</sub>. Three surrogates, barban, 2,4,5-T, and caffeine-C<sub>13</sub>, were added to samples analyzed using laboratory schedule 2060. Surrogate compounds were similar in chemical properties to some target analytes but were not expected to be present in the environmental samples. They were used to assess extraction efficiency and to detect potential sample-processing problems in the laboratory.

A summary of surrogate compound recoveries for samples analyzed in 2003 and 2004 is shown in table 7. The surrogate standard recoveries in NWQL schedule 2001 ranged from 85 to 123 and 82 to 120 percent in 2003 and 2004, respectively. For the 2060 schedule, the surrogate standard recovery ranged from 66 to 134 and 4 to 151 percent in 2003 and 2004, respectively. The smallest minimum recoveries were obtained from barban and 2,4,5-T at 4 and 30 percent, respectively. The median recovery for all the surrogate standards that could be calculated ranged from 75 to 110 percent indicating overall acceptable method performance.

## Results of Analyses

In the “Supplemental Information” section at the back of this report, results of analyses of water samples from 22 surface-water sampling sites are shown in tables 12–17 by analytical method as previously described. Statistical summaries of reported concentrations are provided in tabular form in the following sections. For the calculation of the statistics in these tables, all nondetections were treated as zero.

**Table 6.** Percentage recoveries of chlorothalonil in extracts of reagent-water samples fortified at 0.025 microgram per liter, extracted by solid-phase extraction in July–August 2003, and analyzed by gas chromatography/mass spectrometry in March 2004.

[µg/L, micrograms per liter]

Laboratory identification number	Collection date (month/day/year)	Collection time (24-hour)	Fortification level (µg/L)	Recovery (percent)
20012430321	08/31/01	1605	0.025	115
20012430322	08/31/01	1600	.025	116
20012490116	09/06/01	1600	.025	109
20012490117	09/06/01	1605	.025	93
20012560174	09/13/01	1600	.025	85
20012560175	09/13/01	1605	.025	82
20012820104	10/09/01	1600	.025	78
20012820105	10/09/01	1605	.025	90

**Table 7.** Percentage recoveries of surrogate compounds in samples from 22 surface-water sampling sites in five Southern States using U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedules 2001 and 2060, 2003–04.

[Values are percentage recovered. E, estimated; NA, not applicable]

Year	Laboratory schedule	Surrogate compound	Number of samples	Percentage recoveries		
				Maximum	Minimum	Median
2003	2001	diazinon-d <sub>10</sub>	64	123	92	103
	2001	alpha HCH-d <sub>6</sub>	64	111	85	96
	2060	Barban	2	134	E82	NA
	2060	2,4,5-T	2	104	66	NA
	2060	caffeine-C <sub>13</sub>	2	E79	68	NA
2004	2001	diazinon-d <sub>10</sub>	20	120	94	110
	2001	alpha HCH-d <sub>6</sub>	20	103	82	94
	2060	Barban	19	105	E4	E75
	2060	2,4,5-T	19	119	E30	E84
	2060	caffeine-C <sub>13</sub>	19	E151	74	E105

## Chlorothalonil and Its Degradation Products

The development of the LC/MS method by the USGS OGRL was critical to a better understanding of the occurrence and transport of chlorothalonil and its three principle degradation products, 4-hydroxy-chlorothalonil, 1,3-diamide-chlorothalonil, and 1-amide-4-hydroxy-chlorothalonil. Concentrations of chlorothalonil and three of its degradation products using LC/MS analysis are shown in table 12, and concentrations using GC/MS analysis by the USGS Methods and Research Development Group are shown in table 13 in the “Supplemental Information” section at the back of this report. A statistical summary of LC/MS and GC/MS chlorothalonil analytical results is shown in table 8. Chlorothalonil was detected in 4 (4 percent) of the 113 water samples analyzed by LC/MS, with concentrations ranging from 0.089 to 0.433 µg/L. Of

the 113 water samples analyzed by LC/MS, the chlorothalonil degradation product, 4-hydroxy-chlorothalonil, was detected in 26 of the samples with a 23-percent detection rate. This degradation product had a minimum detected concentration of 0.002 µg/L and a maximum concentration of 0.930 µg/L. The remaining two chlorothalonil degradation products, 1-amide-4-hydroxy-chlorothalonil and 1,3-diamide-chlorothalonil, had detections of 0.020 and 0.161 µg/L, respectively.

Chlorothalonil was detected in 5 (7 percent) of the 68 sample extracts analyzed by GC/MS (table 8). Low levels of chlorothalonil at 0.01 µg/L were estimated from minimum area counts of the lowest calibration standard that could be reliably determined with all ions present in correct abundance. In many samples, a peak with the correct retention time for chlorothalonil (21.26 minutes) and the two most abundant ions (264 and 266 m/z) were present, but chlorothalonil could not

**Table 8.** Statistical summary of concentrations of chlorothalonil and three chlorothalonil degradation products determined by liquid chromatography/mass spectrometry (U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas) and gas chromatography/mass spectrometry (U.S. Geological Survey Methods and Research Development Group, Lakewood, Colorado) for water samples collected from 22 sampling sites in five Southern States, 2003–04.

[<LRL, less than laboratory reporting level; NA, not applicable]

Compound	Number of samples	Number of samples at or above laboratory reporting levels	Concentrations (micrograms per liter)				
			Mean	Median	90th percentile	Maximum	Minimum
Liquid chromatography/mass spectrometry (LRL = 0.020 and 0.050 microgram per liter)							
Chlorothalonil	113	4	0.150	0.135	<LRL	0.433	0.089
1,3-diamide of chlorothalonil	113	1	NA	NA	NA	.161	NA
1 amide-4-hydroxy of chlorothalonil	113	1	NA	NA	NA	.020	NA
4-hydroxy of chlorothalonil	113	26	<LRL	<LRL	<LRL	.930	.002
Gas chromatography/mass spectrometry (LRL = 0.01 microgram per liter)							
Chlorothalonil	68	5	.001	LRL	LRL	.035	.004

be confirmed because the lower abundance confirming ions (124 and 229 m/z) were lacking.

Chlorothalonil was detected in only one of the samples (Pond Creek near Milton, July 29, 2003) analyzed by both the LC/MS and the GC/MS. Of the five samples where chlorothalonil was detected by the GC/MS method, four of the detections were less than the LRL of the LC/MS. The reasons for this discrepancy are not known. The low concentrations at which chlorothalonil and its degradation products were detected in surface water is demonstrated in table 8, which shows that none of the chlorothalonil compounds were detected at concentrations greater than the LRLs at the 90th percentile of the chlorothalonil concentrations.

## Other Selected Pesticides and Their Degradation Products

Concentrations of selected pesticides and their degradation products analyzed as part of NWQL schedules 2001 and 2060 and detected in one or more samples are shown in tables 14 and 15, respectively, in the “Supplemental Information” section. A statistical summary for both NWQL schedules is shown in table 9. Although LRLs ranged from 0.003 to 0.050 µg/L for NWQL schedule 2001 and 0.008 to 0.040 µg/L for NWQL schedule 2060 (table 4), compound concentrations were estimated as low as 0.001 µg/L depending on the sample matrix (table 9).

Eighty-four water samples were analyzed by NWQL schedule 2001 (table 9). Twenty-one of the 52 parent pesticides and pesticide degradation products were detected at or above their LRL (see table 4). Metolachlor, the most

frequently detected pesticide, was present in 58 percent of the samples, followed by atrazine (50 percent), and deethylatrazine (27 percent), which is a degradation product of atrazine.

NWQL schedule 2060 (table 4) contains 62 parent pesticides and pesticide degradation products. Eighteen compounds were detected at or above LRLs (table 9). 2-hydroxyatrazine, a triazine degradation product, and caffeine were detected in 48 percent of the samples, whereas atrazine, bentazon, diuron, and tebuthion were all detected in 29 percent of the samples. Chlorothalonil had two estimated detections 0.061 and 0.161 µg/L. Fenuron also had two detections (9.5 percent) and contained the highest reported concentration at 1.51 µg/L of all compounds analyzed using NWQL schedule 2060.

## Dissolved Organic Carbon and Suspended Sediment

Results for dissolved organic carbon concentrations, suspended-sediment concentrations, and percentage of silt- and clay-sized particles are presented in table 16 in the “Supplemental Information” section at the back of this report, and a statistical summary is shown in table 10. Dissolved organic carbon concentrations ranged from 1.2 to 41 mg/L (table 16). Suspended-sediment concentrations ranged from 3 to 1,329 mg/L, and percentage of silt- and clay-sized particles ranged from 21 to 98 percent in the suspended-sediment samples.

**Table 9.** Statistical summary of concentrations of selected pesticides and pesticide degradation products determined by U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedules 2001 and 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[E, estimated; LD, less than method detection level; <LRL, less than laboratory reporting level; <, less than]

Herbicide	Number of samples	Percentage of samples at or above laboratory reporting level	Concentrations (micrograms per liter)				
			Mean	Median	90th percentile	Maximum	Minimum
Schedule 2001							
Alachlor	84	9.5	0.001	<LRL	LD	0.041	0.010
Atrazine	84	50	.019	.002E	.028	.505	.008
Carbaryl	84	3.6	.001	<LRL	LD	.027E	.006E
Carbofuran	84	1.2	<.001	<LRL	LD	.006E	.006E
Chlorpyrifos	84	6.0	.001	<LRL	LD	.018	.008
Cyanazine	84	2.4	<.001	<LRL	LD	.011E	.008E
Deethylatrazine	84	27	.003	<LRL	.009	.050	.003E
Diazinon	84	1.2	<.001	<LRL	LD	.011	.011
Ethalfuralin	84	3.6	<.001	<LRL	LD	.022	.009
Malathion	84	3.6	.001	<LRL	LD	.033	.033
Metolachlor	84	58	.008	.006	.019	.063	.013
Metribuzin	84	7.1	.001	<LRL	LD	.046	.009
Parathion	84	1.2	<.001	<LRL	LD	.007E	.007E
Pendimethalin	84	3.6	.001	<LRL	LD	.040	.040
Prometon	84	16	.002	<LRL	.005	.031	.005E
Propanil	84	1.2	<.001	<LRL	LD	.003E	.003E
Propargite	84	6.0	.013	<LRL	LD	.032	.007E
Simazine	84	12	.003	<LRL	.006	.117	.006
Terbuthiuron	84	13	.002	<LRL	.007	.022	.018
Terbacil	84	1.2	<.001	<LRL	LD	.008E	.008E
Trifluralin	84	3.6	<.001	<LRL	LD	.013	.008E
Schedule 2060							
2,4-D	21	24	0.009	<LRL	0.037	0.056	0.026
2-Hydroxyatrazine	21	48	.024E	<LRL	.054	.143	.009E
Acifluorfen	21	4.8	.001	<LRL	LD	.029	.029
Atrazine	21	29	.005	<LRL	.014	.031	.005E
Bensulfuron-methyl	21	4.8	<.001	<LRL	LD	.006E	.006E
Bentazon	21	29	.019	<LRL	.026	.280	.007E
Caffeine	21	48	.021	<LRL	.037	.125	.014E
Chlorothalonil	21	9.5	.011	<LRL	LD	.161	.061
Deisopropylatrazine	21	4.8	<.001	<LRL	LD	.007E	.007E

**Table 9.** Statistical summary of concentrations of selected pesticides and pesticide degradation products determined by U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedules 2001 and 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[E, estimated; LD, less than method detection level; &lt;LRL, less than laboratory reporting level; &lt;, less than]

Herbicide	Number of samples	Percentage of samples at or above laboratory reporting level	Concentrations (micrograms per liter)				
			Mean	Median	90th percentile	Maximum	Minimum
Schedule 2060—Continued							
Dinoseb	21	9.5	0.005	<LRL	LD	0.087	0.008E
Diuron	21	29	.052	<LRL	.151	.685	.017
Fenuron	21	9.5	.073	<LRL	LD	1.5	.016E
Fluometuron	21	14	.002	<LRL	.009	.022	.009E
Norflurazon	21	10	<.001	<LRL	LD	.008E	.008E
Oryzalin	21	19	.016	<LRL	.048	.127	.043
Propiconazole	21	10	.002	<LRL	LD	.026	.005E
Tebuthiuron	21	29	.009	<LRL	.023	.090	.005E
Triclopyr	21	14	.033	<LRL	.093	.355	.093

## Associated Streamflow and Physical Properties

The streamflow discharge measurements, gage heights, and physical properties associated with each surface-water sample were recorded at all sites during the 2003–04 sampling and are listed in table 17 in the “Supplemental Information” section at the back of this report. A statistical summary of these data is shown in table 11.

## Conclusions

Chlorothalonil is a fungicide that has been used in the United States for more than 30 years. It has a wide range of uses, including agricultural, home, garden, and industrial. The greatest use of chlorothalonil is on peanuts in the States of Alabama, Florida, and Georgia. The field half-life for chlorothalonil ranges from 10 to 60 days and this, coupled with large application amounts and the practice of frequent, repeated applications, could promote the offsite movement of this fungicide. Because chlorothalonil has the potential to be transported away from the point of application through spray drift, field runoff, or unsaturated zone transport, it has been detected in surface water, rainfall, and air samples, whereas chlorothalonil degradation products have been detected in ground-water samples. Chlorothalonil also has been classified as a probable carcinogen by the U.S. Environmental Protection Agency as tests have shown very high toxicity to both fish and aquatic invertebrates.

This report documents the results of analyses of chlorothalonil and its degradation products in surface water in five Southern States—Alabama, Florida, Georgia, Oklahoma, and Texas. In 2003, sampling was conducted at 22 surface-water sites located in the five States. Samples were collected during three sampling periods extending through the peanut-growing season (June–September), with the exception of one site each in Oklahoma and Texas, which were sampled twice. In 2004, sampling was a modified version of the 2003 sampling in which water samples were collected at 9 of the 22 surface-water sampling sites in three States (Alabama, Florida, and Georgia) within 48 hours after storms.

An analytical method, using solid-phase extraction (SPE) and liquid chromatography/mass spectrometry (LC/MS), to determine chlorothalonil and three degradation products was developed by the U.S. Geological Survey’s (USGS) Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kansas. The development of the LC/MS method was critical to a better understanding of the occurrence and transport of chlorothalonil and its three principle degradation products, 4-hydroxy-chlorothalonil, 1,3-diamide-chlorothalonil, and 1-amide-4-hydroxy-chlorothalonil. Of the 113 water samples analyzed by LC/MS, chlorothalonil was detected in one sample during 2003 and three samples during 2004 from water collected at sites in Alabama, Florida, and Georgia. Concentrations ranged from 0.089 to 0.433 µg/L. The primary degradation product, 4-hydroxy-chlorothalonil, was reported in 26 samples during 2003–04 with a concentration range of 0.002 to 0.930 µg/L. The degradation product 1-amide-4-hydroxy-chlorothalonil was detected in one sample at a con-

**Table 10.** Statistical summary of concentrations of dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[mg/L, milligrams per liter; &lt;, less than; mm, milligrams]

Herbicide	Number of samples	Percentage of samples at or above laboratory reporting levels	Concentrations or percentage				
			Mean	Median	90th percentile	Maximum	Minimum
Dissolved organic carbon, in mg/L	92	100	11	7.9	20	41	1.2
Suspended sediment, in mg/L	74	100	54	16	42	1,329	3
Silt- and clay-sized particles (<0.062 mm), in percent	70	100	71	74	93	98	28

**Table 11.** Statistical summary of streamflow and physical properties determined for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

Streamflow or physical property	Number of samples	Percentage of samples at or above laboratory reporting level	Measurement				
			Mean	Median	90th percentile	Maximum	Minimum
Instantaneous discharge, in cubic feet per second	98	100	186	37.1	811	2,329	1.3
Specific conductance, in microsiemens per centimeter at 25 degrees Celsius	97	100	240	69	580	3,760	22
pH, in standard units	97	100	6.4	6.4	7.8	8.2	4.4
Water temperature, in degrees Celsius	46	100	24.2	24.2	25.9	32.5	16.2
Dissolved oxygen, in milligrams per liter	46	100	5.8	5.7	8.5	11	1.5

centration of 0.020 µg/L, whereas 1,3-diamide-chlorothalonil was detected in one sample at a concentration of 0.161 µg/L.

The USGS Methods and Research Development Group developed a method for analysis of chlorothalonil by gas chromatography/mass spectrometry (GC/MS) in an effort to achieve a lower laboratory reporting level (LRL) than the USGS National Water-Quality Laboratory (NWQL) schedule 2060 which contains the compound chlorothalonil at a LRL of 0.035 µg/L. The group succeeded in achieving a lower GC/MS LRL of 0.01 µg/L. Chlorothalonil was detected in 5 of 68 water samples analyzed by the custom GC/MS method with a concentration range of 0.004 to 0.035 µg/L, whereas chlorothalonil was detected in 2 of 21 water samples analyzed by NWQL schedule 2060 with estimated concentrations of 0.061 and 0.161 µg/L. The GC/MS analytical method demonstrated stable retention times, quantitation, and abundance percentage response.

As expected, chlorothalonil was detected only infrequently and at relatively low concentrations. Notably, chlorothalonil's major degradation product, 4-hydroxy-chlorothalonil, was detected most frequently and occurred generally at higher concentrations in water samples than did the parent fungicide. Analytical results showed that the methods were

valuable for acquiring information about the occurrence of the fungicide chlorothalonil. The data also reaffirm that 4-hydroxy-chlorothalonil is the dominant degradation product in the peanut-growing environment as noted in previous studies.

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## Supplemental Information

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28 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides

**Table 12.** Concentrations of chlorothalonil and three chlorothalonil degradation products analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[ND, no detection; Sample type: R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site name	Date of collection (month/day year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	4-hydroxy-chlorothalonil	1,3-diamide-chlorothalonil	1-amide-4-hydroxy-chlorothalonil
Alabama								
1	Big Creek at State Highway 203 near Rehobeth	06/25/03	1220	R	<0.050	<0.050	<0.050	<0.050
		08/06/03	1140	R	<.050	<.050	<.050	<.050
		09/17/03	1220	R	<.050	<.050	<.050	<.050
2	Cedar Creek at East Cook Road near Pansey	06/26/03	1210	R	<.050	<.050	<.050	<.050
		08/04/03	1105	R	<.050	.110	<.050	<.050
		09/15/03	1545	R	<.050	<.050	<.050	<.050
		06/15/04	1250	R	<.020	.066	<.050	.020
		09/17/04	1220	R	<.020	.136	<.050	<.020
3	Cowarts Creek above Cottonwood	06/26/03	1515	R	<.050	<.050	<.050	<.050
		08/05/03	0900	R	<.050	<.050	<.050	<.050
		09/16/03	1225	R	<.050	<.050	<.050	<.050
4	Cowarts Creek near Love Hill	06/25/03	1730	R	<.050	<.050	<.050	<.050
		08/05/03	1300	R	<.050	<.050	<.050	<.050
		09/16/03	1550	R	<.050	<.050	<.050	<.050
5	Spring Creek at County Road 55 near Geneva	06/25/03	0810	R	<.050	<.050	<.050	<.050
		08/06/03	0810	R	<.050	<.050	<.050	<.050
		09/17/03	0900	R	<.050	<.050	<.050	<.050
Florida								
6	Moore Creek near Chumuckla	06/23/03	1125	R	<0.050	<0.050	<0.050	<0.050
		07/29/03	1225	R	<.050	<.050	<.050	<.050
		09/25/03	1200	R	<.050	<.050	<.050	<.050
7	Pond Creek near Milton	06/23/03	1500	R	<.050	<.050	<.050	<.050
		07/29/03	1435	R	.120	<.050	<.050	<.050
		09/24/03	1400	R	<.050	<.050	<.050	<.050
		06/14/04	1310	R	<.020	<.020	<.050	<.020
		09/23/04	0830	R	<.020	.007	<.050	<.020
		09/23/04	0830	R	<.020	.008	<.050	<.020

**Table 12.** Concentrations of chlorothalonil and three chlorothalonil degradation products analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[ND, no detection; Sample type: R, regular environmental; &lt;, less than; --, no data]

Map number (fig. 1)	Site name	Date of collection (month/day year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	4-hydroxy-chlorothalonil	1,3-diamide-chlorothalonil	1-amide-4-hydroxy-chlorothalonil
Florida—Continued								
8	Russ Mill Creek at Union Road near Cottondale	06/24/03	1330	R	<0.050	<0.050	<0.050	<0.050
		08/05/03	1640	R	<.050	<.050	<.050	<.050
		09/16/03	0825	R	<.050	<.050	<.050	<.050
9	West Fork Big Coldwater Creek near Allentown	06/24/03	0900	R	<.050	<.050	<.050	<.050
		07/30/03	0800	R	<.050	<.050	<.050	<.050
		09/25/03	0845	R	<.050	<.050	<.050	<.050
Georgia								
10	Big Creek at Crystal Lake Road near Irwinville	07/16/03	1340	R	<.050	<.050	<.050	<.050
		08/13/03	0710	R	<.050	<.050	<.050	<.050
		09/24/03	0715	R	<.050	<.050	<.050	<.050
11	Black Creek near Blynton	07/14/03	1020	R	<.050	<.050	<.050	<.050
		08/11/03	0945	R	<.050	<.050	<.050	<.050
		09/08/03	0900	R	<.050	<.050	<.050	<.050
		09/08/03	0915	R	<.050	<.050	<.050	<.050
		09/08/03	0930	R	<.050	<.050	<.050	<.050
		09/08/03	0945	R	<.050	<.050	<.050	<.050
		09/08/03	1000	R	<.050	<.050	<.050	<.050
		09/08/03	1015	R	<.050	<.050	<.050	<.050
		09/08/03	1030	R	<.050	<.050	<.050	<.050
		09/08/03	1045	R	<.050	<.050	<.050	<.050
		09/08/03	1100	R	<.050	<.050	<.050	<.050
		09/08/03	1115	R	<.050	<.050	<.050	<.050
		09/08/03	1130	R	<.050	<.050	<.050	<.050
		09/08/03	1145	R	<.050	<.050	<.050	<.050
		09/22/03	1230	R	<.050	<.050	<.050	<.050
10/18/03	1820	R	<.050	<.050	<.050	<.050		
10/18/03	1850	R	<.050	<.050	<.050	<.050		
10/18/03	1920	R	<.050	<.050	<.050	<.050		

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**Table 12.** Concentrations of chlorothalonil and three chlorothalonil degradation products analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[ND, no detection; Sample type: R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site name	Date of collection (month/day year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	4-hydroxy-chlorothalonil	1,3-diamide-chlorothalonil	1-amide-4-hydroxy-chlorothalonil
Georgia—Continued								
11	Black Creek near Blichton— Continued	10/18/03	1950	R	<0.050	<0.050	<0.050	<0.050
		10/18/03	2030	R	<.050	<.050	<.050	<.050
		06/23/04	0430	R	<.020	.009	<.050	<.020
		06/23/04	0630	R	<.020	.009	<.050	<.020
		06/23/04	0730	R	<.020	.011	<.050	<.020
		06/23/04	0830	R	<.020	.014	<.050	<.020
		06/23/04	0930	R	<.020	.008	<.050	<.020
		06/24/04	0915	R	<.020	.013	<.050	<.020
		09/06/04	0940	R	<.020	<.020	<.050	<.020
		09/06/04	2140	R	<.020	.010	<.050	<.020
		09/07/04	0340	R	<.020	<.020	<.050	<.020
		09/07/04	0940	R	<.020	<.020	<.050	<.020
		09/07/04	1540	R	<.020	<.020	<.050	<.020
12	Bridge Creek at James King Road near Doerun	07/15/03	1150	R	<.050	<.050	<.050	<.050
		08/12/03	1000	R	<.050	.120	<.050	<.050
		09/23/03	0800	R	<.050	<.050	<.050	<.050
		07/08/04	1900	R	<.020	.019	<.020	<.020
		09/06/04	1346	R	.089	.008	<.020	<.020
13	Coheele Creek at River Road near Hilton	06/26/03	0815	R	<.050	<.050	<.050	<.050
		08/04/03	1435	R	<.050	<.050	<.050	<.050
		09/15/03	1220	R	<.050	<.050	<.050	<.050
		06/15/04	1510	R	<.020	.031	<.050	<.020
		09/17/04	1530	R	<.020	.174	<.050	<.020
14	Little Abrams Creek at GA Highway 313 near Doles	07/15/03	1500	R	<.050	.190	<.050	<.050
		08/12/03	1245	R	<.050	.850	<.050	<.050
		08/12/03	1300	R	<.050	<.050	<.050	<.050
		09/23/03	1350	R	<.050	<.050	<.050	<.050
		07/08/04	1030	R	.433	.930	<.050	<.020
		07/08/04	1215	R	.150	.350	<.050	<.020

**Table 12.** Concentrations of chlorothalonil and three chlorothalonil degradation products analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[ND, no detection; Sample type: R, regular environmental; &lt;, less than; --, no data]

Map number (fig. 1)	Site name	Date of collection (month/day year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	4-hydroxy-chlorothalonil	1,3-diamide-chlorothalonil	1-amide-4-hydroxy-chlorothalonil
Georgia—Continued								
15	Reedy Creek at U.S. Highway 129 near Ocilla	07/16/03	0745	R	<0.050	<0.050	<0.050	<0.050
		08/13/03	1345	R	<.050	<.050	<.050	<.050
		09/24/03	1340	R	<.050	<.050	<.050	<.050
16	Warrior Creek near Sumner	07/15/03	0750	R	<.050	<.050	<.050	<.050
		08/12/03	0715	R	<.050	<.050	<.050	<.050
		09/23/03	1020	R	<.050	<.050	<.050	<.050
		07/08/04	1410	R	<.020	.022	<.050	<.020
		07/08/04	1530	R	<.020	.281	.161	<.020
17	Willacoochee Creek at Frank Road near Ocilla	07/16/03	1100	R	<.050	<.050	<.050	<.050
		08/13/03	0930	R	<.050	<.050	<.050	<.050
		09/24/03	1000	R	<.050	<.050	<.050	<.050
Oklahoma								
18	Cobb Creek near Eakly	07/15/03	1030	R	<.050	<.050	<.050	<.050
		07/30/03	1200	R	<.050	<.050	<.050	<.050
		12/03/03	1015	R	<.050	<.050	<.050	<.050
		08/15/04	1630	R	<.020	.002	<.050	<.020
		08/28/04	1700	R	<.020	.018	<.050	<.020
		10/07/04	2130	R	<.020	<.020	<.050	<.020
19	Cobb Creek near Fort Cobb	07/17/03	1430	R	<.050	<.050	<.050	<.050
		12/03/03	1400	R	<.050	<.050	<.050	<.050
		08/15/04	1930	R	<.020	.002	<.050	<.020
		08/30/04	1300	R	<.020	<.020	<.050	<.020
		10/12/04	1230	R	<.020	<.020	<.050	<.020
Texas								
20	Beaver Creek near Electra	07/14/03	1255	R	<.050	<.050	<.050	<.050
		07/18/03	1415	R	<.050	<.050	<.050	<.050
		08/30/03	1305	R	<.050	<.050	<.050	<.050
21	Sabana River near DeLeon	07/09/03	1240	R	<.050	<.050	<.050	<.050
		09/03/03	1030	R	<.050	<.050	<.050	<.050
		12/11/03	1130	R	<.050	<.050	<.050	<.050

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**Table 12.** Concentrations of chlorothalonil and three chlorothalonil degradation products analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kansas, for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[ND, no detection; Sample type: R, regular environmental; <, less than; --, no data]

Map number (fig. 1)	Site name	Date of collection (month/day year)	Collection time (24-hour)	Sample type	Concentrations, in micrograms per liter			
					Chlorothalonil	4-hydroxy-chlorothalonil	1,3-diamide-chlorothalonil	1-amide-4-hydroxy-chlorothalonil
Texas—Continued								
22	San Miguel Creek near Tilden	07/15/03	1050	R	<0.050	<0.050	<0.050	<0.050
		07/17/03	0910	R	<.050	<.050	<.050	<.050
		09/04/03	1100	R	<.050	<.050	<.050	<.050

**Table 13.** Concentrations of chlorothalonil analyzed by the U.S. Geological Survey Methods and Research Development Group, Lakewood, Colorado, for water samples collected from 22 surface-water sampling sites in five Southern States, July through September 2003.

[Sample type: B, blank; FR, field replicate; R, regular environmental; E, estimated; <, less than]

Map number (fig. 1)	Site name	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentration of chlorothalonil (micrograms per liter)
Alabama					
1	Big Creek at State Highway 203 near Rehobeth	06/25/03	1220	R	<0.01
		08/06/03	1140	R	<.01
		09/17/03	1220	R	<.01
2	Cedar Creek at East Cook Road near Pansey	06/26/03	1210	R	<.01
		08/04/03	1105	R	<.01
		09/15/03	1545	R	<.01
3	Cowarts Creek above Cottonwood	06/26/03	1515	R	<.01
		08/05/03	0900	R	<.01
		09/16/03	1225	R	<.01
4	Cowarts Creek near Love Hill	06/25/03	1730	R	<.01
		08/05/03	1300	R	<.01
		09/16/03	1550	R	<.01
5	Spring Creek at County Road 55 near Geneva	06/25/03	0810	R	<.01
		08/06/03	0810	R	<.01
		09/17/03	0900	R	<.01
Florida					
6	Moore Creek near Chumuckla	06/23/03	1125	R	<.01
		07/29/03	1145	B	<.01
		07/29/03	1215	R	<.01
7	Pond Creek near Milton	06/23/03	1500	R	<.01
		06/23/03	1501	FR	<.01
		07/29/03	1435	R	E.007
		09/24/03	1400	R	<.01
8	Russ Mill Creek at Union Road near Cottondale	06/24/03	1330	R	<.01
		08/05/03	1640	R	<.01
		09/16/03	0825	R	<.01

**34 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides**

**Table 13.** Concentrations of chlorothalonil analyzed by the U.S. Geological Survey Methods and Research Development Group, Lakewood, Colorado, for water samples collected from 22 surface-water sampling sites in five Southern States, July through September 2003.—Continued

[Sample type: B, blank; FR, field replicate; R, regular environmental; E, estimated; <, less than]

Map number (fig. 1)	Site name	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentration of chlorothalonil (micrograms per liter)
Florida—Continued					
9	West Fork Big Coldwater Creek near Allentown	06/24/03	0745	B	<0.01
		06/24/03	0900	R	<.01
		07/30/03	0800	R	<.01
Georgia					
10	Big Creek at Crystal Lake Road near Irwinville	07/16/03	1340	R	<.01
		08/13/03	0710	R	<.01
		09/24/03	0715	R	<.01
11	Black Creek near Blythe	07/14/03	1020	R	<.01
		08/11/03	0945	R	<.01
		09/22/03	1230	R	<.01
12	Bridge Creek at James King Road near Doerun	07/15/03	1150	R	<.01
		08/12/03	1000	R	<.01
		09/23/03	0800	R	<.01
		09/23/03	0801	B	<.01
13	Coheelee Creek at River Road near Hilton	06/26/03	0815	R	E.004
		08/04/03	1435	R	E.006
		09/15/03	1220	R	<.01
14	Little Abrams Creek at GA Highway 313 near Doles	07/15/03	1500	R	<.01
		08/12/03	1245	B	<.01
		08/12/03	1300	R	.035
		09/23/03	1350	R	<.01
15	Reedy Creek at U.S. Highway 129 near Ocilla	07/16/03	0745	R	<.01
		08/13/03	1345	R	<.01
		09/24/03	1340	R	<.01
16	Warrior Creek near Sumner	07/15/03	0745	B	<.01
		07/15/03	0750	R	<.01
		08/12/03	0715	R	E.005
		09/23/03	1020	R	<.01

**Table 13.** Concentrations of chlorothalonil analyzed by the U.S. Geological Survey Methods and Research Development Group, Lakewood, Colorado, for water samples collected from 22 surface-water sampling sites in five Southern States, July through September 2003.—Continued

[Sample type: B, blank; FR, field replicate; R, regular environmental; E, estimated; <, less than]

Map number (fig. 1)	Site name	Date of collection (month/day/year)	Collection time (24-hour)	Sample type	Concentration of chlorothalonil (micrograms per liter)
Georgia—Continued					
17	Willacoochee Creek at Frank Road near Ocilla	07/16/03	1100	R	<0.01
		08/13/03	0930	R	<.01
		09/24/03	1000	R	<.01
Oklahoma					
18	Cobb Creek near Eakly	07/15/03	1030	R	<.01
		07/15/03	1033	B	<.01
		07/30/03	1200	R	<.01
19	Cobb Creek near Fort Cobb	07/15/03	1430	R	<.01
Texas					
20	Beaver Creek near Electra	07/18/03	1415	R	<.01
		08/30/03	1305	R	<.01
21	Sabana River near DeLeon	07/09/03	1240	R	<.01
		09/03/03	1030	R	<.01
		09/03/03	1030	R	<.01
		12/11/03	1130	R	<.01
22	San Miguel Creek near Tilden	07/15/03	1050	R	<.01
		07/17/03	0910	R	<.01
		09/04/03	1100	R	<.01

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Site identification number	Date (month/day/year)	Collection time (24-hour)	Concentrations, in micrograms per liter					
					Ala-chlor	Atra-zine	Carb-aryl	Car-bo-furan	Chlor-pyri-fos	Cy-ana-zine
Alabama										
1	Big Creek at State Highway 203 near Rehobeth	02358765	06/25/03	1220	<0.005	<0.007	<0.041	<0.02	<0.005	<0.018
			08/06/03	1140	<.005	<.007	<.041	<.02	<.005	<.018
			09/17/03	1220	<.005	<.007	<.041	<.02	<.005	<.018
2	Cedar Creek at East Cook Road near Pansey	02343848	06/26/03	1210	<.005	<.007	<.041	<.02	<.005	<.018
			08/04/03	1105	.0069	<.007	<.041	<.02	<.005	<.018
			09/15/03	1545	<.005	<.007	<.041	<.02	<.005	<.018
			06/15/04	1250	<.005	E.005	<.041	<.02	<.005	<.018
			09/17/04	1220	<.005	.012	<.041	<.02	<.005	<.018
3	Cowarts Creek above Cottonwood	0235878075	06/26/03	1515	<.005	.013	<.041	<.02	<.005	<.018
			08/05/03	0900	<.005	<.007	<.041	<.02	<.005	<.018
			09/16/03	1225	<.005	<.007	<.041	<.02	<.005	<.018
4	Cowarts Creek near Love Hill	0235878055	06/25/03	1730	<.005	.014	<.041	<.02	<.005	<.018
			08/05/03	1300	<.005	<.007	<.041	<.02	<.005	<.018
			09/16/03	1550	<.005	<.007	<.041	<.02	<.005	<.018
5	Spring Creek at County Road 55 near Geneva	02365100	06/25/03	0810	<.005	.013	<.041	<.02	<.005	<.018
			08/06/03	0810	<.005	<.007	<.041	<.02	<.005	<.018
			09/17/03	0900	E.004	E.006	<.041	<.02	<.005	<.018
Florida										
6	Moore Creek near Chumuckla	02375800	06/23/03	1125	.010	<.007	<.041	<.02	<.005	<.018
			07/29/03	1215	.015	<.007	<.041	E.006	<.005	<.018
			09/25/03	1200	.008	<.007	<.041	<.02	<.005	<.018
7	Pond Creek near Milton	02370700	06/23/03	1500	<.005	<.007	<.041	<.02	<.005	<.018
			07/29/03	1435	<.005	<.007	<.041	<.02	<.005	<.018
			09/24/03	1400	<.005	<.007	<.041	<.02	<.005	<.018
			06/14/04	1310	<.005	<.007	<.041	<.02	<.005	<.018
			09/23/04	0830	<.005	<.007	<.041	<.02	<.005	<.018
8	Russ Mill Creek at Union Road near Cottondale	02358778	06/24/03	1330	<.005	E.006	<.041	<.02	<.005	<.018

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Site identification number	Date (month/day/year)	Collection time (24-hour)	Concentrations, in micrograms per liter					
					Ala-chlor	Atra-zine	Carb-aryl	Car-bo-furan	Chlor-pyri-fos	Cy-ana-zine
Florida—Continued										
8	Russ Mill Creek at Union Road near Cottondale	02358778	08/05/03	1640	<0.005	<0.007	<0.041	<0.02	<0.005	<0.018
			09/16/03	0825	<.005	<.007	<.041	<.02	<.005	<.018
9	West Fork Big Coldwater Creek near Allentown	02370400	06/24/03	0900	<.005	<.007	<.041	<.02	<.005	<.018
			07/30/03	0800	.011	<.007	<.041	<.02	<.005	<.018
			09/25/03	0845	.006	<.007	<.041	<.02	<.005	<.018
Georgia										
10	Big Creek at Crystal Lake Road near Irwinville	02315919	07/16/03	1340	<.005	.010	<.041	<.02	<.005	<.018
			08/13/03	0710	<.005	.010	E.007	<.02	<.005	<.018
			09/24/03	0715	<.005	<.007	<.041	<.02	<.005	<.018
11	Black Creek near Blitchton	02202600	07/14/03	1020	<.005	<.007	<.041	<.02	<.005	<.018
			08/11/03	0945	<.005	<.007	<.041	<.02	<.005	<.018
			09/22/03	1230	<.005	<.007	<.041	<.02	<.005	<.018
			06/23/04	0630	<.005	<.007	<.041	<.02	<.005	<.018
			06/24/04	0915	<.005	<.007	<.041	<.02	<.005	<.018
			09/07/04	0340	<.005	<.007	<.041	<.02	<.005	<.018
12	Bridge Creek at James King Road near Doerun	2327314	07/15/03	1115	<.005	.016	<.041	<.02	<.005	<.018
			08/12/03	1000	<.005	.012	<.041	<.02	<.005	<.018
			09/23/03	0800	<.005	<.007	<.041	<.02	<.005	<.018
			07/08/04	1900	<.005	E.006	<.041	<.02	.018	<.018
			09/06/04	1345	<.005	<.007	<.041	<.02	.008	<.018
13	Coheelee Creek at River Road near Hilton	2343410	06/26/03	0815	<.005	<.007	<.041	<.02	<.005	<.018
			08/04/03	1435	<.005	.505	<.041	<.02	<.005	<.018
			09/15/03	1220	<.005	.018	<.041	<.02	<.005	<.018
			06/15/04	1510	<.005	.013	<.041	<.02	.018	E.008
			09/17/04	1530	<.005	.012	<.041	<.02	.008	<.018
14	Little Abrams Creek at GA Highway 313 near Doles	2350522	07/15/03	1500	<.005	<.007	<.041	<.02	<.005	<.018
			08/12/03	1300	.041	.012	<.041	<.02	<.005	<.018
			09/23/03	1350	<.005	.284	<.041	<.02	<.005	<.018
			07/08/04	1035	<.005	.064	<.041	<.02	E.004	<.018

38 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Site identification number	Date (month/day/year)	Collection time (24-hour)	Concentrations, in micrograms per liter					
					Ala-chlor	Atra-zine	Carb-aryl	Car-bo-furan	Chlor-pyri-fos	Cy-ana-zine
Georgia—Continued										
15	Reedy Creek at U.S. Highway 129 near Ocilla	2316217	07/16/03	0745	<0.005	0.014	<0.041	<0.02	<0.005	<0.018
			08/13/03	1345	<.005	.023	E.006	<.02	<.005	<.018
			09/24/03	1340	<.005	E.005	<.041	<.02	<.005	<.018
16	Warrior Creek near Sumner	2317870	07/15/03	0750	<.005	.011	<.041	<.02	<.005	<.018
			08/12/03	0715	<.005	.044	<.041	<.02	<.005	E.011
			09/23/03	1020	<.005	.018	<.041	<.02	<.005	<.018
			07/08/04	1420	<.005	.014	<.041	<.02	<.005	<.018
			09/06/04	1530	<.005	<.007	<.041	<.02	<.005	<.018
17	Willacoochee Creek at Frank Road near Ocilla	02316134	07/16/03	1100	<.005	.014	<.041	<.02	<.005	<.018
			08/13/03	0930	<.005	.016	<.041	<.02	<.005	<.018
			09/24/03	1000	<.005	.008	<.041	<.02	<.005	<.018
Oklahoma										
18	Cobb Creek near Eakly	07325800	07/15/03	1030	<.005	E.006	<.041	<.02	<.005	<.018
			07/30/03	1200	<.005	.010	<.041	<.02	<.005	<.018
			12/03/03	1015	<.005	.009	<.041	<.02	<.005	<.018
			08/15/04	1630	<.005	.014	<.041	<.02	<.005	<.018
			08/28/04	1700	<.005	<.007	<.041	<.02	<.005	<.018
			10/07/04	2130	<.005	.018	<.041	<.02	<.005	<.018
19	Cobb Creek near Fort Cobb	07326000	07/15/03	1430	<.005	.043	<.041	<.02	<.005	<.018
			12/03/03	1400	<.005	<.007	<.041	<.02	<.005	<.018
			08/15/04	1930	<.005	.038	<.041	<.02	<.005	<.018
			08/30/04	1300	<.005	.034	<.041	<.02	<.005	<.018
			10/12/04	1230	<.005	.028	<.041	<.02	<.005	<.018
Texas										
20	Beaver Creek near Electra	07312200	07/18/03	1415	<.005	.024	<.041	<.02	<.005	<.018
			08/30/03	1305	<.005	.024	<.041	<.02	<.005	<.018
21	Sabana River near DeLeon	08099300	07/09/03	1240	<.005	<.007	<.041	<.02	<.005	<.018
			09/03/03	1030	<.005	<.007	<.041	<.02	<.005	<.018
			12/11/03	1130	<.005	<.007	<.041	<.02	<.005	<.018

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Site identification number	Date (month/day/year)	Collection time (24-hour)	Concentrations, in micrograms per liter					
					Ala-chlor	Atra-zine	Carb-aryl	Car-bo-furan	Chlor-pyri-fos	Cy-ana-zine
22	San Miguel Creek near Tilden	08206700	07/15/03	1050	<0.005	0.122	<0.041	<0.02	<0.005	<0.018
			07/17/03	0910	<.005	.008	E.027	<.02	<.005	<.018
			09/04/03	1100	<.005	<.007	<.041	<.02	<.005	<.018

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter									
		Deethyl-atra-zine	Diazi-non	Ethal-flur-alin	Mala-thion	Metol-achlor	Metri-buzin	Para-thion	Pendi-meth-alin	Prom-eton	Prop-anil
Alabama											
1	Big Creek at State Highway 203 near Rehobeth	<0.006	<0.005	<0.009	<0.027	<0.006	<0.006	<0.010	<0.022	<0.010	<0.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
2	Cedar Creek at East Cook Road near Pansey	<.006	<.005	<.009	<.027	E.009	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.012	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.008	<.006	<.010	<.022	<.010	<.011
		E.004	<.005	E.003	<.027	E.007	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	.015	<.011
3	Cowarts Creek above Cottonwood	<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
4	Cowarts Creek near Love Hill	<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	E.004	<.011
5	Spring Creek at County Road 55 near Geneva	E.005	<.005	<.009	<.027	.014	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.01	<.006	<.010	<.022	<.010	<.011
Florida											
6	Moore Creek near Chumuckla	<.006	<.005	<.009	<.027	.016	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.025	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.021	<.006	<.010	<.022	<.010	<.011
7	Pond Creek near Milton	<.006	<.005	<.009	<.027	E.005	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.004	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.007	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.011	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter									
		Deethyl-atra-zine	Diazi-non	Ethal-flur-alin	Mala-thion	Metol-achlor	Metri-buzin	Para-thion	Pendi-meth-alin	Prom-eton	Prop-anil
Florida—Continued											
8	Russ Mill Creek at Union Road near Cottdale	E0.006	<0.005	<0.009	<0.027	<0.006	<0.006	<0.010	<0.022	<0.010	<0.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
9	West Fork Big Coldwater Creek near Allentown	<.006	<.005	<.009	<.027	.049	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.015	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.015	<.006	<.010	<.022	<.010	<.011
Georgia											
10	Big Creek at Crystal Lake Road near Irwinville	<.006	<.005	<.009	<.027	.058	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.014	.009	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.010	<.006	<.010	<.022	<.010	<.011
11	Black Creek near Blitchton	<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	E.007	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
12	Bridge Creek at James King Road near Doerun	E.004	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		E.004	<.005	<.009	<.027	E.006	E.004	<.010	<.022	E.003	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		E.003	<.005	<.009	<.027	E.007	<.006	<.010	<.022	.005	<.011
		<.006	<.005	<.009	<.027	E.005	<.006	<.010	<.022	<.010	<.011
13	Coheelee Creek at River Road near Hilton	<.006	<.005	<.009	<.027	E.009	<.006	<.010	<.022	<.010	<.011
		E.022	<.005	<.009	<.027	.063	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.009	<.006	<.010	<.022	<.010	<.011
		E.003	<.005	.022	<.027	.0173	<.006	<.010	E.010	.005	<.011
		<.006	<.005	<.009	<.027	.0190	<.006	<.010	<.022	<.010	<.011
14	Little Abrams Creek at GA Highway 313 near Doles	<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	.046	<.010	<.022	<.010	<.011

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter									
		Deethyl-atra-zine	Diazi-non	Ethal-flur-alin	Mala-thion	Metol-achlor	Metri-buzin	Para-thion	Pendi-meth-alin	Prom-eton	Prop-anil
Georgia—Continued											
14	Little Abrams Creek at GA Highway 313 near Doles	E0.050	<0.005	<0.009	<0.027	E0.005	E0.005	<0.010	<0.022	<0.010	<0.011
		E.004	<.005	.009	<.027	E.007	<.006	<.010	E.013	E.005	<.011
15	Reedy Creek at U.S. Highway 129 near Ocilla	<.006	<.005	<.009	<.027	.023	<.006	<.010	<.022	<.010	<.011
		E.005	<.005	<.009	<.027	.016	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	E.008	<.006	E.007	<.022	<.010	<.011
16	Warrior Creek near Sumner	<.006	<.005	<.009	<.027	E.010	<.006	<.010	<.022	.030	<.011
		E.005	<.005	<.009	<.027	.013	E.004	<.010	<.022	E.005	<.011
		<.006	<.005	<.009	<.027	E.006	<.006	<.010	<.022	<.010	<.011
		<.006	.011	<.009	E.022	.028	<.006	<.010	<.022	.017	E.003
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
17	Willacoochee Creek at Frank Road near Ocilla	<.006	<.005	<.009	<.027	.018	<.006	<.010	<.022	.031	<.011
		<.006	<.005	<.009	<.027	E.010	E.004	<.010	<.022	E.012	<.011
		<.006	<.005	<.009	<.027	E.008	<.006	<.010	<.022	E.013	<.011
Oklahoma											
18	Cobb Creek near Eakly	E.007	<.005	<.009	<.027	E.004	<.006	<.010	<.022	<.010	<.011
		E.009	<.005	<.009	<.027	E.001	<.006	<.010	.040	<.010	<.011
		<.006	<.005	<.009	<.027	E.008	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
19	Cobb Creek near Fort Cobb	E.006	<.005	<.009	<.027	E.006	<.006	<.010	<.022	<.010	<.011
		E.012	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		E.012	<.005	<.009	<.027	E.004	<.006	<.010	<.022	E.004	<.011
		E.012	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		E.012	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
Texas											
20	Beaver Creek near Electra	E.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		E.006	<.005	<.009	.033	<.006	<.006	<.010	<.022	<.010	<.011

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter									
		Deethyl-atra-zine	Diazi-non	Ethal-flur-alin	Mala-thion	Metol-achlor	Metri-buzin	Para-thion	Pendi-meth-alin	Prom-eton	Prop-anil
Texas—Continued											
21	Sabana River near DeLeon	<0.006	<0.005	<0.009	<0.027	E0.010	<0.006	<0.010	<0.022	<0.010	<0.011
		<.006	<.005	<.009	<.027	.019	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
22	San Miguel Creek near Tilden	E.040	<.005	<.009	<.027	E.007	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	<.006	<.006	<.010	<.022	<.010	<.011
		<.006	<.005	<.009	<.027	.019	<.006	<.010	<.022	<.010	<.011

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**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter				
		Propargite	Simazine	Terbuthiuron	Terbacil	Trifluralin
Alabama						
1	Big Creek at State Highway 203 near Rehobeth	<0.023	<0.005	<0.016	<0.034	<0.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
2	Cedar Creek at East Cook Road near Pansey	<.023	<.005	<.016	<.034	<.009
		<.023	.006	E.015	<.034	<.009
		<.023	.007	E.011	<.034	<.009
		<.023	.018	E.011	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
3	Cowarts Creek above Cottonwood	<.023	<.005	<.016	<.034	E.013
		E.012	<.005	<.016	<.034	<.009
		<.023	E.005	<.016	<.034	<.009
4	Cowarts Creek near Love Hill	<.023	<.005	<.016	<.034	<.009
		<.023	.027	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
5	Spring Creek at County Road 55 near Geneva	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
Florida						
6	Moore Creek near Chumuckla	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
7	Pond Creek near Milton	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	E.007	<.034	<.009
		<.023	<.005	E.011	<.034	<.009
		.032	<.005	<.016	<.034	<.009
8	Russ Mill Creek at Union Road near Cottondale	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter				
		Propargite	Simazine	Terbuthiuron	Terbacil	Trifluralin
Florida—Continued						
8	Russ Mill Creek at Union Road near Cottondale	<.023	<.005	<.016	<.034	<.009
9	West Fork Big Coldwater Creek near Allentown	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
Georgia						
10	Big Creek at Crystal Lake Road near Irwinville	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
11	Black Creek near Blitchton	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
12	Bridge Creek at James King Road near Doerun	<.023	<.005	<.016	<.034	<.009
		<.023	.006	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
13	Coheelee Creek at River Road near Hilton	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	E.008
		<.023	<.005	<.016	<.034	<.009
14	Little Abrams Creek at GA Highway 313 near Doles	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	E.007	<.034	<.009
		<.023	.010	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	E.008
15	Reedy Creek at U.S. Highway 129 near Ocilla	<.023	<.005	<.016	<.034	<.009

**Table 14.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2001 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,6-diethylaniline, acetochlor, alpha-HCH, azinphos-methyl, benfluralin, butylate, *cis*-permethrin, dacthal, desulfinylfipronil, desulfinylfipronil amide, dieldrin, disulfoton, EPTC, ethalfluralin, ethoprop, fipronil, fipronil sulfide, fipronil sulfone, fonofos, lindane, linuron, molinate, napropamide, p,p'-DDE, parathion-methyl, pebulate, phorate, propachlor, propyzamide, terbufos, thiobencarb, and triallate. <, less than; E, estimated; --, no data]

Map number (fig. 1)	Site name	Concentrations, in micrograms per liter				
		Propargite	Simazine	Terbuthiuron	Terbacil	Trifluralin
Georgia—Continued						
15	Reedy Creek at U.S. Highway 129 near Ocilla	<0.023	<0.005	<0.016	<0.034	<0.009
		<.023	<.005	<.016	<.034	<.009
16	Warrior Creek near Sumner	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
17	Willacoochee Creek at Frank Road near Ocilla	<.023	<.005	.018	<.034	<.009
		<.023	<.005	E.010	<.034	<.009
		<.023	.117	.022	<.034	<.009
Oklahoma						
18	Cobb Creek near Eakly	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	E.008	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
19	Cobb Creek near Fort Cobb	<.023	<.005	E.004	<.034	<.009
		.007	E.007	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		.008	E.008	<.016	<.034	<.009
		.007	<.005	<.016	<.034	<.009
20	Beaver Creek near Electra	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
21	Sabana River near DeLeon	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
22	San Miguel Creek near Tilden	<.023	<.005	<.016	<.034	<.009
		<.023	<.005	E.008	<.034	<.009
		<.023	<.005	<.016	<.034	<.009
Texas						

**Table 15.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[Water samples analyzed for the following pesticides were not detected: 2,4-D methyl ester, 2,4-DB, 3(4-chlorophenyl)-1-methyl urea, 3-hydroxycarbofuran, 3-ketocarbofuran, aldicarb, aldicarb sulfone, aldicarb sulfoxide, bendiocarb, benomyl, bromacil, bromoxynil, carbaryl, carbofuran, chloramben methyl ester, chlordiamine-s-triazine, chlorimuron-ethyl, clopyralid, cycloate, dacthal monoacid, deethylatrazine, dicamba, dichlorprop, diphenamid, flumetsulam, imazaquin, imazethapyr, imidacloprid, linuron, MCPA, MCPB, metalaxyl, methiocarb, methomyl, metsulfuron-methyl, neburon, nicosulfuron, oxamyl, picloram, propham, propoxur, siduron, sulfometuron-methyl, and terbacil. E, estimated; <, less than]

Map number (fig. 1)	Site name	Site identification number	Date (month/day/year)	Collection time (24-hour)	Concentrations, micrograms per liter		
					2,4-D	2-Hydroxy-atrazine	Acifluorfen
Alabama							
2	Cedar Creek at East Cook Road near Pansey	02343848	06/15/04	1250	0.026	E0.009	<0.028
			09/17/04	1220	<.038	E.019	<.028
Florida							
6	Moore Creek near Chumuckla	02375800	09/25/03	1200	<.038	<.032	<.028
7	Pond Creek near Milton	02370700	06/14/04	1310	<.038	<.032	<.028
			09/23/04	0830	<.038	<.032	<.028
Georgia							
11	Black Creek near Blitchton	02202600	09/22/03	1230	<.038	<.032	<.028
			06/24/04	0915	<.038	<.032	<.028
12	Bridge Creek at James King Road near Doerun	02327314	07/08/04	1900	.030	E.105	<.028
			09/06/04	1345	<.038	E.143	<.028
13	Coheelee Creek at River Road near Hilton	02343410	06/15/04	1510	.056	E.052	.029
			09/17/04	1530	<.038	E.054	<.028
14	Little Abrams Creek at GA Highway 313 near Doles	02350522	07/08/04	1035	<.038	<.032	<.028
			09/06/04	1830	<.038	<.032	<.028
16	Warrior Creek near Sumner	02317870	07/08/04	1420	<.038	<.032	<.028
			09/06/04	1530	<.038	<.032	<.028
Oklahoma							
18	Cobb Creek near Eakly	07325800	08/15/04	1630	<.038	<.032	<.028
			08/28/04	1700	.037	E.025	<.028
			10/07/04	2130	<.038	<.032	<.028
19	Cobb Creek near Fort Cobb	07326000	08/15/04	1930	E.038	E.031	<.028
			08/30/04	1300	<.038	E.038	<.028
			10/12/04	1230	<.038	E.028	<.028

**Table 15.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,4-D methyl ester, 2,4-DB, 3(4-chlorophenyl)-1-methyl urea, 3-hydroxycarbofuran, 3-ketocarbofuran, aldicarb, aldicarb sulfone, aldicarb sulfoxide, bendiocarb, benomyl, bromacil, bromoxynil, carbaryl, carbofuran, chloramben methyl ester, chlordiamine-s-triazine, chlorimuron-ethyl, clopyralid, cycloate, dacthal monoacid, deethylatrazine, dicamba, dichlorprop, diphenamid, flumetsulam, imazaquin, imazethapyr, imidacloprid, linuron, MCPA, MCPB, metalaxyl, methiocarb, methomyl, metsulfuron-methyl, neburon, nicosulfuron, oxamyl, picloram, propham, propoxur, siduron, sulfometuron-methyl, and terbacil. E, estimated; <, less than]

Map number (fig. 1)	Site name	Concentrations, micrograms per liter			
		Atrazine	Bensulfuron-methyl	Bentazon	Caffeine
Alabama					
2	Cedar Creek at East Cook Road near Pansey	<0.008	<0.018	<0.012	<0.018
		<.008	<.018	E.017	.018
Florida					
6	Moore Creek near Chumuckla	<.008	<.018	<.012	<.018
7	Pond Creek near Milton	<.008	<.018	<.012	.027
		<.008	<.018	<.012	E.125
Georgia					
11	Black Creek near Blitchton	<.008	<.018	<.012	<.018
		<.008	<.018	<.012	E.014
12	Bridge Creek at James King Road near Doerun	<.008	<.018	E.026	<.018
		<.008	<.018	<.012	E.087
13	Coheelee Creek at River Road near Hilton	E.005	<.018	E.280	<.018
		<.008	<.018	E.043	E.036
14	Little Abrams Creek at GA Highway 313 near Doles	.031	<.018	E.0241	<.018
		<.008	<.018	<.012	<.018
16	Warrior Creek near Sumner	<.008	<.018	<.012	<.018
		<.008	E.006	<.012	E.037
Oklahoma					
18	Cobb Creek near Eakly	E.010	<.018	<.012	<.018
		<.008	<.018	E.007	.020
		<.008	<.018	<.012	<.018
19	Cobb Creek near Fort Cobb	E.024	<.018	<.012	.037
		.014	<.018	<.012	.030
		.012	<.018	<.012	<.018

**Table 15.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,4-D methyl ester, 2,4-DB, 3(4-chlorophenyl)-1-methyl urea, 3-hydroxycarbofuran, 3-ketocarbofuran, aldicarb, aldicarb sulfone, aldicarb sulfoxide, bendiocarb, benomyl, bromacil, bromoxynil, carbaryl, carbofuran, chloramben methyl ester, chlordiamine-s-triazine, chlorimuron-ethyl, clopyralid, cycloate, dacthal monoacid, deethylatrazine, dicamba, dichlorprop, diphenamid, flumetsulam, imazaquin, imazethapyr, imidacloprid, linuron, MCPA, MCPB, metalaxyl, methiocarb, methomyl, metsulfuron-methyl, neburon, nicosulfuron, oxamyl, picloram, propham, propoxur, siduron, sulfometuron-methyl, and terbacil. E, estimated; <, less than]

Map number (fig. 1)	Site name	Concentrations, micrograms per liter		
		Chlorothalonil	Deisopropylatrazine	Dinoseb
Alabama				
2	Cedar Creek at East Cook Road near Pansey	<0.035	<0.08	<0.038
		<.035	<.08	<.038
Florida				
6	Moore Creek near Chumuckla	<.035	<.08	.008
7	Pond Creek near Milton	<.035	<.08	<.038
		<.035	<.08	<.038
Georgia				
11	Black Creek near Blitchton	<.035	<.08	<.038
		<.035	<.08	<.038
12	Bridge Creek at James King Road near Doerun	<.035	<.08	<.038
		<.035	<.08	E.087
13	Coheelee Creek at River Road near Hilton	<.035	<.08	<.038
		<.035	<.08	<.038
14	Little Abrams Creek at GA Hwy 313 near Doles	E.161	<.08	<.038
		<.035	<.08	<.038
16	Warrior Creek near Sumner	<.035	<.08	<.038
		E.061	<.08	<.038
Oklahoma				
18	Cobb Creek near Eakly	<.035	<.08	<.038
		<.035	<.08	<.038
		<.035	<.08	<.038
19	Cobb Creek near Fort Cobb	<.035	<.08	<.038
		<.035	<.08	<.038
		<.035	E.007	<.038

50 Results of Analyses of the Fungicide Chlorothalonil, Its Degradation Products, and Other Selected Pesticides

**Table 15.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,4-D methyl ester, 2,4-DB, 3(4-chlorophenyl)-1-methyl urea, 3-hydroxycarbofuran, 3-ketocarbofuran, aldicarb, aldicarb sulfone, aldicarb sulfoxide, bendiocarb, benomyl, bromacil, bromoxynil, carbaryl, carbofuran, chloramben methyl ester, chlordiamine-s-triazine, chlorimuron-ethyl, clopyralid, cycloate, dacthal monoacid, deethylatrazine, dicamba, dichlorprop, diphenamid, flumetsulam, imazaquin, imazethapyr, imidacloprid, linuron, MCPA, MCPB, metalaxyl, methiocarb, methomyl, metsulfuron-methyl, neburon, nicosulfuron, oxamyl, picloram, propham, propoxur, siduron, sulfometuron-methyl, and terbacil. E, estimated; <, less than]

Map number (fig. 1)	Site name	Concentrations, micrograms per liter				
		Diuron	Fenuron	Fluometuron	Norflurazon	Oryzalin
Alabama						
2	Cedar Creek at East Cook Road near Pansey	0.685	<0.032	<0.016	<0.020	<0.012
		.164	<.032	<.016	<.020	<.012
Florida						
6	Moore Creek near Chumuckla	<.015	<.032	<.016	.008	<.012
7	Pond Creek near Milton	<.015	<.032	<.016	<.020	<.012
		<.015	<.032	<.016	<.020	<.012
Georgia						
11	Black Creek near Blitchton	E.017	<.032	<.016	<.020	<.012
		<.015	<.032	<.016	<.020	<.012
12	Bridge Creek at James King Road near Doerun	<.015	1.51	<.016	<.020	E.048
		<.015	<.032	<.016	<.020	<.012
13	Coheelee Creek at River Road near Hilton	.049	E.016	E.016	E.008	<.012
		E.023	<.032	E.022	<.020	<.012
14	Little Abrams Creek at GA Highway 313 near Doles	<.015	<.032	<.016	<.020	<.012
		<.015	<.032	E.009	<.020	<.012
16	Warrior Creek near Sumner	E.151	<.032	<.016	<.020	<.012
		<.015	<.032	<.016	<.020	<.012
Oklahoma						
18	Cobb Creek near Eakly	<.015	<.032	<.016	<.020	<.012
		<.015	<.032	<.016	<.020	<.012
		<.015	<.032	<.016	<.020	<.012
19	Cobb Creek near Fort Cobb	<.015	<.032	<.016	<.020	.043
		<.015	<.032	<.016	<.020	.126
		<.015	<.032	<.016	<.020	.127

**Table 15.** Concentrations of selected pesticides and pesticide degradation products analyzed by the U.S. Geological Survey National Water-Quality Laboratory (Lakewood, Colorado) schedule 2060 for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[Water samples analyzed for the following pesticides were not detected: 2,4-D methyl ester, 2,4-DB, 3(4-chlorophenyl)-1-methyl urea, 3-hydroxycarbofuran, 3-ketocarbofuran, aldicarb, aldicarb sulfone, aldicarb sulfoxide, bendiocarb, benomyl, bromacil, bromoxynil, carbaryl, carbofuran, chloramben methyl ester, chlordiamine-s-triazine, chlorimuron-ethyl, clopyralid, cycloate, dacthal monoacid, deethylatrazine, dicamba, dichlorprop, diphenamid, flumetsulam, imazaquin, imazethapyr, imidacloprid, linuron, MCPA, MCPB, metalaxyl, methiocarb, methomyl, metsulfuron-methyl, neburon, nicosulfuron, oxamyl, picloram, propham, propoxur, siduron, sulfometuron-methyl, and terbacil. E, estimated; <, less than]

Map number (fig. 1)	Site name	Concentrations, micrograms per liter		
		Propiconazole	Tebuthiuron	Triclopyr
Alabama				
2	Cedar Creek at East Cook Road near Pansey	<0.010 <.010	E0.005 E.005	<0.026 E.093
Florida				
6	Moore Creek near Chumuckla	<.010	<.032	<.026
7	Pond Creek near Milton	<.010 <.010	<.032 E.006	<.026 <.026
Georgia				
11	Black Creek near Blitchton	<.010 <.010	<.032 <.032	<.026 <.026
12	Bridge Creek at James King Road near Doerun	<.010 E.026	<.032 E.050	<.026 <.026
13	Coheelee Creek at River Road near Hilton	<.010 <.010	<.032 <.032	<.026 <.026
14	Little Abrams Creek at GA Highway 313 near Doles	E.005 <.010	<.032 <.032	.355 <.026
16	Warrior Creek near Sumner	<.010 <.010	<.032 <.032	<.026 <.026
Oklahoma				
18	Cobb Creek near Eakly	<.010 <.010 <.010	<.032 .023 .090	E.245 <.026 <.026
19	Cobb Creek near Fort Cobb	<.010 <.010 <.010	<.032 <.032 <.032	<.026 <.026 <.026

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**Table 16.** Concentrations of dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.

[mg/L, milligrams per liter; NR, not measured; <, less than; mm, millimeters]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Dissolved organic carbon concentration (mg/L)	Suspended-sediment concentration (mg/L)	Percentage of silt- and clay-sized particles (<0.062 mm)
Alabama							
1	Big Creek at State Highway 203 near Rehobeth	02358765	06/25/03	1220	6.2	13	38
			08/06/03	1140	6.4	6	80
			09/17/03	1220	5.5	56	74
2	Cedar Creek at East Cook Road near Pansey	02343848	06/26/03	1210	1.7	10	80
			08/04/03	1105	3.0	5	95
			09/15/03	1545	1.6	4	94
			06/15/04	1250	3.3	14	87
			09/17/04	1220	5.1	26	85
			07/13/05	1815	2.6	36	56
3	Cowarts Creek above Cottonwood	0235878075	06/26/03	1515	3.4	13	74
			08/05/03	0900	5.3	13	63
			09/16/03	1225	3.4	20	67
5	Spring Creek at County Road 55 near Geneva	02365100	06/25/03	0810	7.0	24	73
			08/06/03	0810	8.8	19	59
			09/17/03	0900	12.0	25	48
Florida							
6	Moore Creek near Chumuckla	02375800	06/23/03	1125	2.2	25	56
			07/29/03	1215	1.8	5	21
			09/25/03	1200	1.2	10	64
7	Pond Creek near Milton	02370700	06/23/03	1500	9.2	40	31
			07/29/03	1435	5.4	7	40
			09/24/03	1400	3.8	11	45
			06/14/04	1310	5.6	9	39
			09/23/04	0830	16.0	9	84
			07/14/05	1320	16.0	8	83

**Table 16.** Concentrations of dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[mg/L, milligrams per liter; NR, not measured; &lt;, less than; mm, millimeters]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Dissolved organic carbon concentration (mg/L)	Suspended-sediment concentration (mg/L)	Percentage of silt- and clay-sized particles (<0.062 mm)
Florida—Continued							
8	Russ Mill Creek at Union Road near Cottondale	02358778	06/24/03	1330	2.7	15	63
			08/05/03	1640	5.6	21	61
			09/16/03	0825	2.1	16	89
9	West Fork Big Coldwater Creek near Allentown	02370400	06/24/03	0900	6.4	66	64
			07/30/03	0800	3.6	4	62
			09/25/03	0845	2.8	13	55
Georgia							
10	Big Creek at Crystal Lake Road near Irwinville	02315919	07/16/03	1340	15	7	87
			08/13/03	0710	19	19	57
			09/24/03	0715	18	12	88
11	Black Creek near Blitchton	02202600	07/14/03	1020	41	10	76
			08/11/03	0945	39	13	84
			09/08/03	0900	NR	NR	NR
			09/08/03	0915	NR	NR	NR
			09/08/03	0930	NR	NR	NR
			09/08/03	0945	NR	NR	NR
			09/08/03	1000	NR	NR	NR
			09/08/03	1015	NR	NR	NR
			09/08/03	1030	NR	NR	NR
			09/08/03	1045	NR	NR	NR
			09/08/03	1100	NR	NR	NR
			09/08/03	1115	NR	NR	NR
			09/08/03	1130	NR	NR	NR
			09/08/03	1145	NR	NR	NR
			09/22/03	1230	34	13	61
10/18/03	1820	NR	NR	NR			
10/18/03	1920	NR	NR	NR			
10/18/03	1950	NR	NR	NR			
10/18/03	2030	NR	NR	NR			
06/23/04	0630	35	NR	NR			

**Table 16.** Concentrations of dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[mg/L, milligrams per liter; NR, not measured; &lt;, less than; mm, millimeters]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Dissolved organic carbon concentration (mg/L)	Suspended-sediment concentration (mg/L)	Percentage of silt- and clay-sized particles (<0.062 mm)
Georgia—Continued							
11	Black Creek near Blitchton—Continued		06/24/04	0915	40	10	NR
			09/06/04	0940	18	NR	NR
			09/07/04	0340	25	NR	NR
			07/11/05	1225	40	NR	NR
			07/16/05	1555	34	8	83
12	Bridge Creek at James King Road near Doerun	02327314	07/15/03	1115	11	16	72
			08/12/03	1000	11	14	50
			09/23/03	0800	13	25	87
			07/08/04	1900	12	15	NR
			09/06/04	1345	12	8	86
			07/12/05	1120	9.0	22	87
			07/13/05	1610	4.8	10	94
13	Coheelee Creek at River Road near Hilton	02343410	06/26/03	0815	3.2	12	89
			08/04/03	1435	6.4	47	65
			09/15/03	1220	3.3	3	92
			06/15/04	1510	4.9	17	76
			09/17/04	1530	8.0	42	73
14	Little Abrams Creek at GA Highway 313 near Doles	02350522	07/15/03	1500	16	12	61
			08/12/03	1300	20	32	62
			09/23/03	1350	12	24	83
			07/08/04	1035	16	25	NR
			09/06/04	1830	18	39	98
			07/11/05	1900	13	NR	NR
			07/13/05	0915	NR	19	79
15	Reedy Creek at U.S. Highway 129 near Ocilla	02316217	07/16/03	0745	18	11	78
			08/13/03	1345	21	15	90
			09/24/03	1340	18	14	62
16	Warrior Creek near Sumner	02317870	07/15/03	0750	13	18	50
			08/12/03	0715	18	25	65

**Table 16.** Concentrations of dissolved organic carbon, suspended sediment, and percentage of silt- and clay-sized particles for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[mg/L, milligrams per liter; NR, not measured; &lt;, less than; mm, millimeters]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Dissolved organic carbon concentration (mg/L)	Suspended-sediment concentration (mg/L)	Percentage of silt- and clay-sized particles (<0.062 mm)
Georgia—Continued							
16	Warrior Creek near Sumner—Continued	02317870	09/23/03	1020	14	29	62
			07/08/04	1420	14	11	NR
			09/06/04	1530	15	22	94
			07/12/05	0950	11.0	NR	NR
			07/12/05	1700	12.0	46	81
17	Willacoochee Creek at Frank Road near Ocilla	02316134	07/16/03	1100	16	18	26
			08/13/03	0930	18	22	73
			09/24/03	1000	14	16	81
Oklahoma							
18	Cobb Creek near Eakly	07325800	07/15/03	1030	2.7	NR	NR
			07/30/03	1200	5.0	NR	NR
			12/03/03	1015	2.9	NR	NR
			08/15/04	1630	4.7	74	73
			08/28/04	1700	4.8	1,329	73
19	Cobb Creek near Fort Cobb	07326000	10/07/04	2130	4.9	1,297	85
			07/15/03	1430	3.3	NR	NR
			12/03/03	1400	3.5	NR	NR
			08/15/04	1930	3.9	27	94
			08/30/04	1300	3.8	30	85
10/12/04			1230	3.8	14	94	
Texas							
20	Beaver Creek near Electra	07312200	07/18/03	1415	6.5	NR	NR
			08/30/03	1305	6.6	NR	NR
21	Sabana River near DeLeon	08099300	07/09/03	1240	5.0	NR	NR
			09/03/03	1030	8.4	NR	NR
			12/11/03	1130	4.7	NR	NR
22	San Miguel Creek near Tilden	08206700	07/15/03	1050	7.9	NR	NR
			07/17/03	0910	10	NR	NR
			09/04/03	1100	12	NR	NR

**Table 17.** Results of analysis of streamflow, gage height, and physical properties for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.[ft<sup>3</sup>/s, cubic feet per second; ft, feet;  $\mu$ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NR, not measured]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Streamflow (ft <sup>3</sup> /s)	Gage height (ft)	Specific conductance ( $\mu$ S/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)
Alabama										
1	Big Creek at State Highway 203 near Rehobeth	02358765	06/25/03	1220	NR	NR	67	6.9	NR	NR
			08/06/03	1140	45	NR	66	6.5	NR	NR
			09/17/03	1220	17	NR	65	6.6	NR	NR
2	Cedar Creek at East Cook Road near Pansey	02343848	06/26/03	1210	16	NR	154	7.6	NR	NR
			08/04/03	1105	19	NR	140	7.1	NR	NR
			09/15/03	1545	19	NR	150	7.4	NR	NR
			06/15/04	1250	22	21.6	135	7.2	24	10
			09/17/04	1220	25	21.4	117	7.2	24	7.6
3	Cowarts Creek above Cottonwood	0235878075	06/26/03	1515	29	NR	158	7.1	NR	NR
			08/05/03	0900	110	NR	105	6.9	NR	NR
			09/16/03	1225	58	NR	134	7.3	NR	NR
4	Cowarts Creek near Love Hill	0235878055	06/25/03	1730	21	NR	176	7.6	NR	NR
			08/05/03	1300	46	NR	127	7.1	NR	NR
			09/16/03	1550	25	NR	155	7.4	NR	NR
5	Spring Creek at County Road 55 near Geneva	02365100	06/25/03	0810	48	NR	52	6.6	NR	NR
			08/06/03	0810	81	NR	48	6.2	NR	NR
			09/17/03	0900	39	NR	48	6.3	NR	NR
Florida										
6	Moore Creek near Chumuckla	02375800	06/23/03	1125	28	NR	45	6.3	NR	NR
			07/29/03	1215	27	NR	45	5.9	NR	NR
			09/25/03	1200	26	NR	95	5.8	NR	NR
7	Pond Creek near Milton	02370700	06/23/03	1500	113	NR	25	5.0	NR	NR
			07/29/03	1435	114	NR	22	4.9	NR	NR
			09/24/03	1400	72	NR	34	5.0	NR	NR
			06/14/04	1310	70	3.2	34	5.2	22	7.5
			09/23/04	0830	NR	15.3	29	5.8	22	6.5

**Table 17.** Results of analysis of streamflow, gage height, and physical properties for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued[ft<sup>3</sup>/s, cubic feet per second; ft, feet;  $\mu$ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NR, not measured]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Streamflow (ft <sup>3</sup> /s)	Gage height (ft)	Specific conductance ( $\mu$ S/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)
Florida—Continued										
8	Russ Mill Creek at Union Road near Cottondale	02358778	06/24/03	1330	15	NR	273	7.8	NR	NR
			08/05/03	1640	20	NR	244	7.4	NR	NR
			09/16/03	0825	9	NR	277	7.6	NR	NR
9	West Fork Big Cold-water Creek near Allentown	02370400	06/24/03	0900	318	NR	35	5.7	NR	NR
			07/30/03	0800	227	NR	36	5.3	NR	NR
			09/25/03	0845	198	NR	77	5.4	NR	NR
Georgia										
10	Big Creek at Crystal Lake Road near Irwinville	2315919	07/16/03	1340	5	1.0	60	6.2	26	5.2
			08/13/03	0710	82	4.0	59	5.9	26	5.7
			09/24/03	0715	3	1.0	73	6.2	22	4.8
11	Black Creek near Blitchton	2202600	07/14/03	1020	92	5.0	56	4.7	25	3.8
			08/11/03	0945	2,329	10.7	55	4.4	24	5.2
			09/08/03	0900	807	8.0	56	4.7	NR	NR
			09/08/03	0915	811	8.0	53	4.7	NR	NR
			09/08/03	0930	807	8.0	53	4.7	NR	NR
			09/08/03	0945	811	8.0	52	4.8	NR	NR
			09/08/03	1000	811	8.0	53	4.7	NR	NR
			09/08/03	1015	811	8.0	52	4.7	NR	NR
			09/08/03	1030	811	8.0	52	4.7	NR	NR
			09/08/03	1045	816	8.0	51	4.7	NR	NR
			09/08/03	1100	811	8.0	52	4.6	NR	NR
			09/08/03	1115	811	8.0	52	4.7	NR	NR
			09/08/03	1130	811	8.0	51	4.7	NR	NR
			09/08/03	1145	811	8.0	51	4.7	NR	NR
			09/22/03	1230	32	3.5	57	4.6	24	4.0
10/18/03	1820	66	4.0	59	5.0	NR	NR			
10/18/03	1920	75	4.0	57	5.0	NR	NR			
10/18/03	1950	77	4.0	58	5.0	NR	NR			
10/18/03	2030	78	4.0	58	5.0	NR	NR			
06/23/04	0630	42	4.0	NR	NR	NR	NR			

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**Table 17.** Results of analysis of streamflow, gage height, and physical properties for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued

[ft<sup>3</sup>/s, cubic feet per second; ft, feet; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NR, not measured]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Streamflow (ft <sup>3</sup> /s)	Gage height (ft)	Specific conductance (μS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)
Georgia—Continued										
11	Black Creek near Blythe—Continued	2202600	06/24/04	0915	57	4.0	63	5.4	25	6.1
			09/06/04	0940	31	3.5	NR	NR	NR	NR
			09/07/04	0340	59	4.0	NR	NR	NR	NR
12	Bridge Creek at James King Road near Doerun	2327314	07/15/03	1115	NR	7.0	92	6.6	24	5.3
			08/12/03	1000	57	9.0	73	6.5	24	5.7
			09/23/03	0800	30	8.0	88	6.4	21	4.8
			07/08/04	1900	30	9.0	57	6.7	25	5.9
			09/06/04	1345	2	8.0	93	7.8	24	3.6
13	Coheelee Creek at River Road near Hilton	2343410	06/26/03	0815	12	NR	61	7.2	NR	NR
			08/04/03	1435	141	NR	40	6.0	NR	NR
			09/15/03	1220	13	NR	56	6.9	NR	NR
			06/15/04	1510	36	20.9	55	6.5	24	11
			09/17/04	1530	191	19.5	39	6.2	25	6.4
14	Little Abrams Creek at GA Highway 313 near Doles	2350522	07/15/03	1500	NR	1.0	83	6.2	26	2.8
			08/12/03	1300	4	1.0	77	6.1	24	3.6
			09/23/03	1350	1	1.0	69	6.0	24	2.4
			07/08/04	1035	11	1.0	78	5.9	24	3.6
			09/06/04	1830	3	1.0	71	4.7	25	7.8
15	Reedy Creek at U.S. Highway 129 near Ocilla	2316217	07/16/03	0745	9	9.0	86	6.3	24	2.9
			08/13/03	1345	374	11.8	62	6.0	25	5.7
			09/24/03	1340	2	9.0	110	6.4	22	1.5
16	Warrior Creek near Sumner	2317870	07/15/03	0750	7	6.0	103	6.7	24	5.2
			08/12/03	0715	417	9.7	61	6.2	24	5.7
			09/23/03	1020	169	8.0	60	6.3	23	5.6
			07/08/04	1420	63	7.0	68	6.7	25	5.1
			09/06/04	1530	9	5.0	65	8.0	24	5.1
17	Willacoochee Creek at Frank Road near Ocilla	02316134	07/16/03	1100	12	1.0	127	6.6	26	5.6
			08/13/03	0930	288	3.0	79	6.2	24	4.2
			09/24/03	1000	9	1.0	138	6.8	23	4.6

**Table 17.** Results of analysis of streamflow, gage height, and physical properties for water samples collected from 22 surface-water sampling sites in five Southern States, 2003–04.—Continued[ft<sup>3</sup>/s, cubic feet per second; ft, feet;  $\mu$ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NR, not measured]

Map number (fig. 1)	Site name	Site identification number	Date of collection (month/day/year)	Collection time (24-hour)	Streamflow (ft <sup>3</sup> /s)	Gage height (ft)	Specific conductance ( $\mu$ S/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)
Oklahoma										
18	Cobb Creek near Eakly	07325800	07/15/03	1030	16	4.0	770	7.6	25	8.6
			07/30/03	1200	11	4.0	NR	NR	NR	NR
			12/03/03	1015	12	4.0	842	8.1	NR	NR
			08/28/04	1700	200	7.0	948	7.6	26	5.8
			10/07/04	2130	47	5.0	423	7.6	18	8.1
19	Cobb Creek near Fort Cobb	07326000	07/15/03	1430	.02	NR	546	7.5	29	8.4
			12/03/03	1400	4	4.0	580	7.4	NR	NR
			08/30/04	1300	4	4.0	523	7.8	22	6.9
			10/12/04	1230	3	4.0	526	7.9	16	8.5
Texas										
20	Beaver Creek near Electra	07312200	07/18/03	1415	5	8.0	3,760	8.1	33	7.4
			08/30/03	1305	110	10.5	2,290	7.7	NR	NR
21	Sabana River near DeLeon	08099300	07/09/03	1240	1	2.0	1,205	7.7	27	5.5
			09/03/03	1030	2	2.0	346	7.4	NR	NR
			12/11/03	1130	2	2.0	929	8.1	NR	NR
22	San Miguel Creek near Tilden	08206700	07/15/03	1050	4	2.0	1,640	8.1	29	5.7
			07/17/03	0910	1,230	12.3	234	7.8	26	4.5
			09/04/03	1100	60	4.0	NR	NR	NR	NR

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