In cooperation with the City of Houston

Water-Quality Assessment of Lake Houston Near Houston, Texas, 2000–2004

Scientific Investigations Report

U.S. Department of the Interior
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Cover. (Top) View of pavillions and waterfront of Alexander Deussen Park, looking northwest from Lake Houston spillway levee, November 8, 2005.
(Middle) View of public boat launch and marina at Lake Houston, looking north from FM 1960 bridge, April 26, 2001.
(Bottom) View of the intake tower from the Lake Houston spillway levee, November 8, 2005.

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By Debra A. Sneck-Fahrer, Matthew S. Milburn, Jeffery W. East, and Jeannette H. Oden

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Water-Quality Assessment of Lake Houston Near Houston, Texas, 2000–2004

By Debra A. Sneck-Fahrer, Matthew S. Milburn, Jeffery W. East, and Jeannette H. Oden

Abstract

Lake Houston is a major source of public water supply and recreational resource for the Houston metropolitan area, Texas. Water-quality issues of potential concern for the lake have included nutrient enrichment (orthophosphorus, total phosphorus, nitrite plus nitrate) and aquatic life use (dissolved oxygen). The U.S. Geological Survey, in cooperation with the City of Houston, collected water samples from three sites in Lake Houston and from two streams that discharge to the lake during 2000–2004. Nitrogen compounds, phosphorus, suspended sediment, organic carbon, turbidity, chlorophyll-*a*, and selected pesticide compounds in water were assessed for all sites. Water-quality conditions of the lake and inflow streams were assessed, and loads and yields were computed for selected constituents in the streams. Selected constituents from samples collected in Lake Houston during 1990–2004 were tested for trends. The three sites sampled in Lake Houston characterized water available to the City of Houston pumping station (site AC), water entering the lake from the largely rural eastern subbasin (site EC), and water entering the lake from the more urbanized, western subbasin (site FC). Most constituent concentrations were largest at site FC, smallest at site EC, and intermediate at site AC. Organic nitrogen was the dominant form of nitrogen in samples collected at all sites. Nitrite plus nitrate concentrations were largest at site FC. Total phosphorus concentrations in all samples were larger than that recommended by the U.S. Environmental Protection Agency to limit aquatic growth in reservoirs. There was a wide range in suspended-sediment concentrations and turbidity in the lake. Twelve pesticides were detected. Atrazine and its breakdown product, 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT), were the most commonly detected pesticides; concentrations of atrazine were larger than the U.S. Environmental Protection Agency maximum contaminant level of 3.0 micrograms per liter in two samples at site FC. The relative contributions to the water quality of Lake Houston from the eastern and western subbasins were examined by collecting water samples in Cypress Creek and East Fork San Jacinto River. Nitrate and pesticide concentrations were larger in Cypress Creek than in East Fork San Jacinto River. In Cypress Creek, nitrate was the primary form of nitrogen at low flows. Atrazine exceeded 3.0 micrograms per liter in three of 17 samples, with the maximum measured concentration of 21.3 micrograms per liter. In East Fork San Jacinto River, organic nitrogen was the primary form of nitrogen. Atrazine was detected in six of 15 samples. The maximum atrazine concentration was 0.233 microgram per liter. Constituent yields allowed direct comparison of loads from Cypress Creek and East Fork San Jacinto River. In Cypress Creek, storm yields of nitrite plus nitrate nitrogen for high flows ranged from 8 to 45 pounds per square mile per day; in East Fork San Jacinto River, the maximum storm yield for high flows was 1.47 pounds per square mile per day. At low flows, the median daily yield of dissolved phosphorus from Cypress Creek was 84 times larger than the median daily yield from East Fork San Jacinto River; at high flows, it was 16 times larger. At high flows, the maximum daily yield of atrazine from Cypress Creek was 460 times larger than the maximum daily yield at high flows from East Fork San Jacinto River. The concentrations of most constituents at Lake Houston sites showed no trend during 1990–2004; however, significant trends overall or for particular seasons, or both, were detected at some sites for nitrite plus nitrate, dissolved phosphorus, dissolved organic carbon, chlorophyll-*a*, and diazinon (2000–2004 data only for diazinon).

Introduction

Houston, Texas, is the fourth-largest city and greater Houston the tenth-largest metropolitan area in the Nation, with an estimated population of about 5 million people in 2003 (Texas State Data Center, 2004). Historically, ground water has been the major source of potable water. However, development of this resource has contributed to lowered ground-water levels and land-surface subsidence (Kasmarek and Houston, 2005). These effects, in part, have led water managers to engineer a gradual transition away from ground water to surface water as the principal source of public supply. Currently (2005), a little

more than one-half of Houston's water supply comes from surface water (LJA Engineering & Surveying, Inc., 2000). The overall goal is to increase the use of surface water to supply not less than 80 percent of the total demand by 2030 (Harris-Galveston Coastal Subsidence District, 1999).

Lake Houston is a major source of public water supply and recreational resource for the Houston metropolitan area. Because of its proximity to Houston, the possible effects of urbanization on the quality of inflows to the lake and on the lake have been of concern to water managers. In accordance with Federal Clean Water Act requirements, the Texas Commission on Environmental Quality compiled an inventory of water-body assessments throughout the State that lists those water bodies that are impaired (do not meet applicable water-quality standards) or threatened (are not expected to meet applicable water-quality standards in the near future) (Texas Commission on Environmental Quality, 2002). Lake Houston (segment 1002) was not on the State of Texas 2002 list (known as the 303(d) list) of impaired water bodies. However, it was listed with "concerns" for nutrient enrichment (orthophosphorus, total phosphorus, nitrite plus nitrate nitrogen) and aquatic life use (dissolved oxygen). Information describing the current (2005) status and trends of the water quality of Lake Houston and its inflow tributaries will help water managers assess potential sources of contaminants and their effects on the lake.

Beginning in 1983, the U.S. Geological Survey (USGS), in cooperation with the City of Houston, has collected water-quality and stage data at Lake Houston, as well as water-quality and discharge data for its major tributaries. These data, collected through most of the 1990s, were summarized and interpreted (Liscum and others, 1999) and used to develop a two-dimensional water-quality model of the lake (Liscum and East, 2000). On the basis of findings of these studies, eutrophication has not been a major problem in the lake. However, the findings indicated that sufficient concentrations of nutrients (nitrogen and phosphorus) were present to cause problematic algal blooms. An analysis of sediment-core samples from Lake Houston to identify historical water-quality trends (Van Metre and Sneck-Fahrer, 2002) indicated the need for further study of the effects of urbanization on Lake Houston. To address this need, the USGS, in cooperation with the City of Houston, did a water-quality assessment of Lake Houston and selected major inflow tributaries.

Purpose and Scope

The purpose of this report is to (1) assess concentrations of nitrogen, phosphorus, suspended sediment, organic carbon, turbidity, chlorophyll-*a*, and pesticides in Lake Houston for 2000–2004; (2) summarize data for 2000–2004 and compute loads and yields of selected constituents from two stream inflow sites; and (3) examine possible trends in the water quality of Lake Houston on the basis of data for 1990–2004. Water-quality data presented in this report were collected during February 2000–November 2004 at five sites. Three sampling sites were in Lake Houston; the remaining sites were on two of the seven inflow streams to the lake. Data collected during this study were published in annual USGS Texas water-data reports (Gandara and others, 2001; Gandara, 2002, 2003, 2004; Aragon Long and others, 2005).

Table 1. Subbasin characteristics for Lake Houston near Houston, Texas (modified from Liscum and others, 1999, table 1).

[mi^2, square miles]

Subbasin watershed	Drainage area (mi^2)	Percent of drainage basin
Eastern subbasin		
East Fork San Jacinto River	404	14.3
Peach Creek	151	5.3
Caney Creek	222	7.9
Luce Bayou	210	7.4
Western subbasin		
West Fork San Jacinto River	998	35.3
Spring Creek	453	16.1
Cypress Creek	305	10.8
Lake Houston area[1]	82	2.9
Totals:	2,825	100

[1]That part of the watershed surrounding Lake Houston downstream from tributary inflows.

Description of the Study Area

Lake Houston is located about 25 miles east-northeast of downtown Houston, Texas (fig. 1). It was constructed in 1954 by the City of Houston as a public water supply for Houston and Baytown, as well as for local irrigation. The normal capacity of Lake Houston was computed to be 133,990 acre-feet in 1994 (Texas Water Development Board, 2004). Liscum and East (2000) reported the mean depth of the lake to be 12 feet with a maximum depth of about 50 feet. Computed theoretical residence time for water entering Lake Houston varies with flow conditions from a maximum of about 400 days during extreme low flows to a minimum of about 0.5 day during extreme high flows (Liscum and East, 2000, p. 3). During the 2000–2004 study period, the maximum annual mean residence time was estimated to be about 176 days in water year 2000; the minimum was about 24 days in water year 2004. The average residence time during the entire study period was 61 days.

The drainage basin for Lake Houston (fig. 1) includes parts of seven counties, including large areas of densely populated Harris and Montgomery Counties. The drainage basin can be divided into an eastern subbasin and a western subbasin that comprise four and three stream watersheds, respectively, plus the area immediately surrounding the lake (table 1). The

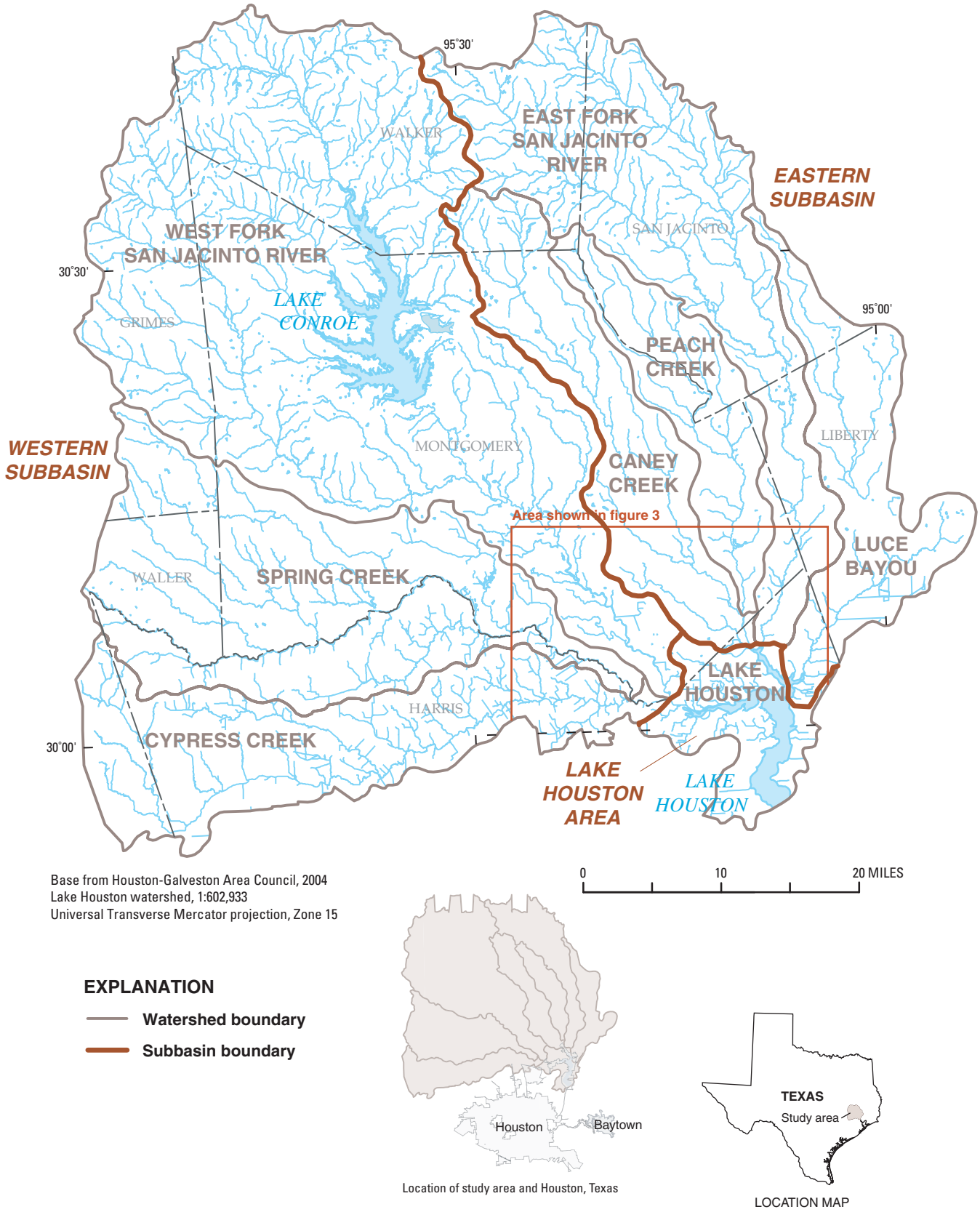

Figure 1. Lake Houston drainage basin (study area) near Houston, Texas.

Cypress Creek watershed in the Lake Houston western subbasin is the most densely populated of the stream watersheds that drain to Lake Houston. The total population of the Cypress Creek watershed in 2000 (Patrick Horton, Houston-Galveston Area Council, written commun., 2005) was about 263,000 people. About 13 percent of the watershed had a population density of 650 to 1,750 people per square mile, and about 0.3 percent of the watershed had a population of density of 1,760 to 5,930 people per square mile. East Fork San Jacinto River in the Lake Houston eastern subbasin is the least densely populated of the stream watersheds that drain to Lake Houston. The total population of the East Fork San Jacinto River watershed in 2000 was about 44,700 people; less than 1.4 percent of the watershed had the maximum population density of 650 to 1,750 people per square mile.

Appreciable differences in land cover characterize the Lake Houston drainage basin (fig. 2). The area that comprises land-cover types related to an increased potential for nutrients and pesticide compounds in storm runoff (developed and cultivated) is about three times greater in the western subbasin than in the eastern subbasin (Houston-Galveston Area Council, 2004). Land cover classified as developed (urban development) in the western subbasin is about 78 percent greater than that in the eastern subbasin. The Cypress Creek watershed has an area of 305 square miles. The primary land-cover type in that watershed in 2002 (fig. 2) was grassland (50 percent), consisting of fields for hay, cattle grazing, and a small amount of agriculture. Woodland (31 percent) was the second-largest land-cover type. About 5 percent of the area in the basin was classified as high-intensity developed. The East Fork San Jacinto River watershed has an area of 404 square miles with most of the area classified as woodland (79 percent), followed by grassland (about 14 percent). The largest concentrations of urban development in the entire Lake Houston drainage basin are in the area immediately surrounding Lake Houston.

The climate in the study area is classified as humid subtropical (Texas State Climatologist, 2004), characterized by cool and temperate winters, long and hot summers, high relative humidity, and prevailing winds from the south and southeast. During 2000–2004, annual precipitation ranged from 45.5 to 82 inches at Intercontinental Airport (IAH), Houston (National Oceanic and Atmospheric Administration, 2005), in the Cypress Creek watershed, about 8 miles west of Lake Houston. Temperatures ranged from a mean of about 55.5 degrees Fahrenheit (°F) in the winter (December–February) to a mean of 83 °F in the summer (June–August), with maximum temperatures during the summer commonly higher than 90 °F.

Sources and Implications of Nitrogen, Phosphorus, Suspended Sediment, Organic Carbon, Turbidity, Chlorophyll-*a*, and Pesticides

Nitrogen compounds naturally occur in the environment, usually small amounts in surface water, and include nitrate, nitrite, organic, or ammonia nitrogen. Nitrate nitrogen is the most common nitrogen compound in water (Hem, 1985). The national background concentration of nitrate nitrogen in streams is about 0.6 milligram per liter (mg/L) (U.S. Geological Survey, 1999, p. 34). Elevated nitrite and ammonia nitrogen concentrations might indicate wastewater input (U.S. Geological Survey, 1999).

Large concentrations of nitrate or nitrite in drinking water might result in infant methemoglobinemia (inability of the blood to absorb oxygen), which causes shortness of breath and blueness of the skin (U.S. Environmental Protection Agency, 1999). In addition, Weyer and others (2001) identified a correlation between nitrate in drinking water and bladder cancer in women. The U.S. Environmental Protection Agency (USEPA) (1999) has set maximum contaminant levels (MCLs) in drinking water (the enforceable standard) of 1 mg/L nitrite nitrogen and 10.0 mg/L nitrate nitrogen. There is no USEPA MCL for ammonia nitrogen.

Total phosphorus includes dissolved forms as well as phosphorus that is attached to sediment particles and in living organisms like algae and bacteria. Dissolved phosphorus includes orthophosphate and organic phosphorus. Phosphorus as phosphate is an essential nutrient for freshwater plants (Hem, 1985). Phosphorus is introduced into water through a variety of sources that include animal waste, domestic and wild waterfowl, tree leaves, and fallout from the atmosphere. In addition, phosphate is an ingredient of many detergents and is found in human waste. The national background concentration of total phosphorus in streams is about 0.1 mg/L (U.S. Geological Survey, 1999, p. 34).

Large phosphorus concentrations have been associated with eutrophication or aging of waters, especially lakes and reservoirs (U.S. Environmental Protection Agency, 1986). Total phosphorus concentrations larger than 0.025 mg/L can stimulate excessive growth of algae and nuisance plants in lakes and reservoirs. Excessive algal growth can result in undesirable taste and odor of the water, as well as interference with coagulation in water-treatment plants. The USEPA has recommended a limit of 0.05 mg/L total phosphorus for a stream where it enters any lake or reservoir and 0.025 mg/L within the lake or reservoir as a goal to limit undesirable aquatic growth.

Suspended sediment is carried to a reservoir with inflowing streams and generally increases with increased streamflow. During storms, large volumes of sediment can be added to streams from surface runoff, especially in areas where the landscape has been disturbed. Urbanized areas, where precipitation is quickly channeled to ditches and storm sewers, add substantial runoff to receiving streams and increase the potential for erosion of streambeds and banks. Sediment is a concern because it can fill reservoirs and inhibit sunlight penetration for aquatic plants. Phosphorus, bacteria, metals, and many organics tend to adsorb to fine silt and clay (Hem, 1985; U.S. Geological Survey, 1999).

All natural waters contain organic material. When compared with inorganic carbon, the amount of carbon contributed by organic material is very small (Hem, 1985); however, organic contributions can have an appreciable effect on the

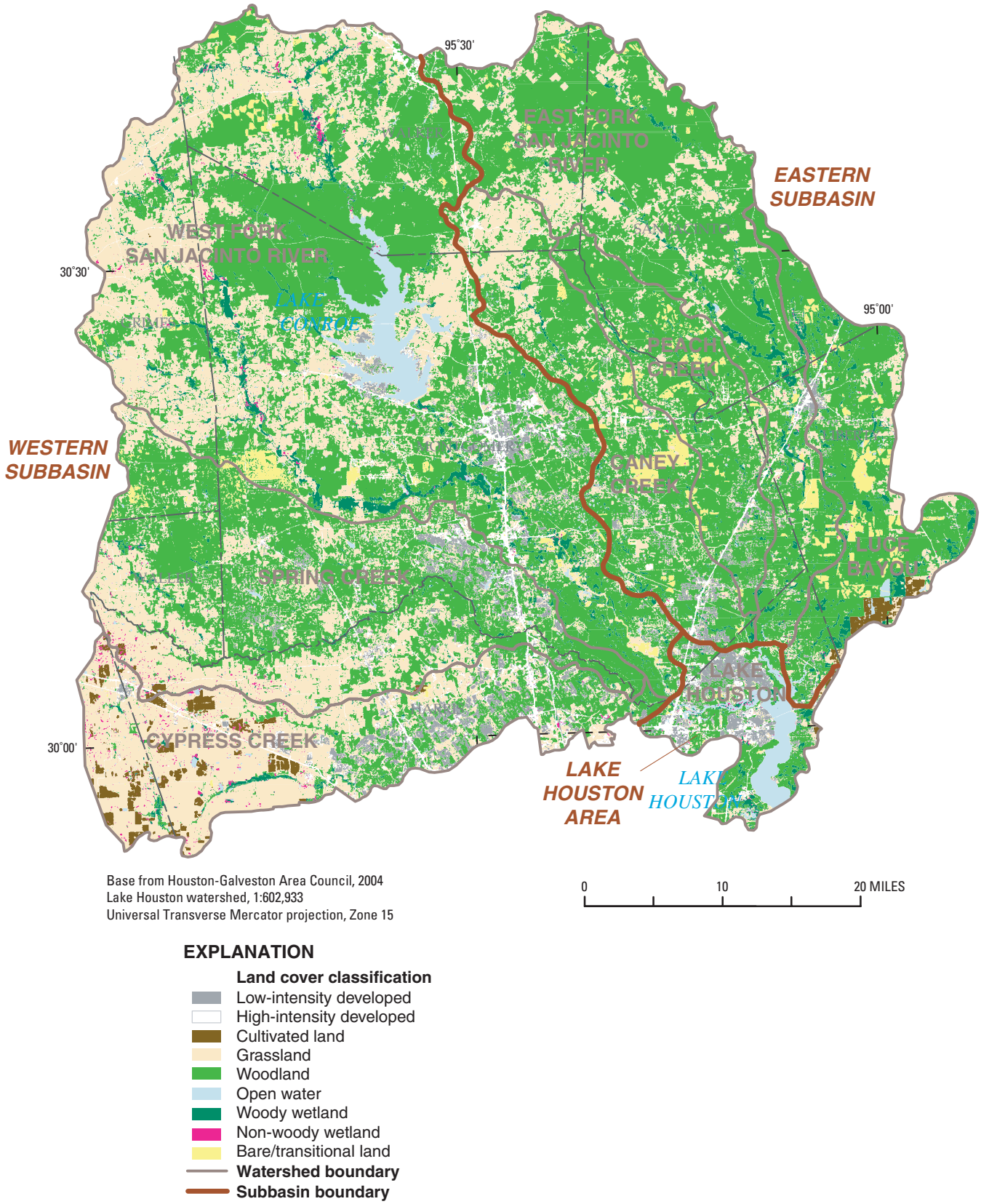

Figure 2. Land-cover distribution in the Lake Houston drainage basin near Houston, Texas, 2002.

Table 2. Data-collection sites at Lake Houston, Cypress Creek, and East Fork San Jacinto River near Houston, Texas, 2000–2004.

[USGS, U.S. Geological Survey; mi^2, square mile]

USGS station number	Station name	Short name (fig. 3)	Location		Drainage area (mi^2)	Population density, 2000[1] (people/mi^2)	Data-collection activity
			Latitude	Longitude			
			Lake Houston				
295516095080801	Lake Houston site AC	AC	29°55'16"	95°08'08"	2,825	312	Periodic water-quality sampling
300158095074601	Lake Houston site EC	EC	30°01'58"	95°07'46"			Periodic water-quality sampling
300209095091201	Lake Houston site FC	FC	30°02'09"	95°09'12"			Periodic water-quality sampling
			Cypress Creek				
08069000	Cypress Creek near Westfield, Tex.	WFCY	30°02'08"	95°25'43"	305	863	Continuous stage and discharge; periodic water-quality sampling; selected stormflow sampling
			East Fork San Jacinto River				
08070200	East Fork San Jacinto River near New Caney, Tex.	EFSJ	30°08'43"	95°07'27"	404	111	Continuous stage and discharge; periodic water-quality sampling; selected stormflow sampling

[1] Source: Patrick Horton, Houston-Galveston Area Council, written commun., 2005.

chemical properties of surface water, such as the reduction and transport of metal oxides (Hem, 1985). Sources of organic carbon include decayed organic material, living organisms found in the water, and sewage. Dissolved and total organic carbon concentrations, along with ultraviolet light absorbance, can give an indication of the potential for formation of trihalomethanes (THMs) in water chlorinated for consumption (Fujii and others, 1998; Potter and Wimsatt, 2003). THMs are classified by the USEPA as probable human carcinogens (U.S. Environmental Protection Agency, 1999).

Although turbidity is not directly associated with adverse health effects in humans, it is used as an indicator of the possible presence of disease-causing organisms. These organisms include bacteria, as well as viral and protozoan pathogens. LeChevallier and others (1981) showed that turbidity particles shield bacteria from the effects of disinfection during water treatment. The USEPA has established an MCL for turbidity in drinking water of 5 nephelometric turbidity units (NTUs). Treatment systems that process surface water are required to have less than 1 NTU in 95 percent of samples (U.S. Environmental Protection Agency, 1999).

Chlorophyll-*a* is a photosynthetic pigment found in algae and other green plants. The concentration of chlorophyll-*a* is used to estimate the amount of phytoplankton or periphyton in a water body (Porter and others, 1993). An excessive amount of algae is a direct cause of esthetic degradation (color, taste, and odor) of a lake or reservoir, and might be a major part of the total turbidity. Decomposition of dead algal cells and other organic matter in a reservoir can increase oxygen loss, releasing iron, manganese, and nutrients, which in turn, supports further biological growth (Thornton and others, 1990).

Pesticides, which include herbicides, insecticides, and fungicides, are used widely in the United States. In urban areas, the most commonly detected compounds include atrazine, simazine, and diazinon (U.S. Geological Survey, 1999). Atrazine and simazine commonly are used for maintenance of roadsides, commercial areas, lawns, and gardens. Diazinon is an insecticide used for homes and gardens. The USEPA has established either MCLs or Health Advisories (HAs) (contaminant goal) for these compounds. For atrazine, the MCL is 3.0 micrograms per liter (µg/L); for simazine, the MCL is 4.0 µg/L; for diazinon, the HA is 6.0 µg/L (U.S. Environmental Protection Agency, 2004).

Acknowledgments

The authors sincerely appreciate the assistance of Patrick Horton, Houston-Galveston Area Council, who provided geographic information system feature datasets used in this report, and Richard Kiesling, Franklin Heitmuller, and Reed Green, USGS, for their critical reviews of the manuscript.

Methods of Study

Water-quality samples were collected at three sites in Lake Houston, one site on Cypress Creek, and one site on East Fork San Jacinto River (fig. 3, table 2). Results from lake sampling

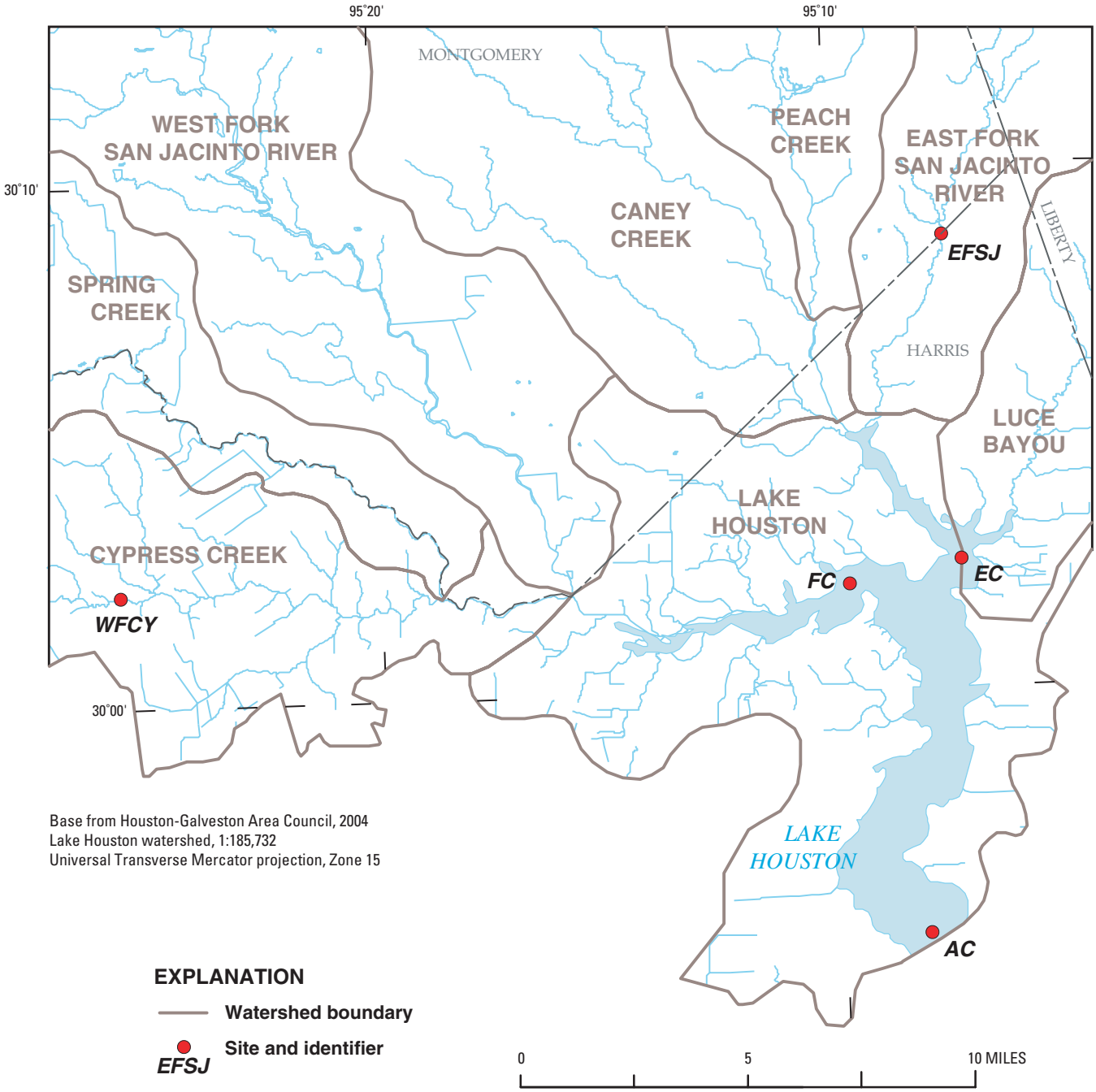

Figure 3. Data-collection sites at Lake Houston, Cypress Creek, and East Fork San Jacinto River near Houston, Texas, 2000–2004.

sites were used to characterize water available to the City of Houston pumping station (site AC); water entering the lake from largely rural, eastern watersheds (site EC); and water entering the lake from the more urbanized, western watersheds (site FC). Results from Cypress Creek were used to represent water quality of inflows from the western subbasin; and results from East Fork San Jacinto River, those from the eastern subbasin. One-hundred eleven physical properties and constituents were measured at each site; concentrations of additional constituents were measured at some sites where possible. The properties and constituents were arranged into six groups: (1) field measurements and physical properties; (2) major cations and anions; (3) nutrients; (4) biological constituents; (5) trace elements (metals); and (6) pesticides. These are documented in the annual USGS Texas water-data reports noted in the Purpose and Scope section. Summary statistics for all field measurements, physical properties, and chemical constituents at each site are in the appendixes.

Data Collection and Analysis

All Lake Houston sampling sites (fig. 3) were located in the thalwegs of pre-existing stream channels. Each site was sampled three times annually during February 2000–September 2004 to characterize winter (November–February), spring (March–June), and summer (July–October) conditions. Water-quality samples were collected at two stream inflow sites. Each inflow site was sampled two times per year during June 2000–September 2004 at low-flow conditions, on most occasions concurrent with sampling at Lake Houston. Beginning in the 2002 water year (October 2001–September 2002), additional samples were collected at each stream inflow site during high flows associated with storms; eight high-flow samples were collected at Cypress Creek (site WFCY), and five high-flow samples were collected at East Fork San Jacinto River (site EFSJ) during April 2002–November 2004.

At each lake site (FC, EC, and AC), water was sampled at specific depths below the surface. Water was pumped from each sampling point through acid-washed tubing using a peristaltic pump. Specific conductance, pH, water temperature, and dissolved oxygen were measured from pumped water at each site at the top (1 foot below the surface), at 10-foot increments, and at the bottom (1 foot above the bottom). Water samples for subsequent analysis of major ions, nutrients, biological constituents, and trace elements were collected at the 1-foot depth only. Water samples for analysis of pesticides were collected separately from three depths (top, mean depth of the site, and bottom) using a thief-type sampler (Lane and others, 2003). Lake-water transparency was measured using a standard Secchi disk.

At each stream inflow site (WFCY and EFSJ), water samples were collected during low-flow conditions using a hand-held sampler. Depth-integrated subsamples were collected at equally spaced vertical sections across the stream (Shelton, 1994). Measurements of specific conductance, pH, water temperature, and dissolved oxygen were made at the same vertical sections used for sample collection. During high flows, water samples were collected with an automated point-sampler that collected discrete samples throughout the storm. The flow-weighted samples were composited to obtain average high-flow constituent concentrations. Grab samples were collected for bacteria and pesticide analyses as single, discrete samples. Stream discharge was recorded at the time of each sample collection by continuous-recording streamflow-gaging stations at each site.

Fecal indicator bacteria analyses were done by membrane filtration (Myers and Wilde, 2003) at the USGS Texas Water Science Center-Houston office. Suspended-sediment concentrations were analyzed at the USGS Louisiana Water Science Center sediment laboratory (Guy, 1969). All other analyses were done by the USGS National Water Quality Laboratory in Denver, Colorado (Wershaw and others, 1987; Fishman and others, 1994; Sandstrom and others, 2001). Improvements in analytical methods and instrumentation occurred during the study period, in some cases resulting in the reduction of a minimum reporting level (MRL).

Quality Assurance and Quality Control

All sample-collection and processing procedures followed are described by Shelton (1994). Data management and documentation were done in accordance with USGS national standards (U.S. Geological Survey, variously dated) to ensure the quality, precision, accuracy, and completeness of collected data. All participants were properly trained and experienced and followed procedures outlined in these documents.

Quality control (QC) samples, which consisted of field blanks, matrix spikes, and replicate samples, were used to determine the extent to which contamination, matrix effects, and measurement variability affected the analytical results (Mueller and others, 1997). In addition to the field QC samples, periodic equipment blanks of deionized water certified to be free of organic and inorganic compounds were used to demonstrate that equipment used for sample collection and processing were not a source of contamination. About 10 percent of the total samples collected during February 2000–November 2004 were field-processed QC samples. Further explanation of QC sample types and their use are described by Mueller and others (1997).

Five field blanks were collected and processed on-site, immediately before an associated environmental sample, to determine potential contamination from field activities associated with data collection. Very low levels of some major ions and metals were detected in two of the five field blanks in concentrations that generally were less than 5 percent of the concentration measured in the environmental sample. One water sample was spiked with known volumes and concentrations of pesticide compounds. Laboratory recoveries from the sample were within method-acceptance ranges for all constituents. Eight replicate samples were collected. Replicate samples were compared to the corresponding environmental samples by calculating the relative percentage difference (RPD) for each constituent. The RPD, which generally was less than 10 percent, was calculated using the equation

$$RPD = |S_1 - S_2| / ((S_1 + S_2)/2) \times 100 , \qquad (1)$$

where

S_1 = concentration from environmental sample; and

S_2 = concentration from replicate sample.

The RPD exceeded 10 percent for nine of 108 sample pairs of major ions and for 17 of 171 sample pairs of trace metals. RPDs larger than 10 percent occurred for four of nine sample pairs associated with organic carbon (total unfiltered organic carbon) and for two of 49 sample pairs associated with nitrogen (ammonia plus organic nitrogen). The RPD exceeded 10 percent primarily when constituent concentrations were very small so that small variability in analytical results caused relatively large RPDs. Because of inherent heterogeneity of some constituents in water, variability of replicate sample collection, sample processing, and laboratory analysis, differences in concentrations caused by sampling imprecision (field) or analytical procedures and instrumentation (laboratory) generally were inseparable.

Load and Yield Computations

A constituent load is the mass of a given constituent that passes a stream cross section per unit time. Two types of loads were computed for this study. For all samples that were collected during low flows and for pesticide analyses during high flows, the discharge used to compute the load was an instantaneous value at the time of sample collection; therefore the instantaneous load is appropriate only for that time, although it was assumed to represent mass transported over a 24-hour period, or daily load. The concentration used was the measured valued for the sample. For samples of nitrogen, phosphorus, orthophosphate, suspended sediment, and organic carbon that were collected over the duration of a storm (high flow) with an automatic sampler, load was computed using the mean stream discharge for the period of sample collection (event mean) and the flow-weighted concentration. Loads computed for high-flow samples represent mass transported for entire storms (which can last from a few hours to a few days) on a daily basis. Because the relatively small number of samples could not adequately represent stream water quality over extended periods, annual loads were not computed.

Daily load was computed using the equation

$$L = Q \times C \times K \tag{2}$$

(Terrio, 1995, p. 38), where

L = constituent load, in pounds per day;
Q = discharge, in cubic feet per second (instantaneous for low flow, event-mean for high flow);
C = constituent concentration, in milligrams per liter or micrograms per liter (single sample for low flow, flow-weighted for high flow); and
K = conversion factor of 5.395 for concentrations reported in milligrams per liter; 0.005395 for concentrations reported in micrograms per liter.

A measure of load-producing characteristics of a watershed is the yield. Daily yield was computed by dividing the daily load of a constituent by the upstream drainage area:

$$Y = L/DA, \tag{3}$$

where

Y = constituent yield, in pounds per square mile per day;
L = constituent load, in pounds per day; and
DA = area of contributing watershed, in square miles.

As with loads, yields are presented for low flows and high flows in the two tributaries. High-flow yields can represent storms of a few hours to a few days, but yields are normalized to a daily basis to allow comparisons among sites and between watersheds.

Trend Testing

Trends in Lake Houston water quality were based on data collected during earlier periods of sample collection (1990–99) (Liscum and others, 1999), in addition to data collected during this study. To differentiate potential seasonal fluctuations in concentrations of nutrients, chlorophyll-*a*, and pesticides, each annual cycle was divided into three periods (winter, spring, and summer), coincident with the timing of samples collected during 2000–2004. To avoid bias, if a site was sampled more than once during a single period of 1 year, the median concentration of each constituent was used for that period. A total of 126 samples (42 samples at each of the three lake sites) was used for trend analysis.

To test whether concentrations increased or decreased over time, time-series graphs and nonparametric statistical techniques (Helsel and Hirsch, 1992) (table 3) were used. Seasonal Kendall tests, which account for seasonal variations so that all the data for a site collectively can be trend tested, were done.

Table 3. Summary of statistical tests used to indicate water-quality trends at Lake Houston near Houston, Texas, 1990–2004 (modified from Helsel and Hirsch, 1992).

[p, p-value[1]; H_0, null hypothesis; H_A, alternative hypothesis; ≤, less than or equal to]

Statistical test	Use	Decision rule	Significance level (p) to reject null hypothesis, H_0
Kendall's tau	A measure of correlation between two independent variables (concentration and time in this study) within a single season	H_0: no correlation H_A: variables are dependent on one another, either positively or negatively	$p \leq .05$
Seasonal Kendall	Removal of seasonal variation to explore possible trends over multiple years	H_0: no correlation H_A: variables are dependent on one another, either positively or negatively	$p \leq .05$
Two-sample Wilcoxon rank-sum	Comparison of two sets of observations to determine if one set tends to produce larger or smaller values than the other set	H_0: The relative distribution of two populations is the same H_A: The relative distribution of two populations is different	$p \leq .05$

[1]The p-value is the probability of obtaining computed test statistic, or one even less likely, when null hypothesis is true (Helsel and Hirsch, 1992, p. 108).

Trends in the data for each site separated by season were identified using Kendall's tau tests. The tests provide p-values (attained significance levels), which in these tests indicate the strength of the evidence for a trend: the smaller the p-value, the stronger the evidence for a trend. Trends commonly are considered significant if the p-value is about .05 or less.

To test whether water-quality conditions differed at different sites, Wilcoxon rank-sum tests were used (Helsel and Hirsch, 1992). This test compares two sets of observations to determine if one site tends to yield larger or smaller values than the other site. No assumptions are made about the distributions of the data. The null hypothesis (what is assumed to be true before the test) for this test was that neither of the two datasets (sites) tends to yield larger or smaller values than the other site—that is, the two datasets are not significantly different. As with the seasonal Kendall and Kendall's tau tests, the Wilcoxon rank-sum test provides a p-value. In this test, the p-value indicates the strength of the evidence that the two datasets are different; they commonly are considered significantly different if the p-value is about .05 or less.

Water-Quality Assessment of Lake Houston

Patterns of chemical and biological constituents in Lake Houston are affected by sedimentation and the water quality of inflowing streams. Patterns periodically might be altered by changes in residence time of water within the lake and mixing of the water column because of wind and solar heating. In general, conditions at the upgradient end of Lake Houston (sites EC and FC) (fig. 3) are dominated by inflowing streams with deposition of coarse-grained particles; as water moves through the lake, lacustrine (lake-like) characteristics became increasingly important, and sediment particle size steadily decreases to that of fine clay near the dam. The general pattern of chemical constituents supplied to the lake is one in which streams in the western subbasin provide larger concentrations of nutrients and sediment to Lake Houston than streams in the eastern subbasin. Chemical concentrations for most constituents were largest at site FC, smallest at site EC, and intermediate at site AC. Nutrients and turbidity, which have opposite effects on algal growth, were both largest at site FC. Statistical results of field measurements, physical properties, and constituents for each data-collection site are shown in appendixes 1–3.

Ambient Conditions, 2000–2004

Organic nitrogen was the dominant form of nitrogen in samples collected in Lake Houston. Total phosphorus concentrations, in all samples, were larger than the concentration (0.025 mg/L) suggested by the USEPA to limit aquatic growth. There was a wide range of turbidity and suspended-sediment concentrations, which reflects the shallow conditions of the lake and periodic turbulence caused by wind, as reported previously by Liscum and East (2000). Overall, chlorophyll-*a* concentrations were small (median 8.2 µg/L). Twelve pesticide compounds were detected. Atrazine and its breakdown product, 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT), were the most commonly detected pesticides; some atrazine concentrations were larger than the USEPA MCL of 3.0 µg/L. Summary statistics for nitrogen compounds, phosphorus, suspended sediment, organic carbon, turbidity, chlorophyll-*a*, and selected pesticides at all three sites combined are listed in table 4.

Nitrogen

Total nitrogen consists of ammonia plus organic nitrogen and nitrite plus nitrate nitrogen (fig. 4). In Lake Houston, the average contribution of ammonia plus organic nitrogen to total nitrogen was about 69 percent. The contribution from nitrite plus nitrate nitrogen was about 31 percent.

The spatial variability of nitrogen concentrations correlated with inflows from urban areas. Median total nitrogen concentrations in samples from Lake Houston (fig. 5) were largest at site FC, smallest at site EC, and intermediate in value at site AC. Total nitrogen concentrations for all samples ranged from 0.33 to 3.1 mg/L. The relative importance of nitrite plus nitrate and ammonia plus organic nitrogen varied at the sites (fig. 4). At site FC, variability in total nitrogen reflected changes in concentrations of nitrite plus nitrate nitrogen, which ranged from less than 0.06 to 2.70 mg/L. Ammonia plus organic nitrogen contributed about 60 percent of the total nitrogen. At site EC, ammonia plus organic nitrogen was the primary constituent, ranging from 0.25 to 0.55 mg/L (fig. 5); nitrite plus nitrate nitrogen contributed about 25 percent of the nitrogen. At site AC, total nitrogen concentrations were intermediate to those at lake inflow sites EC and FC, with ammonia plus organic nitrogen contributing about 63 percent to total nitrogen at site AC.

Concentrations of nitrogen varied during the year. The overall median concentration of nitrite plus nitrate nitrogen in Lake Houston decreased from 0.52 mg/L in winter to less than 0.06 mg/L in late summer. This pattern of decreasing concentrations occurred at all sites.

Phosphorus, Suspended Sediment, and Organic Carbon

Total phosphorus includes dissolved forms as well as phosphorus that is attached to sediment particles and in living organisms like algae and bacteria. The part of total phosphorus that is readily available in the water as a nutrient to algae is the dissolved form. Dissolved phosphorus comprises orthophosphate (fig. 6) and organic phosphorus. Between about 58 and 97 percent of the dissolved phosphorus in Lake Houston samples was orthophosphate phosphorus. Dissolved phosphorus concentrations for all samples (table 4) ranged from less than 0.004 to 0.620 mg/L, with a median concentration of 0.104 mg/L. More than 97 percent of the samples analyzed for dissolved phosphorus had a concentration larger than 0.025 mg/L.

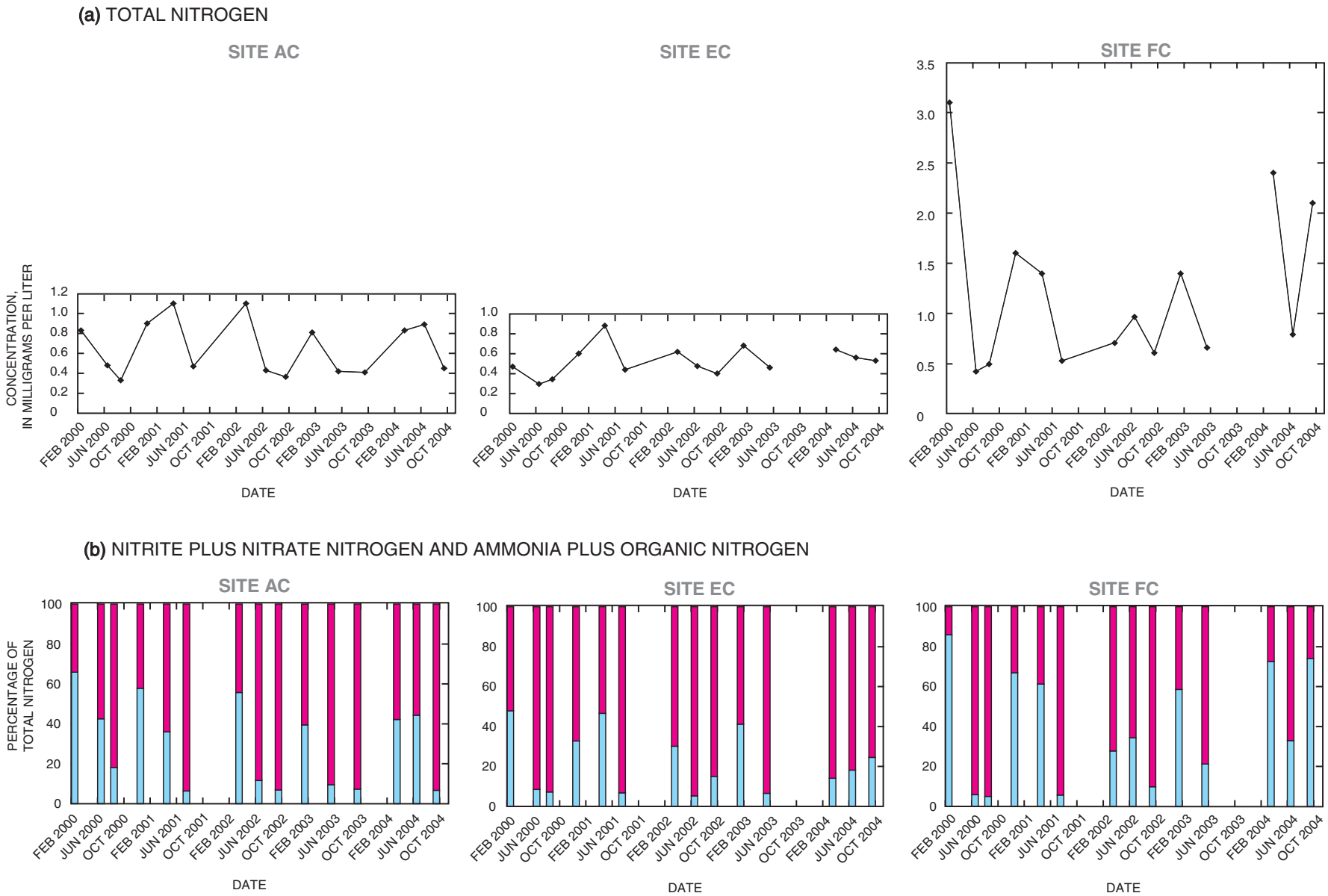

Figure 4. (a) Total nitrogen and (b) relative contributions to total nitrogen of nitrite plus nitrate nitrogen (cyan) and ammonia plus organic nitrogen (magenta) at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

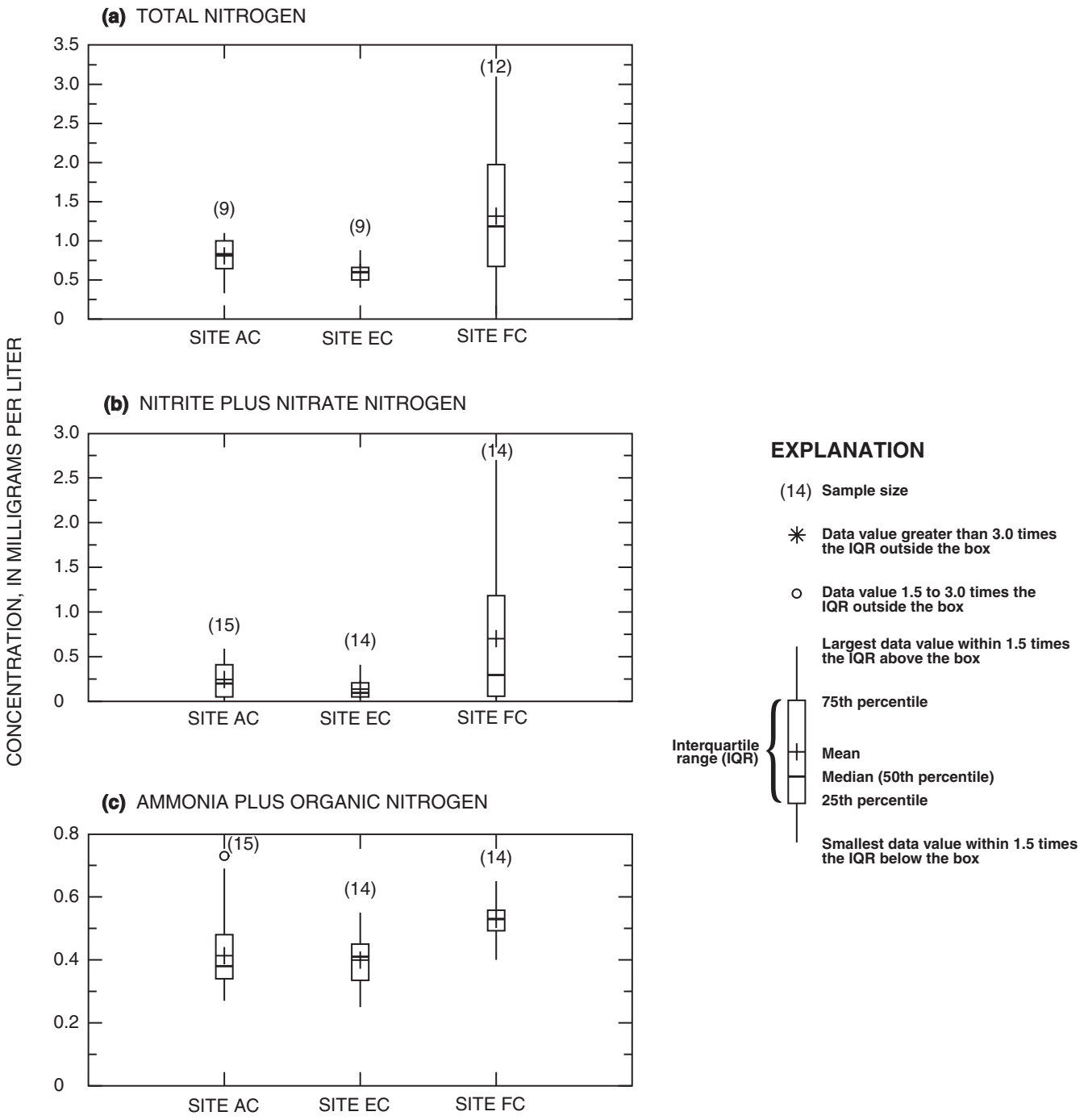

Figure 5. Distribution of (a) total nitrogen, (b) nitrite plus nitrate nitrogen, and (c) ammonia plus organic nitrogen at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

Dissolved phosphorus concentrations varied among sampling sites (fig. 7), similar to the variation of nitrite plus nitrate nitrogen. Dissolved phosphorus concentrations at sites EC and AC were generally less than 0.15 mg/L. Dissolved phosphorus concentrations at site FC were consistently larger than those at other sites; the median concentration was about 4.5 times larger than the median at site EC and about 3.3 times larger than the median at site AC. Comparison of the sites using the Wilcoxon rank-sum test (three tests: EC to FC, FC to AC, AC to EC) demonstrated that dissolved phosphorus concentrations at site FC were significantly different (larger) ($p < .001$) than those at either site AC or site EC. Concentrations at site AC also were significantly different (larger) than those at site EC ($p = .01$). When the data were grouped by season and compared between

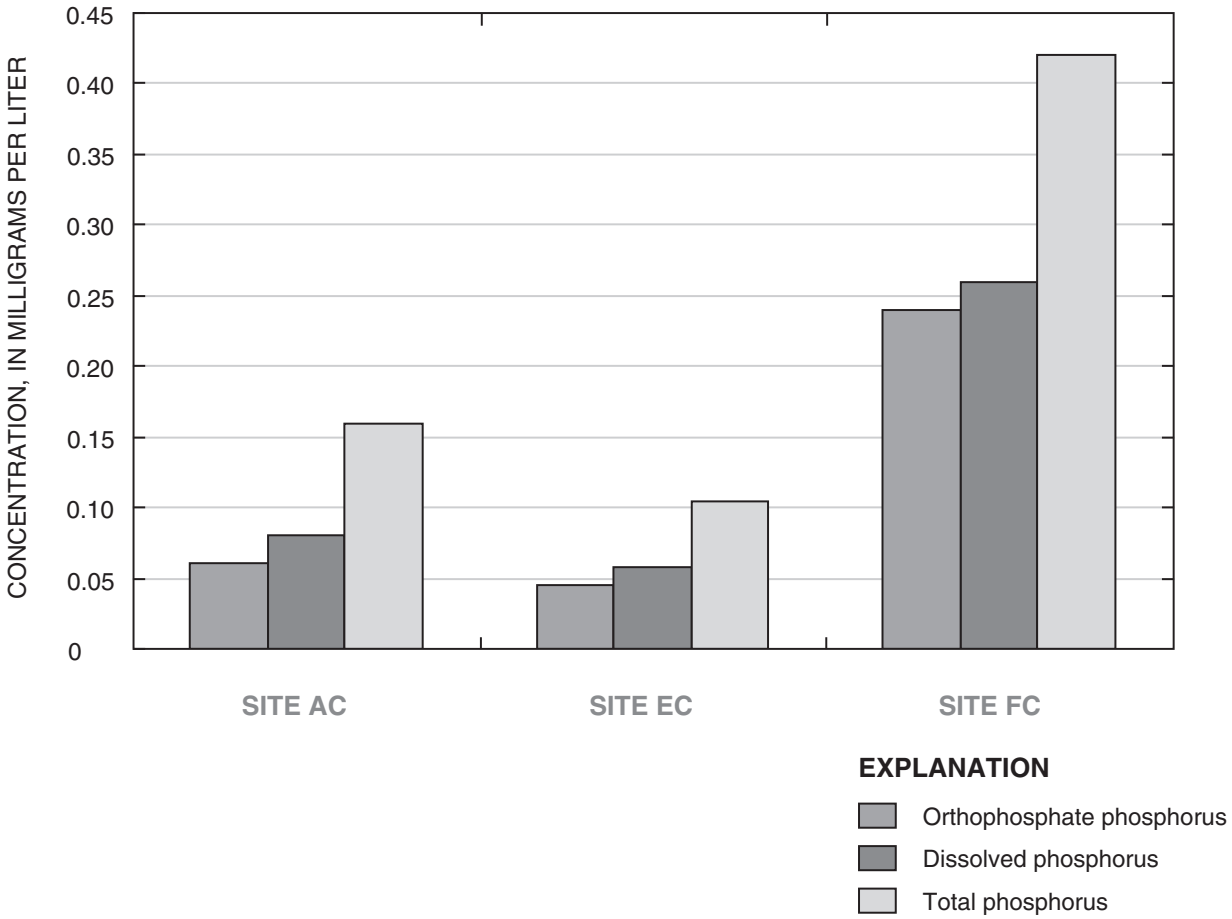

Figure 6. Median concentrations of orthophosphate phosphorus, dissolved phosphorus, and total phosphorus at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

sites, only winter concentrations at site AC were significantly different (larger) (p = .04) than winter concentrations at site EC. A caution, however: The sizes of the seasonal sample groups that were compared in these (and some other) rank-sum tests were small (fewer than 10 samples each). Statistical tests on groups with few data per group might lack the power to detect differences, if they exist, as the power of statistical tests to detect differences increases as sample size increases (Helsel and Hirsch, 1992, p. 107).

The amount of suspended sediment in Lake Houston is a product of several factors that include the intensity and volume of precipitation, discharge from inflowing streams, and intensity and direction of the wind. Sediment concentrations at site FC were about twice those measured at site EC (fig. 7) and three times larger than concentrations at site AC near the dam. Median suspended-sediment concentrations were 43 mg/L at site FC; 23 mg/L at site EC; and 12 mg/L at site AC, the farthest from sediment sources.

The maximum suspended-sediment concentrations at all lake sites (appendixes 1–3) were collected in April 2001. During that month, daily peak wind speeds averaged about 25 miles per hour; immediately preceding sample collection, the wind direction changed from the southeast to north and northeast (National Oceanic and Atmospheric Administration, 2005), parallel to the long axis of the lake. Strong winds with a north-south orientation make the water of Lake Houston very turbulent, which because of the shallowness of the lake, cause resuspension and mixing of bottom sediments. Sediment concentrations in samples collected during this time ranged from 709 to 767 mg/L, between 17 and 59 times larger than the median concentrations at the sites.

Dissolved organic carbon concentrations were consistent throughout the lake; overall the median concentration was 7.7 mg/L (table 4). The largest concentration in all samples was 14.8 mg/L at site EC; the smallest concentration, also at site EC, was 3.7 mg/L (fig. 7). The largest median dissolved organic carbon concentration was at site AC (8.4 mg/L).

Transparency, Turbidity, and Chlorophyll-*a*

Secchi disk transparency and turbidity are two principal indicators of water clarity. Secchi disk transparency was less

Table 4. Statistical summary of nitrogen compounds, phosphorus, suspended sediment, organic carbon, chlorophyll-*a*, and selected pesticides for sites AC, EC, and FC combined, Lake Houston near Houston, Texas, February 2000–September 2004.

[≥, equal to or greater than; mg/L, milligrams per liter; --, not applicable; <, less than; m, meters; NTU, nephelometric turbidity units; µg/L, micrograms per liter; E, estimated]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Ammonia + organic nitrogen, dissolved (mg/L)	43	0.10	43	0.25	0.38	0.44	0.52	0.73
Ammonia + organic nitrogen, total (mg/L)	45	.10	45	.47	.69	.76	.98	1.50
Organic nitrogen[1], dissolved (mg/L)	8	--	--	.26	.39	.43	.52	.59
Ammonia nitrogen, dissolved (mg/L)	43	.04	8	<.04	<.04	<.04	<.04	.12
Nitrite + nitrate nitrogen, dissolved (mg/L)	43	.06	29	<.06	<.06	.19	.41	2.70
Nitrite, dissolved (mg/L)	43	.010	10	<.010	<.010	<.010	.011	.043
Nitrogen[2], total (mg/L)	29	--	--	.33	.60	.81	1.1	3.1
Orthophosphate phosphorus, dissolved (mg/L)	43	.018	40	<.018	.050	.090	.160	.570
Phosphorus, dissolved (mg/L)	43	.004	42	<.004	.059	.104	.185	.620
Phosphorus, total (mg/L)	45	.004	45	.037	.117	.180	.315	.800
Transparency, Secchi depth (m)	45	.01	45	.10	.24	.30	.49	1.15
Turbidity (NTU)	35	1	35	7	22	36	58	270
Suspended sediment (mg/L)	39	1	39	6	17	27	44	767
Organic carbon, dissolved (mg/L)	45	.33	45	3.7	6.6	7.7	9.4	14.8
Organic carbon, total (mg/L)	45	.40	45	6.4	9.6	11.4	13.0	15.5
Chlorophyll-*a* phytoplankton (µg/L)	45	.1	44	<.1	3.0	8.2	21.0	53.9
Atrazine, dissolved (µg/L)	45	.007	45	.043	.182	.454	.835	4.450
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved (µg/L)	45	.006	43	<.006	E.011	E.029	E.069	E.152
Diazinon, dissolved (µg/L)	45	.010	38	<.010	.015	.028	.066	.616
Simazine, dissolved (µg/L)	44	.005	41	<.005	.021	.037	.107	1.21

[1]Ammonia + organic nitrogen minus ammonia nitrogen.

[2]Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

than 1 meter (3.3 feet) in about 98 percent of measurements in Lake Houston; in 84 percent of the measurements, transparency was less than or equal to 0.5 meter (1.6 feet). Transparency was the least near lake inflow sites EC and FC and greatest near the dam at site AC (fig. 8). Turbidity, an optical measure of light scattering, is inversely related to transparency depth. Overall, turbidity ranged from 7 to 270 NTUs (fig. 8, table 4). Median turbidity for all samples was 36 NTUs (table 4); however, the range of values was large at sites AC and FC. The maximum turbidity at site AC was about 10 times greater than the median at that site.

Concentrations of chlorophyll-*a* were used as an indicator of the amount (biomass) of phytoplankton. Chlorophyll-*a* concentrations decreased from the lake inflows to the dam; the largest concentrations were at site FC, which had a median of 16.4 µg/L (fig. 8). Median chlorophyll-*a* concentration at site EC was 9.2 µg/L. The smallest chlorophyll-*a* concentrations were measured in samples at site AC, which had a median of 6.8 µg/L. Overall concentrations in Lake Houston ranged from less than 0.1 to 53.9 µg/L with a median concentration of 8.2 µg/L (table 4). From Wilcoxon rank-sum tests between sites, chlorophyll-*a* concentrations at site FC were significantly different (larger) than those at sites AC ($p < .001$) and EC ($p = .009$). Concentrations at site EC were significantly different (larger) than those at site AC ($p = .029$). Testing the data grouped by season between sites indicated that, for winter and summer, concentrations were not significantly different; for spring, however, concentrations at site FC were significantly

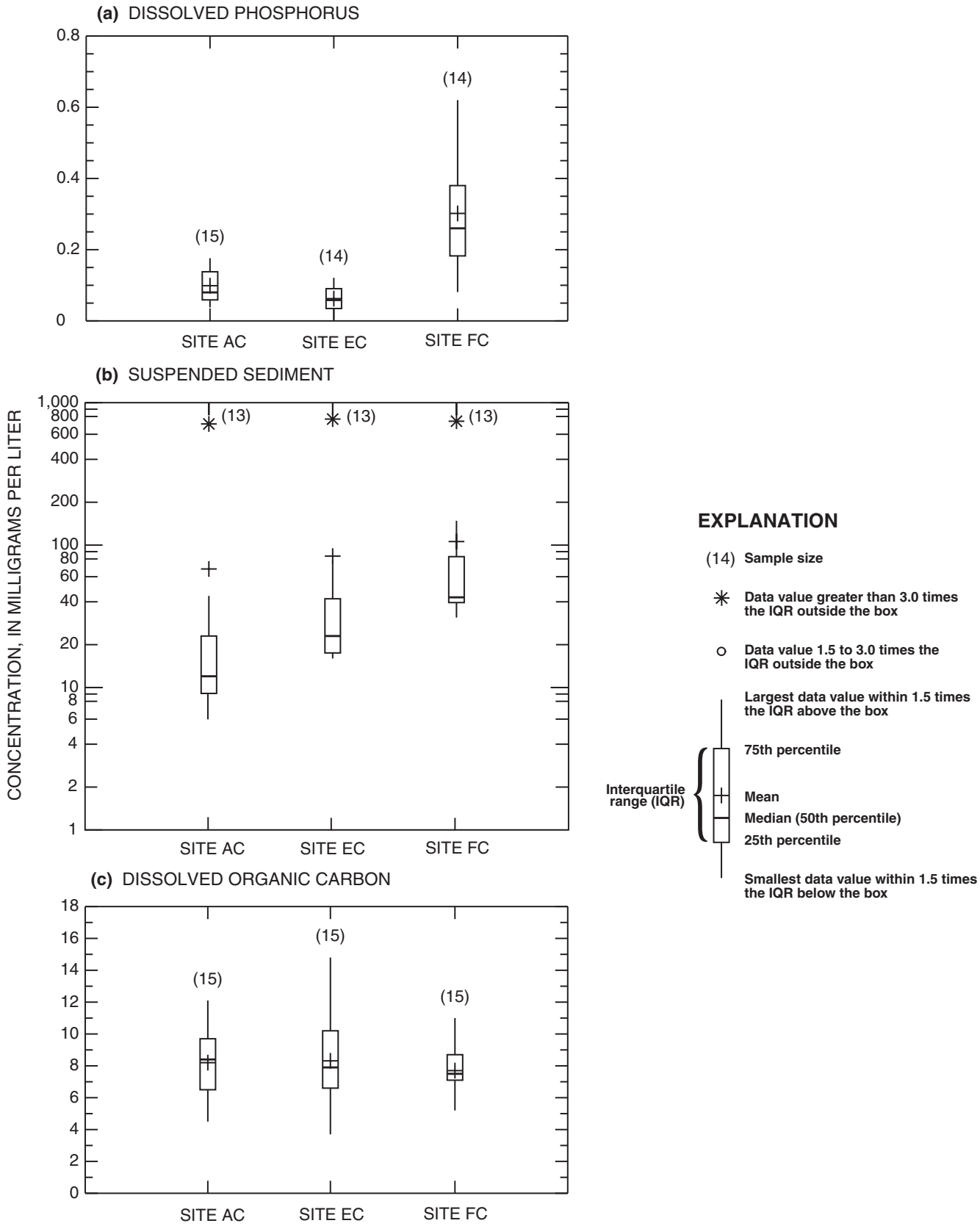

Figure 7. Distribution of (a) dissolved phosphorus, (b) suspended sediment, and (c) dissolved organic carbon at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

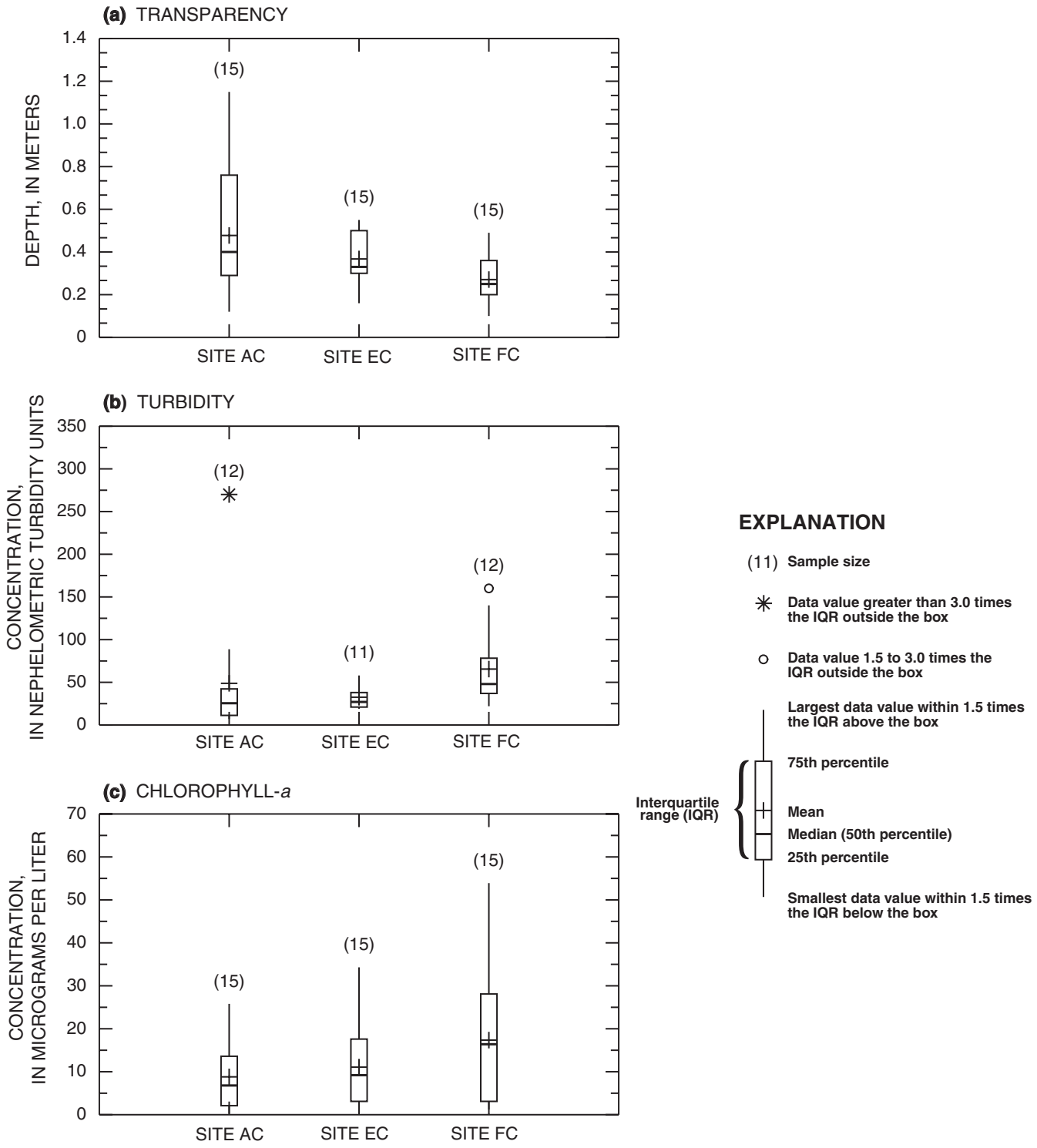

Figure 8. Distribution of (a) transparency, (b) turbidity, and (c) chlorophyll-*a* at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

different (larger) than those at sites EC (p = .007) and AC (p = .002).

In Lake Houston, concentrations of phosphorus, turbidity, and chlorophyll-*a* were largest at the lake inflow sites and decreased downstream to the dam, similar to a pattern of productivity described by Thornton and others (1990). Lee and Rast (1997) reported that nutrients were not the limiting factor for algal production in Lake Houston; light might be the

Table 5. Summary of pesticide detections at sampling sites in Lake Houston, Cypress Creek, and East Fork San Jacinto River, near Houston, Texas, 2000–2004.

Pesticide	Number of detections/number of samples						
	Lake Houston[1]			Cypress Creek[2]		East Fork San Jacinto River[2]	
	Site AC	Site EC	Site FC	Low flow[3]	High flow[4]	Low flow[5]	High flow[6]
Herbicide							
Alachlor	0/15	0/15	0/15	1/9	1/8	0/10	0/5
Atrazine	15/15	15/15	15/15	9/9	8/8	2/10	4/5
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT)	15/15	13/15	15/15	9/9	7/8	0/10	2/5
Metolachlor	5/15	4/15	4/15	1/9	1/8	0/10	0/5
Molinate	1/15	1/15	1/15	0/8	0/8	0/10	0/5
Pendimethalin	0/15	0/15	0/15	2/9	0/8	0/10	0/5
Prometon	7/14	7/13	9/14	4/8	4/7	0/10	0/5
Propyzamide	6/15	3/13	3/15	1/9	1/8	0/10	0/5
Simazine	13/14	13/15	15/15	6/8	8/8	0/10	0/5
Tebuthiuron	4/15	4/15	6/15	0/9	0/8	1/10	0/5
Trifluralin	0/15	0/15	0/15	0/9	1/8	0/10	0/5
Insecticide							
Carbaryl	1/15	1/15	6/15	2/9	7/8	0/10	1/5
Chlorpyrifos	0/15	0/15	1/15	3/8	2/8	0/10	0/5
Desulfinyl fipronil	0/6	0/6	0/6	0/4	3/7	0/4	0/4
Diazinon	13/15	11/15	14/15	7/9	8/8	2/10	3/5
Fipronil	0/6	0/6	3/6	1/4	3/7	0/4	0/4
Malathion	0/15	0/15	0/15	1/9	4/8	0/10	0/5

[1]February 2000–September 2004.

[2]June 2000–September 2004 for low flows; April 2002–November 2004 for high flows.

[3]Instantaneous flow less than 100 cubic feet per second.

[4]Instantaneous flow greater than 350 cubic feet per second or median flow greater than 900 cubic feet per second.

[5]Instantaneous flow less than 200 cubic feet per second.

[6]Instantaneous flow greater than 400 cubic feet per second or median flow greater than 900 cubic feet per second.

limiting factor. Periods of high turbidity caused by mixing of lake waters by wind reduces the amount of light penetrating the water column, thereby limiting algal production.

Pesticides

Twelve pesticide compounds (eight herbicides and four insecticides) were detected in 45 water samples collected at Lake Houston (15 at each site) (table 5). The most commonly detected herbicide compounds were atrazine (45 detections), CIAT, a breakdown product of atrazine (43 detections), and simazine (41 detections). The most commonly detected insecticide was diazinon (38 detections).

Of the median combined atrazine concentration (atrazine plus CIAT), 93 percent was the parent compound and 7 percent was the breakdown product. Combined concentrations ranged from 0.047 to 4.526 µg/L. The median combined concentration in all samples was 0.517 µg/L. The USEPA MCL for atrazine of 3.0 µg/L was exceeded in two samples, both from site FC (fig. 9). Concentrations of atrazine at site FC were consistently larger than those at other lake sites. Atrazine concentrations were smallest at site EC. The atrazine concentrations at site AC were intermediate, possibly reflecting mixing from all inflows to the lake and local runoff.

Diazinon and simazine were detected in Lake Houston in much smaller concentrations than those of atrazine (fig. 9). Small concentrations of these pesticides in Lake Houston might be related to a combination of (1) low use in the drainage basin; (2) lack of stability of the compound in the environment; and, (3) degradation of the parent compound to breakdown products that were not determined. The highest percentage of detections and largest concentrations of both compounds were at site FC.

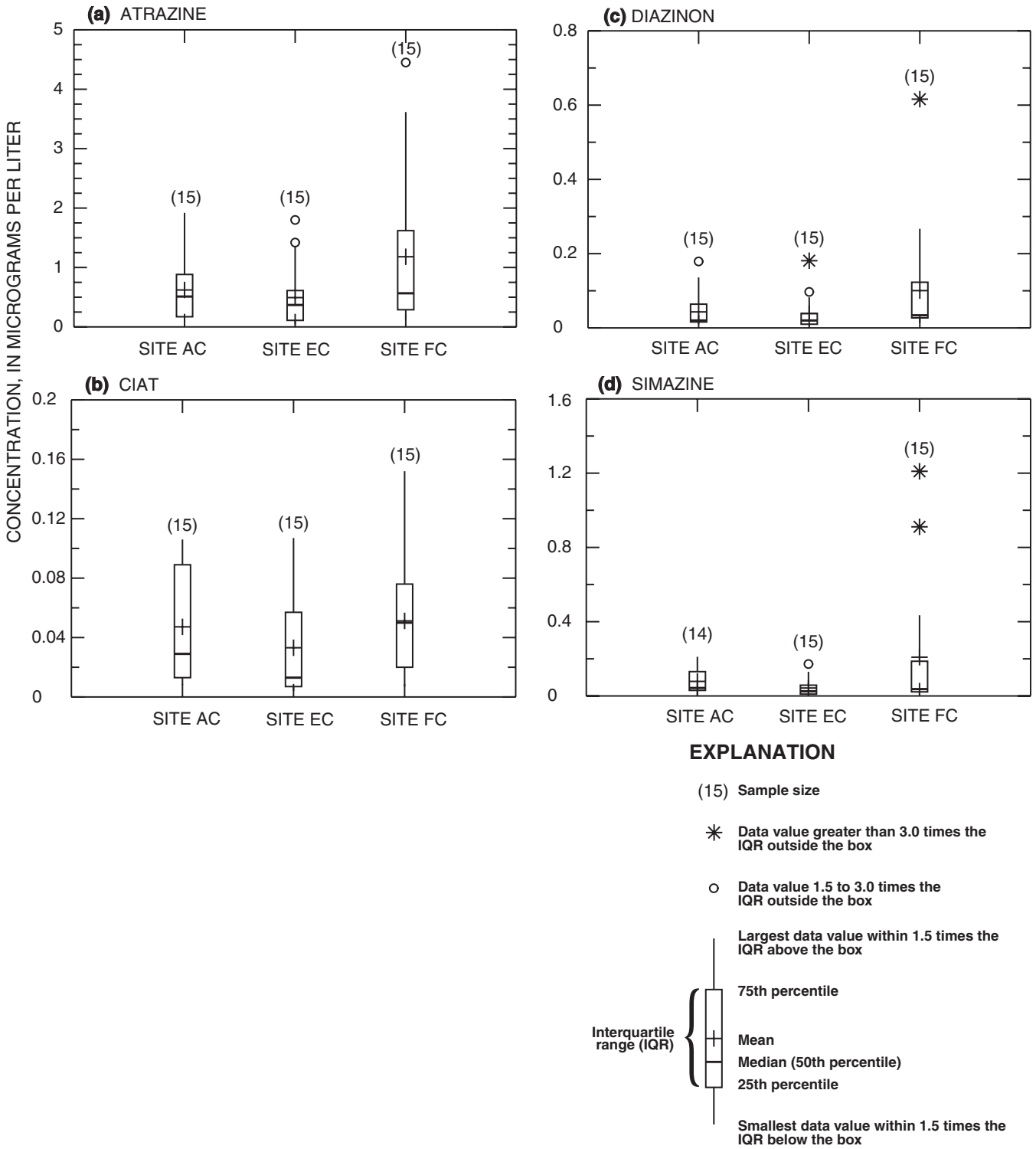

Figure 9. Distribution of (a) atrazine, (b) 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT), (c) diazinon, and (d) simazine at three sites in Lake Houston near Houston, Texas, February 2000–September 2004.

Tributary Inflows, 2000–2004

Water-quality samples were collected at Cypress Creek and East Fork San Jacinto River during low flows and during high flows associated with storms. Low flows in Cypress Creek consisted of instantaneous discharges less than 100 cubic feet per second; high flows consisted of instantaneous discharges greater than 350 cubic feet per second or median discharges

greater than 900 cubic feet per second. In East Fork San Jacinto River, low flows were instantaneous discharges less than 200 cubic feet per second; high flows consisted of instantaneous discharges greater than 400 cubic feet per second or median discharges greater than 900 cubic feet per second. Because samples during high flows were not collected at any time until April 2002, data adequately represent the range of flows from these two streams only during 2002–04 (fig. 10). Statistical results of field measurements, physical properties, and constituents for each data-collection site at low and high flows are shown in appendixes 4–7.

Constituent Concentrations

During low-flow conditions in Cypress Creek, total nitrogen primarily was nitrite plus nitrate nitrogen (fig. 11), which contributed 86 percent of the total nitrogen; nitrate nitrogen was 85 percent of the dissolved nitrogen and nitrite nitrogen was 1 percent. The remainder consisted of organic nitrogen (12 percent) and ammonia nitrogen (2 percent). Nitrate, nitrite, and organic nitrogen were detected in all samples. During high flows in Cypress Creek, the largest contributor to total nitrogen was organic nitrogen, which accounted for about 66 percent. Nitrate (28 percent), ammonia (5 percent), and nitrite (1 percent) nitrogen contributed the remaining dissolved nitrogen. Concentrations of all nitrogen compounds in East Fork San Jacinto River samples were small when compared to those in Cypress Creek samples. During low flows, organic nitrogen was detected in all samples at East Fork San Jacinto River and contributed about 60 percent of the total nitrogen. The remaining nitrogen was in the form of nitrite plus nitrate (fig. 11), which had a maximum concentration of 0.23 mg/L. No samples had detectable concentrations of ammonia or nitrite nitrogen. During high flows in East Fork San Jacinto River, organic nitrogen accounted for about 88 percent of the dissolved nitrogen concentration. Nitrite plus nitrate nitrogen was detected in two of five samples; no concentrations of ammonia nitrogen were detected.

During low flows in Cypress Creek, about 94 percent of the total phosphorus was dissolved. About 90 percent of the dissolved phosphorus was orthophosphate phosphorus (fig. 12). At high flows, about 50 percent of the total phosphorus was dissolved, and 85 percent of the dissolved phosphorus was orthophosphate phosphorus. In all samples at Cypress Creek, concentrations of dissolved phosphorus were larger than 0.05 mg/L (the USEPA-recommended limit for total phosphorus in a stream at the entry to a lake or reservoir) and ranged from 0.10 to 3.47 mg/L. Dissolved phosphorus concentrations were about 10 times larger in Cypress Creek than in East Fork San Jacinto River. All samples at East Fork San Jacinto River had detectable dissolved phosphorus concentrations. Concentrations of dissolved phosphorus in East Fork San Jacinto River during low flows ranged from 0.009 to 0.034 mg/L and contributed about 31 percent of the total phosphorus (fig. 12). Dissolved phosphorus concentrations during high flows ranged from 0.025 to 0.038 mg/L and were about 25 percent of the total phosphorus. Orthophosphate phosphorus was detected in 20 percent of all samples at East Fork San Jacinto River.

Suspended-sediment concentrations were positively correlated with streamflow. In Cypress Creek, suspended-sediment concentrations ranged from 13 to 65 mg/L during low flows, with a median concentration of 26 mg/L (fig. 13). Suspended-sediment concentrations in East Fork San Jacinto River were similar to those in Cypress Creek at low flows; however, at high flows concentrations differed appreciably. During high flows, suspended-sediment concentrations in Cypress Creek ranged from 118 to 957 mg/L, with a median concentration of 308 mg/L, about twice the median concentration at East Fork San Jacinto River. These differences might result from differences in land cover and urbanization in the two watersheds. The primary land cover in the Cypress Creek watershed was grassland, and the primary land cover in the East Fork San Jacinto watershed was woodland (fig. 2). In addition, more than 10 percent of the Cypress Creek watershed was urbanized, which is more than twice the percentage of urbanized area of the East Fork San Jacinto River watershed.

Dissolved organic carbon was detected in all samples from both streams. In Cypress Creek, concentrations ranged from 5.1 to 7.0 mg/L during low-flow conditions and from 5.9 to 32.3 mg/L during high flows associated with storms. Median concentrations during low flows and high flows were 6.5 and 13.4 mg/L, respectively (fig. 14). In East Fork San Jacinto River, dissolved organic carbon concentrations ranged from 2.5 to 10.0 mg/L during low flows and from 9.6 to 15.9 mg/L during high flow (fig. 14).

At least one pesticide was detected in all samples collected at Cypress Creek (table 5). Of 15 pesticides detected, the most common was atrazine (100 percent), followed by CIAT (94.1 percent), diazinon (88.2 percent), and simazine (87.5 percent). The USEPA MCL of 3.0 µg/L was exceeded in three of 17 atrazine samples. Concentrations of all pesticides were larger during high flows associated with storm runoff than during low flows. Atrazine concentrations in Cypress Creek ranged from 0.065 to 8.83 µg/L in samples collected during low flows and from 0.282 to 21.3 µg/L in samples collected during high flows. Median concentrations during low and high flows were 0.612 and 1.09 µg/L, respectively. CIAT was detected only in small concentrations and was about 3 percent of the concentrations of its parent compound, atrazine. Simazine was detected in six of eight samples from low flows at Cypress Creek and concentrations ranged from less than 0.005 to 0.242 µg/L; during high flows, concentrations ranged from 0.009 to 3.27 µg/L. Diazinon was the most frequently detected insecticide in Cypress Creek samples. During low flows, diazinon concentrations ranged from less than 0.010 to 1.08 µg/L. During high flows, concentrations were slightly elevated, ranging from 0.024 to 1.17 µg/L.

Five pesticides were detected in samples collected at East Fork San Jacinto River (table 5). Atrazine was the most commonly detected pesticide, present in six of 15 samples. Atrazine was detected more frequently, as well as at larger concentrations, in high-flow samples than in low-flow samples. Maximum concentrations were 0.019 and 0.233 µg/L during

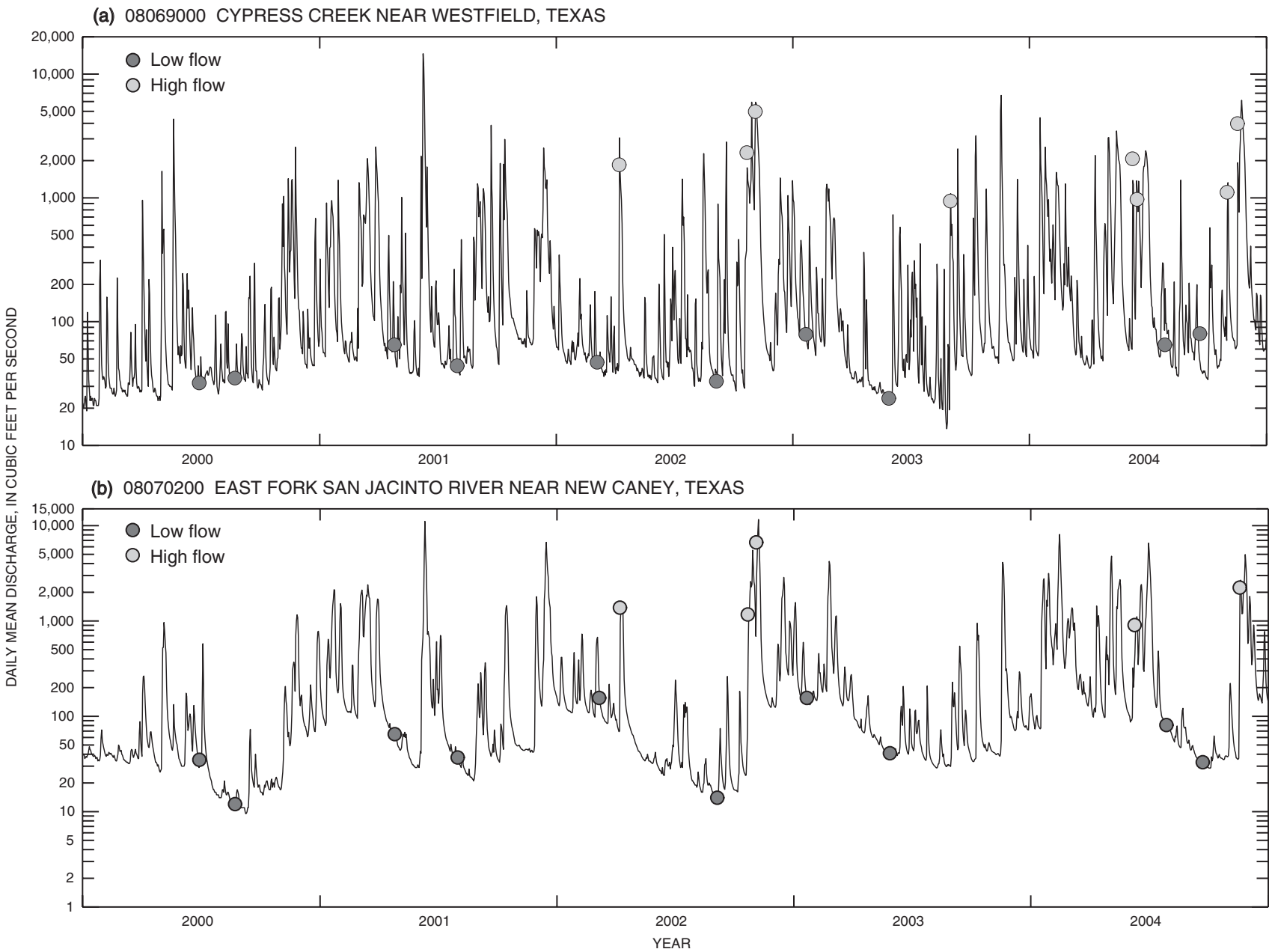

Figure 10. Hydrographs showing discharge, 2000–2004, and water-quality sampling during low flows (June 2000–September 2004) and high flows (April 2002–November 2004) at (a) Cypress Creek and (b) East Fork San Jacinto River near Houston, Texas.

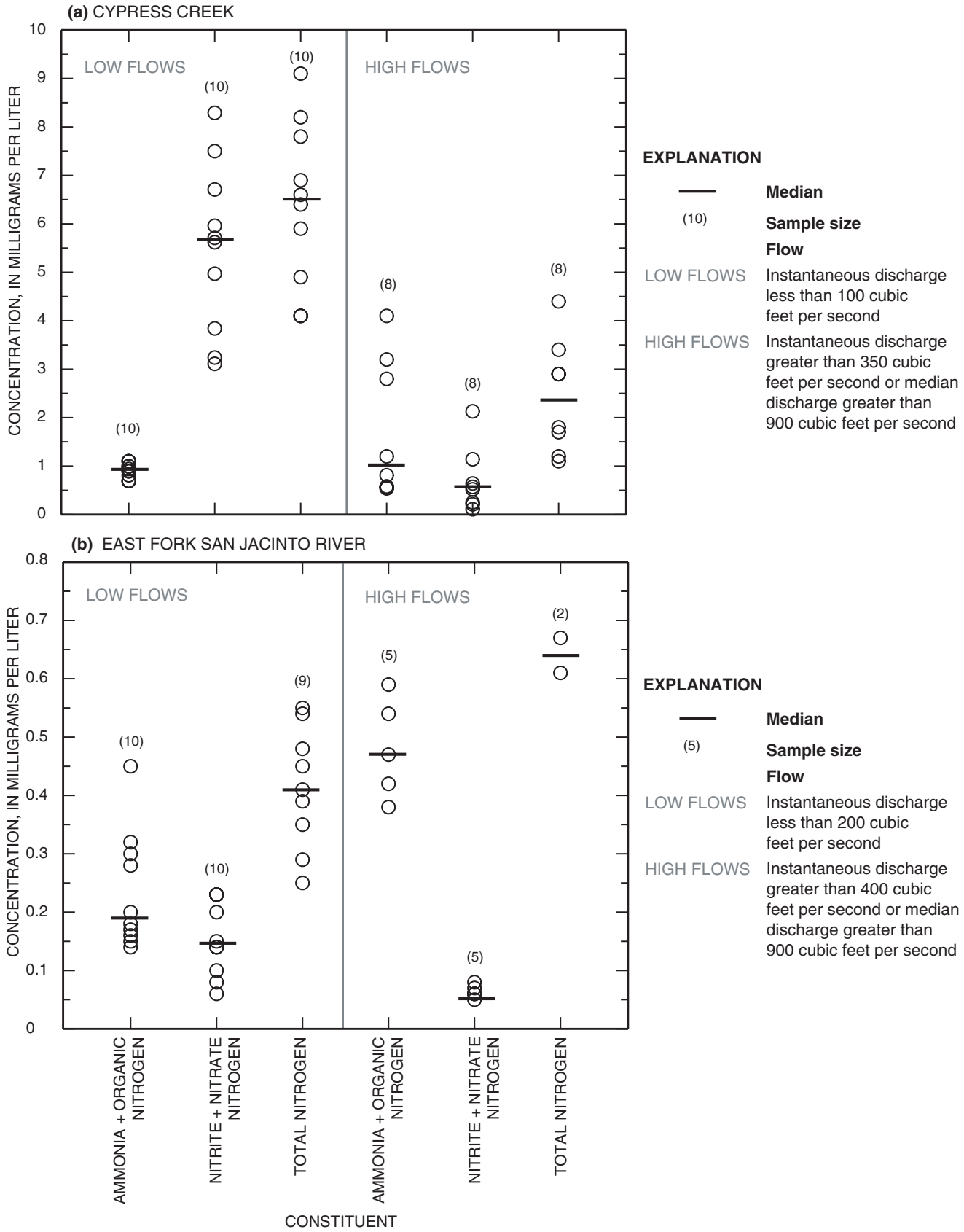

Figure 11. Distribution of nitrogen compounds at low flows (June 2000–September 2004) and high flows (April 2002–November 2004) at (a) Cypress Creek and (b) East Fork San Jacinto River near Houston, Texas.

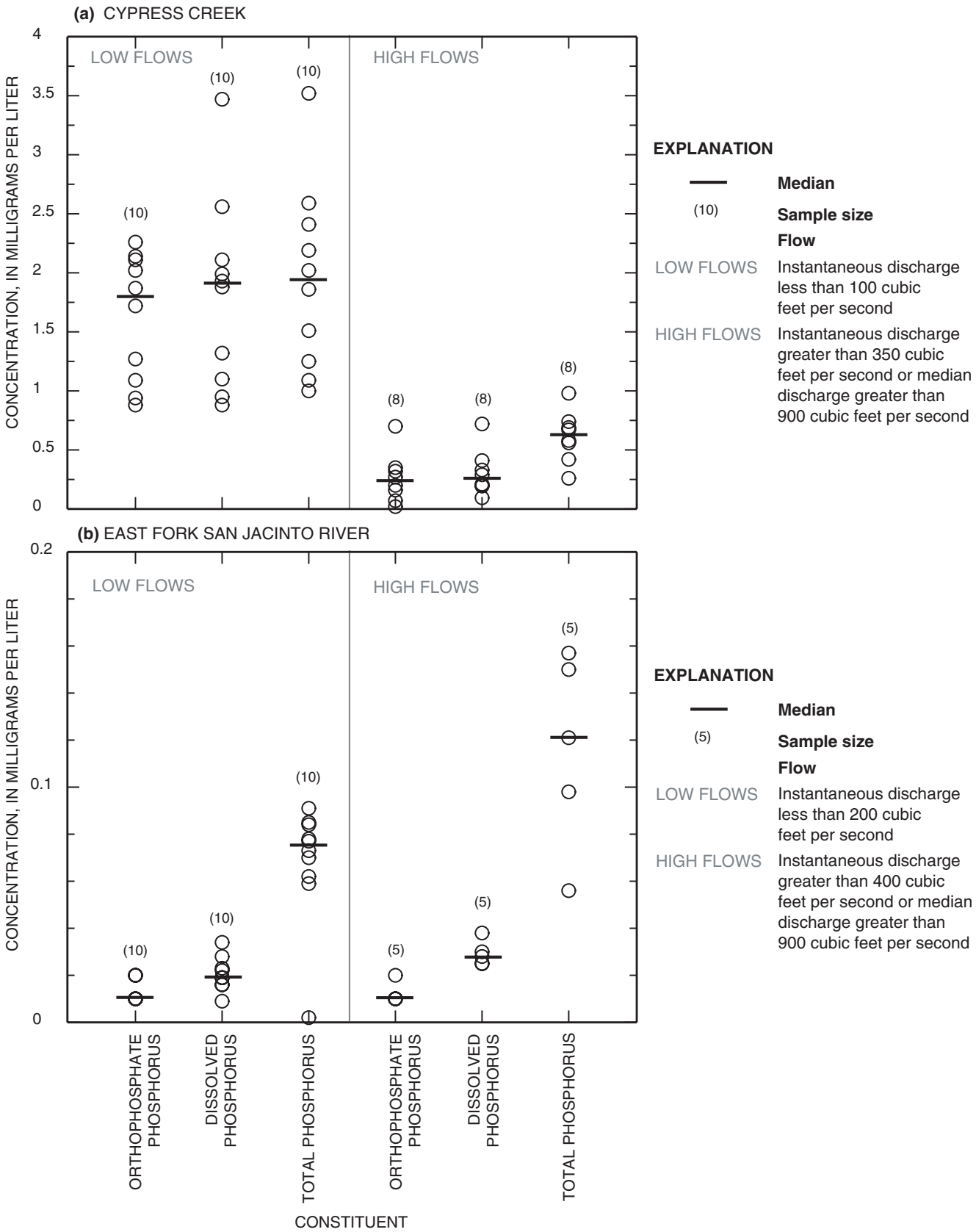

Figure 12. Distribution of orthophosphate phosphorus, dissolved phosphorus, and total phosphorus at low flows (June 2000–September 2004) and high flows (April 2002–November 2004) at (a) Cypress Creek and (b) East Fork San Jacinto River near Houston, Texas.

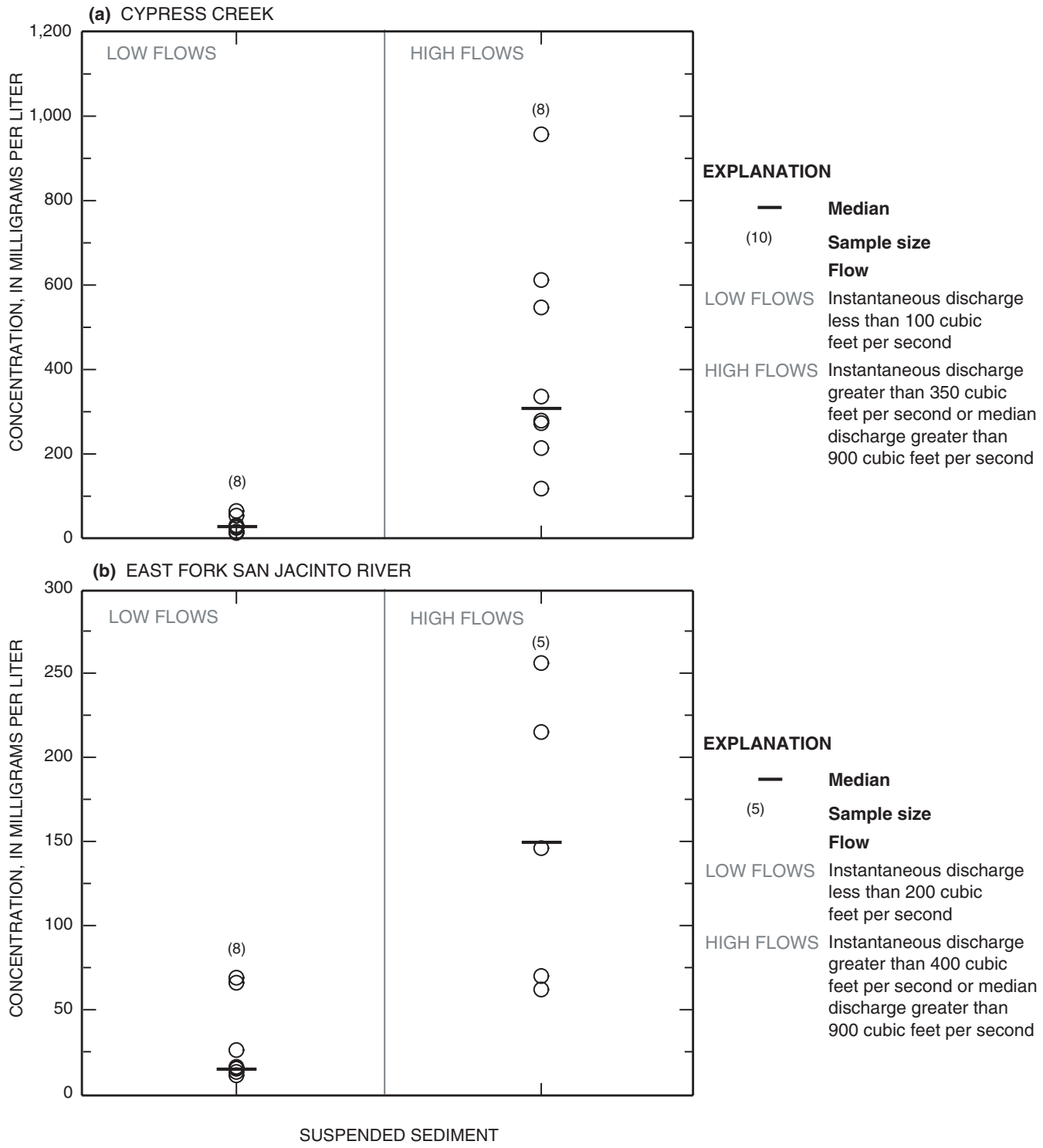

Figure 13. Distribution of suspended sediment at low flows (June 2000–September 2004) and high flows (April 2002–November 2004) at (a) Cypress Creek and (b) East Fork San Jacinto River near Houston, Texas.

low and high flows, respectively. Diazinon, the most commonly detected insecticide in East Fork San Jacinto River, was detected in five of 15 samples. The largest concentration, 0.051 mg/L, was measured in a storm sample.

Loads and Yields

Low-flow and high-flow loads and yields were computed for selected constituents to determine (1) the relative low-flow

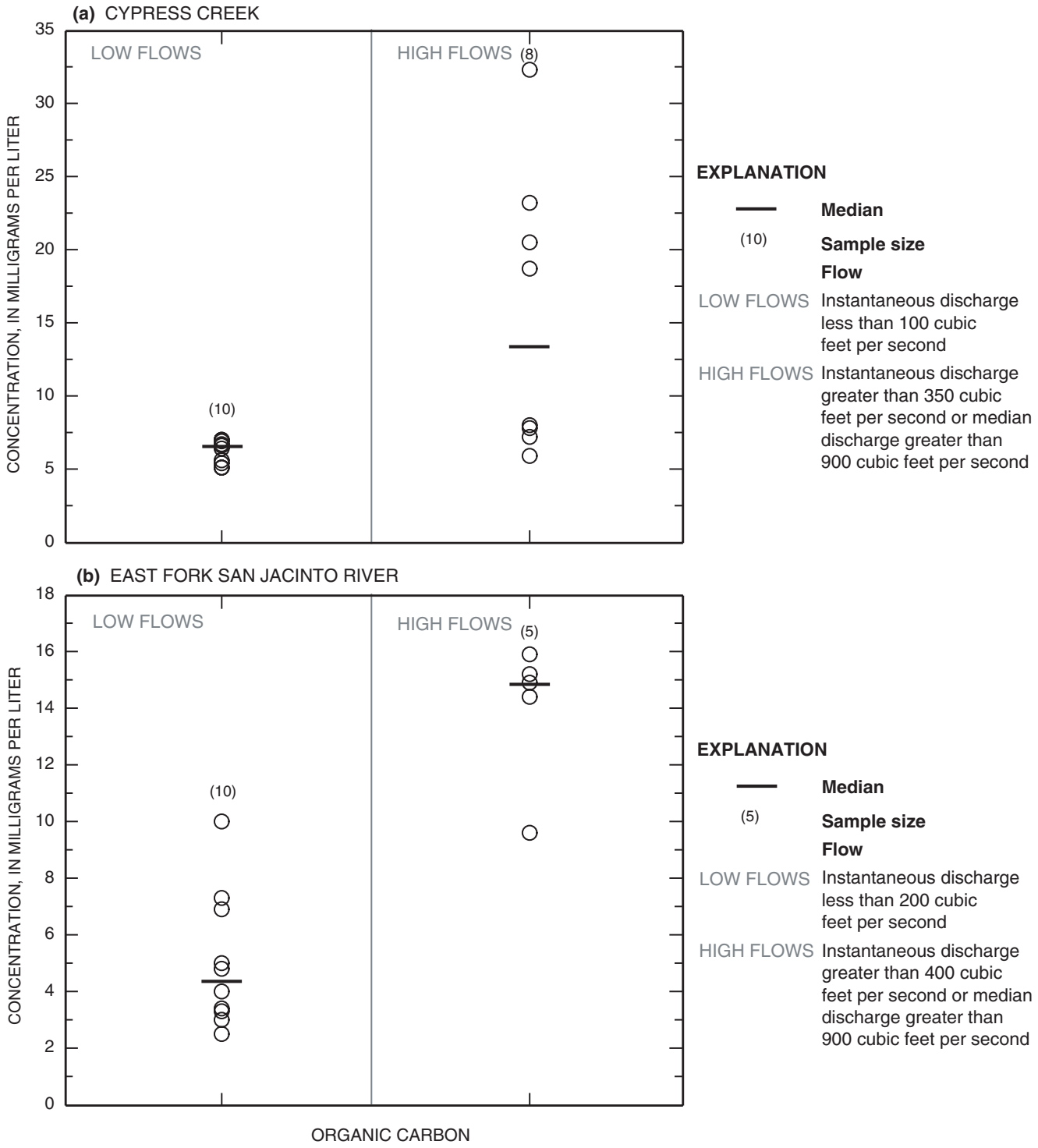

Figure 14. Distribution of organic carbon at low flows (June 2000–September 2004) and high flows (April 2002–November 2004) at (a) Cypress Creek and (b) East Fork San Jacinto River near Houston, Texas.

or storm contribution of constituents, in pounds per day, to Lake Houston from the Cypress Creek and East Fork San Jacinto River watersheds; and (2) the production, in pounds per square mile per day, of constituents within each watershed. Together, they provide some insight into conditions or practices within a watershed that might contribute to the overall quality of water that flows from that watershed. The computed loads and yields for selected constituents from Cypress Creek and East Fork San Jacinto River are listed in tables 6–9.

Table 6. Summary of minimum, median, and maximum loads of selected constituents at low flows and high flows in Cypress Creek near Houston, Texas, 2000–2004.

[lb, pounds; --, load not computed because analytical value less than minimum reporting level; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine]

Constituent	Daily load at low flow[1], June 2000–September 2004 (lb)			Daily load at high flow[2], April 2002–November 2004 (lb)		
	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia + organic nitrogen, dissolved	100	270	384	2,940	9,030	75,200
Ammonia nitrogen, dissolved	--	42.2	66.5	210	733	3,380
Nitrite + nitrate nitrogen, dissolved	772	1,110	3,580	2,490	2,930	13,700
Nitrogen[3], total	893	1,440	3,930	5,770	22,400	77,900
Orthophosphate phosphorus, dissolved	272	319	872	250	1,830	5,800
Phosphorus, dissolved	281	332	859	1,100	2,500	6,220
Phosphorus, total	294	370	945	2,200	7,180	12,400
Suspended sediment	2,330	4,540	27,700	600,000	4,600,000	20,500,000
Organic carbon, dissolved	660	1,610	2,980	40,900	122,000	551,000
Atrazine, dissolved	.020	.079	3.10	2.77	8.30	562
CIAT, dissolved	.002	.009	.152	.103	.330	7.02
Diazinon, dissolved	--	.010	.378	.082	.898	30.9
Simazine, dissolved	--	.002	.061	.018	3.40	24.3

[1]Instantaneous discharge less than 100 cubic feet per second.

[2]Instantaneous discharge greater than 350 cubic feet per second or median discharge greater than 900 cubic feet per second.

[3]Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Table 7. Summary of minimum, median, and maximum loads of selected constituents at low flows and high flows in East Fork San Jacinto River near Houston, Texas, 2000–2004.

[lb, pounds; --, load not computed because analytical value less than minimum reporting level; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine]

Constituent	Daily load at low flow[1], June 2000–September 2004 (lb)			Daily load at high flow[2], April 2002–November 2004 (lb)		
	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia + organic nitrogen, dissolved	11.0	50.2	379	2,640	4,390	16,900
Ammonia nitrogen, dissolved	--	--	25.2	--	--	--
Nitrite + nitrate nitrogen, dissolved	--	36.7	118	--	--	595
Nitrogen[3], dissolved	16.2	102	463	--	[3]--	--
Phosphorus, dissolved	1.23	5.10	19.4	122	208	1,370
Phosphorus, total	--	15.6	65.6	417	947	3,530
Suspended sediment	1,040	7,370	28,800	342,000	1,620,000	2,600,000
Organic carbon, dissolved	220	1,090	8,410	72,800	116,000	548,000
Atrazine, dissolved	--	--	.015	--	.254	1.68
CIAT, dissolved	--	--	--	--	--	.043
Diazinon, dissolved	--	--	.009	--	.175	.369

[1]Instantaneous discharge less than 200 cubic feet per second.

[2]Instantaneous discharge greater than 400 cubic feet per second or median discharge greater than 900 cubic feet per second.

[3]Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Table 8. Summary of minimum, median, and maximum yields of selected constituents at low flows and high flows in Cypress Creek near Houston, Texas, 2000–2004.

[lb/mi^2, pounds per square mile; --, load not computed because analytical value less than minimum reporting level; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine]

Constituent	Daily yield at low flow[1], June 2000–September 2004 (lb/mi^2)			Daily yield at high flow[2], April 2002–November 2004 (lb/mi^2)		
	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia + organic nitrogen, dissolved	0.329	0.885	1.26	9.64	29.6	247
Ammonia nitrogen, dissolved	--	.138	.218	.688	2.40	11.1
Nitrite + nitrate nitrogen, dissolved	2.53	5.05	11.7	8.18	9.60	45.0
Nitrogen, total	2.93	4.71	12.9	18.9	73.3	255
Orthophosphate phosphorus, dissolved	.89	1.05	2.86	.820	6.00	19.0
Phosphorus, dissolved	.92	1.09	2.82	3.61	8.20	20.4
Phosphorus, total	.96	1.21	3.10	7.23	23.6	40.8
Suspended sediment	7.64	14.9	90.8	1,970	15,100	67,400
Organic carbon, dissolved	2.16	5.27	9.78	134	401	1,800
Atrazine, dissolved	6.4×10^{-05}	.0003	.010	.009	.027	1.84
CIAT, dissolved	8.12×10^{-06}	2.96×10^{-05}	.0005	.0003	.001	.023
Diazinon, dissolved	--	3.35×10^{-05}	.001	.0003	.003	.101
Simazine, dissolved	--	6.79×10^{-06}	.0002	6.1×10^{-05}	.011	.080

[1]Instantaneous flow less than 100 cubic feet per second.

[2]Instantaneous flow greater than 350 cubic feet per second or median flow greater than 900 cubic feet per second.

Table 9. Summary of minimum, median, and maximum yields of selected constituents at low flows and high flows in East Fork San Jacinto River near Houston, Texas, 2000–2004.

[lb/mi^2, pounds per square mile; --, load not computed because analytical value less than minimum reporting level; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine]

Constituent	Daily yield at low flow[1], June 2000–September 2004 (lb/mi^2)			Daily yield at high flow[2], April 2002–November 2004 (lb/mi^2)		
	Minimum	Median	Maximum	Minimum	Median	Maximum
Ammonia + organic nitrogen, dissolved	0.027	0.124	0.937	6.53	10.9	41.9
Ammonia nitrogen, dissolved	--	--	.062	--	--	--
Nitrite + nitrate nitrogen, dissolved	--	.091	.292	--	--	1.47
Nitrogen, dissolved	.040	.252	1.14	--	--	--
Phosphorus, dissolved	.003	.013	.048	.302	.516	3.39
Phosphorus, total	--	.038	.162	1.03	2.34	8.74
Suspended sediment	2.56	18.2	71.4	847	4,000	6,430
Organic carbon, dissolved	.545	2.69	20.8	180	287	1,360
Atrazine, dissolved	--	--	3.75×10^{-05}	--	.0006	.004
CIAT, dissolved	--	--	--	--	--	.0001
Diazinon, dissolved	--	--	2.29×10^{-05}	--	.0004	.0009

[1]Instantaneous flow less than 200 cubic feet per second.

[2]Instantaneous flow greater than 400 cubic feet per second or median flow greater than 900 cubic feet per second.

The median daily storm load of total nitrogen for high-flow samples (table 6) in Cypress Creek was more than 15 times larger than the median daily load for low-flow samples. The principal contributor to the total nitrogen load at low flows was nitrite plus nitrate nitrogen; at high flows, the principal contributor was ammonia plus organic nitrogen.

Dissolved nitrogen loads in East Fork San Jacinto River could not be computed for all samples when concentrations of nitrite plus nitrate nitrogen, a part of the computation, were less than the MRL. Where relative contributions could be determined, organic nitrogen was the dominant form of dissolved nitrogen (table 7).

Computed low-flow and high-flow yields of nitrogen compounds (tables 8, 9) were appreciably larger in Cypress Creek than in East Fork San Jacinto River. Differences were most apparent at high flows, when surface runoff was a large contributor to measured concentrations. In Cypress Creek, storm yields of nitrite plus nitrate nitrogen during high flows ranged from about 8 to 45 pounds per square mile per day. In East Fork San Jacinto River, the maximum storm yield of nitrite plus nitrate nitrogen for high flows was 1.47 pounds per square mile per day.

The median daily load of dissolved phosphorus for low flows in Cypress Creek was about 65 times larger than that from East Fork San Jacinto River; the median daily load for high flows was about 12 times larger (tables 6, 7). At both sites, loads and yields of phosphorus increased considerably with discharge. In Cypress Creek, the median daily storm load of dissolved phosphorus for high flows (2,500 pounds) was 7.5 times larger than the median daily load for low flows (332 pounds) (table 6); in East Fork San Jacinto River, the median daily storm load of dissolved phosphorus for high flows (208 pounds) was 41 times larger than the median daily load for low flows (5.10 pounds) (table 7). Corresponding daily yields from Cypress Creek for low flows (1.09 pounds per square mile) and for high flows (8.20 pounds per square mile) (table 8) were 84 and 16 times, respectively, larger than corresponding daily yields from East Fork San Jacinto River for low flows (0.013 pound per square mile) and high flows (0.516 pound per square mile) (table 9).

Both Cypress Creek and East Fork San Jacinto River delivered considerable sediment loads to Lake Houston, especially during high flows. At Cypress Creek, the median daily storm load of suspended sediment for high flows was more than 1,000 times larger than the median daily load for low flows (table 6); the median daily storm load of suspended sediment for high flows in East Fork San Jacinto River was about 220 times larger than the median daily load for low flows (table 7). The median daily yield of suspended sediment for low flows was larger in East Fork San Jacinto River than in Cypress Creek, but the relation was reversed for high flows. The larger median daily storm yield of suspended sediment for high flows (3.8 times larger in Cypress Creek than in East Fork San Jacinto River) could reflect larger impermeable surface area associated with urbanization, loss of vegetation, and increased runoff to the stream. The maximum daily storm yield of suspended sediment for high flows was 67,400 pounds per square mile from Cypress Creek (table 8) and 6,430 pounds per square mile from East Fork San Jacinto River (table 9).

Median daily yields of dissolved organic carbon were larger in Cypress Creek than in East Fork San Jacinto River. The median daily yield of dissolved organic carbon for low flows in the Cypress Creek watershed was 5.27 pounds per square mile, and the median daily storm yield for high flows was 401 pounds per square mile (table 8). In East Fork San Jacinto River, median daily low-flow and storm yields of dissolved organic carbon were 2.69 and 287 pounds per square mile, respectively (table 9).

Data collected during this project supported national findings (U.S. Geological Survey, 1999) that urban areas can be a substantial source of pesticides. Concentrations of pesticides in Cypress Creek and East Fork San Jacinto River, as well as loads and yields, corresponded to the intensity of urbanization in the respective watersheds. Although daily loads and yields for most pesticides were small, the maximum daily load of atrazine for high flows from Cypress Creek was 562 pounds (table 6); the corresponding maximum daily yield for high flows was 1.84 pounds per square mile (table 8), 460 times larger than the maximum daily yield for high flows from East Fork San Jacinto River of 0.004 pound per square mile (table 9). However, because water for pesticide analyses was collected as discrete samples, and not during an entire storm, large atrazine concentrations might represent a slug of the compound in the water; the load and yield from the entire high-flow period might have been considerably different.

Water-Quality Trends, 1990–2004

Tests to indicate trends in the concentrations of selected constituents were done for each Lake Houston site. Initially, graphs of constituent concentrations with time were made to provide insight into possible trends. Seasonal Kendall tests were run on all of the data for each of the three sites, respectively. Then the data for each site were grouped by season and Kendall's tau tests were run to indicate possible trends during each season at a single site over time. The concentrations of most constituents at Lake Houston sites showed no trend during 1990–2004; however significant trends overall or for particular seasons, or both, were detected at some sites for nitrite plus nitrate nitrogen, dissolved phosphorus, dissolved organic carbon, chlorophyll-*a*, and diazinon (table 10).

The 1990–2004 dataset for nitrite plus nitrate nitrogen concentrations contained many nondetections and measured values only slightly larger than the reporting limit; therefore a graph of the constituent over time did not provide insight into possible trends. Seasonal Kendall tests indicated no significant trends in the collective data for each site. Kendall's tau tests on the data separated by season indicated one significant trend at site EC. Winter samples yielded an upward trend ($p = .005$).

Tests of the collective dissolved phosphorus data for 1990–2004 at each of the three sites showed significant downward trends at sites AC and EC ($p = .05$ and .012, respectively).

Table 10. Summary of statistical tests for trends in nitrite plus nitrate nitrogen, dissolved phosphorus, dissolved organic carbon, chlorophyll-*a*, and diazinon at three sites in Lake Houston near Houston, Texas, 1990–2004.

[Only constituents at sites with trends listed]

Constituent	Site	Statistical test	p-value	Results
Nitrite plus nitrate nitrogen, dissolved	EC	Kendall's tau	.005	Upward trend in winter
Phosphorus, dissolved	AC	Seasonal Kendall	.05	Downward trend overall
	EC	Seasonal Kendall	.012	Downward trend overall
	EC	Kendall's tau	.052	Downward trend in summer
Organic carbon, dissolved	AC	Seasonal Kendall	.017	Downward trend overall
	EC	Seasonal Kendall	.026	Downward trend overall
	FC	Seasonal Kendall	.064	Downward trend overall
Chlorophyll-*a* phytoplankton	AC	Seasonal Kendall	.051	Upward trend overall
	AC	Kendall's tau	.042	Upward trend in summer
Diazinon, dissolved	AC	Seasonal Kendall	.004	Downward trend overall[1]

[1]Period 2000–2004 only.

When concentrations by season were analyzed separately, a downward trend was indicated for summer concentrations at site EC, but the level of significance was .052.

Concentrations of dissolved organic carbon at sites AC and EC trended significantly downward for 1990–2004 (p = .017 and .026, respectively). The concentrations at site FC also trended downward, but the level of significance was .064. No significant trends were indicated in the seasonal data.

There was one trend indicated in the collective chlorophyll-*a* data for 1990–2004. The seasonal Kendall test yielded an upward trend at a significance level of .051 for site AC. When data were analyzed separately by season, site AC showed a significant upward trend (p = .042) for summer concentrations.

Pesticide data were not available before 2000. Tests of atrazine and simazine yielded no significant trends in the 2000–2004 data. Diazinon showed a significant downward trend (p = .004) in collective concentrations at site AC. No seasonal trends were indicated.

Implications

Overall, the spatial distribution of chemical constituents in Lake Houston followed a general pattern of largest concentrations at site FC, smallest concentrations at site EC, and intermediate concentrations at site AC near the dam. Although there were few constituent trends in the lake relative to the number of constituents assessed, the findings indicate that urbanization in the western subbasin probably has affected water quality of streams flowing from the subbasin to Lake Houston. The findings also indicate that loads of nutrients, pesticides, and sediment supplied to the lake from the western subbasin could be large, especially during high flows. Moreover, although there was either no change or a decrease in most nutrient concentrations, chlorophyll-*a* concentrations showed an overall increase at site AC, which implies that factors other than nutrients might be important to algal growth in the lake. Collection and analysis of more frequent water samples at both stream inflow and lake sites could provide better resolution of the temporal supply of nutrients, pesticides, and sediment to Lake Houston and allow more comprehensive analysis of their effect on the lake.

Summary

Lake Houston is a major source of public water supply and recreational resource for the Houston metropolitan area, Texas. Because of its proximity to Houston, possible effects of urbanization on the quality of inflows to the lake and on the lake have been of concern to water managers. Although not on the State of Texas 2002 303(d) list for impairment by any water-quality constituents, Lake Houston was listed with "concerns" for nutrient enrichment (orthophosphorus, total phosphorus, nitrite plus nitrate nitrogen) and for aquatic life use (dissolved oxygen). Previous studies have found sufficient nutrients to cause problematic algal blooms as well as contaminants associated with urbanization in bed sediments. The Lake Houston drainage basin can be divided into two subbasins, the eastern subbasin, which is largely woodland, and the western subbasin, which is more urbanized. Land-cover types (developed and cultivated) that are related to an increased potential for nutrients and pesticide compounds in storm runoff encompass about three times the area in the western subbasin as in the eastern subbasin.

This report, prepared in cooperation with the City of Houston, assesses the water quality of Lake Houston on the basis of data collected during 2000–2004 and possible trends in selected

constituents on the basis of data collected during 1990–2004. Water-quality samples were collected in Lake Houston, as well as at Cypress Creek (in the western subbasin) and East Fork San Jacinto River (in the eastern subbasin), during 2000–2004. Nitrogen compounds, phosphorus, suspended sediment, organic carbon, turbidity, and selected pesticide concentrations in water samples were assessed at all sites. Loads and yields were computed for selected constituents in Cypress Creek and East Fork San Jacinto River. Statistical tests used data collected during this study with previously collected data to identify possible water-quality trends in Lake Houston during 1990–2004.

Three sites were sampled in Lake Houston. These sites characterized water available to the City of Houston pumping station (site AC), water entering the lake from largely rural eastern watersheds (site EC), and water entering the lake from urbanized, western watersheds (site FC). Patterns of chemical and biological constituents in Lake Houston were affected by sedimentation and the water quality of inflowing streams. In general, conditions at the upstream end of the lake (sites EC and FC) were dominated by stream processes; site AC, near the dam, was dominated by lacustrine conditions. Most biological and chemical concentrations were largest at site FC, smallest at site EC, and intermediate at site AC.

Organic nitrogen was the dominant form of nitrogen in samples collected in Lake Houston. Nitrite plus nitrate nitrogen concentrations were largest near inflows from the more urbanized, western part of the drainage basin (site FC). Nitrite plus nitrate nitrogen contributed about 25 percent of the dissolved nitrogen in the lake near inflows (site EC) from the eastern subbasin. Concentrations of nitrite plus nitrate and ammonia plus organic nitrogen near the dam (site AC) were intermediate to those at sites EC and FC. About 63 percent of the total nitrogen at site AC was ammonia plus organic nitrogen. Total phosphorus concentrations in more than 97 percent of all samples were larger than 0.025 mg/L, the level recommended by the USEPA to limit aquatic growth. There was a wide range in suspended-sediment concentrations and in turbidity in the lake. The majority of suspended-sediment concentrations ranged from 6 to 98 mg/L; concentrations at site FC were about twice those measured at site EC and three times those at AC. Turbidity ranged from 7 to 270 NTUs in Lake Houston. The maximum turbidity at site AC was about 10 times greater than the median value at that site. Concentrations of chlorophyll-*a* in Lake Houston were small. Median values ranged from 6.8 µg/L at site AC to 16.4 µg/L at site FC. Twelve pesticides were detected. Atrazine and its breakdown product, 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT), were the most commonly detected pesticides; atrazine concentrations were larger than the USEPA MCL of 3.0 µg/L in two samples at site FC.

The relative contributions to the water quality of Lake Houston from the eastern and western subbasins were examined by collecting water samples from the inflow streams, Cypress Creek and East Fork San Jacinto River. At Cypress Creek, nitrite plus nitrate nitrogen accounted for about 86 percent of total nitrogen during low flows; at high flows, organic nitrogen contributed about 66 percent of the total nitrogen. Organic nitrogen was the dominant form of dissolved nitrogen at both low flows (about 60 percent) and high flows (about 88 percent) in East Fork San Jacinto River.

In Cypress Creek, about 94 percent of the total phosphorus at low flows was dissolved; at high flows about 50 percent was dissolved. Dissolved phosphorus concentrations exceeded 0.05 mg/L in all samples at Cypress Creek. Dissolved phosphorus concentrations were about 10 times larger in Cypress Creek than in East Fork San Jacinto River. All samples at East Fork San Jacinto River had dissolved phosphorus detections; concentrations were less than 0.05 mg/L.

Fifteen pesticides were detected in samples at Cypress Creek. Atrazine was detected in all samples at Cypress Creek; concentrations in three of 17 samples exceeded the USEPA MCL of 3.0 µg/L. The largest concentration was 21.3 µg/L (high-flow sample). CIAT, diazinon, and simazine were detected in more than 82 percent of the samples. In samples at East Fork San Jacinto River, atrazine was the most frequently detected pesticide, present in six of 15 samples. The maximum atrazine concentration was 0.233 µg/L (high-flow sample). Diazinon was detected in five of 15 samples.

Constituent loads from the Cypress Creek and East Fork San Jacinto River watersheds were positively correlated with discharge. In Cypress Creek, the median daily storm load of total nitrogen for high flows was more than 15 times larger than the median daily load of total nitrogen for low flows; the median daily storm load of dissolved phosphorus for high flows was 7.5 times the median daily load for low flows; the median daily storm load of suspended sediment for high flows was more than 1,000 times the median daily load for low flows. In East Fork San Jacinto River, the median daily storm load of dissolved phosphorus for high flows was about 41 times larger than the median daily load for low flows; the median daily storm load of suspended sediment for high flows was about 220 times larger than the median daily load for low flows.

Constituent yields, which normalize differences in watershed size, allowed for direct comparison of loads from Cypress Creek and East Fork San Jacinto River. Daily yields of constituents in Cypress Creek were larger than those in East Fork San Jacinto River, especially during high flows. Daily yields of nitrite plus nitrate nitrogen for high flows ranged from about 8 to 45 pounds per square mile from Cypress Creek. In East Fork San Jacinto River, only the maximum daily yield of nitrite plus nitrate nitrogen, 1.47 pounds per square mile, could be computed for high flows. Median daily yields of dissolved phosphorus from Cypress Creek for low flows (1.09 pounds per square mile) and median daily yields for high flows (8.20 pounds per square mile) were 84 and 16 times larger, respectively, than corresponding yields from East Fork San Jacinto River for low flows (0.013 pound per square mile) and high flows (0.516 pound per square mile). The median daily yield of suspended sediment for low flows was larger from East Fork San Jacinto River than in Cypress Creek; however, at high flows, the relation was reversed. This reversal could reflect increased impermeable surface area associated with urbanization in the

Cypress Creek watershed, loss of vegetation, and increased stream runoff. The maximum daily yield of suspended sediment computed during this study for high flows was 67,400 pounds per square mile from Cypress Creek. Daily yields of most pesticides were small; however the maximum daily yield of atrazine from the Cypress Creek watershed was 1.84 pounds per square mile. In contrast, the maximum daily yield of atrazine from East Fork San Jacinto River was 0.004 pound per square mile.

Concentrations of selected constituents in water samples from the Lake Houston sites for 1990–2004 were tested for trends. Seasonal Kendall tests were run on all of the data for each of the three sites, respectively. Kendall's tau tests were run on the data for each site grouped by season. The concentrations of most constituents at Lake Houston sites showed no trend for 1990–2004; however significant trends overall or for particular seasons, or both, were detected at some sites for nitrite plus nitrate nitrogen, dissolved phosphorus, dissolved organic carbon, chlorophyll-*a*, and diazinon (2000–2004 data only for diazinon).

Overall, the spatial distribution of chemical constituents in Lake Houston followed a general pattern of largest concentrations at site FC, smallest concentrations at site EC, and intermediate concentrations at site AC. Although there were few constituent trends in the lake relative to the number of constituents assessed, the findings indicate that urbanization in the western subbasin probably has affected water quality of streams flowing into Lake Houston. Collection of a much larger number of water samples at each site could provide better resolution of the temporal supply of nutrients, pesticides, and sediment to Lake Houston and allow more comprehensive analysis of their effect on the lake.

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Appendixes

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Appendix 1. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site AC, February 2000–September 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; <, less than; m, meters; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; --, not applicable or not computed; cols./100 mL, colonies per 100 milliliters, E, estimated; µg/L, micrograms per liter]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	15	0.1	15	124	158	192	232	327
pH, unfiltered (standard units)	15	.1	15	7.2	7.3	7.6	7.9	8.4
Water temperature (°C)	15	.1	15	11.3	15.9	27.8	29.4	30.5
Dissolved oxygen (mg/L)	15	.1	15	5.4	5.9	7.4	8.3	10.0
Residue, dissolved (mg/L)	15	10	15	96	102	125	139	190
Residue, suspended (mg/L)	15	10	8	<10	<10	10	14	26
Color (platinum cobalt units)	15	1	15	25	40	80	170	350
Transparency, Secchi depth (m)	15	.01	15	.12	.29	.40	.76	1.15
Turbidity (NTU)	12	1	12	7	11	26	42	270
Suspended sediment (mg/L)	13	1	13	6	9	12	23	709
UV absorbance, 254 nanometers (units/cm)	15	.0035	15	.124	.204	.286	.340	.461
UV absorbance, 280 nanometers (units/cm)	15	.0035	15	.091	.149	.213	.249	.347
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	15	1	15	38	41	48	51	61
Calcium, dissolved	15	.02	15	12.2	13.4	15.9	16.9	19.8
Magnesium, dissolved	15	.008	15	1.72	1.84	2.05	2.27	2.70
Potassium, dissolved	15	.16	15	2.30	2.65	3.18	3.67	3.88
Sodium, dissolved	15	.20	15	8.49	12.3	17.8	25.0	41.3
Alkalinity (as $CaCO_3$), dissolved	14	1	14	25	36	40	56	67
Bicarbonate, dissolved	14	1	14	31	43	48	68	78
Carbonate, dissolved	10	1	1	<1	<1	<1	<1	E2
Chloride, dissolved	15	.20	15	13.7	16.5	22.1	28.3	47.6
Fluoride, dissolved	15	.20	3	<.20	<.20	<.20	<.20	.20
Sulfate, dissolved	15	.18	15	5.3	6.0	7.4	8.4	12.7
Silica, dissolved	15	.04	15	3.14	7.47	8.45	9.44	11.9
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	15	.10	15	.27	.34	.38	.48	.73
Ammonia + organic nitrogen, total	15	.10	15	.55	.62	.72	.75	.84
Ammonia nitrogen, dissolved	15	.04	1	<.04	<.04	<.04	<.04	E.04
Nitrite + nitrate nitrogen, dissolved	15	.06	9	<.06	<.06	.20	.41	.59
Nitrite nitrogen, dissolved	15	.010	2	<.010	<.010	<.010	<.010	.021
Nitrogen[1], dissolved	9	--	--	.33	.64	.83	1.0	1.1
Nitrogen[1], total	9	--	--	.64	.96	1.1	1.2	1.3
Orthophosphate phosphorus, dissolved	15	.018	15	.03	.05	.06	.12	.16
Phosphorus, dissolved	15	.004	15	.038	.059	.080	.138	.176
Phosphorus, total	15	.004	15	.082	.120	.159	.210	.240
Organic carbon, dissolved	15	.33	15	4.5	6.5	8.4	9.7	12.1
Organic carbon, total	15	.40	15	6.4	8.5	10.7	11.8	14.1

Footnote at end of table.

Appendix 1. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site AC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	15	0.1	15	255	334	364	662	1,370
Plankton, biomass, dry weight	15	.1	15	261	342	373	676	1,420
Biomass/chlorophyll ratio, plankton (number)	13	--	--	330	439	2,020	11,600	30,000
E. coli bacteria (cols./100 mL)	15	1	15	E1	2	34	72	160
Fecal coliform bacteria (cols./100 mL)	15	1	15	E1	4	34	160	380
Fecal streptococcus bacteria (cols./100 mL)	15	1	15	E1	4	28	150	230
Chlorophyll-*a* phytoplankton (µg/L)	15	.1	15	.3	2.1	6.8	13.6	25.8
Chlorophyll-*b* phytoplankton (µg/L)	15	.1	10	<.1	<.1	.3	1.8	2.3
Trace elements (µg/L)								
Aluminum, dissolved	15	1.6	15	2.0	3.0	4.0	8.0	523
Antimony, dissolved	15	.2	4	<.20	<.20	<.20	.22	.35
Arsenic, dissolved	15	2.0	9	<2.0	<2.0	2.0	3.5	8.0
Barium, dissolved	15	.2	15	47	50	56	64	108
Beryllium, dissolved	12	.06	1	<.06	<.06	<.06	<.06	.09
Cadmium, dissolved	12	.04	0	--	--	--	--	--
Chromium, dissolved	14	.8	0	--	--	--	--	--
Cobalt, dissolved	12	.014	12	.096	.118	.164	.247	.281
Copper, dissolved	15	.4	15	.8	1.5	1.8	3.0	4.5
Iron, dissolved	15	10	12	<10	11	33	93	545
Lead, dissolved	12	.08	8	<.08	<.08	.13	.21	1.72
Manganese, dissolved	15	.2	15	.40	1.1	2.7	7.0	24.7
Mercury, dissolved	15	.2	0	--	--	--		--
Molybdenum, dissolved	15	.4	15	.40	.50	.80	1.3	1.6
Nickel, dissolved	15	.06	15	.91	1.10	1.20	1.53	1.89
Selenium, dissolved	15	3.0	0	--	--	--	--	--
Silver, dissolved	15	1.0	0	--	--	--	--	--
Uranium, dissolved	12	.04	12	.09	.14	.17	.22	.27
Zinc, dissolved	15	1.0	13	<1.0	1.4	2.8	3.5	53.5
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	15	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	15	.006	15	E.008	E.013	E.029	E.089	E.106
Acetochlor, dissolved	15	.006	0	--	--	--	--	--
Alachlor, dissolved	15	.005	0	--	--	--	--	--
alpha-HCH, dissolved	15	.005	0	--	--	--	--	--
Atrazine, dissolved	15	.007	15	.082	.171	.511	.883	1.920
Azinphos-methyl, dissolved	15	.050	0	--	--	--	--	--
Benfluralin, dissolved	15	.010	0	--	--	--	--	--
Butylate, dissolved	15	.004	0	--	--	--	--	--
Carbaryl, dissolved	15	.041	1	<.041	<.041	<.041	<.041	E.072
Carbofuran, dissolved	15	.020	0	--	--	--	--	--
Chlorpyrifos, dissolved	15	.005	0	--	--	--	--	--

Footnote at end of table.

Appendix 1. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site AC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)—Continued								
cis-Permethrin, dissolved	15	0.006	0	--	--	--	--	--
Cyanazine, dissolved	15	.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	15	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	6	.012	0	--	--	--	--	--
Diazinon, dissolved	15	.010	13	<0.010	0.016	0.020	0.064	0.179
Dieldrin, dissolved	15	.009	0	--	--	--	--	--
Disulfoton, dissolved	15	.020	0	--	--	--	--	--
EPTC, dissolved	15	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	15	.009	0	--	--	--	--	--
Ethopropos, dissolved	15	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	6	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	6	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	6	.024	0	--	--	--	--	--
Fipronil, dissolved	6	.016	0	--	--	--	--	--
Fonofos, dissolved	15	.003	0	--	--	--	--	--
Lindane, dissolved	15	.004	0	--	--	--	--	--
Linuron, dissolved	15	.035	0	--	--	--	--	--
Malathion, dissolved	15	.027	0	--	--	--	--	--
Methyl parathion, dissolved	15	.015	0	--	--	--	--	--
Metolachlor, dissolved	15	.013	5	<.013	<.013	<.013	.020	.054
Metribuzin, dissolved	15	.006	0	--	--	--	--	--
Molinate, dissolved	15	.004	1	<.004	<.004	<.004	<.004	.017
Napropamide, dissolved	15	.007	0	--	--	--	--	--
p,p'-DDE, dissolved	15	.006	0	--	--	--	--	--
Parathion, dissolved	15	.010	0	--	--	--	--	--
Pebulate, dissolved	15	.004	0	--	--	--	--	--
Pendimethalin, dissolved	15	.022	0	--	--	--	--	--
Phorate, dissolved	15	.011	0	--	--	--	--	--
Prometon, dissolved	14	.010	7	<.010	<.010	<.010	E.010	E.010
Propyzamide, dissolved	15	.004	6	<.004	<.004	<.004	.011	.020
Propachlor, dissolved	15	.025	0	--	--	--	--	--
Propanil, dissolved	15	.011	0	--	--	--	--	--
Propargite, dissolved	15	.020	0	--	--	--	--	--
Simazine, dissolved	14	.005	13	<.005	.030	.043	.131	.211
Tebuthiuron, dissolved	15	.020	4	<.020	<.020	<.020	.040	.080
Terbacil, dissolved	15	.034	0	--	--	--	--	--
Terbufos, dissolved	15	.020	0	--	--	--	--	--
Thiobencarb, dissolved	15	.010	0	--	--	--	--	--
Tri-allate, dissolved	15	.002	0	--	--	--	--	--
Trifluralin, dissolved	15	.009	0	--	--	--	--	--

[1] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 2. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site EC, February 2000–September 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; <, less than; m, meters; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; --, not applicable or not computed; cols./100 mL, colonies per 100 milliliters, E, estimated; µg/L, micrograms per liter]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	15	0.1	15	60	150	192	220	280
pH, unfiltered (standard units)	15	.1	15	6.5	7.2	7.5	8.2	8.9
Water temperature (°C)	15	.1	15	11.8	18.9	28.3	30.9	32.7
Dissolved oxygen (mg/L)	15	.1	15	4.1	6.0	7.2	8.6	10.1
Residue, dissolved (mg/L)	14	10	14	63	106	127	142	158
Residue, suspended (mg/L)	15	10	13	<10	13	20	25	40
Color (platinum cobalt units)	15	1	15	30	52	100	125	200
Transparency, Secchi depth (m)	15	.01	15	.16	.30	.33	.50	.55
Turbidity (NTU)	11	1	15	19	21	27	38	58
Suspended sediment (mg/L)	13	1	15	16	18	23	42	767
UV absorbance, 254 nanometers (units/cm)	14	.0035	14	.194	.227	.283	.392	.536
UV absorbance, 280 nanometers (units/cm)	14	.0035	14	.142	.165	.209	.294	.399
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	14	1	14	17	40	44	50	66
Calcium, dissolved	14	.02	14	5.4	12.9	14.4	15.9	21.6
Magnesium, dissolved	14	.008	14	.93	1.97	2.13	2.28	2.92
Potassium, dissolved	14	.16	14	1.29	1.94	2.86	3.26	3.87
Sodium, dissolved	14	.20	14	3.58	11.8	18.0	23.4	33.4
Alkalinity (as $CaCO_3$), dissolved	13	1	13	12	30	41	48	60
Bicarbonate, dissolved	13	1	13	14	36	50	59	73
Carbonate, dissolved	9	1	0	--	--	--	--	--
Chloride, dissolved	14	.20	14	5.54	18.8	24.4	30.3	40.0
Fluoride, dissolved	14	.20	3	<.20	<.20	<.20	<.20	.20
Sulfate, dissolved	14	.18	14	2.9	6.0	7.2	8.8	9.1
Silica, dissolved	14	.04	14	4.5	7.4	8.5	10.4	12.4
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	14	.10	14	.25	.34	.41	.45	.55
Ammonia + organic nitrogen, total	15	.10	15	.47	.66	.74	.79	.97
Ammonia nitrogen, dissolved	14	.04	1	<.04	<.04	<.04	<.04	.04
Nitrite + nitrate nitrogen, dissolved	14	.06	9	<.06	<.06	.10	.21	.41
Nitrite nitrogen, dissolved	14	.010	1	<.010	<.010	<.010	<.010	.017
Nitrogen[1], dissolved	9	--	--	.40	.50	.60	.66	.88
Nitrogen[1], total	9	--	--	.76	.84	.88	.96	1.1
Orthophosphate phosphorus, dissolved	14	.020	11	<.020	.026	.045	.075	.100
Phosphorus, dissolved	14	.004	13	<.004	.035	.058	.091	.121
Phosphorus, total	15	.004	15	.037	.082	.105	.190	.208
Organic carbon, dissolved	15	.33	15	3.7	6.6	7.9	10.2	14.8
Organic carbon, total	15	.40	15	6.7	8.4	10.9	13.3	15.5

Footnote at end of table.

Appendix 2. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site EC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	14	0.1	14	322	362	462	676	1,370
Plankton, biomass, dry weight	14	.1	14	331	373	471	691	1,400
Biomass/chlorophyll ratio, plankton (number)	11	--	--	286	529	655	3,420	8,300
E. coli bacteria (cols./100 mL)	15	1	15	E2	7	18	40	190
Fecal coliform bacteria (cols./100 mL)	15	1	15	E1	1	12	60	680
Fecal streptococcus bacteria (cols./100 mL)	15	1	15	E1	4	16	48	580
Chlorophyll-*a* phytoplankton (µg/L)	15	.1	14	<.1	3.1	9.2	17.6	34.3
Chlorophyll-*b* phytoplankton (µg/L)	15	.1	13	<.1	.2	.8	1.2	2.2
Trace elements (µg/L)								
Aluminum, dissolved	14	1.6	14	2.0	3.0	8.5	22	70
Antimony, dissolved	10	.20	1	<.20	<.20	<.20	<.20	.25
Arsenic, dissolved	14	2.0	6	<2.0	<2.0	<2.0	3.0	4
Barium, dissolved	14	.2	14	33	51	59	60	65
Beryllium, dissolved	11	.06	1	<.06	<.06	<.06	<.06	.6
Cadmium, dissolved	11	.04	0	--	--	--	--	--
Chromium, dissolved	13	.8	0	--	--	--	--	--
Cobalt, dissolved	11	.014	11	.082	.177	.213	.258	.364
Copper, dissolved	14	.4	14	1.2	1.4	1.7	1.8	3.0
Iron, dissolved	14	10	13	<10	21	40	176	273
Lead, dissolved	11	.08	8	<.08	<.08	.13	.22	.35
Manganese, dissolved	14	1.0	12	<1.0	2.6	8.6	24.5	34.5
Mercury, dissolved	14	.20	0	--	--	--	--	--
Molybdenum, dissolved	13	.4	11	<.4	.40	.70	1.0	1.8
Nickel, dissolved	14	.06	14	.84	1.05	1.17	1.48	2.17
Selenium, dissolved	14	3.0	0	--	--	--	--	--
Silver, dissolved	14	1.0	0	--	--	--	--	--
Uranium, dissolved	11	.04	11	.09	.11	.15	.19	.26
Zinc, dissolved	14	1.0	12	<1.0	1.0	1.6	2.6	6.5
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	15	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	15	.006	13	<.006	E.007	E.013	E.057	E.107
Acetochlor, dissolved	15	.006	0	--	--	--	--	--
Alachlor, dissolved	15	.005	0	--	--	--	--	--
alpha-HCH, dissolved	15	.005	0	--	--	--	--	--
Atrazine, dissolved	15	.007	15	.043	.110	.369	.612	1.800
Azinphos-methyl, dissolved	15	.050	0	--	--	--	--	--
Benfluralin, dissolved	15	.010	0	--	--	--	--	--
Butylate, dissolved	15	.004	0	--	--	--	--	--
Carbaryl, dissolved	15	.041	1	<.041	<.041	<.041	<.041	E1.81
Carbofuran, dissolved	15	.020	0	--	--	--	--	--

Footnote at end of table.

Appendix 2. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site EC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)—Continued								
Chlorpyrifos, dissolved	15	0.005	0	--	--	--	--	--
cis-Permethrin, dissolved	15	.006	0	--	--	--	--	--
Cyanazine, dissolved	15	.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	15	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	6	.012	0	--	--	--	--	--
Diazinon, dissolved	15	.010	11	<0.010	<0.010	0.020	0.039	0.181
Dieldrin, dissolved	15	.009	0	--	--	--	--	--
Disulfoton, dissolved	15	.020	0	--	--	--	--	--
EPTC, dissolved	15	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	15	.009	0	--	--	--	--	--
Ethopropos, dissolved	15	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	6	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	6	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	6	.024	0	--	--	--	--	--
Fipronil, dissolved	6	.016	0	--	--	--	--	--
Fonofos, dissolved	15	.003	0	--	--	--	--	--
Lindane, dissolved	15	.004	0	--	--	--	--	--
Linuron, dissolved	15	.035	0	--	--	--	--	--
Malathion, dissolved	15	.027	0	--	--	--	--	--
Methyl parathion, dissolved	15	.015	0	--	--	--	--	--
Metolachlor, dissolved	15	.013	4	<.013	<.013	<.013	.014	.029
Metribuzin, dissolved	15	.006	0	--	--	--	--	--
Molinate, dissolved	15	.004	1	<.004	<.004	<.004	<.004	.017
Napropamide, dissolved	15	.007	0	--	--	--	--	--
p,p'-DDE, dissolved	15	.006	0	--	--	--	--	--
Parathion, dissolved	15	.010	0	--	--	--	--	--
Pebulate, dissolved	15	.004	0	--	--	--	--	--
Pendimethalin, dissolved	15	.022	0	--	--	--	--	--
Phorate, dissolved	15	.011	0	--	--	--	--	--
Prometon, dissolved	13	.010	7	<.010	<.010	E.010	E.010	E.010
Propyzamide, dissolved	13	.004	3	<.004	<.004	<.004	<.004	.012
Propachlor, dissolved	15	.025	0	--	--	--	--	--
Propanil, dissolved	15	.011	0	--	--	--	--	--
Propargite, dissolved	15	.020	0	--	--	--	--	--
Simazine, dissolved	15	.009	13	<.009	.010	.025	.058	.172
Tebuthiuron, dissolved	15	.020	4	<.020	<.020	<.020	.020	.070
Terbacil, dissolved	15	.034	0	--	--	--	--	--
Terbufos, dissolved	15	.020	0	--	--	--	--	--
Thiobencarb, dissolved	15	.010	0	--	--	--	--	--
Tri-allate, dissolved	15	.002	0	--	--	--	--	--
Trifluralin, dissolved	15	.009	0	--	--	--	--	--

[1] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 3. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site FC, February 2000–September 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; m, meters; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; <, less than; --, not applicable or not computed; cols./100 mL, colonies per 100 milliliters, E, estimated; µg/L, micrograms per liter]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	15	0.1	15	111	240	331	465	490
pH, unfiltered (standard units)	15	.1	15	7.0	7.5	8.0	8.9	9.1
Water temperature (°C)	15	.1	15	12.5	20.8	27.8	31.0	32.8
Dissolved oxygen (mg/L)	15	.1	15	5.0	5.7	8.0	9.7	11.5
Residue, dissolved (mg/L)	14	10	14	83	147	203	263	299
Residue, suspended (mg/L)	15	10	15	14	30	38	49	126
Color (platinum cobalt units)	15	1	15	40	70	100	200	250
Transparency, Secchi depth (m)	15	.01	15	.10	.20	.25	.36	.49
Turbidity (NTU)	12	1	12	22	37	48	78	160
Suspended sediment (mg/L)	13	1	13	31	40	43	83	741
UV absorbance, 254 nanometers (units/cm)	14	.0035	14	.172	.199	.218	.294	.437
UV absorbance, 280 nanometers (units/cm)	14	.0035	14	.131	.148	.160	.220	.331
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	14	1	14	30	50	62	75	83
Calcium, dissolved	14	.02	14	9.6	16.2	20.4	24.7	26.9
Magnesium, dissolved	14	.008	14	1.39	2.42	2.88	3.24	3.76
Potassium, dissolved	14	.16	14	2.43	3.64	4.62	5.09	6.39
Sodium, dissolved	14	.20	14	8.33	22.6	36.3	61.0	66.7
Alkalinity (as $CaCO_3$), dissolved	13	1	13	24	50	61	84	113
Bicarbonate, dissolved	13	1	13	26	50	69	100	112
Carbonate, dissolved	10	1	4	<1	<1	<1	12	24
Chloride, dissolved	14	.20	14	9.5	27.2	40.4	63.2	78.1
Fluoride, dissolved	14	.20	10	<.20	<.20	.20	.30	.90
Sulfate, dissolved	14	.18	14	4.7	9.6	13.0	16.2	20.2
Silica, dissolved	14	.04	14	5.07	7.21	9.16	11.6	13.0
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	14	.10	14	.40	.49	.53	.56	.65
Ammonia + organic nitrogen, total	15	.10	15	.55	.97	1.10	1.30	1.50
Organic nitrogen[1], dissolved	6	--	--	.38	.42	.44	.55	.59
Organic nitrogen[1], total	6	--	--	.44	.77	1.10	1.42	1.50
Ammonia nitrogen, dissolved	14	.04	6	<.04	<.04	<.04	.09	.12
Nitrate[2] nitrogen, dissolved	9	--	--	.12	.28	.83	1.58	2.66
Nitrite + nitrate nitrogen, dissolved	14	.05	11	<.05	.05	.30	1.18	2.70
Nitrite nitrogen, dissolved	14	.010	7	<.010	<.010	.010	.035	.043
Nitrogen[3], dissolved	11	--	--	.61	.71	1.4	2.1	3.1
Nitrogen[3], total	11	--	--	1.2	1.4	1.7	2.7	4.1
Orthophosphate phosphorus, dissolved	14	.018	14	.060	.160	.240	.355	.570
Phosphorus, dissolved	14	.004	14	.081	.183	.260	.380	.620
Phosphorus, total	15	.004	15	.128	.290	.420	.490	.800
Organic carbon, dissolved	15	.33	15	5.2	7.1	7.5	8.7	11.0
Organic carbon, total	15	.40	15	9.5	11.4	12.0	13.2	14.5

Footnote at end of table.

Appendix 3. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site FC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	14	0.1	14	350	361	447	694	1,410
Plankton, biomass, dry weight	14	.1	14	358	373	456	716	1,440
Biomass/chlorophyll ratio, plankton (number)	12	--	--	186	357	604	6,180	13,800
E. coli bacteria (cols./100 mL)	15	1	15	E1	20	28	88	270
Fecal coliform bacteria (cols./100 mL)	15	1	15	E2	4	44	120	850
Fecal streptococcus bacteria (cols./100 mL)	15	1	15	E4	15	38	130	1,100
Chlorophyll-*a* phytoplankton (µg/L)	15	.1	15	1.2	3.1	16.4	28.1	53.9
Chlorophyll-*b* phytoplankton (µg/L)	15	.1	13	<.1	.3	1.2	2.1	4.0
Trace elements (µg/L								
Aluminum, dissolved	14	1.6	14	2.0	3.8	6.0	7.8	52
Antimony, dissolved	14	.2	8	<.2	<.2	.23	.29	.32
Arsenic, dissolved	14	2.0	12	<2.0	2.0	2.0	6.0	6.0
Barium, dissolved	14	.2	14	49	59	66	74	89
Beryllium, dissolved	14	.06	0	--	--	--	--	--
Cadmium, dissolved	14	.04	1	<.04	<.04	<.04	<.04	.04
Chromium, dissolved	14	.8	0	--	--	--	--	--
Cobalt, dissolved	14	.014	14	.225	.339	.485	.922	1.88
Copper, dissolved	14	.4	14	1.7	2.0	2.3	2.5	3.5
Iron, dissolved	14	10	8	<10	<10	10	56	157
Lead, dissolved	14	.08	10	<.08	.08	.18	.26	.37
Manganese, dissolved	14	1.0	13	<1.0	1.6	3.0	18.0	40.7
Mercury, dissolved	14	.20	0	--	--	--	--	--
Molybdenum, dissolved	14	.4	14	.6	1.0	1.9	2.8	3.8
Nickel, dissolved	14	.06	14	.94	1.17	1.36	2.00	2.72
Selenium, dissolved	14	3.0	0	--	--	--	--	--
Silver, dissolved	14	1.0	0	--	--	--	--	--
Uranium, dissolved	11	.04	11	.14	.20	.29	.54	.97
Zinc, dissolved	14	1.0	13	<1.0	1.9	2.6	4.0	8.5
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	15	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	15	.006	15	E.007	E.020	E.050	E.076	E.152
Acetochlor, dissolved	15	.006	0	--	--	--	--	--
Alachlor, dissolved	15	.005	0	--	--	--	--	--
alpha-HCH, dissolved	15	.005	0	--	--	--	--	--
Atrazine, dissolved	15	.007	15	.114	.289	.566	1.620	4.450
Azinphos-methyl, dissolved	15	.050	0	--	--	--	--	--
Benfluralin, dissolved	15	.010	0	--	--	--	--	--
Butylate, dissolved	15	.004	0	--	--	--	--	--
Carbaryl, dissolved	15	.041	6	<.041	<.041	<.041	.063	E1.250
Carbofuran, dissolved	15	.020	0	--	--	--	--	--
Chlorpyrifos, dissolved	15	.005	1	<.005	<.005	<.005	<.005	.008
cis-Permethrin, dissolved	15	.006	0	--	--	--	--	--

Footnote at end of table.

Appendix 3. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides at Lake Houston, site FC, February 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)								
Cyanazine, dissolved	15	0.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	15	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	6	.012	0	--	--	--	--	--
Diazinon, dissolved	15	.015	14	<0.015	0.027	0.034	0.123	0.616
Dieldrin, dissolved	15	.009	0	--	--	--	--	--
Disulfoton, dissolved	15	.020	0	--	--	--	--	--
EPTC, dissolved	15‘	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	15	.009	0	--	--	--	--	--
Ethopropos, dissolved	15	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	6	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	6	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	6	.024	0	--	--	--	--	--
Fipronil, dissolved	6	.016	3	<.016	<.016	<.016	E.019	E.019
Fonofos, dissolved	15	.003	0	--	--	--	--	--
Lindane, dissolved	15	.004	0	--	--	--	--	--
Linuron, dissolved	15	.035	0	--	--	--	--	--
Malathion, dissolved	15	.027	0	--	--	--	--	--
Methyl parathion, dissolved	15	.015	0	--	--	--	--	--
Metolachlor, dissolved	15	.013	4	<.013	<.013	<.013	.013	.057
Metribuzin, dissolved	15	.006	0	--	--	--	--	--
Molinate, dissolved	15	.004	1	<.004	<.004	<.004	<.004	.015
Napropamide, dissolved	15	.007	0	--	--	--	--	--
p,p′-DDE, dissolved	15	.006	0	--	--	--	--	--
Parathion, dissolved	15	.010	0	--	--	--	--	--
Pebulate, dissolved	15	.004	0	--	--	--	--	--
Pendimethalin, dissolved	15	.022	0	--	--	--	--	--
Phorate, dissolved	15	.011	0	--	--	--	--	--
Prometon, dissolved	14	.010	9	<.010	<.010	.010	.020	.050
Propyzamide, dissolved	15	.018	3	<.018	<.018	<.018	<.018	.045
Propachlor, dissolved	15	.025	0	--	--	--	--	--
Propanil, dissolved	15	.011	0	--	--	--	--	--
Propargite, dissolved	15	.020	0	--	--	--	--	--
Simazine, dissolved	15	.005	15	E.008	.022	.037	.187	1.210
Tebuthiuron, dissolved	15	.020	6	<.020	<.020	<.020	.040	.120
Terbacil, dissolved	15	.034	0	--	--	--	--	--
Terbufos, dissolved	15	.020	0	--	--	--	--	--
Thiobencarb, dissolved	15	.010	0	--	--	--	--	--
Tri-allate, dissolved	15	.002	0	--	--	--	--	--
Trifluralin, dissolved	15	.009	0	--	--	--	--	--

[1] Ammonia + organic nitrogen minus ammonia nitrogen.

[2] Nitrite + nitrate nitrogen minus dissolved nitrite nitrogen.

[3] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 4. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at Cypress Creek, June 2000–September 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; <, less than; --, not applicable or not computed; cols./100 mL, colonies per 100 milliliters, E, estimated; >, greater than; µg/L, micrograms per liter]

Constituent	Number of analyses	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	10	0.1	10	467	477	678	826	933
pH, unfiltered (standard units)	10	.1	10	7.4	7.5	7.8	8.2	8.6
Water temperature (°C)	10	.1	10	11.5	21.0	28.2	29.8	31.9
Dissolved oxygen (mg/L)	10	.1	10	3.5	5.6	6.7	9.2	9.6
Residue, dissolved (mg/L)	10	10	10	282	286	404	493	551
Residue, suspended (mg/L)	10	10	10	16	24	28	52	53
Color (platinum cobalt units)	10	1	10	15	36	60	125	200
Turbidity (NTU)	8	1	8	14	28	68	83	96
Suspended sediment (mg/L)	8	1	8	13	15	26	48	65
UV absorbance, 254 nanometers (units/cm)	10	1	10	.141	.149	.170	.241	.521
UV absorbance, 280 nanometers (units/cm)	10	.0035	10	.106	.113	.128	.181	.410
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	10	1	10	68	72	89	99	100
Calcium, dissolved	10	.02	10	22.4	22.4	28.6	31.2	32.7
Magnesium, dissolved	10	.008	10	3.01	3.86	4.34	5.04	5.31
Potassium, dissolved	10	.16	10	6.28	6.94	9.72	10.2	10.6
Sodium, dissolved	10	.20	10	61.8	64.8	103	132	139
Alkalinity (as $CaCO_3$), dissolved	10	1	10	93	108	129	168	225
Bicarbonate, dissolved	10	1	10	99	130	171	203	262
Carbonate, dissolved	9	1	4	<1	<1	<1	3.5	7.0
Chloride, dissolved	10	.20	10	48.3	53.3	79.8	102	119
Fluoride, dissolved	10	.20	10	.34	.40	.50	.62	.70
Sulfate, dissolved	10	.18	10	15.9	16.5	23.6	29.2	30.0
Silica, dissolved	10	.04	10	11.8	13.8	15.2	17.2	17.6
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	10	.10	10	.69	.78	.92	1.02	1.10
Ammonia + organic nitrogen, total	10	.10	10	.99	1.08	1.30	1.40	1.40
Organic nitrogen[1], dissolved	9	--	--	.65	.70	.75	.86	.90
Organic nitrogen, total	9	--	--	.90	1.04	1.10	1.20	1.30
Ammonia nitrogen, dissolved	10	.04	8	<.04	.04	.12	.16	.28
Nitrate[2] nitrogen, disssolved	9	--	--	3.04	3.39	5.54	7.05	8.23
Nitrite + nitrate nitrogen, dissolved	10	.06	10	3.11	3.69	5.66	6.91	8.29
Nitrite nitrogen, dissolved	9	.010	9	.035	.058	.072	.093	.219
Nitrogen[3], dissolved	10	--	--	4.1	4.7	6.5	7.9	9.1
Nitrogen[3], total	10	--	--	4.5	5.0	6.7	8.2	9.6
Orthophosphate phosphorus, dissolved	10	.020	10	.88	1.05	1.80	2.12	2.26
Phosphorus, dissolved	10	.004	10	.88	1.06	1.90	2.22	3.47
Phosphorus, total	10	.004	10	1.00	1.21	1.94	2.46	3.52
Organic carbon, dissolved	10	.33	10	5.1	5.3	6.5	6.9	7.0
Organic carbon, total	10	.40	10	6.1	7.7	9.0	10.8	11.4

Footnote at end of table.

Appendix 4. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at Cypress Creek, June 2000–September 2004—Continued.

Constituent	Number of analyses	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	10	0.1	10	295	359	440	667	1,340
Plankton, biomass, dry weight	10	.1	10	300	367	451	681	1,380
E. coli bacteria (cols./100 mL)	10	1	10	E4	96	120	190	4,000
Fecal coliform bacteria (cols./100 mL)	10	1	10	150	200	550	850	>6,000
Fecal streptococcus bacteria (cols./100 mL)	10	1	10	64	110	140	250	580
Chlorophyll-*a* phytoplankton (µg/L)	10	.1	9	<.1	.38	1.4	5.0	22.0
Chlorophyll-*b* phytoplankton (µg/L)	10	.1	6	<.1	<.1	.2	.7	2.6
Trace elements (µg/L)								
Aluminum, dissolved	10	1.6	10	4.0	5.0	7.5	9.2	12
Antimony, dissolved	8	.2	8	E.24	.26	.30	.35	.47
Arsenic, dissolved	10	2.0	10	2.0	4.0	4.5	5.0	7.0
Barium, dissolved	10	.2	10	79	84	94	103	116
Beryllium, dissolved	8	.06	0	--	--	--	--	--
Cadmium, dissolved	8	.04	7	<.04	.04	.05	.06	.07
Chromium, dissolved	8	.8	0	--	--	--	--	--
Cobalt, dissolved	8	.014	8	.462	.515	.625	.724	1.19
Copper, dissolved	10	.4	10	3.8	4.5	5.0	5.7	6.0
Iron, dissolved	10	10	7	<10	<10	16	36	49
Lead, dissolved	8	.08	8	.12	.17	.20	.24	.32
Manganese, dissolved	10	1.0	9	<1.0	1.2	11.9	28.9	34.1
Mercury, dissolved	8	.2	0	--	--	--	--	--
Molybdenum, dissolved	10	.4	10	2.9	3.2	4.4	7.2	8.7
Nickel, dissolved	10	.06	10	.88	1.12	1.48	1.90	2.67
Selenium, dissolved	10	3.0	0	--	--	--	--	--
Silver, dissolved	10	1.0	0	--	--	--	--	--
Uranium, dissolved	8	.04	8	.30	.34	.40	.47	.67
Zinc, dissolved	10	1.0	10	8.2	14.4	20.0	26.6	29.7
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	9	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	9	.006	9	E.009	E.016	E.038	E.162	E.434
Acetochlor, dissolved	9	.006	0	--	--	--	--	--
Alachlor, dissolved	9	.005	1	<.05	<.05	<.05	<.05	.072
alpha-HCH, dissolved	9	.005	0	--	--	--	--	--
Atrazine, dissolved	9	.007	9	.065	.145	.612	3.73	8.83
Azinphos-methyl, dissolved	9	.050	0	--	--	--	--	--
Benfluralin, dissolved	9	.010	0	--	--	--	--	--
Butylate, dissolved	9	.004	0	--	--	--	--	--
Carbaryl, dissolved	9	.041	2	<.041	<.041	<.041	<.041	E.168
Carbofuran, dissolved	9	.020	0	--	--	--	--	--
Chlorpyrifos, dissolved	8	.005	3	<.005	<.005	<.005	.005	.013
cis-Permethrin, dissolved	9	.006	0	--	--	--	--	--

Footnote at end of table.

Appendix 4. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at Cypress Creek, June 2000–September 2004—Continued.

Constituent	Number of analyses	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)—Continued								
Cyanazine, dissolved	9	0.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	9	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	4	.012	0	--	--	--	--	--
Diazinon, dissolved	9	.010	7	<0.010	0.018	0.079	0.338	1.08
Dieldrin, dissolved	9	.009	0	--	--	--	--	--
Disulfoton, dissolved	9	.020	0	--	--	--	--	--
EPTC, dissolved	9	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	9	.009	0	--	--	--	--	--
Ethopropos, dissolved	9	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	4	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	4	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	4	.024	0	--	--	--	--	--
Fipronil, dissolved	4	.016	1	<.016	<.016	<.016	<.016	E.025
Fonofos, dissolved	9	.003	0	--	--	--	--	--
Lindane, dissolved	9	.004	0	--	--	--	--	--
Linuron, dissolved	9	.035	0	--	--	--	--	--
Malathion, dissolved	9	.027	1	<.027	<.027	<.027	<.027	.039
Methyl parathion, dissolved	9	.015	0	--	--	--	--	--
Metolachlor, dissolved	9	.013	1	<.013	<.013	<.013	<.013	.137
Metribuzin, dissolved	9	.006	0	--	--	--	--	--
Molinate, dissolved	8	.004	0	--	--	--	--	--
Napropamide, dissolved	9	.007	0	--	--	--	--	--
p,p'-DDE, dissolved	9	.006	0	--	--	--	--	--
Parathion, dissolved	9	.010	0	--	--	--	--	--
Pebulate, dissolved	9	.004	0	--	--	--	--	--
Pendimethalin, dissolved	9	.022	2	<.022	<.022	<.022	<.022	.034
Phorate, dissolved	9	.011	0	--	--	--	--	--
Prometon, dissolved	8	.010	4	<.010	<.010	.015	.020	.100
Propyzamide, dissolved	9	.004	1	<.004	<.004	<.004	<.004	.102
Propachlor, dissolved	9	.025	0	--	--	--	--	--
Propanil, dissolved	8	.011	0	--	--	--	--	--
Propargite, dissolved	8	.020	0	--	--	--	--	--
Simazine, dissolved	8	.005	6	<.005	.008	.016	.057	.242
Tebuthiuron, dissolved	9	.020	0	--	--	--	--	--
Terbacil, dissolved	9	.034	0	--	--	--	--	--
Terbufos, dissolved	9	.020	0	--	--	--	--	--
Thiobencarb, dissolved	9	.010	0	--	--	--	--	--
Tri-allate, dissolved	9	.002	0	--	--	--	--	--
Trifluralin, dissolved	9	.009	0	--	--	--	--	--

[1] Ammonia + organic nitrogen minus ammonia nitrogen.

[2] Nitrite + nitrate nitrogen minus dissolved nitrite nitrogen.

[3] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 5. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at Cypress Creek, April 2002–November 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; --, not applicable or not computed; <, less than; cols./100 mL, colonies per 100 milliliters, µg/L, micrograms per liter; E, estimated]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	8	0.1	8	67.0	104	160	306	485
pH, unfiltered (standard units)	8	.1	8	6.4	6.9	7.1	7.5	7.6
Water temperature (°C)	8	.1	8	15.9	19.2	22.2	24.6	25.1
Dissolved oxygen (mg/L)	7	.1	7	6.0	6.4	7.1	8.8	8.9
Residue, dissolved (mg/L)	8	10	8	54	73	87	146	167
Residue, suspended (mg/L)	8	10	8	88	126	237	376	540
Color (platinum cobalt units)	8	1	8	88	119	200	250	250
Turbidity (NTU)	6	.01	6	110	132	225	302	340
Suspended sediment (mg/L)	8	1	8	118	244	308	580	957
UV absorbance, 254 nanometers (units/cm)	8	1	8	.229	.253	.302	.350	.689
UV absorbance, 280 nanometers (units/cm)	8	.0035	8	.182	.199	.232	.278	.552
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	8	1	8	17	23	24	39	48
Calcium, dissolved	8	.02	8	5.11	7.22	7.90	13.0	15.6
Magnesium, dissolved	8	.008	8	1.07	1.10	1.32	1.74	2.08
Potassium, dissolved	8	.16	8	2.57	3.01	3.84	5.44	5.81
Sodium, dissolved	8	.20	8	3.20	10.6	12.0	24.1	39.8
Alkalinity (as $CaCO_3$), dissolved	7	1	7	27	32	36	61	67
Bicarbonate, dissolved	7	1	7	33	39	44	74	82
Carbonate, dissolved	7	1	0	--	--	--	--	--
Chloride, dissolved	8	.20	8	3.10	7.88	9.60	20.2	29.2
Fluoride, dissolved	8	.20	4	<.20	<.20	<.20	.20	.30
Sulfate, dissolved	8	.18	8	2.1	3.4	5.4	6.7	8.4
Silica, dissolved	8	.04	8	3.66	4.48	4.84	7.29	9.71
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	8	.10	8	.54	.56	1.0	3.1	4.1
Ammonia + organic nitrogen, total	8	.10	8	1.5	1.8	2.2	5.4	7.1
Organic nitrogen[1], dissolved	5	--	--	.51	.54	1.1	2.9	3.8
Organic nitrogen[1], total	5	--	--	1.4	1.9	2.3	5.8	6.8
Ammonia nitrogen, dissolved	8	.04	7	<.04	.04	.04	.24	.29
Nitrate[2] nitrogen, disssolved	7	--	--	.16	.18	.54	1.12	2.10
Nitrite + nitrate nitrogen, dissolved	8	.06	8	.11	.22	.54	1.02	2.13
Nitrite nitrogen, dissolved	8	.010	7	<.01	.012	.023	.047	.070
Nitrogen[3], dissolved	8	--	--	1.1	1.3	2.4	3.3	4.4
Nitrogen[3], total	8	--	--	2.0	2.6	3.3	5.7	7.3
Orthophosphate phosphorus, dissolved	8	.020	7	<.02	.07	.20	.32	.70
Phosphorus, dissolved	8	.004	8	.10	.20	.25	.39	.72
Phosphorus, total	8	.004	8	.26	.46	.62	.73	.98
Organic carbon, dissolved	8	.33	8	5.9	7.4	13.4	22.5	32.3
Organic carbon, total	8	.40	8	14.3	18.9	22.6	34.5	36.3

Footnote at end of table.

Appendix 5. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at Cypress Creek, April 2002–November 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	8	0.1	8	759	826	1,130	1,690	1,870
Plankton, biomass, dry weight	8	.1	8	780	850	1,170	1,740	1,950
E. coli bacteria (cols./100 mL)	6	1	6	150	1,700	3,100	5,900	7,900
Fecal coliform bacteria (cols./100 mL)	6	1	6	210	2,100	4,900	5,800	6,000
Fecal streptococcus bacteria (cols./100 mL)	6	1	6	980	1,700	4,800	6,500	8,200
Chlorophyll-*a* phytoplankton (µg/L)	7	.1	6	<.1	1.1	2.8	8.7	9.9
Chlorophyll-*b* phytoplankton (µg/L)	7	.1	4	<.1	<.1	.1	.8	E1.0
Trace elements (µg/L)								
Aluminum, dissolved	8	1.6	8	10	14	22	77	404
Antimony, dissolved	7	.17	7	E.17	E.17	.22	.31	.32
Arsenic, dissolved	8	2.0	8	2.0	2.2	4.0	5.0	6.0
Barium, dissolved	8	.2	8	25	32	38	48	161
Beryllium, dissolved	8	.06	0	--	--	--	--	--
Cadmium, dissolved	8	.04	5	<.04	<.04	.04	.09	.11
Chromium, dissolved	8	.8	1	<.8	<.8	<.8	<.8	.9
Cobalt, dissolved	8	.014	8	.085	.104	.169	.237	.516
Copper, dissolved	8	.4	8	2.7	3.0	3.6	4.6	5.0
Iron, dissolved	8	10	8	41	65	76	96	179
Lead, dissolved	8	.08	8	.12	.14	.32	.48	.55
Manganese, dissolved	8	.60	8	.90	1.2	2.4	4.9	51.1
Mercury, dissolved	8	.02	0	--	--	--	--	--
Molybdenum, dissolved	8	.4	7	<.4	.70	.70	1.2	1.9
Nickel, dissolved	8	.06	8	.90	.99	1.13	1.70	1.82
Selenium, dissolved	8	3.0	0	--	--	--	--	--
Silver, dissolved	8	1.0	0	--	--	--	--	--
Uranium, dissolved	8	.04	8	.07	.07	.08	.16	.17
Zinc, dissolved	8	1.0	8	4.1	6.7	27.6	320	349
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	8	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	8	.015	7	<.015	E.020	E.044	E.053	E.266
Acetochlor, dissolved	8	.010	0	--	--	--	--	--
Alachlor, dissolved	8	.005	1	<.005	<.005	<.005	<.005	.020
alpha-HCH, dissolved	8	.005	0	--	--	--	--	--
Atrazine, dissolved	8	.007	8	.282	.918	1.09	1.30	21.3
Azinphos-methyl, dissolved	8	.050	0	--	--	--	--	--
Benfluralin, dissolved	8	.010	0	--	--	--	--	--
Butylate, dissolved	8	.004	0	--	--	--	--	--
Carbaryl, dissolved	8	.041	7	<.041	E.153	E.195	E.343	E.655
Carbofuran, dissolved	8	.020	0	--	--	--	--	--
Chlorpyrifos, dissolved	8	.005	2	<.005	<.005	<.005	<.005	.055
cis-Permethrin, dissolved	8	.006	0	--	--	--	--	--

Footnote at end of table.

Appendix 5. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at Cypress Creek, April 2002–November 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)								
Cyanazine, dissolved	8	0.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	8	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	7	.004	3	<0.004	<0.004	<0.004	E0.004	E0.006
Diazinon, dissolved	8	.010	8	.024	.066	.192	.242	1.17
Dieldrin, dissolved	8	.009	0	--	--	--	--	--
Disulfoton, dissolved	8	.020	0	--	--	--	--	--
EPTC, dissolved	8	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	8	.009	0	--	--	--	--	--
Ethopropos, dissolved	8	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	7	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	7	.010	0	--	--	--	--	--
Fipronil sulfone, dissolved	7	.024	0	--	--	--	--	--
Fipronil, dissolved	7	.031	3	<.031	<.031	<.031	.049	E.070
Fonofos, dissolved	8	.003	0	--	--	--	--	--
Lindane, dissolved	8	.004	0	--	--	--	--	--
Linuron, dissolved	8	.035	0	--	--	--	--	--
Malathion, dissolved	8	.027	4	<.027	<.027	<.027	.047	.072
Methyl parathion, dissolved	8	.015	0	--	--	--	--	--
Metolachlor, dissolved	8	.013	1	<.013	<.013	<.013	<.013	.100
Metribuzin, dissolved	8	.006	0	--	--	--	--	--
Molinate, dissolved	8	.003	0	--	--	--	--	--
Napropamide, dissolved	8	.007	0	--	--	--	--	--
p,p′-DDE, dissolved	8	.005	0	--	--	--	--	--
Parathion, dissolved	8	.010	0	--	--	--	--	--
Pebulate, dissolved	8	.004	0	--	--	--	--	--
Pendimethalin, dissolved	8	.022	0	--	--	--	--	--
Phorate, dissolved	8	.011	0	--	--	--	--	--
Prometon, dissolved	7	.010	4	<.010	<.010	E.010	.010	.020
Propyzamide, dissolved	8	.004	1	<.004	<.004	<.004	<.004	.039
Propachlor, dissolved	8	.025	0	--	--	--	--	--
Propanil, dissolved	8	.011	0	--	--	--	--	--
Propargite, dissolved	8	.020	0	--	--	--	--	--
Simazine, dissolved	8	.005	8	.009	.019	.35	.59	3.27
Tebuthiuron, dissolved	8	.020	0	--	--	--	--	--
Terbacil, dissolved	8	.034	0	--	--	--	--	--
Terbufos, dissolved	8	.020	0	--	--	--	--	--
Thiobencarb, dissolved	8	.010	0	--	--	--	--	--
Tri-allate, dissolved	8	.006	0	--	--	--	--	--
Trifluralin, dissolved	8	.009	1	<.009	<.009	<.009	<.009	.015

[1] Ammonia + organic nitrogen minus ammonia nitrogen.

[2] Nitrite + nitrate nitrogen minus dissolved nitrite nitrogen.

[3] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 6. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at East Fork San Jacinto River, June 2000–September 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; <, less than; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; --, not applicable or not computed; cols./100 mL, colonies per 100 milliliters, E, estimated; µg/L, micrograms per liter]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	10	0.1	10	177	184	186	204	228
pH, unfiltered (standard units)	10	.1	10	6.7	6.8	7.0	7.2	7.5
Water temperature (°C)	10	.1	10	12.5	17.4	25.4	27.1	29.3
Dissolved oxygen (mg/L)	10	.1	10	6.6	6.8	7.7	8.7	10.2
Residue, dissolved (mg/L)	10	10	10	105	110	116	122	146
Residue, suspended (mg/L)	10	10	7	<10	<10	14	22	31
Color (platinum cobalt units)	10	1	10	25	36	61	75	80
Turbidity (NTU)	8	.01	8	8.9	14	20	34	46
Suspended sediment (mg/L)	8	1	11	11	14	16	56	69
UV absorbance, 254 nanometers (units/cm)	10	1	10	.087	.130	.178	.272	.346
UV absorbance, 280 nanometers (units/cm)	10	.0035	10	.066	.100	.132	.211	.258
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	10	1	10	35	37	46	50	56
Calcium, dissolved	10	.02	10	10.9	12.0	15.2	16.4	18.4
Magnesium, dissolved	10	.008	10	1.81	1.83	1.99	2.18	2.41
Potassium, dissolved	10	.16	10	1.29	1.48	1.54	1.83	2.36
Sodium, dissolved	10	.20	10	13.6	14.6	16.2	18.6	19.4
Alkalinity (as $CaCO_3$), dissolved	10	1	10	14	25	32	36	38
Bicarbonate, dissolved	10	1	10	17	30	40	44	46
Carbonate, dissolved	7	1	0	--	--	--	--	--
Chloride, dissolved	10	.20	10	27.4	28.2	29.2	33.3	35.8
Fluoride, dissolved	10	.20	0	--	--	--	--	<.20
Sulfate, dissolved	10	.18	10	2.8	4.1	4.4	6.0	6.5
Silica, dissolved	10	.04	10	5.25	10.4	13.7	15.5	16.8
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	10	.10	10	.14	.16	.19	.30	.45
Ammonia + organic nitrogen, total	10	.10	10	.31	.34	.38	.42	.64
Ammonia nitrogen, dissolved	10	.04	0	--	--	--	--	--
Nitrite + nitrate nitrogen, dissolved	10	.06	9	<.06	.10	.14	.23	.23
Nitrite nitrogen, dissolved	10	.010	0	--	--	--	--	--
Nitrogen[1], dissolved	9	--	--	.25	.32	.41	.51	.55
Nitrogen[1], total	9	--	--	.46	.50	.55	.63	.73
Orthophosphate phosphorus, dissolved	10	.020	2	<.020	<.020	<.020	.020	.020
Phosphorus, dissolved	10	.004	10	.009	.016	.019	.024	.034
Phosphorus, total	10	.004	9	<.004	.061	.075	.084	.091
Organic carbon, dissolved	10	.33	10	2.5	3.2	4.4	7.0	10.0
Organic carbon, total	10	.40	10	3.8	4.1	5.9	8.4	10.7

Footnote at end of table.

Appendix 6. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at East Fork San Jacinto River, June 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	9	0.1	9	280	329	344	500	1,300
Plankton, biomass, dry weight	9	.1	9	284	335	350	511	1,350
E. coli bacteria (cols./100 mL)	10	1	10	E12	37	65	89	100
Fecal coliform bacteria (cols./100 mL)	10	1	10	E15	43	110	120	140
Fecal streptococcus bacteria (cols./100 mL)	10	1	10	E6	56	88	130	180
Chlorophyll-*a* phytoplankton (µg/L)	9	.1	8	<.1	.4	.8	1.3	1.7
Chlorophyll-*b* phytoplankton (µg/L)	9	.1	2	<.1	<.1	<.1	<.1	E.2
Trace elements (µg/L)								
Aluminum, dissolved	10	1.6	10	1.0	2.0	4.0	6.8	12
Antimony, dissolved	8	.3	0	--	--	--	--	--
Arsenic, dissolved	10	2.0	0	--	--	--	--	--
Barium, dissolved	10	.2	10	54	60	64	70	75
Beryllium, dissolved	8	.06	0	--	--	--	--	--
Cadmium, dissolved	8	.04	1	<.04	<.04	<.04	<.04	.10
Chromium, dissolved	10	.8	1	<.8	<.8	<.8	<.8	.8
Cobalt, dissolved	8	.014	8	.316	.330	.341	.376	.437
Copper, dissolved	10	.4	10	.8	.9	1.0	1.7	2.3
Iron, dissolved	10	10	10	23	33	60	122	163
Lead, dissolved	8	.08	3	<.08	<.08	<.08	.11	.21
Manganese, dissolved	10	.2	10	40.5	43.8	54.1	65.0	67.4
Mercury, dissolved	10	.2	0	--	--	--	--	--
Molybdenum, dissolved	8	.4	0	--	--	--	--	--
Nickel, dissolved	10	.06	10	.49	.62	1.20	1.34	1.87
Selenium, dissolved	10	3.0	0	--	--	--	--	--
Silver, dissolved	10	1.0	0	--	--	--	--	--
Uranium, dissolved	8	.04	6	<.04	.04	.06	.10	.13
Zinc, dissolved	10	1.0	10	1.1	1.2	1.6	2.8	3.2
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	10	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	10	.006	0	--	--	--	--	--
Acetochlor, dissolved	10	.006	0	--	--	--	--	--
Alachlor, dissolved	10	.005	0	--	--	--	--	--
alpha-HCH, dissolved	10	.005	0	--	--	--	--	--
Atrazine, dissolved	10	.010	2	<.010	<.010	<.010	<.010	.019
Azinphos-methyl, dissolved	10	.050	0	--	--	--	--	--
Benfluralin, dissolved	10	.010	0	--	--	--	--	--
Butylate, dissolved	10	.004	0	--	--	--	--	--
Carbaryl, dissolved	10	.041	0	--	--	--	--	--
Carbofuran, dissolved	10	.020	0	--	--	--	--	--
Chlorpyrifos, dissolved	10	.005	0	--	--	--	--	--

Footnote at end of table.

Appendix 6. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from low flows at East Fork San Jacinto River, June 2000–September 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)—Continued								
cis-Permethrin, dissolved	10	0.006	0	--	--	--	--	--
Cyanazine, dissolved	10	.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	10	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	4	.012	0	--	--	--	--	--
Diazinon, dissolved	10	.005	2	<0.005	<0.005	<0.005	<0.005	0.019
Dieldrin, dissolved	10	.009	0	--	--	--	--	--
Disulfoton, dissolved	10	.020	0	--	--	--	--	--
EPTC, dissolved	10	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	10	.009	0	--	--	--	--	--
Ethopropos, dissolved	10	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	4	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	4	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	4	.024	0	--	--	--	--	--
Fipronil, dissolved	4	.016	0	--	--	--	--	--
Fonofos, dissolved	10	.003	0	--	--	--	--	--
Lindane, dissolved	10	.004	0	--	--	--	--	--
Linuron, dissolved	10	.035	0	--	--	--	--	--
Malathion, dissolved	10	.027	0	--	--	--	--	--
Methyl parathion, dissolved	10	.015	0	--	--	--	--	--
Metolachlor, dissolved	10	.013	0	--	--	--	--	--
Metribuzin, dissolved	10	.006	0	--	--	--	--	--
Molinate, dissolved	10	.004	0	--	--	--	--	--
Napropamide, dissolved	10	.007	0	--	--	--	--	--
p,p'-DDE, dissolved	10	.006	0	--	--	--	--	--
Parathion, dissolved	10	.010	0	--	--	--	--	--
Pebulate, dissolved	10	.004	0	--	--	--	--	--
Pendimethalin, dissolved	10	.022	0	--	--	--	--	--
Phorate, dissolved	10	.011	0	--	--	--	--	--
Prometon, dissolved	10	.020	0	--	--	--	--	--
Propyzamide, dissolved	10	.004	0	--	--	--	--	--
Propachlor, dissolved	10	.025	0	--	--	--	--	--
Propanil, dissolved	10	.011	0	--	--	--	--	--
Propargite, dissolved	10	.020	0	--	--	--	--	--
Simazine, dissolved	10	.011	0	--	--	--	--	--
Tebuthiuron, dissolved	10	.020	1	<.020	<.020	<.020	<.020	.030
Terbacil, dissolved	10	.034	0	--	--	--	--	--
Terbufos, dissolved	10	.020	0	--	--	--	--	--
Thiobencarb, dissolved	10	.010	0	--	--	--	--	--
Tri-allate, dissolved	10	.002	0	--	--	--	--	--
Trifluralin, dissolved	10	.009	0	--	--	--	--	--

[1] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

Appendix 7. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at East Fork San Jacinto River, April 2002–November 2004.

[≥, equal to or greater than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; NTU, nephelometric turbidity units; UV, ultraviolet; cm, centimeters; $CaCO_3$, calcium carbonate; --, not applicable or not computed; <, less than; cols./100 mL, colonies per 100 milliliters, µg/L, micrograms per liter; E, estimated]

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Field measurements and physical properties								
Specific conductance, unfiltered (µS/cm)	5	0.1	5	45	57	64	101	134
pH, unfiltered (standard units)	5	.1	5	6.0	6.3	6.5	7.0	7.1
Water temperature (°C)	5	.1	5	15.4	17.6	19.1	19.8	24.2
Dissolved oxygen (mg/L)	5	.1	5	6.7	7.1	7.1	8.1	8.5
Residue, dissolved (mg/L)	5	10	5	38	66	75	80	86
Residue, suspended (mg/L)	5	10	5	28	48	62	91	180
Color (platinum cobalt units)	5	1	5	125	125	125	150	200
Turbidity (NTU)	4	.01	4	58	60	62	72	80
Suspended sediment (mg/L)	5	1	5	62	70	150	215	256
UV absorbance, 254 nanometers (units/cm)	5	1	5	.286	.419	.522	.557	.658
UV absorbance, 280 nanometers (units/cm)	5	.0035	5	.219	.319	.396	.422	.505
Major cations and anions (mg/L)								
Hardness (as $CaCO_3$), total	5	1	5	13	17	17	27	29
Calcium, dissolved	5	.02	5	3.84	5.19	5.28	8.72	9.77
Magnesium, dissolved	5	.008	5	.711	.905	.966	1.16	1.31
Potassium, dissolved	5	.16	5	1.73	1.87	1.90	1.98	2.15
Sodium, dissolved	5	.20	5	2.67	3.71	4.79	6.46	7.19
Alkalinity (as $CaCO_3$), dissolved	4	1	4	8	11	14	17	20
Bicarbonate, dissolved	4	1	4	10	14	17	21	25
Carbonate, dissolved	4	1	0	--	--	--	--	--
Chloride, dissolved	5	.20	5	5.0	6.0	9.0	11.5	13.6
Fluoride, dissolved	5	.20	0	--	--	--	--	--
Sulfate, dissolved	5	.18	5	2.5	3.2	3.4	3.4	4.1
Silica, dissolved	5	.04	5	3.96	5.61	5.69	6.37	9.12
Nutrients (mg/L)								
Ammonia + organic nitrogen, dissolved	5	.10	5	.38	.42	.47	.54	.59
Ammonia + organic nitrogen, total	5	.10	5	.84	.85	.96	.98	1.2
Ammonia nitrogen, dissolved	5	.04	0	--	--	--	--	--
Nitrite + nitrate nitrogen, dissolved	5	.06	2	<.06	<.06	<.06	.07	.08
Nitrite nitrogen, dissolved	5	.008	1	<.008	<.008	<.008	<.008	.008
Nitrogen[1], dissolved	2	--	--	--	--	--	--	.67
Orthophosphate phosphorus, dissolved	5	.020	1	<.02	<.02	<.02	<.02	.02
Phosphorus, dissolved	5	.004	5	.025	.025	.028	.030	.038
Phosphorus, total	5	.004	5	.056	.098	.121	.150	.157
Organic carbon, dissolved	5	.33	5	9.6	14.4	14.9	15.2	15.9
Organic carbon, total	5	.40	5	15.0	16.4	18.7	19.0	20.8

Footnote at end of table.

Appendix 7. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at East Fork San Jacinto River, April 2002–November 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Biological constituents								
Plankton, biomass, ash weight	5	0.1	5	723	930	1,010	1,470	1,510
Plankton, biomass, dry weight	5	.1	5	740	956	1,040	1,500	1,550
E. coli bacteria (cols./100 mL)	4	1	4	2,100	2,500	3,900	3,500	5,800
Fecal coliform bacteria (cols./100 mL)	4	1	4	2,300	2,600	3,200	4,700	5,800
Fecal streptococcus bacteria (cols./100 mL)	4	1	4	3,100	3,400	4,200	5,400	6,000
Chlorophyll-*a* phytoplankton (µg/L)	4	.2	3	<.2	<.2	.8	1.5	E1.8
Chlorophyll-*b* phytoplankton (µg/L)	4	.1	1	<.1	<.1	<.1	<.1	E.2
Trace elements (µg/L)								
Aluminum, dissolved	5	1.6	5	16	39	44	58	303
Antimony, dissolved	5	.2	0	--	--	--	--	--
Arsenic, dissolved	5	2.0	0	--	--	--	--	--
Barium, dissolved	5	.2	5	23	25	31	44	46
Beryllium, dissolved	5	.06	1	<.06	<.06	<.06	<.06	.09
Cadmium, dissolved	5	.04	2	<.04	<.04	<.04	.04	.04
Chromium, dissolved	5	.8	0	--	--	--	--	--
Cobalt, dissolved	5	.014	5	.067	.105	.106	.162	.175
Copper, dissolved	5	.4	5	2.2	2.3	2.5	2.8	3.0
Iron, dissolved	5	10	5	122	154	173	204	335
Lead, dissolved	5	.08	5	.12	.13	.17	.29	.43
Manganese, dissolved	5	1.0	5	.9	1.9	4.4	6.7	8.7
Mercury, dissolved	5	.2	0	--	--	--	--	--
Molybdenum, dissolved	5	.4	0	--	--	--	--	--
Nickel, dissolved	5	.06	5	1.41	1.43	1.50	1.50	1.57
Selenium, dissolved	5	3.0	0	--	--	--	--	--
Silver, dissolved	5	1.0	0	--	--	--	--	--
Uranium, dissolved	5	.04	5	.08	.12	.12	.13	.14
Zinc, dissolved	5	1.0	5	3.1	3.7	5.9	6.1	6.7
Pesticides (µg/L)								
2,6-Diethylaniline, dissolved	5	.006	0	--	--	--	--	--
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT), dissolved	5	.015	2	<.006	<.006	<.006	E.006	E.006
Acetochlor, dissolved	5	.006	0	--	--	--	--	--
Alachlor, dissolved	5	.005	0	--	--	--	--	--
alpha-HCH, dissolved	5	.005	0	--	--	--	--	--
Atrazine, dissolved	5	.007	4	<.007	.010	.023	.118	.233
Azinphos-methyl, dissolved	5	.050	0	--	--	--	--	--
Benfluralin, dissolved	5	.010	0	--	--	--	--	--
Butylate, dissolved	5	.004	0	--	--	--	--	--
Carbaryl, dissolved	5	.041	1	<.041	<.041	<.041	<.041	E.121
Carbofuran, dissolved	5	.020	0	--	--	--	--	--

Footnote at end of table.

Appendix 7. Statistical summary of field measurements and physical properties, major cations and anions, nutrients, biological constituents, trace elements, and pesticides in samples collected from high flows at East Fork San Jacinto River, April 2002–November 2004—Continued.

Constituent	Number of samples	Minimum reporting level	Number of detections ≥ reporting level	Concentration				
				Minimum	25th percentile	Median	75th percentile	Maximum
Pesticides (µg/L)—Continued								
Chlorpyrifos, dissolved	5	0.005	0	--	--	--	--	--
cis-Permethrin, dissolved	5	.006	0	--	--	--	--	--
Cyanazine, dissolved	5	.018	0	--	--	--	--	--
Dacthal (DCPA), dissolved	5	.003	0	--	--	--	--	--
Desulfinyl fipronil, dissolved	4	.012	0	--	--	--	--	--
Diazinon, dissolved	5	.005	3	<0.005	<0.005	0.017	0.018	0.051
Dieldrin, dissolved	5	.009	0	--	--	--	--	--
Disulfoton, dissolved	5	.020	0	--	--	--	--	--
EPTC, dissolved	5	.004	0	--	--	--	--	--
Ethalfluralin, dissolved	5	.009	0	--	--	--	--	--
Ethopropos, dissolved	5	.005	0	--	--	--	--	--
Desulfinylfipronil amide, dissolved	4	.029	0	--	--	--	--	--
Fipronil sulfide, dissolved	4	.013	0	--	--	--	--	--
Fipronil sulfone, dissolved	4	.024	0	--	--	--	--	--
Fipronil, dissolved	4	.016	0	--	--	--	--	--
Fonofos, dissolved	5	.003	0	--	--	--	--	--
Lindane, dissolved	5	.004	0	--	--	--	--	--
Linuron, dissolved	5	.035	0	--	--	--	--	--
Malathion, dissolved	5	.027	0	--	--	--	--	--
Methyl parathion, dissolved	5	.015	0	--	--	--	--	--
Metolachlor, dissolved	5	.013	0	--	--	--	--	--
Metribuzin, dissolved	5	.006	0	--	--	--	--	--
Molinate, dissolved	5	.003	0	--	--	--	--	--
Napropamide, dissolved	5	.007	0	--	--	--	--	--
p,p′-DDE, dissolved	5	.003	0	--	--	--	--	--
Parathion, dissolved	5	.010	0	--	--	--	--	--
Pebulate, dissolved	5	.004	0	--	--	--	--	--
Pendimethalin, dissolved	5	.022	0	--	--	--	--	--
Phorate, dissolved	5	.011	0	--	--	--	--	--
Prometon, dissolved	5	.010	0	--	--	--	--	--
Propyzamide, dissolved	5	.004	0	--	--	--	--	--
Propachlor, dissolved	5	.025	0	--	--	--	--	--
Propanil, dissolved	5	.011	0	--	--	--	--	--
Propargite, dissolved	5	.020	0	--	--	--	--	--
Simazine, dissolved	5	.005	0	--	--	--	--	--
Tebuthiuron, dissolved	5	.020	0	--	--	--	--	--
Terbacil, dissolved	5	.034	0	--	--	--	--	--
Terbufos, dissolved	5	.020	0	--	--	--	--	--
Thiobencarb, dissolved	5	.010	0	--	--	--	--	--
Tri-allate, dissolved	5	.006	0	--	--	--	--	--
Trifluralin, dissolved	5	.009	0	--	--	--	--	--

[1] Nitrite + nitrate nitrogen plus ammonia + organic nitrogen.

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