



In cooperation with the U.S. Air Force

**Spatial Distribution and Trends in Trace Elements,  
Polycyclic Aromatic Hydrocarbons, Organochlorine  
Pesticides, and Polychlorinated Biphenyls in  
Lake Worth Sediment, Fort Worth, Texas**

**Water-Resources Investigations Report 03-4269**

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**By Glenn R. Harwell, Peter C. Van Metre, Jennifer T. Wilson, and  
Barbara J. Mahler**

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**In cooperation with the U.S. Air Force**

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Gale A. Norton, Secretary

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Charles G. Groat, Director

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**For additional information write to**

**District Chief  
U.S. Geological Survey  
8027 Exchange Dr.  
Austin, TX 78754-4733  
E-mail: [dc\\_tx@usgs.gov](mailto:dc_tx@usgs.gov)**

**Copies of this report can be purchased from**

**U.S. Geological Survey  
Information Services  
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Denver, CO 80225-0286  
E-mail: [infoservices@usgs.gov](mailto:infoservices@usgs.gov)**

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# Spatial Distribution and Trends in Trace Elements, Polycyclic Aromatic Hydrocarbons, Organochlorine Pesticides, and Polychlorinated Biphenyls in Lake Worth Sediment, Fort Worth, Texas

By Glenn R. Harwell, Peter C. Van Metre, Jennifer T. Wilson, *and* Barbara J. Mahler

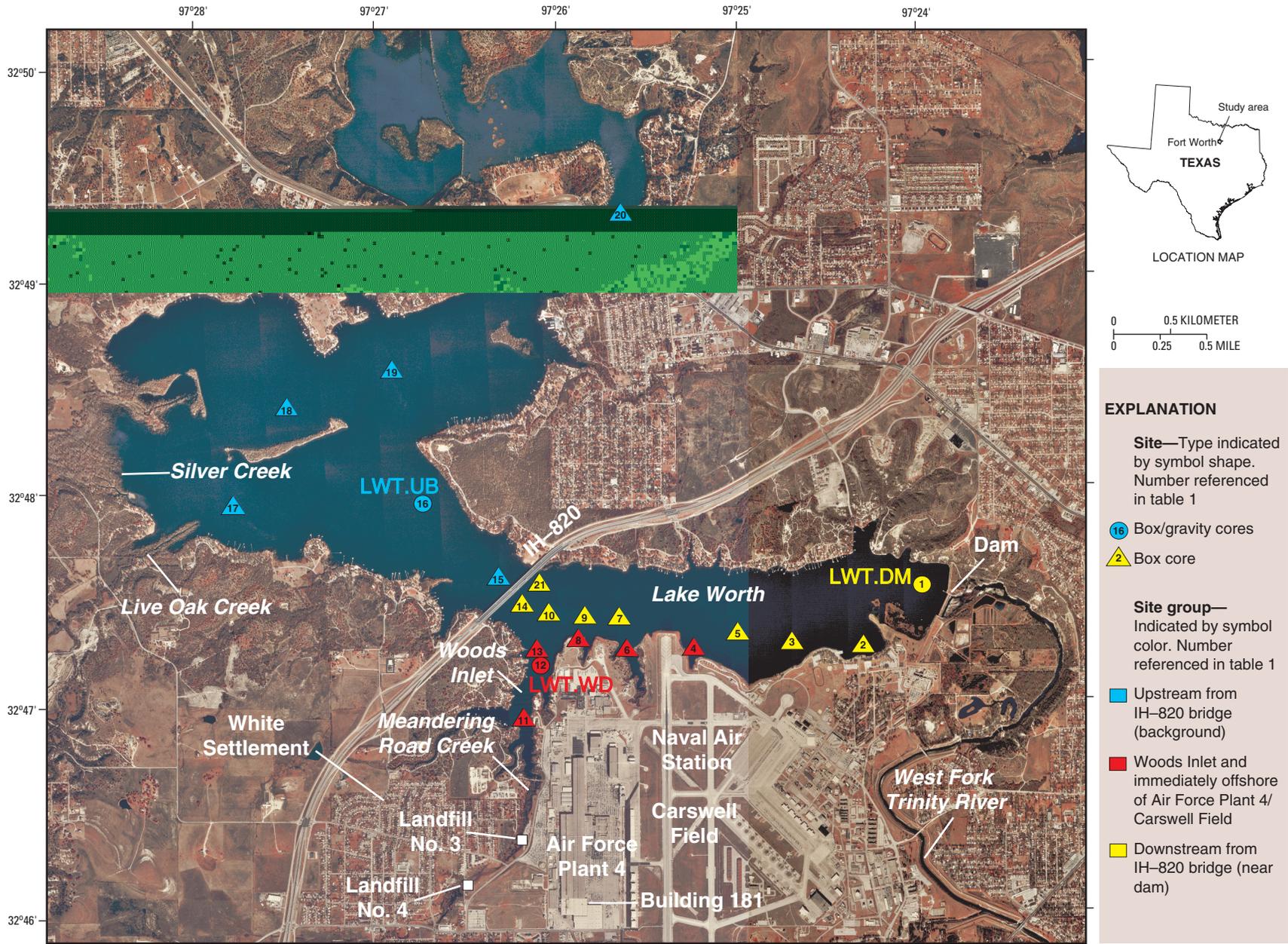
## Abstract

In spring 2000, the Texas Department of Health issued a fish consumption advisory for Lake Worth in Fort Worth, Texas, because of elevated concentrations of polychlorinated biphenyls (PCBs) in fish. In response to the advisory and in cooperation with the U.S. Air Force, the U.S. Geological Survey collected 21 surficial sediment samples and three gravity core sediment samples to assess the spatial distribution and historical trends of selected hydrophobic contaminants, including PCBs, and to determine, to the extent possible, sources of hydrophobic contaminants to Lake Worth. Compared to reference (background) concentrations in the upper lake, elevated PCB concentrations were detected in the surficial sediment samples collected in Woods Inlet, which receives surface runoff from Air Force facilities and urban areas. Gravity cores from Woods Inlet and from the main part of the lake near the dam indicate that the concentrations of PCBs were three to five times higher in the 1960s than in 2000. A regression method was used to normalize sediment concentrations of trace elements for natural variations and to distinguish natural and anthropogenic contributions to sediments. Concentrations of several trace elements—cadmium, chromium, copper, lead, and zinc—were elevated in sediments in Woods Inlet, along the shoreline of Air Force facilities, and in the main lake near the dam. Concentrations of these five trace elements have decreased since 1970. Polycyclic aromatic hydrocarbons also were elevated in the same areas of the lake. Concentrations

of total polycyclic aromatic hydrocarbons, normalized with organic carbon, were mostly stable in the upper lake but steadily increased near the dam, except for small decreases since 1980. The Woods Inlet gravity core showed the largest increase of the three core sites beginning about 1940; total polycyclic aromatic hydrocarbon concentrations in post-1940 sediments from the core showed three apparent peaks about 1960, 1984, and 2000. The concentrations of organochlorine pesticides were low relative to consensus-based sediment-quality guidelines and either decreased or remained constant since 1970. The two likely sources of hydrophobic contaminants to the lake are urban areas around the lake and the drainage area of Meandering Road Creek that contributes runoff to Woods Inlet and includes Air Force facilities.

## INTRODUCTION

Lake Worth is a reservoir on the West Fork Trinity River on the western edge of Fort Worth, Tex. (fig. 1). Air Force Plant 4 (AFP4) and Naval Air Station/Joint Reserve Base, Carswell Field are located on the southern shore of Lake Worth, west of the dam and east of IH-820 (fig. 1). AFP4 was placed on the U.S. Environmental Protection Agency (USEPA) National Priorities List of the most serious known hazardous waste sites in the Nation in August 1990 as a result of ground-water contamination (U.S. Environmental Protection Agency, 1990). In October 1990, a Preliminary Assessment/Site Inspection and a Remedial Investigation/Feasibility Study (RI/FS) were begun of the site to characterize the extent of contamination. The USEPA and the (then) Texas Natural Resource Conservation Commission approved the RI/FS in September 1995, and a final



**Figure 1.** Location of study area and approximate sampling locations in Lake Worth, Fort Worth, Texas, 2000–2001.

Record of Decision was issued in July 1996 that described possible remedial actions.

In July 1998, the Texas Department of Health and the Agency for Toxic Substances and Disease Registry evaluated the available environmental information from the Preliminary Assessment/Site Inspection and concluded that an indeterminate public health hazard from exposure to contaminants through the food chain existed in Lake Worth (Texas Department of Health, 1998). The conclusion was reached after finding elevated concentrations of contaminants such as polychlorinated biphenyls (PCBs) in small, non-edible fish species. In spring 2000, following fish sampling by the U.S. Geological Survey (USGS) (Moring, 2002), the Texas Department of Health issued a consumption advisory that stated eating fish from Lake Worth would pose a “significant health risk” because of high concentrations of PCBs detected in samples of larger fish (Texas Department of Health, 2000).

The occurrence of PCBs in larger fish prompted the study documented in this report done by the USGS in cooperation with the U.S. Air Force, to sample and analyze Lake Worth bottom sediments for sediment-bound contaminants. Runoff from the contributing drainage area to Lake Worth, which, in addition to AFP4 and Carswell Field, includes urban development, is a potential source to the lake of sediment-bound compounds like PCBs. PCBs, trace elements, polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides are hydrophobic and therefore tend to adsorb to soil and sediment.

## Purpose and Scope

The purpose of this report is to present and interpret the chemical data from the analysis of bottom sediments from Lake Worth. The interpretation of the data has three objectives:

1. To describe the spatial distribution of selected hydrophobic contaminants in surficial bottom sediments in Lake Worth.
2. To describe historical trends in selected hydrophobic contaminants in Lake Worth near AFP4 and Carswell Field and at locations remote from the facilities.
3. To determine, to the extent possible, major natural and anthropogenic sources of hydrophobic contaminants to Lake Worth.

To accomplish these objectives, surficial sediment samples (top 2 centimeters [cm]) were collected at 21 sites and analyzed for major and trace elements, PAHs, organochlorine pesticides, PCBs, and grain size. Major elements include aluminum, calcium, iron, magnesium, potassium, and titanium. Trace elements include arsenic, cadmium, chromium, copper, lead, nickel, and zinc. The surficial sediment samples were collected to describe contaminant spatial distributions. The sites were distributed throughout the lake (fig. 1) to include areas along the shoreline of Air Force facilities, the mouths of major tributaries, areas near the dam that are influenced by all sources of contaminants to the lake, and areas in the upper part of the lake not affected by the Air Force facilities and less affected by urbanization.

At three of the 21 sites in which surficial sediment was collected, gravity cores were collected to investigate historical trends in selected contaminants. Gravity core sediment samples were analyzed for major and trace elements, PAHs, organochlorine pesticides, PCBs, grain size, and cesium-137 ( $^{137}\text{Cs}$ ) (for sediment dating). The locations of the three gravity core sites were in the main part of the lake near the dam, in Woods Inlet near the mouth of Meandering Road Creek, and in the upper part of the lake upstream from the IH-820 bridge. Respectively, these sites were selected to represent historical trends in contaminants for a site influenced by all inputs of contaminants to the lake, a site influenced by runoff from AFP4, and a reference site upstream from AFP4 and much of the urban influence to the lake.

## Study Area

Lake Worth (fig. 1) is in western Tarrant County. The reservoir was completed in 1914 by the City of Fort Worth to serve as a municipal water supply. In addition to water supply, Lake Worth is a source of recharge to the underlying Paluxy aquifer that supplies municipal water to the community of White Settlement. Lake Worth has a storage capacity of 47 million cubic meters ( $\text{m}^3$ ) and a surface area of 13.2 square kilometers ( $\text{km}^2$ ). The drainage area to the reservoir totals 5,350  $\text{km}^2$  (Ruddy and Hitt, 1990). The surrounding area to the south and east is mostly urban, and the area to the north and northwest is mostly residential. The western part of the watershed is principally rangeland.

About 6 kilometers (km) upstream from Lake Worth on the West Fork Trinity River is Eagle Mountain Lake. Eagle Mountain Lake was constructed in 1932

and has a storage capacity about five times larger than that of Lake Worth (Ulery and others, 1993) making it an efficient trap for sediment eroded from most of the Lake Worth watershed. The geologic formations that crop out in the vicinity of Lake Worth, including the part of the watershed downstream from Eagle Mountain Lake, include the Paluxy Formation, Goodland Limestone, and Walnut Formation. The upper part of the Paluxy Formation consists of mudstone interbedded with fine-grained sandstone. The Goodland Limestone consists of limestone interbedded with marl and shale beds. The Walnut Formation consists equally of clay and limestone (Kuniansky and Hamrick, 1998).

AFP4 occupies 2.44 km<sup>2</sup> and was developed in 1942 to manufacture aircraft. Prior to 1973, waste materials (waste oils, fuels, solvents, paint residues, and spent process chemicals) were placed in on-site landfills or burned during fire training exercises (Texas Department of Health, 1998).

Certain areas were identified during the RI/FS as having soil and sediment contaminant concentrations that potentially pose an excess risk to human health or the environment or that exceed the lower threshold of a defined acceptable risk range. These areas include soils associated with two landfills, Landfill No. 3 (LF3) and Landfill No. 4 (LF4), sediment along Meandering Road Creek and Woods Inlet, and soil beneath Building 181 (fig. 1). Along the western edge of LF3 and east of Meandering Road Creek, soil samples were collected with trace element concentrations (copper, lead, and zinc) high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7–11). Other contaminants detected along the western edge of LF3 include cadmium, trichloroethene (TCE), and benzo(a)pyrene (a PAH). Soil samples along the western edge of LF4 also had trace element concentrations (cadmium and copper) high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7–11). Other contaminants detected along the western edge of LF4 include TCE, benzo(a)pyrene, arsenic, and zinc. Sediment samples from Meandering Road Creek yielded arsenic, cadmium, copper, lead, silver, and zinc. Sediment samples were collected at sites offshore from AFP4, in a cove near the northeastern corner of AFP4, and in Woods Inlet. Contaminants detected at those sites include arsenic, cadmium, copper, lead, silver, zinc, TCE, and PCBs (Aroclors 1254 and 1260).

## Acknowledgments

The authors thank U.S. Air Force personnel at the Naval Air Station/Joint Reserve Base in Fort Worth for their interest and cooperation in this study.

## METHODS AND PRELIMINARY COMPUTATIONS/ANALYSES

### Collection of Bottom Sediment Samples

The 21 surficial sediment samples were collected from 21 sites (fig. 1; table 1, at end of report) with a 14-by 14-by 20-cm Wildco box corer with an acrylic liner that penetrated to about 20 cm into the sediment. The top 2 cm of each box core sample was retained in the acrylic liner as a representative sample and homogenized with a Teflon spoon. A subsample for analysis of organic compounds was transferred to a baked-glass jar, and a subsample for analysis of major and trace elements and grain size was transferred to a polypropylene jar. Samples were stored on ice until they were shipped overnight for analysis.

The three gravity cores were collected from three sites (fig. 1, table 1) using a Benthos gravity corer with a 6-cm diameter, 3.1-m long barrel with a polycarbonate core liner. Cores were subsampled on-site by vertical extrusion of the sediment in measured increments using a piston pushed into the bottom of the liner. The gravity core from site 12 near the mouth of Meandering Road Creek (LWT.WD) was subsampled every 5 cm from the top of the core to a depth of 60 cm and every 10 cm from 60 cm to 190 cm. The remaining 6 cm from 190 cm to the bottom of the core also was subsampled. The gravity cores from site 1 in the main part of the lake near the dam (LWT.DM) and site 16 in the upper part of the lake upstream from the IH-820 bridge (LWT.UB) were subsampled every 5 cm throughout their entire length. Not all subsamples were analyzed for all constituents. Each subsample was homogenized and split. Samples for analysis of organic compounds were transferred to a baked-glass jar, and samples for analysis of major and trace elements, grain size, and <sup>137</sup>Cs were transferred to a polypropylene jar.

Sampling tools were washed between each sample using phosphate-free detergent and tap water followed by a tap water rinse. A dilute acid or methanol rinse as suggested in some protocols (Radke, 1997; Shelton and Capel, 1994) was not done because of logistical complications and because it was considered unnecessary on the basis of previous experience with

this type of sampling. Sediment cores were processed on-site to avoid disturbance in transport, and about 60 samples were processed over several days for this study. On-site rinsing with acid and methanol would have appreciably extended subsampling time and caused problems with waste collection and disposal at the lakeshore site where cores were processed. Collection and analysis of numerous lake cores using the methods described in this report have shown no detectable cross-contamination of samples during core collection and processing. This conclusion is based on the consistent lack of detection of  $^{137}\text{Cs}$  and synthetic organic compounds in deeper, older sediments from cores, even when upper layers of sediment in the same cores were moderately to highly contaminated (for example, Van Metre and Callender, 1997; Van Metre, Callender, and Fuller, 1997). Lack of detection of these constituents in older sediments from the three cores analyzed during the study described in this report indicates no detectable sample contamination. These older samples, in effect, make excellent equipment blanks because they are the target sampling matrix (sediment), are initially free of the compounds being measured, and are exposed to all of the sampling equipment being used.

## Analytical Methods

Radiochemical analysis for  $^{137}\text{Cs}$  activity was done by gamma spectroscopy at Severn Trent Laboratories, Inc., Richland, Wash., under contract with the USGS National Water Quality Laboratory (NWQL). The USGS sediment laboratory in Iowa City, Iowa, did the grain size analyses using sieve and pipette methods (Guy, 1969).

Samples for analysis of major and trace elements were freeze-dried and ground to a fine powder. Samples were completely digested using a mixture of hydrochloric-nitric-perchloric-hydrofluoric acids and analyzed by inductively-coupled plasma/mass spectrometry at the NWQL in Denver, Colo. (Briggs and Meier, 1999). Quality control was provided by determining the elemental concentrations for duplicate samples and for a variety of soil, lake, and marine reference samples. One of every eight samples analyzed (12 percent) was analyzed in duplicate (or replicate if more than two samples). Quality-assurance results for trace elements are reported with other trace element analytical results. No quality issues with major and trace element data were encountered.

Upon receipt of the samples, personnel at the NWQL extracted, isolated, and analyzed the samples for PAHs, organochlorine pesticides, and PCBs using a variation of the procedures of Foreman and others (1995) and Furlong and others (1996). Briefly, sediment was extracted overnight with dichloromethane in a Soxhlet apparatus. Two aliquots of the sample extract were injected into a polystyrene-divinylbenzene gel permeation column (GPC) and eluted with dichloromethane to remove sulfur and partially isolate the target analytes from coextracted high-molecular-weight interferences such as humic substances. The first aliquot was analyzed for PAHs and alkyl-PAHs by capillary-column gas chromatography with detection by mass spectrometry (MS). The second aliquot was further split into two fractions by combined alumina/silica adsorption chromatography prior to determination of the organochlorine pesticides and PCBs by dual capillary-column gas chromatography with electron capture detection.

Variations on the procedures of Furlong and others (1996) for the determination of PAHs included the addition of a silica column cleanup step following the GPC step and the use of selected ion monitoring (SIM) MS to reduce chemical interferences and improve detection limits. Nineteen parent PAHs, 10 specific alkyl-PAHs, and the homologous series of alkyl-PAHs were determined for this study. Total PAH is the sum of 18 of the 19 parent PAHs (excluding perylene) plus the homologous series.

Quality control for PAH, organochlorine pesticide, and PCB data was provided by analyzing laboratory duplicate samples (one of every 12 samples was analyzed in duplicate), spiked reagent samples, and monitoring recovery of surrogate compounds. Quality-assurance results are reported with other analytical results, respectively. No quality issues with these data were evident.

## Age Dating and Mass Accumulation Rates

Because  $^{137}\text{Cs}$  sorbs strongly to fine-grained sediments, it is useful for dating sediments exposed to atmospheric fallout, including lake and ocean sediment cores (Durrance, 1986). Large-scale nuclear weapons testing released appreciable amounts of  $^{137}\text{Cs}$  to the atmosphere beginning about 1952, and atmospheric concentrations peaked during 1963–64. Profiles of  $^{137}\text{Cs}$  activity can provide two date markers in reservoirs built before about 1950—the first occurrence

during 1952–53 and the peak in 1964. Two other date markers also are useful when assigning dates to sections of the core: the reservoir construction date matched to the pre-reservoir land surface in the lower part of the core and the sampling date at the top of the core (Van Metre and Callender, 1997).

Ages for samples at depth intervals between known depth-date markers were assigned on the basis of mass accumulation rate (MAR), not linear sedimentation rate. MARs are used because they automatically adjust for compaction in a core, whereas linear sedimentation rates do not.

MARs were calculated by first estimating porosity of each sample by

$$\text{Porosity} = (\text{WW} - \text{WD}) / ((\text{WW} - \text{WD}) + (\text{WD} - \text{WT}) / \text{DS}), \quad (1)$$

where

WW = wet weight (grams),

WD = dry weight (grams),

WT = tare weight of container (grams), and

DS = density of solids (grams per cubic centimeter).

The density of solids was assumed to be 2.5 grams per cubic centimeter ( $\text{g}/\text{cm}^3$ ), and 1 gram (g) of water equals 1 cubic centimeter ( $\text{cm}^3$ ) of water.

Porosity then was used to estimate the dry mass per square centimeter contained in each sample interval by

$$\text{Dry mass} = (1 - \text{porosity}) \times \text{DS} \times \text{Th}, \quad (2)$$

where

Th = thickness of the sample interval (centimeters).

Dry mass for each sample interval plus interpolated dry mass, if any intervals were not analyzed, were summed to yield cumulative mass (CM) for the core and for each date-bounded interval ( $\text{CM}_j$ ). The constant MAR for each date-bounded interval was calculated by dividing the CM (grams per square centimeter) by the time interval represented (year) to yield MAR (grams per square centimeter per year):

$$\text{MAR} = \frac{\text{CM}}{\text{time interval}}. \quad (3)$$

Once a MAR is calculated it can be used to assign dates to intervening samples. If the date-bounded interval ends at the top of the core, the deposition date of sample  $i$  is calculated by

$$\text{Date}_i = \text{Sample date} - (\text{CM}_i / \text{MAR}), \quad (4)$$

where

Sample date = date of core collection (decimal years), and

$\text{CM}_i$  = cumulative mass from the top of the core down to the depth represented by the midpoint of sample  $i$ .

In many cases, MAR changes with depth in a core. A simple case is where different MARs are calculated before and after the  $^{137}\text{Cs}$  peak in 1964. Samples above the depth of the  $^{137}\text{Cs}$  peak (deposited after 1964) are assigned dates using equation 3. Samples below the depth of the  $^{137}\text{Cs}$  peak are dated by

$$\text{Date}_i = \text{Date marker}_j - ((\text{CM}_i - \text{CM}_j) / \text{MAR}_j), \quad (5)$$

where

Date marker $_j$  = date of the marker at the top of the interval containing sample  $i$ ,

$\text{CM}_j$  = cumulative mass to Date marker $_j$ , in grams per square centimeter, and

MAR $_j$  = MAR for the interval containing sample  $j$ , in grams per square centimeter per year.

For example, the  $^{137}\text{Cs}$  peak in a core is at 48 to 50 cm with a  $\text{CM}_j$  of 18.9 grams per square centimeter ( $\text{g}/\text{cm}^2$ ). The pre-reservoir surface is at 90 cm with a CM of 42.7 g, resulting in a MAR for this interval (MAR $_j$ ) of 0.7 gram per square centimeter per year ( $\text{g}/\text{cm}^2\text{-yr}$ ) [(42.7 – 18.9)/(1964 – 1930)]. The estimated deposition date of sample  $i$ , at 60- to 62-cm depth with  $\text{CM}_i$  equal 24.0  $\text{g}/\text{cm}^2$ , is given by

$$\text{Date}_i = 1964.0 - ((24.0 - 18.9) / 0.7) = 1956.7$$

Other chemical parameters that can be used to corroborate the age assignments obtained using  $^{137}\text{Cs}$  and core lithology are peaks in lead and total DDT and changes in the profiles of elements. Lead concentrations in urban lake and reservoir sediment cores peaked consistently in the mid-1970s, coinciding with the switch from leaded to unleaded gasoline (Van Metre and Callender, 1997). Total DDT concentrations in core sediments generally peaked in the early to mid-1960s, coincident with peak use of DDT in the United States (Van Metre and others, 1998). DDT use was banned in the United States in 1972. Elements such as aluminum and calcium reflect the bulk mineralogical characteristics of sediments. When a major change in sediment source area occurs, it is likely that concentrations of

these elements will change. Sharp breaks in concentration profiles of elements can corroborate a known change in sediment source area. All of these methods were used to assign dates to core samples and to investigate the reasonableness of the date assignments.

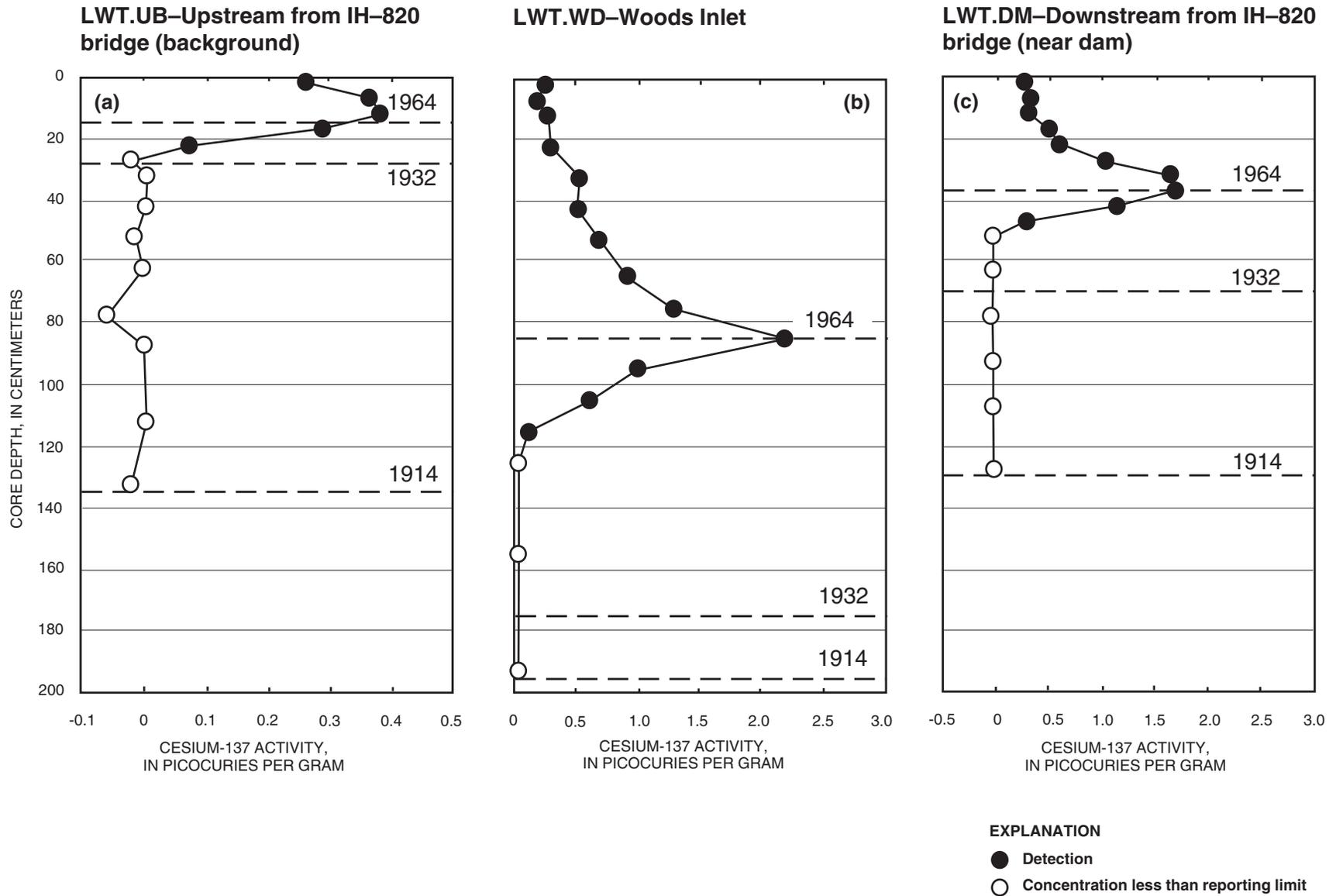
The  $^{137}\text{Cs}$  activity profiles for the three gravity cores from Lake Worth indicate differences in sedimentation rates between sites (fig. 2). Core LWT.UB, collected in the upper part of the lake, has an unusual  $^{137}\text{Cs}$  profile with nondetections most of the way up the core and a low-activity rounded peak in the top 20 cm of the core. Although at first glance this profile seems anomalous, the construction of Eagle Mountain Lake immediately upstream from Lake Worth on the West Fork Trinity River in 1932 provides a logical explanation. Eagle Mountain Lake has a conservation storage capacity about five times greater than that of Lake Worth and captures nearly all of the runoff from the watershed of Lake Worth. Thus, it is likely that sedimentation rates in Lake Worth declined dramatically after 1932, especially in the upper part of the lake upstream from the larger tributary inflows.

Assuming the center of the peak in core LWT.UB at about 15 cm represents the  $^{137}\text{Cs}$  peak in 1964 results in MARs of 0.14 and 2.05  $\text{g}/\text{cm}^2\text{-yr}$  for the periods 1964–2001 and 1914–64, respectively. The MAR of 0.14  $\text{g}/\text{cm}^2\text{-yr}$  was used to assign dates back in time to about 1932, assuming that the large change in MAR occurred coincident with the construction of Eagle Mountain Lake in 1932. The remaining mass in the core must then be accounted for with a very large MAR of 5.46  $\text{g}/\text{cm}^2\text{-yr}$  applied to the period 1914–32 (fig. 3; table 2, at end of report). This calculation puts 1932 at only about 30 cm deep in the core, compared to a pre-reservoir depth of 135 cm. Although this large difference in sedimentation rate and the assumptions it is based on might seem questionable, element concentration profiles in the core provide some supporting evidence for the age assignments. Elements such as aluminum and calcium reflect the bulk mineralogical characteristics of sediments. On average, aluminum and calcium represent 78 percent of the total mass of the measured elements in sampled sediments from Lake Worth. When a major change in sediment source area occurs, element concentrations likely will change. Sharp breaks in concentration profiles of most elements (including aluminum, calcium, iron, magnesium, potassium, and titanium) in core LWT.UB occur between about 20 and 30 cm, which is consistent with the assumption that construction of Eagle Mountain Lake

greatly altered sedimentation in the upper part of Lake Worth and the age assignment of 1932 at about 30 cm (fig. 4; table 3, at end of report).

A similar temporal pattern but with a much less pronounced difference in MAR was computed for core LWT.DM. A MAR of 0.34  $\text{g}/\text{cm}^2\text{-yr}$  was computed for 1932–2001 on the basis of the  $^{137}\text{Cs}$  peak at 35 to 40 cm (fig. 2). Extrapolating this rate down core to an estimated date of 1932 results in a rate of 2.14  $\text{g}/\text{cm}^2\text{-yr}$  for the lower part of the core. As was the case with LWT.UB, the assignment of dates in the 1930s (60 to 80 cm) is supported by changes in element concentrations in this part of the core (fig. 4; table 3). The smaller differences in sedimentation rates before and after 1932 at the lower lake site compared to the upper lake site could be caused by several factors including additional sediment reaching the lower lake site from tributaries flowing directly into the lake (such as Meandering Road Creek, Live Oak Creek, and Silver Creek) and proportionally much higher sedimentation rates from the West Fork Trinity River to the upper lake site prior to 1932.

The core LWT.WD has a  $^{137}\text{Cs}$  profile (fig. 2) characterized by a distinct first occurrence and sharp peak, a smooth exponential decrease above the peak, and a large peak-to-top-of-core concentration ratio (Van Metre and Callender, 1997). Using the pre-reservoir surface (196 cm in 1914), the  $^{137}\text{Cs}$  first occurrence (115 cm in 1953), the  $^{137}\text{Cs}$  peak (85 cm in 1964), and the sampling date (0 cm in 2001) as depth-date markers resulted in three calculated MARs: 1.17, 1.36, and 0.95  $\text{g}/\text{cm}^2\text{-yr}$  for the time intervals 1914–53, 1953–64, and 1964–2001, respectively (table 2). Dates were assigned to samples between these depth-date markers using the mass profile in the core and these MARs. The range in sedimentation rates is less variable (compared to the differences in rates in other cores) because the core was taken from a site in Woods Inlet with little or no influence from activities upstream from the main lake, such as the construction of Eagle Mountain Lake. The changes in element chemistry also are less pronounced in this core compared to the other cores (fig. 4). Aluminum, iron, potassium, and titanium concentrations might have decreased over time, but at a lower rate of change compared to the rates of change indicated in the profiles for those elements for core LWT.UB. Calcium concentrations might have increased over time, but again at a lower rate. Magnesium concentrations have remained about the same over time. These changes could result from the relatively gradual



**Figure 2.** Cesium-137 profiles in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

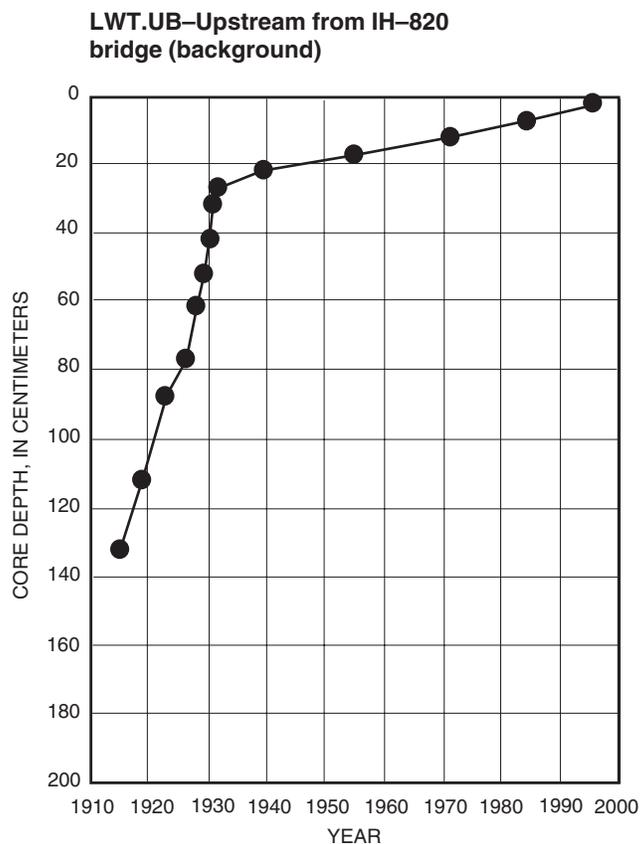
development of the watershed to Woods Inlet over time, which caused changes in soil erosion patterns.

The profiles of two other chemical constituents, lead and total DDT, corroborate age dates for cores LWT.DM and LWT.WD. The lead peak in LWT.WD was assigned a reasonable date of 1974 and the total DDT peak a reasonable date of 1960. There are two lead peaks in LWT.DM dated as 1969 and 1991, adding little to the understanding of age dates; however, the total DDT peak is at a reasonable date of 1969.

### Normalization Techniques and Statistical Tests

Trace elements in aquatic sediments are known to be associated with the finer grain-size fractions because the elements typically are retained on sediment by surface reactions and finer-grained sediments have greater surface area than coarse-grained sediments (Horowitz and Elrick, 1987; Horowitz and others, 1995). To investigate the variability in trace element concentrations, sediment data sometimes are normalized by dividing the trace element concentration by some bulk sediment property such as percentage of silt and clay or aluminum, iron, titanium, or total organic carbon concentration (Van Metre and Callender, 1996). The term “normalize” does not imply that trace element concentrations are made to fit a normal distribution after dividing by some sediment property. Normalization can remove some of the natural variability in elemental concentrations among samples caused by changes in bulk sediment properties, which makes detection of differences among sample concentrations, for example, those caused by anthropogenic effects, easier. This concept of normalization assumes that the normalizing constituent explains all of the natural variability in the trace element and that trace element concentrations are zero if the normalizing constituent is absent (intercept is zero). The normalized value is proportional to some background condition but does not provide a direct indication of the amount of anthropogenic enrichment (for example, mass of contaminant added by anthropogenic activities).

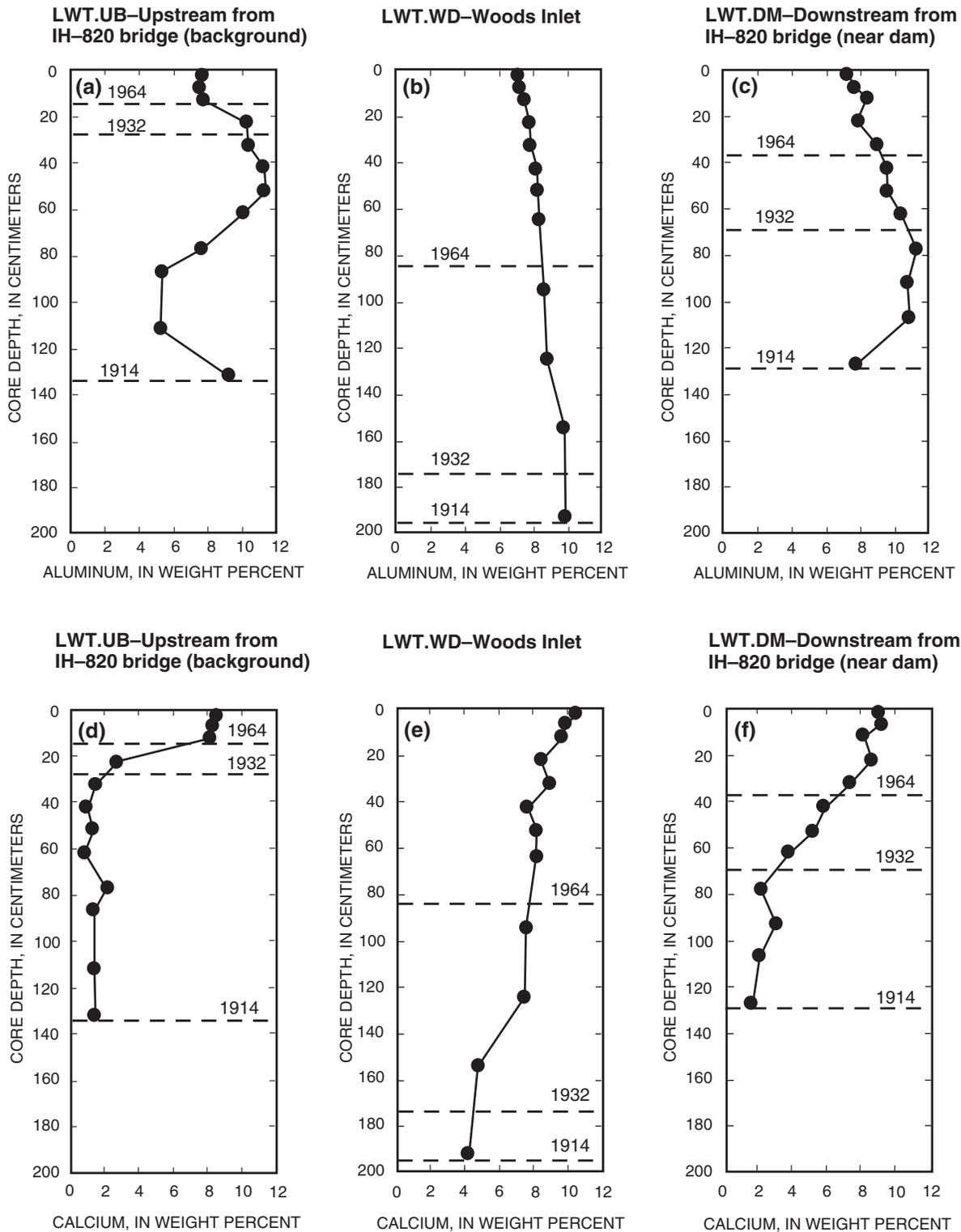
An alternative normalizing method was used for the Lake Worth sediment samples. First, background samples were identified on the basis of the locations of sampling sites in the lake and knowledge of sediment chemistry. Sites upstream from the IH-820 bridge and AFP4 and much of the urban influence to the lake were selected to represent background conditions. They



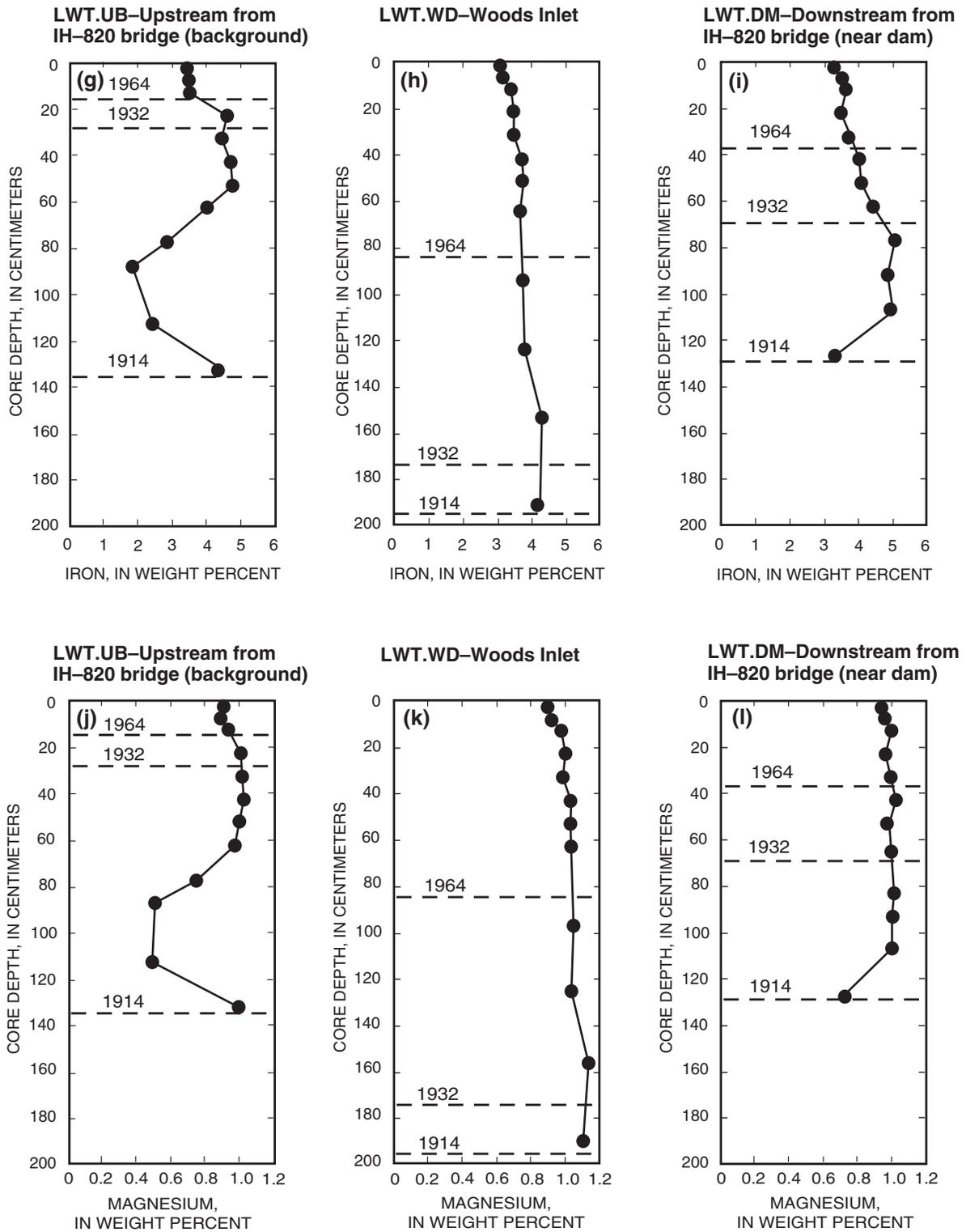
**Figure 3.** Depth versus cesium-137 date in gravity core sample from background site upstream from IH-820 bridge in Lake Worth, Fort Worth, Texas, 2000–2001.

include 12 samples from gravity core LWT.UB and surficial samples from sites 15, 16, 17, 18, 19, and 20. Simple linear regression equations developed from trace element and bulk sediment properties of background samples were used to estimate expected background concentrations for all samples. Assuming the estimates are reliable, any measured trace element concentration significantly above the regression line (for example, at a 95-percent confidence level) can be attributed to an anthropogenic influence. By this approach, much of the natural variation in the effects of bulk sediment properties can be accounted for, and a zero intercept between element concentrations and the normalizing variable is not forced.

Correlation was used to assess relations between trace element concentrations and possible explanatory variables (such as percent clay content; percent silt and clay content; aluminum, iron, and titanium concentrations) and to select the explanatory variable for

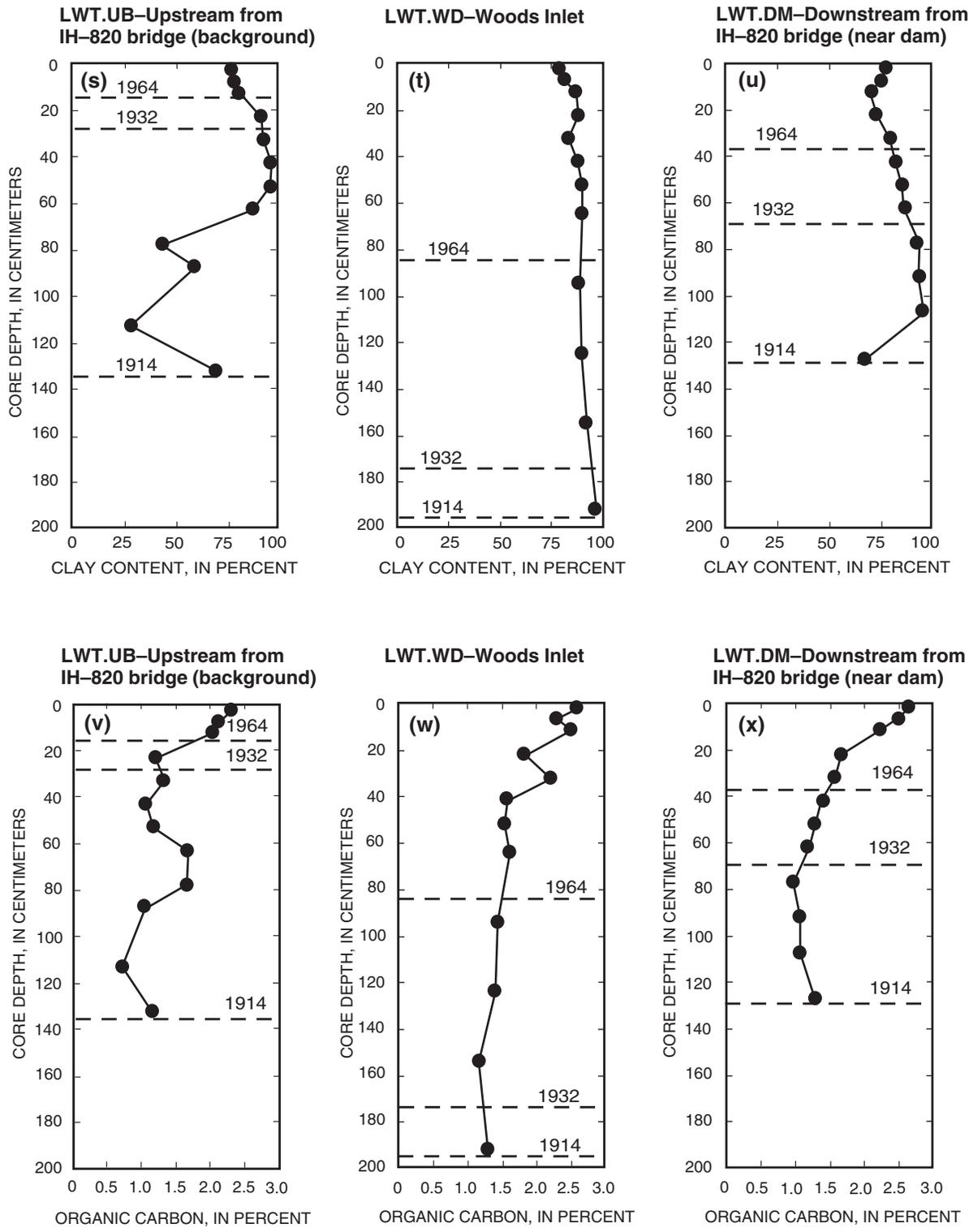


**Figure 4a–f.** Sediment characteristics and selected major elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.



**Figure 4g–l.** Sediment characteristics and selected major elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.





**Figure 4s–x.** Sediment characteristics and selected major elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

regression analysis. Inspection of boxplots and normal probability plots of trace element concentrations and the explanatory variables indicated data not normally distributed. Boxplots and probability plots are recommended for normality testing, as explained in detail in Helsel and Hirsch (1992). The Kendall's tau correlation coefficient was used to assess the relations. Kendall's tau is a nonparametric test that measures the strength of the monotonic relation between two variables and does not require the data to be normally distributed (Helsel and Hirsch, 1992). Statistically significant correlations were defined as those with p-values less than or equal to .05.

After the explanatory variable (aluminum) was selected, simple linear regression was performed on sample concentrations of arsenic, cadmium, copper, lead, nickel, and zinc from sites upstream from IH-820 to estimate background concentrations of those elements. A best-fit line, along with its 95-percent confidence interval, on the regression graphs was then used to indicate whether measured trace element concentrations were significantly greater than background concentrations.

Several graphs were used to test the assumptions of linear regression. Scatterplots of the residuals and the predicted values were used to look for changing variance, or heteroscedasticity. Residuals plots that show changing variance are curved, which indicate that a transformation of the response variable, in this case trace element concentration, might be necessary. Boxplots and probability plots of the residuals were investigated for normality. Normality of the residuals is necessary to estimate confidence intervals, but linear regression makes no assumptions about the distributions of either the explanatory or the response variable (Helsel and Hirsch, 1992).

To compare selected constituent concentrations between groups (background samples, Woods Inlet and immediately offshore of AFP4/Carswell Field samples, and downstream samples), two nonparametric tests were used. The Kruskal-Wallis test for differences between medians from several different groups was used to indicate whether at least one group median was significantly different (p-value less than or equal to .05) from the other two groups (Helsel and Hirsch, 1992). If at least one median was significantly different from medians of the other groups, a multiple comparison test (Dunn's test) (Gibbons, 1985) was used to indicate which group(s) were different also at the .05 significance level.

Two samples with anomalously high lead concentrations (LWT.UB [site 16] 50 to 55 cm and 60 to 65 cm) and one sample with anomalously high copper concentration (site 15) were excluded from statistical tests. Lead concentrations from the two samples were excluded when testing for relations between lead and normalizing constituents and when performing regression on background samples. Similarly, the copper concentration from site 15 was not used when testing for relations between copper and normalizing constituents and when performing regression on background samples. The purpose of the regression procedure is to estimate background concentrations in sediment from Lake Worth. The lead concentrations in the two excluded samples are about 14 (LWT.UB 50 to 55 cm) and 32 (LWT.UB 60 to 65 cm) times greater than other samples in the core and are higher than peak lead concentrations in many urban lakes (Callender and Van Metre, 1997). The copper concentration at site 15 is about 3.4 times greater than other surficial sediment samples collected from upstream sites. Although the causes of these anomalous concentrations are not known, they clearly do not represent typical background conditions upstream from the IH-820 bridge. Therefore, they were excluded.

### **Grain Size and Organic Carbon**

The results of grain-size analyses for the gravity core and surficial sediment samples are presented in table 3. Clay content in the gravity core sediment samples with respect to depth is presented in figure 4. Sampled sediments are almost exclusively silt and clay (particles less than 63 micrometers [ $\mu\text{m}$ ]). The median percentages of silt and clay in sampled sediments are 100 and 98 percent for gravity cores and surficial samples, respectively. The median percentages of clay-size particles (less than 4  $\mu\text{m}$ ) are 86 and 78 percent for gravity cores and surficial samples, respectively. Two of the surficial sediment samples (sites 2 and 17) were collected near shore and were predominately sands. Four gravity core samples also had slightly coarse grain size. Three samples from LWT.UB at depths of 77.5, 87.5, and 112.5 cm and the deepest sample at 127.5 cm from LWT.DM all had a lower percentage (less than 70 percent) of clay-size particles than the other gravity core samples. The other gravity core samples are relatively homogenous with respect to the percentage of clay-size particles; all gravity core samples had a high percentage of silt- and clay-size particles.

Total organic carbon in the surficial sediment samples ranged from 0.91 to 2.85 percent by weight (table 3) with a median of 2.38 percent. The two predominately sand samples had 0.91 and 1.09 percent total organic carbon. The remaining 19 samples were relatively homogeneous with respect to total organic carbon, ranging from 2.24 to 2.85 percent. This overall homogeneity in terms of grain size and total organic carbon reduces the amount of variability in trace element and organic compound concentrations caused by variations in bulk sediment properties; homogeneity therefore improves the ability to detect anthropogenic influences.

Profiles of total organic carbon in the three gravity cores are similar (fig. 4), decreasing from about 2.5 percent at the sediment surface to about 1.0 percent near the bottom of the cores. In some lakes and reservoirs, the decrease in total organic carbon with depth has been attributed to the gradual breakdown of organic carbon, an example of diagenesis, the chemical alteration of the sediments after deposition (Callender, 2000). The trends in total organic carbon in the Lake Worth cores and trends in other elements (fig. 4) suggest that the construction of Eagle Mountain Lake in 1932 also might have contributed to changes in total organic carbon concentrations.

## **SPATIAL DISTRIBUTION AND HISTORICAL TRENDS OF SELECTED HYDROPHOBIC CONTAMINANTS**

### **Trace Elements**

One objective of this report is to identify, to the extent possible, major natural and anthropogenic sources of contaminants to Lake Worth. For synthetic organic compounds like PCBs, any occurrence is anthropogenic; however, trace elements are naturally occurring, and concentrations can vary substantially in different geologic materials (Drever, 1988). The ability to distinguish natural from anthropogenic sources of trace elements requires knowledge of those natural sources.

The three geologic formations (Paluxy Formation, Goodland Limestone, and Walnut Formation) that crop out in the vicinity of Lake Worth and its sediment-contributing watershed, the part of the watershed downstream from Eagle Mountain Lake, could have different background concentrations of trace elements; however, as all three are represented in each of the major tributaries

(Kuniansky and Hamrick, 1998, fig. 3) no major geologic difference occurs among tributaries. Typical concentrations of trace elements in surface soils in the watershed are not available; however, various physical and chemical processes cause differences in element concentrations in soils, streambed sediments, and lake sediments, including selective erosion, dissolution, leaching, sorting by particle size, and deposition. Therefore, knowing background soil concentrations will not necessarily tell us background lake sediment concentrations (Edward Callender, U.S. Geological Survey, written commun., 2003).

Trace element concentrations in sediment sometimes are compared to sediment quality guidelines. MacDonald and others (2000) determined a probable effect concentration (PEC) for trace elements. The PEC is the sediment concentration in freshwater ecosystems above which adverse effects (to benthic organisms) are expected to occur more often than not. The PECs for arsenic, cadmium, chromium, copper, lead, nickel, and zinc are 33, 4.98, 111, 149, 128, 48.6, and 459 micrograms per gram ( $\mu\text{g/g}$ ), respectively (MacDonald and others, 2000). Throughout the discussion of the spatial distribution of trace elements, comparisons will be made to the PEC. The PEC for each of the trace elements also is listed in table 3 after the core sample concentrations.

### **Regression Results**

To assist in the selection of the normalizing constituent, Kendall's tau correlation coefficients between selected trace element concentrations and several possible normalizing constituents were computed for the subset of background samples and for all samples (table 4, at end of report). The correlations typically are stronger when only the background samples are included. This indicates that more of the variability in trace element concentrations in background samples is explained by changes in bulk sediment properties than for all samples, including those potentially affected by anthropogenic influences. The correlations between concentrations of iron and trace elements and between aluminum and trace elements are similar and are stronger than those between other possible normalizing variables and trace elements (table 4). Because aluminum is a relatively chemically stable indicator of clay content, it was selected over the more reactive iron as the normalizing variable for the Lake Worth samples.

The results of linear regression analysis (table 5, at end of report) show that aluminum accounts for 54 to 98 percent of the variability (as indicated by coefficients of determination) in all of the background trace element concentrations except cadmium (23 percent), although the slope and intercept even for the cadmium relation are significant at the .05 level. The slopes and the intercepts, except those of arsenic, nickel, and zinc, also are significant at the .05 level. The lower significance for arsenic, nickel, and zinc intercepts indicates that a zero intercept between aluminum and each of these elements is possible. The slope defines how much the trace element concentration changes when the aluminum concentration changes. As expected, the slope terms in all of the regression equations are positive, indicating that trace element concentrations increase with increases in aluminum concentrations (clay content).

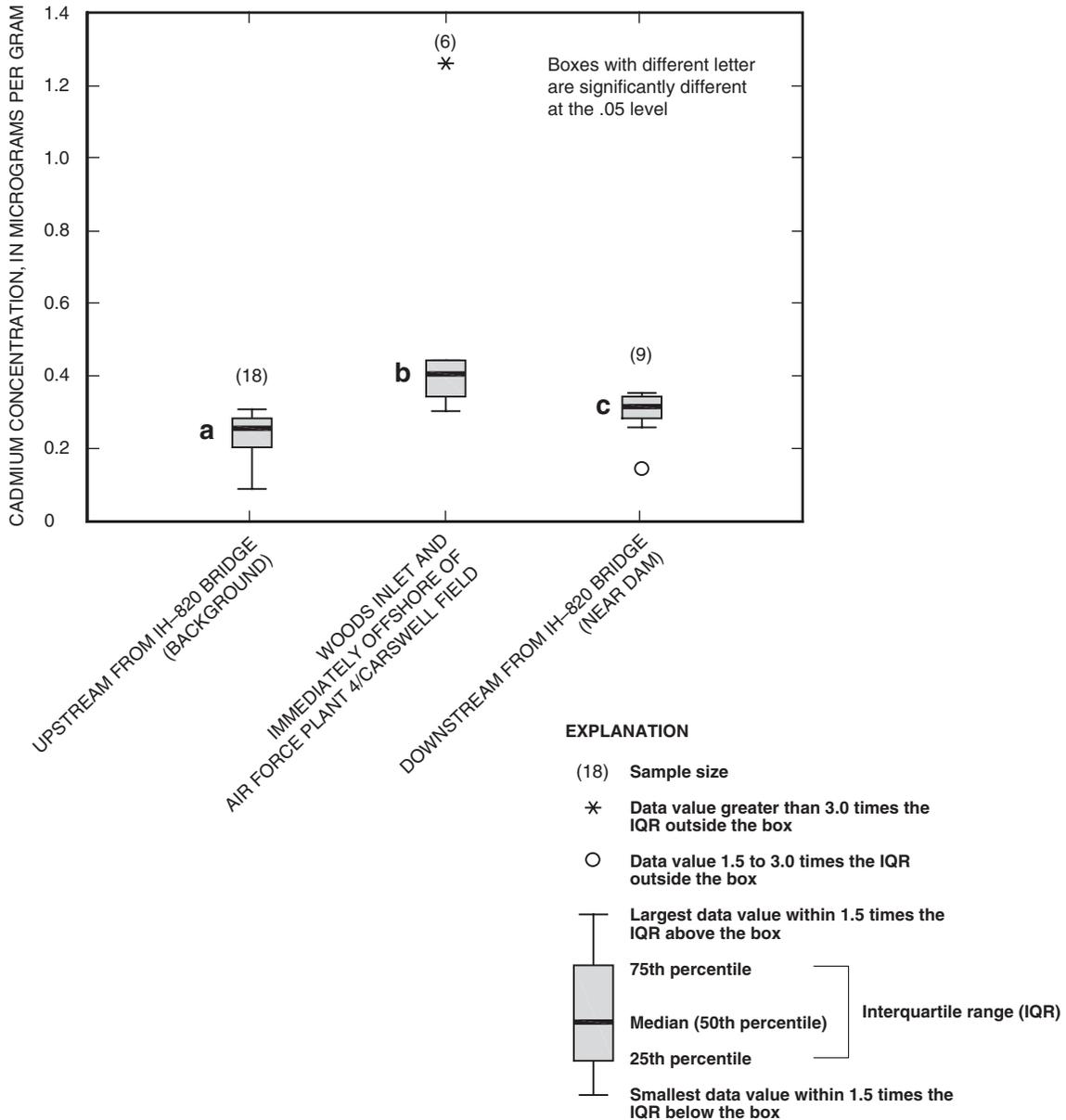
The assumptions underlying the regression-based normalization approach are that the samples used to develop the regression equations are representative of background concentrations in all samples in the lake and that the trace elements of interest vary linearly with variations in some quantified bulk sediment property or major element. The latter assumption, linear relations, was tested graphically and statistically. The former assumption is more difficult to test; however, several samples provide supporting evidence for this assumption. The samples are the bottom samples from the Woods Inlet (LWT.WD) and near-dam (LWT.DM) cores that predate the establishment of the Air Force facilities and most of the urban development in the area (samples dated as prior to 1934). These samples are addressed in the following discussion of the spatial distribution of trace elements. By supporting the assertion that the regression equations reasonably predict background concentrations of trace elements, sample results also support the assumption that trace element concentrations significantly greater than predicted background (those that plot above the 95-percent confidence interval on a regression graph) are elevated because of anthropogenic activities in the watershed.

Inspection of graphs of regression residuals and predicted values do not indicate problems associated with changing variance. Residuals plots do indicate that the regression equations tend to over-predict historical background trace element concentrations; however, in all cases the difference between the actual and the predicted value divided by the observed range of concentrations is less than 20 percent.

## Spatial Distribution of Trace Elements

Three groups of samples were compared to evaluate spatial differences in trace element concentrations relative to potential source areas of contaminants to the lake. Samples were grouped with the same logic used to select the three gravity core sites. The three groups were designed to represent sediment quality in (1) “background samples” from an area of the lake not affected by runoff from urban areas or the Air Force facilities (upstream from I-820 bridge), (2) “Woods Inlet and immediately offshore of AFP4/Carswell Field samples” from areas directly influenced by runoff from the Air Force facilities and urban areas to the south and west, and (3) “downstream samples” from an area influenced by all inputs to the lake. The background samples were identified in the discussion of normalization techniques and statistical tests. The Woods Inlet and immediately offshore of AFP4/Carswell Field samples are from sites 4, 6, 8, 11, 12, LWT.WD (top of core), and 13. The downstream samples are from sites 1, LWT.DM (top of core), 2, 3, 5, 7, 9, 10, 14, and 21. Deep, old samples from cores LWT.WD and LWT.DM were excluded from spatial comparisons because of large changes in contaminant concentrations with time at these two sites.

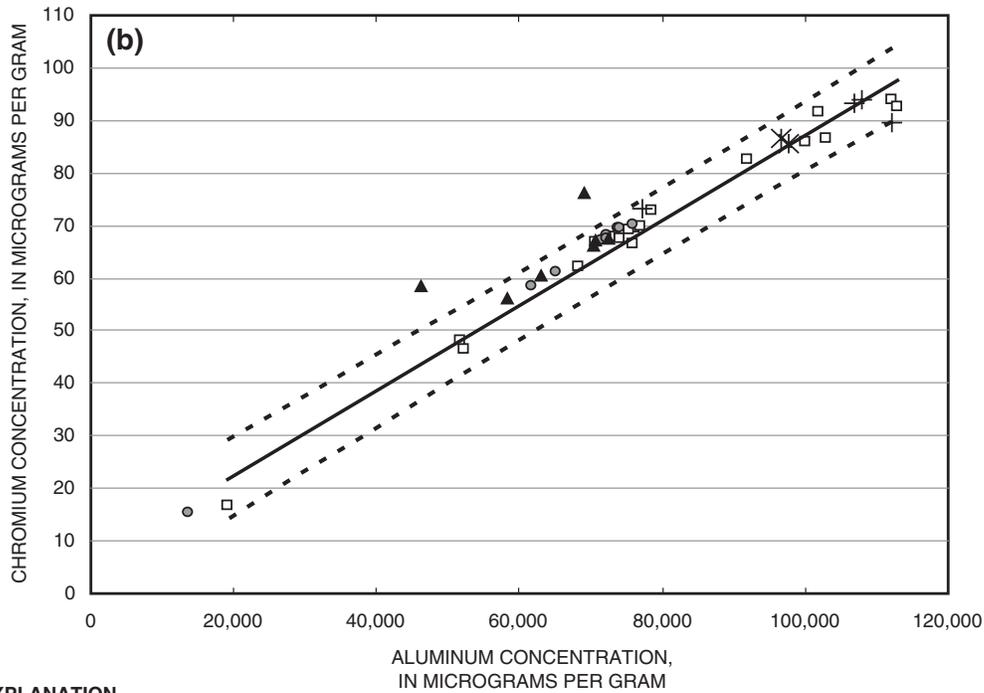
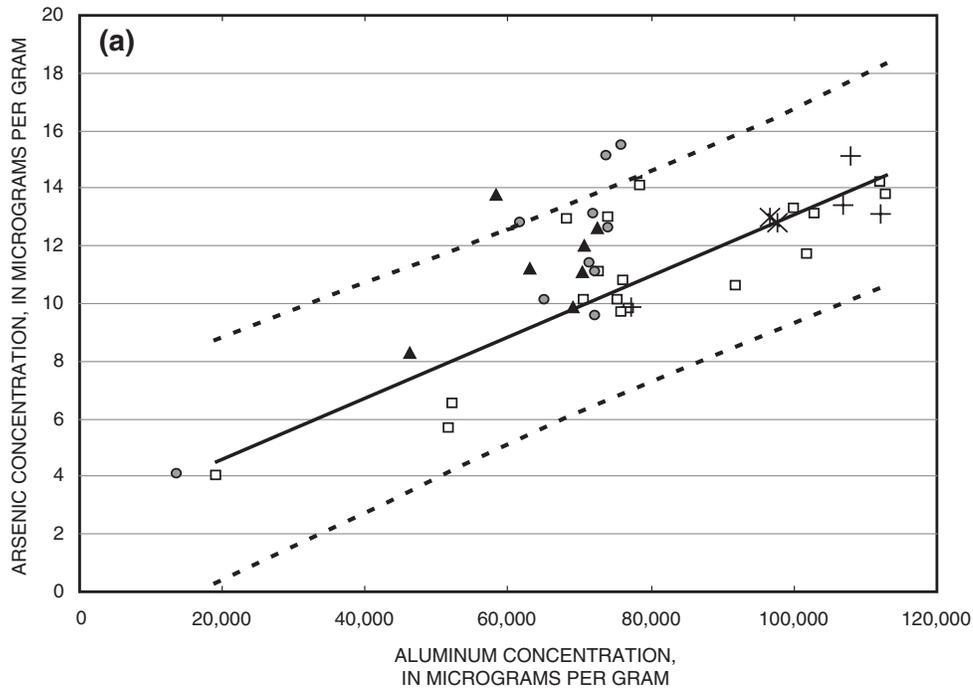
As noted in the discussion of the regression results, aluminum concentrations do not explain much of the variability in cadmium concentrations. Therefore, the non-normalized values were used to compare cadmium concentrations between groups. Cadmium concentrations were compared using the Kruskal-Wallis test. Results of the Kruskal-Wallis test indicate that at least one of the groups has a median cadmium concentration significantly different (at the .05 significance level) from medians of the other groups. In other words, at least one of the groups is significantly different from the other groups. According to Dunn’s multiple comparison test, all three groups are significantly different from one another. Cadmium concentrations were significantly higher at Woods Inlet and immediately offshore of AFP4/Carswell Field and downstream sites than at background sites (p-values = 0, .014, respectively); and concentrations at Woods Inlet and immediately offshore of AFP4/Carswell Field sites were significantly higher than at downstream sites (p-value = .05) (fig. 5). The extreme outlier in the Woods Inlet and immediately offshore of AFP4/Carswell Field boxplot of figure 5 is from site 11. Site 11 is the most upstream site in Woods Inlet and closest to LF3 and LF4 (fig. 1), where cadmium concentrations measured during the RI/FS along



**Figure 5.** Comparison of cadmium concentrations in lake sediment from selected areas of Lake Worth, Fort Worth, Texas, 2000–2001.

the western edge of LF4 were reported as high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7-11). Cadmium also was detected during the RI/FS in other samples collected offshore of AFP4 and Carswell Field. Although significantly greater than background concentrations, cadmium concentrations in sampled Lake Worth sediments (even at site 11) are all less than the PEC of 4.98 µg/g (MacDonald and others, 2000).

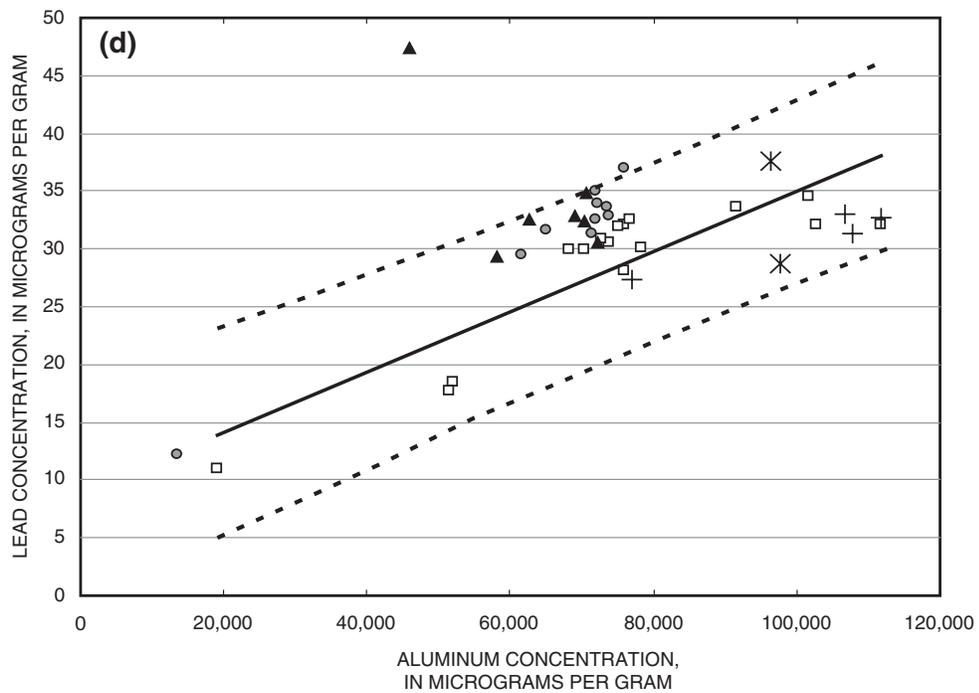
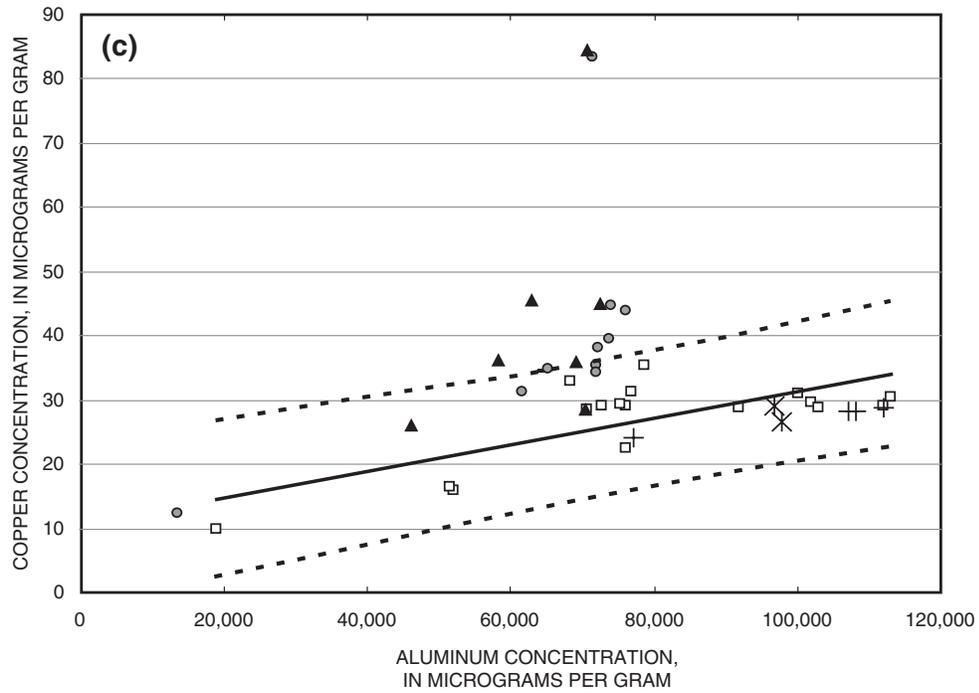
To investigate the spatial distribution and variability of trace elements, concentrations were plotted in relation to aluminum concentrations for the three groups identified: background samples, Woods Inlet and immediately offshore of AFP4/Carswell Field samples, and downstream samples (fig. 6). As discussed in normalization techniques and statistical tests, the regression line fit to the background samples was plotted with the upper and lower 95-percent confidence



**EXPLANATION**

- - - - - Boundary of 95-percent confidence interval
- Regression line, LWT.UB (background) concentrations
- Upstream from IH-820 bridge (background)
- ▲ Woods Inlet and immediately offshore of Air Force Plant 4/Carswell Field
- Downstream from IH-820 bridge
- × LWT.WD pre-1934 concentration
- + LWT.DM pre-1934 concentration

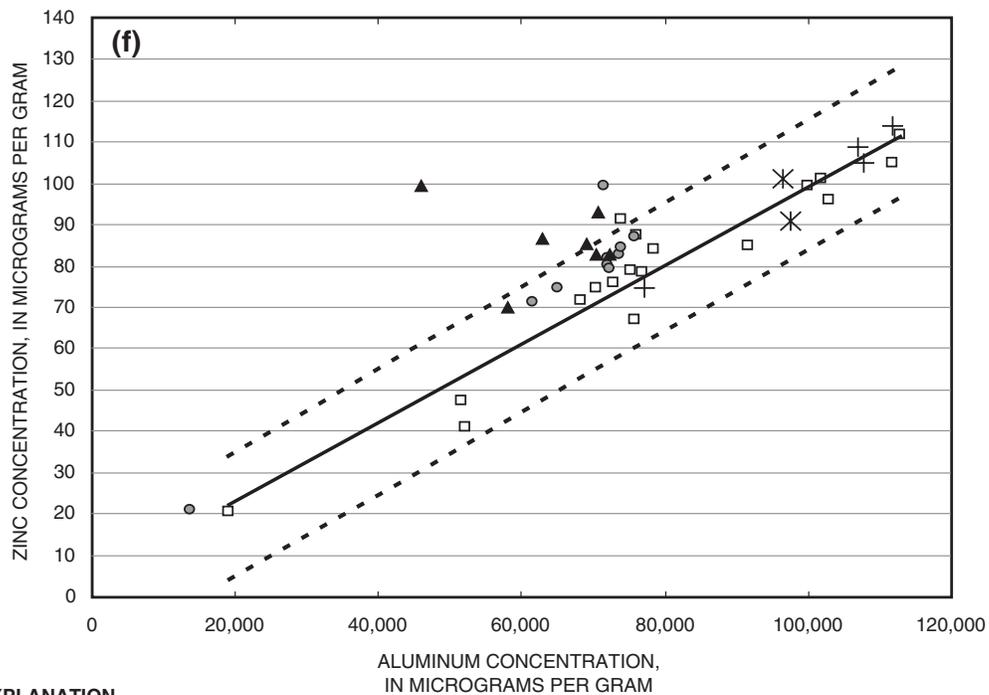
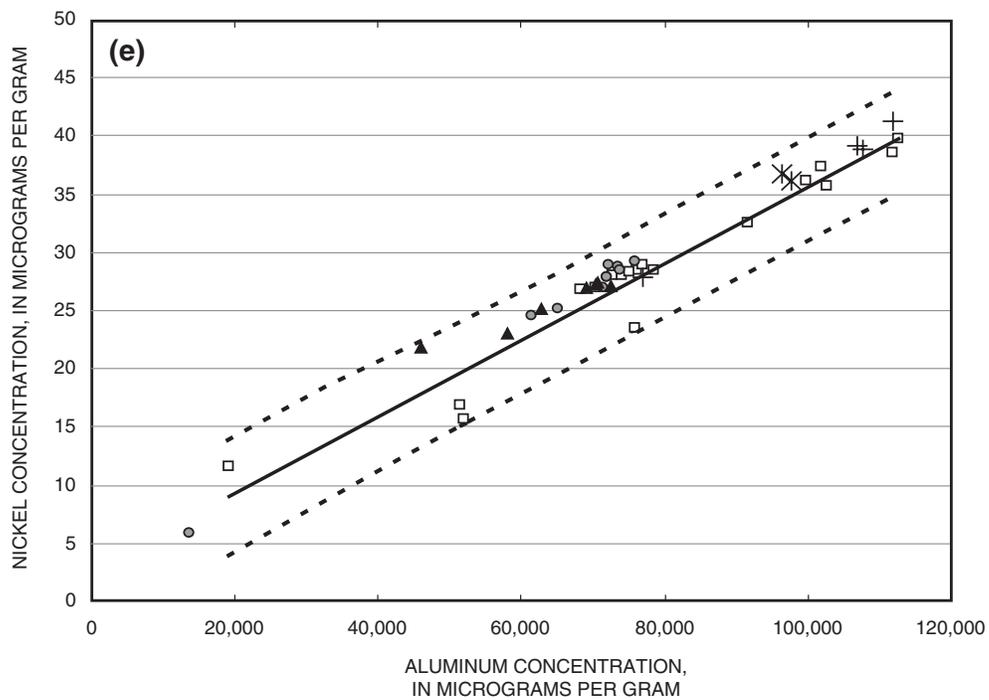
**Figure 6a–b.** Regression analyses to describe spatial distribution of trace elements in sediment from Lake Worth, Fort Worth, Texas, 2000–2001.



**EXPLANATION**

- - - - - Boundary of 95-percent confidence interval
- Regression line, LWT.UB (background) concentrations
- Upstream from IH-820 bridge (background)
- ▲ Woods Inlet and immediately offshore of Air Force Plant 4/Carswell Field
- Downstream from IH-820 bridge
- × LWT.WD pre-1934 concentration
- + LWT.DM pre-1934 concentration

**Figure 6c-d.** Regression analyses to describe spatial distribution of trace elements in sediment from Lake Worth, Fort Worth, Texas, 2000–2001.



**EXPLANATION**

- - - - - Boundary of 95-percent confidence interval
- Regression line, LWT.UB (background) concentrations
- Upstream from IH-820 bridge (background)
- ▲ Woods Inlet and immediately offshore of Air Force Plant 4/Carswell Field
- Downstream from IH-820 bridge
- × LWT.WD pre-1934 concentration
- + LWT.DM pre-1934 concentration

**Figure 6e–f.** Regression analyses to describe spatial distribution of trace elements in sediment from Lake Worth, Fort Worth, Texas, 2000–2001.

intervals for the relation. Trace element concentrations significantly higher than background concentrations, presumably because of anthropogenic sources, plot above the upper confidence interval of the regression line (fig. 6).

The sample concentrations from the Woods Inlet (LWT.WD) and downstream (LWT.DM) cores that predate the establishment of the Air Force facilities and most of the urban development in the area (samples dated as prior to 1934) provide supporting evidence of the assumption that the samples used to develop the regression equations are representative of background concentrations in all samples in the lake. If the assumption is true, then the pre-1934 concentrations should plot within the 95-percent confidence intervals in figure 6, which they do in all cases. The samples actually plot close to and both above and below the regression line for most trace elements. By supporting the assertion that the regression equations reasonably predict background concentrations of trace elements, sample results also support the assumption that trace element concentrations significantly greater than predicted background concentrations are elevated because of anthropogenic activities in the watershed.

Sites 1, 3, 4, and 5 had arsenic concentrations significantly greater than background concentrations (fig. 6a; table 3). Ninety-four percent of the arsenic concentrations from downstream surficial samples or from Woods Inlet and immediately offshore of AFP4/Carswell Field surficial samples plot above the regression line, which suggests that some anthropogenic enrichment of arsenic could be occurring at these sites. On the basis of the locations of the four sites (fig. 1) where arsenic concentrations are significantly greater than background concentrations, the higher concentrations probably are not the result of AFP4 activities. Arsenic was detected during the RI/FS in soil samples collected from Meandering Road Creek, along the western edge of LF4, and at sites offshore from AFP4 and within Woods Inlet. However, samples collected during this study within Woods Inlet and immediately offshore of AFP4/Carswell Field (except for site 4) do not show significantly elevated arsenic concentrations. None of the samples collected has arsenic concentrations greater than the PEC of 33.0  $\mu\text{g/g}$  (MacDonald and others, 2000).

Chromium concentrations in downstream samples have a distribution about the regression line that is similar to that of arsenic concentrations, with 94 percent of concentrations plotting above the line and two con-

centrations exceeding the upper 95-percent confidence interval (fig. 6b), both from Woods Inlet and immediately offshore of AFP4/Carswell Field samples. None of the samples has chromium concentrations greater than the PEC of 111  $\mu\text{g/g}$  (MacDonald and others, 2000). With the data available, it is not possible to determine an anthropogenic source, specifically urbanization or AFP4 activities; however, during the RI/FS, chromium was not detected in soil samples collected from Woods Inlet or offshore of AFP4 and Carswell Field (RUST Geotech, 1996).

Almost all copper concentrations from downstream samples (94 percent) plot above the regression line, and many of the concentrations (65 percent) were significantly higher than what would be expected from natural conditions, including those from five of the seven samples from Woods Inlet and immediately offshore of AFP4/Carswell Field (fig. 6c). All copper concentrations were less than the PEC of 149  $\mu\text{g/g}$  (MacDonald and others, 2000). As with other constituents, the anthropogenic source of copper in Woods Inlet is not known; however, copper was detected in sediment samples collected along the western edge of LF3 and LF4 and east of Meandering Road Creek during the RI/FS at concentrations high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7–11). Copper also was detected at sites offshore of AFP4 and in Woods Inlet (RUST Geotech, 1996).

Lead concentrations in almost all downstream samples (94 percent) plot above the regression line, and two concentrations were significantly higher than what would be expected from natural conditions; the highest lead concentrations were detected in Woods Inlet and immediately offshore of AFP4/Carswell Field samples (fig. 6d). Lead is a common urban contaminant (Van Metre and Callender, 1997). Lead was detected in soil samples collected during the RI/FS along the western edge of LF3 and east of Meandering Road Creek. The lead concentrations were reported as high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7–11). Some of the lead in the downstream samples could result from the use of lead in gasoline until the 1970s.

Nickel concentrations in all downstream samples were within the upper and lower 95-percent confidence intervals, indicating that none of the samples had concentrations significantly higher than what would be expected from natural conditions (fig. 6e). Nickel was not detected in the soil samples collected during the RI/FS, and nickel concentrations in all samples

collected in this study were less than the PEC of 48.6  $\mu\text{g/g}$  (MacDonald and others, 2000).

Zinc concentrations in all downstream samples plot above the regression line, and 29 percent of zinc concentrations were significantly higher than what would be expected from natural conditions (fig. 6f). Three of the five samples with a significant anthropogenic contribution were from Woods Inlet and immediately offshore of AFP4/Carswell Field. All zinc concentrations were less than the PEC of 459  $\mu\text{g/g}$  (MacDonald and others, 2000). Zinc is another trace element that was detected at elevated concentrations in soil samples during the RI/FS with concentrations high enough to “show a potential for excess ecological risk” (RUST Geotech, 1996, p. 7–11). The areas identified were along the western edge of LF3 and east of Meandering Road Creek. Zinc also was detected in sediment samples at sites offshore of AFP4, in a cove near the northeast corner of AFP4, and in Woods Inlet. Elevated zinc concentrations in response to urbanization have been reported for sediment cores from White Rock Lake in Dallas (Van Metre and Callender, 1997) and for the Chattahoochee River below Atlanta, Ga. (Callender and Rice, 2000).

### Historical Trends in Trace Elements

The regression equations developed to estimate background concentrations of selected trace elements could be used to analyze the natural and anthropogenic influences on temporal variability of concentrations in Lake Worth. The equations were used to predict the background trace element concentrations (except for cadmium) in gravity core samples on the basis of the measured aluminum concentration of each sample. The predicted background concentrations and the measured concentrations are plotted relative to the deposition date determined by  $^{137}\text{Cs}$  age dating (fig. 7). The difference between the two (measured minus predicted) is interpreted to be the anthropogenic contribution of trace elements over time in each of the cores. No difference or a negative difference between measured concentrations in the Woods Inlet core samples and downstream core samples and the predicted background concentration is interpreted as no anthropogenic contribution.

Predicted background and measured arsenic concentrations generally are similar in all three cores, and none of the measured concentrations in deep, old samples is significantly higher than predicted background concentrations (fig. 7a). Although some modest anthro-

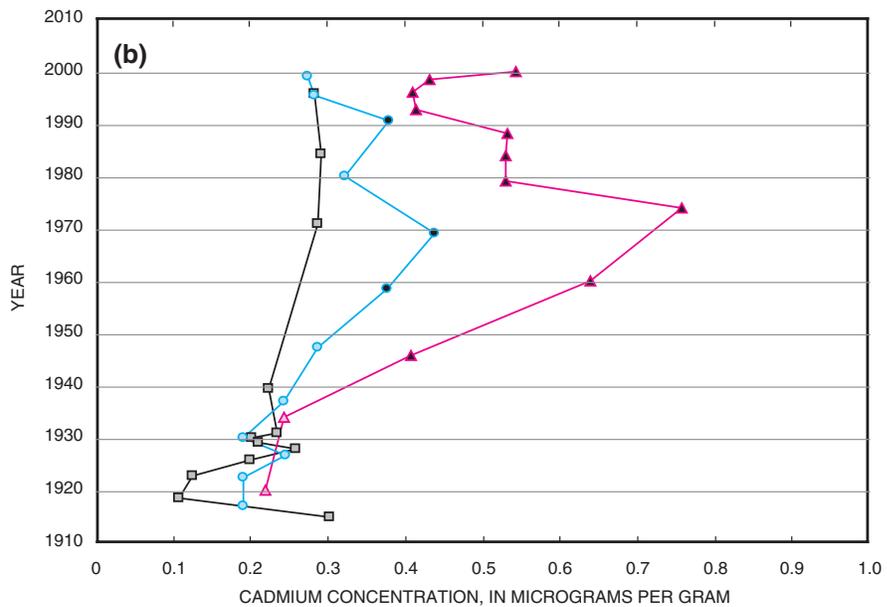
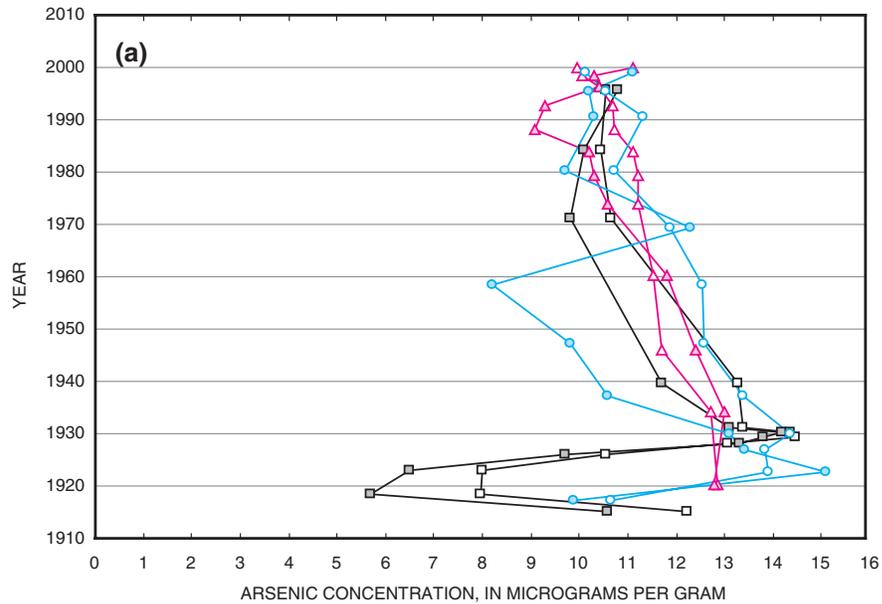
pogenic source of arsenic was indicated by the spatial distribution, none is suggested temporally at these three sites. Taken together, these data indicate the lack of any appreciable anthropogenic source of arsenic to the lake.

Pre-1930 cadmium data from the upstream core (LWT.UB) show much variability. Cadmium concentrations decrease from about 0.3 to about 0.1  $\mu\text{g/g}$  for two samples then increase (fig. 7b). This pattern is consistent for all trace elements in core LWT.UB and probably results from changes in bulk sediment properties. These older samples have lower clay content than the other core samples from LWT.UB. The oldest sample from core LWT.DM also has less clay than other samples in that core and lower trace element concentrations than younger samples in that core (fig. 7b).

To varying degrees, anthropogenic cadmium, copper, lead, and zinc all began to increase in the Woods Inlet core (LWT.WD) beginning in the 1940s, peaked in the 1970s, and moderately or sharply decreased to the present (2000). For cadmium, which was not normalized and regressed because aluminum concentrations explain only 23 percent of the variability in cadmium, concentrations from core LWT.UB are assumed indicative of background concentrations over time at all three sites. Thus the anthropogenic contribution can be estimated by the differences between the concentrations at core LWT.UB and the other two cores (fig. 7b).

An anthropogenic contribution to both LWT.WD and LWT.DM (downstream) core sites might have occurred. Cadmium concentrations peaked in both cores in the early 1970s, with a second peak in the early 1990s in LWT.DM. A recent increase from about 0.4 to about 0.5  $\mu\text{g/g}$  in LWT.WD may or may not indicate a real trend in anthropogenic loading. The chemistry of sediments soon after deposition can be altered before burial and isolation from the water column (Callender, 2000), so small differences in the top few centimeters of sediment should be viewed with caution. The similar dates of peak cadmium concentrations in both the Woods Inlet and downstream cores indicate that the source of cadmium to both sites is the same. The contribution might be greater at the Woods Inlet site.

Chromium concentrations in cores LWT.WD and LWT.DM increased to greater than predicted background concentrations in the 1940s and remained consistently greater than background concentrations until the 1980s (fig. 7c). The apparent anthropogenic enrichment is relatively modest, reaching a maximum of about 9  $\mu\text{g/g}$  in LWT.WD and about 20  $\mu\text{g/g}$  in LWT.DM.

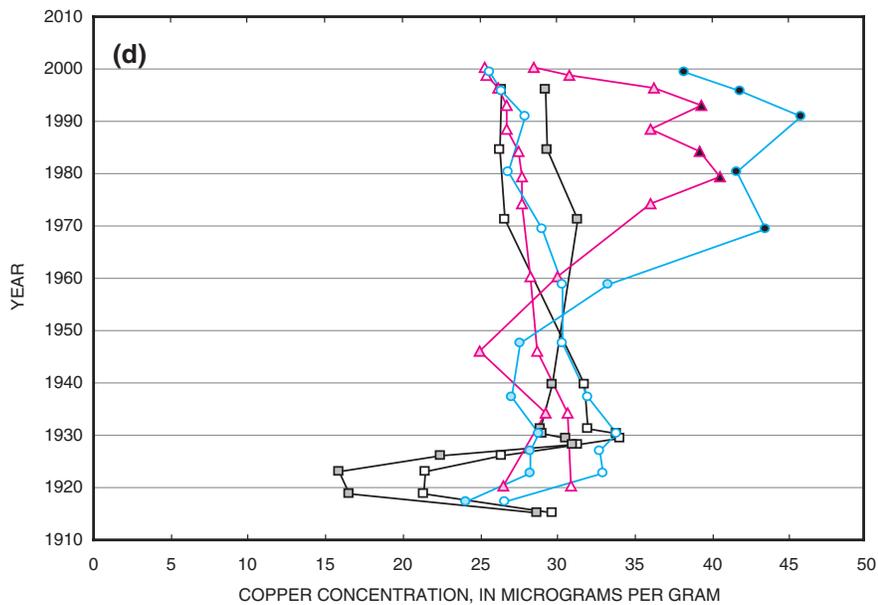
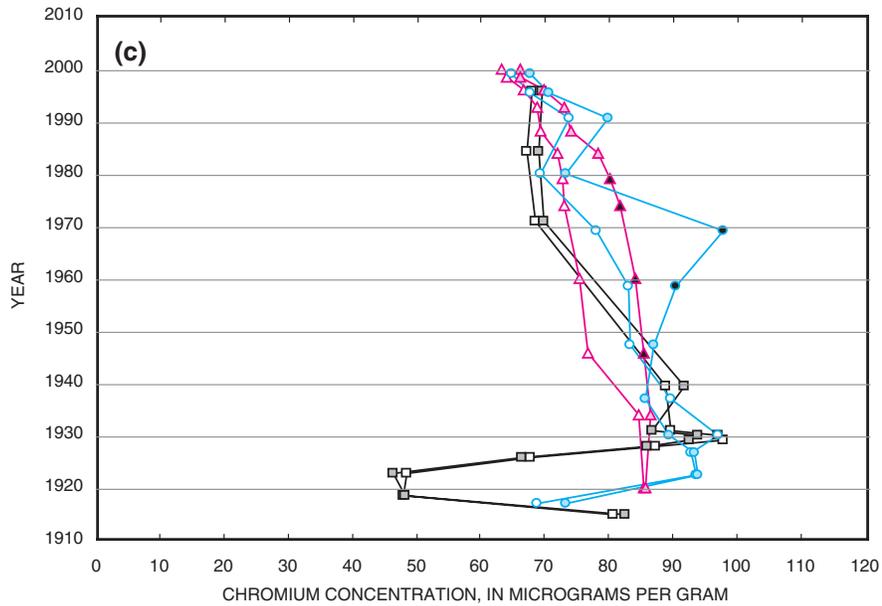


**EXPLANATION**

- LWT.UB—Upstream from IH-820 bridge (background); measured concentration
- LWT.UB predicted concentration
- ▲— LWT.WD—Woods Inlet; measured concentration
- ▲— LWT.WD predicted concentration
- LWT.DM—Downstream from IH-820 bridge (near dam); measured concentration
- LWT.DM predicted concentration

Blackened symbol indicates measured concentration more than two standard deviations above mean of LWT.UB (background) measured concentration

**Figure 7a–b.** Historical trends of trace elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.



**EXPLANATION**

—□— LWT.UB—Upstream from IH-820 bridge (background);  
measured concentration

—□— LWT.UB predicted concentration

—△— LWT.WD—Woods Inlet; measured concentration

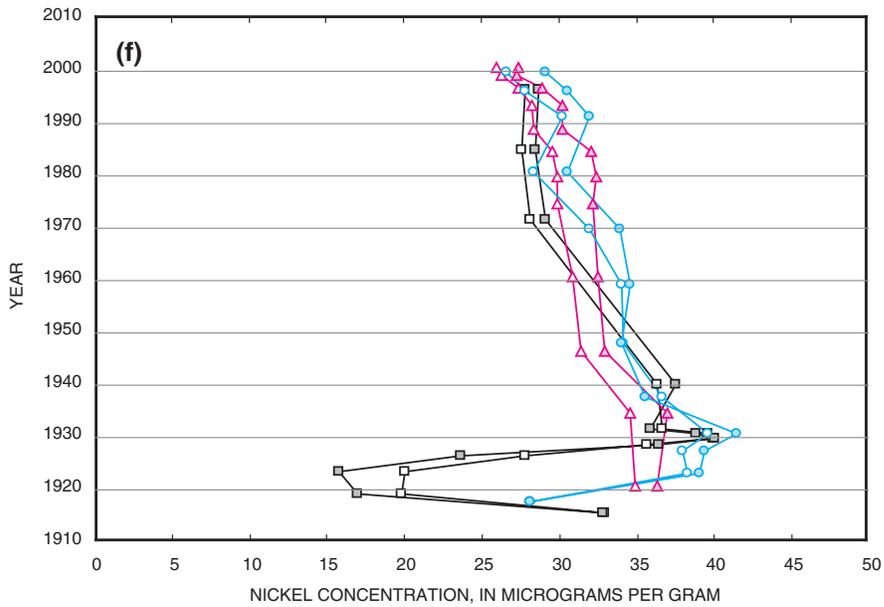
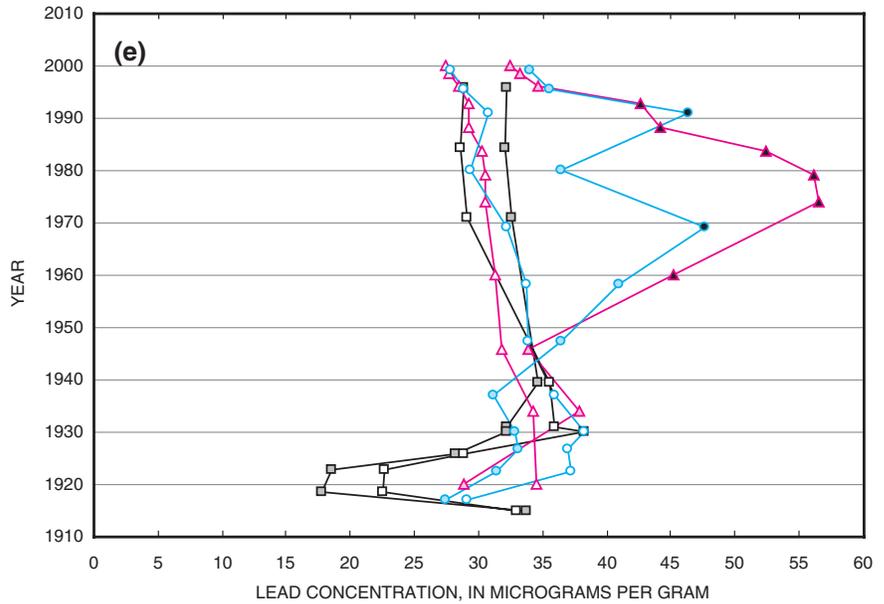
—△— LWT.WD predicted concentration

—○— LWT.DM—Downstream from IH-820 bridge (near dam);  
measured concentration

—○— LWT.DM predicted concentration

Blackened symbol indicates measured concentration more than two standard deviations above mean of LWT.UB (background) measured concentration

**Figure 7c–d.** Historical trends of trace elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

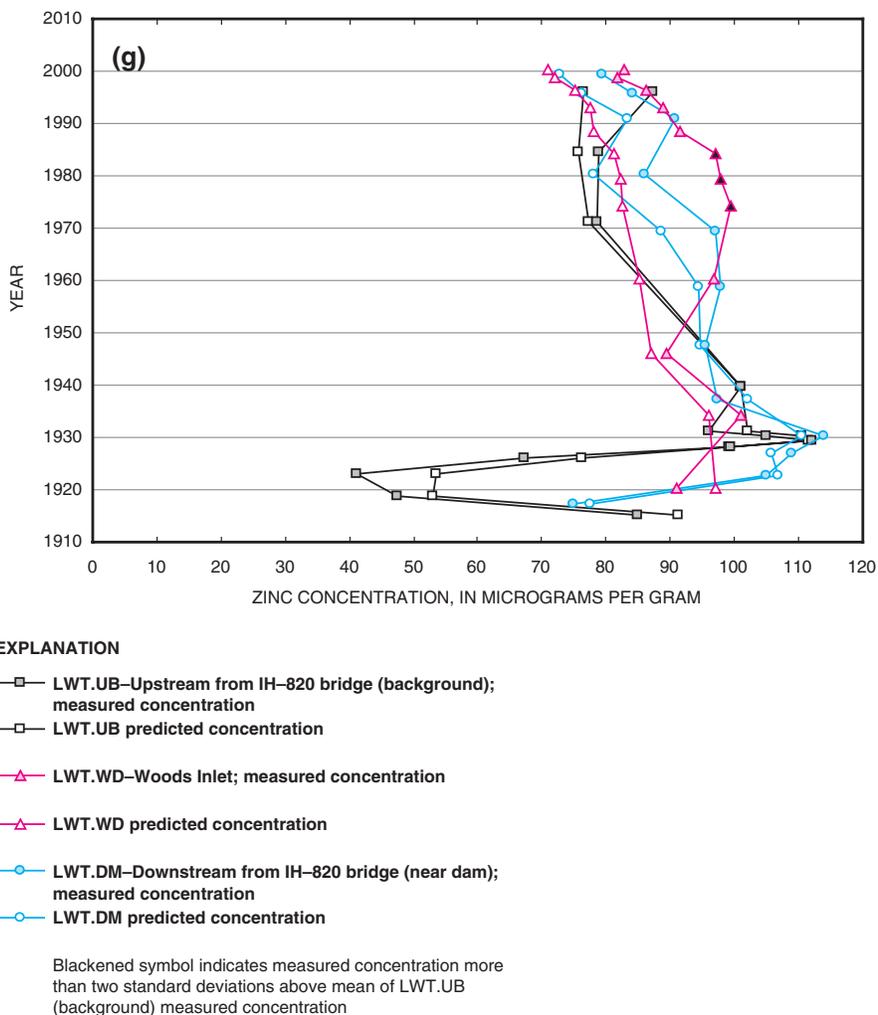


**EXPLANATION**

- LWT.UB—Upstream from IH-820 bridge (background); measured concentration
- LWT.UB predicted concentration
- ▲— LWT.WD—Woods Inlet; measured concentration
- △— LWT.WD predicted concentration
- LWT.DM—Downstream from IH-820 bridge (near dam); measured concentration
- LWT.DM predicted concentration

Blackened symbol indicates measured concentration more than two standard deviations above mean of LWT.UB (background) measured concentration

**Figure 7e–f.** Historical trends of trace elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.



**Figure 7g.** Historical trends of trace elements in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

Anthropogenic copper concentrations might have increased to significant concentrations in gravity core samples from about the late 1950s to peak concentrations about 1980 and 1990 for LWT.WD and LWT.DM, respectively (fig. 7d). Concentrations decreased at both sites in recent sediments but remain significantly greater than predicted background concentrations to the top of the near-dam core. Copper concentrations in core LWT.UB also might have increased to greater than background concentrations over time; however, these concentrations are not significantly greater than background concentrations at a 95-percent confidence level.

Lead concentrations in urban lake and reservoir sediments peaked consistently in the mid-1970s coinciding with the switch from leaded to unleaded

gasoline (Van Metre and Callender, 1997). Significant anthropogenic lead contributions peaked in the mid-1970s in LWT.WD and have since steadily decreased (fig. 7e). Core LWT.DM has two significant lead peaks, about 1969 and 1991, with a low concentration in between. It is not clear if this peak-trough-peak pattern is anomalous in lead loading or if it is simply an artifact of unexplained variability in these few samples. Lead concentrations have decreased at LWT.DM since 1991. With two notable exceptions that are not shown on figure 7e, lead concentrations in LWT.UB have not been significantly higher than background concentrations over time. The exceptions are two samples from deep, old intervals (late 1920s) in which lead concentrations were 400 and 930 µg/g, much greater than the PEC of

128 µg/g (McDonald and others, 2000). The cause of the very high lead concentrations in these two samples is unknown. Because of their spatial and temporal locations, they cannot be attributed to lead use in gasoline or AFP4 or Carswell Field activities. These concentrations are similar to those detected in bed sediments collected below heavily mined areas of Montana, where Fey and others (2000) found that lead increased from background concentrations of 59 µg/g to concentrations of 870 µg/g. Because the high lead concentrations are 50 to 65 cm deep in the sediment core, they likely do not pose a threat to aquatic life.

As was the case with spatial variability, trends in nickel concentrations do not indicate any significant anthropogenic enrichment in the lake (fig. 7f). Actual concentrations of nickel match the predicted background concentrations closely in all three cores.

Zinc concentrations in LWT.WD might have been influenced by human activities (fig. 7g). The anthropogenic contributions at LWT.WD increased from the mid-1940s to the mid-1970s and then began to decrease, a temporal pattern repeated for other trace elements. In the mid-1970s and early 1980s, the anthropogenic contribution of zinc in Woods Inlet reached concentrations significantly higher than that expected from natural conditions and has since decreased. At the near-dam site, zinc concentrations in LWT.DM have remained relatively similar to predicted background concentrations.

### Polycyclic Aromatic Hydrocarbons

PAHs are organic chemicals that are relatively unreactive and are very hydrophobic and thus persistent in aquatic sediments. Unsubstituted, or parent, compounds consist only of carbon and hydrogen (carbon-benzene rings with hydrogen atoms attached). Substituted compounds are those PAHs in which one or more of the attached hydrogen atoms have been replaced by alkyl groups. Hydrophobicity and resistance of PAHs to degradation increase with increasing number of rings and, within a homologous series, with increasing alkylation. A homologous series comprises compounds with the same benzene ring structure but with varying numbers of alkyl substitutions.

The presence and distribution of PAHs in the environment is largely a result of incomplete combustion of coal, oil, wood, and petroleum. PAHs are an environmental issue because some of these compounds are toxic, mutagenic, or are known or suspected car-

cinogens. Fifteen parent PAHs are on the USEPA Priority Pollutant list and have numerical water-quality standards (U.S. Environmental Protection Agency, 2002).

The largest concentrations of PAHs generally are found in urbanized areas, where the potential sources include atmospheric deposition, surface runoff, sewage effluents, industrial effluents, and spills and leakage of fossil fuels (Eganhouse and Gossett, 1991; Van Metre and others, 2000). Other sources include natural seepage of hydrocarbons, erosion of exposed shales and coal seams (Eganhouse and Gossett, 1991), and forest and prairie fires (Blumer and Youngblood, 1975).

The analytical method used for this study quantifies 19 parent PAHs and their alkylated homologues with two to seven rings. In general, individual PAH compounds correlate to each other in environmental samples. The main exception to this pattern is that uncombusted fuels and organic matter tend to contain proportionally more of the lower molecular weight, 2- and 3-ringed compounds and more of the alkyl-substituted compounds, whereas combustion byproducts (for example, soot, street dust, vehicle exhaust) tend to contain proportionally more of the higher molecular weight, 4- to 7-ringed, parent compounds.

Therefore, the occurrence and distribution of PAHs often can be evaluated using several summary measures: concentrations of total PAH and total major-combustion PAH (Barrick and Prahl, 1987), and the ratio of 2- and 3-ringed compounds plus homologues to total major-combustion PAH (Van Metre and others, 2000)—in other words, the ratio of PAHs predominately from uncombusted sources to those predominately from combusted sources. Total PAH, as computed in this report, is the sum of 18 of the 19 parent PAHs (excluding perylene) plus the homologous series. The major-combustion PAHs are 4- to 6-ringed parent PAHs all detected at relatively higher concentrations in PAH from combustion sources. They are fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, indeno(1,2,3-c,d)-pyrene, and benzo(g,h,i)perylene (Barrick and Prahl, 1987).

Laboratory reporting levels vary for different hydrocarbons because of variations in sample mass, sample matrix, and analytical interferences. In some cases, the laboratory will report a concentration less than the reporting level as an estimated value. In the computation of total combustion PAH and total

PAH, estimated values were included. Nondetections (reported as less than the reporting level) were treated as zeros. Nondetection might mean the constituent was not present in the sample, but it also could mean that it was there at the same concentration or even greater than an estimated value, or at a concentration less than the reporting level, but interferences prevented detection. Estimated values differ from other quantitative values because the laboratory cannot report the estimated value with the same level of confidence.

### Spatial Distribution of PAHs

Total PAH and total combustion PAH concentrations were compared among the three lake areas (groups of samples)—upstream (from IH-820 bridge), Woods Inlet and immediately offshore of AFP4/Carswell Field, and downstream (from IH-820 bridge). Kruskal-Wallis tests were run to indicate whether at least one group of concentrations was significantly different from another, followed by Dunn's tests to indicate which group(s) were significantly different. Total PAH and total combustion PAH concentrations were significantly higher at Woods Inlet and immediately offshore of AFP4/Carswell Field sites than at background (upstream) sites (both  $p$ -values = 0) (fig. 8). Total PAH and total combustion PAH concentrations also were higher at downstream sites than at background sites ( $p$ -values = .0004, .0013, respectively). Neither total PAH nor total combustion PAH concentrations at Woods Inlet and immediately offshore of AFP4/Carswell Field sites were significantly higher than those at downstream sites ( $p$ -values = .32, .08, respectively), although the  $p$ -value from the total combustion PAH comparison test (.08) shows some evidence of difference between Woods Inlet and immediately offshore of AFP4/Carswell Field and downstream concentrations.

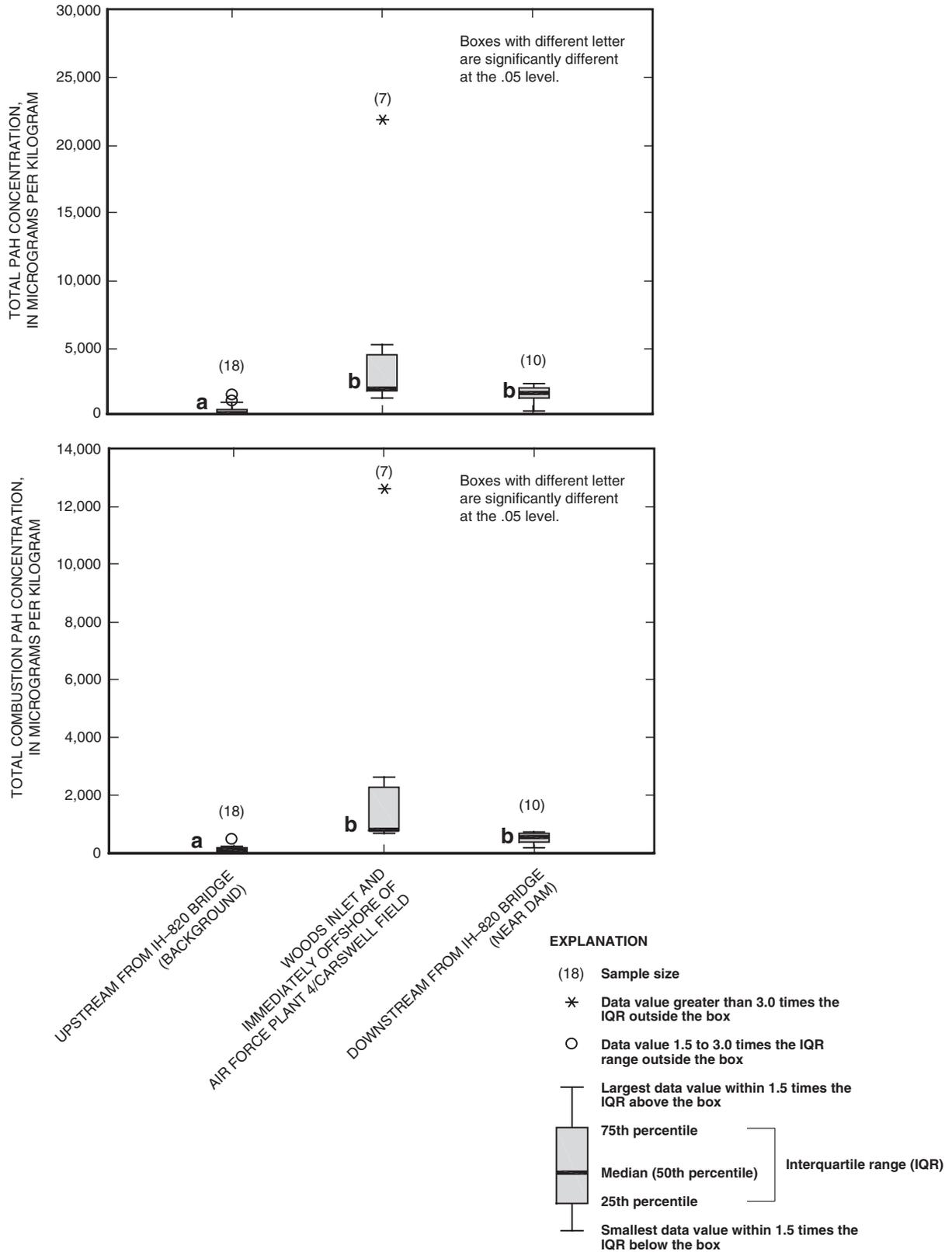
Concentrations of total combustion PAH in surficial sediment in the upper lake (upstream sites 17–20) ranged from 111 to 254 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ) at sites 17 and 20, respectively (table 6, at end of report). Concentrations were about 400 to 600  $\mu\text{g}/\text{kg}$  in four surficial samples (sites 10, 14, 15, and 21) from near the IH-820 bridge where there are numerous vehicle-related sources of PAH; Van Metre and others (2000) showed positive relations between PAH trends in sediment cores and vehicular traffic in data from 10 urban lakes. Considerably larger concentrations of combustion PAH, 1,950 and 2,640  $\mu\text{g}/\text{kg}$ , were detected in two small inlets (sites 8 and 6) near the north side

of AFP4 and Carswell Field compared to concentrations at upstream sites. The highest concentration measured, 12,600  $\mu\text{g}/\text{kg}$ , was at site 11 in Woods Inlet and adjacent to AFP4, an area of the lake that also receives drainage from the urbanized areas to the south and west. These results suggest that urban areas around the lake, and the Air Force facilities, are sources of PAHs to the lake.

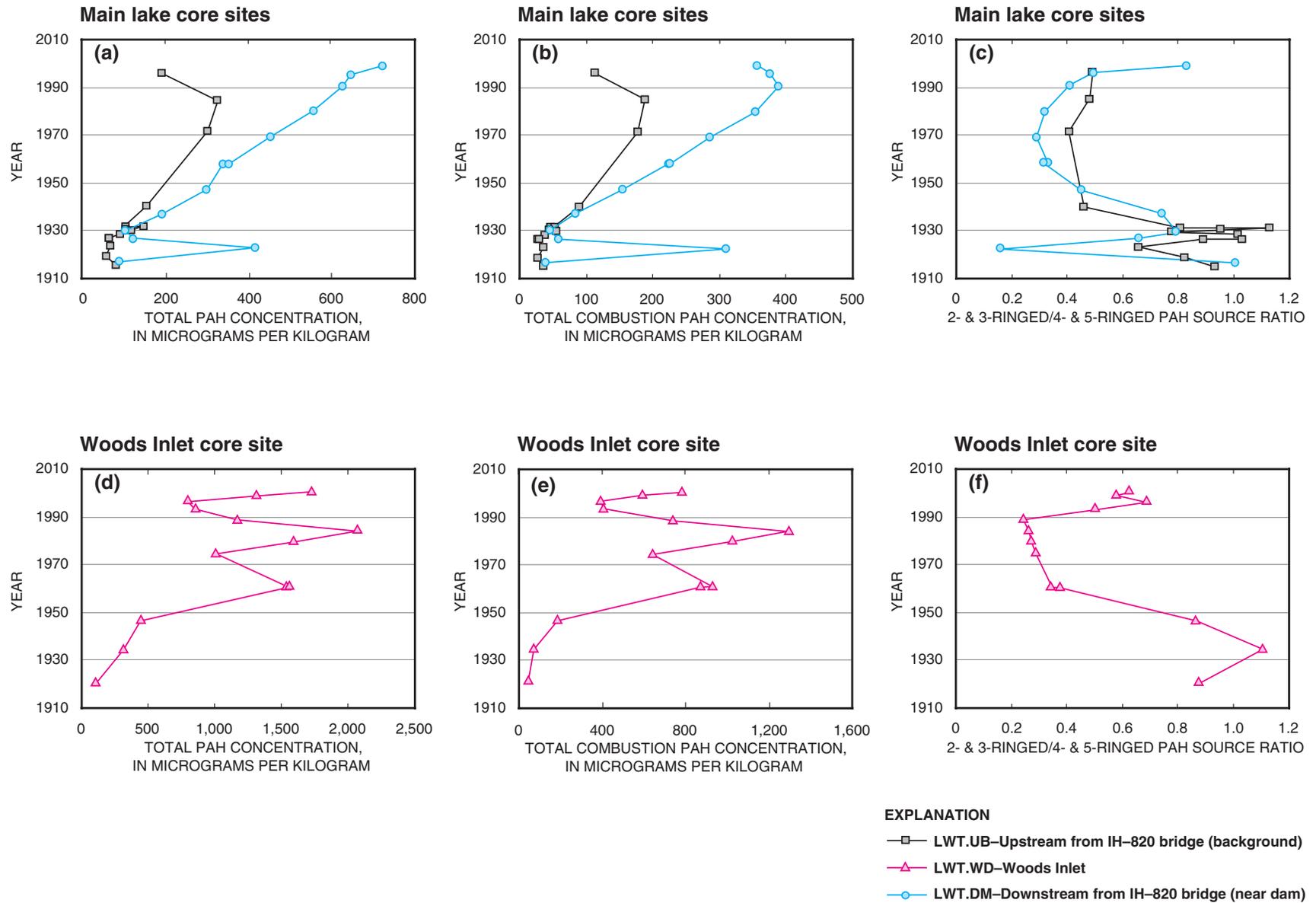
In general, PAH concentrations are less than sediment-quality guidelines. The threshold effect concentration (TEC) (the sediment concentration below which adverse effects to benthic biota are not expected to occur) and the PEC for total PAH are 1,610 and 22,800  $\mu\text{g}/\text{kg}$ , respectively (MacDonald and others, 2000). The two lowest total PAH concentrations, 372 and 334  $\mu\text{g}/\text{kg}$ , were from near-shore sites 2 and 17, respectively, which are predominately sand. Organic carbon in these two samples, 0.91 and 1.09 percent, respectively, also was less than the median organic carbon fraction of 2.38 percent for all sites. PAH and other nonpolar (little intermolecular association and insoluble in water) organic compounds are strongly associated with the organic fraction in sediments (Smith and others, 1988), thus smaller concentrations at these two sites would be expected. Total PAH concentrations at all upstream sites were less than the TEC (table 6). Concentrations at most Woods Inlet and immediately offshore of AFP4/Carswell Field sites and downstream sites were greater than the TEC but were much less than the PEC. The highest total PAH concentration, 21,900  $\mu\text{g}/\text{kg}$ , was at site 11 (same sample that yielded the total combustion PAH concentration of 12,600  $\mu\text{g}/\text{kg}$ ), similar to the PEC of 22,800  $\mu\text{g}/\text{kg}$ , which indicates that PAH concentrations in the upper part of Woods Inlet are at levels of possible concern for benthic biota. The RI/FS identified LF4 as having benzo(a)pyrene at levels that pose a human health risk (RUST Geotech, 1996).

### Historical Trends in PAHs

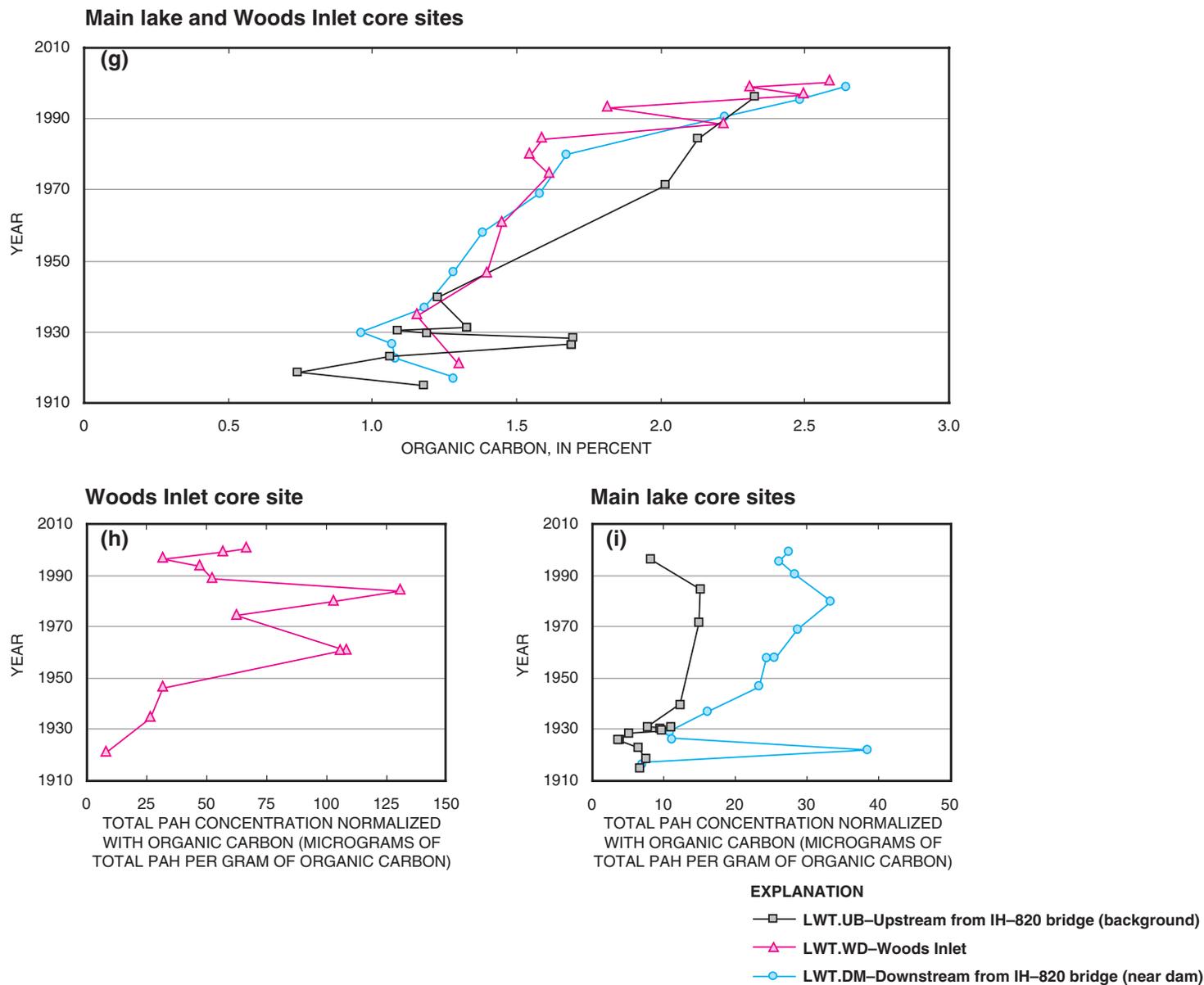
With the exception of one sample in the downstream core (LWT.DM), concentrations of total combustion PAH are less than 100  $\mu\text{g}/\text{kg}$  in samples deposited before 1940 in all three cores (fig. 9b, e). Temporal trends in the two main lake cores (LWT.UB and LWT.DM) are similar with large, steady increases from about 1930 to about 1990 then small decreases at the very tops of the cores. The magnitude of the increase



**Figure 8.** Comparison of total polycyclic aromatic hydrocarbon (PAH) and total combustion PAH concentrations in lake sediment from selected areas of Lake Worth, Fort Worth, Texas, 2000–2001.



**Figure 9a–f.** Historical trends of total polycyclic aromatic hydrocarbon (PAH) and total combustion PAH concentrations, PAH source ratios, and organic carbon in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.



**Figure 9g–i.** Historical trends of total polycyclic aromatic hydrocarbon (PAH) and total combustion PAH concentrations, PAH source ratios, and organic carbon in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

at the near-dam site (LWT.DM) is considerably larger than that at the upper lake site (LWT.UB), probably reflecting additional PAH inputs from intervening urban development (including the interstate highway) and possibly from the Air Force facilities.

The general trend of total combustion PAH concentrations in the Woods Inlet core (LWT.WD) is similar to those of the two other cores but with more variability. Peaks in concentration occur about 1960 and again in the mid-1980s (fig. 9e). After a decrease in the early 1990s, the top two samples indicate a recent increase at the top of the core. The peak concentration of combustion PAH in LWT.WD is 1,300  $\mu\text{g}/\text{kg}$  (fig. 9e) compared to peaks of 188 and 388  $\mu\text{g}/\text{kg}$  in LWT.UB and LWT.DM (fig. 9b), respectively. Larger concentrations in Woods Inlet are not surprising considering the much smaller and more developed drainage area of Woods Inlet compared to those of the main lake sites.

One consideration in evaluating trends in nonpolar organic compounds, including PAHs and organochlorine compounds, is the effect of organic carbon on concentrations. Organic carbon is relatively uniform in surficial sediments across Lake Worth, with the exceptions (two predominately sand sites) noted; however, organic carbon increases appreciably over time in all three sediment cores (fig. 9g). The typical approach of adjusting for variations in organic carbon in sediment samples is to normalize concentrations with organic carbon. Simple normalization is to divide compound concentrations by percent organic carbon assuming, in effect, that the entire compound occurs in the organic carbon fraction of the sediment. Carbon-normalized trends in total PAH (fig. 9h, i) indicate more salient PAH peaks in about 1960 and 1984 in the Woods Inlet core and very little change in PAH concentrations in the upper lake. Otherwise, the trends are similar in shape to non-normalized total combustion PAH trends (fig. 9b, e).

### PAH Assemblage

The dominant sources of PAH can be indicated by the ratio of 2- and 3-ringed compounds plus homologues (PAHs primarily from uncombusted sources) to total combustion PAH (Van Metre and others, 2000). Larger ratios indicate the dominance of natural and fuel-related PAHs (uncombusted) whereas smaller ratios indicate the dominance of combustion-related PAHs. Combustion PAHs, as indicated by source ratios of

about 0.5 or less, predominate in urban lakes around the United States (Van Metre and others, 2000, fig. 2).

PAH source ratios in the Lake Worth cores tend to vary inversely with PAH concentrations, which shows a shift from natural and uncombusted PAH to combustion PAH as concentrations increased in the middle of the century (fig. 9b, c, e, f). Source ratios at all three sites (fig. 9c, f) from about 1950 to 1990 indicate the predominance of combustion sources. It is not clear what the apparent shift back toward uncombusted sources at the very tops of the Woods Inlet and near-dam cores means. One possibility is that fuel-related sources have recently increased or combustion sources have decreased, or both. However, it is also possible that chemical reactions at the tops of the cores are affecting the source ratio. The lower-molecular-weight PAHs (2- and 3-ringed compounds) are more water-soluble than the higher-weight PAHs. Losses of PAHs to the water column soon after sediment deposition might preferentially occur for the lower-weight PAHs causing an apparent shift to a more combustion-like ratio below the top few centimeters of sediment. Another possibility is that the breakdown of organic matter in sediment after deposition (diagenesis) is responsible for the sharp decrease in organic carbon in the top 10 to 15 cm of each core, and that this breakdown is leading to more losses of the lower-weight PAHs.

### Organochlorine Pesticides

Organochlorine pesticides are characterized by their persistence in the environment and their tendency to accumulate in biota (Smith and others, 1988). DDT, chlordane, and dieldrin are well known examples of organochlorine pesticides that commonly are detected in urban and agricultural reservoir and lake sediments (Van Metre and Callender, 1997). Organochlorine pesticides detected in the Lake Worth surficial sediment samples included chlordane and DDE, one of two major breakdown products of DDT (table 7, at end of report). At box core site 11 in Woods Inlet, the chlordane concentration was estimated at 13  $\mu\text{g}/\text{kg}$ . At all box core sites, DDE concentrations were less than or equal to 2  $\mu\text{g}/\text{kg}$ . Concentrations of both pesticides are low compared to PECs (chlordane, 17.6  $\mu\text{g}/\text{kg}$ ; DDE, 31.3  $\mu\text{g}/\text{kg}$ ) (MacDonald and others, 2000) and to concentrations in other Fort Worth (Van Metre and others, 2003) and Dallas urban lake sediments (Van Metre and Callender, 1997).

Organochlorine pesticide concentrations also were low in the three gravity cores. Maximum DDE concentrations were 4.4 and 2.6  $\mu\text{g}/\text{kg}$  in the near-dam (LWT.DM) and Woods Inlet (LWT.WD) cores; those samples were deposited in about 1970 and 1960, respectively. DDD, the other major breakdown product of DDT, also was detected in the Woods Inlet and near-dam cores, and dieldrin was detected in the near-dam core. Concentrations of those pesticides (table 7) also were low compared to PECs (DDD, 28.0  $\mu\text{g}/\text{kg}$ ; dieldrin, 61.8  $\mu\text{g}/\text{kg}$ ). No organochlorine pesticides were detected in the upper-lake core, indicating little historical anthropogenic input of those contaminants to that site in the upper lake.

### Polychlorinated Biphenyls

PCBs had widespread industrial and commercial uses, primarily as insulation fluids for electrical transformers and in appliances. PCBs commonly are found in urban lake and reservoir sediments. Concentrations in sediment cores from urban lakes peaked in the mid-to-late 1960s, at the height of their use, then decreased following restrictions imposed in 1971 (Van Metre, Callender, and Fuller, 1997; Van Metre, Wilson, and others, 1998). Because of variable numbers and positions of chlorine atoms, 209 individual PCB compounds, called congeners, are possible. PCBs were marketed as Aroclors, mixtures of many congeners. The analytical method used for this report quantifies PCBs as one of the three common Aroclor mixtures (1242, 1254, and 1260). Laboratory reporting levels range from 5 to 20  $\mu\text{g}/\text{kg}$  for each Aroclor, depending on sample mass, sample matrix, and analytical interferences. As with PAHs, the laboratory sometimes will report a concentration less than the reporting level as an estimated value. Total PCB is the sum of the three Aroclors. Estimated values were used in the computation of total PCB, and nondetections were treated as zeros. The concentrations of the three Aroclors and total PCB in sediment samples are listed in table 7.

### Spatial Distribution of PCBs

PCBs were not detected in any of the upper-lake surficial samples (fig. 10) nor in the upper-lake gravity core samples (table 7). Seven of 13 surficial samples from the middle and lower lake had detectable PCBs (although less than the laboratory reporting level) with a maximum estimated concentration of 12  $\mu\text{g}/\text{kg}$ . Estimated total PCB concentrations in the three surficial

samples from Woods Inlet were 15, 20, and 140  $\mu\text{g}/\text{kg}$ , with the highest concentration at site 11, the farthest upstream in Woods Inlet.

Although the estimated concentration of 140  $\mu\text{g}/\text{kg}$  is high relative to the other Lake Worth samples, it is typical of concentrations in some urban lakes and is much less than the PEC of 676  $\mu\text{g}/\text{kg}$  (MacDonald and others, 2000). Surficial sediment concentrations of PCBs in Lake Como, Fosdic Lake, and Echo Lake (three small urban lakes in Fort Worth) were 37, 99, and 156  $\mu\text{g}/\text{kg}$ , respectively (Van Metre and others, 2003). The watersheds of all three of these lakes, however, are nearly 100-percent urban. White Rock Lake in Dallas, more comparable in size to Lake Worth but more urbanized (76-percent urban land use in the 1990s), had a surficial PCB concentration of 13  $\mu\text{g}/\text{kg}$  in a sediment core collected in 1996 (P.C. Van Metre, U.S. Geological Survey, unpub. data, 1996). All lake sediments in the previous studies referred to were sampled and analyzed with the same methods as those used for the Lake Worth samples.

In the RI/FS, Aroclor 1254 was detected in sediments where Meandering Road Creek enters Lake Worth at levels with the potential to cause excess risk to largemouth bass (RUST Geotech, 1996).

### Historical Trends in PCBs

A clear picture of temporal trends in total PCB concentrations is indicated by the gravity cores (fig. 11). Total PCB concentrations were not detected in the upper-lake core (LWT.UB) samples and in samples deposited prior to the late 1940s in the near-dam core (LWT.DM) and Woods Inlet core (LWT.WD) samples. A single large peak occurred during the 1960s, followed by an exponential decrease to the top of the two downstream cores (fig. 11a, c). The peak concentration in the Woods Inlet core was 50  $\mu\text{g}/\text{kg}$  in the 90- to 100-cm interval, about three times greater than the estimated concentration of 16  $\mu\text{g}/\text{kg}$  at the top of the core (table 7). The 50- $\mu\text{g}/\text{kg}$  peak also is about three times greater than the peak estimated concentration of 18  $\mu\text{g}/\text{kg}$  in the near-dam core, where total PCB in the most recent sample was about 7  $\mu\text{g}/\text{kg}$ . Similarly shaped profiles, with (proportionately) slightly larger peaks, result from normalizing PCB concentrations with organic carbon in the cores (fig. 11b, d). The trends indicate decreases in recent years but also suggest PCBs continue to enter the lake, probably attached to suspended sediments in runoff during storms.

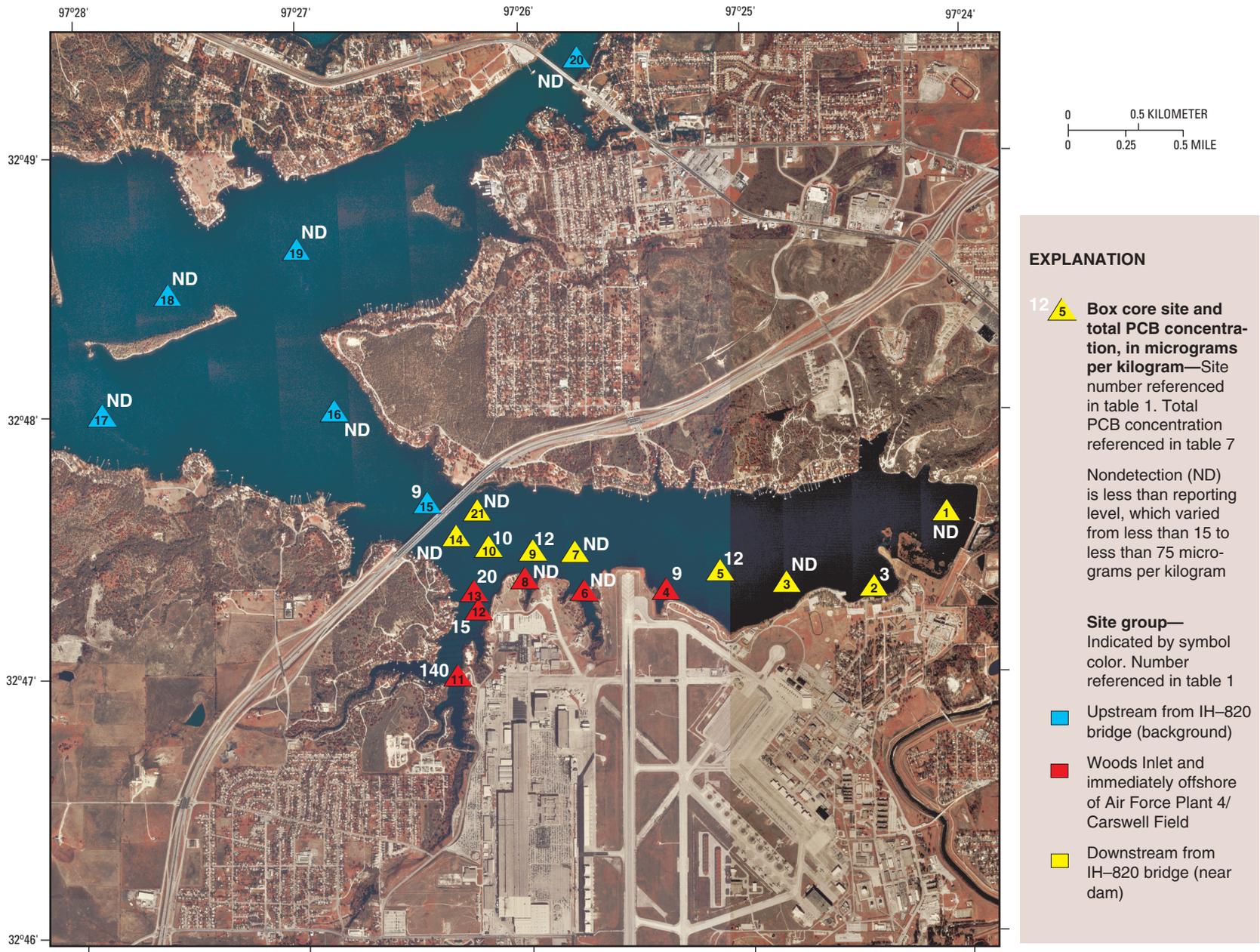
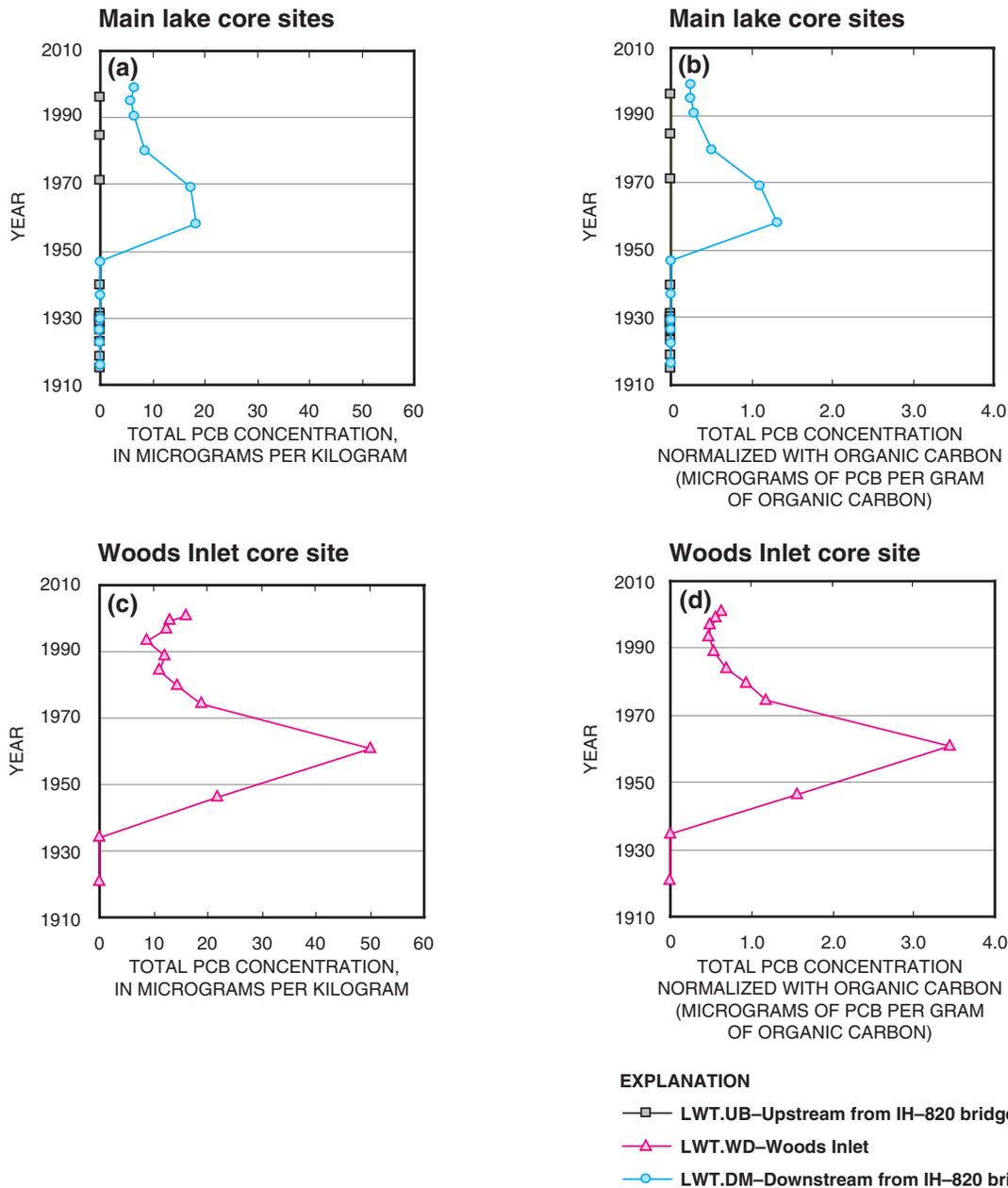


Figure 10. Spatial distribution of total polychlorinated biphenyls (PCBs) in surficial sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001.



**Figure 11.** Historical trends of polychlorinated biphenyls (PCBs) in gravity core samples from Lake Worth, Fort Worth, Texas, 2000–2001.

Similar temporal trends in PCBs are common in urban-affected lakes (Van Metre and others, 1998). Total PCB concentrations in White Rock Lake in Dallas, for example, peaked at 44  $\mu\text{g}/\text{kg}$  in about 1970 and were 13  $\mu\text{g}/\text{kg}$  at the top of the core in about 1996, a ratio of about 3.3. Ratios of peak to top-of-core concentrations of slightly more than 3 also were computed for Echo and Fosdic Lakes in Fort Worth. How-

ever, larger peaks are possible as indicated by a peak concentration in Lake Como, also in Fort Worth, that was about 12 times greater than the top-of-core concentration (Van Metre and others, 2003). These patterns suggest that larger concentrations of PCBs could occur in deeper sediments farther upstream in Woods Inlet, for example below site 11, where the surface concentration was 140  $\mu\text{g}/\text{kg}$ .

## Possible Sources of PCBs

The spatial and temporal distributions of PCBs indicate that the most likely sources of PCBs to Lake Worth are in the drainage area of Woods Inlet. A similar conclusion can be drawn for PAHs and selected trace elements, with much higher concentrations in samples from Woods Inlet than those in the main lake and in the upper lake. Although it is clear that sources of these contaminants are in the Woods Inlet watershed, numerous potential urban sources exist for trace elements, PAHs, and PCBs in addition to the industrial sources at AFP4. Quantification of the relative amounts of PCBs and other contaminants detected in Lake Worth sediments contributed by AFP4, Carswell Field, and the urban areas farther upstream is not possible with existing data.

## SUMMARY

Spatial distributions and temporal trends in trace elements, PAHs, organochlorine pesticides, and PCBs analyzed in 21 surficial sediment and three core sediment samples were evaluated to describe overall sediment quality in Lake Worth and to identify, to the extent possible, potential sources of contaminants. The highest concentrations of selected trace elements (cadmium, chromium, copper, lead, and zinc), PAHs, organochlorine pesticides, and PCBs were in Woods Inlet, along the shoreline of AFP4/Carswell Field, and in the main lake downstream from the IH-820 bridge; and the lowest concentrations were upstream from the IH-820 bridge. For many contaminants, including cadmium, lead, zinc, PAHs, chlordane, and PCBs, the highest concentrations in the lake were detected at the most upstream site in Woods Inlet (site 11). These concentrations, supported by a regression-based normalizing procedure that accounts for natural and anthropogenic sources of trace elements, are evidence of anthropogenic effects on sediment quality in Lake Worth. There are two likely sources of these contaminants: (1) urban areas around the lake and (2) the drainage area of Meandering Road Creek that contributes runoff to Woods Inlet and includes Air Force facilities. Quantifying the relative contribution of these sources to contaminant occurrence in the lake is not possible with existing data.

Trends in contaminant concentrations in the core samples indicate whether sediment quality in Lake Worth is getting better or worse with respect to trace elements and hydrophobic organic contaminants. Of the seven trace elements evaluated, five might have been

significantly greater than background concentrations at some time since formation of the lake in 1914. They are cadmium, chromium, copper, lead, and zinc. Of these five, cadmium, lead, and zinc concentrations were the highest in the Woods Inlet core, all with peaks in the 1970s. Chromium and copper concentrations were the highest in the near-dam core with peaks around 1970 and 1990, respectively. Concentrations of all five historically elevated trace elements have decreased since 1970. Total PAH concentrations, normalized to organic carbon, were mostly stable in the upper-lake core but steadily increased in the near-dam core, except for small decreases since 1980. The Woods Inlet core showed the largest increase of the three core sites beginning about 1940. Total PAH concentrations in sediments deposited since 1940 were variable in the Woods Inlet core with three apparent peaks around 1960, 1984, and 2000. The concentrations of the organochlorine pesticides were low relative to consensus-based PECs and were either decreasing or remaining constant. PCBs were not detected in the upper-lake core but show profiles with a single large peak in the 1960s in the Woods Inlet and near-dam cores. PCB concentrations in 2000 were about one-third historical peak concentrations. Although this trend indicates improvement in recent years, it also suggests PCBs continue to enter the lake, probably attached to suspended sediments in runoff during storms.

Almost all (96.5 percent) of the sediment samples collected from Lake Worth have contaminant concentrations less than published consensus-based PECs that were developed on the basis of toxicity. PCB concentrations in Lake Worth sediments were much less than the PEC, which suggests that they do not pose a direct toxicity risk to benthic organisms; however, PCBs have bioaccumulated in tissues of fish in Lake Worth. In spring 2000, the Texas Department of Health issued a fish consumption advisory for Lake Worth because of elevated PCB concentrations in fish. Predicting the concentration of PCBs in fish on the basis of PCB concentrations in sediment is difficult; however, the presence of PCBs in fish in Lake Worth is confirmation that bioaccumulation of PCBs is occurring. Furthermore, because PCBs are very hydrophobic, the bottom sediments in the lake are a likely source of PCBs to the fish.

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**Table 1.** Descriptive information for sediment sampling locations in Lake Worth, Fort Worth, Texas, 2000–2001

[AFP4, Air Force Plant 4; --, unknown]

Sample site (fig. 1)	Site description or location <sup>1</sup>	Longitude	Latitude	Sample date	Sample type	Water depth (meters)
1/LWT.DM	Downstream (near dam)	97°25'04"	32°47'31"	01/16/2001	Box/gravity cores	7.0
2	Downstream (near dam)	97°25'22"	32°47'16"	01/16/2001	Box core	4.0
3	Downstream (near dam)	97°25'46"	32°47'17"	01/16/2001	Box core	6.1
4	Woods Inlet/AFP4/Carswell Field	97°26'19"	32°47'16"	01/16/2001	Box core	--
5	Downstream (near dam)	97°26'04"	32°47'20"	01/17/2001	Box core	6.1
6	Woods Inlet/AFP4/Carswell Field	97°26'41"	32°47'16"	01/17/2001	Box core	4.3
7	Downstream (near dam)	97°26'44"	32°47'25"	01/17/2001	Box core	4.9
8	Woods Inlet/AFP4/Carswell Field	97°26'58"	32°47'19"	01/17/2001	Box core	4.3
9	Downstream (near dam)	97°26'56"	32°47'25"	01/17/2001	Box core	5.5
10	Downstream (near dam)	97°27'07"	32°47'26"	01/17/2001	Box core	4.9
11	Woods Inlet/AFP4/Carswell Field	97°27'16"	32°46'56"	01/17/2001	Box core	3.8
12/LWT.WD	Woods Inlet/AFP4/Carswell Field	97°27'14"	32°47'09"	11/01/2000	Box/gravity cores	--
13	Woods Inlet/AFP4/Carswell Field	97°27'11"	32°47'16"	01/17/2001	Box core	4.9
14	Downstream (near dam)	97°27'16"	32°47'28"	01/17/2001	Box core	4.9
15	Upstream (background)	97°27'24"	32°47'36"	01/17/2001	Box core	4.6
16/LWT.UB	Upstream (background)	97°27'39"	32°47'55"	11/02/2000	Box/gravity cores	4.7
17	Upstream (background)	97°28'52"	32°47'57"	01/17/2001	Box core	1.5
18	Upstream (background)	97°28'34"	32°48'25"	01/17/2001	Box core	3.7
19	Upstream (background)	97°27'59"	32°48'35"	01/17/2001	Box core	3.5
20	Upstream (background)	97°26'41"	32°49'19"	01/17/2001	Box core	2.1
21	Downstream (near dam)	97°27'10"	32°47'34"	01/17/2001	Box core	4.6

<sup>1</sup> Downstream (near dam), Woods Inlet/AFP4/Carswell Field, and upstream (background) are groupings used in report—Downstream (near dam) samples are downstream from IH–820 bridge; Woods Inlet/AFP4/Carswell Field samples are within Woods Inlet or offshore of AFP4/Carswell Field; upstream (background) samples are upstream from IH–820 bridge.

**Table 2.** Mass accumulation rates computed from cesium-137 concentrations in gravity core sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001

[--, not applicable]

Time period	Mass accumulation rates (grams per square centimeter per year)		
	LWT.UB	LWT.WD	LWT.DM
1914–32	5.46	--	2.14
1914–53	--	1.17	--
1953–64	--	1.36	--
1964–2001	.14	.95	--
1932–2001	.14	--	.34

**Table 3.** Concentrations of selected major and trace elements, grain size, and forms of carbon in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001

[In micrograms per gram except as noted; --, not applicable; PEC, probable effect concentration (MacDonald and others, 2000); dupl., duplicate sample; repl., replicate sample]

Sample site	Age date	Sample interval (cm)	Aluminum	Calcium	Iron	Magnesium	Potassium	Titanium	Arsenic
<b>Box cores</b>									
1	--	0–2	62,000	67,000	29,000	7,300	12,000	2,700	13
2	--	0–2	14,000	6,100	6,100	1,200	6,000	1,100	4.1
3	--	0–2	74,000	70,000	35,000	8,600	14,000	3,300	15
4	--	0–2	58,000	61,000	28,000	6,900	12,000	2,800	14
5	--	0–2	76,000	72,000	36,000	8,900	14,000	3,400	16
6	--	0–2	71,000	87,000	32,000	8,200	13,000	2,900	12
7	--	0–2	74,000	72,000	34,000	8,800	13,000	3,300	13
8	--	0–2	63,000	80,000	29,000	7,600	12,000	2,800	11
9	--	0–2	72,000	81,000	34,000	8,700	13,000	3,300	13
9dupl.	--	0–2	75,000	82,000	34,000	8,700	14,000	3,400	14
10	--	0–2	72,000	79,000	33,000	8,400	13,000	3,200	11
11	--	0–2	46,000	120,000	20,000	5,700	8,100	2,000	8.3
12	--	0–2	69,000	96,000	30,000	8,400	12,000	3,000	9.9
12repl.	--	0–2	73,000	100,000	31,000	8,600	13,000	3,300	10
12repl.	--	0–2	73,000	100,000	31,000	8,400	13,000	3,100	9.7
13	--	0–2	73,000	90,000	33,000	8,600	13,000	3,100	13
14	--	0–2	72,000	83,000	33,000	8,500	13,000	3,100	9.6
15	--	0–2	74,000	80,000	33,000	8,500	13,000	3,400	13
16	--	0–2	71,000	78,000	32,000	8,600	13,000	3,300	10
17	--	0–2	19,000	91,000	8,900	2,800	4,200	1,100	4.0
18	--	0–2	68,000	92,000	32,000	8,300	13,000	3,400	13
19	--	0–2	73,000	63,000	33,000	8,400	14,000	3,700	11
20	--	0–2	79,000	39,000	36,000	8,900	16,000	4,100	14
21	--	0–2	65,000	68,000	29,000	7,300	13,000	3,300	10
<b>Gravity cores</b>									
LWT.WD	2000.4	0–5	71,000	100,000	31,000	9,000	12,000	3,300	11
LWT.WDdupl.	2000.4	0–5	73,000	100,000	31,000	8,900	13,000	3,300	11
LWT.WD	1998.8	5–10	71,000	99,000	32,000	9,100	13,000	3,300	10
LWT.WD	1996.5	10–15	75,000	96,000	34,000	9,800	14,000	3,500	10
LWT.WDdupl.	1996.5	10–15	77,000	96,000	34,000	9,200	13,000	3,500	11
LWT.WD	1992.9	20–25	77,000	85,000	35,000	10,000	14,000	3,600	9.3
LWT.WD	1988.5	30–35	78,000	88,000	35,000	9,900	14,000	3,600	9.1
LWT.WD	1984.0	40–45	81,000	76,000	37,000	10,000	15,000	3,700	10
LWT.WD	1979.5	50–55	82,000	80,000	38,000	10,000	15,000	3,700	10

**Table 3.** Concentrations of selected major and trace elements, grain size, and forms of carbon in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Age date	Sample interval (cm)	Aluminum	Calcium	Iron	Magnesium	Potassium	Titanium	Arsenic
<b>Gravity cores—Continued</b>									
LWT.WD	1974.2	60–70	83,000	80,000	37,000	10,000	15,000	3,800	11
LWT.WD	1960.4	90–100	85,000	75,000	37,000	10,000	15,000	3,800	12
LWT.WD	1946.2	120–130	87,000	74,000	38,000	10,000	14,000	3,800	12
LWT.WD	1934.2	150–160	97,000	47,000	43,000	11,000	17,000	4,300	13
LWT.WDdupl.	1934.2	150–160	100,000	48,000	43,000	11,000	17,000	4,400	13
LWT.WD	1920.4	190–196	98,000	42,000	42,000	11,000	18,000	4,600	13
LWT.DM	1999.4	0–5	72,000	89,000	33,000	9,500	14,000	3,300	11
LWT.DM	1995.7	5–10	76,000	90,000	35,000	9,900	14,000	3,500	10
LWT.DM	1991.1	10–15	84,000	81,000	36,000	11,000	16,000	3,600	10
LWT.DM	1980.4	20–25	78,000	85,000	35,000	9,900	15,000	3,500	9.7
LWT.DM	1969.5	30–35	89,000	72,000	38,000	11,000	16,000	3,700	12
LWT.DM	1958.5	40–45	95,000	58,000	40,000	11,000	17,000	3,900	8.2
LWT.DM	1947.5	50–55	95,000	51,000	40,000	10,000	17,000	4,100	9.8
LWT.DM	1937.4	60–65	100,000	38,000	44,000	11,000	18,000	4,400	11
LWT.DM	1930.2	75–80	110,000	22,000	50,000	11,000	20,000	4,700	13
LWT.DM	1927.1	90–95	110,000	29,000	48,000	11,000	20,000	4,800	13
LWT.DM	1922.8	105–110	110,000	20,000	49,000	11,000	20,000	4,900	15
LWT.DM	1917.2	125–130	77,000	16,000	33,000	7,300	18,000	4,400	9.9
LWT.UB	1996.0	0–5	76,000	84,000	34,000	9,200	14,000	3,600	11
LWT.UB	1984.5	5–10	75,000	82,000	35,000	9,000	14,000	3,500	10
LWT.UB	1971.3	10–15	77,000	80,000	35,000	9,400	14,000	3,600	9.8
LWT.UB	1939.7	20–25	100,000	27,000	46,000	11,000	19,000	4,600	12
LWT.UB	1931.2	30–35	100,000	14,000	44,000	11,000	21,000	5,100	13
LWT.UB	1930.3	40–45	110,000	9,600	47,000	11,000	21,000	5,300	14
LWT.UB	1929.4	50–55	110,000	13,000	47,000	11,000	21,000	5,200	14
LWT.UBdupl.	1929.4	50–55	110,000	12,000	47,000	11,000	20,000	5,100	14
LWT.UB	1928.2	60–65	100,000	8,200	40,000	9,900	21,000	5,500	13
LWT.UB	1926.2	75–80	76,000	20,000	29,000	7,500	18,000	4,800	9.7
LWT.UB	1923.1	85–90	52,000	13,000	19,000	5,100	15,000	3,400	6.5
LWT.UB	1918.7	110–115	52,000	13,000	24,000	5,100	14,000	3,200	5.7
LWT.UB	1915.0	130–135	92,000	14,000	43,000	10,000	20,000	4,800	11
PEC	--	--	--	--	--	--	--	--	33

**Table 3.** Concentrations of selected major and trace elements, grain size, and forms of carbon in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Cad-mium	Chro-mium	Copper	Lead	Nickel	Zinc	Silt and clay (percent)	Clay (percent)	Total organic carbon (percent)	Inorganic carbon (percent)
<b>Box cores</b>										
1	0.3	59	31	30	25	71	92	73	2.74	1.98
2	.1	15	12	12	6	21	41	14	.91	.16
3	.3	70	40	34	29	83	98	83	2.85	2.07
4	.3	56	36	29	23	70	95	69	2.27	1.82
5	.3	70	44	37	29	87	99	86	2.82	2.10
6	.4	67	84	35	27	93	98	77	2.56	2.50
7	.3	70	45	33	28	85	98	84	2.33	2.09
8	.4	60	46	33	25	87	96	71	2.33	2.37
9	.3	68	35	33	28	82	99	84	2.56	2.35
9dupl.	.3	68	36	32	29	82	--	--	--	--
10	.3	67	83	31	27	99	98	80	2.29	2.30
11	1.3	59	26	48	22	99	89	47	2.58	3.61
12	.4	76	36	33	27	86	99	80	2.39	2.89
12repl.	.5	67	43	33	28	84	--	--	--	--
12repl.	.5	68	36	33	29	86	--	--	--	--
13	.3	67	45	31	27	83	99	82	2.35	2.65
14	.4	68	34	35	28	80	99	81	2.30	2.41
15	.3	68	91	31	28	91	99	79	2.51	2.33
16	.3	67	29	30	27	75	99	76	2.39	2.34
17	.1	17	9.9	11	12	21	35	17	1.09	2.98
18	.3	62	33	30	27	72	100	76	2.43	2.76
19	.3	68	29	31	28	76	99	79	2.38	1.82
20	.3	73	35	30	29	84	98	78	2.28	1.02
21	.3	61	35	32	25	75	95	70	2.24	2.00
<b>Gravity cores</b>										
LWT.WD	.5	66	29	33	27	83	99	79	2.59	2.82
LWT.WDdupl.	.4	68	28	33	27	82	--	--	--	--
LWT.WD	.4	66	31	33	27	82	99	81	2.31	2.68
LWT.WD	.4	70	36	35	29	86	100	86	2.50	2.30
LWT.WDdupl.	.4	70	35	35	28	85	--	--	--	--
LWT.WD	.4	73	39	43	30	89	100	87	1.82	2.45
LWT.WD	.5	74	36	44	30	92	99	83	2.22	2.03
LWT.WD	.5	78	39	52	32	97	100	87	1.59	2.23
LWT.WD	.5	80	41	56	32	98	100	89	1.55	2.16

**Table 3.** Concentrations of selected major and trace elements, grain size, and forms of carbon in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Cad-mium	Chro-mium	Copper	Lead	Nickel	Zinc	Silt and clay (percent)	Clay (percent)	Total organic carbon (percent)	Inorganic carbon (percent)
<b>Gravity cores—Continued</b>										
LWT.WD	0.8	82	36	57	32	99	100	89	1.62	2.11
LWT.WD	.6	84	30	45	32	97	100	88	1.45	2.03
LWT.WD	.4	85	25	34	33	90	100	89	1.40	2.02
LWT.WD	.2	87	29	38	37	100	100	91	1.16	1.20
LWT.WDdupl.	.2	88	28	38	35	100	--	--	--	--
LWT.WD	.2	86	27	29	36	91	100	96	1.30	1.01
LWT.DM	.3	68	38	34	29	79	97	78	2.64	2.43
LWT.DM	.3	71	42	36	30	84	98	76	2.48	2.39
LWT.DM	.4	80	46	46	32	91	98	71	2.22	2.29
LWT.DM	.3	73	42	37	30	86	99	74	1.67	2.15
LWT.DM	.4	98	43	48	34	97	99	80	1.58	1.92
LWT.DM	.4	90	33	41	34	98	99	84	1.38	1.49
LWT.DM	.3	87	28	37	34	96	100	86	1.28	1.30
LWT.DM	.2	86	27	31	35	97	100	88	1.18	.87
LWT.DM	.2	90	29	33	41	110	100	93	.96	.42
LWT.DM	.2	93	28	33	39	110	100	95	1.07	.64
LWT.DM	.2	94	28	31	39	110	100	97	1.08	.38
LWT.DM	.2	73	24	27	28	75	99	68	1.28	.28
LWT.UB	.3	70	29	32	29	87	99	77	2.33	2.29
LWT.UB	.3	69	29	32	28	79	99	79	2.13	2.24
LWT.UB	.3	70	31	33	29	79	99	81	2.02	2.17
LWT.UB	.2	92	30	35	37	100	99	92	1.23	.57
LWT.UB	.2	87	29	32	36	96	100	93	1.33	.19
LWT.UB	.2	94	29	32	39	110	100	97	1.09	.09
LWT.UB	.2	93	31	400	40	110	100	96	1.19	.17
LWT.UBdupl.	.2	92	30	400	39	110	--	--	--	--
LWT.UB	.3	86	31	930	36	99	100	88	1.70	.03
LWT.UB	.2	66	22	28	24	67	100	43	1.69	.45
LWT.UB	.1	47	16	19	16	41	99	59	1.06	.31
LWT.UB	.1	48	17	18	17	47	88	28	.74	.43
LWT.UB	.3	83	29	34	33	85	100	70	1.18	.49
PEC	4.98	111	149	128	48.6	459	--	--	--	--

**Table 4.** Kendall's tau correlation coefficients between trace elements and potential normalizing variables in sediments from Lake Worth, Fort Worth, Texas

[Correlation coefficient in plain font indicates correlation significant at .01 level; correlation coefficient in bold font indicates correlation significant at .05 level; correlation coefficient underlined indicates correlation not significant (p-value >.05)]

Trace element	Background samples <sup>1</sup>					All samples				
	Silt and clay (percent)	Clay (percent)	Normalizing variable			Silt and clay (percent)	Clay (percent)	Aluminum	Iron	Titanium
			Aluminum	Iron	Titanium					
Aluminum	<b>.49</b>	0.70	1.00	0.87	0.75	0.61	0.63	1.00	0.88	0.77
Iron	<b>.40</b>	.75	.87	1.00	.66	.57	.67	.88	1.00	.70
Titanium	.59	.54	.75	.66	1.00	.66	.49	.77	.70	1.00
Arsenic	<b>.41</b>	.64	.56	.59	.53	<u>.20</u>	.39	.27	.32	<b>.23</b>
Cadmium	<u>.13</u>	<u>.09</u>	<u>.06</u>	<u>.11</u>	<u>-.03</u>	<u>0</u>	<u>.06</u>	<u>-.11</u>	<u>-.07</u>	<b>-.22</b>
Chromium	.40	.74	.90	.96	.70	.56	.63	.85	.85	.67
Copper <sup>2</sup>	<u>.17</u>	<b>.42</b>	<b>.36</b>	<b>.44</b>	<u>.26</u>	<u>-.18</u>	<u>.02</u>	<u>-.06</u>	<u>0</u>	<b>-.22</b>
Lead <sup>3</sup>	<u>.36</u>	.65	.70	.78	.51	<b>.21</b>	.32	.29	.36	<u>.14</u>
Nickel	<b>.42</b>	.73	.88	.93	.66	.56	.67	.87	.91	.69
Zinc	<b>.40</b>	.72	.78	.83	.58	.42	.60	.61	.64	.43

<sup>1</sup> From sites 15, 16, 17, 18, 19, 20, and LWT.UB.

<sup>2</sup> Anomalously high copper concentration in sample at site 15 excluded when testing for relations between copper and normalizing constituents.

<sup>3</sup> Anomalously high lead concentrations in two samples (LWT.UB 50–55 and 60–65 centimeters) excluded when testing for relations between lead and normalizing constituents.

**Table 5.** Linear regression equations used to estimate background trace element concentrations and anthropogenic contributions in sediment from Lake Worth, Fort Worth, Texas

[Al, aluminum concentration in micrograms per gram]

Trace element	Equation	No. of samples to generate model	p-values (slope, intercept)	F-statistic	Model p-value	Coefficient of determination	Standard error of the estimate
Arsenic	$1.059^{-4}(Al)+2.487$	18	(0, .10)	37.72	0	0.70	1.661
Cadmium	$1.353^{-6}(Al)+0.126$	18	(.04, .02)	4.788	.04	.23	.05959
Chromium	$8.097^{-4}(Al)+6.255$	18	(0, .02)	748.236	0	.98	2.852
Copper	$2.059^{-4}(Al)+10.721$	17	(0, .02)	17.296	0	.54	4.765
Nickel	$3.269^{-4}(Al)+2.755$	18	(0, .12)	253.349	0	.94	1.979
Lead	$2.609^{-4}(Al)+8.992$	16	(0, .01)	42.729	0	.75	3.443
Zinc	$9.539^{-4}(Al)+3.788$	18	(0, .55)	158.79	0	.91	7.294

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001

[In micrograms per kilogram except as noted; cm, centimeters; --, not applicable; E, estimated; <, less than; dupl., duplicate sample]

Sample site	Age date	Sample interval (cm)	Phenol	p-Cresol	Naphthalene	C1-128 Isomers	2-Ethyl-naphthalene	2,6-Dimethylnaphthalene	1,6-Dimethylnaphthalene	C2-128 Isomers	Ace-naphthylene	1,2-Dimethylnaphthalene	Ace-naphthene
<b>Box cores</b>													
1	--	0–2	E44.3	E17.8	E4.8	244	<25	548	38.2	613	E8.6	E13.3	<25
2	--	0–2	E7.1	E3.6	E.9	E2.1	<5	29.4	E3.2	32.2	E1.9	E2.0	E1.4
2dupl.	--	0–2	E6.7	E4.6	E.9	E2.7	<5	31.8	E3.4	34.1	E1.9	<5	E.85
3	--	0–2	E53.8	E21.7	E4.6	329	<25	594	59.4	650	E10.2	<25	<25
4	--	0–2	E32.9	E14.9	E3.8	<20	<20	304	21.8	338	E8.7	E9.3	E4.6
5	--	0–2	E29.3	E21.2	E5.3	220	E5.0	536	38.3	606	E10.9	E15.1	E4.4
6	--	0–2	E29.3	E19.2	E6.6	165	<25	359	41.9	403	E22.5	<25	E12.9
6dupl.	--	0–2	E38.7	E15.6	E4.6	150	<25	302	35.5	337	E17.5	<25	E11.0
7	--	0–2	E23.2	E16.3	E3.8	154	<20	304	22.1	341	E9.6	<20	E4.8
8	--	0–2	E37.1	E16.4	E6.1	133	<20	267	23.9	260	E19.8	<20	E7.5
9	--	0–2	E57.4	E15.5	E3.7	E9.0	E3.8	327	25.6	365	E8.6	<25	E4.4
10	--	0–2	E29.7	E14.3	E3.5	E7.5	E3.3	300	E21.0	327	E8.0	E9.5	E2.1
11	--	0–2	E32.4	E38.3	39.4	104	E6.8	219	36.9	307	45.5	E9.1	118
12	--	0–2	14.3	E5.7	E2.0	E3.5	<10	150	10.8	175	E4.6	<10	E4.3
13	--	0–2	E26.7	E16.0	E3.8	E8.6	E4.1	348	26.8	380	E10.0	E10.8	E5.1
14	--	0–2	E46.2	E23.2	E4.7	172	<25	360	27.7	390	E8.9	<25	E4.3
15	--	0–2	E23.5	E15.0	E4.0	E8.5	E3.9	335	E24.5	363	E8.4	E10.8	E3.9
16	--	0–2	27.5	E5.6	E1.6	E5.4	<15	38.1	E3.7	88.4	E4.2	<15	E.78
17	--	0–2	E8.7	E5.4	E1.4	23.6	<5	49.6	E4.6	54	E1.4	<5	E1.2
18	--	0–2	E31.3	E18.4	E3.3	110	<25	228	E20.4	258	E5.4	E7.0	<25
19	--	0–2	E49.7	E18.2	E4.2	121	<20	208	E17.7	223	E6.9	<20	<20
20	--	0–2	E53.6	E17.4	E3.6	110	<20	151	E13.8	179	E7.6	<20	<20
21	--	0–2	E46.9	E12.1	E3.0	125	<20	217	22.2	247	E6.4	<20	E3.7
<b>Gravity cores</b>													
LWT.WD	2000.4	0–5	18.2	E6.1	E2.5	E3.8	<15	219	23.1	254	E6.4	<15	E5.0
LWT.WD	1998.8	5–10	11.2	E5.0	E1.7	E3.6	<10	152	E9.1	178	E5.5	<10	E3.5
LWT.WD	1996.5	10–15	E7.0	E2.4	E2.0	E3.2	<10	105	E7.2	124	E4.2	E2.1	E2.3
LWT.WD	1992.9	20–25	13.8	<10	E1.6	E2.2	<10	73.8	E5.0	89.8	E4.3	<10	<10
LWT.WD	1988.5	30–35	E6.0	E3.0	E2.2	E2.8	<10	54.9	<10	<10	E5.1	E2.4	E3.8
LWT.WD	1984.0	40–45	14.6	E2.2	E3.1	E3.2	<10	37.0	<10	49.9	E6.6	E1.2	7.4
LWT.WD	1979.5	50–55	E9.4	E2.0	E2.6	E2.6	<10	26.2	<10	37.3	E5.9	<10	E5.6
LWT.WD	1974.2	60–70	22.4	E2.1	E2.0	E1.9	<10	25.1	E2.0	35.3	E4.4	<10	E3.2
LWT.WD	1960.4	90–100	17.6	E2.6	E2.5	<10	<10	23.1	<10	45.6	E8.2	14.3	E5.4

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Age date	Sample interval (cm)	Phenol	p-Cresol	Naphthalene	C1-128 Isomers	2-Ethyl-naphthalene	2,6-Dimethyl-naphthalene	1,6-Dimethyl-naphthalene	C2-128 Isomers	Ace-naphthylene	1,2-Dimethyl-naphthalene	Ace-naphthene
<b>Gravity cores—Continued</b>													
LWT.WDdupl.	1960.4	90–100	16.2	E2.1	E2.7	E2.9	E1.6	25.2	<10	54.5	E7.8	12.6	E5.4
LWT.WD	1946.2	120–130	18.9	E1.4	E1.6	E1.4	<10	15.6	E1.4	22.2	E2.0	<10	E2.0
LWT.WD	1934.2	150–160	33.9	E2.3	E1.3	<10	<10	23.0	<10	30	E1.6	<10	E1.7
LWT.WD	1920.4	190–196	10.8	E1.2	E1.1	<10	<10	E6.4	<10	10.3	E1.2	<10	E2.1
LWT.DM	1999.4	0–5	26.5	E15.3	E2.5	E3.0	<15	102	E8.4	157	E5.2	<15	E.5
LWT.DM	1995.7	5–10	19.2	E19.5	E2.2	E2.7	<10	57.5	E4.8	79.3	E4.3	<10	E1.0
LWT.DM	1991.1	10–15	13.0	E11.4	E2.1	E3.6	<10	46.3	E4.1	70.6	E3.2	E.4	E.8
LWT.DM	1980.4	20–25	E7.3	E2.7	E1.5	E1.7	<10	36.3	E2.6	40.3	E2.6	<10	E1.7
LWT.DM	1969.5	30–35	15.0	E3.2	E2.0	E2.9	E.1	11.9	E1.4	18.2	E2.2	<10	E.9
LWT.DM	1958.5	40–45	E9.4	E2.8	E2.0	E2.8	E.2	E7.9	E1.2	12.8	E2.0	<10	E1.0
LWT.DMdupl.	1958.5	40–45	E8.5	E2.7	E1.5	E2.2	E.2	E9.2	E1.3	15.3	E1.8	E.3	E.8
LWT.DM	1947.5	50–55	E8.2	E3.5	E1.8	E2.5	E.1	E8.7	E1.4	12.4	E1.9	<10	E1.0
LWT.DM	1937.4	60–65	E7.8	E3.1	E2.0	E2.4	E.3	E7.5	E1.1	14.5	E1.7	E.4	E1.2
LWT.DM	1930.2	75–80	10.2	E1.5	E1.3	E1.6	<10	11.2	E1.2	15.4	<10	<10	<10
LWT.DM	1927.1	90–95	E9.6	<10	E1.0	<10	<10	E9.5	<10	13.8	<10	<10	E1.4
LWT.DM	1922.8	105–110	13.8	E4.0	E2.1	E2.4	E.2	E1.7	E.7	E5.2	E1.5	<10	E1.5
LWT.DM	1917.2	125–130	12.2	E2.4	E1.2	E1.7	E.1	E1.5	E.5	E4.6	E.8	E.3	E2.0
LWT.UB	1996.0	0–5	26.7	E3.8	E1.0	E2.0	<10	E7.6	E1.9	12.8	E2.3	<10	E.4
LWT.UB	1984.5	5–10	17.0	E4.2	E1.4	E2.7	<10	14.3	E2.3	27.2	E3.9	<10	E.7
LWT.UB	1971.3	10–15	10.6	E3.6	E1.3	E1.8	<10	16.3	E2.0	23.7	E3.5	<10	E.6
LWT.UB	1939.7	20–25	12.2	E2.6	E1.1	E1.5	<10	E3.4	E.9	E6.7	E2.2	<10	E.5
LWT.UB	1931.2	30–35	19.5	E5.0	E1.1	<10	<10	E2.9	<10	E4.4	E1.8	<10	E1.4
LWT.UBdupl.	1931.2	30–35	23.4	E4.5	E1.6	E6.9	<10	E4.1	E2.0	E8.7	E2.1	<10	E1.7
LWT.UB	1930.3	40–45	14.6	E1.8	E.8	E1.1	<10	E.7	E.6	E4.3	E1.4	<10	E1.0
LWT.UB	1929.4	50–55	17.8	E2.3	E1.0	E1.3	E.2	E2.3	E1.0	E6.6	E1.5	<10	E1.1
LWT.UB	1928.2	60–65	13.4	E3.2	E.9	E1.0	E.2	E.9	E.8	E4.0	E1.4	E.4	E1.4
LWT.UB	1926.2	75–80	9.8	E3.3	E1.2	E.8	E.2	E.4	E.5	E3.2	E1.1	<5	E1.0
LWT.UBdupl.	1926.2	75–80	8.3	E3.3	E1.3	E.8	E.1	E.7	E.6	E2.8	E.9	<5	E1.0
LWT.UB	1923.1	85–90	14.0	E3.4	E1.2	E1.0	E.2	E.5	E.4	E3.0	E1.1	E.2	E1.1
LWT.UB	1918.7	110–115	8.9	E2.0	E.6	E.9	E.1	E.4	E.5	E2.2	E.8	<5	E.2
LWT.UB	1915.0	130–135	14.3	E2.1	E.9	<5	E.3	E.6	E.5	E3.0	E1.0	<5	E.9

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	C3-128 Isomers	2,3,6-Trimethylnaphthalene	C4-128 Isomers	1-Methyl-9H-fluorene	C5-128 Isomers	2-Methylanthracene	4,5-Methylene-phenanthrene	C1-178 Isomers	1-Methylphenanthrene	C2-178 Isomers	C3-178 Isomers	C4-178 Isomers
<b>Box cores</b>												
1	87.5	E8.8	<25	<25	<25	<25	E8.0	E18.8	E6.0	31.3	38.2	13.0
2	12.8	E1.8	<5	E2.0	<5	<5	E3.5	8.5	E2.1	8.4	10.6	<5
2dupl.	<5	6.6	<5	<5	<5	<5	E2.8	7.1	E1.8	7.1	<5	<5
3	90.8	E7.6	<25	<25	<25	<25	E11.1	28.8	E6.0	47.8	41.7	12.8
4	68.3	E6.8	<20	E7.3	<20	<20	E12.0	39.2	E7.5	38.7	46.6	<20
5	89.9	E9.9	E24.6	E11.1	<30	<30	E12.8	50.1	E8.1	45.1	67.0	<30
6	87.2	E10.3	<25	<25	<25	E17.8	28.9	104	E16.5	51.5	98.8	<25
6dupl.	70.2	E6.5	<25	E5.7	<25	E12.8	E23.9	88.4	E12.8	50.4	72.0	<25
7	53.3	E6.9	<20	<20	<20	E9.1	E11.4	23.6	E6.3	29.0	49.5	<20
8	68.7	E7.2	<20	<20	<20	E15.4	20.5	42.1	E13.3	60.8	82.2	E10.8
9	60.1	E8.2	<25	E8.1	<25	<25	E11.8	35.8	E7.1	35.4	51.1	<25
10	85.1	E6.3	<25	E8.6	<25	<25	E10.7	28.9	E6.4	29.9	45.2	<25
11	152	11.3	<10	13.0	<10	53.4	155	498	70.7	225	582	20.1
12	<10	E1.8	<10	<10	<10	E2.9	E9.4	24	E4.3	23.1	39	<10
13	63.9	E7.4	<25	E9.4	<25	<25	E14.1	38.0	E8.0	44.6	65.0	<25
14	57.1	E6.2	<25	<25	<25	<25	E9.8	E18.7	E6.0	31.5	46.0	<25
15	78	E7.0	<25	E8.5	<25	<25	E9.6	36.7	E6.7	37.8	54.0	<25
16	E13.9	E.9	<15	E1.6	<15	E2.9	E4.6	30.3	E3.4	E9.6	E7.0	<15
17	13.4	E1.8	<5	<5	<5	E2.7	E2.8	5.2	E1.8	8.9	9.8	<5
18	56.2	E6.2	<25	E6.4	<25	<25	E7.5	E21.6	E5.7	31.3	32.1	E11.7
19	44.4	E7.4	<20	E7.0	<20	<20	E8.0	E18.2	E5.6	29.7	32.0	E10.2
20	42.9	<20	<20	E8.5	<20	<20	E7.4	E17.5	E5.7	26.9	23.7	E9.7
21	46.1	E5.0	<20	E4.4	<20	<20	E8.6	E17.2	E5.6	28.2	31.5	<20
<b>Gravity cores</b>												
LWT.WD	33.8	E2.4	<15	<15	<15	<15	E10.1	43.3	E5.6	31.1	38	<15
LWT.WD	20.9	E2.4	<10	<10	<10	<10	E8.2	29.4	E4.1	21	33	<10
LWT.WD	26.7	E1.4	<10	<10	<10	<10	E5.9	23.0	E2.9	17	32.6	<10
LWT.WD	13.9	<10	<10	<10	<10	E2.6	E5.5	17.2	E2.8	14.1	25.3	<10
LWT.WD	<10	E9.7	<10	<10	<10	E3.2	E8.6	30.2	E4.4	20.1	55.5	<10
LWT.WD	19.2	<10	<10	<10	<10	E4.6	15.1	44.9	E7.8	29.4	50	<10
LWT.WD	15.3	<10	<10	<10	<10	E4.2	12.3	39.0	E6.2	22.6	47.7	<10
LWT.WD	11.7	<10	<10	<10	<10	E3.0	E7.5	23.9	E4.3	16.2	31.7	<10
LWT.WD	45.3	E2.0	<10	<10	<10	E4.2	19.0	34.0	E5.7	27.4	70.6	<10

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	C3-128 Isomers	2,3,6-Trimethylnaphthalene	C4-128 Isomers	1-Methyl-9H-fluorene	C5-128 Isomers	2-Methylanthracene	4,5-Methylene-phenanthrene	C1-178 Isomers	1-Methylphenanthrene	C2-178 Isomers	C3-178 Isomers	C4-178 Isomers
<b>Gravity cores—Continued</b>												
LWT.WDdupl.	49.7	E2.4	<10	E3.7	<10	E4.2	20.2	35.3	E6.2	24	69	<10
LWT.WD	<10	<10	<10	<10	<10	E2.4	E8.2	15.0	E2.7	17.5	67	17.8
LWT.WD	E7.9	<10	<10	<10	<10	E1.5	E3.3	E8.8	E2.0	E7.9	15.3	<10
LWT.WD	E9.4	<10	<10	<10	<10	E1.2	E2.6	E4.5	E1.1	E3.4	E5.8	<10
LWT.DM	46.7	E1.5	19.8	E1.3	<15	E2.0	E4.6	20.7	E2.9	E12.0	E11.0	<15
LWT.DM	32.2	E1.3	E8.4	E2.0	<10	E2.3	E5.2	17.1	E2.9	11.4	E7.3	<10
LWT.DM	25.8	E1.2	<10	E1.7	<10	E2.0	E5.6	15.2	E2.9	E9.8	E6.8	<10
LWT.DM	<10	E1.2	<10	<10	<10	E2.1	E3.5	14.4	E2.0	E7.2	17.7	<10
LWT.DM	12.7	E1.0	<10	E1.4	<10	E1.9	E3.6	11.6	E2.0	E6.0	E4.3	<10
LWT.DM	15.8	E.9	<10	E1.1	<10	E1.8	E4.1	E9.7	E1.8	E5.9	E4.1	<10
LWT.DMdupl.	10.5	E.9	<10	E1.4	<10	E1.6	E4.1	10.0	E1.9	E6.1	E4.8	<10
LWT.DM	12.9	E.9	<10	E1.2	<10	E1.9	E7.0	E9.9	E1.7	E6.9	E6.5	<10
LWT.DM	15.1	E.9	<10	E1.5	<10	E1.5	E5.3	E7.2	E1.4	E5.8	E4.1	<10
LWT.DM	<10	<10	<10	<10	<10	<10	E2.3	E3.9	<10	E3.6	E7.2	<10
LWT.DM	<10	<10	<10	<10	<10	E1.2	E2.6	E4.2	E1.1	E4.6	E7.9	<10
LWT.DM	11.3	E.8	<10	E1.3	<10	E1.2	E3.6	E6.4	E1.6	E4.3	E3.7	<10
LWT.DM	8.6	E.6	<5	E1.4	<5	E1.0	E2.9	E4.7	E1.1	E3.0	E2.2	<5
LWT.UB	11.6	E.8	<10	E1.4	<10	E2.4	E3.2	E9.3	E1.5	E5.8	<10	<10
LWT.UB	14.6	E.8	<10	E1.5	<10	E2.3	E4.2	13.3	E1.7	E8.1	E4.4	<10
LWT.UB	E7.6	E.8	<10	E1.5	<10	E2.3	E3.6	E8.9	E1.7	E7.0	E5.6	<10
LWT.UB	E5.5	E.6	<10	E1.3	<10	E1.9	E2.2	E8.1	E1.2	E4.3	E4.0	<10
LWT.UB	<10	<10	<10	<10	<10	E2.6	E3.8	E7.6	E1.7	E5.8	E8.8	<10
LWT.UBdupl.	E7.9	<10	<10	<10	<10	E3.0	E4.4	E8.1	E2.2	E6.9	10	<10
LWT.UB	E7.0	E.6	<10	E1.4	<10	<10	E3.3	E6.9	E1.4	E5.2	E4.8	E3.6
LWT.UB	E8.1	E.6	<10	E1.5	<10	E1.8	E4.1	E6.8	E1.4	E4.3	E4.0	<10
LWT.UB	E9.6	E.5	<10	E1.8	<10	E1.6	E3.3	E6.7	E1.0	E3.9	<10	<10
LWT.UB	E5.0	E.3	<5	E1.4	<5	E1.1	E2.3	E3.6	E.8	E2.3	E1.8	<5
LWT.UBdupl.	E4.4	E.4	<5	E1.3	<5	<5	E2.3	E3.4	E.7	E2.5	<5	<5
LWT.UB	<5	E.4	<5	E1.4	<5	E1.2	E2.6	E3.6	E.7	E2.1	<5	<5
LWT.UB	E4.1	E.3	<5	E1.1	<5	E1.2	E1.7	E3.4	E.8	E2.2	E1.9	<5
LWT.UB	7.2	E.4	<5	E1.3	<5	<5	E2.5	E4.2	E.9	E3.2	E3.0	<5

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	1-Methylpyrene	C1-202 Isomers	C2-202 Isomers	C5-178 Isomers	C3-202 Isomers	C1-228 Isomers	C4-202 Isomers	C5-202 Isomers	C2-228 Isomers	Perylene	C1-252 Isomers	C3-228 Isomers	C2-252 Isomers
<b>Box cores</b>													
1	7.5	38.4	62.8	<25	<25	45.2	<25	<25	<25	940	129	<25	<25
2	E2.5	16.8	19.5	<5	<5	12.5	<5	<5	<5	140	23.3	<5	<5
2dupl.	E2.3	13.1	12.2	<5	<5	10.5	<5	<5	<5	139	15.1	<5	<5
3	9.4	56.2	56.6	<25	<25	58.6	<25	<25	<60	1,310	229	<45	<25
4	E9.7	72.9	78.1	<20	20.6	57.6	<20	<20	26	999	133	55.3	<30
5	E10.7	62.8	73.5	<30	<30	55.7	<30	<30	<50	1,150	128	<100	<50
6	E20.6	199	269	<25	49.3	183	<50	<25	<60	1,280	385	<50	132
6dupl.	E15.5	159	277	<25	45	138	<50	<25	<80	1,180	362	<40	105
7	E8.7	73.3	80.2	<20	18.6	55.9	<20	<20	<40	1,280	220	31.6	25.6
8	E14.9	136	208	<20	53.8	118	<20	<20	<30	986	238	<20	125
9	E8.9	62.2	75.1	<25	E16.0	55.3	<25	<25	<25	1,170	118	<50	<25
10	E8.5	56.0	51.9	<25	E21.2	50.1	<25	<25	<25	1,150	132	<60	<25
11	75.0	937	1,110	<10	212	689	<10	<10	284	768	1,260	<10	542
12	E4.8	60.4	51.8	<10	19.6	45.4	<10	<10	<10	585	<350	<10	<10
13	E10.3	70.6	74.9	<25	E17.6	63.8	<25	<25	<35	992	135	<80	<25
14	E7.5	48.0	83.0	<25	<25	47.7	<25	<25	<25	1,270	209	<25	<25
15	E8.3	48.7	47.7	<25	E19.5	49.5	<25	<25	<50	1,350	121	<40	<30
16	E2.7	20.3	E5.2	<15	<15	E9.1	<15	<400	<15	881	17.3	<15	<15
17	E2.2	11.6	23.4	<5	<5	14.9	<5	<5	<5	201	35.8	<5	<5
18	E6.6	29.6	E22.3	<25	<25	27.1	<25	<25	<25	857	137	<25	<25
19	E 6.7	27.9	27.7	<20	E10.6	22.0	<20	<20	<20	1,130	97.6	<30	<20
20	E7.5	30.7	34.9	<20	<20	26.5	<20	<20	<30	884	139	20	<20
21	E6.3	40.7	39.5	<20	E12.2	36.0	<20	<20	<20	888	115	23.9	<20
<b>Gravity cores</b>													
LWT.WD	E5.6	65.5	67.9	<15	18.3	58.2	<15	<15	<15	1,290	187	<15	20.5
LWT.WD	E4.4	54.2	51.9	<10	14.2	36.5	<10	<10	<40	1,080	165	<60	17.5
LWT.WD	E3.2	33.3	34.7	<10	13	32.7	<10	<10	12	798	<400	<10	<10
LWT.WD	E3.0	33.5	32.7	<10	18.5	25.2	<10	<10	<30	1,390	111	<10	11.6
LWT.WD	E5.0	65.1	62.1	<10	20.4	44.4	<10	<10	26.1	1,180	<360	<10	<10
LWT.WD	E8.4	108	82.3	<10	34.4	74.5	<10	<10	30.3	1,210	<400	<10	41.3
LWT.WD	E6.7	85.8	64.4	<10	26.0	60.9	<10	<10	15.4	1,180	<530	<10	<10
LWT.WD	E4.3	50.4	56.2	<10	15.3	39.6	<10	<10	<40	1,480	<320	<10	<10
LWT.WD	8.2	101	81.6	<10	30.1	53.9	<10	<10	18.5	1,460	<650	<10	<10

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	1-Methylpyrene	C1-202 Isomers	C2-202 Isomers	C5-178 Isomers	C3-202 Isomers	C1-228 Isomers	C4-202 Isomers	C5-202 Isomers	C2-228 Isomers	Perylene	C1-252 Isomers	C3-228 Isomers	C2-252 Isomers
<b>Gravity cores—Continued</b>													
LWT.WDdupl.	E8.2	106	76.8	<10	27.1	53.2	<10	<10	31.5	1,530	<530	<10	E2.2
LWT.WD	E3.6	34.3	32.2	<10	14.5	E1.3	<10	<10	E1.0	1,180	<340	<10	<10
LWT.WD	E1.6	16.6	12.6	<10	E2.3	E9.0	<10	<10	<10	1,770	103	<10	E6.3
LWT.WD	<10	E7.4	E4.4	<10	<10	E3.9	<10	<10	<10	1,700	<250	<10	<10
LWT.DM	E2.3	25.3	<15	<15	<15	15.1	<15	<300	<15	854	18.6	<15	<15
LWT.DM	E2.5	25.6	E8.9	<10	<10	14.2	<10	<170	E8.1	975	13.9	<10	<10
LWT.DM	E2.6	27.6	E8.6	<10	<10	13.8	<10	<100	<10	1,170	17.6	<10	<10
LWT.DM	E2.4	29.3	24.4	<10	<10	21.4	<10	<10	<20	1,140	<275	<10	<10
LWT.DM	E2.3	24.6	17.2	<10	<10	10.2	<15	<20	<10	1,820	13.5	<10	E7.9
LWT.DM	E2.0	21.8	14.7	<10	<10	E9.3	<10	<10	<10	1,860	<10	<10	<10
LWT.DMdupl.	E2.1	21.2	E4.4	<10	<10	E9.4	<10	<15	<10	1,890	<15	<10	<10
LWT.DM	E2.0	21.1	14.3	<10	<10	E9.7	<10	<20	E6.0	1,820	16.4	<10	<10
LWT.DM	E2.2	15.2	E5.9	<10	<10	E6.5	<10	<10	E4.3	2,160	E8.5	<10	<10
LWT.DM	E1.1	E8.0	E7.5	<10	<10	E4.1	<10	<10	<10	1,680	<250	<10	<10
LWT.DM	<10	E8.8	E7.3	<10	<10	E4.0	<10	<10	<10	1,600	<200	<10	<10
LWT.DM	E2.0	16.7	<10	<10	<10	E6.9	<15	<15	<10	1,630	<10	<10	<10
LWT.DM	E.6	5.7	<5	<5	<5	<5	<5	<15	<5	907	<5	<5	<5
LWT.UB	E2.1	12.1	E3.1	<10	<10	<10	<10	<115	<10	361	<10	<10	<10
LWT.UB	E2.4	18.0	<10	<10	<10	E7.8	<10	<160	<10	912	10.1	<10	<10
LWT.UB	E2.2	17.9	E5.2	<10	<10	E9.6	<10	<90	<10	1,220	E9.5	<10	<10
LWT.UB	E1.6	E9.8	<10	<10	<10	E4.8	<10	<20	<10	1,850	<10	<10	<10
LWT.UB	E2.2	<10	<10	<10	<10	E3.3	<10	<10	E3.1	1,720	<200	E5.2	<10
LWT.UBdupl.	E2.5	<10	E5.8	<10	<10	E4.4	<10	<10	E3.4	E2,360	<250	E7.5	<10
LWT.UB	E1.5	E8.2	E2.8	<10	<10	<10	<10	<10	<10	2,070	<10	<10	<10
LWT.UB	E1.6	E9.3	E2.4	<10	<10	<10	<10	<15	<10	2,220	<10	<10	<10
LWT.UB	E1.3	E6.2	<10	<10	<10	<10	<10	<20	<10	1,410	<10	<10	<10
LWT.UB	E.8	E4.0	<5	<5	<5	<5	<5	<20	<5	496	<5	<5	<5
LWT.UBdupl.	E1.0	E3.8	<5	<5	<5	<5	<5	<25	<5	551	<5	<5	<5
LWT.UB	E.9	E4.7	<5	<5	<5	<5	<5	<20	<5	495	<5	<5	<5
LWT.UB	E.9	E4.5	<5	<5	<5	<5	<5	<10	<5	414	<5	<5	<5
LWT.UB	E1.1	5.5	<5	<5	<5	E2.2	<5	<15	<5	553	<5	<5	<5

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	C4-228 Isomers	C3-252 Isomers	C4-252 Isomers	C5-228 Isomers	C5-252 Isomers	Coronene	Fluorene	Phenanthrene	Anthracene	Dibenzo-(a,h)-anthracene	Fluoranthene	Pyrene	Benz(a)-anthracene
<b>Box cores</b>													
1	<60	<25	<25	<200	<25	<25	E8.5	E23.0	E15.3	E11.0	79.5	61.5	32.9
2	<5	<5	<5	<5	<5	E1.4	E2.8	15.2	E5.0	E3.8	38.0	28	17.5
2dupl.	<5	<5	<5	<5	<5	E1.1	E2.4	6.0	E3.6	E3.1	23.3	18.0	11.7
3	<60	<25	<25	<170	<25	<25	E10.4	35.0	E20.7	12.9	117	89.2	50.2
4	<20	<20	<20	<20	<20	E6.5	E9.2	46.2	E19.1	E14.9	155	119	67.0
5	<30	<30	<30	<30	<30	E7.1	E12.4	39.6	E22.0	E15.2	137	107	58.7
6	<80	38.6	24.7	<130	<25	E11.9	E19.0	182	50.9	39.8	496	376	222
6dupl.	<50	31.4	E16.1	<100	<25	E7.0	E14.9	156	43.1	31.3	414	313	181
7	<50	<20	<20	<100	<20	<20	E9.3	53.2	20.8	E12.8	142	110	61.0
8	<60	43.9	<20	<130	<20	<20	E13.1	125	38.6	33.4	365	266	127
9	<25	<25	<25	<25	<25	E5.0	E9.4	43.1	E20.1	E12.7	130	100	53.2
10	<25	<25	<25	<25	<25	E5.8	E9.8	35.0	E17.2	E11.2	108	84.6	48.2
11	<10	110	<10	<10	<10	E35.5	114	1,410	299	189	2,690	1,960	1,170
12	<10	<10	<10	<10	<10	E5.3	E5.8	56.9	15.8	11.8	139	110	51.9
13	<25	<25	E12.8	<25	<25	E6.4	E12.0	50.1	E21.5	E16.1	151	118	67.9
14	<50	<25	<25	<130	<25	<25	E9.3	29.2	E17.2	E11.4	93.4	74.8	43.9
15	<25	<25	<25	<25	<25	E5.0	E10.0	29.9	E17.1	E10.2	87.3	69.4	40.0
16	<15	<15	<15	<30	<15	E2.6	E2.8	E13.6	E5.4	E3.6	37.8	31.1	15.8
17	<15	<5	<5	<25	<5	E1.8	E2.5	8.1	E4.0	E2.6	20.8	15.6	10.4
18	<60	<25	<25	<100	<25	<25	E8.0	E14.7	E12.6	E8.0	44.2	34.9	E21.2
19	<35	<20	<20	<60	<20	<20	E8.2	E12.6	E13.4	E8.4	41.1	33.3	22.0
20	<40	<20	<20	<50	<20	E4.7	E8.3	E12.1	E13.4	E7.5	44.0	35.2	23.4
21	<30	<20	<20	<60	<20	<20	E7.4	29.0	E14.3	E8.6	78.5	61.6	35.4
<b>Gravity cores</b>													
LWT.WD	<15	<15	<15	<15	<15	<15	E6.0	63.2	18.2	19.1	154	123	61.2
LWT.WD	<10	<10	<10	<10	<10	E.3	E4.8	41.2	13.8	14.6	109	89.2	42.1
LWT.WD	<10	<10	<10	<10	<10	E2.3	E3.7	27.6	10.7	7.5	74.7	61.0	27.6
LWT.WD	<10	<10	<10	<10	<10	E2.1	E3.1	27.3	10.6	E6.6	72.8	61.3	29.0
LWT.WD	<10	<10	<10	<10	<10	E5.1	E4.2	51.8	15.1	12.1	146	118	54.6
LWT.WD	<10	17.8	<10	<10	<10	E7.9	E7.4	108	26.5	22.4	234	191	106
LWT.WD	<10	<10	<10	<10	<10	E7.1	E5.6	87.8	19.9	16.7	180	144	81.2
LWT.WD	<10	<10	<10	<10	<10	E4.3	E3.7	48.6	11.7	10.5	130	105	40.4
LWT.WD	<10	<10	<10	<10	<10	E7.7	E5.3	70.5	18.2	14.3	181	153	64.1

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	C4-228 Isomers	C3-252 Isomers	C4-252 Isomers	C5-228 Isomers	C5-252 Isomers	Coronene	Fluorene	Phenanthrene	Anthracene	Dibenzo-(a,h)-anthracene	Fluoranthene	Pyrene	Benz(a)-anthracene
<b>Gravity cores—Continued</b>													
LWT.WDdupl.	<10	<10	<10	<10	<10	E4.8	E6.0	66.4	16.1	18.9	180	148	58.9
LWT.WD	<10	<10	<10	E.5	E2.1	E1.3	E2.8	15.0	E4.0	E1.9	39.6	34.6	10.6
LWT.WD	<10	<10	<10	<10	<10	E.8	E2.3	E5.6	E2.5	E1.0	12.6	12.2	E3.8
LWT.WD	<10	<10	<10	<10	<10	<10	E2.2	E4.8	E1.8	<10	E9.6	E8.6	E2.0
LWT.DM	<15	<15	<15	<15	<15	E2.0	E2.6	15.2	E5.2	E3.9	57.9	47.2	22.1
LWT.DM	<10	<10	<10	<10	<10	E1.6	E2.5	16.7	E5.5	E4.9	60.6	49.4	23.7
LWT.DM	<10	<10	<10	<10	<10	E1.7	E2.1	16.9	E5.2	E5.0	63.0	52.9	24.6
LWT.DM	<10	<10	<10	<10	<10	E2.5	E2.2	22.6	E6.9	E3.8	62.1	57.3	22.6
LWT.DM	<10	<10	<10	<10	<10	E2.5	E1.8	17.3	E4.8	E4.0	45.1	44.5	18.5
LWT.DM	<10	<10	<10	<10	<10	E1.2	E1.8	14.7	E4.1	E2.8	34.4	36.6	15.3
LWT.DMdupl.	<10	<10	<10	<10	<10	E.9	E1.8	14.0	E4.0	E2.3	34.6	36.8	15.2
LWT.DM	<10	<10	<10	<10	<10	E1.1	E1.9	10.5	E3.3	E1.6	23.8	26.1	10.6
LWT.DM	<10	<10	<10	<10	<10	E.7	E1.9	E5.1	E2.6	E1.0	11.8	14.4	E5.6
LWT.DM	<10	<10	<10	<10	<10	<10	E1.3	E3.1	<10	E1.2	E7.0	E8.0	E2.0
LWT.DM	<10	<10	<10	<10	<10	<10	E1.6	E4.0	E1.7	<10	E9.8	E9.7	E2.6
LWT.DM	<10	<10	<10	<10	<10	E27.6	E1.9	E9.0	E2.7	E2.4	26.7	41.5	10.4
LWT.DM	<5	<5	<5	<5	<5	<5	E2.6	8.0	E1.8	E.6	9.3	7.6	E2.1
LWT.UB	<10	<10	<10	<10	<10	<10	E2.0	E7.6	E3.3	E1.6	22.0	18.5	E9.2
LWT.UB	<10	<10	<10	<10	<10	E1.7	E2.5	10.8	E4.2	E2.5	33.3	28.2	14.6
LWT.UB	<10	<10	<10	<10	<10	E1.8	E2.0	10.0	E4.2	E2.2	31.4	26.8	13.9
LWT.UB	<10	<10	<10	<10	<10	E1.4	E1.4	E5.6	E2.7	E1.7	13.3	15.5	E6.8
LWT.UB	<10	<10	<10	<10	<10	E2.0	E2.5	E4.6	E3.1	E1.7	E7.3	E9.0	E3.7
LWT.UBdupl.	<10	<10	<10	E2.1	<10	E1.8	E2.9	E5.2	E3.3	E1.9	E9.0	11.3	E4.1
LWT.UB	<10	<10	<10	<10	<10	E1.1	E1.5	E4.2	E2.2	E.9	E8.6	10.4	E4.0
LWT.UB	<10	<10	<10	<10	<10	E1.4	E2.5	E5.5	E2.4	E1.1	12.7	12.7	E4.2
LWT.UB	<10	<10	<10	<10	<10	E1.2	E2.4	E7.1	E2.4	E.8	E9.0	E8.2	E3.0
LWT.UB	<5	<5	<5	<5	<5	E.9	E3.1	5.2	E1.4	E.7	6.4	5.2	E2.0
LWT.UBdupl.	<5	<5	<5	<5	<5	E.9	E3.3	5.1	E1.5	E.6	6.0	E4.9	E2.1
LWT.UB	<5	<5	<5	<5	<5	E1.0	E3.6	6.3	E1.6	E.8	7.1	5.9	E2.2
LWT.UB	<5	<5	<5	<5	<5	E.9	E1.2	E3.4	E1.5	E.8	5.8	5.3	E2.4
LWT.UB	<5	<5	<5	<5	<5	E1.2	E2.8	5.8	E1.9	E.8	7.3	5.7	E2.7

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Chry-sene	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Benzo(e)-pyrene	Benzo(a)-pyrene	Indeno-(1,2,3-c,d)-pyrene	Benzo-(g,h,i)-perylene	Total combustion PAH	Total PAH	2- & 3-Ringed/4- & 5-ringed PAH source ratio
<b>Box cores</b>										
1	41.7	74.5	28.9	43.3	43.2	55.0	E20.4	481	1,870	0.677
2	16.4	20.9	14.1	11.7	18.5	17.2	8.9	191	372	.267
2dupl.	11.2	14.7	11.0	8.4	13.7	13.4	6.6	132	254	.212
3	54.8	80.2	52.0	57.5	58.8	71.7	28.6	660	2,360	.560
4	70.4	102	66.4	53.8	76.8	78.6	39.5	829	1,920	.286
5	64.3	96.0	60.8	52.8	72.1	80.6	41.4	771	2,320	.563
6	245	322	176	229	242	236	99.1	2,640	5,180	.240
6dupl.	204	300	144	185	195	194	75.2	2,210	4,400	.234
7	67.8	93.1	55.7	66.4	68.8	68.9	33.7	767	2,040	.301
8	192	253	153	175	161	191	69.6	1,950	3,780	.233
9	59.4	76.7	57.6	44.0	59.2	65.4	32.9	678	1,680	.309
10	50.1	73.9	44.7	37.2	52.1	56.3	30.5	586	1,520	.305
11	1,170	1,520	792	E827	1,070	959	430	12,600	21,900	.220
12	68	69.0	57.9	48.6	66.7	56.1	21.5	689	1,240	.251
13	73.3	118	47.3	54.0	76.8	76.0	39.0	821	1,930	.336
14	45.8	63.6	44.0	45.9	48.1	53.6	E22.4	536	1,720	.366
15	42.3	57.9	36.0	31.2	43.1	49.9	27.3	484	1,450	.317
16	18.9	26.1	19.6	18.7	21.1	17.4	E10.3	217	459	.160
17	9.4	13.9	7.3	8.3	10.5	9.9	E5.0	111	334	.341
18	E18.9	29.9	E19.8	E19.0	E23.2	27.5	E12.7	251	1,050	.441
19	E19.5	37.2	E14.7	E16.3	23.8	27.0	E11.5	246	971	.344
20	21.1	36.9	E15.7	E14.6	24.6	26.3	12.3	254	981	.337
21	36.8	50.6	29.3	28.4	36.7	38.7	16.4	412	1,250	.366
<b>Gravity cores</b>										
LWT.WD	80.3	87.5	64.8	58.1	83.4	72.5	E3.9	789	1,730	.204
LWT.WD	57.4	64.6	49.7	44.1	59.2	52.0	32.6	600	1,310	.180
LWT.WD	38.1	51.8	25.9	29.9	37.3	34.2	14.5	395	808	.213
LWT.WD	38.3	39.9	34.0	31.6	41.1	33.6	25.6	407	858	.104
LWT.WD	71.6	77.7	63.3	52.2	72.4	60.8	26.8	743	1,170	.089
LWT.WD	138	164	89.8	92.2	135	106	47.9	1,300	2,080	.124
LWT.WD	111	128	81.3	73.7	105	84.3	39.4	1,030	1,600	.120
LWT.WD	64.5	77.2	47.2	45.1	59.3	51.4	24.0	644	1,020	.084
LWT.WD	90.2	100	84.5	65.1	83.2	73.8	35.1	930	1,570	.124

**Table 6.** Concentrations of selected polycyclic aromatic hydrocarbons (PAHs) in sediment samples from Lake Worth, Fort Worth, Texas, 2000–2001—Continued

Sample site	Chry-sene	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Benzo(e)-pyrene	Benzo(a)-pyrene	Indeno-(1,2,3-c,d)-pyrene	Benzo-(g,h,i)-perylene	Total combustion PAH	Total PAH	2- & 3-Ringed/4- & 5-ringed PAH source ratio
<b>Gravity cores—Continued</b>										
LWT.WDdupl.	86.2	97.0	62.5	63.3	78.6	67.4	32.2	874	1,540	0.127
LWT.WD	19.7	19.4	10.4	17.5	15.8	14.0	8.5	190	447	.115
LWT.WD	E6.9	E8.4	E4.7	E7.1	E6.0	E7.0	E5.5	74.2	311	.041
LWT.WD	E4.3	E4.9	E4.3	E3.8	E4.8	E4.5	E2.6	49.4	112	.025
LWT.DM	34.2	44.2	36.6	36.2	33.0	27.7	E17.9	357	725	.243
LWT.DM	35.9	51.8	40.7	37.7	34.3	E25.1	E15.6	375	645	.136
LWT.DM	36.6	48.1	44.8	38.0	36.2	E26.6	E17.0	388	626	.101
LWT.DM	35.3	31.0	40.4	27.5	33.7	29.8	15.0	355	555	.075
LWT.DM	28.3	34.2	27.0	26.6	24.7	21.6	E15.9	286	452	.039
LWT.DM	22.4	25.1	23.9	23.3	18.9	E14.8	E9.4	224	352	.036
LWT.DMdupl.	22.5	30.8	20.9	22.8	19.3	E13.6	E8.1	225	337	.034
LWT.DM	15.4	17.8	13.7	16.7	12.6	10.2	E7.4	154	297	.034
LWT.DM	E7.6	E8.6	E7.1	10.6	E7.2	E5.8	E4.9	83.6	191	.027
LWT.DM	E3.8	E5.9	E3.1	E4.2	E6.0	E4.7	E2.3	47.0	105	.021
LWT.DM	E4.6	E6.0	E6.3	E4.4	E6.1	E5.9	E3.2	58.6	119	.023
LWT.DM	18.7	19.0	18.9	37.5	34.7	27.7	E74.5	310	417	.027
LWT.DM	E3.4	E4.3	E2.2	E4.2	E2.8	E2.3	E1.2	39.4	88	.042
LWT.UB	E9.1	13.2	E9.6	E8.8	10.8	E9.5	E4.0	115	191	.119
LWT.UB	16.2	23.4	17.7	17.5	17.1	13.1	E7.2	188	324	.081
LWT.UB	15.8	21.3	16.8	16.0	16.6	13.1	E7.0	179	303	.052
LWT.UB	E7.4	11.0	E8.3	E7.7	E8.8	E7.3	E4.9	91.0	154	.022
LWT.UB	E3.2	E5.9	E2.9	E1.6	E5.1	E4.6	E3.6	46.9	103	.021
LWT.UBdupl.	E3.8	E6.3	E4.3	E1.8	E4.7	E5.2	E3.8	54.3	147	.025
LWT.UB	E4.2	E5.7	E4.4	<10	<10	E4.8	E2.9	45.0	103	.020
LWT.UB	E4.8	E6.5	E5.8	<10	<10	E6.0	E3.6	56.3	117	.019
LWT.UB	E4.0	E5.0	E3.4	<10	<10	E4.0	E2.5	39.1	90	.027
LWT.UB	E3.2	E3.9	E2.2	<5	<5	E3.4	E1.7	28.0	65	.055
LWT.UBdupl.	E3.0	E4.0	E2.2	E2.7	<5	E3.3	E1.3	29.5	63	.045
LWT.UB	E3.7	5.1	E3.2	E3.1	<5	E3.8	E1.9	36.0	68	.045
LWT.UB	E2.4	E3.4	E2.6	<5	<5	E3.4	E1.9	27.2	57	.051
LWT.UB	E3.1	E4.3	E2.8	E3.9	<5	E3.8	E2.1	35.7	81	.056

**Table 7.** Concentrations of selected organochlorine pesticides and polychlorinated biphenyls (PCBs) in sediment samples from Lake Worth, Fort Worth Texas, 2000–2001

[In micrograms per kilogram; cm, centimeters; --, not applicable; <, less than; E, estimated; dupl., duplicate sample]

Sample site	Age date	Sample interval (cm)	Chlor-dane	DDE	DDD	DDT	Diel-drin	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCB
<b>Box cores</b>											
1	--	0–2	<20	E1.7	<2.0	<2.0	<2.0	<20	<20	<20	<60
2	--	0–2	<5	E.4	<.5	<.5	<.5	<5	E1	E2	E3
3	--	0–2	<25	E2.0	<2.5	<2.5	<2.5	<25	<25	<25	<75
4	--	0–2	<15	E1.0	<1.5	<1.5	<1.5	<15	E3	E6	E9
5	--	0–2	<30	E1.4	<3.0	<3.0	<3	<30	E5	E7	E12
6	--	0–2	<20	E1.6	<2.0	<2.0	<2.0	<20	<20	<20	<60
6dupl.	--	0–2	<20	E1.5	<2.0	<2.0	<2.0	<20	<20	<20	<60
7	--	0–2	<20	E1.5	<2.0	<2.0	<2.0	<20	<20	<20	<60
8	--	0–2	<20	E1.5	<2.0	<2.0	<2.0	<20	<20	<20	<60
9	--	0–2	<20	E1.1	<2.0	<2.0	<2.0	<20	E5	E7	E12
10	--	0–2	<20	E1.0	<2.0	<2.0	<2.0	<20	E5	E5	E10
11	--	0–2	E13	E1.7	<1.0	<2.5	<1.0	E22	E60	E57	E140
12	--	0–2	<10	E.7	<1.0	<1.0	<1.0	<10	E9	E6	E15
13	--	0–2	<20	E1.1	<2.0	<2.0	<2.0	<20	E10	E10	E20
14	--	0–2	<20	E1.5	<2.0	<2.0	<2.0	<20	<20	<20	<60
15	--	0–2	<20	E1.0	<2.0	<2.0	<2.0	<20	E4	E5	E9
16	--	0–2	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
17	--	0–2	<5	E.4	<.6	<.5	<.5	<5	<5	<5	<15
18	--	0–2	<20	E1.2	<2.0	<2.0	<2.0	<20	<20	<20	<60
19	--	0–2	<20	E1.2	<2.0	<2.0	<2.0	<20	<20	<20	<60
20	--	0–2	<20	E1.1	<2.0	<2.0	<2.0	<20	<20	<20	<60
21	--	0–2	<15	E1.2	<1.5	<1.5	<1.5	<15	<15	15	<45
<b>Gravity cores</b>											
LWT.UB	1996.0	0–5	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.UB	1984.5	5–10	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.UB	1971.3	10–15	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.UB	1939.7	20–25	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.UB	1931.2	30–35	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1930.3	40–45	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1929.4	50–55	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.UB	1928.2	60–65	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1926.2	75–80	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1923.1	85–90	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1918.7	110–115	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.UB	1915.0	130–135	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.WD	2000.4	0–5	<10	E.7	<1.0	<1.0	<1.0	<10	E9	E7	E16
LWT.WD	1998.8	5–10	<10	E.7	<1.0	<1.0	<1.0	<10	E7	E6	E13
LWT.WD	1996.5	10–15	<10	E.7	<1.0	<1.0	<1.0	<10	E7	E5	E12
LWT.WD	1992.9	20–25	<10	E.7	<1.0	<1.0	<1.0	<10	E4	E4	E9
LWT.WD	1988.5	30–35	<10	E.9	<1.0	<1.0	<1.0	<10	E7	E6	E12
LWT.WD	1984.0	40–45	<5	1.0	<.5	<.5	<.5	<5	E6	E5	E11
LWT.WD	1979.5	50–55	<5	1.7	<.5	<.5	<.5	<5	E9	E6	E14
LWT.WD	1974.2	60–70	<5	2.1	<.5	<.5	<.5	<5	12	7	19
LWT.WD	1960.4	90–100	<5	2.6	1.7	<.5	<.5	<5	26	24	50
LWT.WDdupl.	1960.4	90–100	<5	2.4	1.4	<.5	<.5	<5	26	24	50
LWT.WD	1946.2	120–130	<5	1.0	0.8	<.5	<.5	<5	17	5	22
LWT.WD	1934.2	150–160	<10	<1.0	<1.0	<1.0	<1.0	<10	<10	<10	<30
LWT.WD	1920.4	190–196	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15

**Table 7.** Concentrations of selected organochlorine pesticides and polychlorinated biphenyls (PCBs) in sediment samples from Lake Worth, Fort Worth Texas, 2000–2001—Continued

Sample site	Age date	Sample interval (cm)	Chlor-dane	DDE	DDD	DDT	Diel-drin	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCB
<b>Gravity cores—Continued</b>											
LWT.DM	1999.4	0–5	<10	E1.2	<1.0	<1.0	E.4	<10	E3	E3	E7
LWT.DM	1995.7	5–10	<10	E1.2	<1.0	<1.0	E.3	<10	E3	E3	E6
LWT.DM	1991.1	10–15	<10	E1.2	<1.0	<1.0	E.3	<10	E3	E3	E6
LWT.DM	1980.4	20–25	<5	1.4	<.5	<.5	<.5	<5	E5	E4	E9
LWT.DM	1969.5	30–35	<10	E4.4	1.2	<1.0	E.3	<10	E9	E8	E17
LWT.DM	1958.5	40–45	<10	E3.5	1.1	<1.0	E.3	<10	E7	E11	E18
LWT.DM	1947.5	50–55	<10	E1.8	1.3	<1.0	E.3	<10	<10	<10	<30
LWT.DM	1937.4	60–65	<10	E.4	<1.0	<1.0	E.3	<10	<10	<10	<30
LWT.DM	1930.2	75–80	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.DM	1927.1	90–95	<5	<.5	<.5	<.5	<.5	<5	<5	<5	<15
LWT.DM	1922.8	105–110	<10	E.2	E.2	<1.0	E.2	<10	<10	<10	<30
LWT.DM	1917.2	125–130	<5	E.2	<.5	<.5	E.2	<5	<5	<5	<15