

## Bottom Sediments of Lorence Creek Lake, San Antonio, Texas, Reflect Contaminant Trends in an Urbanizing Watershed

Historical use of pesticides and rapid urbanization have left their mark on the chemistry of bottom sediments in Lorence Creek Lake (fig. 1) in the northern part of San Antonio, Tex. Several metals, organochlorine compounds (pesticides and polychlorinated biphenyls [PCBs]), and polycyclic aromatic hydrocarbons (PAHs) detected in bottom sediments of the lake have temporal trends indicating anthropogenic (human) sources. Lorence Creek Lake is not unique; the same metals and organic compounds are routinely found in lake sediments in urbanizing watersheds (Van Metre and Callender, in press).

Many common agricultural and urban contaminants tend to chemically adhere to sediments. As rain washes sediment particles from streets and fields, these contaminants are flushed into streams and lakes and can infiltrate ground water. In karst (dissolutioned limestone) terrain, recharge and ground-water flow are rapid, and sediments in recharge water can remain in suspension and be transported great distances underground (Mahler and Lynch, 1998). When runoff containing sediment particles flows into lakes, the velocity slows and particles settle to the bottom. Over time, layers of sediment are deposited that leave a partial record of historical water quality. This record can be revealed by collecting and analyzing sediment cores from the bottom of lakes and reservoirs (Van Metre and Callender, 1997).

This fact sheet summarizes the chemistry of sediment cores collected from Lorence Creek Lake. The study was designed to

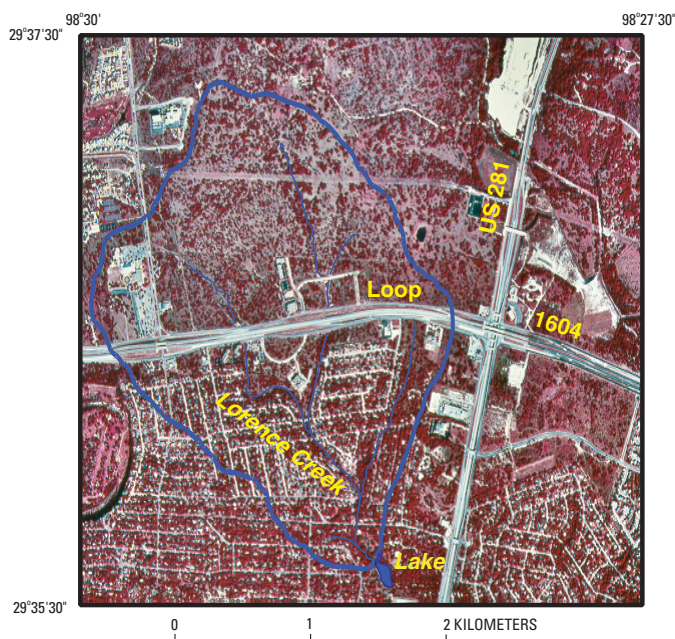
assess the effects of development on water quality of a stream that likely recharges the Edwards aquifer in San Antonio. Lorence Creek Lake is in karst terrain in the northern part of San Antonio in a primarily residential area known as Hollywood Park. The lake was constructed on private property about 1962 and was used primarily for stock watering; currently (1999), the lake is public property. It is located in the Lorence Creek watershed, which drains to Salado Creek about 6.4 kilometers south-southwest of the lake. Lorence Creek Lake has a surface area of about 2 hectares (about 4 acres) and has a depth of 1 meter or less. The drainage area of the lake is about 5 square kilometers.

Land use in the Lorence Creek watershed upstream of the lake has gone through a series of changes since the early 1950s when it was predominately rangeland. By the late 1960s, about 12 percent of the land was urban, mostly single-family housing. By the late 1970s, urban land had increased to 25 percent of the watershed upstream of the lake, and by 1992, 55 percent of the land was urban—including a major divided highway (Loop 1604), a large church, and several commercial properties in addition to the residential areas.

### How We Sampled and Age-Dated Lake Sediments

Cores of bottom sediments in Lorence Creek Lake were collected in August 1996 at the center of the lake, about 50 meters upstream of the dam. The site cored was in the deepest part of the lake (about 1 meter). Two cores were collected using a hand corer. The cores were 6.3 centimeters in diameter and about 27 and 38 centimeters long. Subsamples from one of the cores were collected every 2 or 3 centimeters for analysis of cesium-137 ( $^{137}\text{Cs}$ ) and major and trace elements; and subsamples similarly collected from the other core were analyzed for organochlorine compounds and PAHs.

Ages of core sediments were dated using a combination of physical and chemical markers. The top of a core was assigned the year of sampling, 1996; the bottom of the core was assigned 1962, the estimated completion date for construction of the lake. Pre-reservoir sediment, which was identified in a core by the presence of coarse sand and pebbles, was at a depth of 27 centimeters. Depths of core subsamples were correlated with the  $^{137}\text{Cs}$  content of the subsamples. Measurable concentrations of  $^{137}\text{Cs}$ , a radioactive by-product of nuclear weapons testing with a half-life of about 30 years, first appeared in the atmosphere about 1952, peaked during 1963–64, and decreased to nearly zero by the mid-1970s. The rate of sedimentation was assumed constant between 1964 (the assigned  $^{137}\text{Cs}$  peak in the lake sediments) and 1996 (the sampling year).



**Figure 1.** Lorence Creek watershed upstream of Lorence Creek Lake (USGS National Aerial Photography Program photograph, January 1995).

## What We Found—In the Context of What We Know

Concentrations of metals, organochlorine compounds, and PAHs in Lorence Creek Lake sediments change over time and reflect the historical concentrations of those constituents in the water that has entered the lake since its construction. The information on constituent sources discussed below, unless otherwise referenced, is from the Agency for Toxic Substances and Disease Registry (ATSDR) (1999a).

### Arsenic

Arsenic concentrations in Lorence Creek Lake sediments peaked in the mid-1960s at a relatively high concentration (fig. 2) compared to those in other urban lake sediments (Van Metre and Callender, 1997), before much urban development occurred in the watershed upstream of the lake. The source of the arsenic during the 1960s is unknown, although a possible source is pesticides containing arsenic. Organic arsenic is the active ingredient in some pesticides, mostly weed killers. The decrease in arsenic concentrations to a low level in recent years is a notable trend, as arsenic is the number-one-ranked substance on the ATSDR/U.S. Environmental Protection Agency (EPA) list of top 20 hazardous substances for 1997 (Agency for Toxic Substances and Disease Registry, 1999b).

### Lead

Concentrations of lead in Lorence Creek Lake sediments peaked in the mid-1970s and decreased about 66 percent by 1996. Peaks in lead concentrations in urban reservoir sediment cores in the United States consistently occur in the 1970s and have been attributed primarily to the use of lead in gasoline until the early-to-mid 1970s (Callender and Van Metre, 1997). In addition to lead's elimination from gasoline, lead concentrations in paints, ceramics, caulk, and pipe solder have been reduced greatly in recent years—but fairly stable sediment concentrations since the mid-1980s reflect its continued, although reduced, presence in urban runoff.

### Mercury

Mercury concentrations in Lorence Creek Lake sediments peaked in the late 1970s and, like lead, decreased to fairly stable levels through 1996. The specific factors responsible for the temporal pattern of mercury in the lake sediments are unknown; although similar trends in mercury concentrations, with increases coincident with initial urban development in the watershed upstream of the lake and then decreases in concentration more recently, have been reported for lake sediments in Minneapolis, Minn. (Engstrom and Swain, 1997). Mercury can enter the air from the burning of coal and waste and from manufacturing plants. It can enter water and soil at waste-disposal sites. Some types of pesticides and household products contain mercury (Pais and Jones, 1997).

### Zinc

Zinc concentrations in lake sediments were fairly constant through the 1980s but increased in the 1990s to their maximum in 1996. The increasing trend in zinc concentrations probably is associated with increasing urbanization in the watershed upstream of the lake because zinc has many commercial uses. Automobile tires contain zinc (Van Assche and Martin, 1999) and could be a source in Lorence Creek and other urban watersheds, where similar increasing zinc trends have been reported (Van Metre and Callender, 1997).



A dry Lorence Creek at Loop 1604, September 1999 (photograph by M.B. Nyman, U.S. Geological Survey).

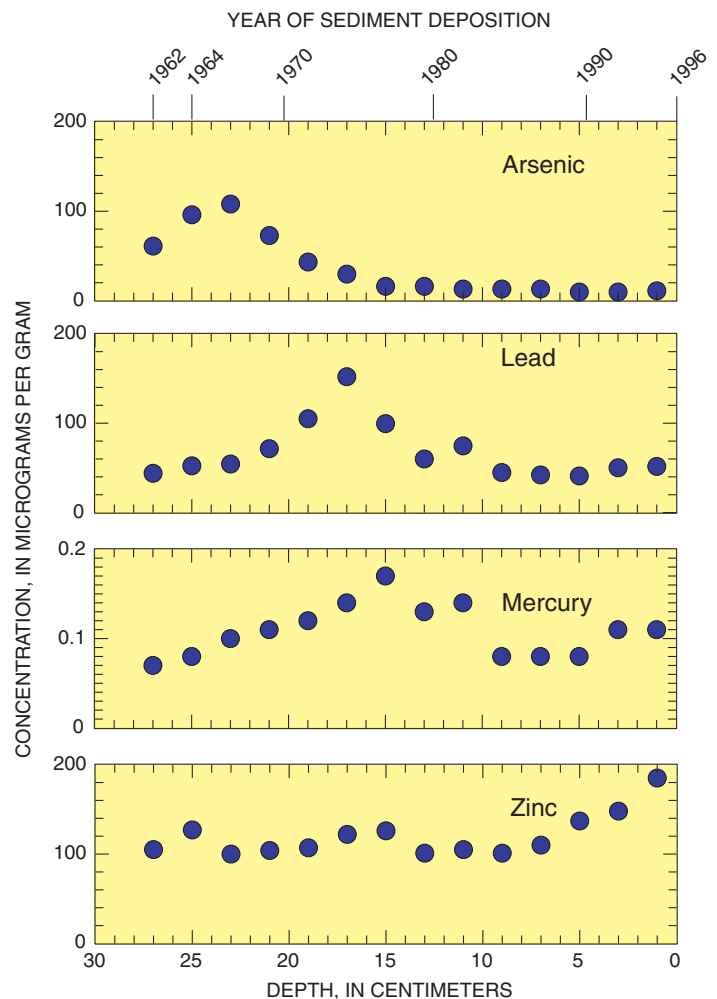


Figure 2. Concentrations of metals in sediment cores.

## DDT

The concentration of total DDT (sum of DDT, DDD, and DDE) in Lorence Creek Lake sediments (fig. 3) peaked in the mid-1960s, soon after use in the United States peaked (Rapaport and others, 1985). DDT breaks down to DDD and DDE, which also are toxic and resistant to further chemical decomposition. The use of DDT was banned by the EPA in 1972, but DDT lasts for years in the soil (2 to 15 years for one-half the DDT in soil to break down [Agency for Toxic Substances and Disease Registry, 1999a]). Detection of DDD and DDE in the upper parts of the core indicates that DDT breakdown products are continuing to enter Lorence Creek Lake, probably with soils eroding from the watershed upstream of the lake.

## Chlordane

Chlordane concentrations in Lorence Creek Lake sediments increased from the 1960s to the 1990s and were highest in the most recently deposited sediments. A similar trend was reported for chlordane in sediments of White Rock Lake in Dallas (Van Metre and others, 1997). Chlordane has been used as an agricultural and urban insecticide since 1948. In 1983, EPA banned most uses of chlordane and in 1988 banned all uses except for fire ant control in power transformers and for depletion of existing stocks by homeowners (U.S. Environmental Protection Agency, 1990). Like DDT, chlordane tends to adhere to soil particles and can last for years in the soil. The increasing trend in concentrations 8 years after the ban on almost all uses reflects the persistence of chlordane in the environment and the probability of continuing use.

## PCBs

PCB concentrations in lake sediments peaked in the mid-1960s, decreased substantially during the 1970s, and remained fairly stable during the 1980s and 1990s. PCBs are a group of organic chemicals that, because they are fire resistant and good insulators, have been widely used as coolants and lubricants in transformers, capacitors, and other electrical equipment. The trend of PCB concentrations in Lorence Creek Lake sediments generally reflects the production and regulation of PCBs in the United States. Production of PCBs increased in the 1960s, peaked in 1970, and was voluntarily stopped in the 1970s (Smith and others, 1988). Because of environmental persistence and toxicity, their manufacture and use in the United States was banned by EPA in the late 1970s.

## PAHs

PAH concentrations in Lorence Creek Lake sediments (fig. 4) peaked in the mid-1970s and again in the mid 1990s. PAHs are a group of compounds formed during the incomplete burning of fossil fuels, garbage, or other organic substances. Sources include vehicle exhaust, burning coal, forest fires and agricultural burning, asphalt roads, and tar; therefore, the recent increase in PAH concentrations might be associated with several sources. According to trends in sediment PAH concentrations in four urban lakes in other parts of the United States, PAH concentrations tend to increase with increasing watershed urbanization (Van Metre and Callender, in press).

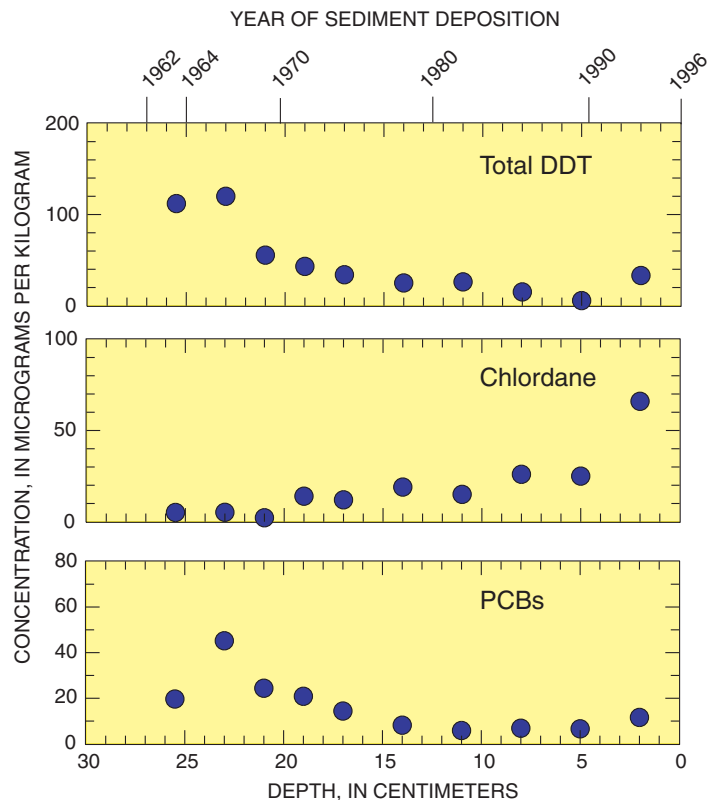


Figure 3. Concentrations of organochlorine compounds in sediment cores.

## Implications

The implications of trends in contaminants in urban runoff in the Lorence Creek watershed upstream of the lake are mixed. For some regulated contaminants like lead, DDT, and PCBs, the news is good—restrictions on their use have apparently led to substantial decreases in concentrations in water entering Lorence Creek Lake. For zinc, PAHs, and chlordane, the news is not good. As evident in other watersheds, concentrations of zinc and PAHs continue to increase as urbanization increases. Eight years after almost all uses of chlordane were banned, chlordane concentrations in the Lorence Creek Lake sediments are still increasing, suggesting continuing use in the watershed upstream of the lake.

What is the net effect of all the trends? Is sediment quality getting better or worse? To answer these questions, the ratios of contaminant concentrations to sediment quality guidelines developed

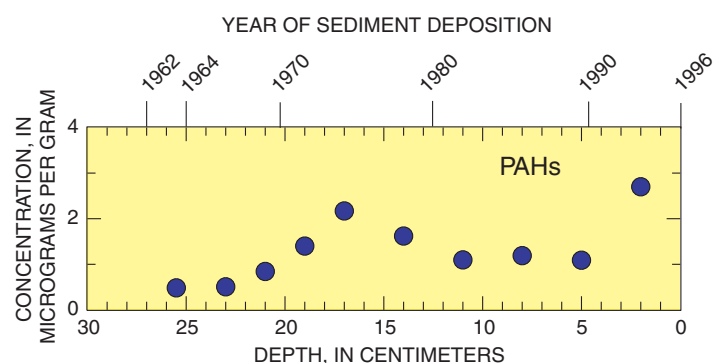
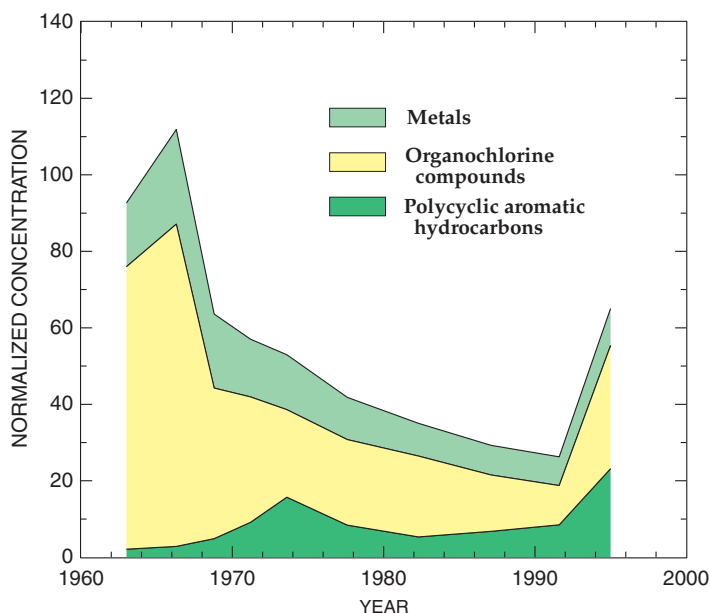


Figure 4. Concentration of polycyclic aromatic hydrocarbons (PAHs) in sediment cores.



**Figure 5.** Contaminant concentrations normalized to Environment Canada (1995) sediment quality guidelines.

by Environment Canada (1995) were computed. The guidelines use a broadly accepted approach for identifying levels of sediment contaminants that are expected to adversely affect aquatic life. The guidelines are not directly related to human health. The computed ratios (normalized concentrations) were composited on a graph (fig. 5). The higher the composite normalized concentration, the more toxic the sediment. Therefore, a decrease in the composite normalized concentration over time indicates sediment quality is improving. Several conclusions are evident from the graph:

- Overall sediment quality has improved since the 1960s with large decreases in organochlorine compounds and some decreases in metals.
- The recent increase in chlordane (fig. 3) causes an increase in toxicity from organochlorine compounds.
- Of the three groups of contaminants, PAHs are the only one steadily increasing through the mid-1990s.

Although the overall trend in sediment quality is good news, steady increases in chlordane and PAHs raise long-term concerns for the health of aquatic life in the watershed upstream of the lake and for the quality of urban runoff that likely recharges the Edwards aquifer. Additionally, the increases in chlordane and PAHs are an indicator of water-quality degradation from urbanization, and their occurrence suggests other urban-related contaminants (not analyzed for in this study) could be present.

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