Prepared in cooperation with the
CITY OF OLATHE, KANSAS

The Lake Olathe Watershed—Understanding an Important Resource

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Water quality in the Lake Olathe watershed (fig. 1), northeast Kansas, is being investigated as part of a cooperative agreement between the city of Olathe and the U.S. Geological Survey. Lake Olathe is used as a source of drinking water and recreation for the Olathe community. Chemical and biological processes are being investigated using bottom-sediment and water samples collected from Cedar Lake, Cedar Creek (the main tributary to Lake Olathe), and Lake Olathe. The information from this investigation will assist the city of Olathe in developing a comprehensive watershed protection plan and can be used to inform the community of the importance of maintaining and protecting water quality in Lake Olathe.

Introduction

Lake Olathe was built in 1956 and provides drinking water to the citizens of Olathe and is an important recreational resource. Since impoundment of the lake, drinking water from Lake Olathe has had frequent, almost annual, taste-and-odor problems (Lee and Sears, 1985). Although the water can be treated to remove taste and odor, the process is expensive and does not address the causes of the problem.

In 2000, the city of Olathe, in cooperation with the U.S. Geological Survey (USGS) and with support from the Kansas Department of Health and Environment (KDHE) and U.S. Environmental Protection Agency (USEPA), began an investigation to evaluate the water quality of the Lake Olathe watershed. The goal of the ongoing investigation is to better understand the concentration of chemicals in stream and lake water and to identify the conditions and processes in the lake and watershed that lead to algal growth and taste-and-odor problems in drinking water from Lake Olathe. The information from this investigation will assist the city of Olathe in developing a comprehensive watershed protection plan and can be used to inform the community of the importance of maintaining and protecting water quality in Lake Olathe.

Why Look at the Watershed?

Industrial, agricultural, and residential activities, and associated chemicals in a watershed can affect the water and aesthetic quality of lakes located downstream from those activities. Inorganic chemicals, such as nutrients (species of phosphorus and nitrogen) and trace elements (arsenic, chromium, zinc, and others), that are transported to streams and lakes in runoff can degrade the water supply and increase the cost of treating drinking water. Excess nutrients can stimulate algal production (algal blooms) and reduce the recreational value of lakes. Death and decay of the algal blooms can release chemicals believed to cause taste-and-odor problems in drinking water. Trace elements may be harmful to human health and the aquatic community if concentrations exceed certain limits. Some organic chemicals (pesticides) used in crop production can adsorb to sediment particles and may be transported to streams and lakes in runoff. Under certain conditions these sediment-bound

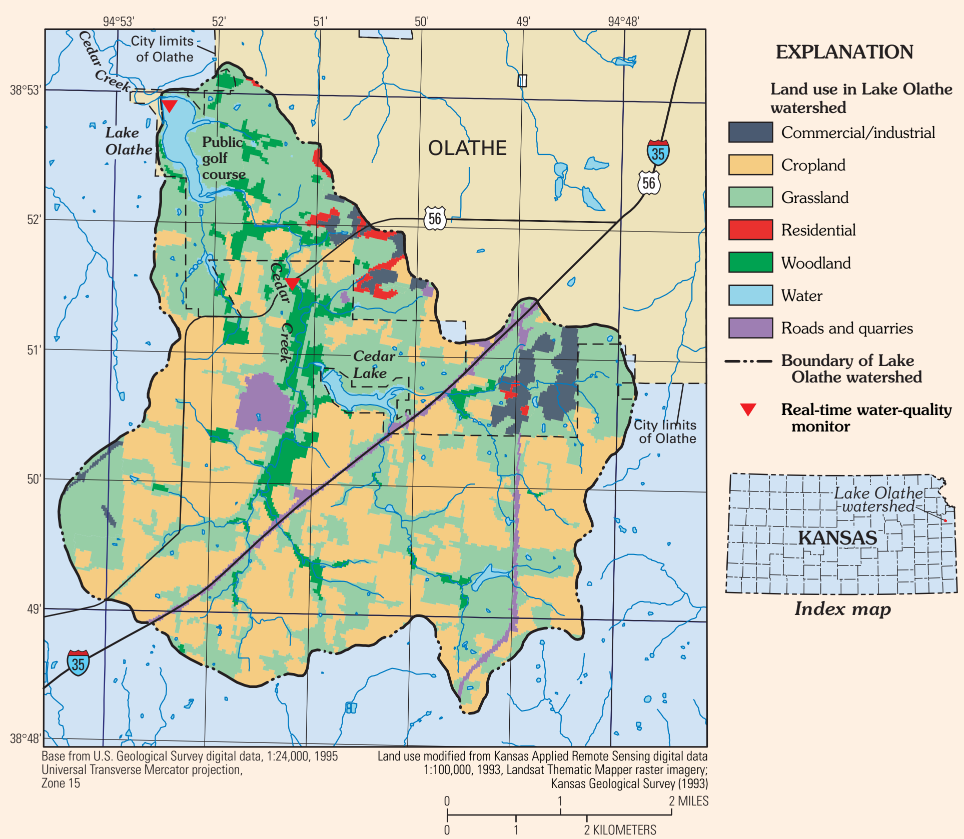

Figure 1. Location of Lake Olathe watershed, land use in the watershed, and real-time water-quality monitors.

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chemicals may be released back to the water column. Therefore, understanding sediment transport through the watershed is important to the understanding of water quality in Lake Olathe.

Description of the Lake Olathe Watershed

The Lake Olathe watershed has an area of 16.9 square miles (10,800 acres) and includes Cedar Lake and Lake Olathe as well as Cedar Creek, the main tributary joining the two lakes (fig. 1). The watershed is experiencing rapid development and urbanization. The population in the watershed was about 1,400 people in 2000, and that number is expected to increase in the future (Carly S. Adams, city of Olathe, written commun., 2002). Lake Olathe is located within the city limits of Olathe, and there are no other towns in the watershed. An 18-hole public golf course abuts Lake Olathe on the east. Eighty-three percent of the watershed is agricultural cropland and grassland (Kansas Geological Survey, 1993).

Using Bottom Mapping and Sediment Sampling to Help Understand Watershed Processes

Prior to collecting sediment samples, mapping of the lake bottom (contouring) was done in July 2000 at Cedar Lake and Lake Olathe, from which a contour map of the bottom of each lake was developed. Bottom-sediment samples from both Cedar Lake and Lake Olathe provided information that was used to help describe the effects of industrial, agricultural, and residential activities in the watershed since lake impoundment.

An analysis of bottom contouring indicated that approximately 340 acre-feet (595 million pounds) of sediment was deposited in Cedar Lake from 1938 to 2000, and approximately 320 acre-feet (567 million pounds) of sediment was deposited in Lake Olathe from 1956 to 2000 (Mau, 2002). Compared to the original design volumes of each lake, Cedar Lake has lost about 50 percent of its water-storage capacity to sediment deposition, whereas Lake Olathe has lost about 10 percent of its original capacity. Cedar Lake and other small impoundments in the watershed have reduced sediment transport to and extended the design life of Lake Olathe.

Chemical analysis of the lake bottom sediment indicated large mean concentrations of phosphorus and some trace elements, but few organic chemicals (Mau, 2002). Total phosphorus yields (in pounds per acre of watershed per year) from the watershed to Cedar Lake were the largest among the lake and reservoir watersheds in Kansas studied by the USGS (table 1). Large phosphorus yields to a lake or reservoir can lead to eutrophication (nutrient enrichment) that degrades water quality. In addition, large nutrient concentrations provide a food source for phytoplankton (algae) that may cause algal blooms and possibly endanger other aquatic species. Seasonal algal blooms are common in Cedar Lake and Lake Olathe and are suspected partial causes of taste-and-odor problems in drinking water obtained from Lake Olathe.

Table 1. Total phosphorus sediment loads and yields estimated for Cedar Lake, Lake Olathe, and other selected lake or reservoir watersheds in Kansas

[million lb, million pounds; mg/kg, millgrams per kilogram; lb/yr, pounds per year; (lb/acre)/yr, pounds per acre per year]

Lake or reservoir watershed	Number of years since storage began	Mean annual phosphorus load (lb/yr)	Mean annual phosphorus yield [(lb/acre)yr]
Cedar Lake	62	14,700	3.74
Lake Olathe	45	9,720	.91
Webster Reservoir[1]	42	29,400	.04
Cheney Reservoir[2]	34	226,000	.38
Tuttle Creek Lake[3]	37	2,520,000	.41
Hillsdale Lake[4]	15	154,000	1.7

[1]Christensen (1999), Mau and Christensen (2000).
[2]Mau (2001).
[3]Data on file with U.S. Geological Survey, Lawrence, Kansas, and Mau and Christensen (2000).
[4]Juracek (1997) and Mau and Christensen (2000).

Concentrations of six trace elements identified in bottom sediment from Cedar Lake and Lake Olathe (arsenic, chromium, copper, lead, nickel, and zinc) exceeded the sediment-quality guidelines established by USEPA for some sensitive aquatic organisms (U.S. Environmental Protection Agency, 1998). These guidelines are screening tools and not intended for regulatory purposes. Trace elements occur naturally in the environment, and the relatively large concentrations could be due more to sediment transport and accumulation of these natural elements in the lake than to industrial, agricultural, or residential activities in the watershed.

Insecticides were detected infrequently in bottom sediment from Cedar Lake and Lake Olathe. However, herbicides such as alachlor, atrazine, and metolachlor were detected in bottom sediment from both lakes.

Chemical Sampling of Cedar Creek and Lake Olathe

Beginning in June 2000, water samples have been and continue to be collected during February through November from Cedar Creek and Lake Olathe. Water samples are collected during low-flow and storm-runoff conditions.

Total phosphorus concentrations in several water samples collected from Cedar Creek and Lake Olathe during storm runoff and non-runoff visits in 2000 exceeded the recommended guideline of 0.10 milligram per liter established by USEPA to avoid algal blooms (U.S. Environmental Protection Agency, 1986). There is no current drinking-water standard for phosphorus in Kansas. However, most of the water samples collected in 2001 from Cedar Creek and Lake Olathe contained total phosphorus concentrations that were less than the guideline. Total phosphorus in water samples from Cedar Creek and Lake Olathe can originate from agricultural, industrial, or residential activities in the watershed or from natural background sources. Phosphorus in Lake Olathe also may be attributed, in part, to internal loading, which is the release of phosphorus into the water column from the lake bottom sediment that originated from the previously mentioned sources.

Atrazine is the most common synthetic organic chemical identified in water samples from Cedar Creek and Lake Olathe. Atrazine is a water soluble herbicide frequently used for weed control on corn and soybean crops and often is detected in surface and ground water throughout the Midwestern States (Goolsby and others, 1991). Long-term health effects from exposure to atrazine may include cardiovascular damage, retinal and some muscle degeneration, and possibly cancer (U.S. Environmental Protection Agency, 2001). The USEPA has established an allowable Maximum Contaminant Level (MCL) of 3.0 µg/L (micrograms per liter) as an annual average in drinking water. During 2001, atrazine concentrations exceeded 3.0 µg/L in six untreated water samples from Cedar Creek and Lake Olathe but did not exceed 3.0 µg/L as an annual average (fig. 2). Precipitation and stream discharge were greater in 2001 compared to 2000, which resulted in greater transport of atrazine through the watershed.

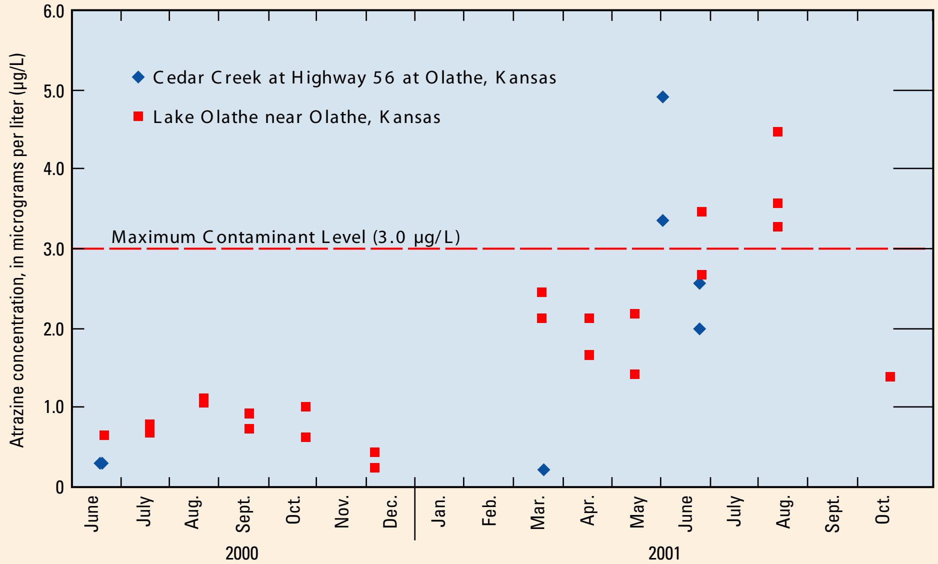

Figure 2. Atrazine concentrations in water samples collected from Cedar Creek and Lake Olathe, June 2000–October 2001. Maximum Contaminant Level from U.S. Environmental Protection Agency (2001).

Biological Sampling of Cedar Creek and Lake Olathe

Water samples also continue to be collected from Cedar Creek and Lake Olathe for analysis of indicator bacteria (fecal coliform, *E. coli*, and enterococci) to determine whether animal and human-related wastes are entering Lake Olathe. These bacteria may indicate the presence of potential pathogens that can affect human health. During 2000 and 2001, concentrations of indicator bacteria in Cedar Creek during storm runoff commonly exceeded the secondary contact recreational use (including wading, fishing, hunting) standards of 2,000 colonies per 100 milliliters of water established by KDHE (Kansas Department of Health and Environment, 2001) but were substantially less than these standards during low-flow sampling. Concentrations of bacteria in Lake Olathe never exceeded the KDHE primary contact recreational use (including boating, swimming, water skiing) standards of the geometric mean of 200 colonies per 100 milliliters of water in five samples during a 30-day period.

In addition to bacteria sampling, water from Cedar Creek and Lake Olathe continues to be sampled for chlorophyll-*a*, which is present in most algae and is used as a measurement of algal biomass and production and as an indication of potential eutrophication. Lakes and streams with concentrations of chlorophyll-*a* greater than 12 to 20 µg/L are considered eutrophic (nutrient enriched) by KDHE (Kansas Department of Health and Environment, 1998). Water samples collected from Cedar Creek in 2000 and 2001 for chlorophyll-*a* frequently exceeded 12 to 20 µg/L, and chlorophyll-a concentrations in all water samples collected from Lake Olathe equalled or exceeded 12 to 20 µg/L during 2000 and 2001 (fig. 3). The effects of eutrophication in lakes are numerous, including loss of habitat for aquatic species, decreases in biodiversity, decreases in desirability as a water supply and for recreation, and lost revenues from decreased water-supply use and recreational activities.

Two compounds frequently associated with taste-and-odor problems in water supplies, 2-methylisoborneol (MIB) and geosmin, are degradation products of certain species of cyanobacteria (blue-green algae). MIB is responsible for musty or moldy odors in drinking water, and geosmin is responsible for earthy odors. The blue-green algae most often appear in lakes and reservoirs of the Northern Hemisphere during the late summer months (August and early September) when water temperatures and light are optimal for the growth of the algae. However, in July 2000, optimal conditions were reached for algal blooms in Lake Olathe, and large concentrations of geosmin were observed (fig. 3) that coincided with community complaints of "foul-tasting" drinking water. Hydrologic conditions in Lake Olathe were very different in 2001, with more precipitation and less residence time of water in the

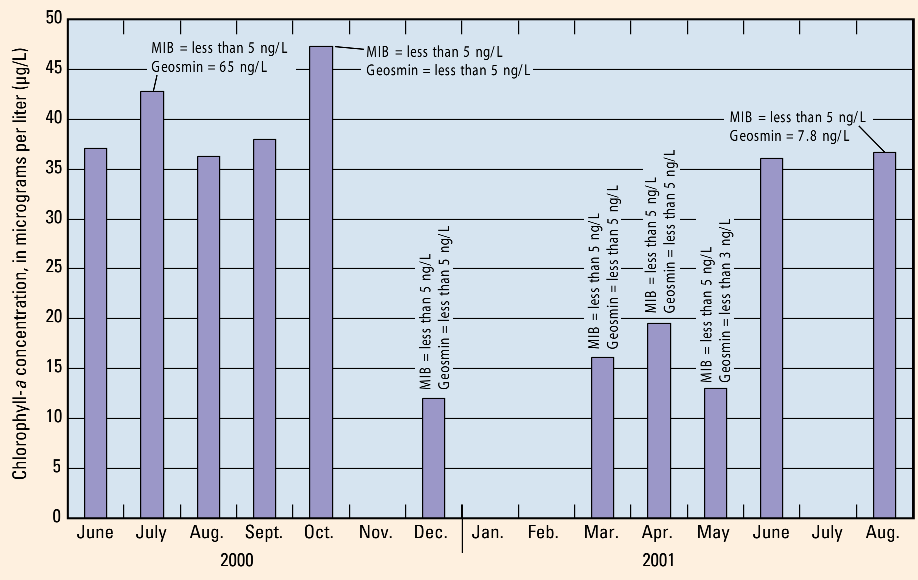

Figure 3. Chlorophyll-*a* concentrations in micrograms per liter (µg/L) and 2-methyl-isoborneal (MIB) and geosmin concentrations in nanograms per liter (ng/L) in water from Lake Olathe, June 2000–August 2001. Chlorophyll-*a* concentrations greater than 12 µg/L are considered eutrophic as defined by Kansas Department of Health and Environment (1998).

lake. Geosmin was then detected in one sample but at a concentration nearly an order of magnitude less than the detection in 2000; there were no taste-and-odor complaints in 2001.

Real-Time Water-Quality Monitoring of Cedar Creek and Lake Olathe

A real-time water-quality notification system is being developed for Lake Olathe to assist the city of Olathe in anticipating when taste-and-odor problems or problems in using the lake for recreation may occur. The notification system consists of two water-quality monitors suspended in Cedar Creek and Lake Olathe that measure specific conductance, pH, water temperature, dissolved oxygen, chlorophyll-*a*, and turbidity (see figs. 1 and 4). These physical properties are measured hourly, and the data are transmitted via satellite to computers at the USGS office in Lawrence, Kansas, where the data are made accessible on the World WideWeb (http://ks.water.usgs.gov/Kansas/qw/olathe/).

These data, in addition to data from analysis of water samples collected from Cedar Creek and Lake Olathe, are being used to develop statistical relations that can be used by city officials as a predictive tool to help anticipate taste-and-odor problems in water supplies from Lake Olathe so that they might take steps to minimize the detrimental effects to the drinking-water supply and recreational activities.

Development of a Watershed Protection Plan

With assistance from Kansas State University (KSU, Manhattan) and the Kansas Biological Survey (KBS, Lawrence), through the Kansas Urban Water Quality Restoration and Protection Initiative, the city of Olathe is working to develop a watershed protection plan that will help ensure the long-term environmental health of Lake Olathe. In particular, the plan will address a variety of current and future environmental programs that will directly affect the Lake Olathe watershed, including the Source Water Assessment Program, Total Maximum Daily Loads, and Phase-II Stormwater Regulations.

As additional results of the monitoring and assessment activities become available, KSU and KBS will offer technical assistance to facilitate the development of a water-quality protection plan for the Lake Olathe watershed. This assistance includes a geographic information system (GIS) model that will allow the city to test different land-use alternatives and their potential effects on the watershed (C.S. Adams, city of Olathe, oral commun., 2002).

Figure 4. Real-time water-quality monitor used in Cedar Creek and Lake Olathe.

Development of a comprehensive watershed protection plan for Lake Olathe will be responsive to community needs and will likely involve the establishment of a steering committee to engage public participation from local residents and other stakeholders in the watershed in the decisionmaking process. A major component of the plan will be educational outreach efforts to inform local residents of the importance of maintaining water quality in Lake Olathe and how they can help to protect this important community resource.

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For more information about the water-quality monitoring and assessment activities in the Lake Olathe watershed, visit the USGS web site at:
URL
http://ks.water.usgs.gov/Kansas/qw/olathe/
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