18 Tuttle Creek Lake

18.1 General Background

Tuttle Creek Lake was impounded in 1962 and reached full pool on 29 April 16963. The primary water quality threats to Tuttle Creek Lake and its' watershed are sedimentation, herbicides, nutrients, and bacterial contamination. The lake is listed on Kansas's 303(d) list for water quality impairment due to eutrophication, atrazine, alachlor, pH, copper, silt, and *E. coli* (inflows). The atrazine TMDL was approved in 2005 by KDHE, while the other TMDLs were implemented in 1999. A watershed restoration and protection strategy (WRAPS) group formed during 2006. The goals and objectives of the WRAPS group will be to protect Tuttle Creek Lake and ultimately remove it from the 303(d) list of impaired waters.

18.1.1 Location

Tuttle Creek Lake is located 8 km (5 miles) north of Manhattan, Kansas. The dam is located on the Big Blue River at river km 16 (river mile 10) above the confluence with the Kansas River. The watershed flows south from Nebraska and includes counties of . Historic water quality sample sites at Tuttle Creek Lake include 3 lake, 1 outflow, and 2 inflow (Figure 18.1).

Figure 18.1. Tuttle Creek Lake area map with sample site locations.

18.1.2 Authorized Purposes: Flood control, recreation, navigation, water quality improvement, and fish and wildlife management.

18.1.3 State Use Designations: Primary contact recreation, drinking water supply, expected aquatic life support, food procurement.

18.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	1,136.0	1,903.4	53,600	
Multipurpose	1,075.0	299.5	14,000	112
Total		2,202.9		

Total watershed area: 9,600 sq miles (6,144,00 A)

Watershed ratio: 114.63 FC / 438.86 MP

Average Annual Inflow: 1,860,074 acre-feet
Average Annual outflow: 000 acre-feet
Average flushing rate: 0.15 years
Sediment inflow (measured): 216,145 acre-feet (1962 – 2000)
Water management Plan: Approved 16 April 1974; minor revisions January 1995
Historic stage hydrograph: 1996 – 2006 (Figure 18.2)

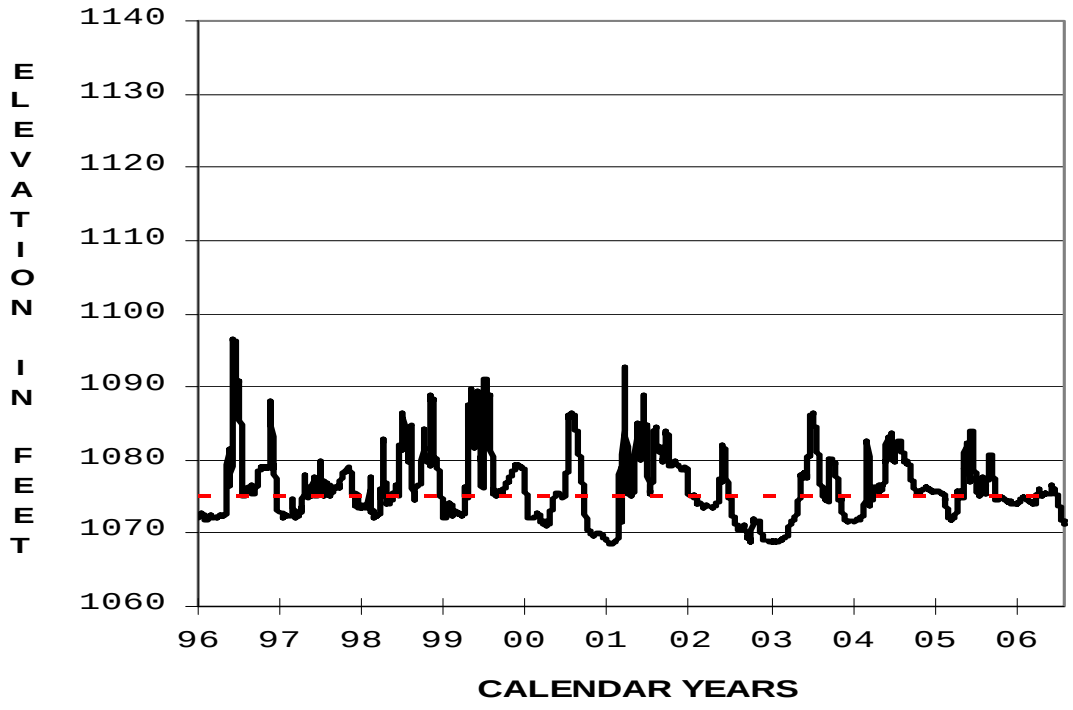

Figure 18.2. Pool elevation hydrograph from 1996 – 2006 (red-dashed line is the multipurpose pool elevation – 1075.0 msl).

18.2 2006 Activities

Tuttle Creek Lake was categorized at an 'ambient' lake during 2006, thus samples were collected from the three lake sites (Sites 3, 8 & 11). In addition, the two inflow sites (Site 30 and 32) were sampled to collect data for the bi-state atrazine watershed project. See Figure 18.1 for specific locations. Sample collections occurred from May through September 2006, with monthly vertical profiles (temperature, DO, pH, conductivity, and turbidity) recorded at the three lake sites. Tuttle Creek Lake staff (OF-TC) providing field sampling assistance during 2006 included Gene Scherer and Paul Weidhaas. Brian McNulty, OF-TC Operations Manager, provided insight and background regarding Tuttle Creek Lake. Multiple meetings were attended to participate in the WRAPS group.

18.3 2006 Data

Comparative historic data consists of monthly (April – September) data collected from 1996 through 2005. Samples were collected from April through September 2006.

18.3.1 Inflow

Inflow samples were collected from two watershed sites located on the Big Blue River at Highway 77 (Site 30) and Black Vermillion River (Site 32). Historically, water quality parameters are most variable at these sites due to influences of runoff events and climatic variations within the watershed.

18.3.2 Lake

Nitrogen is an essential nutrient to aquatic life. However, excessive concentrations can result in algal blooms, low DO levels, taste and odor issues in drinking water, and even fish kills. Tuttle Creek Lake holds the distinction of having the highest median concentration for total nitrogen (TN) and second highest for total phosphorus (TP) within the district. Therefore, the influx of such large quantities of nutrients leads to a very eutrophic lake. Median concentrations range from 2.1 – 2.3 mg/L within the lake (Sites 3, 8 & 11) , 1.6 – 2.6 mg/L at the inflows (Sites 30 and 32, respectively), and 2.3 mg/L in the outfall (Site 27)(Figure 18.3). These concentrations exceed EPA's proposed ecoregional nutrient criteria value of 0.36 mg/L TN. Monthly and annual variability in TN is evident at all sites within the watershed, as depicted in Figure 18.4 for Site 30.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. Surface water sample median TP concentrations collected from 1996 through 2006 range from 0.27 – 0.33 mg/L at lake sites, 0.3 – 0.56 mg/L at the inflows (Sites 32 and 30, respectively), and 0.25 mg/L in the outflow (Site 27)(Figure 18.5). These median values exceed EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L TP.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios $\geq$ 20:1 are indicative of desirable algal communities, whereas ratios $\leq$ 12:1 are indicative of bloom-forming cyanobacteria (blue green algae). As would be expected, there is high monthly and annual variability in the TN:TP ratio at all sites. Median TN:TP ratios at all three lake sites are < 12, indicating the lake is at risk for cyanobacteria blooms (Figure 18.5). High turbidity rates may moderate the expected high risk during wet inflow years.

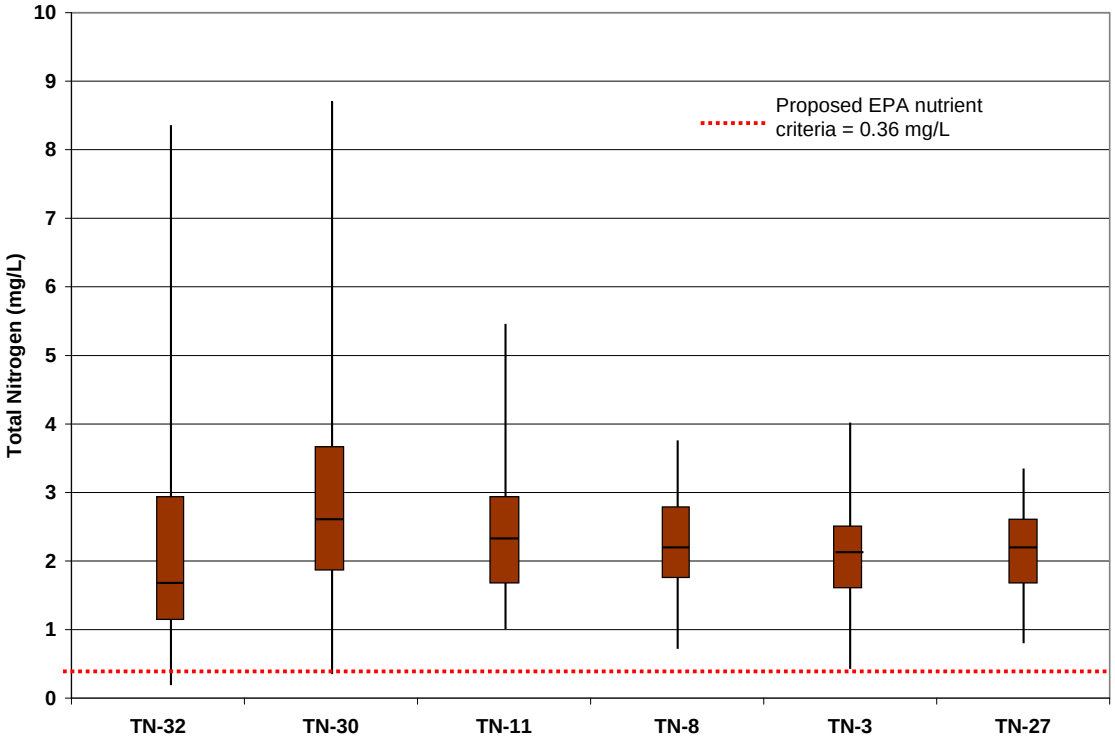

Figure 18.3. Box plots of surface water sample total nitrogen concentrations measured by site from 1996 through 2006 at Tuttle Creek Lake.

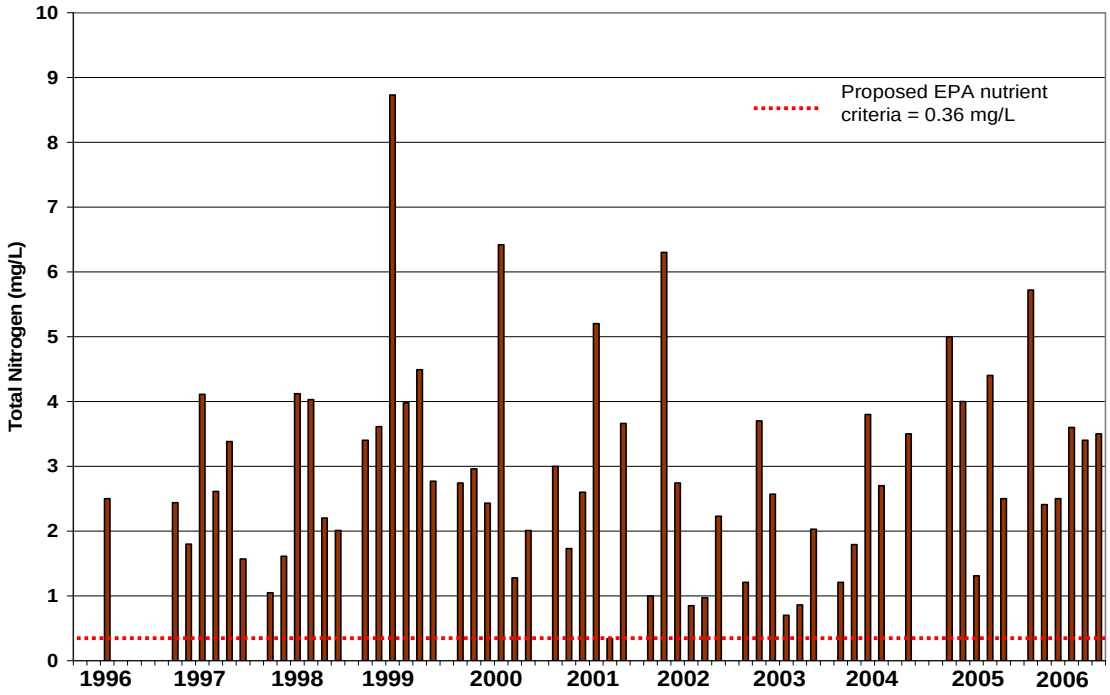

Figure 18.4. Graph of surface water sample total nitrogen concentrations by sample at Tuttle Creek Site 30 (Big Blue River) from 1996 through 2006.

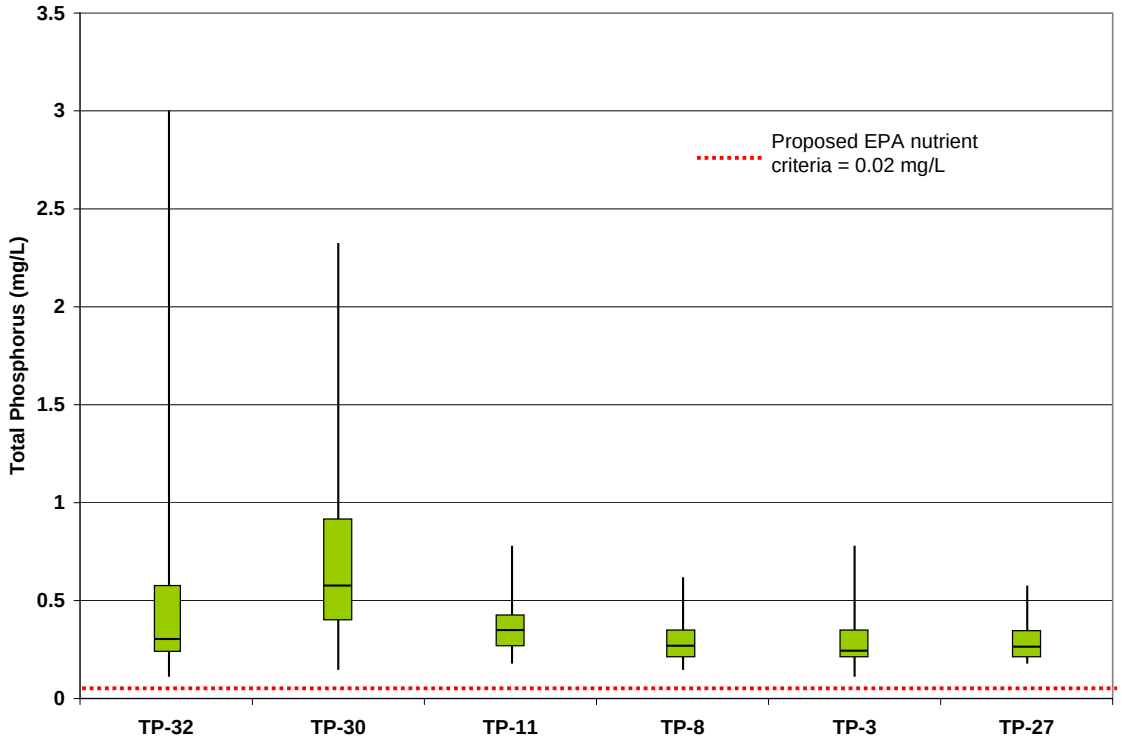

Figure 18.5. Box plots of surface water sample total phosphorus concentrations by site from 1996 through 2006 at Tuttle Creek Lake.

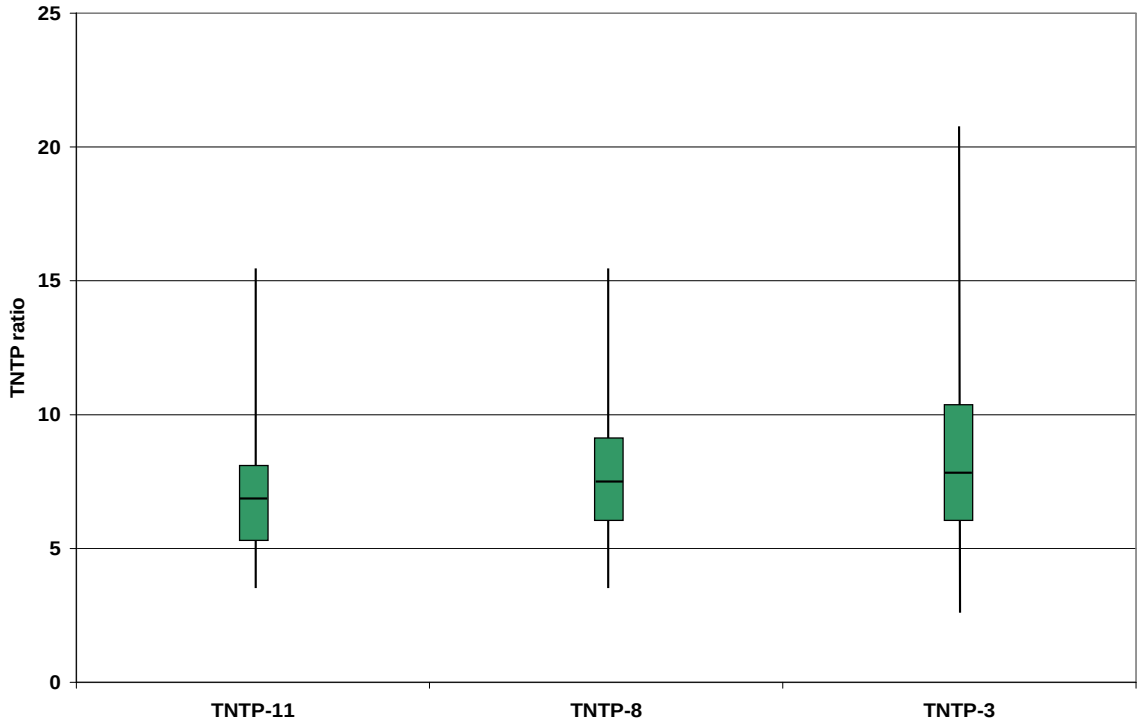

Figure 18.6. Box plots of total nitrogen : total phosphorus (TN : TP) by site from 1996 through 2006 at Tuttle Creek Lake.

Secchi depth was measured in April, June, August and September. Variability was detected between and within sites and between years by site (Figure 18.7). In contrast to 2005, greater water clarity was observed at lower (Site 3) and mid lake (Site 8) during most months of 2006. This would be expected due to the prolonged drought and limited inflows, which would allow suspended sediment to settle out of solution. Very limited water clarity was measured at Site 11 (uplake; mean = 0.23 m), while limited water clarity was measured at Sites 8 (mid-lake; mean = 0.6 m) and 3 (tower; mean = 0.61 m).

Mean chlorophyll a concentrations ranged from 9 to 14 ug/L during July and August 2005. Chlorophyll concentrations responded to increased water clarity during 2006, as July concentrations ranged from 53 – 62 ug/L. This is expected in a lake with very high nutrient concentrations, especially in years of reduced inflow and greater light penetration.

Concentrations of the herbicides atrazine and alachlor have been significant enough to warrant listing of the waters on the states 303d list. Median atrazine concentrations (1.1 – 1.6 ug/L) are less than EPA's drinking water maximum contaminant level (MCL) of 3 ug/L (Figure 18.8). However, individual samples measured from 1996 through 2006 are significant enough to exceed the MCL. Figure 18.9 depicts the individual sample concentrations measured by date at Site 32 (Black Vermillion River) inflow. Median alachlor concentrations from surface water samples collected at lake sites range from 1.0 – 1.1 ug/L, which are less than EPA's drinking water MCL of 2 ug/L (Figure 18.10).

Metals were not analyzed from samples collected during 2006. However, samples were collected in 2005. Total iron exceeded EPA's Drinking Water Standard of Secondary Maximum Contaminant Levels (SMCL) of 300 ug/L from surface samples collected during August at all three lake sites (1057 – 5269 ug/L), inflows (2071 – 33,624 ug/L) and outflow (1091 ug/L). The extremely elevated levels on the Big Blue River at Blue Rapids is a concern to the lake. Implications are directed at drinking water facilities related to taste and staining issues. In addition, surface samples collected during August exceeded EPA's SMCL for manganese (50 ug/L) at the inflow sites, upper lake and mid-lake sites. Sample concentrations ranged from 60 – 718 ug/L, with the highest concentrations measured at Site 30 (Big Blue River). Implications are directed at drinking water facilities due to taste and stain issues. Lead was also exceeded at Site 30 (20 ug/L).

Vertical profiles were recorded during sample trips in April and June through September 2006. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Based on these profiles, the lake was weakly stratified thermally during June and September, and nearly iso-thermal during August (Figure 18.11). Chemical stratification was most pronounced during July, and relatively homogenous across depths during August and September.

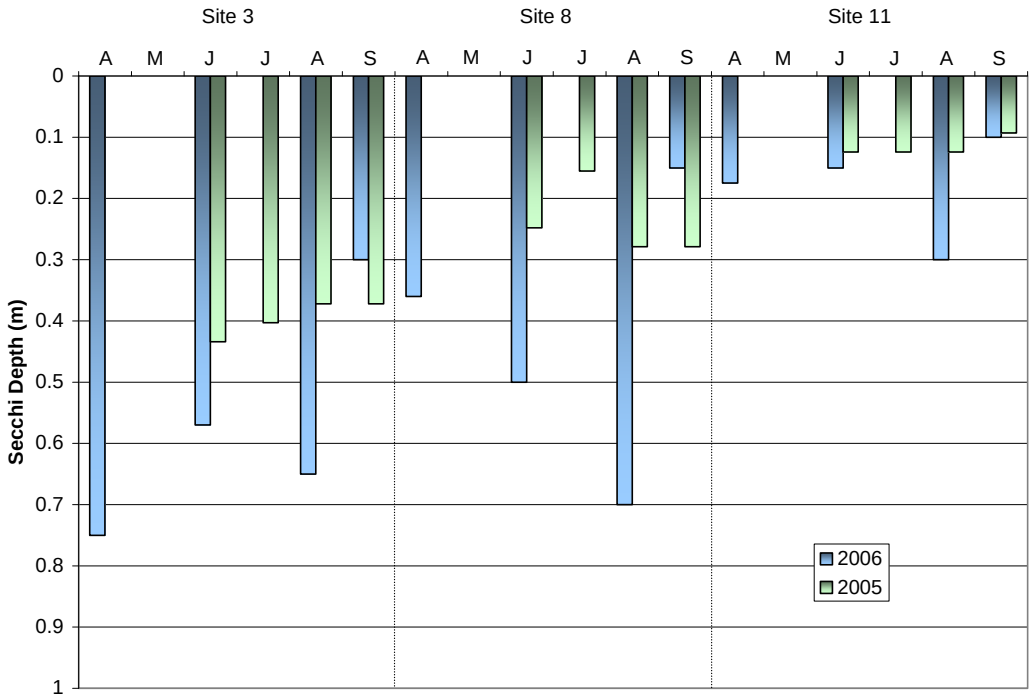

Figure 18.7. Secchi depth measurements by site from April through September 2006 at Tuttle Creek Lake.

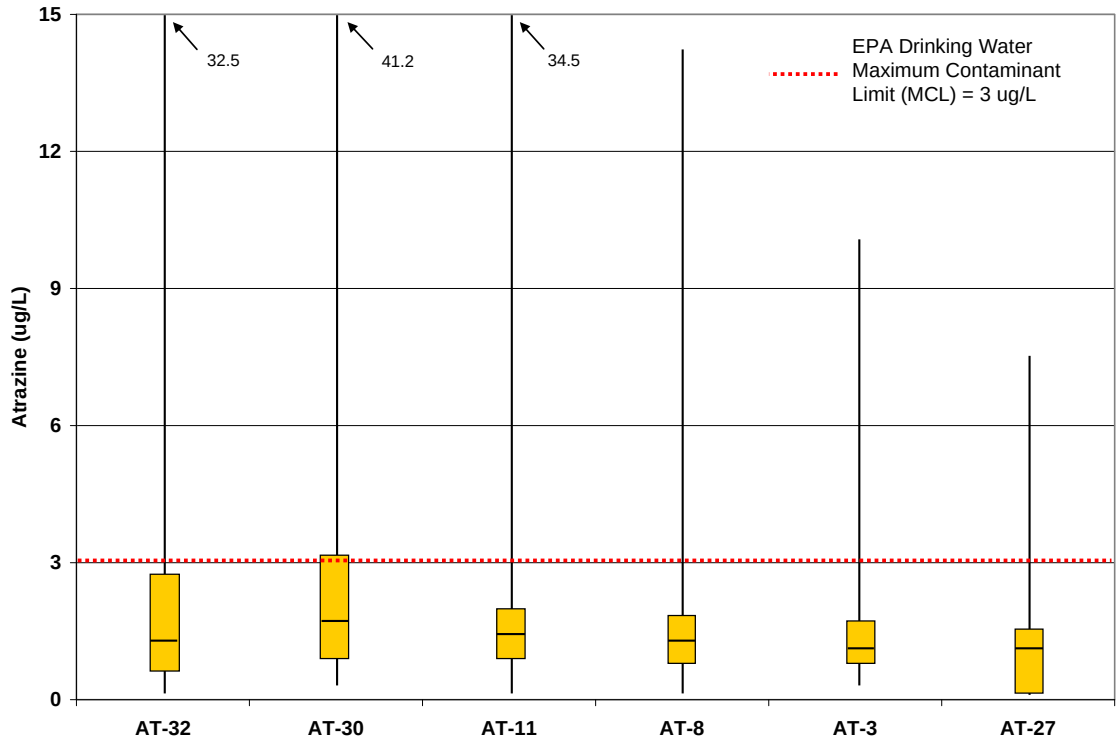

Figure 18.8. Box plots of surface water sample atrazine concentrations measured by site from 1996 through 2006 at Tuttle Creek Lake.

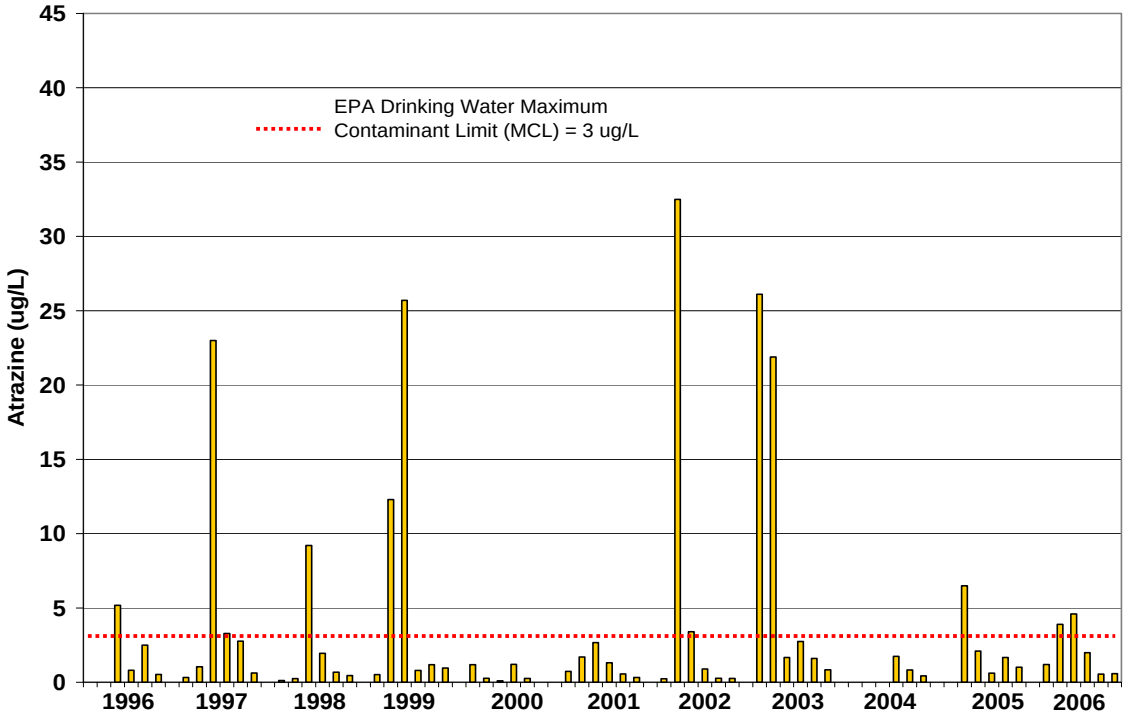

Figure 18.9. Atrazine concentrations from surface water samples by sample date collected at Site 32 (Black Vermillion River) inflow to Tuttle Creek Lake from 1996 through 2006.

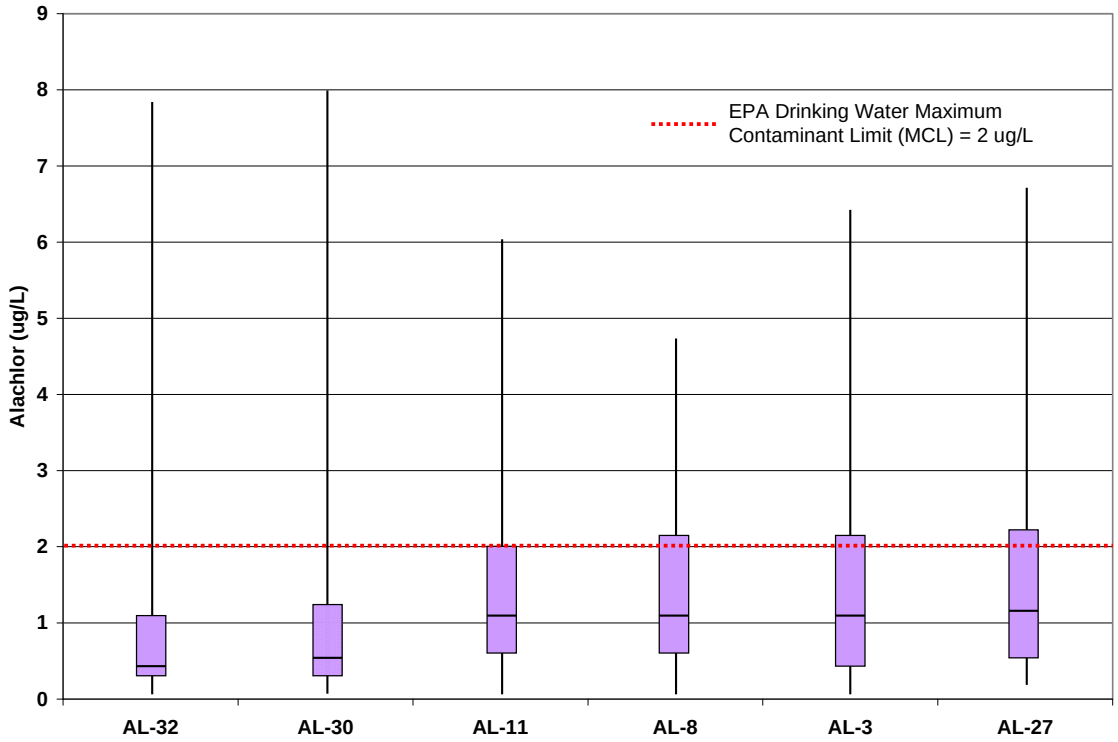

Figure 18.10. Box plots of surface water sample alachlor concentrations measured by site from 1996 through 2006 at Tuttle Creek Lake.

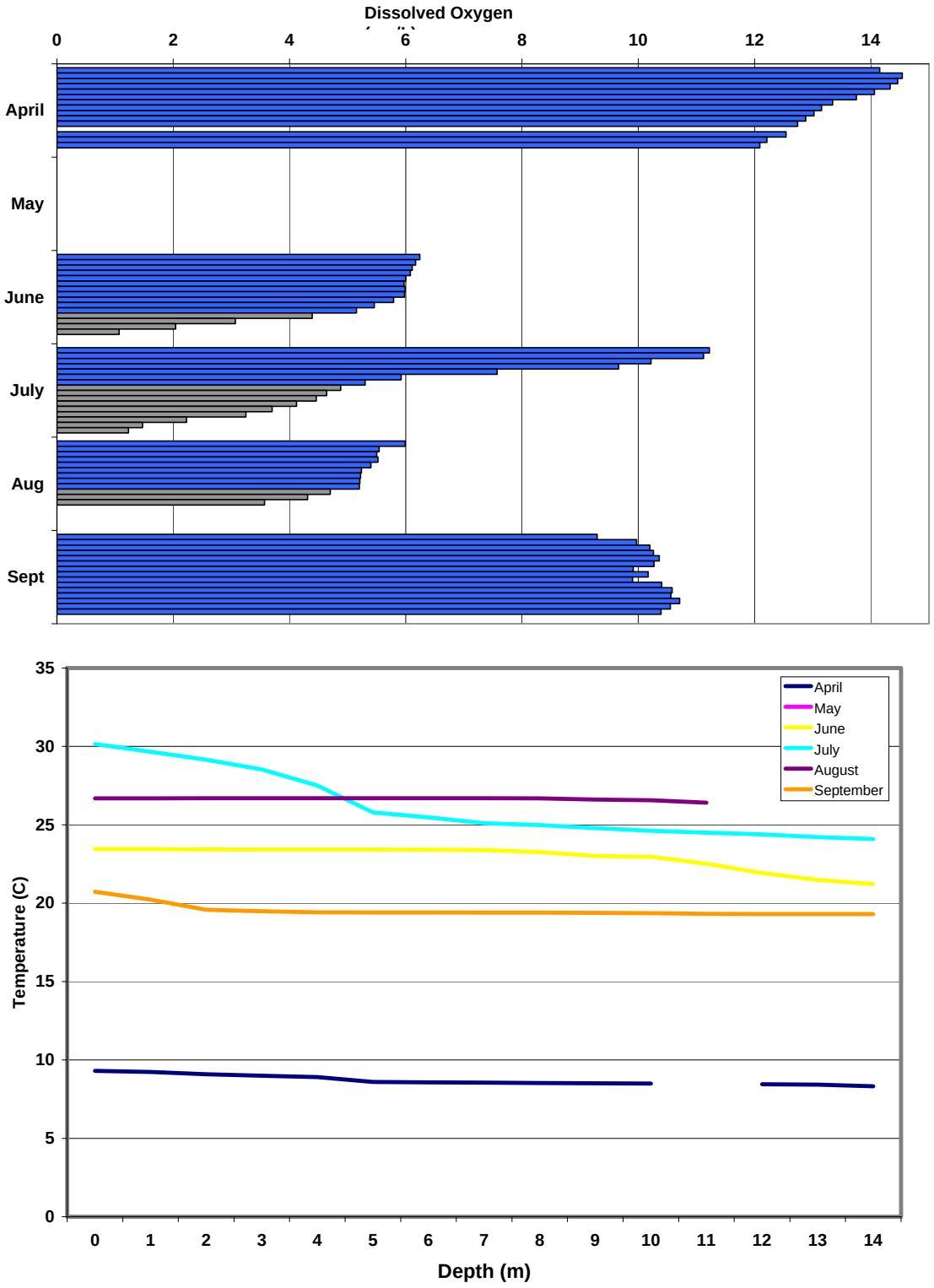

Figure 18.11. Dissolved oxygen concentration (mg/L) histogram and temperature (°C) plot from vertical profiles recorded at Site 3 (Tower) during June, July and September 2006 at Tuttle Creek Lake.

18.3.3 Outflow

Outflow samples were not collected during 2006 from the stilling basin (Site 27).

18.4 Future Activities and Recommendations

Sampling activities for 2007 will include continuation of 'ambient' monitoring from April through September, as well as conducting monthly vertical profile at each of the lake sites. As part of the bi-state EPA Targeted Watershed grant project (2006 – 2010) within the Tuttle Creek watershed, funds will be spent during the next few years to promote conservation agricultural practices and education programs related to water quality improvements. No-till farming and riparian buffer strips are two of the cost-effective conservation practices designed to reduce agricultural runoff. For our part, CENWK will continue to sample inflow sites monthly (April – September) for nutrients and herbicides. Due to concerns of potentially toxic bluegreen algae, phycocyanin concentrations will be monitored for the cyanotoxin microcystin during August and September. Geosmin, associated with taste and odor issues in drinking water, will be examined from samples collected near the tower from July through September. Sediment – nutrient and metals will be examined during 2007 to provide a comparative point on potential resuspension sources. Caffeine will be measured at several sites around the lake as a surrogate for human impacts resulting from failing septic systems, WWTP's, illicit dumping from boats, etc. Involvement with the Blue River WRAPS group will continue. Monitoring and consultation regarding the projected 10-year dam modification project at Tuttle Creek will also continue during the next year. The inclusion of another inflow site is proposed for Mill Creek. This site would provide additional watershed data, especially in an area more likely to develop in future years. Due to shallow water conditions at Site 11, this upper lake sampling site will be relocated to Site 10.