7 Kanopolis Lake

7.1 General Background

Kanopolis Lake was impounded on 17 February 1948, and reached full pool on 19 July 1948. The primary threats to water quality in Kanopolis Lake are sedimentation, nutrients, and fecal bacteria. Kanopolis Lake is listed on the states 303d – Impaired Waters – list due to eutrophication, chloride, and sulfate. A TMDL was implemented in 2003 to address eutrophication issues, while TMDLs to address chloride and sulfate were approved in 2004. The Smoky Hill / Big Creek WRAPS was approved in 2005 and charged with addressing water quality issues and TMDLs within the Kanopolis Lake watershed. Specific water quality goals for the WRAPS include DO concentrations > 5 mg/L, biological oxygen demand (BOD) < 3.5 mg/L, total dissolved solids (TDS) < 808 mg/L, total suspended solids (TSS) < 101 mg/L, and fecal bacteria ≤ 200 cfu/100 ml for swimming and ≤ 2000 cfu / 100 ml for boating and fishing. These water quality goals hope to be achieved through implementation of best management practices (ie, vegetative buffers, nutrient management plans) throughout the watershed. A rainbow trout fishery is maintained by the Kansas Parks and Wildlife Department in the Kanopolis Lake tailrace area. This winter fishery is supported by stocked fish, and the season runs from 15 October through 15 April.

7.1.1 Location

A dam built 293.9 km (183.7 miles) upstream of the confluence with the Kansas River on the Smoky Hill River formed Kanopolis Lake. The lake is located approximately 27 km (17 miles) southeast of Ellsworth, Kansas, and 48 km (30 miles) southwest of Salina, Kansas. Historic water quality sample sites in the Kanopolis Lake watershed include 2 lake, 1 outflow, and 1 inflow sites (Figure 7.1).

7.1.2 Authorized Purposes

Authorized Purposes: flood control, water supply, water quality, supplemental low-water flow, recreation, and fish and wildlife management.

7.1.3 State Use Designations:

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

7.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	1,508	369.3	13,958	
Multipurpose	1,463	49.5	3,406	41
Total		418.8		

Total watershed area: 7,695 sq miles (total upstream area)
2,330 sq miles (total local drainage area below Cedar Bluff Lake; 1,491,200 acres)
Watershed ratio: 106.81 FC / 437.82 MP

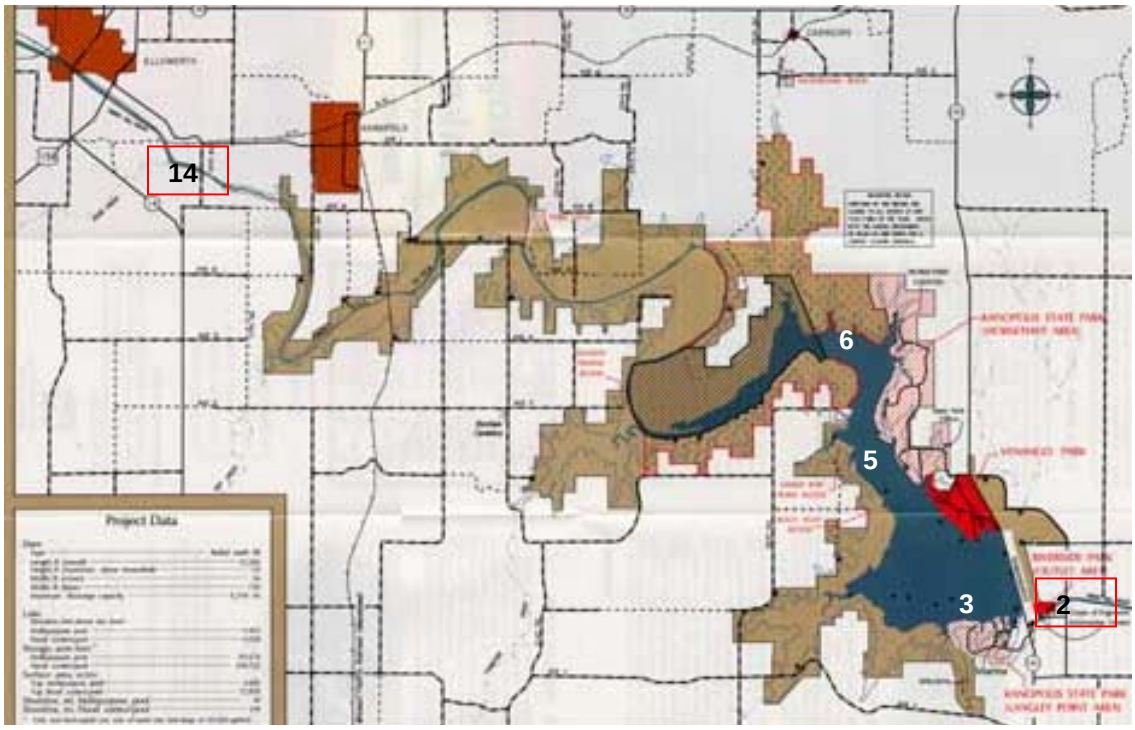

Figure 7.1. Kanopolis Lake area map with sample site locations and site numbers.

Average Annual Inflow:	166,620 acre-feet/yr (1982 – 2006)
Average Annual outflow:	000 acre-feet
Sediment inflow (measured):	28,704 acre-feet (1948 – 1993)
Flushing rate:	0.30 years
Water management Plan:	Approved 30 October 1984
Historic stage hydrograph:	1996 – 2006 (Figure 7.2)

7.2 2006 Activities

Kanopolis Lake was categorized as an 'intensive' lake during 2006, thus lake and inflow / outflow sites were all sampled (see Figure 7.1). In addition, Site 20 was added to increases knowledge of watershed contributions; Site 20 is located on the Smoky Hill River at the Hwy 281 bridge in Russell County. Analyses added during 2006 included sulfates and glyphosate. Grab samples were collected monthly from April through September, and vertical profiles were recorded at both lake sites during monthly trips. Kanopolis Lake staff (OF-KA) providing field sampling assistance during 2006 included Nolan Fisher and Jason Hurley. Ken Nelson, OF-KA Operations Manager, provided insight and background regarding Kanopolis Lake.

7.3 2006 Data

Comparative historic water quality data consists of monthly (April – September) data collected from 1996 through 2004 / 2005. Samples were collected from April though September during 2006. An extremely prolonged drought has impacted this western and central Kansas watershed, such that all boat ramps were closed throughout the

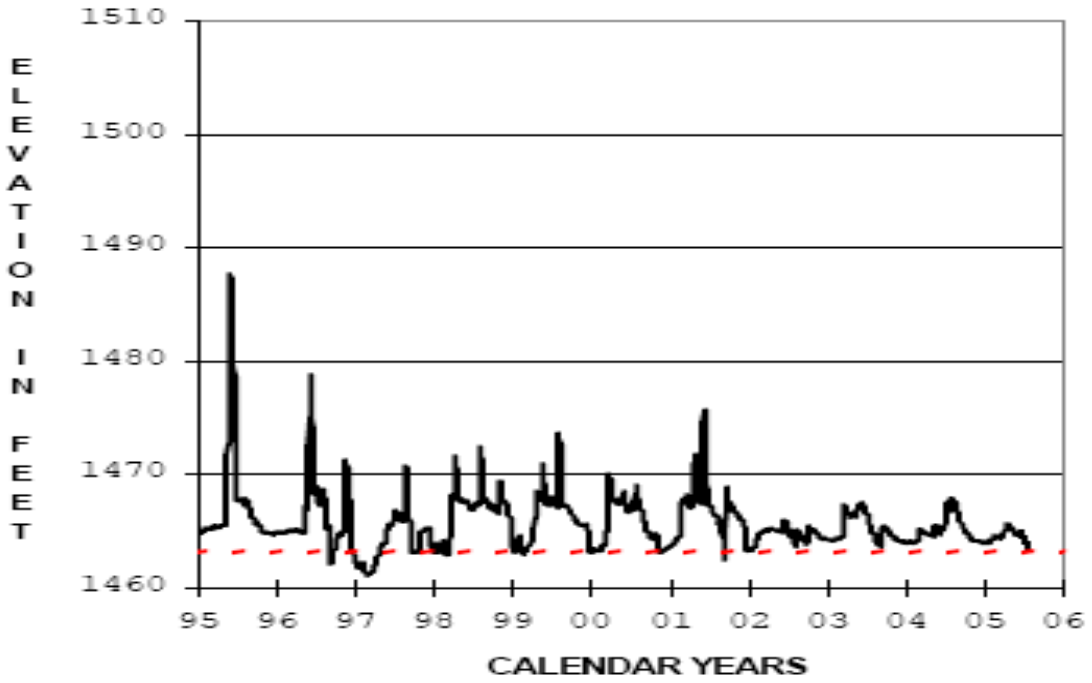

Figure 7.2. Pool elevation hydrograph from 1995 - 2005

recreation season due to extremely low lake levels (Figure 7.2). Such a drought would be expected to impact water quality – both positively and negatively.

7.3.1 Inflow

Kanopolis Lake inflow samples were collected from two sites (Sites 14 and 20) on the Smoky Hill River during 2006.

7.3.2 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. Total nitrogen (TN) concentrations measured in Kanopolis lake and its' inflow remain some of the highest compared to the other district lakes. Median TN concentrations from samples collected between 1996 and 2006 ranged from 1.0 – 1.1 mg/L (Figure 7.3). Annual and monthly variability in TN concentrations are evident from both inflow (Site 14) and main lake sample (Site 3) sites (Figures 7.4 and 7.5, respectively). With few exceptions, all samples from the Kanopolis Lake watershed exceed EPA's proposed ecoregional nutrient criteria value of 0.56 mg/L TN.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. Median total phosphorus (TP) concentrations (0.07 – 0.1 mg/L) for all sites monitored exceed EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L (Figure 7.6). The mean TP concentrations (0.126 – 0.179 mg/L) are currently below the WRAPS target goal of 0.26 mg/L, but greatly exceed EPA's proposed ecoregional nutrient criteria of 0.02 mg/L. The elevated TP concentrations are expected due to sedimentation levels

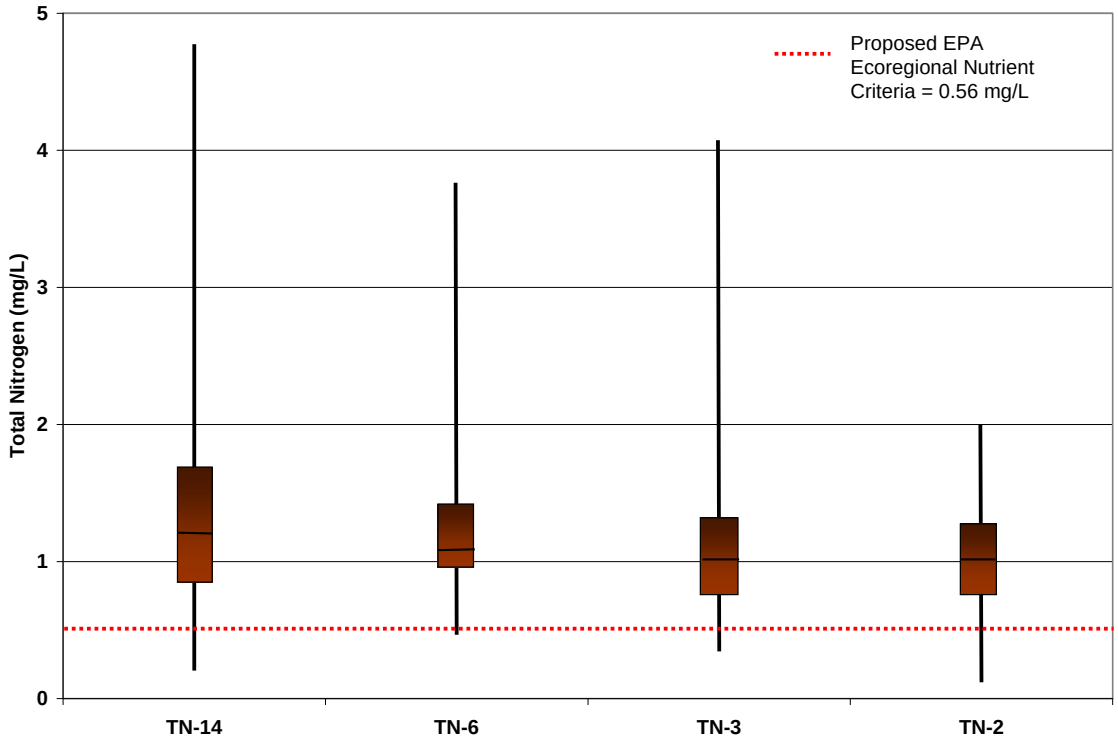

Figure 7.3. Box plots of surface water sample total nitrogen concentrations measured by site from 1996 through 2006 at Kanopolis Lake.

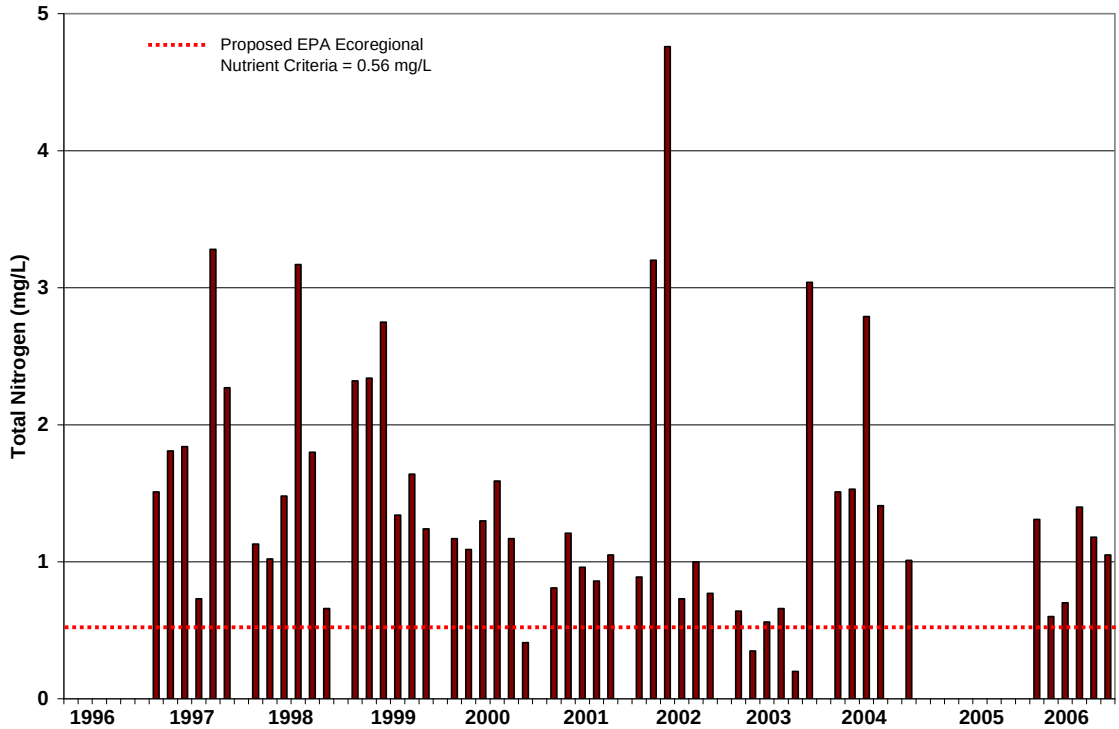

Figure 7.4. Total nitrogen concentrations by sample date collected from 1997 through 2006 at Kanopolis Lake Site 14 (Smoky Hill River inflow).

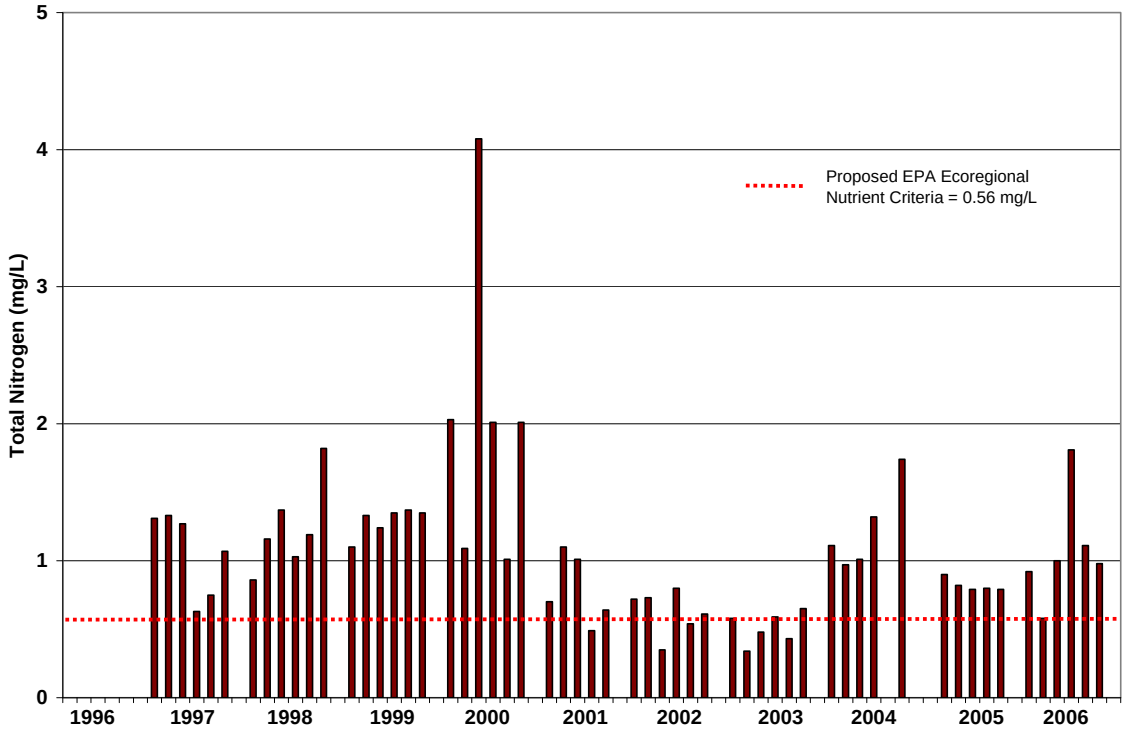

Figure 7.5. Total nitrogen concentrations by sample date collected from 1997 through 2006 at Kanopolis Lake Site 3 (Tower site).

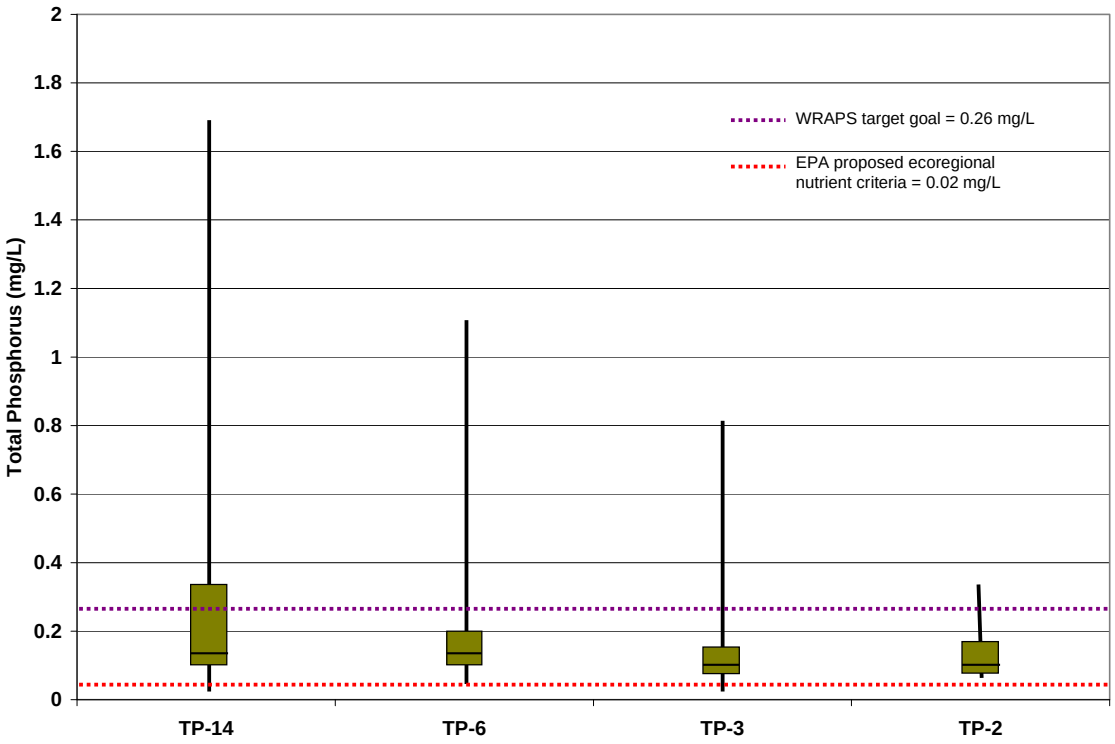

Figure 7.6. Box plots of surface water sample total phosphorus concentrations measured by site from 1996 through 2006 at Kanopolis Lake.

within the lake and wind-driven sediment resuspension. Such TP concentrations are among the highest within the district.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios ≥ 20:1 are indicative of desirable algal communities, whereas ratios ≤ 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; see Figure 7.7 as an example at Site 3. Median TN:TP ratios at both lake sites and the Smoky Hill River inflow were ≤ 12, which typically is indicative of a lake at risk for cyanobacteria blooms (Figure 7.8). Kanopolis Lake has the lowest mean TN:TP ratio for lake sites within the district. However, the elevated turbidity level and limited light penetration should act to minimize cyanobacteria blooms.

One target of the Smoky Hill WRAPS is a total suspended solids (TSS) target of < 101 mg/L. Figure 7.9 presents TSS data by site during sampling trips from 2004 through 2006. The data is presented longitudinally from within the watershed -- Site 2 is the outfall and Site 20 is the Smoky Hill River at Hwy 281. Samples of TSS in exceedence of the 101 mg/L target were recorded at Site 5 (upper lake site) during 2004, and from inflows in 2005 (Site 14) and 2006 (Site 20); no samples were collected from Site 20 during either 2004 or 2005. Low measurements were recorded in-lake the past two years, which is an artifact of minimal inflows related to the drought.

Measurements of conductivity (uS/cm), pH, and turbidity (NTU) were recorded during each sampling trip to the inflow and outflow sites during 2006. Inflow samples (Sites 20 and 14) reflected minimal rain event impulses within the upper inflows of Kanopolis Lake (Figure 7.10). For example, at Site 20 a depression in conductivity – indicating overland flow inputs – and rise in turbidity was detected following a rainevent in the upper watershed. This input was not detected downstream at Site 14 due to drought conditions. As expected, outflow (Site 2) measurements of conductivity, pH, and turbidity were very stable.

Monthly variability in mean chlorophyll *a* was detected at both lakes sites (Figure 7.11). Mean chlorophyll *a* concentrations were at least 2x higher at both lakes in 2006 vs 2005 (Figure 7.11), and this is most likely due to reduced turbid inflows and lower TSS (drought impacts). Chlorophyll *a* concentrations ranged from 23 - 48 ug/L at the mid-lake site and 31 - 42 ug/L at the dam site. Secchi depth was variable between months and sites during 2006, with clearest conditions during May (Figure 7.12). Mean summer secchi depths indicated water clarity was limited at both the mid-lake (0.49 m; 1.6 ft) and dam sites (0.57 m; 1.6 ft).

Relative concentrations of phycocyanins, or bluegreen algae, were measured vertically throughout the water column during each monthly sample trip. Such profiles provided information on monthly as well as within lake distribution changes. Figure 7.13 depicts vertical distribution of phycocyanins measured at Site 3 (Tower) from May through September. Concentrations in the upper waters peaked in July, but distributions were more consistent throughout the water column during September.

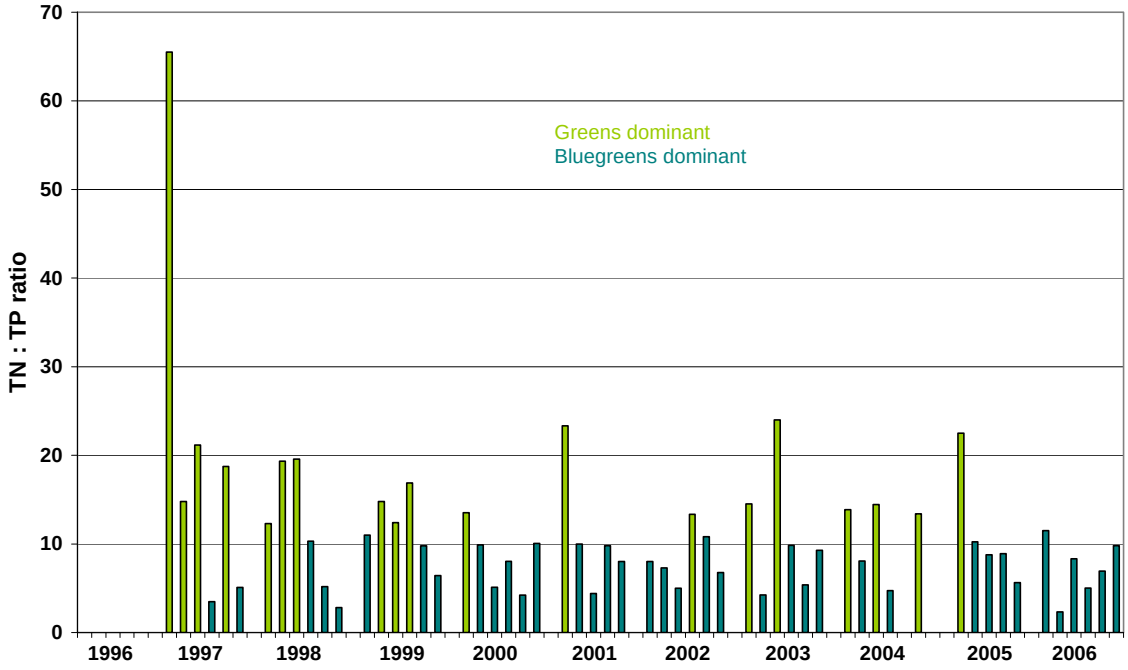

Figure 7.7. Graph of total nitrogen : total phosphorus ratio (TN:TP) by sample from 1997 through 2006 at Kanopolis Lake Site 3 (dam).

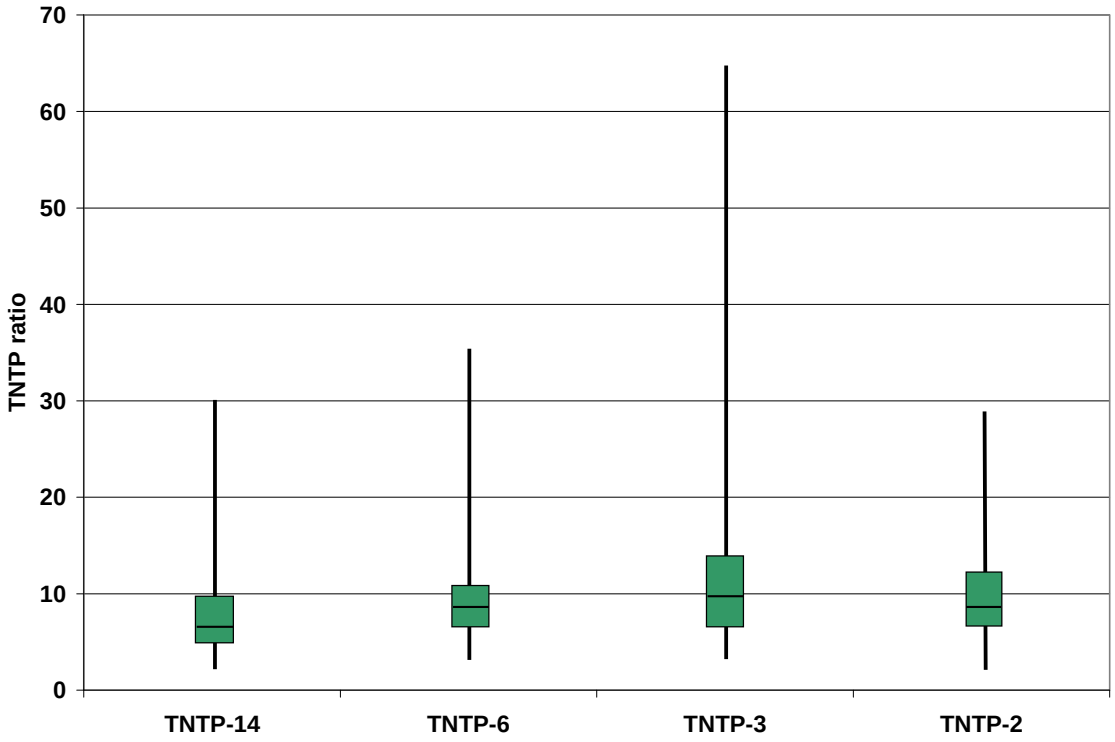

Figure 7.8. Box plots of total nitrogen : total phosphorus (TN : TP) ratio by site from samples collected between 1997 – 2006 at Kanopolis Lake.

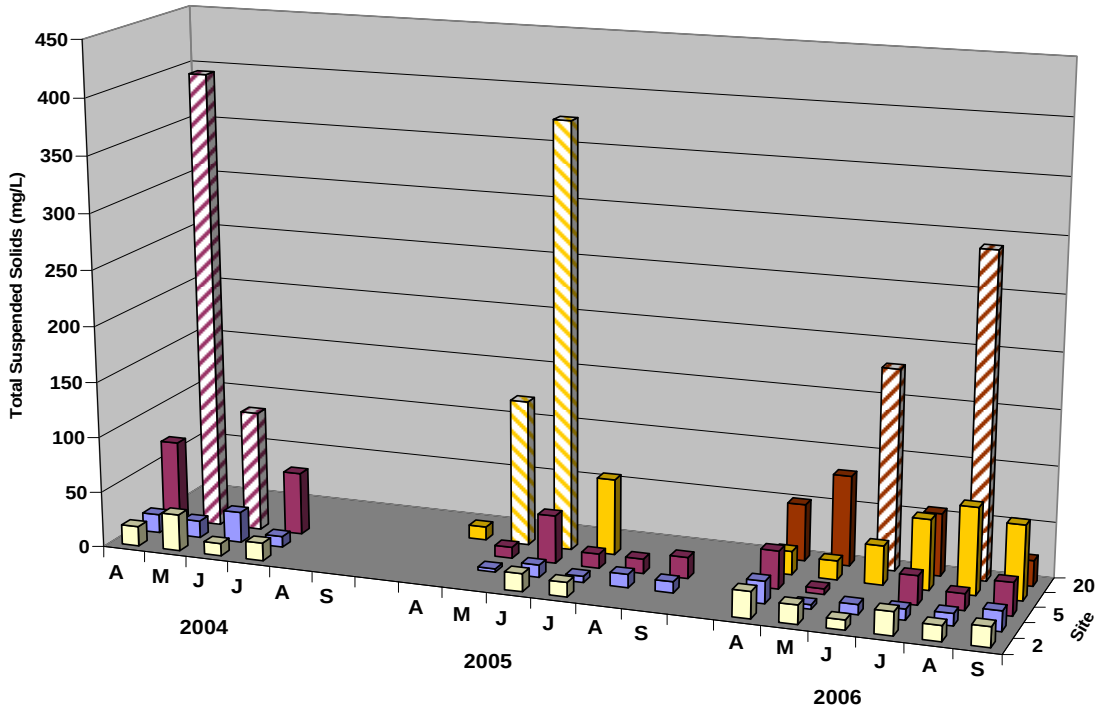

Figure 7.9. Total suspended solids (mg/L) measured by site from 2004 – 2006 at Kanopolis Lake.

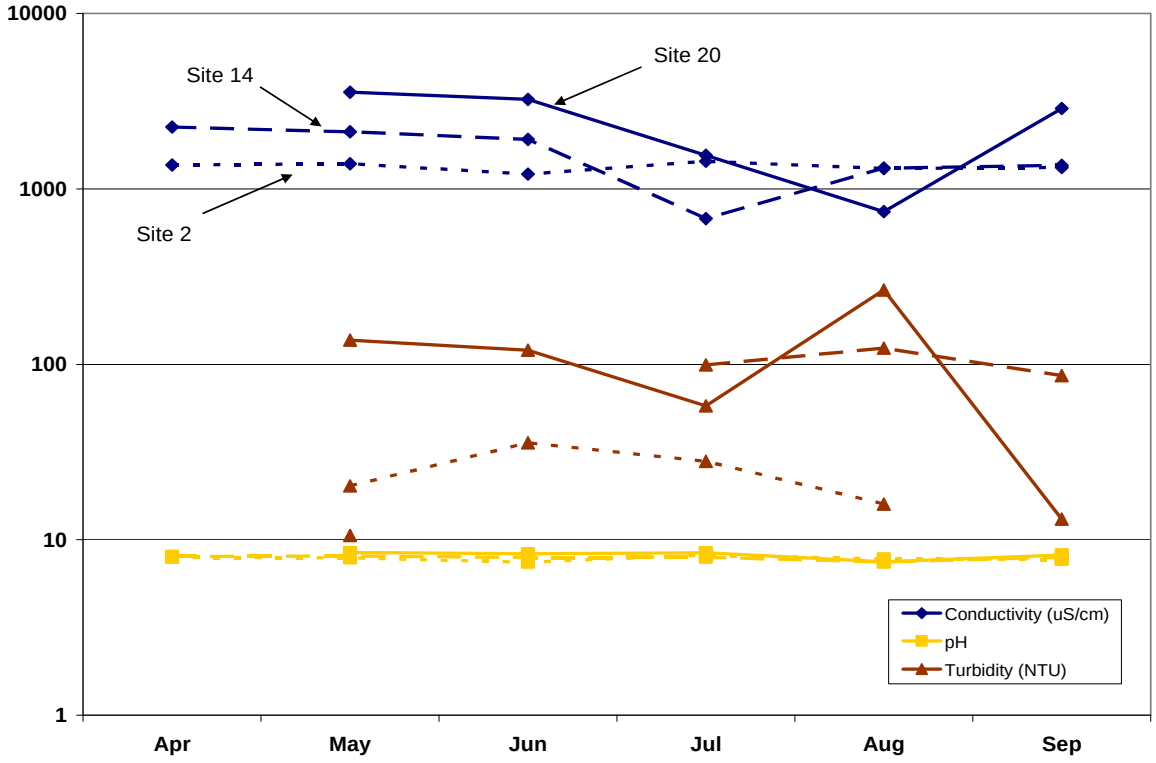

Figure 7.10. Plots of ambient surface water measurements of conductivity (uS/cm), pH, and turbidity (NTU) from inflows (Sites 20 and 14) and outflow (Site 2) in the Kanopolis Lake watershed during 2006.

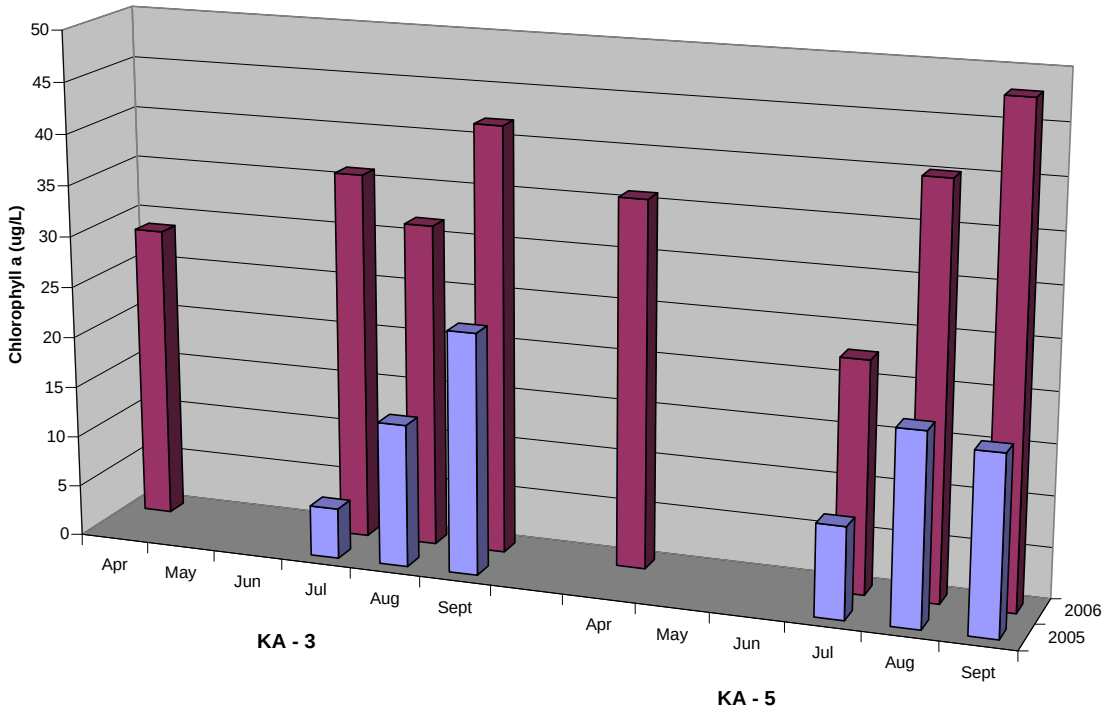

Figure 7.11. Comparison of mean chlorophyll a concentrations (ug/L) by site (3 = Tower; 5 = mid-lake) at Kanopolis Lake during 2005 and 2006.

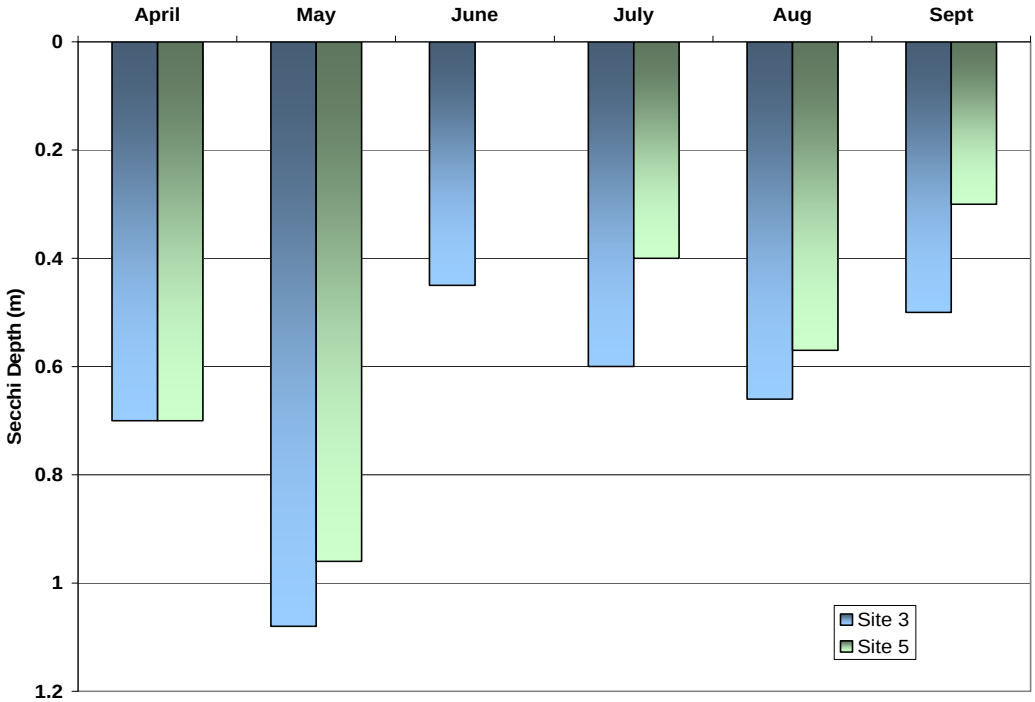

Figure 7.12. Comparison of secchi depth (water clarity) between lake sites from April through September 2006 in Kanopolis Lake.

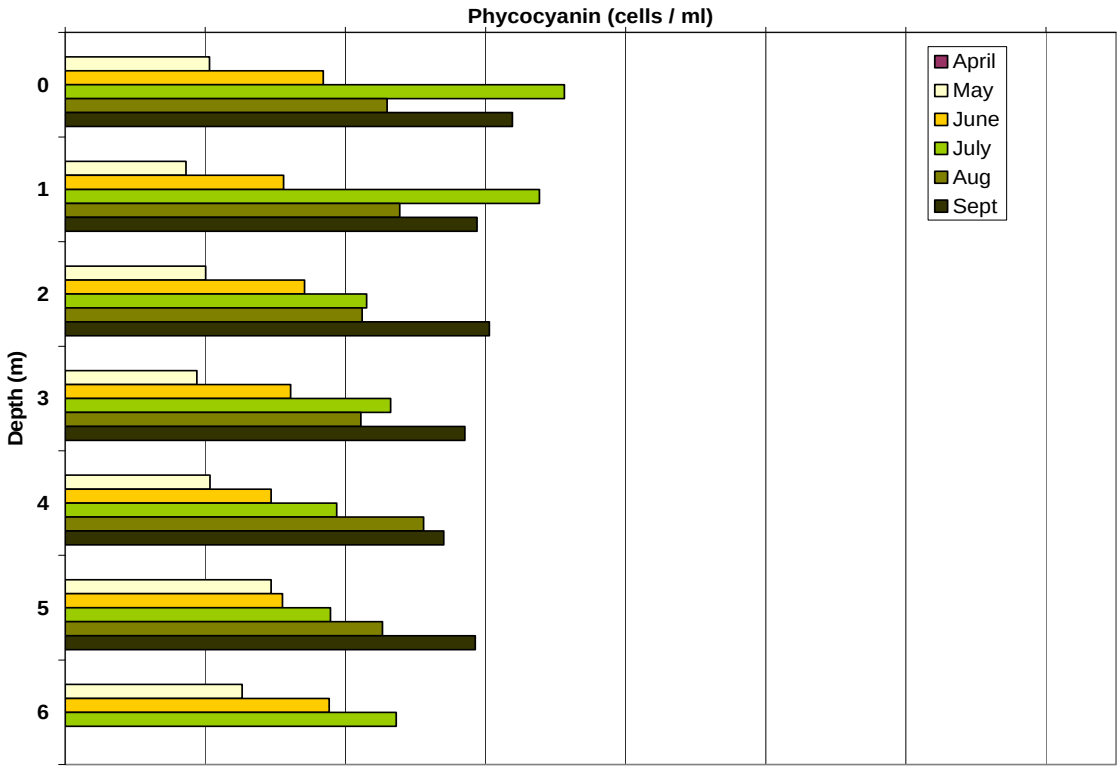

Figure 7.13. Relative concentrations of phycocyanin (bluegreen algae) (cells / ml) measured monthly by depth at Kanopolis Lake Site 3 (Tower) during 2006.

The median atrazine concentrations from surface water samples collected between 1996 and 2006 (0.7 – 0.73 ug/L) were all below EPA's drinking water maximum contaminant level of 3 ug/L (Figure 7.14). These concentrations are some of the lowest within the district. Interestingly, samples exceeding the drinking water standard have been detected in the Smoky Hill River inflows during June of 2002 and 2003 (Figure 7.15). Median cyanazine concentrations ranged from 0.05 – 0.06 ug/L from lake sites (Figure 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 both inflow sites, the outfall (625 ug/L), and upper lake site (533 ug/L); only the lower lake site did not exceed the SMCL (261 ug/L). Total iron at Site 20 was 7495 ug/L and 2890 ug/L at Site 14. These concentrations reflect local geology and arid conditions in the upper reaches of the watershed. Total iron concentrations ranged from 477 to 683 ug/L for bottom samples collected at Sites 3 and 5, respectively. Elevated levels 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 all sites (range = 67 – 198 ug/L) with the exception of Site 3 (35 ug/L). Implications are directed at drinking water facilities due to taste and stain issues. 7.16).

Monthly variability and longitudinal differences in sulfate concentrations were detected throughout the watershed during 2006 (Figure 7.17). Site 20 exceeded the SMCL in all months except July. A similar pattern was observed at Site 14, which is an inflow site just above the lake. All samples from both lake sites and the outflow were below the

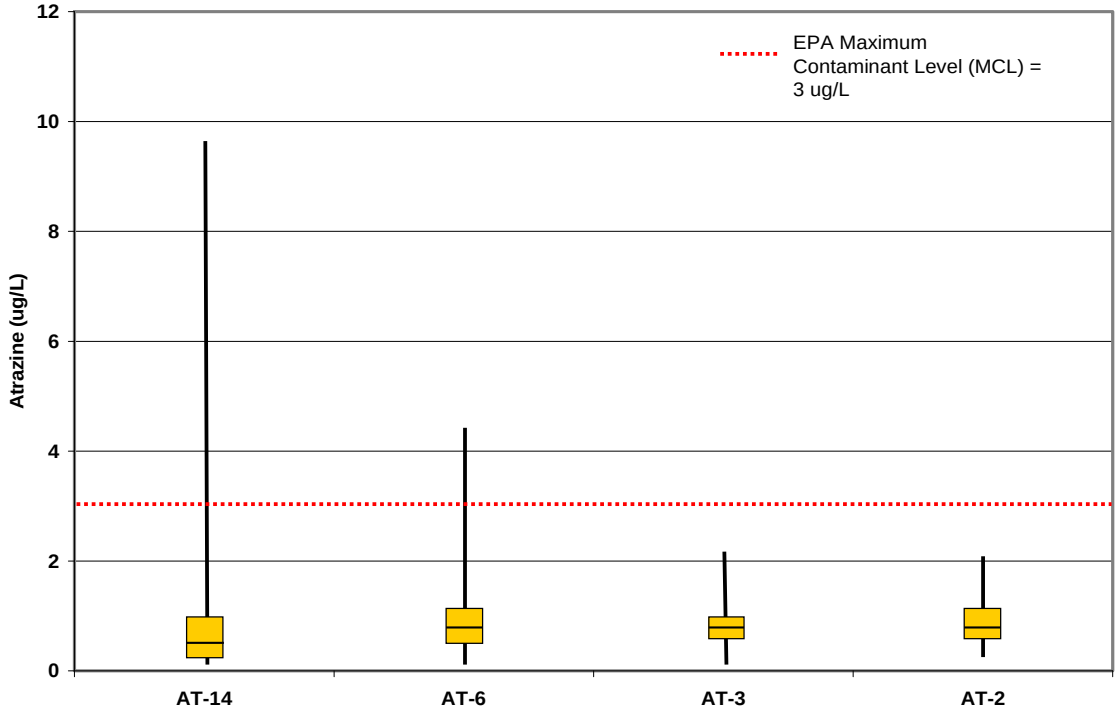

Figure 7.14. Box plot of surface water sample atrazine concentrations measured at lake sites from 1996 through 2006 at Kanopolis Lake.

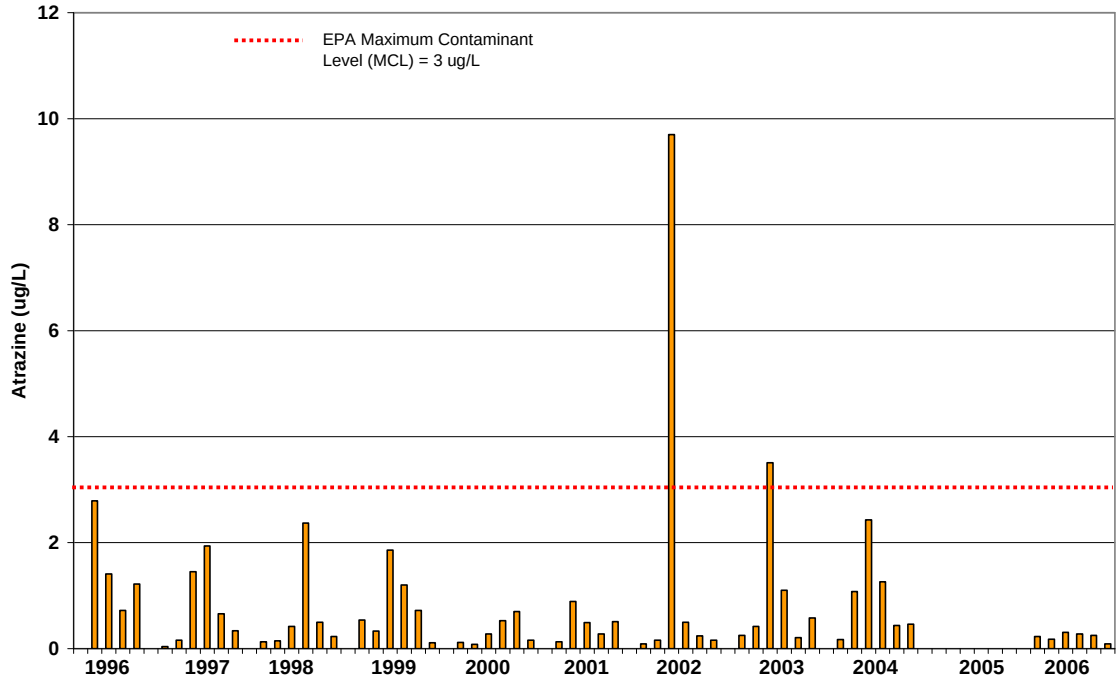

Figure 7.15. Atrazine concentrations by date for samples collected between 1996 and 2006 at Site 14 (Smoky Hill River inflow) in the Kanopolis Lake watershed.

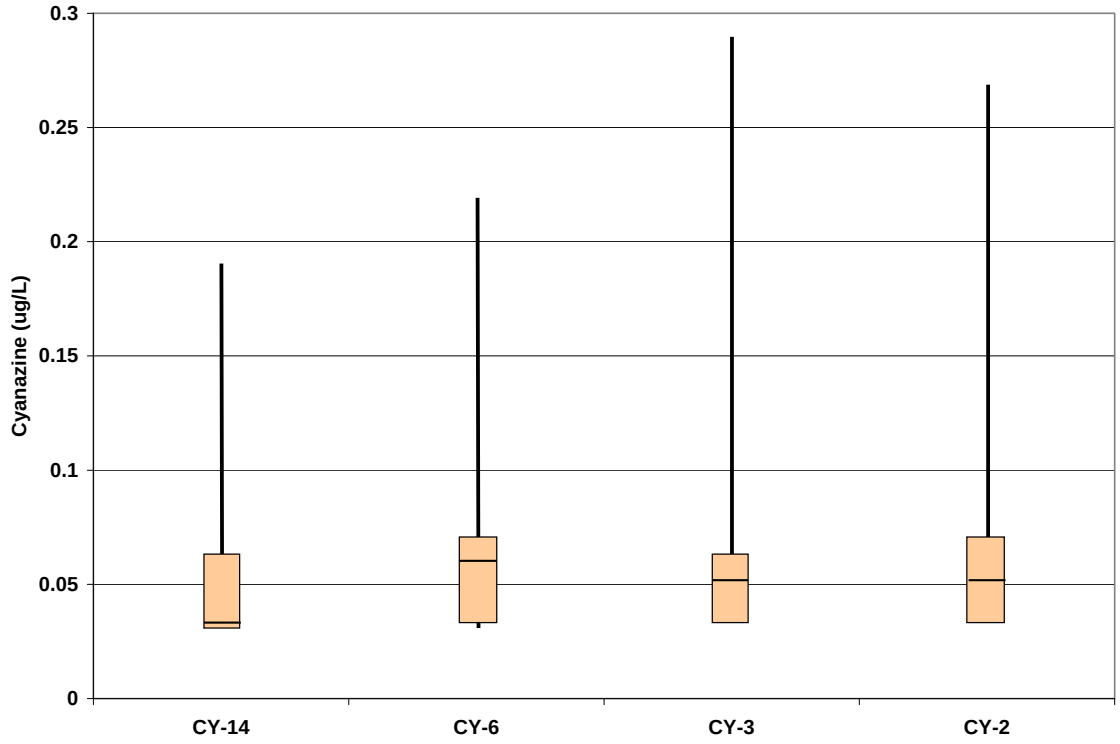

Figure 7.16. Box plot of surface water sample cyanazine concentrations measured at lake sites from 1996 through 2006 at Kanopolis Lake.

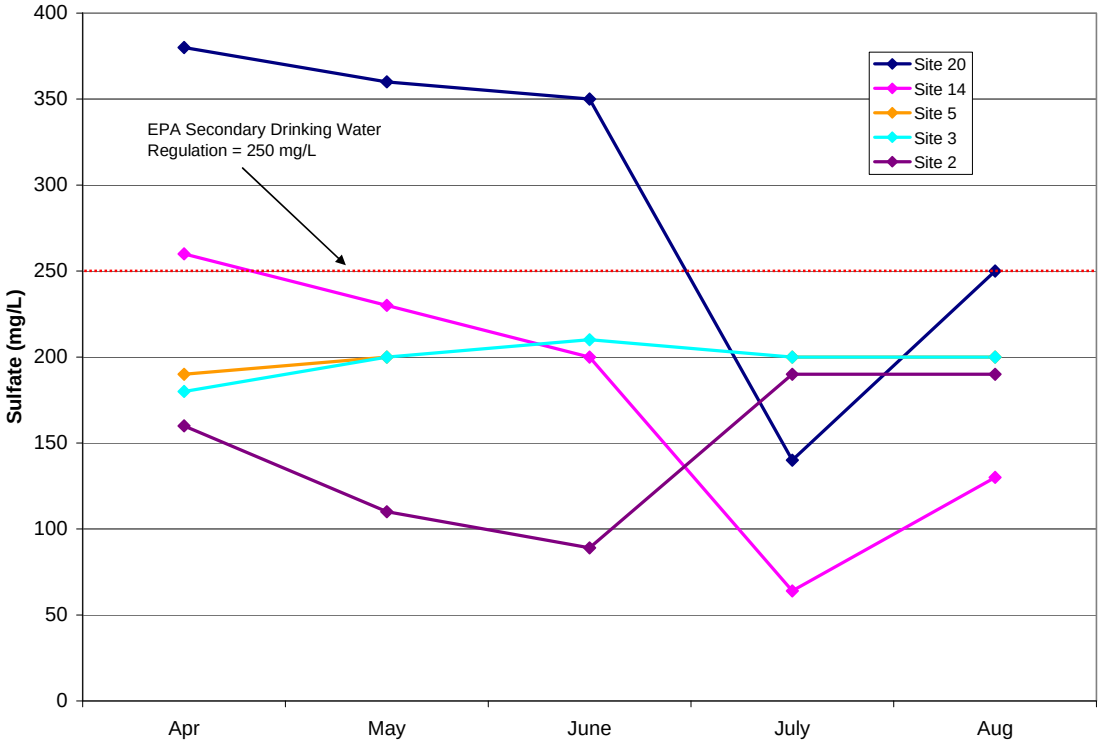

Figure 7.17. Longitudinal plot of sulfate concentrations (mg/L) measured from surface water samples in the Kanopolis Lake watershed during 2006.

SMCL.

Vertical profiles were recorded during monthly sampling trips to Kanopolis Lake in 2006 (Figure 7.18). Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. The lake was stratified both chemically and thermally during July, with stratification beginning at 2 m in depth. The lake was thoroughly mixed during both August and September.

Fecal bacteria (*E. coli*) samples were collected from three locations at Venego beach prior to three major holidays (Memorial Day, July 4th, and Labor Day) during 2006. No samples exceeded the single sample maximum of 732 colonies / 100 ml for a whole-body contact during the recreational season (Figure 7.19). With limited inflows due to prolonged drought conditions, blooms of fecal bacteria would not be expected.

7.3.3 Outflow

Outflow samples were collected from Kanopolis Lake during 2006. Summarized data on Site 2 is included in discussions of lakes sites listed above.

7.4 Future Activities and Recommendations

Sampling activities for 2007 will include transition to 'ambient' monitoring from May through September, as well as conducting a single vertical profile at each of the two lake sites during July or August. In an effort to gather baseline phycocyanin data, the lake 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 metal samples will be collected from both lake sites during the summer to provide a baseline for possible resuspension sources. This data will also be useful in discussions concerning dredging of lake sediments. 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. Continue to work with the Smoky Hill / Big Creek WRAPs group to achieve water quality improvements within the Kanopolis Lake watershed.

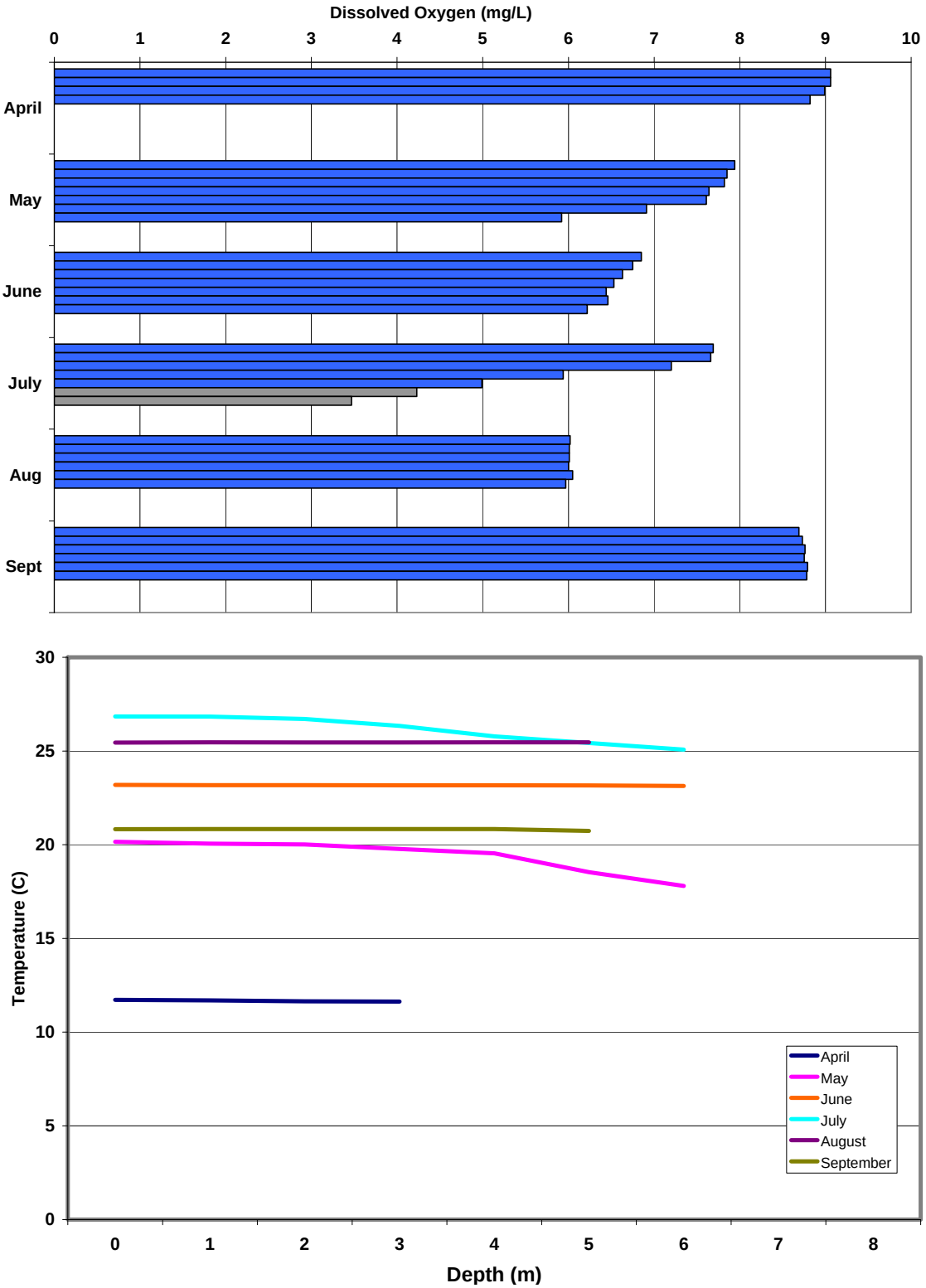

Figure 7.18. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plot from a vertical profile recorded at Site 3 during 20 July 2005 at Kanopolis Lake.

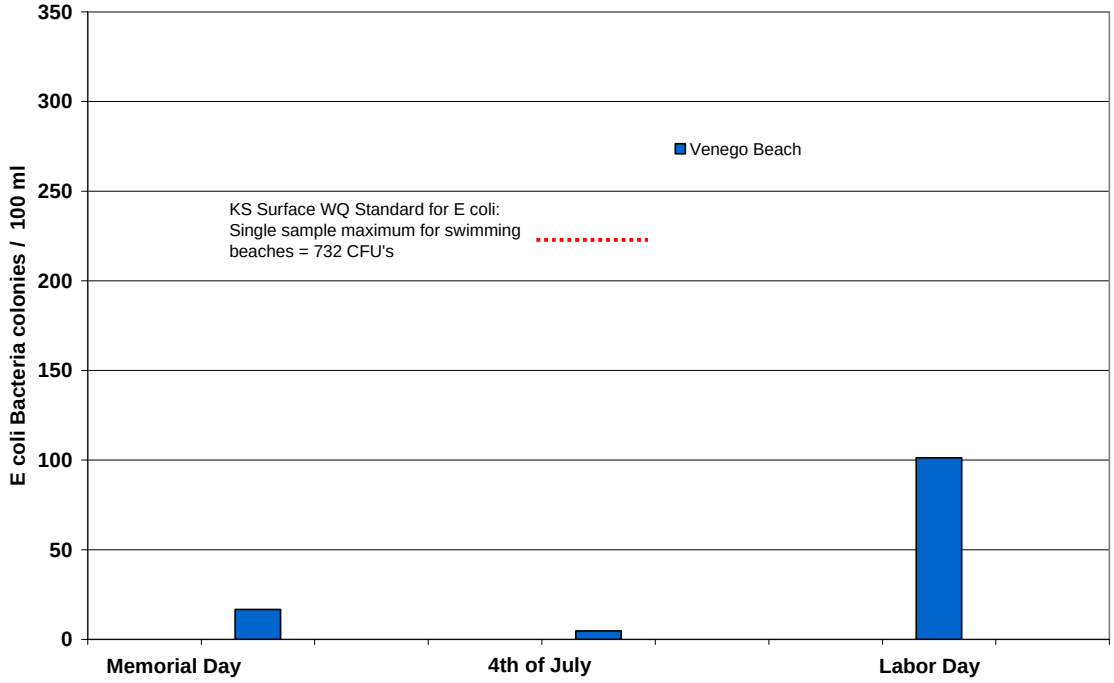

Figure 7.19. Fecal bacteria colonies per 100 ml samples from beach samples collected prior to major holidays at Kanopolis Lake during 2006.