11 Milford Lake

11.1 General Background

Milford Lake was impounded and reached conservation pool in 1967. The main threats to Milford Lake's water quality are sedimentation, nutrients, and bacterial contamination. The lake is list on the state's 2004 303(d) list for eutrophication (high) and DO (low). The KDHE is currently developing a TMDL to address the eutrophication listing. Wetland restoration has occurred in the upper reaches of the lake and on the Republican River through the efforts Kansas Wildlife and Parks, KAWS, and Corps Section 1135 program. Additional information on these efforts can be located at http://www.nwk.usace.army.mil/projects/milford/introduction.htm.

11.1.1 Location

Milford Lake is located approximately 6.4 km (4 miles) northwest of Junction City, Kansas. The dam is located at river km 13.3 (river mile 8.3) on the Republican River. Milford Lake is the largest lake in Kansas, based on surface acreage (15,709 acres) and 163 shoreline miles. The watershed includes portions of Clay, Dickinson, and Riley counties, as well as the upper Republican River system. Historic water quality sample sites at Milford Lake include 3 lake, 1 outflow, and 1 inflow (Figure 11.1).

11.1.2 Authorized Purposes: Flood control, water supply, water quality, navigation, recreation, and fish and wildlife conservation.

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

11.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	1,176.2	752.9	33,000	
Multipurpose	1,144.4	372.3	16,000	163
Total		112.1		

Total watershed area: 24,880 sq miles (15,923,200 A)

Watershed ratio: 482.5 FC / 995.2 MP

Average Annual Inflow: 777,708 acre-feet
Average Annual outflow: 000 acre-feet
Average flushing rate: 0.59 years
Sediment inflow (measured): 47,935 acre-feet (1967 – 1994)
Water management Plan: Approved December 1984; minor revisions January 1995
Historic stage hydrograph: 1996 – 2006 (Figure 11.2)

Figure 11.1. Milford Lake area map with sample site locations and sample numbers.

11.2 2006 Activities

Milford Lake was categorized as an 'intensive' lake during 2006, thus lake and inflow / outflow sites were all sampled (see Figure 11.1). Samples were collected from April through September during 2006. An initial meeting of the Milford Lake Watershed Restoration and Protection Strategy (WRAPS) was held in August, 2006. Milford Lake staff (OF-MI) providing field assistance with the WQP during 2006 included Brent Logan and Ken Wenger. R.J. Harms, Operations Manager, provided technical insight and background knowledge on Milford Lake.

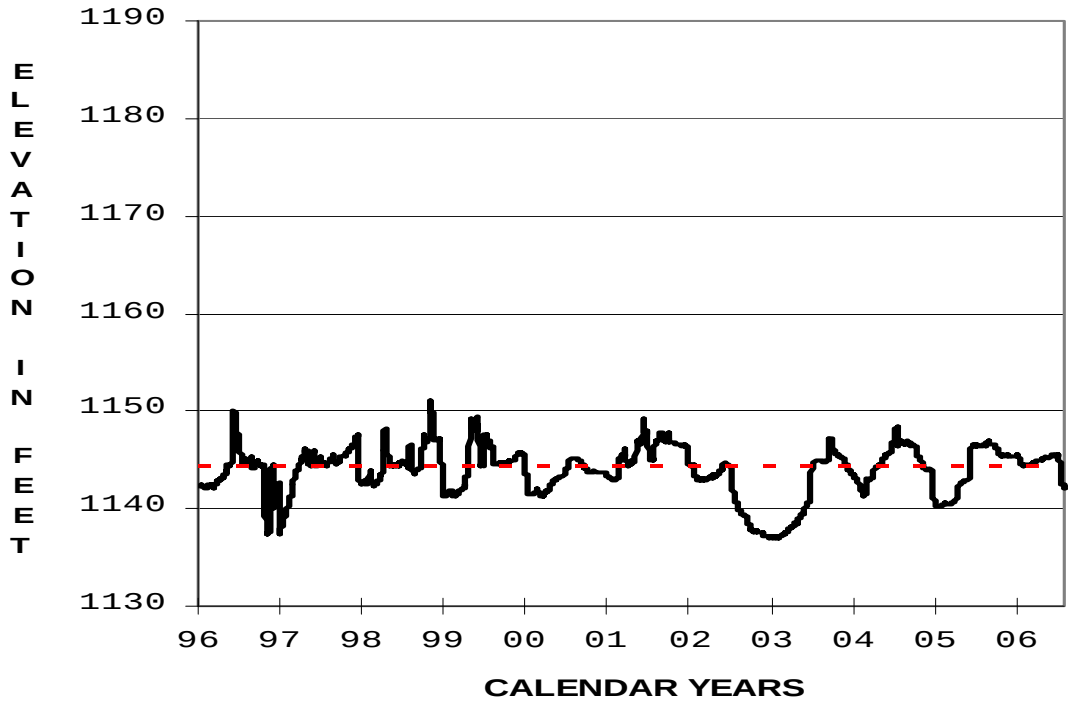

Figure 11.2. Pool elevation hydrograph from 1996 – 2006 (red-dashed line is the multipurpose pool elevation – 1144.4 msl).

11.3 2006 Data

Comparative historic data consists of monthly (April – September) data collected from1996 through 2005. Samples were collected at inflow, lake, and outflow sites from April through September, 2006.

11.3.1 Inflow

Milford Lake inflow samples were collected from Sites 24 on the Republican River near Clay Center during 2006. Historically, nutrient concentrations (nitrogen and phosphorus) and contaminants are most variable at this site due to influences of runoff events within the watershed. Please see comments for lake sites below on specific parameters.

11.3.2 Lake

Milford Lake is classified as eutrophic based on total nitrogen (TN) and total phosphorus (TP) median concentrations and chlorophyll *a* values. 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. Median TN concentrations range from 0.93 – 1.56 mg/L (Figure 11.3), which is above EPA's proposed ecoregional nutrient criteria value of 0.44 mg/L TN. The median TN concentrations, comprising data collected between 1996 and 2006, are the third highest within the district -- only Tuttle Creek and Kanopolis have higher median concentrations. Monthly and annual variability in TN, evident at all sites, is depicted in Figure 11.4 from surface samples collected at Site 5 (upper).

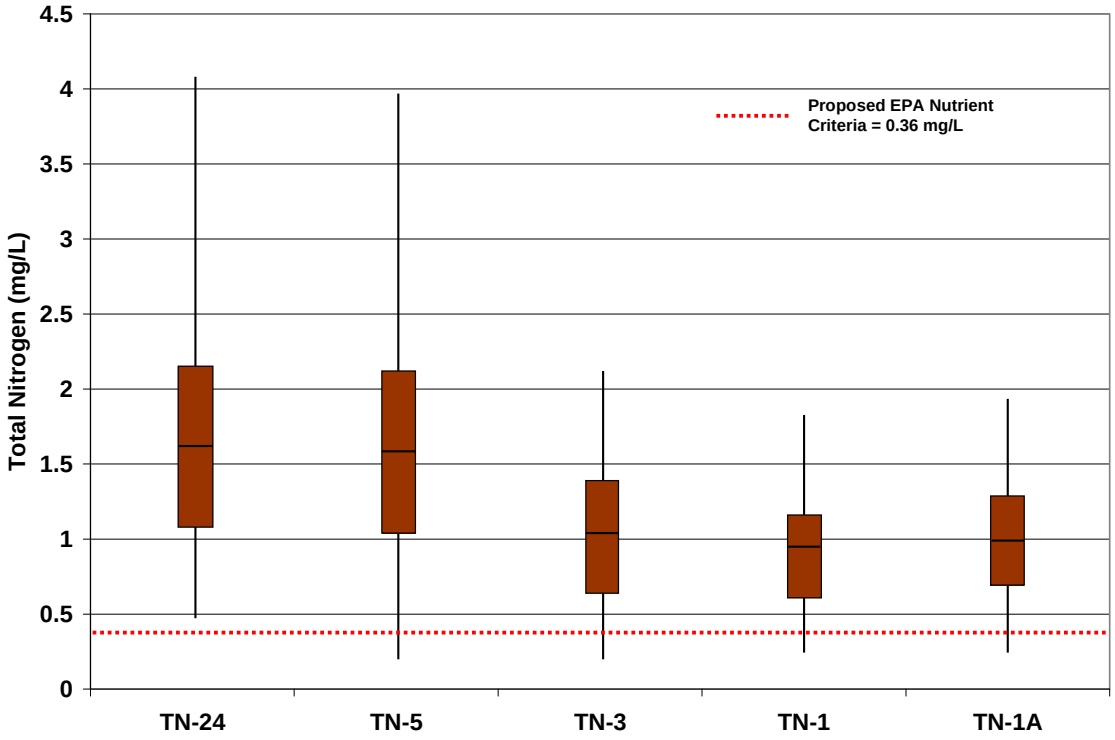

Figure 11.3. Box plots of surface water sample total nitrogen concentrations measured at lake sites from 1996 through 2006 at Milford Lake.

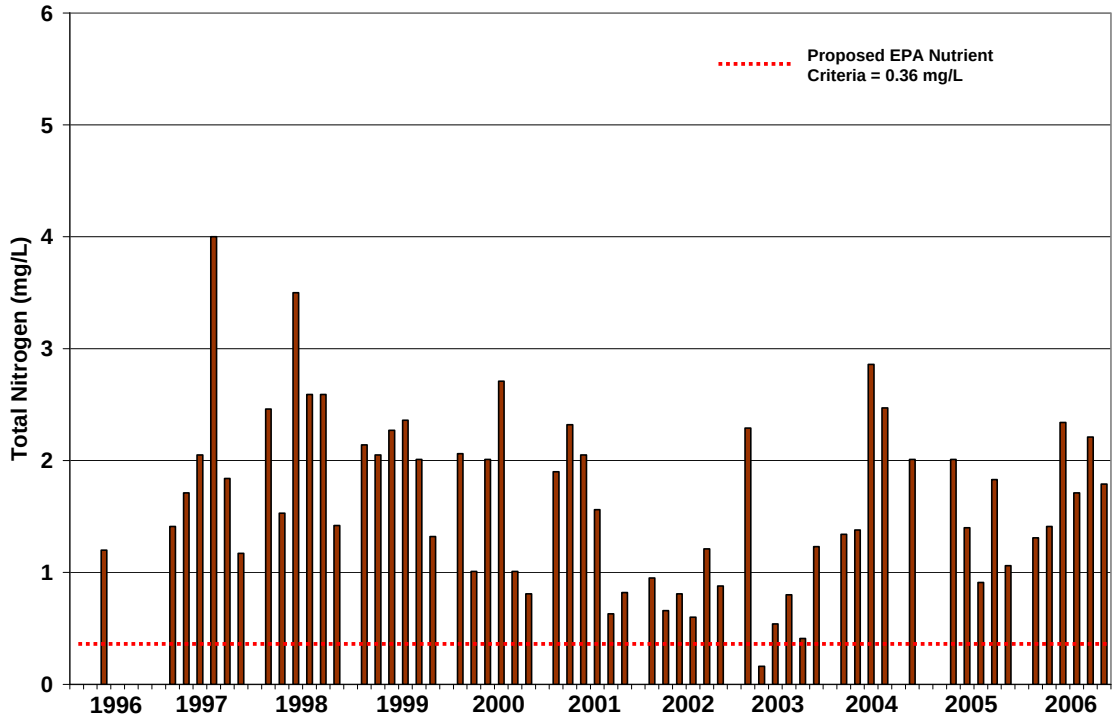

Figure 11.4. Total nitrogen concentrations by surface water sample date collected at Site 5 in Milford Lake from 1996 through 2006.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. Median TP concentrations range from 0.16 – 0.29 mg/L (Figure 11.5), which is above EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L TP. These median concentrations are also among the highest for district lakes. Longitudinal differences in TP concentration exist between the inflow (Site 24) and upper lake (Site 5) sites in comparison to the mid-lake (Site 3) and lower-lake tower sites (Site 1).

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, as is depicted by the range of values at Site 1 (Figure 11.6). Median TN:TP ratios at all three lake sites are < 12, indicating the lake is at risk for cyanobacteria blooms (Figure 11.7).

Monthly variability in mean chlorophyll *a* was detected at all three lakes sites (Figure 11.8). Mean summer chlorophyll *a* concentrations from the three lake sites ranged from 25 – 118 ug/L during 2006, with highest values measured from Site 5.

Secchi depth (water clarity) was measured monthly at all three lake sites. Water clarity was significantly lower at Site 5 than Site 1 (Figure 11.9), with very limited clarity at Site 5 (mean = 0.06m) but moderately clear at Site 1 (mean = 1.0; Site 3 exhibited relatively clear water (mean = 0.72m). Secchi depth measurements during May indicated extremely clear water conditions, with a measurement of 3.54 m at Site 1.

The median atrazine concentrations from surface water samples collected from 1996 - 2006 (1.1 – 1.5 ug/L) were all below EPA's drinking water maximum contaminant level of 3 ug/L (Figure 11.10). These concentrations are some of the higher within the district. However, individual samples measured during that time period are significant enough to greatly exceed the MCL – even a sample collected from Site 24 during June 2006 (4.9 ug/L). It is also important to note that drought conditions may have some impact on concentrations measured this year. Figure 11.11 depicts individual sample concentrations measured by date at Site 24 (Republican River inflow site).

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 11.12 depicts vertical distribution of phycocyanins measured at Site 1 (Tower) from May through September. Elevated concentrations were prevalent throughout the entire water column during June, declined during July and August, and increased again in September. The highest concentrations within the district were measured at Milford Lake on 22 August as an extremely large bluegreen algal bloom was prevalent and persisted for about 5 days. These concentrations were 45 – 62X background concentrations. Samples were delivered to USGS – Lawrence for analyses. Their preliminary results for specific concentrations of cyanotoxins were as follows: Anatoxin-a (significant), Microcystin RR (significant), Microcystin LR (significant), Microcystin YR (significant), and Microcystin LW (trace).

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 inflow (Site 24 = 8521 ug/L), upper lake (Site 5; 7271ug/L), midlake (Site 3; 394 ug/L), and outflow (Site 1A = 717 ug/L). Total iron concentrations from bottom samples in the

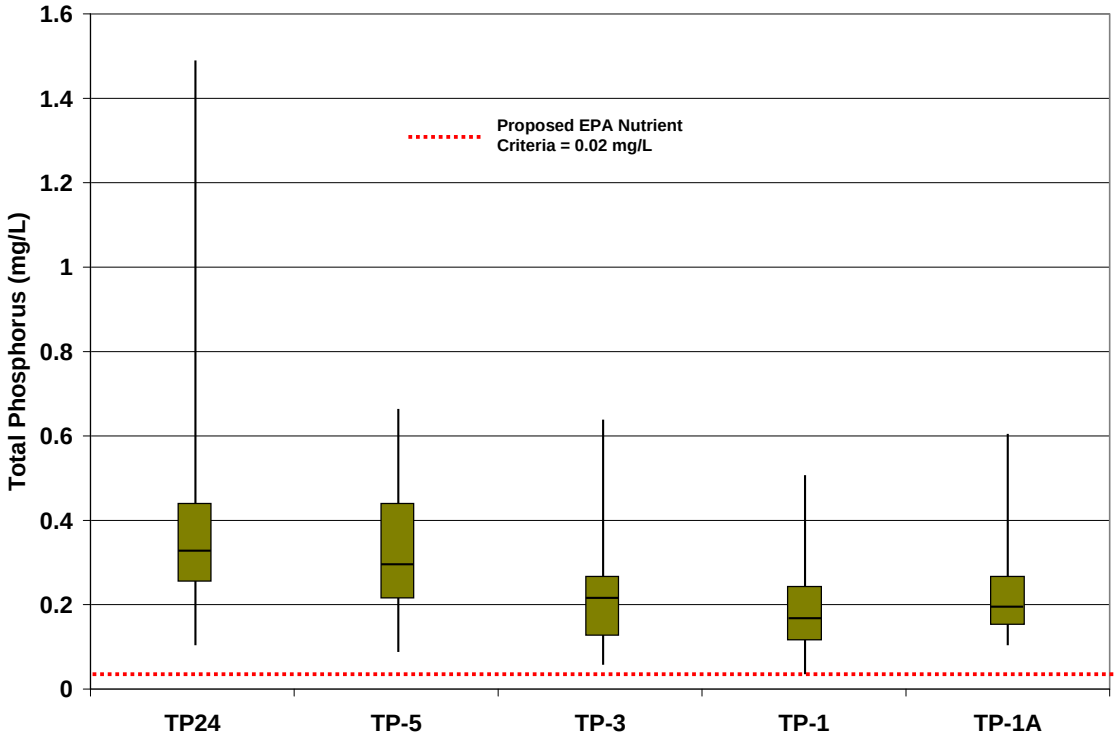

Figure 11.5. Box plots of surface water sample total phosphorus concentrations measured at lake sites from 1996 through 2006 at Milford Lake.

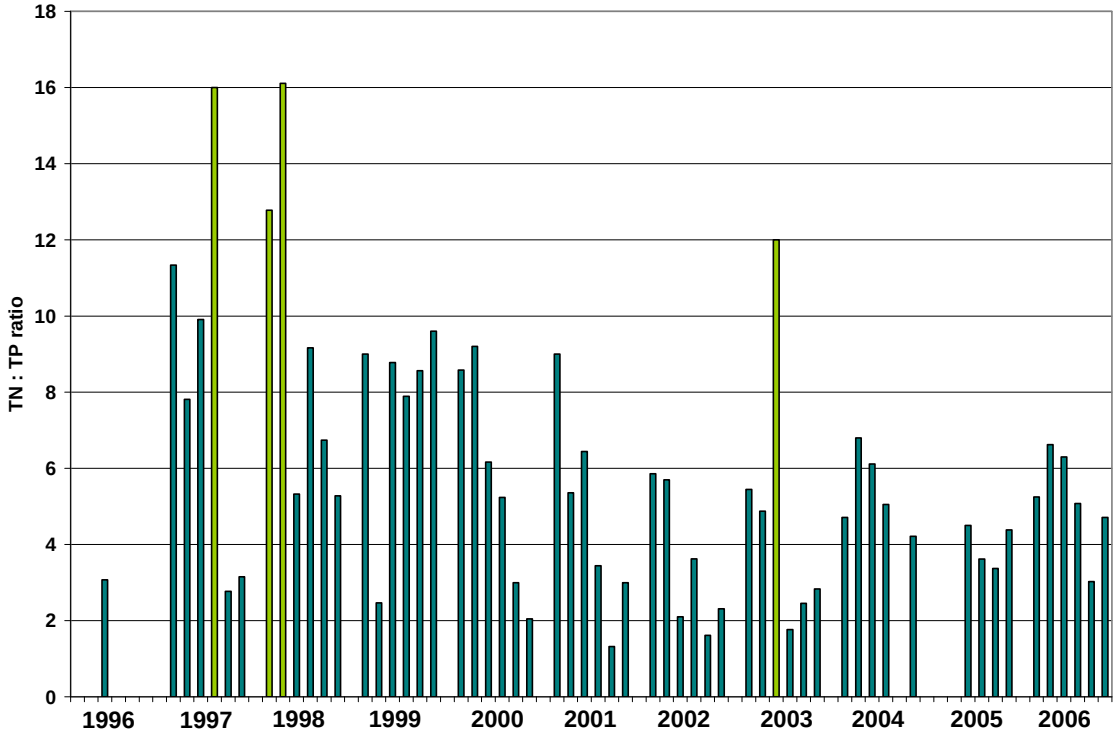

Figure 11.6. Total nitrogen : total phosphorus ratio variability by sample date and year from Site 1 in Milford Lake from 1996 through 2006.

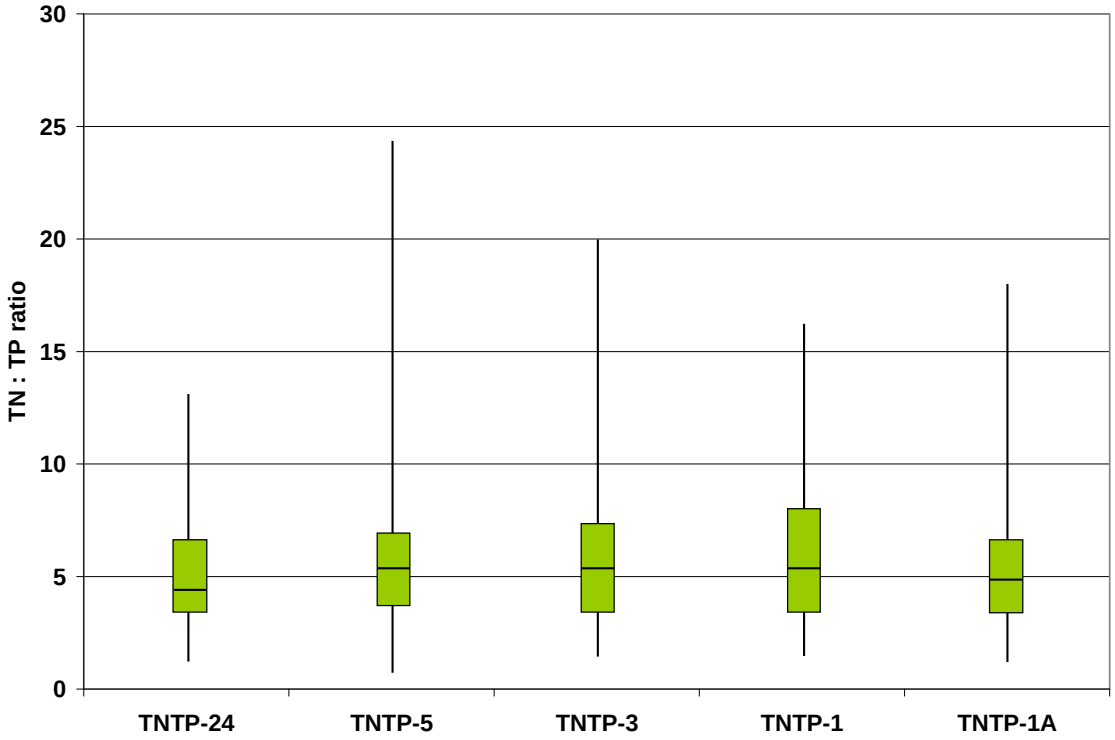

Figure 11.7. Box plots of total nitrogen : total phosphorus (TN : TP) ratio by site from 1996 through 2006 at Milford Lake.

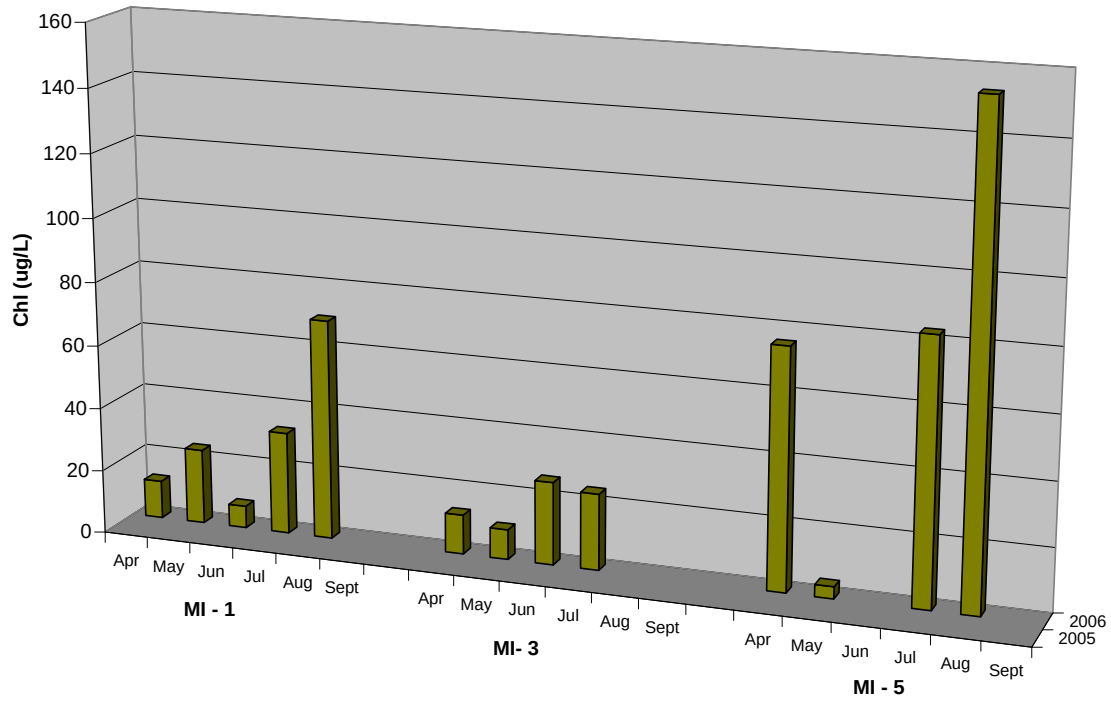

Figure 11.8. Comparison of mean chlorophyll a concentrations (ug/L) by date and site (1 = Tower; 3 = Mid; 5 = Upper) at Milford Lake during 2006.

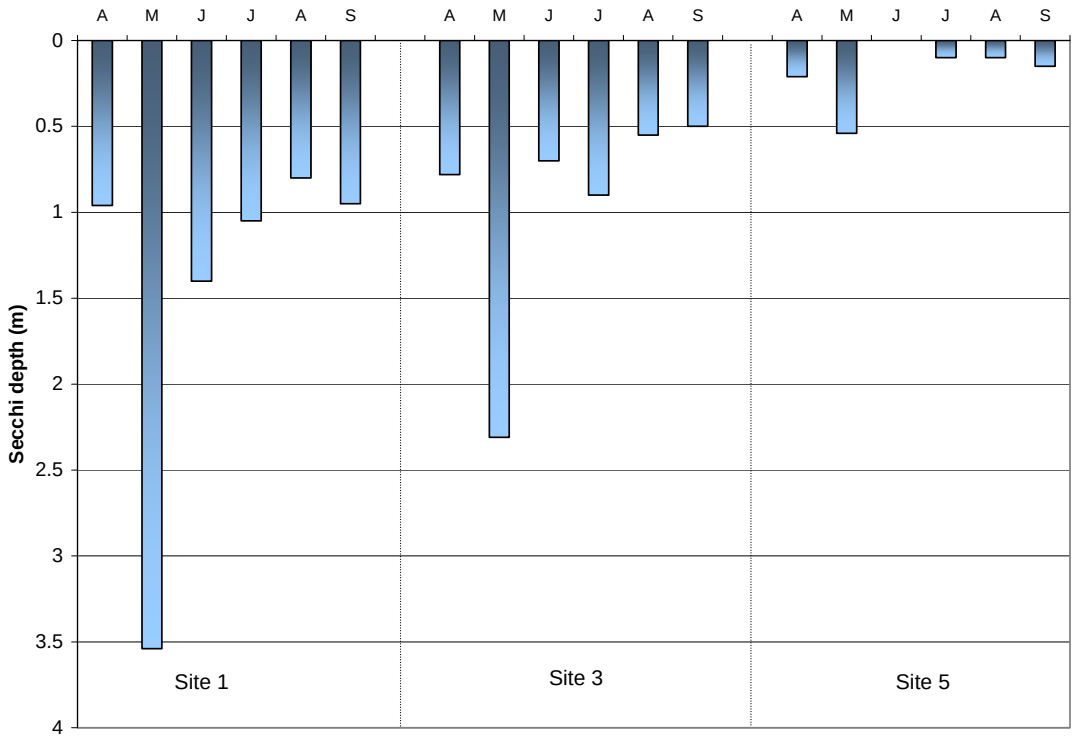

Figure 11.9. Plot of secchi depth (water clarity) measured by date and site during 2006 at Milford Lake.

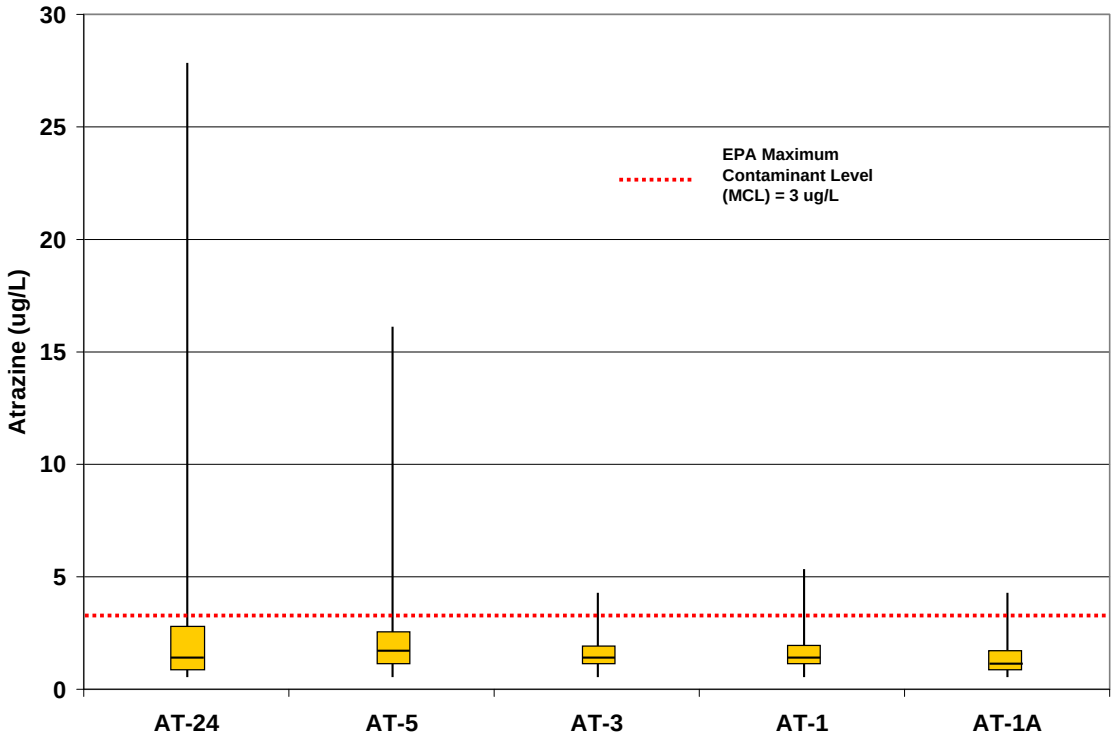

Figure 11.10. Box plots of surface water sample atrazine concentrations measured at lake sites, inflow (Site 24), and outflow (Site 1A) from 1996 through 2006 at Milford Lake.

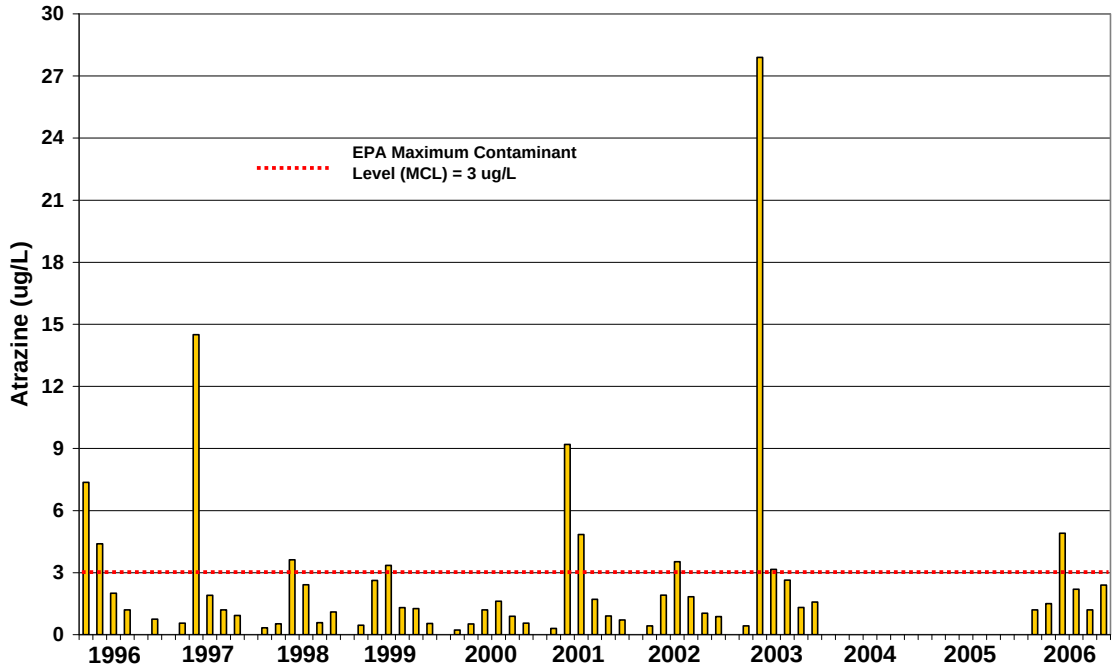

Figure 11.11. Atrazine concentrations by sample date from surface water samples collected at Site 24 (Republican River inflow) in Milford Lake from 1996 through 2006.

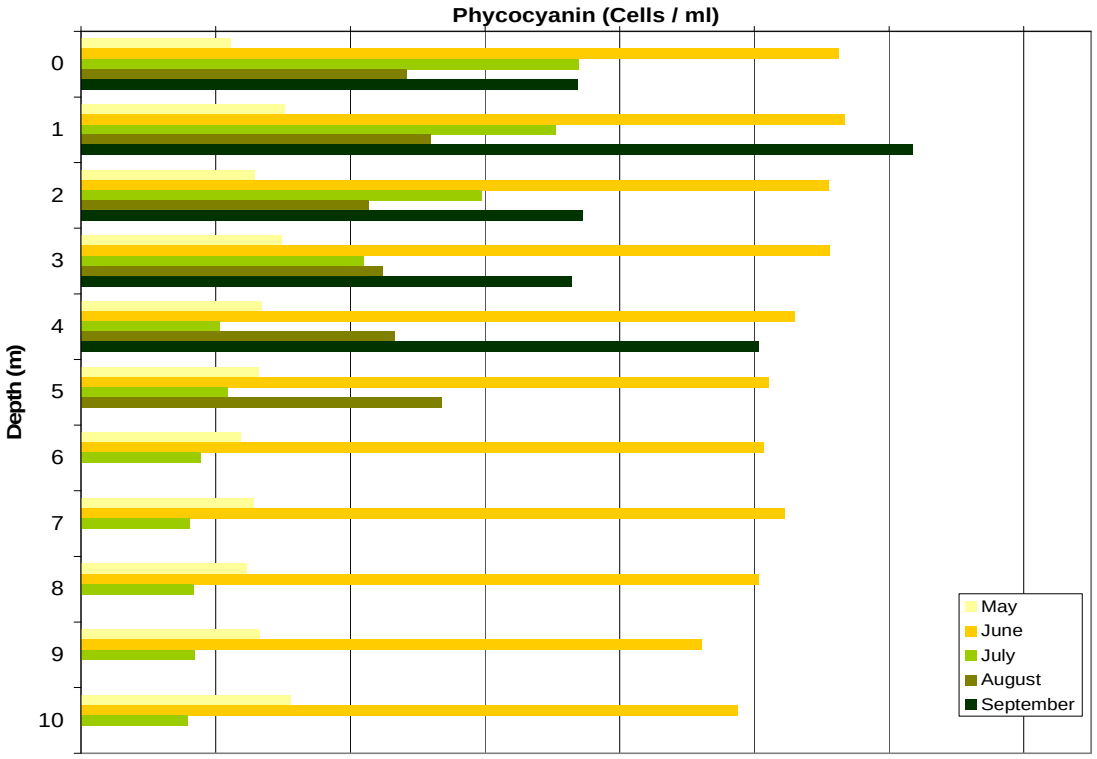

Figure 11.12. Relative concentrations of phycocyanin (bluegreen algae) (cells / ml) measured monthly by depth at Milford Lake Site 1 (Tower) during 2006.

lake ranged from 194 – 16286 ug/L, which reflects anoxic conditions throughout the lake. 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 both the inflow site (Site 24 = 223 ug/L), upper lake (Site 5; 208 ug/L), mid lake (Site 3; 79), and outflow (Site 1A = 143 ug/L). The SMCL for total manganese was exceeded in bottom samples from midlake and upper lake sites (range = 109 – 371 ug/L). Implications are directed at drinking water facilities due to taste and stain issues.

Vertical profiles were recorded monthly from April through September. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. The lake was stratified chemically from June through August, with stratification beginning around 9 m in depth (Figure 11.13). The lake was weakly stratified thermally, which is typical of large windswept Kansas lakes.

Fecal bacteria (*E. coli*) samples were collected from all three beaches prior to major recreational season holidays during 2006. None of the mean samples exceeded the state standard for single sample whole-body contact (732 colonies / 100 ml)(Figure 11.14).

11.3.3 Outflow

Outflow samples were collected from Milford Lake during 2006. Summarized data on Site 1A is included in discussions of lake sites listed above.

11.4 Future Activities and Recommendations

Sampling activities for 2007 will include transition to 'ambient' monitoring from May through September, as well as conducting a monthly vertical profile at each of the three 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. 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. Future Republican river WRAPS meetings will be attended, and data will be shared for modeling efforts and discussions.

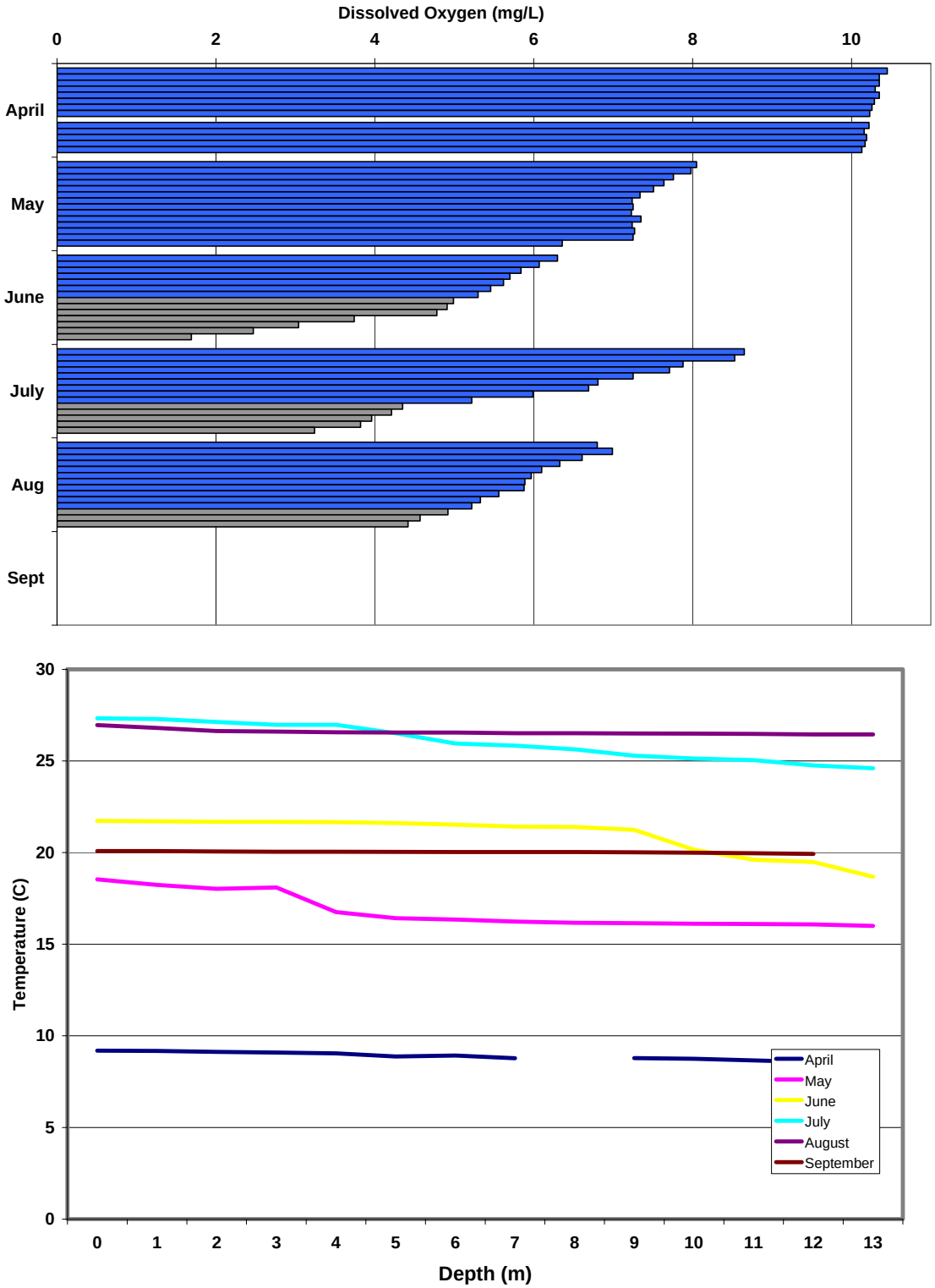

Figure 11.13. Dissolved oxygen concentration (mg/L) histogram and temperature (°C) plot from a vertical profile recorded at Site 1 on 8 August 2006 at Milford Lake.

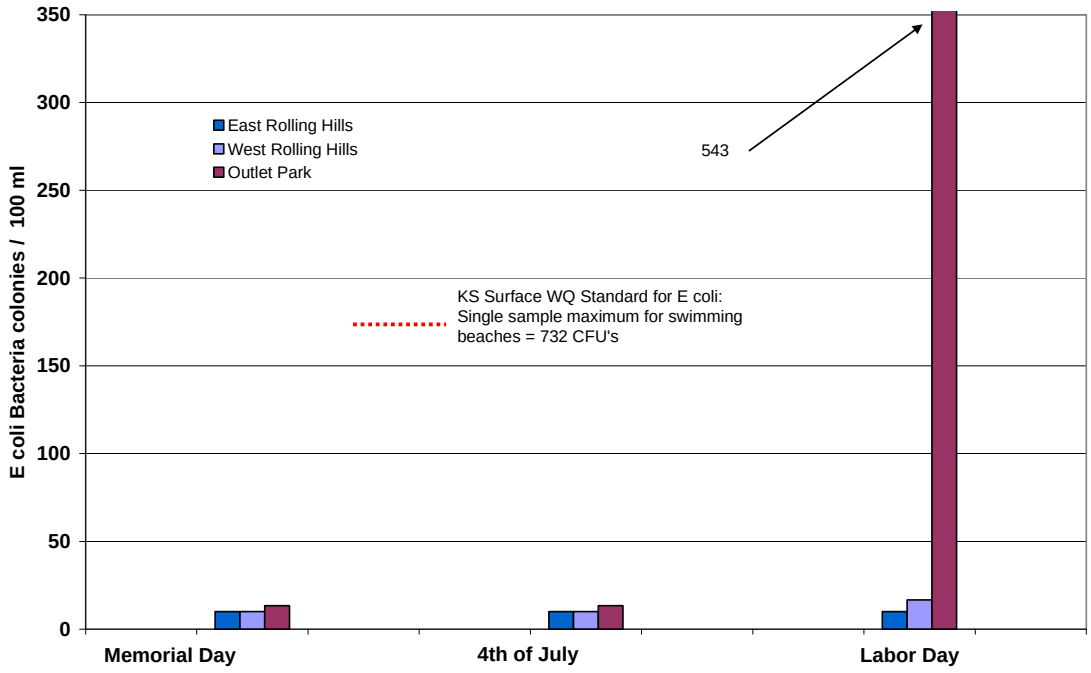

Figure 11.14. Mean fecal bacteria (E. coli) (colonies per 100 ml) results from samples at three swimming beaches collected from April through September during 2006 at Milford Lake.