

4 Harlan County Lake

4.1 General Background

Harlan County Lake was impounded on 14 November 1952 and reached full pool on 14 June 1957. The primary water quality threats to Harlan County Lake are nutrients, sediment and toxic cyanobacteria blooms. A drought continues to seriously impact the lake such that it currently contains one-half the surface acreage. Sample site 5 replaced site 7 during 2003 because site 7 was no longer accessible due to the drought. During normal water level years, the lake experiences a 4 – 6 ft drawdown related to irrigation releases (June – August). Dredging has occurred to maintain boat access to both the Patterson Harbor marina and the Gremlin Cove marina. Bluegreen algae blooms have occurred at the lake in the recent past (<http://www.deq.state.ne.us/>).

4.1.1 Location

The Harlan County Lake is located 12.8 km (8 miles) east of Alma, Nebraska. The dam, located on the Republican River, is located 371.7 km (232.3 miles) upstream of the confluence with the Kansas River. Historic water quality sample sites include 3 lake, 1 outflow, and 1 inflow sites (Figure 4.1).

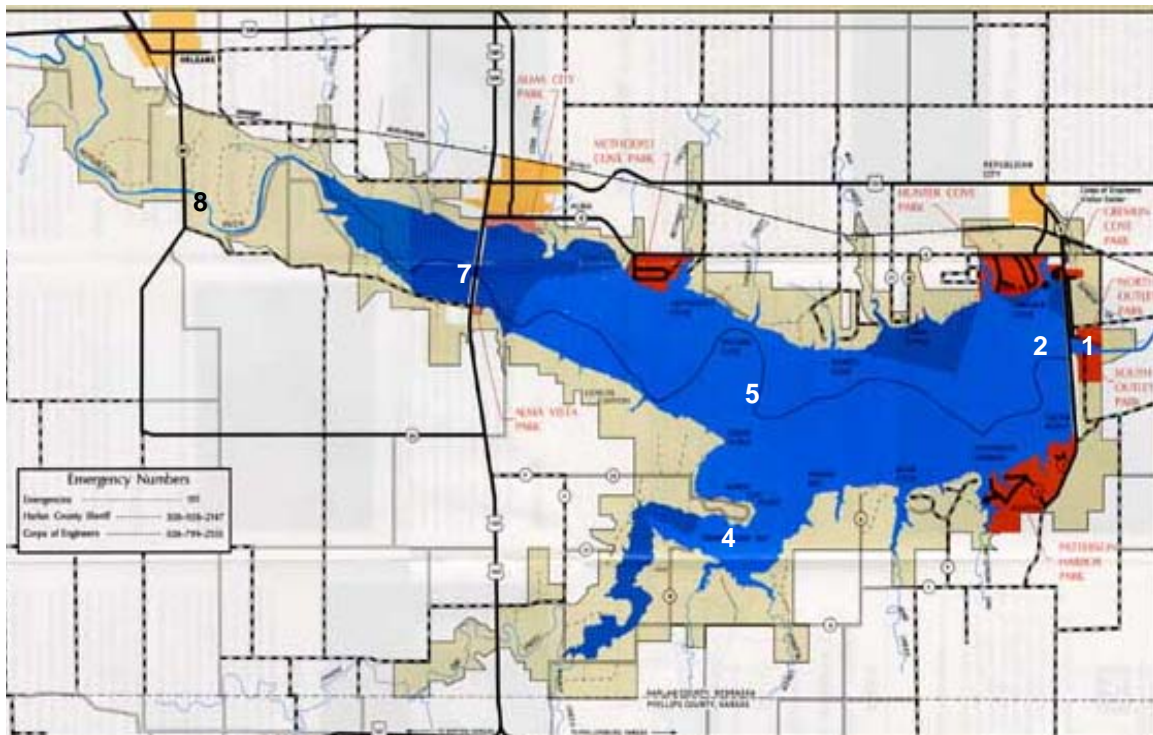


Figure 4.1. Harlan County Lake area map with sample site locations and site numbers.

4.1.2 Authorized Purposes: flood control, irrigation, recreation, and fish and wildlife.

4.1.3 State Use Designations: recreation, warmwater aquatic life, agricultural water supply, and aesthetics.

4.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	1,973.5	500.0	23,431	
Multipurpose	1,946.0	314.1	13,305	54
Total		814.1		

Total watershed area: 13,536 sq miles (total upstream area)
 7,169 sq miles (total local drainage below upstream dams;
 4,588,160 A)

Watershed ratio: 195.82 FC / 344.84 MP

Average Annual Inflow: 149,984 acre-feet/yr (1982 – 2006)

Sediment inflow (measured): 38,548 acre-feet (1952 – 2000)

Flushing rate: 2.09 years

Water management Plan: Approved 10 May 2001

Historic stage hydrograph: 1995 – 2005 (Figure 4.2)

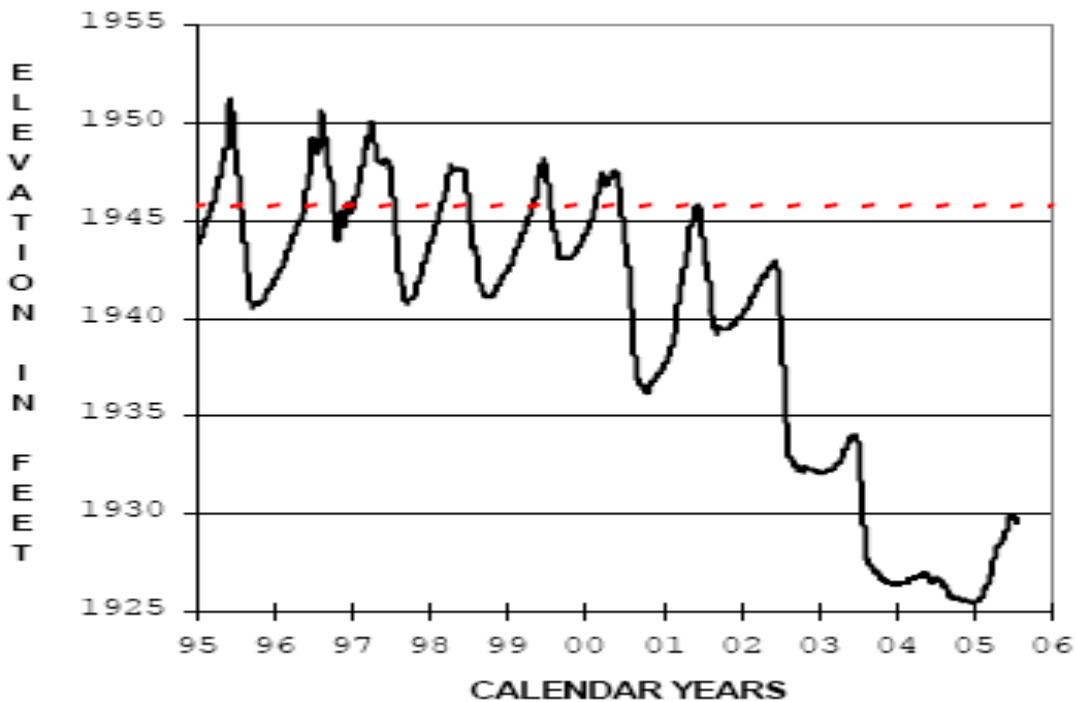


Figure 4.2. Pool elevation hydrograph from 1995 – 2005. Red-dashed line is multipurpose pool elevation.

4.2 2006 Activities

Harlan County Lake was categorized as an ‘ambient’ lake during 2006, with sample collection occurring from June through September. Surface samples were to be collected from inflow and outflow sites, while surface and bottom samples were collected at the three lake sites. Vertical profiles (temperature, DO, pH, conductivity, and turbidity) were recorded at the three lake sites during each sampling trip. However, because of the drought, no inflow or outflow samples were collected during the year. Harlan County Lake staff (OF-HC) providing field sampling assistance during 2006 included Jim Brown and Larry Janicek. Jim Bowen, OF-HC Operations Manager, provided insight and background information regarding Harlan County Lake.

4.3 2006 Data

Comparative historic data includes samples collected monthly (April – September) from 1996 through 2005. Samples were collected from June through September during 2006.

4.3.1 Inflow

No inflow samples were collected due to the prolonged drought impacts. No visible water was present at site 8 throughout the study period. No samples have been collected at site 8 since July 2003 because of dry conditions.

4.3.2 Lake

Based on TN, TP and chlorophyll a concentrations, Harlan County Lake is classified very eutrophic. Nitrogen is an essential nutrient for 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 concentrations from surface samples are relatively consistent between lake sites, with means ranging from 0.94 – 1.17 mg/L (Figure 4.3). These concentrations are significantly greater than Nebraska Dept of Environmental Quality’s (NEDEQ) nutrient criteria target of 0.57 mg/L, and are among the highest median TN concentrations within the district.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. The median total phosphorus values range from 0.12 – 0.17 mg/L (Figure 4.4), which is significantly greater than NEDEQ’s nutrient criteria of 0.033 mg/L. The prolonged drought can have some positive impact on water quality, as sediment inflows cease there are less nutrients (i.e., phosphorus) delivered to the lake. As the lake becomes more shallow, wind resuspension of sediment potentially increases the bioavailability of phosphorus; this nutrient is essential for algal blooms.

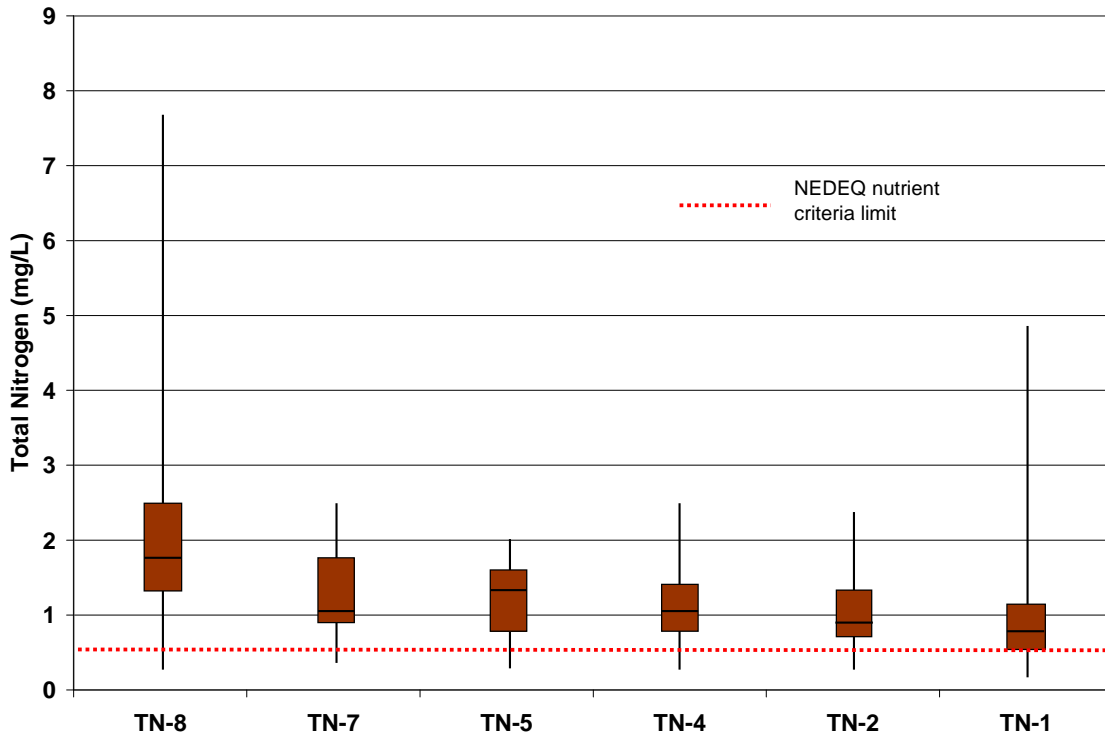


Figure 4.3. Box plots of surface water sample total nitrogen concentrations measured by site from 1996 through 2006 at Harlan County Lake.

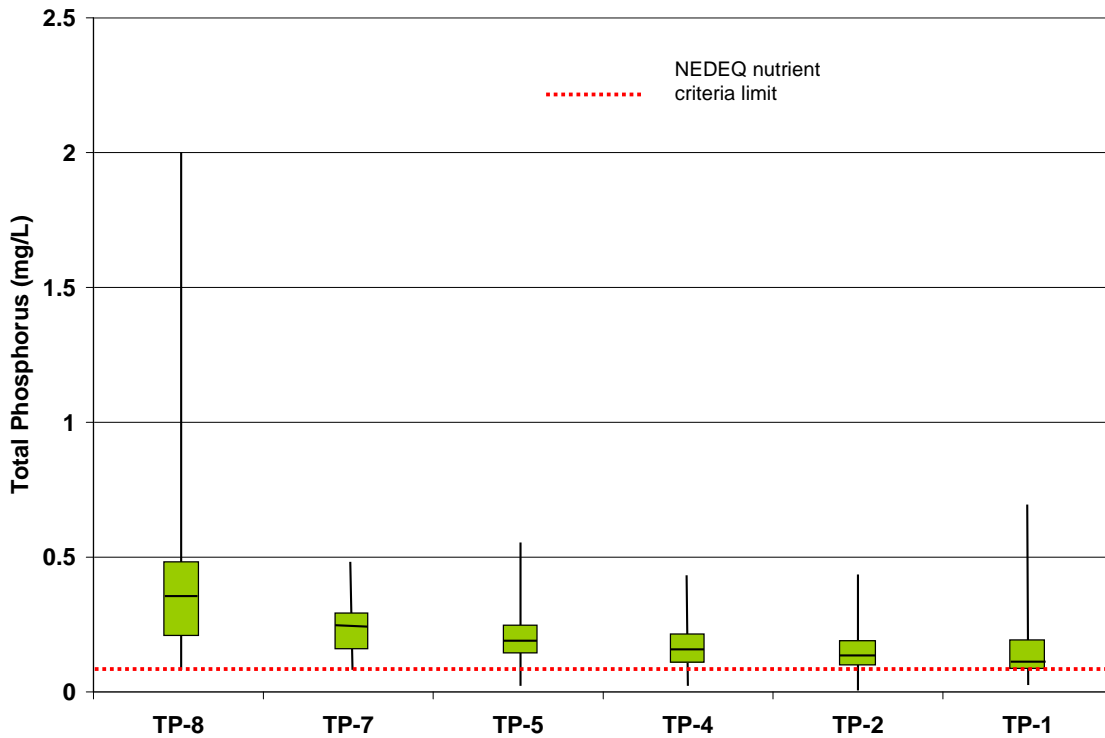


Figure 4.4. Box plots of surface water sample total phosphorus concentrations measured by site from 1996 through 2006 at Harlan Count Lake.

Harlan County experiences some of the lowest median TN : TP ratio values within the district. There is high monthly and annual variability in TN : TP ratios at all sites, with lowest ratios typically present during late summer and fall months. Figure 4.5 depicts such variability as measured at Site 2. Median values range from 5.5 – 7.2 (Figure 4.6), which is strongly indicative for the presence of bloom-forming cyanobacteria (blue-green algae). Thus, this lake is at risk for future cyanobacteria blooms, which pose a serious threat to animals and humans. Recently, lakes in Nebraska have experienced outbreaks of toxic cyanobacteria blooms.

Chlorophyll a concentrations range from 12.15 – 40.08 ug/L from samples collected during 2005, which exceed NDEQ's nutrient criteria target value of 8 ug/L. These values are indicative of a highly eutrophic environment, and were expected based on a shallow, windswept waterbody.

Atrazine samples were last collected from surface samples at all three lakes sites during 2005. As one would expect with a seasonally applied herbicide, monthly and seasonal variability in concentrations is experienced at all sites. Median atrazine concentrations (0.95 – 1.1 ug/L; Figure 4.7) from samples collected between 1996 and 2005 are less than the EPA drinking water MCL of 3 ug/L. However, spikes measured during spring samples have exceeded the MCL. Highest concentrations historically have been measured at Site 8 (Republican River inflow), with values ranging from 0.08 – 12 ug/L (see Figure 4.8). No inflow samples were collected during 2006 due to drought conditions.

Secchi depths at Site 2 historically range from 0.18 – 0.69 m, which is significantly less than EPA's ecoregional target of 1.3 m. Historically high sediment inflows have impacted water clarity. Resuspension of sediment related to prevailing winds and shallow depth (drought) most likely influence current water clarity. Total suspended solids (TSS) samples corroborate the reduced water clarity, as TSS concentrations from surface samples ranged from 5 – 51 mg/L and near-bottom samples ranged from 21 – 210 mg/L.

No vertical profiles were recorded during 2006. However, profiles recorded during 2005 are presented in Figure 4.9. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Based on these profiles, the lake stratified both thermally and chemically between a depth of 3 – 4 m during June and a depth of 6-7 m during July (Figure 4.9). Stratification is typical of eutrophic lakes, and weak stratification is expected in south-central Nebraska lakes due to strong prevailing winds. These winds keep the lake mixed both thermally and chemically. The lake had 'turned over', or destratified, by the mid-September sample trip.

Fecal coliform (*E coli*) bacteria were monitored by lake personnel prior to three major holidays (i.e., Memorial Day, 4th of July, Labor Day) during the 2006 recreational season. None of the median values exceeded NDEQ's single sample maximum (235 colonies / 100 ml) during either 2005 or 2006 (Figure 4.10). In addition, *E coli* samples were last collected by NDEQ at the north swimming beach during 2002. The results were highly variable during the recreational season (Figure 4.11). Two samples exceeded the single

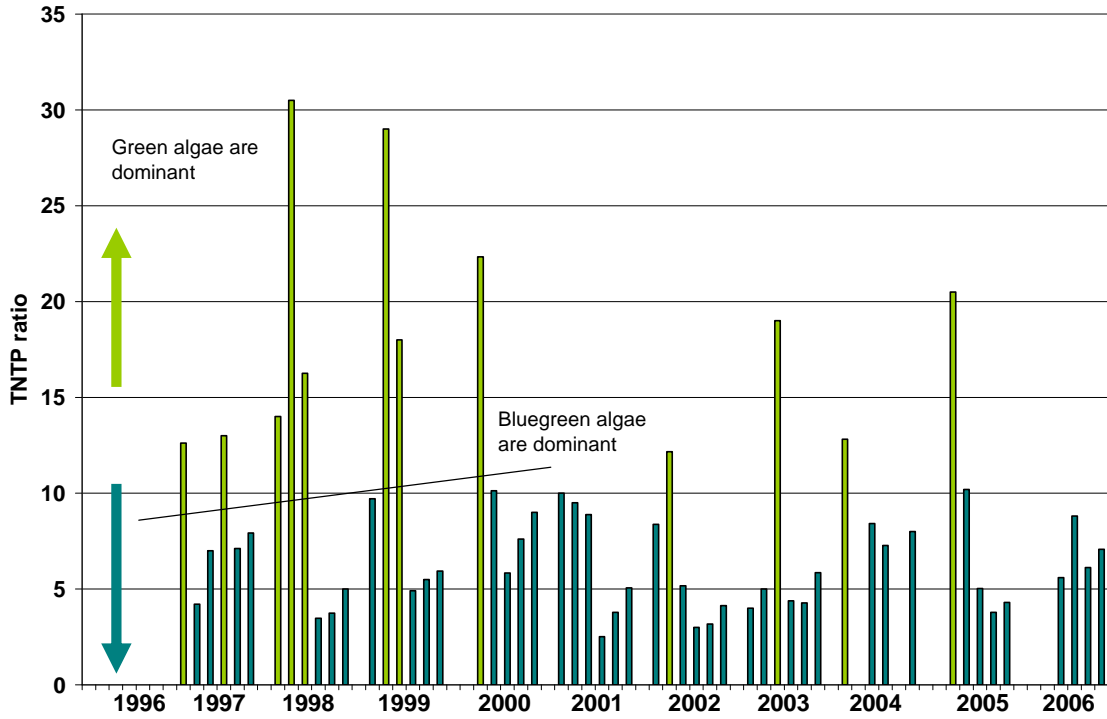


Figure 4.5. Graph of total nitrogen : total phosphorus ratio (TN:TP) by sample at Site 2 of Harlan County Lake from 1996 through 2006.

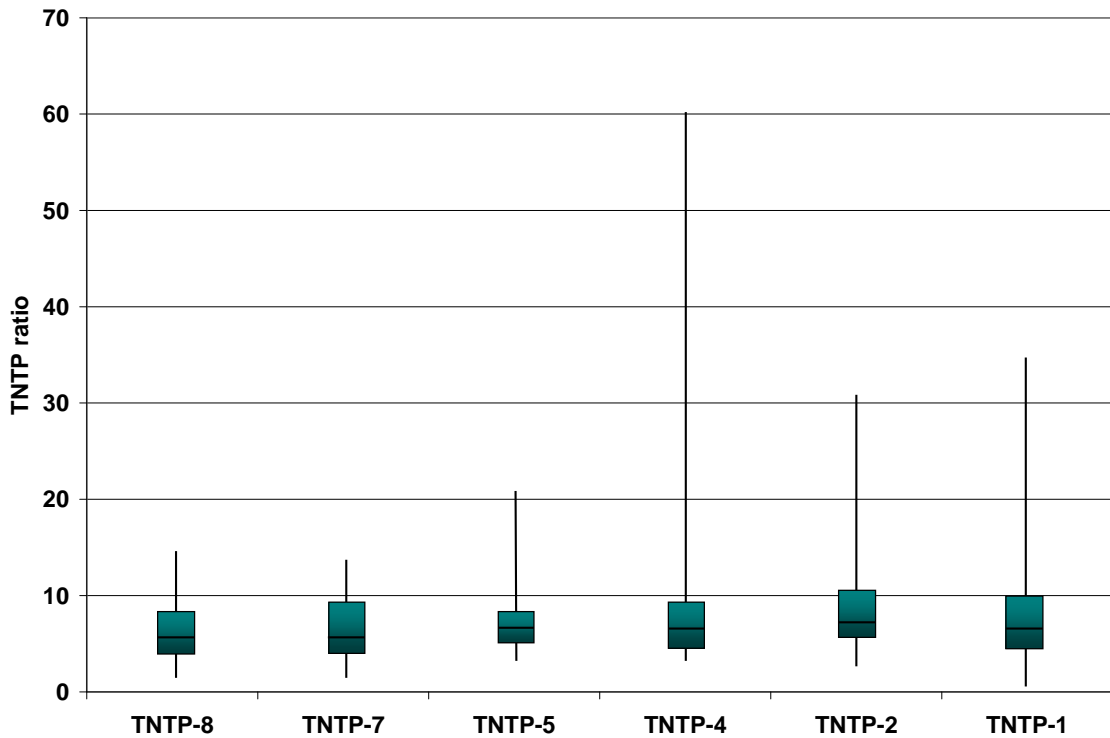


Figure 4.6. Box plots of total nitrogen : total phosphorus ratio from surface water samples by site from 1996 through 2006 at Harlan County Lake.

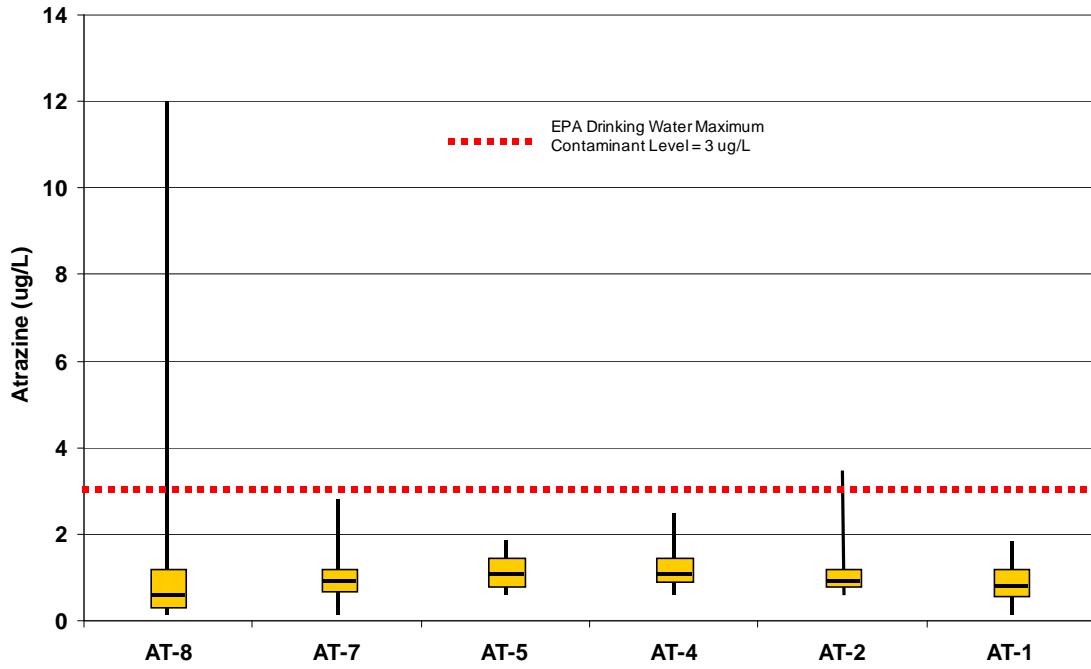


Figure 4.7. Atrazine concentrations by sample site at Harlan County Lake from 1996 through 2005.

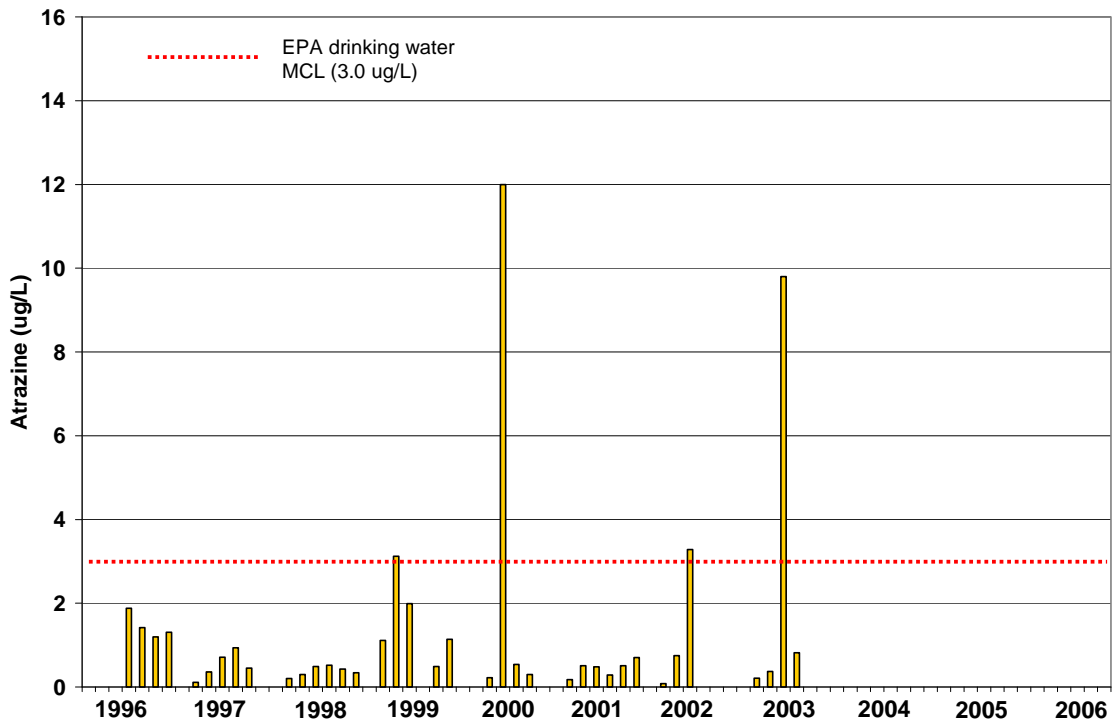


Figure 4.8. Atrazine concentrations by sample date at Harlan County Lake Site 8 (Republican River inflow) from 1996 through 2006.

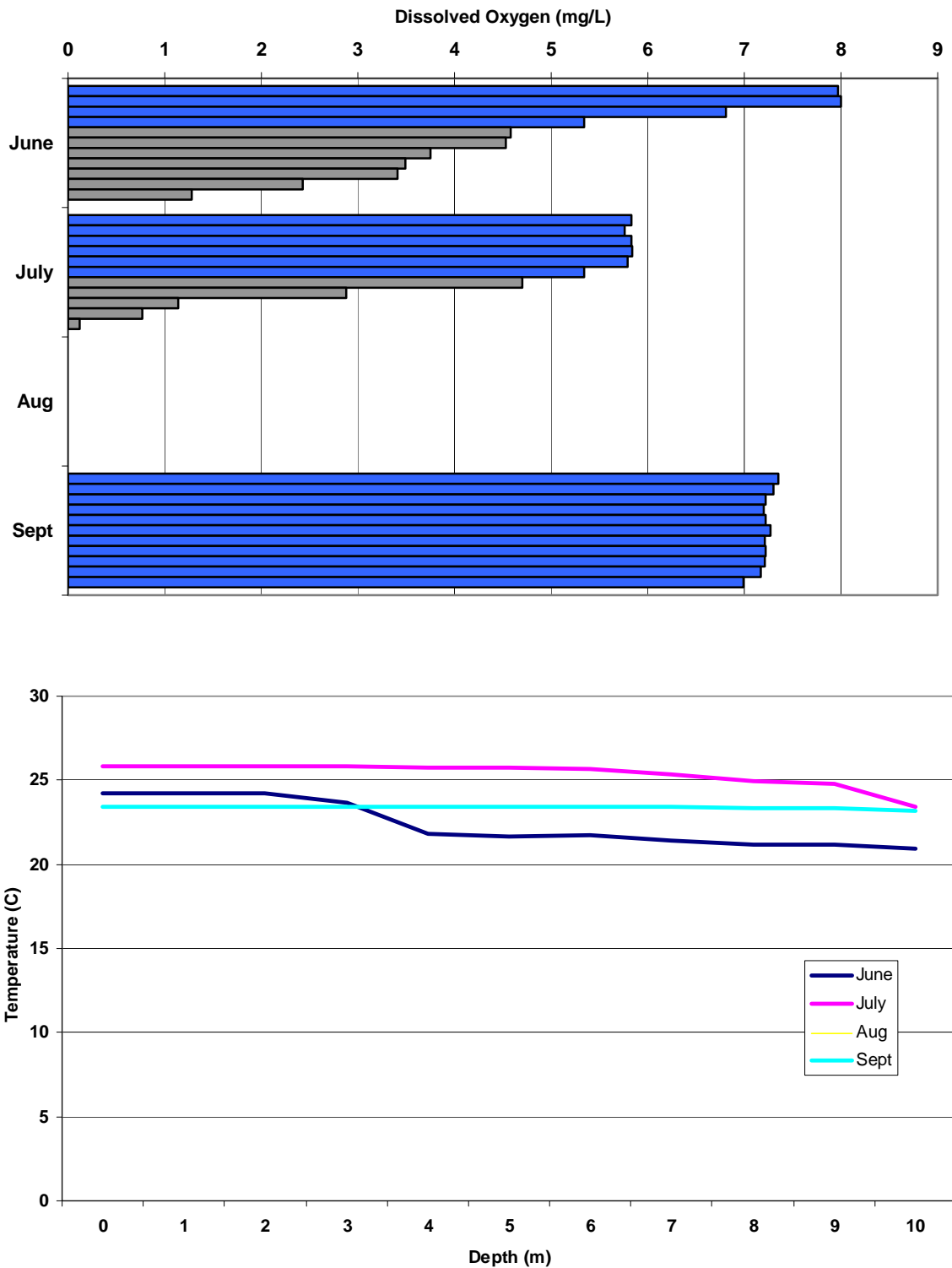


Figure 4.9. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plots by sample dates from vertical profiles recorded at Site 2 during 2005 at Harlan County Lake.

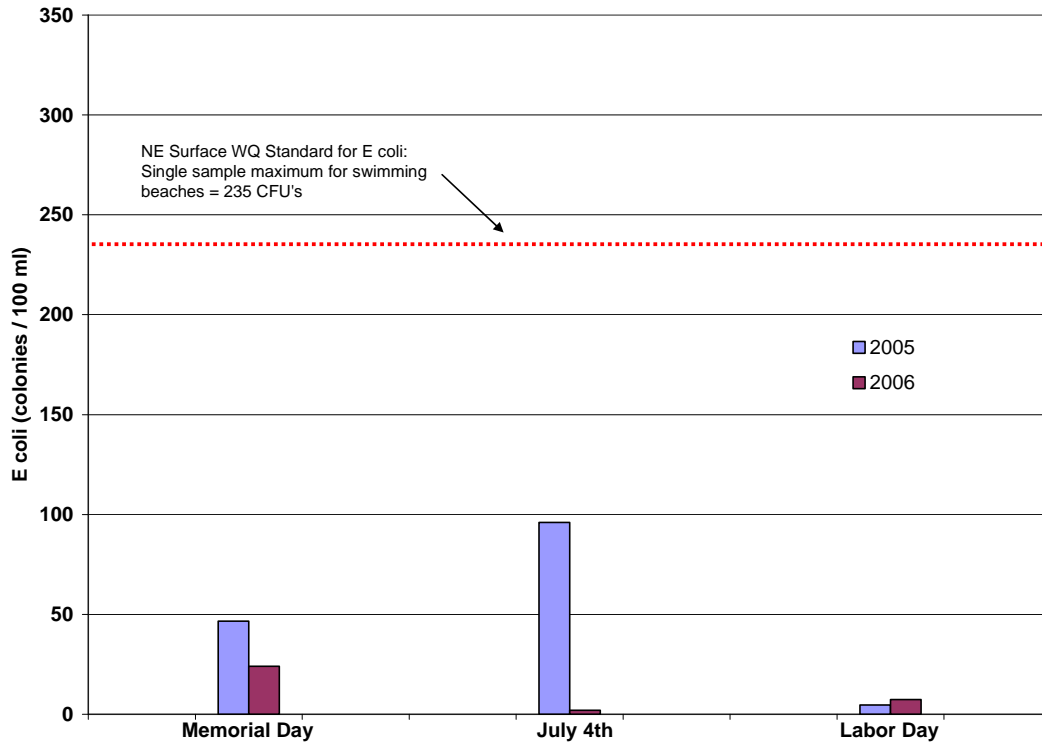


Figure 4.10. Fecal bacteria (E coli) monitoring results from USACE pre-holiday monitoring at Harlan County Lake's north beach during 2005 and 2006.

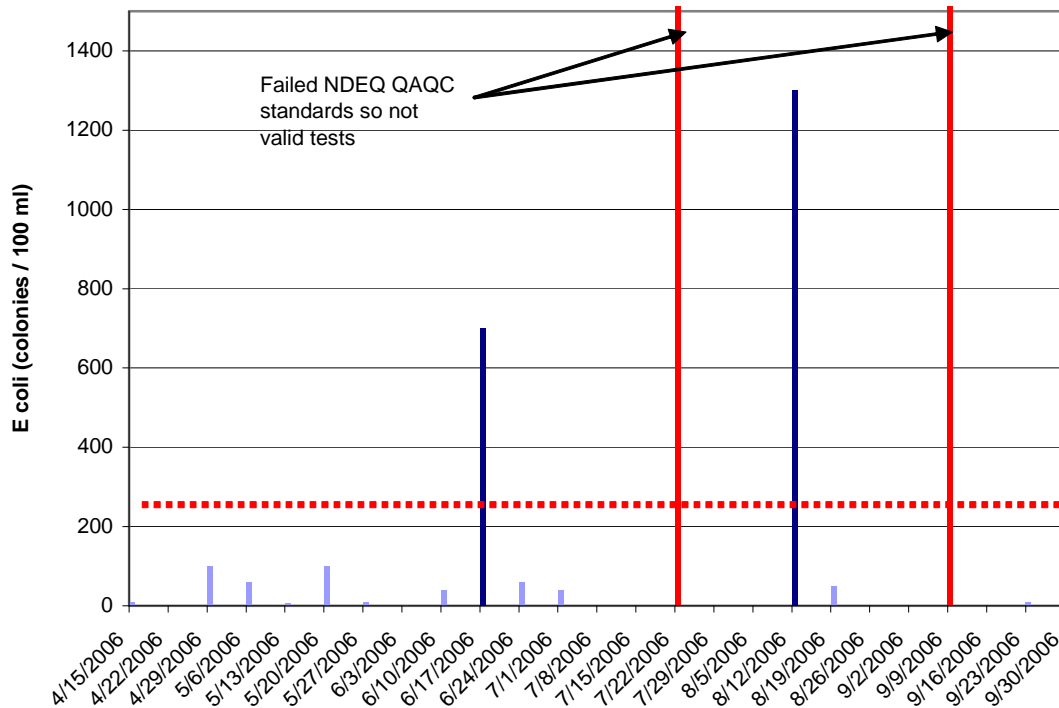


Figure 4.11. Fecal bacteria (E coli) monitoring results from NDEQ 2002 weekly testing at Harlan County Lake's north beach.

sample maximum, while another two samples exceeded the single sample maximum but failed their internal QAQC protocol.

4.3.3 Outflow

Because no water has been released from the lake the past two years, no outflow samples (site 1) have been collected since 2003.

4.4 Future Activities and Recommendations

Sampling activities for 2007 will continue monthly 'ambient' monitoring from May through September, as well as conducting at least one summer vertical profile at each of the three lake sites. Due to elevated TP concentrations and low TN : TP ratios, this lake will be monitored for the cyanotoxin microcystin during August and September. Nebraska Dept of Environmental Quality (NEDEQ) continues to monitor the lake for bluegreen algal blooms. 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. NEDEQ is scheduled to conduct intensive monitoring throughout the Republican River watershed during 2007.
