Copan Lake Water Quality: 2020

The Copan Lake dam is located about nine miles north of Bartlesville, Oklahoma (OK) and two miles SW of Copan, OK in Washington County, OK at river mile 7.4 on the Little Caney River, a tributary of the Caney River. The impoundment and watershed are within Hydrologic Unit Code 11070106. The reservoir extends north-northeast of the dam about six miles, and the watershed extends north and northwest through Montgomery and Chautauqua Counties in Kansas with headwaters in Elk County, Kansas. The conservation pool of Copan Lake was first filled in March 1984 after construction began in November 1972. Authorized purposes include flood damage reduction, water supply, water quality, fish and wildlife, and recreation. The project was designed and is regulated to provide maximum flood protection on Little Caney, Caney, and Verdigris Rivers when operated in conjunction with Hulah Lake and Oologah Lake. The total drainage area above the dam is ~505 square miles (Figure 1). Land use/cover (Dewitz, 2023) in the basin is dominated by grassland/pasture (~66%), forest (~22%), and cropland (5%). Based on a 2002 bathymetric survey (Texas Water Development Board, 2003), at the conservation pool elevation of 710.0 feet (NGVD 29), lake capacity had diminished by about 20% since impoundment due to sedimentation. Descriptive characteristics of Copan Lake are included in Table 1.

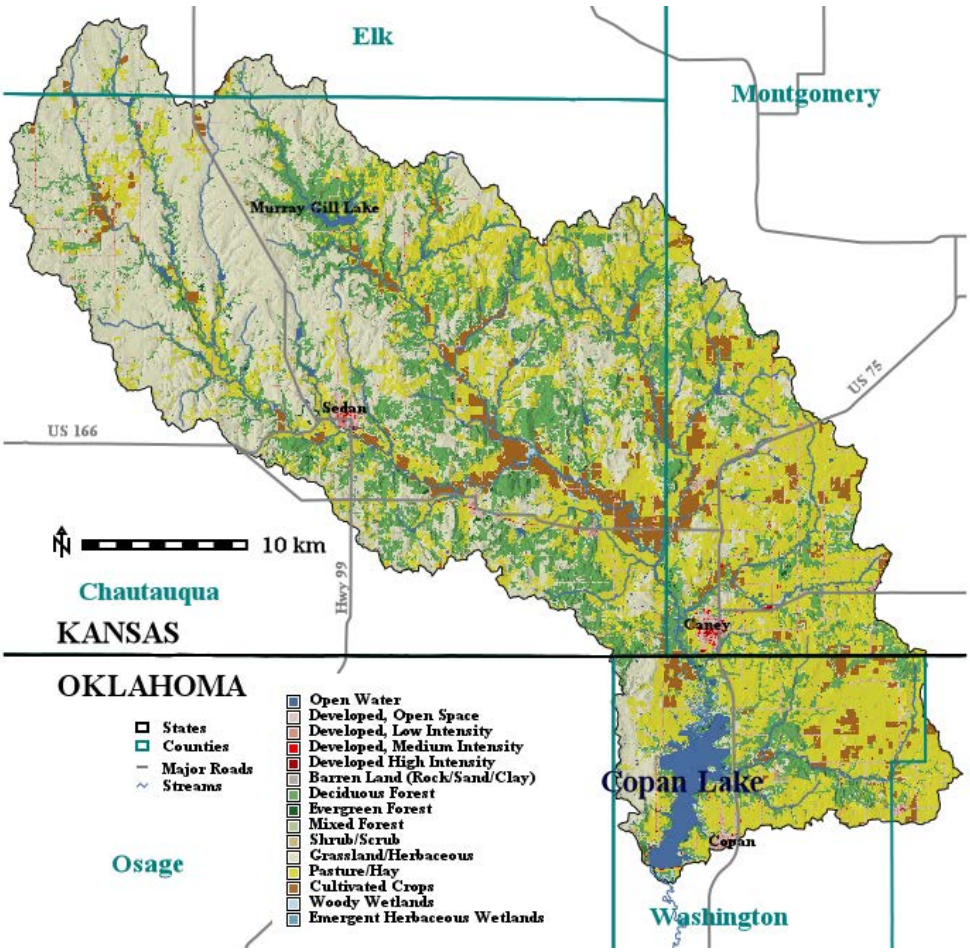

Figure 1. The Copan Lake (Little Caney River) Watershed above the Copan Lake Dam.

Table 1. Descriptive Characteristics of Copan Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	710.0 ft. NGVD	216.41 m
Lake Surface Area (Conservation Pool)	4,400 ac	1,780 ha
Lake Volume (Conservation Pool)	34,645 ac-ft	$42.734*10^6$ m^3
Total Drainage Area (contributing)	505 mi^2	1,308 km^2
Mean Depth	7.9 ft.	2.4 m
Maximum Depth (Conservation Pool)	37 ft.	11.3 m
Shoreline Length	49.7 mi	79.98 km
Shoreline Development Index	5.5	5.5
Annual Inflow, Average 1936 – 2020 [Water Years]	246,880 ac-ft	$304.522*10^6$ m^3
Annual Inflow, 2020 [Calendar Year]	456,865 ac-ft	$563.535*10^6$ m^3
Hydraulic Residence Time, 2021 [Calendar Year]	33.4 d	0.9 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2020 Annual Water Control Report (U.S. ACE - SWD RCC, 2021), Tulsa District's Water Control page for Copan Lake (U.S. ACE - Tulsa District, 2023), and the 2002 bathymetric survey (Texas Water Development Board, 2003).

Designated beneficial uses of the impoundment created by the Copan Lake Dam include Public and Private Water Supply, Fish and Wildlife Propagation as a Warm Water Aquatic Community, Agriculture, Primary Body Contact Recreation, Aesthetics, and the lake and watershed are designated as a Sensitive Public and Private Water Supply (OAC, 2023). Based on the 2022 Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ 2022), Copan Lake is listed as impaired by turbidity affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community, by high algal concentrations affecting Public and Private Water Supply, and mercury affecting fish consumption.

Physical and chemical water quality data were collected monthly by USACE from three in-lake sites, the stilling basin, and one upstream site at Copan Lake beginning 01 June and ending 08 September 2020 to define existing limnological conditions, provide a basis for future water quality investigations, and to support operational and environmental missions of the Tulsa District. Sampled sites included COPOKN0223 (over channel at the dam), COPOKN0224 (mid-lake W of Washington Cove Park), COPOKN0225 (upper lake SE of Osage Plains Park), COPOKN0222 (downstream of the stilling basin below the dam), and COPKSS0054 (Little Caney River W of Caney, KS). In-lake sites were accessed by boat, and samples were collected from locations over the deepest portion of the stream channel (thalweg). Sampling locations are identified in Figure 2.

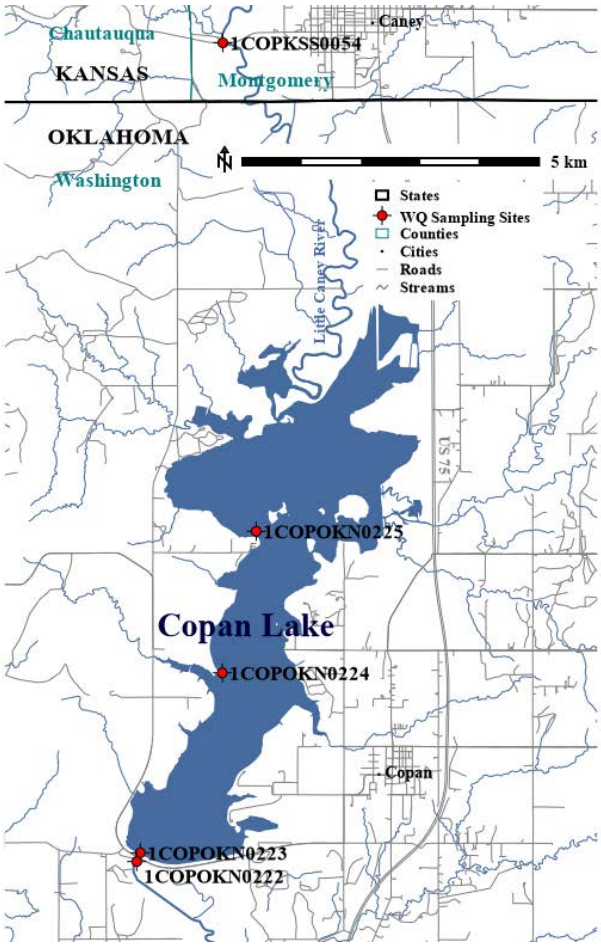

Figure 2. Locations of water quality sampling sites at Copan Lake, OK, 2020.

The Copan Lake pool was at or above the conservation pool elevation throughout the sampling period in calendar year 2020. Calendar year 2020 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3. Water quality samples were not collected in April and May 2020 due to high lake levels.

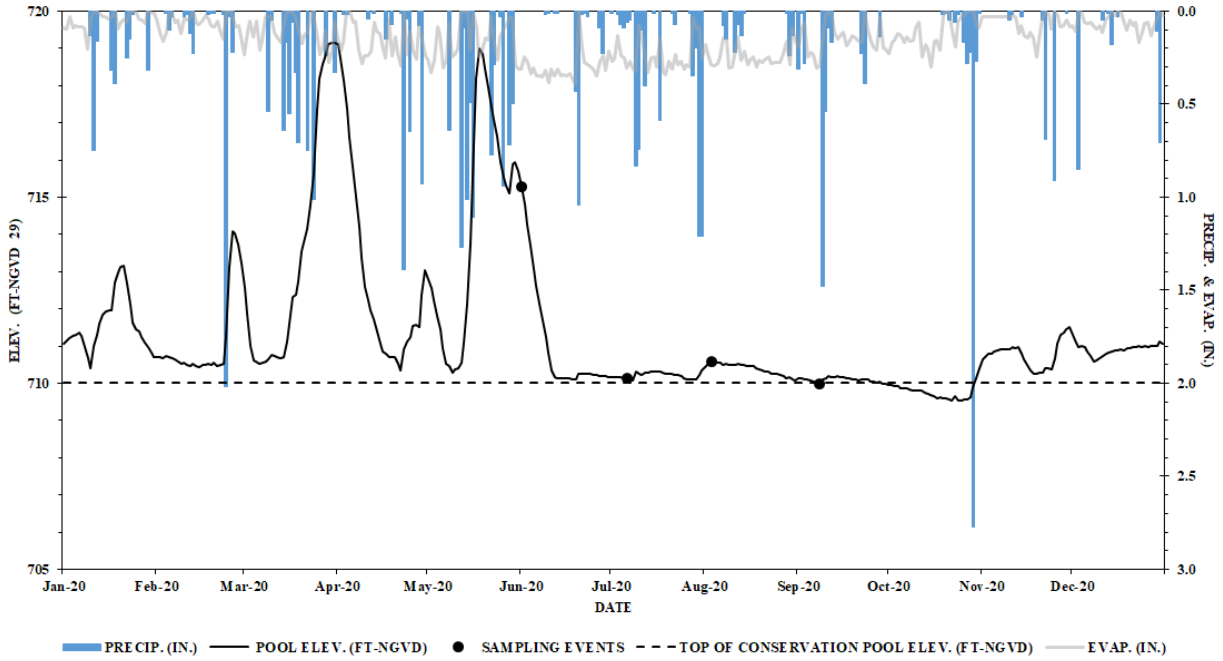

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Copan Lake, OK, 2020.

Water temperatures varied seasonally (ranging from 18.21 to 30.46 ºC) peaking in July. Weak thermal stratification was observed at all in-lake sites in June. The study period lakewide median dissolved oxygen concentration (DO) was 5.48 mg/l. Observed in-lake DO ranged from 0.14 to 9.39 mg/l. Lowest DO concentrations were observed at depth at COPOKN0224 (mid-lake) in June and July. Highest DO concentrations were observed near the surface at sites COPOKN0224 and COPOKN0225 in September. Lakewide total organic carbon concentrations were high with a study period median of 7.56 mg/l. Observed median total organic carbon concentrations were highest at the upper lake site, COPOKN0225 (8.11 mg/l).

Specific conductance (median 237 µS/cm) was moderate, consistent with regional geology. Total dissolved solids median concentration was 153.5 mg/l. Low chloride and sulfate concentrations (medians 13.8 and 9.31 mg/l, respectively) were observed. Alkalinity levels (median 96.2 mg/l as $CaCO_3$) imply a system capable of maintaining pH levels. Hardness levels, median 98.45 mg/l as $CaCO_3$, indicate moderately 'hard' water. Observed in-lake pH (7.18 to 8.91) ranged within regional norms. Highest pH was recorded near the surface at all in-lake sites in July, and lowest pH was recorded in June at depth at sites COPOKN0224 and COPOKN0225.

The lake was moderately turbid through the 2020 study. Median Secchi depth was 0.44 meters. Median Secchi depth increased from site COPOKN0225 (0.33 m) down-lake to the dam site (COPOKN0223, 0.55 m). In-lake median turbidity was 40.3 NTUs, and 77% of all in-lake observations were greater than or equal to 25 NTUs. Median total suspended solids concentrations (21.5 mg/l) decreased from the upper lake site (COPOKN0225, 34.5 mg/l) down to the dam site (COPOKN0223, 15.5 mg/l). The euphotic zone at Canton Lake ranged from 1.7 to 2.4 meters with greatest depths in June and July.

Lakewide ammonia concentrations (median 0.04 mg/l) and nitrite plus nitrate concentrations (median 0.06 mg/l) were moderate to low. Total Kjeldahl nitrogen concentrations (median 0.60 mg/l) were moderately high. Estimated lakewide median surface total nitrogen concentration during the 2020 study was 0.66 mg/l. Total phosphorus concentrations ranged between 0.08 and 0.23 mg/l (median 0.15 mg/l). Detectable concentrations of dissolved ortho-phosphate, median 0.05 mg/l, were present in all samples. Nitrogen to phosphorus ratios (N:P) in 2020 were <10 (median 5.28) indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-*a* concentrations (in-lake) ranged from 5.0 to 22.3 µg/l, with a median concentration of 17.3 µg/l. All in-lake observations of chlorophyll-a concentration, except at COPOKN0223 in June (5.0 µg/l), were greater than 11 µg/l. Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton sampled at Copan Lake site COPOKN0223. Cyanophyte (blue-green 'algae' that are photosynthetic bacteria) abundance increases through the sampled period, while biovolume shows consistent representation of Bacillariophytes (diatoms), Cryptophytes (flagellated algae), and others. Figure 5 summarizes zooplankton densities observed in 2020 (note the log scale density axis). Cladocerans, Copepods, and Rotifers were well represented across the sampling period. Ostracods (tiny crustaceans that feed on filamentous algae) appeared in lower densities near COPOKN0223 in June, and in low densities at COPOKN0224 and COPOKN0225 (not shown) in July and August.

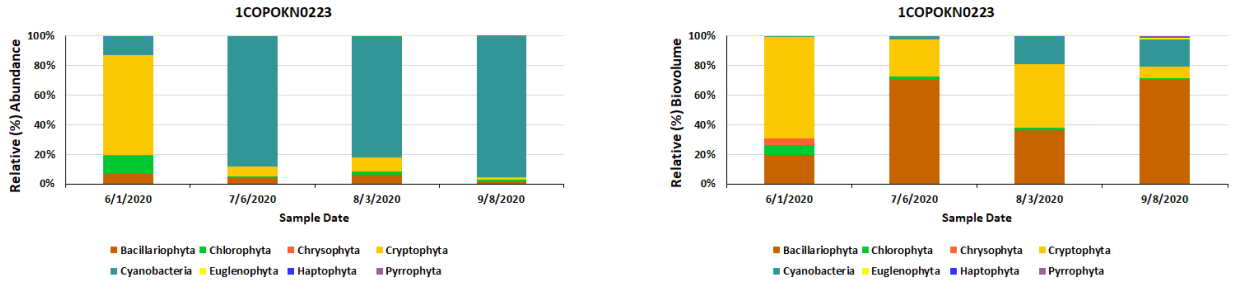

Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at COPOKN0223, June through September 2020.

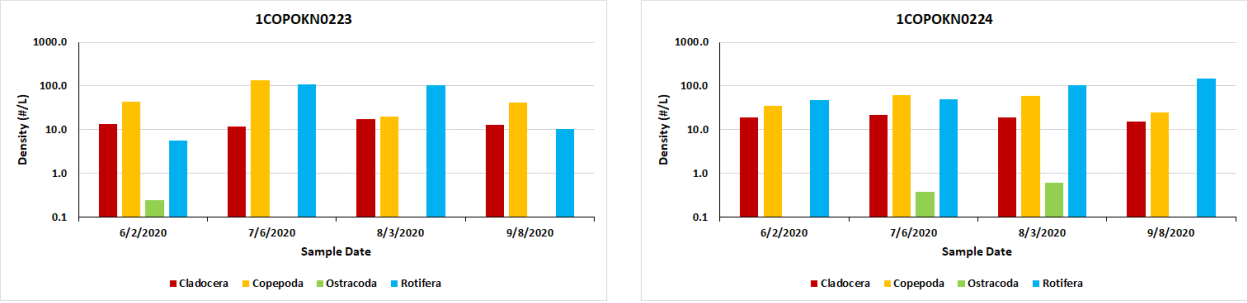

Figure 5. Zooplankton density at COPOKN0223 (left) and COPOKN0224 (right) June through September 2020.

Trophic status of Copan Lake was assessed using all three metrics of Carlson's trophic state index (TSI) at each in-lake site. Indexes based on Secchi depth (TSI(SD)) and surface total phosphorus (TSI(TP)) indicated a hyper-eutrophic lake with lakewide median values of 71.8 and 73.6, respectively. The index developed from chlorophyll-*a* concentrations (TSI(CHLa)) indicated a more moderate level of eutrophy, 58.5 (Figure 6).

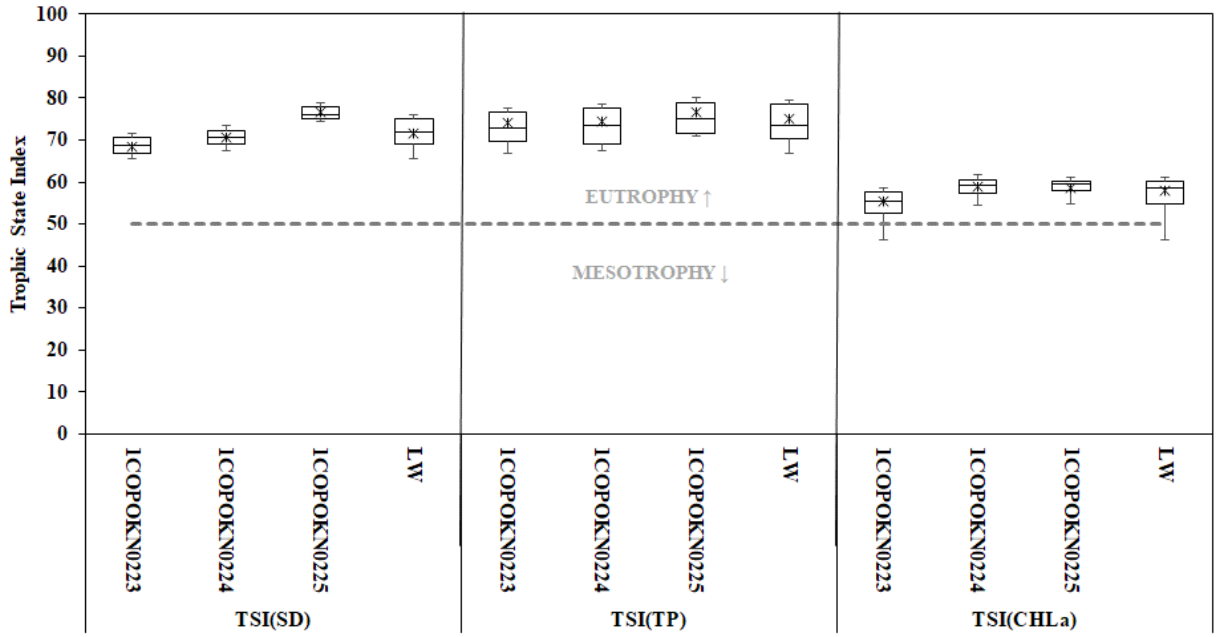

Figure 6. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Copan Lake, OK, June through September 2020.

Total iron (median 0.59 mg/l) and manganese (median 0.20 mg/l) concentrations were high. Reportable concentrations of arsenic were found in all in-lake samples collected with a median concentration of 0.0048 mg/l. Reportable concentrations of chromium, copper, lead, nickel, and zinc were noted in all in-lake samples. One (of 24) samples had a reportable concentration of mercury.

Sampling period results from the upstream site, COPKSS0054, compared to in-lake, showed higher total suspended solids (median 68.0 mg/l), and also higher ammonia, total Kjeldahl nitrogen, nitrite plus nitrate, and iron (medians 0.09, 0.73, 0.40, and 0.85 mg/l, respectively). Water samples collected from below the dam at site COPOKN0222 revealed constituent levels and concentrations comparable to samples collected from depth at the dam site (COPOKN0223), although slightly higher median concentrations of ammonia, nitrite plus nitrate, total phosphorus, dissolved orthophosphate, iron, and manganese were noted.

USACE previously conducted water quality sampling at Copan Lake, OK in 1994 and 2006. Both efforts indicated summer month thermal stratification with associated hypoxia at depth, and reduced water clarity. Nutrients, both nitrogen and phosphorus, were present in concentrations sufficiently high to support a highly productive system. Iron and manganese concentrations were high. Assessment of priority pollutant metals indicates the consistent presence of arsenic below concentrations of concern. Reportable concentrations of mercury were less frequent in 2020 than in the 1994 and 2006 sampling efforts.