

## Pine Creek Lake Water Quality: 2018

The Pine Creek Lake dam is located at river mile 145.3 on the Little River about five miles northwest of Wright City, McCurtain County, Oklahoma (OK). The impoundment extends ~9.5 miles north-northwest upstream of the dam following the Little River channel, with a significant branch extending west-southwest of the dam following the Pine Creek channel. Pine Creek Lake, within Hydrologic Unit Code (HUC) 1114010703 (Middle Little River) is a multipurpose project for flood control, water supply, water quality, fish and wildlife, and recreation. The project was designed and is regulated to provide for maximum flood protection on the Little River and on the Red River when operated in conjunction with the Little River and Red River Basin Systems. Construction began in February 1963 and the conservation pool was filled in January 1970. Pine Creek Lake is operated along with Broken Bow (OK) and DeQueen (Arkansas) Lakes to provide maximum flood control benefits to the upper limits of Millwood Lake (Arkansas). The total drainage area above the dam is 635 square miles with headwaters of the Little River reaching into the mountainous country of Le Flore County in southeast Oklahoma. The full watershed is shown in Figure 1. Land use/cover (Dewitz, 2023) in the basin is dominated by forest (74%), grassland/pasture (~11%), and scrub/shrub (~10%). Based on a 2011 bathymetric survey (Wilson & Company, Inc., 2011), at the conservation pool elevation of 438.0 feet (NGVD 29), lake capacity has diminished about 15% since impoundment due to sedimentation. Descriptive characteristics of Pine Creek Lake are included in Table 1.

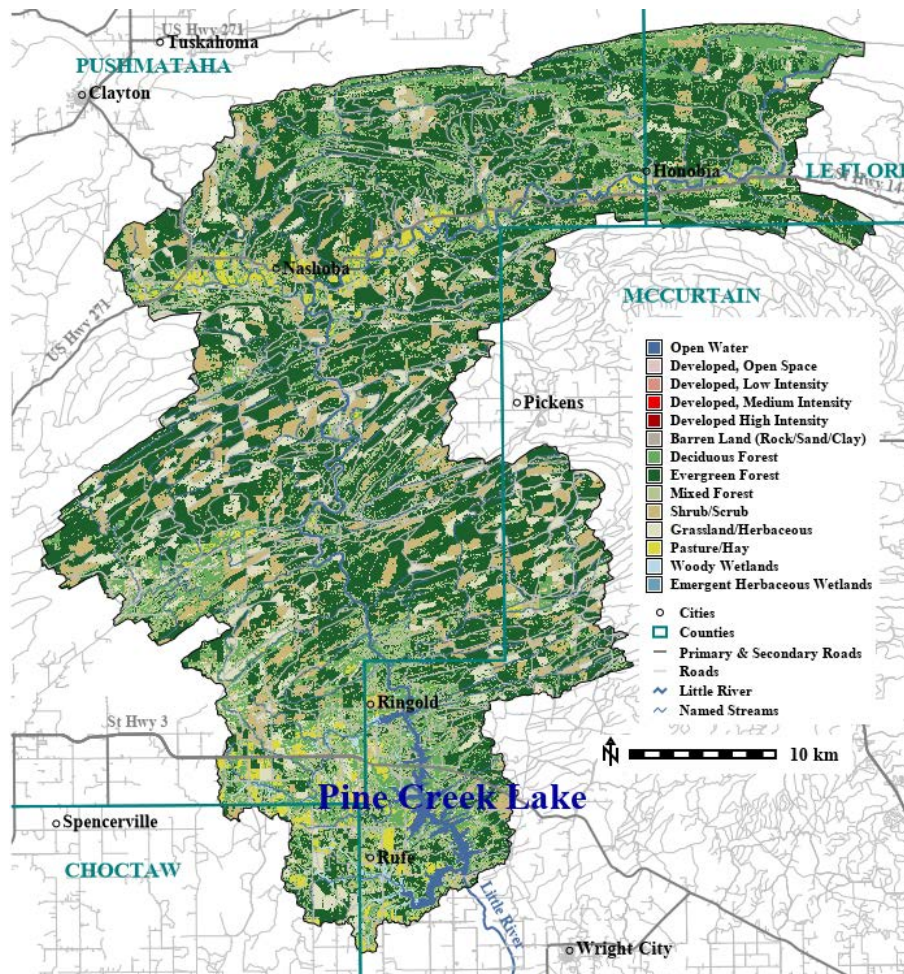


Figure 1. The Pine Creek Lake (Little River) Watershed above the Pine Creek Lake Dam.

**Table 1. Descriptive Characteristics of Pine Creek Lake, OK.**

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	438.0 ft. NGVD	133.5 m
Lake Surface Area (Conservation Pool)	3,755 ac	1,519.6 ha
Lake Volume (Conservation Pool)	51,792 ac-ft	63.885*10 <sup>6</sup> m <sup>3</sup>
Total Drainage Area (contributing)	635 mi <sup>2</sup>	1,644.6 km <sup>2</sup>
Mean Depth	13.8 ft.	4.2 m
Maximum Depth (Conservation Pool)	50 ft.	15.25 m
Shoreline Length	90.5 mi	145.6 km
Shoreline Development Index	10.7	10.7
Annual Inflow, Average 1938 – 2018 [Water Years]	674,500 ac-ft	831.98*10 <sup>6</sup> m <sup>3</sup>
Annual Inflow, 2018 [Calendar Year]	863,805 ac-ft	1,065.49*10 <sup>6</sup> m <sup>3</sup>
Hydraulic Residence Time, 2018 [Calendar Year]	35.5 d	0.10 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2018 Annual Water Control Report (U.S. ACE - SWD RCC, 2019), Tulsa District's Water Control page for Pine Creek Lake (U.S. ACE - Tulsa District, 2023), and the 2011 bathymetric survey (Wilson & Company, Inc., 2011).

Designated beneficial uses of the impoundment created by the Pine Creek 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 reservoir and the Little River upstream are designated as High Quality Waters (OAC, 2023). Based on the 2022 Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ 2022), Pine Creek Lake is listed as impaired by low dissolved oxygen concentrations, elevated lead concentrations, and low pH affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community; and also impaired by mercury concentrations affecting Fish and Shellfish Consumption.

Physical and chemical water quality data were collected monthly by USACE from three in-lake sites and the tailwater beginning 24 April and ending 18 September 2018 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 PCROKS0147 (channel at the dam), PCROKS0146 (mid-lake), PCROKS0145 (upper lake at State Highway 3 bridge), and PCROKS0171 (tailwater below dam). Sites PCROKS0147, PCROKS0146, and PCROKS0145 were accessed by boat from locations over the deepest portion of the stream channel (thalweg). Sampling locations are identified in Figure 2.

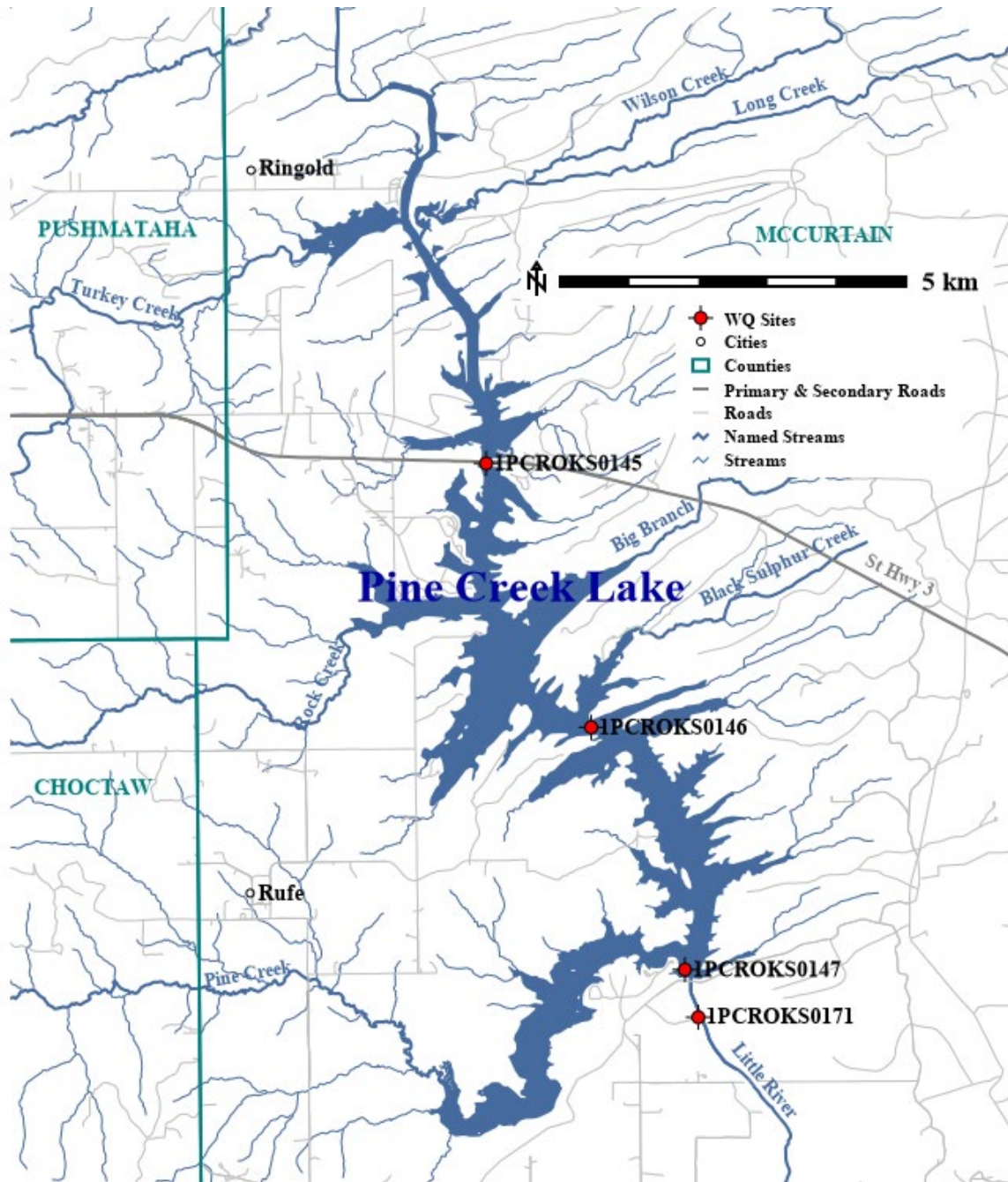
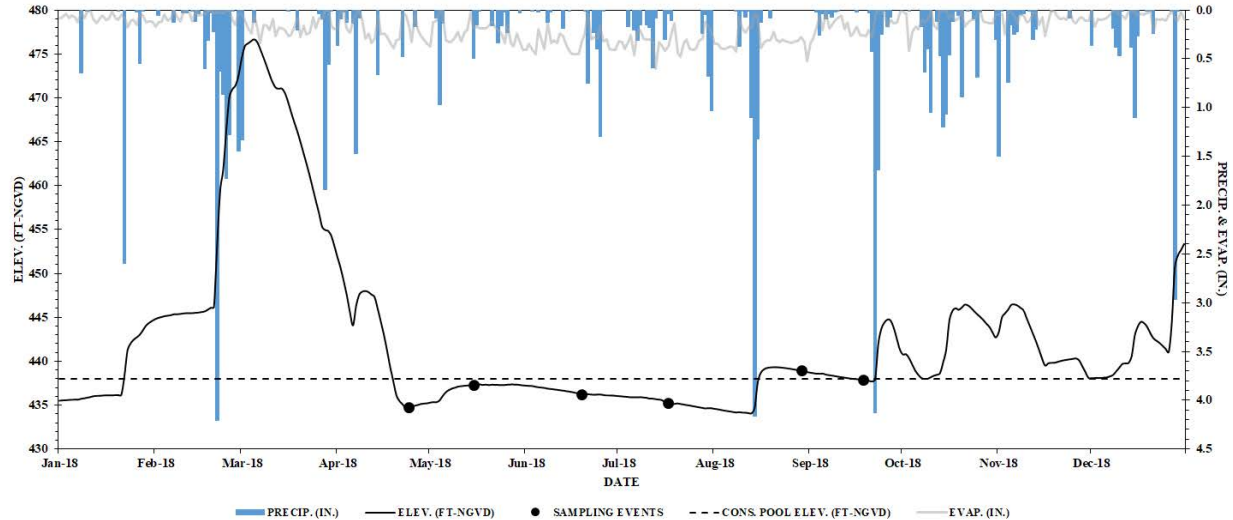


Figure 2. Locations of water quality sampling sites at Pine Creek Lake, OK, 2018.

The Pine Creek Lake pool was near the conservation pool elevation April through September 2018. Calendar year 2018 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.



**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 Pine Creek Lake, OK, 2018.**

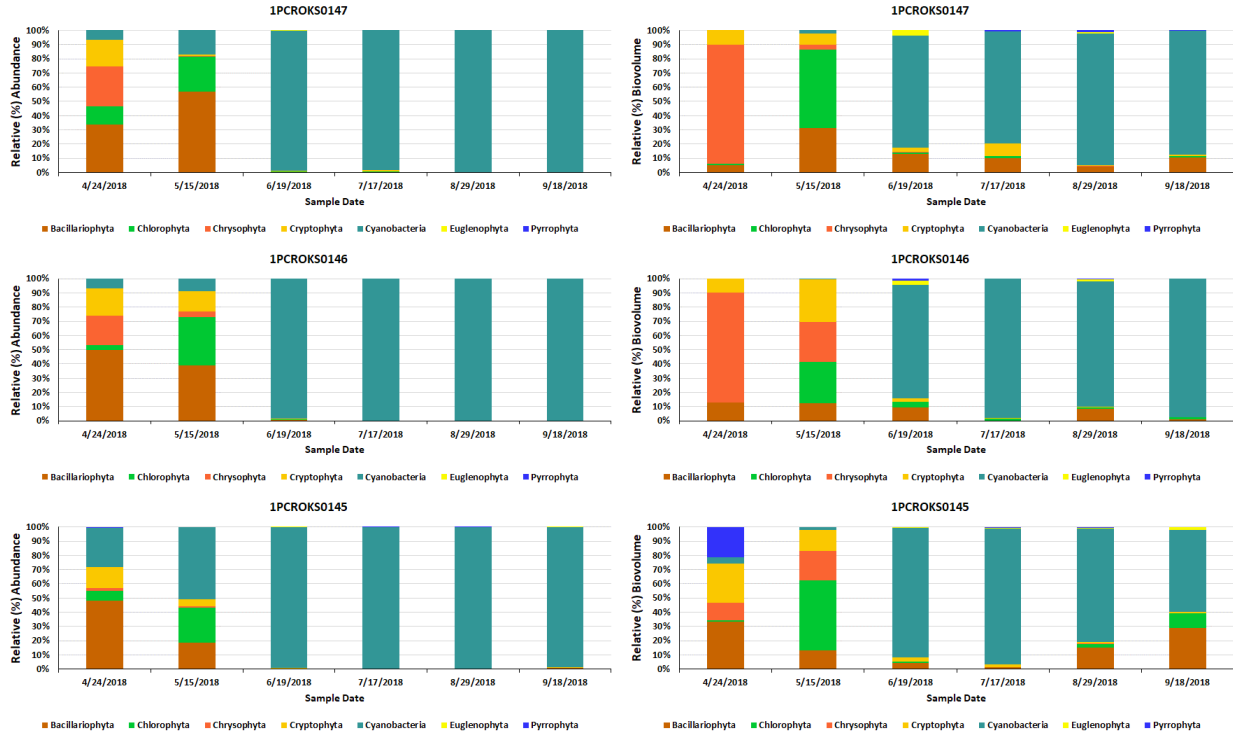
Water temperatures varied seasonally (ranging from 14.56 to 31.82 °C) peaking in July. All observations >30 °C occurred in July at all three in-lake sites from the surface to 3-meters depth. Water temperature observations <16 °C occurred in April 2018 all three in-lake sites at depth. Thermal stratification was noted beginning in May 2018 at all three in-lake sites (PCROKS0147, PCROKS0146 and PCROKS0145) continuing through September. The study period lakewide median dissolved oxygen concentration (DO) was 3.26 mg/l. Median DO was nominally higher at the dam site (PCROKS0147, 3.74 mg/l) and lowest at PCROKS0145 (2.56 mg/l). Observed in-lake DO ranged from 0.07 to 9.45 mg/l. DO concentrations (<2 mg/l) were observed May 2018 at PCROKS0145 (8-meters and below), and at all three in-lake sites June through September. June through September 2018, no less than 60% of the water column was hypoxic (DO ≤2 mg/l) at all three in-lake sites. Highest DO concentrations (>8.5 mg/l) were observed at PCROKS0147 in April (surface to 4-meters depth) and September (surface). Total organic carbon (TOC) concentrations were high with a lakewide study period median of 7.68 mg/l. Observed site median total organic carbon concentrations were comparable. Bottom sample TOC concentrations (median 8.84 mg/l) were consistently higher than surface concentrations (median 7.21 mg/l).

Specific conductance, ranging from 37.0 to 184.0 μS/cm (lakewide median 45.0 μS/cm), was low. Median site conductance was similar at all three sites. Highest conductance levels were recorded at depth in August and September. Total dissolved solids median concentration was 62.0 mg/l with site medians ranging from 60.15 (PCROKS0147) to 65.0 (PCROKS0145) mg/l. Lakewide chloride and sulfate concentrations (medians 2.35 and 3.29 mg/l, respectively) were low. Alkalinity levels (lakewide median 12.15 mg/l as CaCO<sub>3</sub>) suggest a system with limited buffering capacity to maintain pH levels. Hardness levels, lakewide median 11.3 mg/l as CaCO<sub>3</sub>, indicate 'soft' water. Low hardness waters have a reduced ability to complex and reduce toxicity of metal contaminants. Observed in-lake pH ranged from 6.20 to 8.90 (median 6.66) and 85% of all observations were <7. Highest pH (>8.5) was recorded near the surface at PCROKS0147 and PCROKS0146 in July. Lowest pH was recorded in August at depth at PCROKS0147 and PCROKS0145.

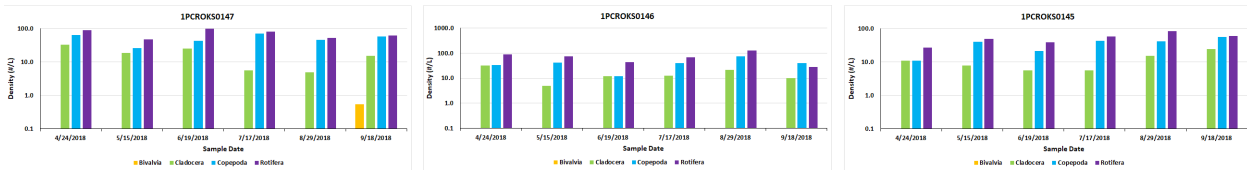
Median lakewide Secchi depth was 0.89 meters. Through the sampling period, median Secchi depth was lowest in the upper lake (PCROKS0145, 0.70 m) and highest at the dam site (PCROKS0147, 0.95 m). Lakewide median turbidity was 18.3 NTUs, and 32% of all in-lake observations were greater than or equal to 25 NTUs. Median site turbidity progressively increased from PCROKS0147 (15.7 NTUs) to PCROKS0145 (19.3 NTUs). Median lakewide total suspended solids concentration was 8.88 mg/l, with median site concentrations increasing from PCROKS0147 (7.5 mg/l) to PCROKS0145 (11.5 mg/l). The euphotic zone at Pine Creek Lake site PCROKS0147 ranged from 1.5 to 3.5 meters with depths of 3.5 meters in July, August, and September.

Lakewide ammonia concentrations (median 0.11 mg/l) and nitrite plus nitrate concentrations (median 0.04 mg/l) were moderate to low, respectively. Highest ammonia concentrations were found in bottom samples at in-lake sites (median 0.66 mg/l). Total Kjeldahl nitrogen concentrations (lakewide median 0.67 mg/l) were highest in the bottom samples from the three in-lake sites (median 1.04 mg/l). Estimated lakewide median surface total nitrogen concentration during the 2018 study was 0.57 mg/l. Total phosphorus concentrations lakewide ranged between 0.01 and 0.21 mg/l (median 0.02 mg/l). Detectable concentrations of dissolved ortho-phosphate, lakewide median 0.01 mg/l, were present in 8% of samples collected. Nitrogen to phosphorus ratios (N:P) in 2018 were >20 (median 35.4) indicating a tendency toward phosphorus limited phytoplankton growth.

Chlorophyll-a concentrations (in-lake) ranged from 4.7 to 31.3 µg/l, with a median concentration of 20.9 µg/l. Median chlorophyll-a concentrations were highest at the upper lake site (PCROKS0145, 21.85 µg/l). Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton sampled at Pine Creek Lake sites. Bacillariophyte (diatoms), Chlorophyte (green algae), Chrysophyte (*Mallomonas* exclusively), Cryptophyte (flagellated unicellular algae), and Cyanophyte (blue green 'algae' that are photosynthetic bacteria) abundance is diverse in April and May shifting to Cyanophyte dominance June through September. Relative biovolume graphics show a similar pattern by site and season. *Mallomonas*, a Chrysophyte, is an indicator of deteriorating conditions in water. Figure 5 summarizes zooplankton densities observed in 2018 (note the log scale density axis) at PCROKS0147, PCROKS0146, and PCROKS0145. Cladocerans, Copepods, and Rotifers were generally well represented across the sampled period. Quantifiable Bivalve density, specifically *Dreissena* (zebra mussels) veligers, were noted only in September 2018 at PCROKS0147.

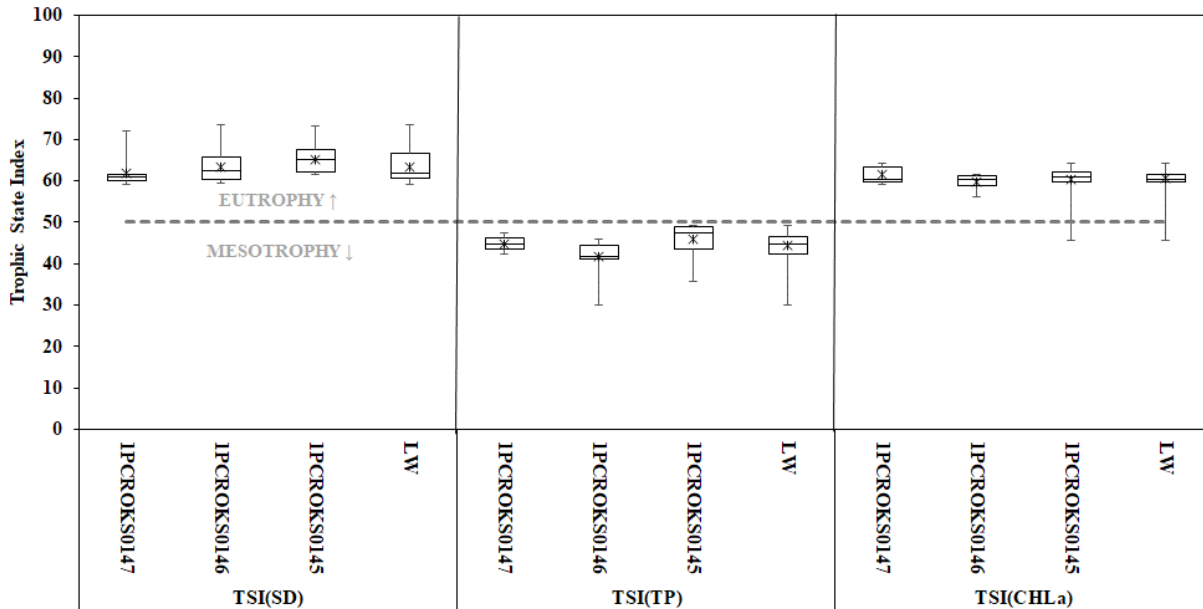


**Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at PCROKS0147, PCROKS0146, and PCROKS0145 April through September 2018.**



**Figure 5. Zooplankton density at PCROKS0147, PCROKS0146, and PCROKS0145 April through September 2018.**

Trophic status of Pine Creek Lake was assessed using all three metrics of Carlson's trophic state index (TSI) at each in-lake site and the lake as a whole. Median lakewide indexes based on Secchi depth (TSI(SD)) and chlorophyll-a concentrations (TSI(CHL<sub>a</sub>)) were >60.0. The median lakewide index developed from surface total phosphorus concentrations (TSI(TP)), 44.6, was significantly lower (Figure 6). While surface total phosphorus concentrations were generally low in 2018, Pine Creek Lake exhibited symptoms of eutrophy.



**Figure 6. Distributions of Carlson's Trophic State 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(CHL a)) at Pine Creek Lake, OK, April through September 2018.**

Total iron (lakewide median 1.02 mg/l) and manganese (lakewide median 0.15 mg/l) concentrations were high. Lakewide median bottom total iron and manganese concentrations were 3.44 and 0.82 mg/l, respectively. Reportable concentrations of arsenic were found in all in-lake samples collected, with a median concentration of 0.0012 mg/l. Reportable concentrations of copper, nickel, and zinc were noted in all in-lake samples. Reportable concentrations of chromium and lead were present in 39 and 75%, respectively, of samples collected. Detectable mercury concentrations were noted in 39% of all samples. Statistical summaries of water quality parameters from the tailwater (PCROKS0171) were comparable to data collected at depth at PCROKS0147.

USACE previously conducted water quality sampling at Pine Creek Lake, OK in 1989 and 2000. Observations at Pine Creek Lake revealed thermal stratification and hypolimnetic hypoxia June through August. Water clarity was relatively good with no turbidity observations >25 NTUs, and mean Secchi depth was 0.98 m. The water had limited buffering capacity because of low alkalinity. Lake pH was circumneutral, tending toward the acidic side (<7). Nutrients nitrogen and phosphorus were seasonally variable but present in concentrations sufficient to support a productive system. Iron and manganese concentrations were high. Using total phosphorus and chlorophyll-a as indicators, the lake was classified as eutrophic.