El Dorado Lake Water Quality: 2023

The El Dorado Lake dam is located on the Walnut River, a tributary of the Arkansas River at river mile 114.7, about two miles northeast of the city of El Dorado in Butler County, Kansas within Hydrologic Unit Code 1103001703. Construction began in October 1973. The present reservoir incorporated two smaller lakes already in existence, Bluestem Lake and the 'old' El Dorado Lake. The conservation pool of El Dorado Lake was first filled in February 1985 after final storage began in June 1981. Authorized purposes include flood damage reduction, water supply, water quality, fish and wildlife, and recreation. The watershed above the El Dorado Lake dam site extends northeast ~20 miles with an east/west width of ~14 miles and encompasses ~244 square miles (Figure 1) with basin elevations ranging from about 1,333 feet below the dam to ~1,635 feet. Land use/cover in the basin (Dewitz, 2023) is dominated by grassland/pasture (80.7%) and cultivated cropland (6.2%). At the conservation pool elevation of 1,339.0 feet (NGVD 29), lake capacity has diminished by about 7.6% since construction due to sedimentation (KWO, 2017). The most recent bathymetric survey conducted in 2010 (KBS, 2012) indicated an annual conservation pool sedimentation rate of 349 ac-ft/yr since embankment closure. Descriptive characteristics of El Dorado Lake are included in Table 1.

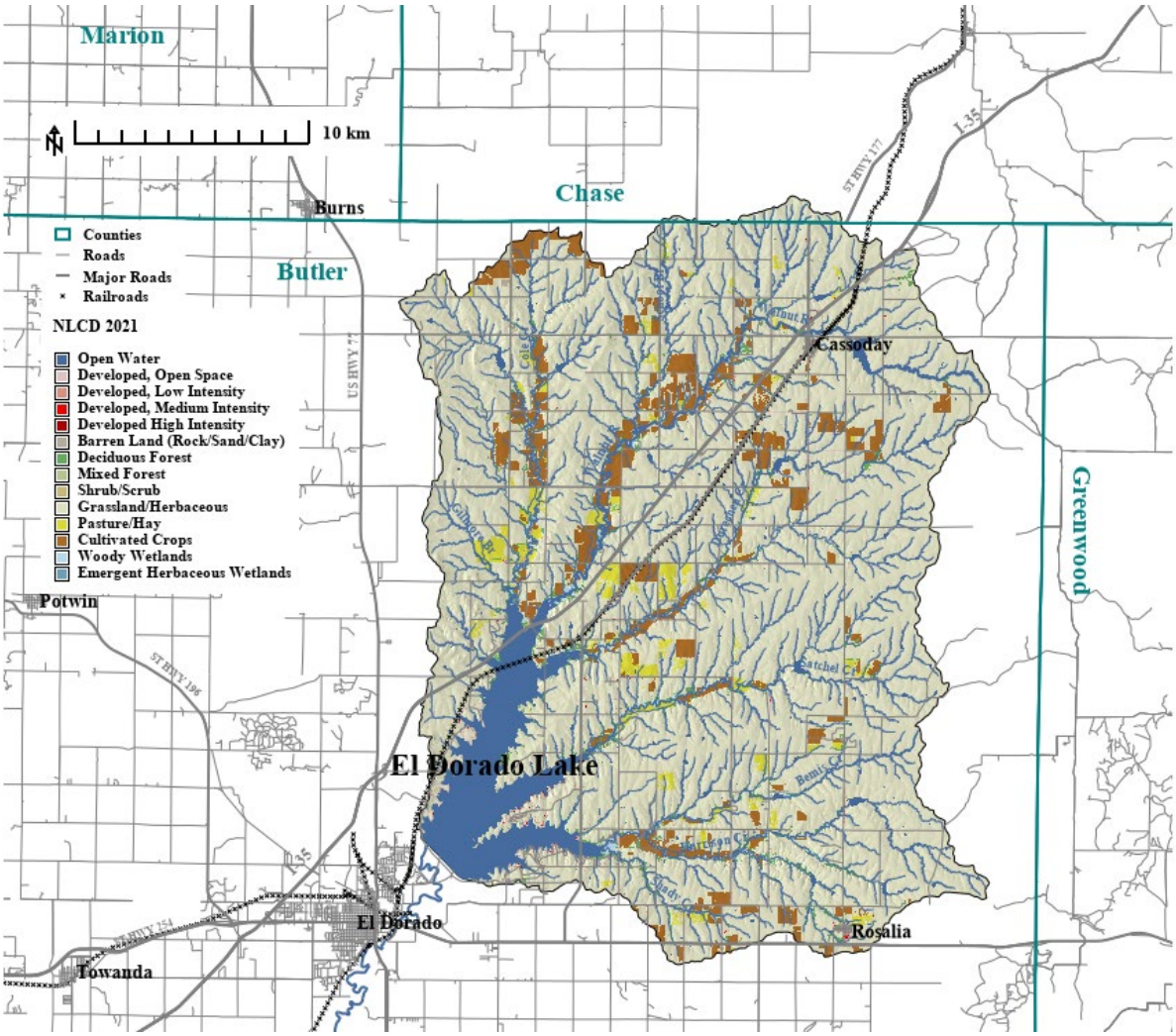

Figure 1. The El Dorado Lake (Walnut River) Watershed above the El Dorado Lake dam.

Table 1. Descriptive Characteristics of El Dorado Lake, KS.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,339.0 ft. NGVD	408.13 m
Lake Surface Area (Conservation Pool)	7,408 ac	2,997.92 ha
Lake Volume (Conservation Pool)	153,641 ac-ft	189,513,383 m^3
Total Drainage Area	244.6 mi^2	633.63 km^2
Mean Depth	20.7 ft	6.3 m
Maximum Depth (Conservation Pool)	67.5 ft	20.5 m
Shoreline Length	84.6 mi	136.14 km
Shoreline Development Index	7.0	7.0
Annual Inflow, Average 1922– 2022 [Water Years]	88,860 ac-ft	109,607,196 m^3
Total Annual Inflow, 2023 [Calendar Year]	30,962 ac-ft	38,191,065 m^3
Hydraulic Residence Time, 2023 [Calendar Year]	1, 504 d	4.1 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2022 Annual Water Control Report (U.S. ACE - SWD RCC, 2023), and Tulsa District's Water Control page for El Dorado Lake (U.S. ACE - Tulsa District, 2024),

Use designations (KDHE, 2021) for El Dorado Lake include expected aquatic life (AL), primary contact recreation (CR), domestic water supply (DS), food procurement (FP), ground water recharge (GR), industrial water supply (IW), irrigation use (IR), and livestock watering (LW). Based on the 2022 Kansas Integrated Water Quality Assessment (KDHE, 2022), El Dorado Lake is listed as impaired by eutrophication affecting aquatic life, domestic water supply, and primary body contact recreation; and impaired by siltation affecting domestic water supply. Total daily maximum load (TMDL) documentation has been prepared (2020) addressing these impairments.

Physical and chemical water quality data were collected by USACE monthly from three in-lake sites and the stilling basin at El Dorado Lake beginning 11 April and ending 12 September 2023 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 ELDKSS0026 over the channel at the dam, ELDKSS0051 mid-lake over the channel, ELDKSS0052 at the upper end of the lake near a railroad bridge, and finally ELDKSS0025 in the stilling basin below the dam. In-lake sites were accessed by boat, and samples were collected from locations over the deepest portion of the stream channel (thalweg). Diminishing pool elevation through the sampling period prevented boat access to site ELDKSS0052 from June through September 2023. Water samples representing site ELDKSS0052 were collected from shore near the site June through September. Sampling locations are identified in Figure 2.

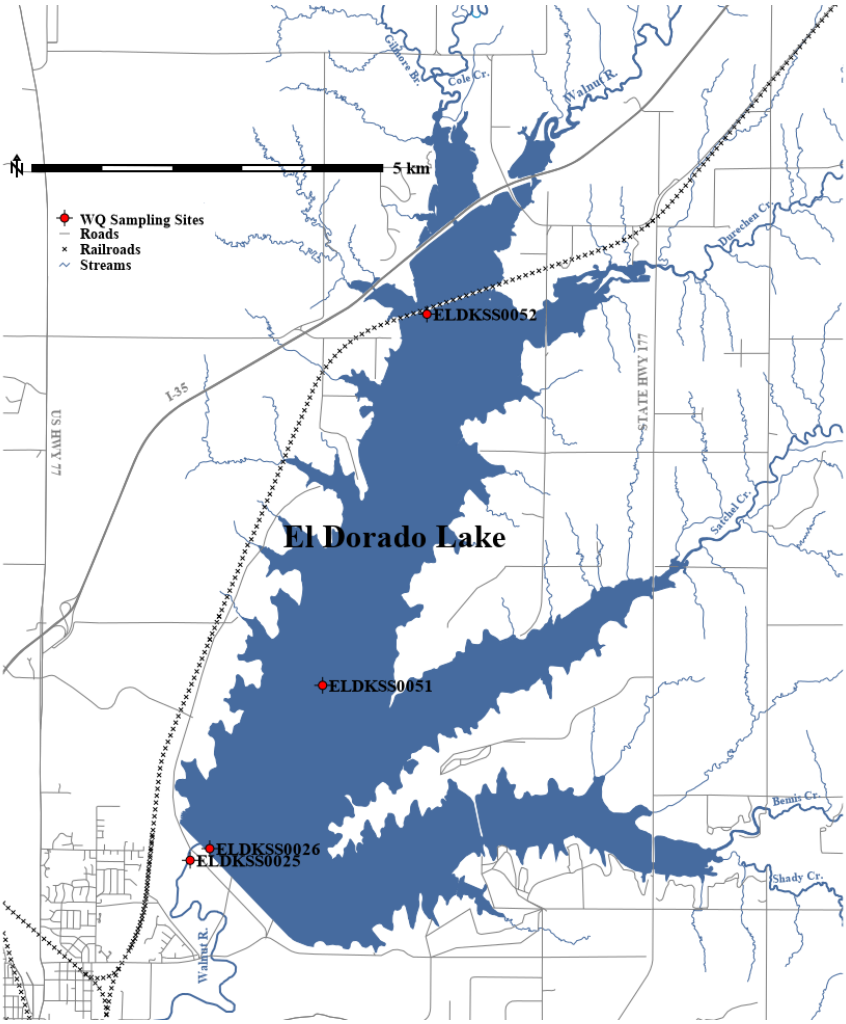

Figure 2. Locations of water quality sampling sites at El Dorado Lake, KS, 2023.

The El Dorado Lake pool elevation was below conservation pool elevation throughout the 2023 effort. Pool elevation was 1,336.14-feet in April decreasing to 1,333.33-feet in September. Cumulative normal precipitation (1990-2020) at the end of September for Cassoday, KS, a weather station in the upper El Dorado Lake watershed, is ~31-inches (SCIPP, 2024). Basin cumulative precipitation at the end of September 2023 was 14.23-inches. Calendar year 2023 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

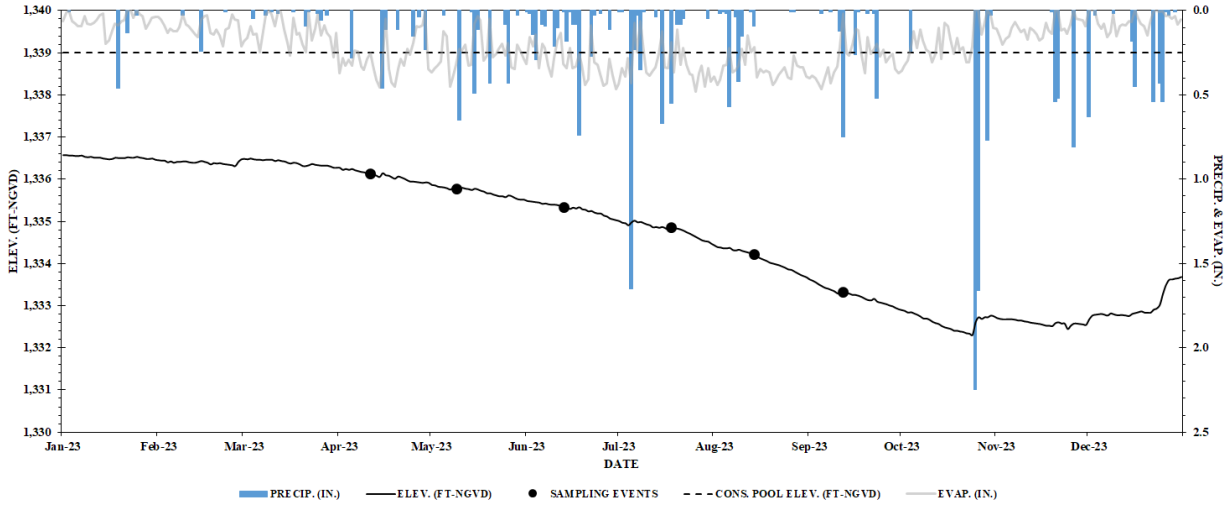

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at El Dorado Lake, KS, 2023.

Water temperatures through the sampling period ranged from 11.01 to 28.67 ºC. Water temperatures <12 ºC were observed at depths of 8 meters and below at ELDKSS0026 and ELDKSS0051 in April. Water temperatures >26 ºC were recorded at all in-lake sites in August, down to depths of 10 and 8 meters below the surface at ELDKSS0026 and ELDKSS0051, respectively. The reservoir experienced thermal stratification starting in June extending through July at ELDKSS0051, and August at ELDKSS0026. The study period median dissolved oxygen concentration was 7.26 mg/l. Hypoxia, dissolved oxygen concentration <2 mg/l, was observed at depth at the dam site (ELDKSS0026) in July and August, and at depth at the mid-lake site (ELDKSS0051) in June and July. Lakewide total organic carbon concentrations were moderate with a study period median of 5.2 mg/l.

Specific conductance, median 263 µS/cm, was lower than the historical norm. Total dissolved solids median concentration was 151 mg/l. Median concentrations of calcium, magnesium, sodium, and potassium were 34.55, 5.63, 8.42, and 3.72 mg/l, respectively. Low to moderate chloride and sulfate concentrations (medians 6.67 and 5.51 mg/l, respectively) were observed. Alkalinity levels (median 120.0 mg/l as $CaCO_3$) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 109 mg/l as $CaCO_3$, indicate 'moderately hard' water. Observed pH (7.39 to 8.67) ranged within historical norms. Highest pH observations were recorded at mid-depth at ELDKSS0026 and ELDKSS0051 in August. Lowest pH observations were recorded at depth at ELDKSS0026 and ELDKSS0051 in July.

Maximum recorded Secchi depth was 1.3 meters, and the study period median was 0.94 meters. Secchi depth measured at the upper lake site, ELDKSS0052 (April and May only), was significantly lower (median 0.33 m). Lake-wide median turbidity was 14.3 NTU. Approximately 46% of all turbidity observations exceeded 25 NTU. Total suspended solids concentrations (lakewide median 7.5 mg/l) were lower in surface observations (median 6.5 mg/l) compared to bottom observations (median 11.0 mg/l). The euphotic zone at El Dorado Lake, ranging from 1.6 meters (May) to 4.6 meters (June), averaged 3.7 meters during the 2023 study.

Ammonia concentrations were moderate (lakewide median 0.12 mg/l), and nitrite plus nitrate concentrations were low (median 0.03 mg/l). Total Kjeldahl nitrogen concentrations (median 0.40 mg/l) were moderate. Estimated median surface (0.5 m) total nitrogen concentration

during the 2023 study was ~0.38 mg/l. Total phosphorus concentrations ranged between 0.02 and 0.09 mg/l (median 0.04 mg/l). Twenty-one of thirty-six observations of dissolved ortho-phosphate, concentration median 0.02 mg/l, were above the analysis method detection limit. Surface nitrogen to phosphorus concentration ratios (N:P) in 2023 were >10 in April, June, and July, and <10 in May, August, and September with a lakewide median of 8.8.

Chlorophyll-*a* concentrations ranged from 2.0 to 11.5 µg/l, with a lakewide median concentration of 5.9 µg/l. Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton observed at El Dorado Lake by sampling date. Relative abundance of Cyanophytes, Bacillariophytes, Chlorophytes, and Cryptophytes remained relatively stable through the sampling period. Relative biovolume indicates seasonal representation by Bacillariophytes and Pyrrophytes. Figure 5 summarizes zooplankton densities observed in 2023 at ELDKSS0026 (note the log scale density axis). Cladocerans, Copepods, and Rotifers were well represented across the sampling period, and Bivalves, exclusively *Dreissena* (Zebra mussel) veligers, were present June through September.

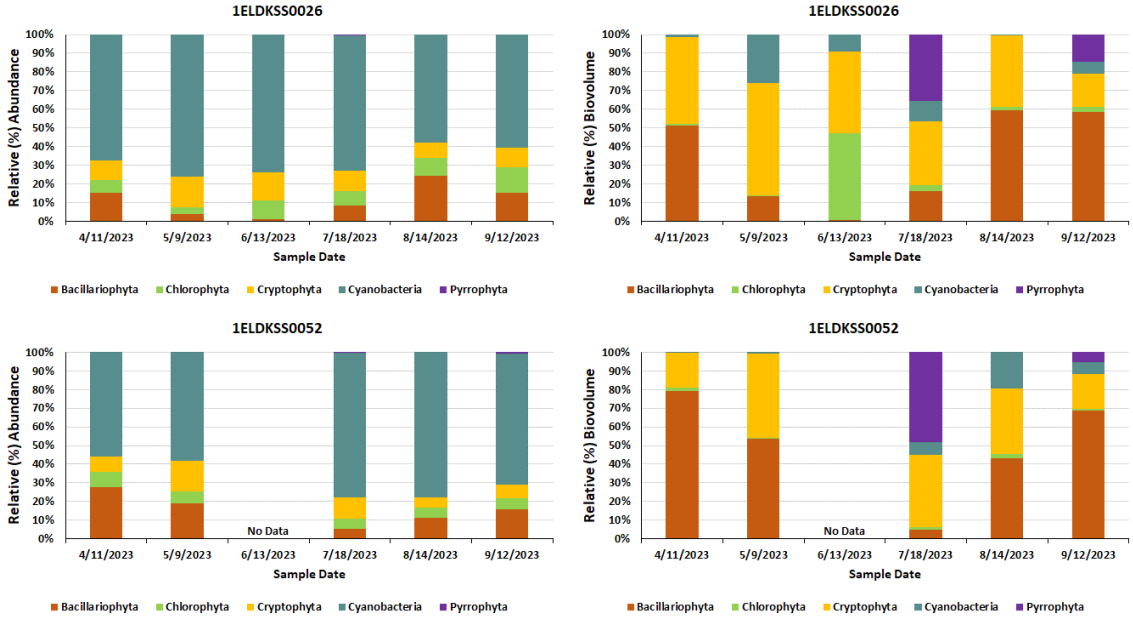

Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at ELDKSS0026, and ELDKSS0052 April through September 2023.

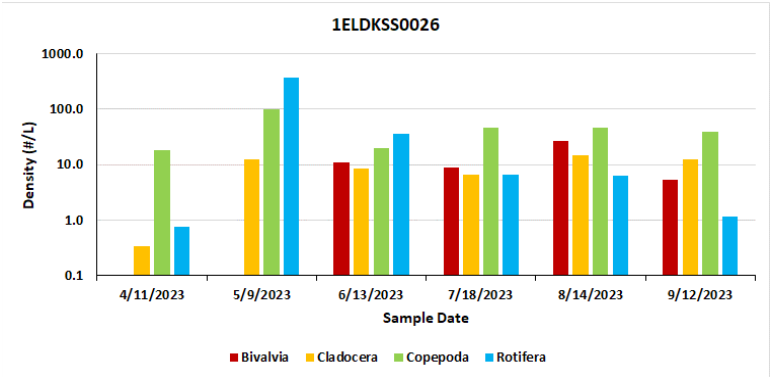

Figure 5. Zooplankton density at ELDKSS0026 April through September 2023.

The trophic status of El Dorado Lake in 2023, assessed using Carlson's trophic state index (TSI), indicated a moderately eutrophic lake as measured by Secchi depth (TSI(SD), median 60.0). Index values developed from total phosphorus concentrations (TSI(TP), 53.2) and chlorophyll-*a* concentrations (TSI(CHLa), 48.0) indicated low level eutrophy and high level mesotrophy, respectively (Figure 6).

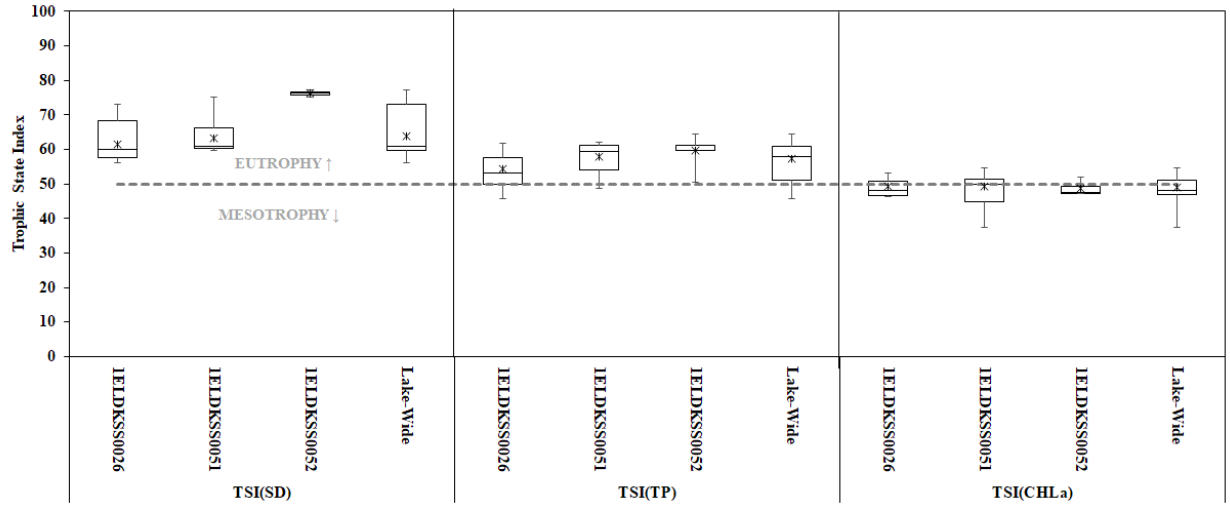

Figure 6. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lakewide, based on observations of Secchi Depth [TSI(SD)], surface total phosphorus concentrations [TSI(TP)], and chlorophyll-*a* concentrations [TSI(CHLa)] at El Dorado Lake, KS, April through September 2023.

Total iron (median 0.21 mg/l) and manganese (median 0.03 mg/l) concentrations were moderate. Highest average lakewide concentrations of iron were noted in May (0.43 mg/l). All samples revealed detectable concentrations of metal pollutants arsenic, chromium, copper, nickel, and zinc. Detectable lead and mercury concentrations were found in 69% and 17%, respectively, of samples collected.

Water samples collected from the El Dorado Lake stilling basin in 2023 (site ELDKSS0025) revealed mean and median parameter results comparable to in-lake data collected near the dam (ELDKSS0026).

USACE conducted water quality studies of El Dorado Lake, KS in 1998 and 2013. Thermal stratification and hypoxia was noted beginning in June 1998 and 2013 at ELDKSS0026 (dam site). Lake waters were moderately more turbid in both 1998 and 2013 than 2023. Median ammonia, total Kjeldahl nitrogen, total nitrogen, and total phosphorus concentrations in 2023 were comparable to prior observations.