El Dorado Lake Water Quality: 2013

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. 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 is dominated by grassland/pasture (~81%) and cultivated cropland (~5.7%). 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. The most recent bathymetric survey conducted in 2010 indicated an annual conservation pool sedimentation rate of 349 ac-ft/yr since embankment closure reducing the original conservation pool volume by greater than 5,000 ac-ft. A comparison of bathymetric surveys performed in 2004 and 2010 suggests a higher conservation pool sedimentation rate, in that interval, of 753 ac-ft/yr. Descriptive characteristics of El Dorado Lake are included in Table 1.

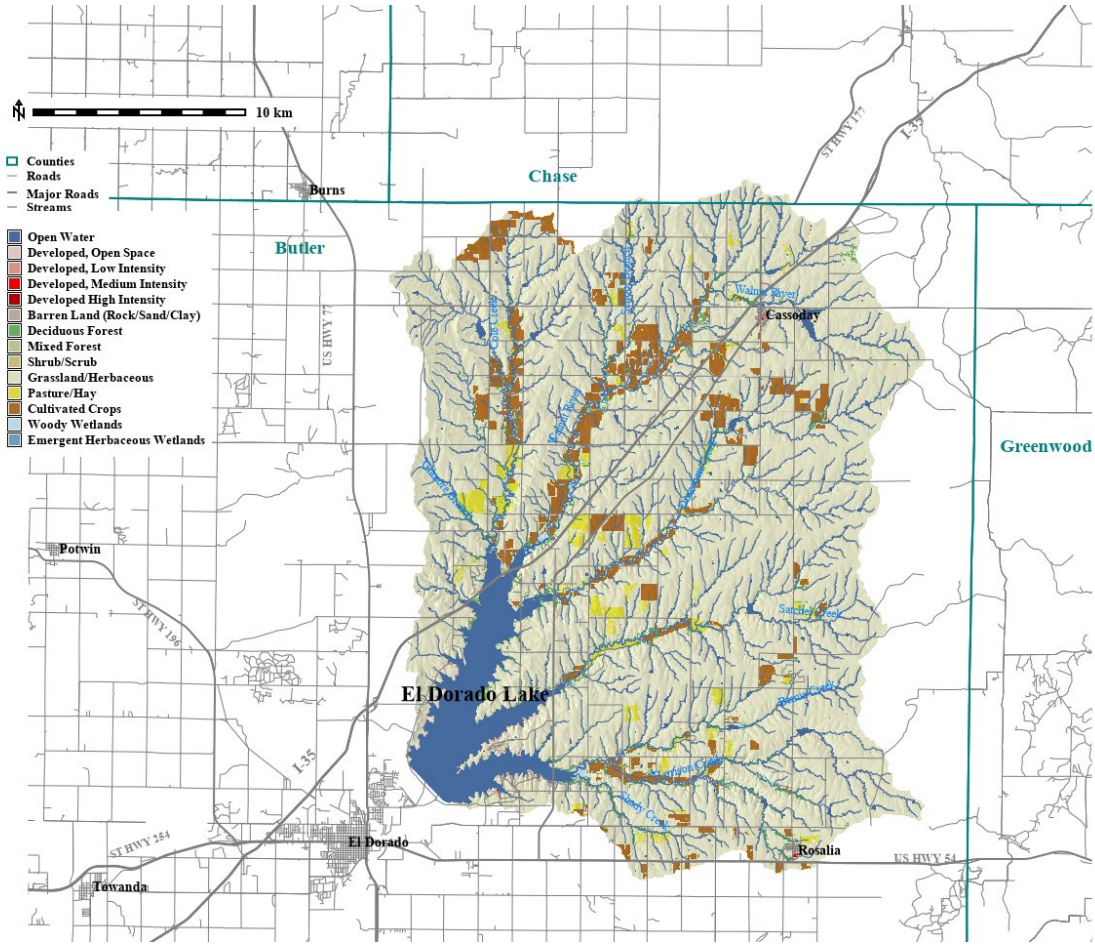

Figure 1. The El Dorado Lake, KS Watershed.

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	20.74 ft.	6.32 m
Maximum Depth (Conservation Pool)	59.0 ft.	17.98 m
Shoreline Length	84.6 mi	136.14 km
Shoreline Development Index	7.01	7.01
Annual Inflow, Average 1929– 2013 [Water Years]	89,800 ac-ft	110,766,669 m^3
Total Annual Inflow, 2013 [Calendar Year]	105,590 ac-ft	130,243,347 m^3
Hydraulic Residence Time, 2013 [Calendar Year]	487.66 d	1.34 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2013 Annual Water Control Report (U.S. ACE - SWD RCC, 2014), and Tulsa District's Water Control page for El Dorado Lake (U.S. ACE - Tulsa District, 2020),

Use designations (KDHE, 2013) 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, and siltation affecting water supply.

Physical and chemical water quality data were collected by USACE approximately monthly from three in-lake sites and the stilling basin at El Dorado Lake beginning March 12 and ending September 10, 2013 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 the 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). Sampling locations are identified in Figure 2.

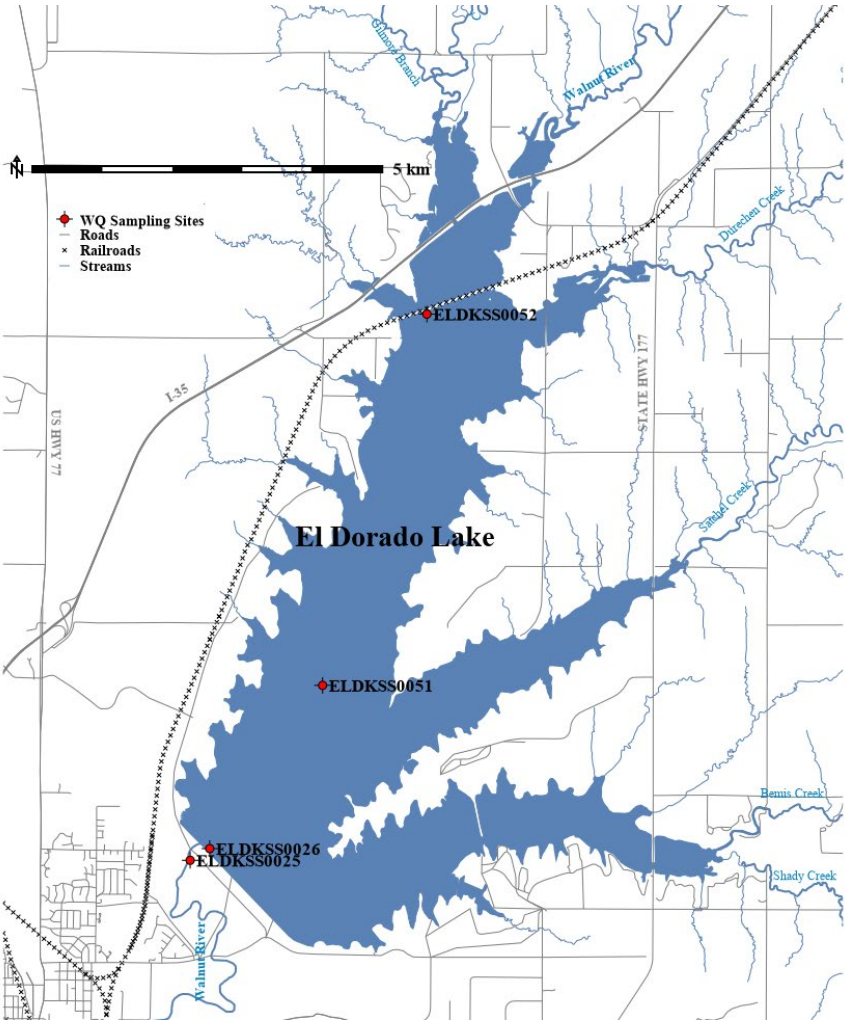

Figure 2. Locations of water quality sampling sites at El Dorado Lake, KS, 2013.

The El Dorado Lake pool elevation was below conservation pool elevation until August 2013. Significant and frequent rainfall-runoff events in late July and early August increased pool elevation by almost 8 feet in a two to three week period. Calendar year 2013 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

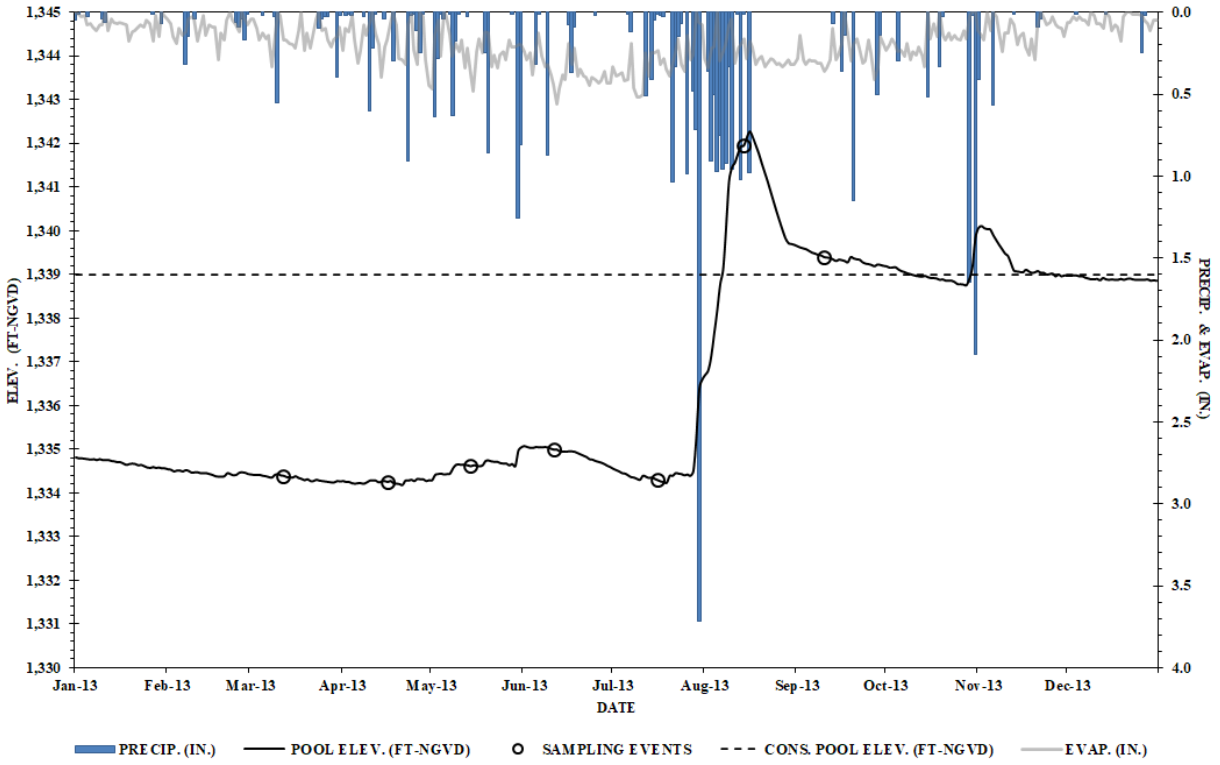

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at El Dorado Lake, KS, 2013.

Water temperatures generally increased through the sampling period (ranging from 17.32 to 20.56 ºC) peaking in September. Lake-wide water temperatures, on earliest sampling dates (March and April), displayed nominal variation. The reservoir experienced thermal stratification starting in June and extending into September 2013 with significant temperature variation between surface and depth. The study period median dissolved oxygen concentration was 8.4 mg/l. Hypoxia, dissolved oxygen concentration <2 mg/l, was observed at depth at the dam site (ELDKSS0026) June through September, at depth at the mid-lake site (ELDKSS0051) in August and September, and at the upper lake site (ELDKSS0052) in August. Lake-wide total organic carbon concentrations were moderate, peaking in August, with a study period median of 3.8 mg/l.

Specific conductance (median 288 µS/cm) was moderately elevated, consistent with regional norms. Total dissolved solids median concentration was 186 mg/l. Median concentrations of calcium, magnesium, sodium, and potassium were 37.10, 6.54, 9.88, and 3.50 mg/l, respectively. Low to moderate chloride and sulfate concentrations (medians 8.27 and 9.28 mg/l, respectively) were observed. Lake-wide concentrations of chloride and sulfate dropped ~2 mg/l coincident with late July and early August inflows. Alkalinity levels (median 141.0 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 (6.92 to 8.34) ranged within regional norms.

The lake was moderately turbid through 2013. Maximum recorded Secchi depth was 1.35 meters, and the study period median was 0.85 meters. Lake-wide median turbidity was 20.6 NTU. Approximately 32% of all turbidity observations exceeded 25 NTU. Total suspended

solids concentrations (median 6.0 mg/l) were about two to three times higher in April related to extreme wind and wave action. The euphotic zone at El Dorado Lake was typically ~2 meters.

Ammonia concentrations were typically low (median 0.017 mg/l), and nitrite plus nitrate concentrations were also low (median 0.02 mg/l). Total Kjeldahl nitrogen concentrations (median 0.44 mg/l) were moderate. Estimated median total nitrogen concentration during the 2013 study was ~0.46 mg/l. Total phosphorus concentrations ranged between <0.04 and 0.118 mg/l (median 0.031 mg/l). Only two of 33 observations of dissolved ortho-phosphate concentration, median 0.050 mg/l, were above the analysis method detection limit. Surface nitrogen to phosphorus concentration ratios (N:P) in 2013 were generally >10 (median 19.1), indicating likely phosphorus limitation of algal growth at El Dorado Lake.

Chlorophyll-*a* concentrations ranged from 1.8 to 14.5 µg/l, with a median concentration of 6.4 µg/l. An increasing temporal chlorophyll-a concentration trend was evident through August 2013 when observations at each of the three in-lake sites were greater than 10 µg/l. The trophic status of El Dorado Lake in 2013, assessed using Carlson's trophic state index (TSI), indicated a eutrophic lake as measured by Secchi depth (TSI(SD), 62.3) . The index developed from total phosphorus concentrations (TSI(TP), 49.8) and chlorophyll-*a* concentrations (TSI(CHLa), 48.7) indicated low level eutrophy or high level mesotrophy (Figure 4).

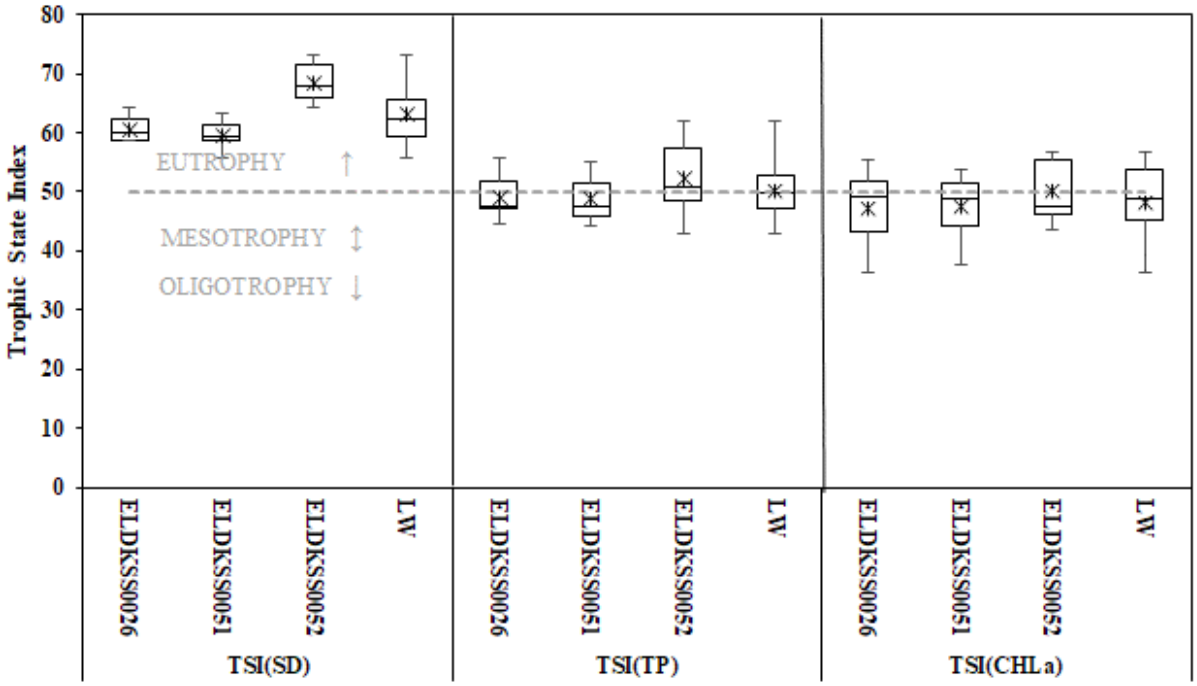

Figure 4. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lake-wide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CH)La) at El Dorado Lake, KS, 12-MAR through 10-SEP-2013.

Total iron (median 0.164 mg/l) and manganese (median 0.023 mg/l) concentrations were moderate to low. Highest concentrations of each were noted at depth in August and September, respectively. Water samples from El Dorado Lake were analyzed for total concentrations of priority pollutant metals. None exceeded current acute or chronic criteria for aquatic life.

Water samples were collected from the El Dorado Lake stilling basin in 2013 (site ELDKSS0025). Generally, mean and median parameter results are directly comparable to in-lake data collected near the dam (ELDKSS0026).

USACE conducted a water quality study of El Dorado Lake, KS in 1998. Thermal stratification and anoxia within the hypolimnion was noted beginning in June 1998 at ELDKSS0026 (dam site). Lake waters were moderately turbid (Secchi depth and turbidity medians of 0.57 meters and 20.1 NTUs, respectively). Median ammonia and total Kjeldahl nitrogen concentrations were significantly higher than 2013 observations with concentrations of 0.25 and 1.125 mg/l, respectively. Total phosphorus 1998 median concentration was 0.049 mg/l. A comparison of data from the three in-lake stations (ELDKSS0026, ELDKSS0051, and ELDKSS0052) indicates generally similar water quality conditions between 1998 and 2013.