

Council Grove Lake Water Quality: 2010

The Council Grove Lake dam is located on the Neosho River at river mile 449.9 about 1.5 miles northwest of the city of Council Grove in Morris County, Kansas within Hydrologic Unit Code 11070201. The conservation pool of Council Grove Lake was first filled in June 1965 after final storage began in October 1964. Authorized purposes include flood damage reduction, water supply, water quality control, fish and wildlife, and recreation. The watershed above the Council Grove dam site extends northwest ~14 miles, and WSW and ESE in a 'fan' shape that is up to 27 miles wide and encompasses ~261 square miles (Figure 1) with basin elevations ranging from about 1,220 feet below the dam to ~1,561 feet. Land use/cover in the basin is dominated by grassland/pasture (~60%) and cultivated cropland (~28%). At the conservation pool elevation of 1,274.0 feet (NGVD 29), lake capacity has diminished by about 16% since construction due to sedimentation. The most recent bathymetric survey conducted in 2008 indicated an annual conservation pool sedimentation rate of 189 ac-ft/yr since embankment closure reducing the original conservation pool volume by greater than 8,000 ac-ft. Descriptive characteristics of Council Grove Lake are included in Table 1.

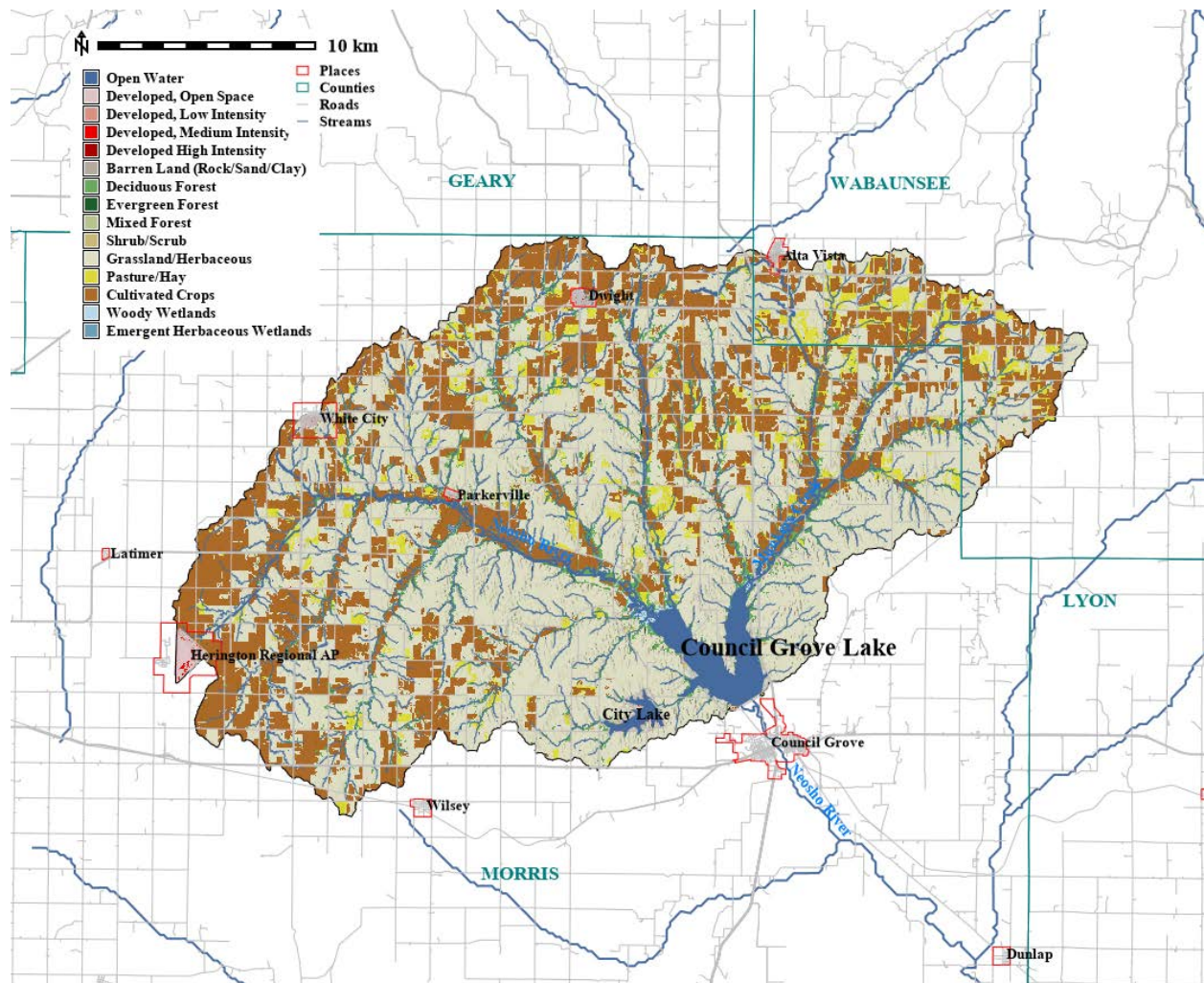


Figure 1. The Council Grove Lake, KS Watershed.

Table 1. Descriptive Characteristics of Council Grove Lake, KS.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,274.0 ft. NGVD	388.3 m
Lake Surface Area (Conservation Pool)	2,835 ac	1,147.3 ha
Lake Volume (Conservation Pool)	43,984 ac-ft	54,253,465 m ³
Total Drainage Area	261 mi ²	676 km ²
Mean Depth	15.5 ft.	4.73 m
Maximum Depth (Conservation Pool)	34 ft.	10.4 m
Shoreline Length	26.6 mi	42.8 km
Shoreline Development Index	3.56	3.56
Annual Inflow, Average 1949 – 2012 [Water Years]	95,600 ac-ft	117,920,860 m ³
Annual Inflow, 2010 [Calendar Year]	126,450 ac-ft	155,973,775 m ³
Hydraulic Residence Time, 2010 [Calendar Year]	141d	0.39 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2012 Annual Water Control Report (U.S. ACE - SWD RCC, 2013), Tulsa District's Water Control page for Council Grove Lake (U.S. ACE - Tulsa District, 2023), and the 2008 KBS Bathymetric Survey (Kansas Biological Survey, 2009).

Use designations (KDHE, 2013) for Council Grove 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), Council Grove 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 Council Grove Lake beginning 14-APR and ending 28-SEP-2010 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 COUKSS0056 over the channel at the dam, COUKSS0057 just outside Canning Creek Cove near Canning Creek Cove Public Use Area, COUKSS0058 outside Richey Cove near Richey Cove and Custer Park Public Use Areas, and finally COUKSS0055 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.

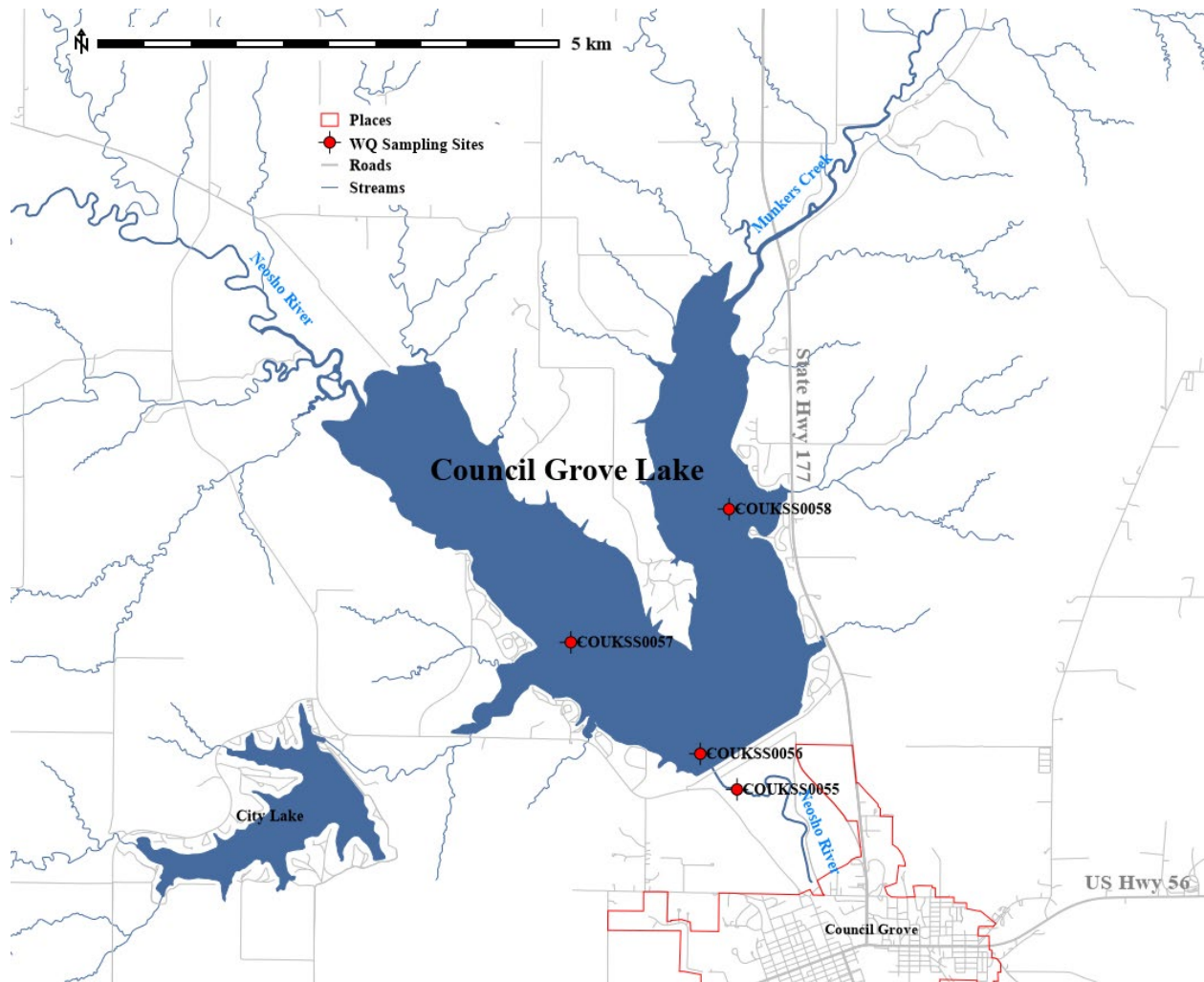


Figure 2. Locations of water quality sampling sites at Council Grove Lake, KS, 2010.

The Council Grove Lake pool elevation was at or above the seasonal conservation pool elevation throughout calendar year 2010 due to frequent rainfall-runoff events. Calendar year 2010 lake elevation, seasonal conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

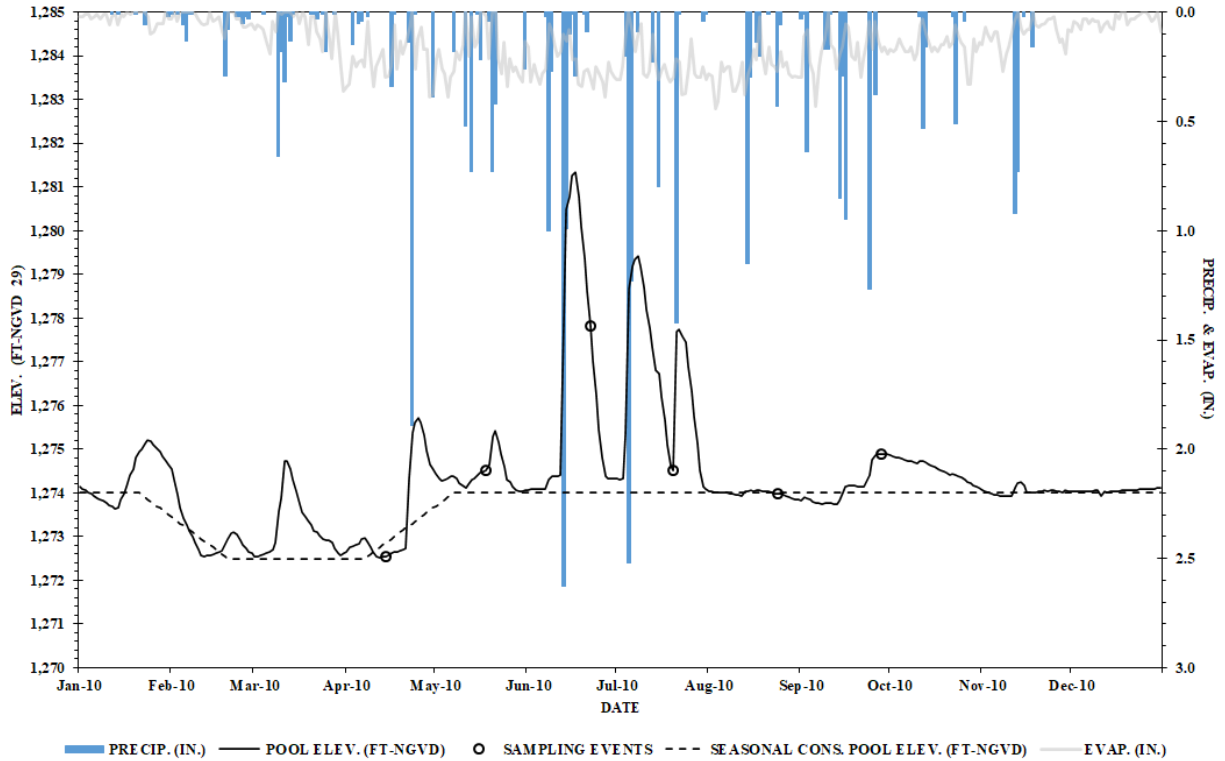


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), seasonal conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at Council Grove Lake, KS, 2010.

Water temperatures varied seasonally (ranging from 14.86 to 29.15 °C) peaking in July. Lake-wide water temperatures, on individual sampling dates, displayed nominal variation in April, May, August, and September. The reservoir experienced weak thermal stratification starting in June and extending into July 2010 with significant temperature variation between surface and depth. The study period median dissolved oxygen concentration was 6.93 mg/l. Anoxic conditions, dissolved oxygen concentration <1 mg/l, were observed at depth (8 meters and below) at the dam site in July. Lake-wide total organic carbon concentrations were moderately high with a study period median of 6.23 mg/l.

Specific conductance (median 315 $\mu\text{S}/\text{cm}$) was moderately elevated, consistent with regional norms. Total dissolved solids median concentration was 198.6 mg/l. Low to moderate chloride and sulfate concentrations (medians 4.32 and 14.3 mg/l, respectively) were observed indicating other components (minerals, cations) contributing to dissolved solids. Alkalinity levels (median 142.0 mg/l as CaCO_3) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 142 mg/l as CaCO_3 , indicate 'moderately hard' water. Observed pH (7.24 to 8.49) ranged within regional norms. Highest (surface) and lowest (bottom) pH was recorded in July corresponding with thermal stratification.

The lake was moderately turbid through 2010. Maximum recorded Secchi depth was 0.40 meters, and the study period median was 0.33 meters. Lake-wide median turbidity was 33.3 NTU. Total suspended solids concentrations (median 14.4 mg/l) paralleled turbidity observations with highest concentrations observed in bottom samples from the dam site, COUKSS0056. The euphotic zone at Council Grove Lake was typically <1 meter.

Ammonia concentrations were typically low (median 0.022 mg/l), and nitrite plus nitrate concentrations were moderate to high (median 0.38 mg/l). Total Kjeldahl nitrogen concentrations (median 0.54 mg/l) were moderate. Estimated median total nitrogen concentration during the 2010 study was ~0.92 mg/l. Total phosphorus concentrations ranged between 0.134 and 0.294 mg/l (median 0.181 mg/l). Observations of dissolved ortho-phosphate, median 0.138 mg/l, were moderately elevated throughout the lake. Nitrogen to phosphorus ratios (N:P) in 2010 were <10 (mean 5.2), indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-a concentrations ranged from 3.3 to 34.3 µg/l, with a median concentration of 6.6 µg/l. Highest concentrations were observed in April 2010 at all three in-lake sites. The trophic status of Council Grove Lake in 2010, assessed using Carlson's trophic state index (TSI), indicated a hyper-eutrophic lake as measured by Secchi depth (TSI-SD) and total phosphorus concentrations (TSI-TP). The index developed from chlorophyll-a concentrations (TSI-CHLa) indicated a more moderate level of eutrophy (Figure 4).

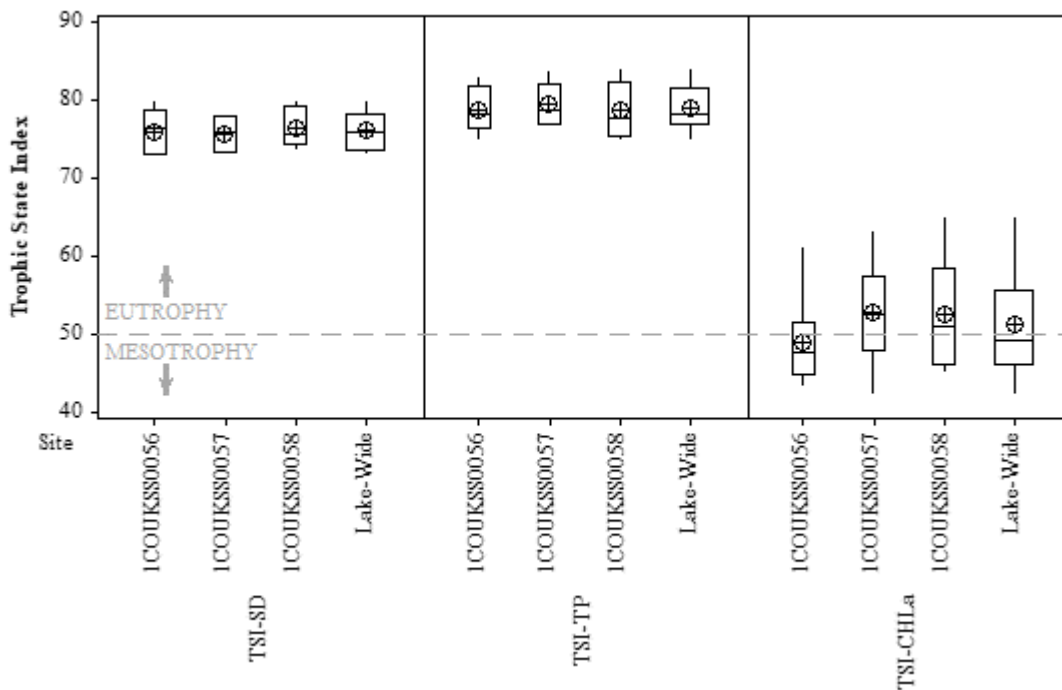


Figure 4. Distributions of Carlson's Trophic State Index (TSI), by sampling site and lake-wide, based on observations of Secchi Depth (TSI-SD), surface total phosphorus concentrations (TSI-TP), and chlorophyll-a concentrations (TSI-CHLa) at Council Grove Lake, KS, 14-APR through 28-SEP-2010.

Total iron (median 0.572 mg/l) and manganese (median 0.072 mg/l) concentrations were relatively high. Highest concentrations of each were noted at depth in May and July, respectively. Reportable concentrations of arsenic were found in all samples collected with a median concentration of 0.0033 mg/l. Chromium and nickel were detected in 87% of samples collected with median concentrations of 0.0020 and 0.0035 mg/l, respectively. Detectable concentrations of mercury were noted in ~50% of samples collected.

Water samples were collected each sampling trip in the stilling basin below the Council Grove Lake dam at site COUKSS0055. Mean and median parameter results paralleled data collected in-lake near the dam (COUKSS0056) with differences including higher mean total suspended solids, total Kjeldahl nitrogen, total phosphorus, total organic carbon, iron, lead, manganese, and zinc, due in part to withdrawal depth of the outlet conduit.

USACE conducted a water quality study of Council Grove Lake, KS in 1997 and indicated concerns with respect to high nutrient concentrations and the potential for cyanophyte blooms. The 1997 report recommended continued awareness of low dissolved oxygen concentrations and elevated concentrations of iron and mercury.