Fort Supply Lake Water Quality: 2011

The Fort Supply Lake dam is located at river mile 5.5 on Wolf Creek, a tributary of the North Canadian River, about one mile south of the town of Fort Supply and 12-miles northwest of Woodward in Woodward County, Oklahoma (OK). Fort Supply Lake was authorized as part of the Upper Arkansas River Flood Control Project. The reservoir was developed to provide flood control storage, water conservation for municipal uses, and recreation benefits. The reservoir is an integral part of the North Canadian River Basin Flood Control Plan that also includes Optima and Canton Reservoirs as well as the Oklahoma City floodway. The impoundment extends about three miles south from the dam outlet works along the channel of Wolf Creek. The reservoir and lower watershed are within Hydrologic Unit Code (HUC) 1110203 (Lower Wolf), and the upper portion of the watershed, within HUC 11100202 (Upper Wolf), extends to near Spearman, Texas. Construction of the Fort Supply Lake dam began in October 1938 and the conservation pool filled in June 1942. The total drainage area above the dam is 1,915 square miles with a contributing area of 1,494 square miles (Figure 1). Land use/cover (U.S. Geological Survey, 2014) in the basin is dominated by grassland/pasture (~64%), cropland (~22%), and scrub/shrub (~11%). Based on a 2010 flood pool survey (Wilson & Company, Inc., 2010), at the conservation pool elevation of 2,004 feet (NGVD 29), lake capacity has diminished by about 33% since construction. Descriptive characteristics of Fort Supply Lake are included in Table 1.

Figure 1. The Fort Supply Lake (Wolf Creek) Watershed above the Fort Supply Lake Dam.

Table 1. Descriptive Characteristics of Fort Supply Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	2,004.0 ft NGVD	610.82 m
Lake Surface Area (Conservation Pool)	1,691 ac	684.3 ha
Lake Volume (Conservation Pool)	12,220 ac-ft	$15.073*10^6$ m^3
Total Drainage Area (contributing)	1,494 mi^2	3,869 km^2
Mean Depth	7.2 ft	2.2 m
Maximum Depth (Conservation Pool)	20 ft	6.1 m
Shoreline Length	16.7 mi	26.9 km
Shoreline Development Index	2.9	2.9
Annual Inflow, Average 1923 – 2010 [Water Years]	51,100 ac-ft	$63.031*10^6$ m^3
Annual Inflow, 2011 [Calendar Year]	17,572 ac-ft	$21.675*10^6$ m^3
Hydraulic Residence Time, 2011 [Calendar Year]	221.7 d	0.61 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2021), the FY 2011 Annual Water Control Report (U.S. ACE - SWD RCC, 2012), Tulsa District's Water Control page for Fort Supply Lake (U.S. ACE - Tulsa District, 2024), and the 2010 Lidar survey (Wilson & Company, Inc., 2010).

Designated beneficial uses of the reservoir created by the Fort Supply 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 Sensitive Public and Private Water Supply and as a Nutrient Limited Watershed (OAC, 2023a). Protocols assessing support of designated beneficial uses, in accordance with the Clean Water Act (CWA) Sections 303(d) and 305(b), are included in OAC, 2023b. Impairments of designated uses are listed in the biennial Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ). The 2022 Integrated Report (ODEQ 2022) documents Fort Supply Lake water quality as impaired with respect to designated beneficial uses Public and Private Water Supply and Fish and Wildlife Propagation as a Warm Water Aquatic Community with identified issues including excess algal growth and turbidity, respectively.

Physical and chemical water quality data were collected monthly, March through September 2011, from four in-lake sites and the tailwater at Fort Supply Lake 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 1SUPOKN0069 (channel near dam), 1SUPOKN0070 (near Beaver Point boat ramp), 1SUPOKN0071 (near Cottonwood Point boat ramp), 1SUPOKN0228 (near mouth of Wolf Creek), and 1SUPOKN0227 (tailwater, downstream). 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.

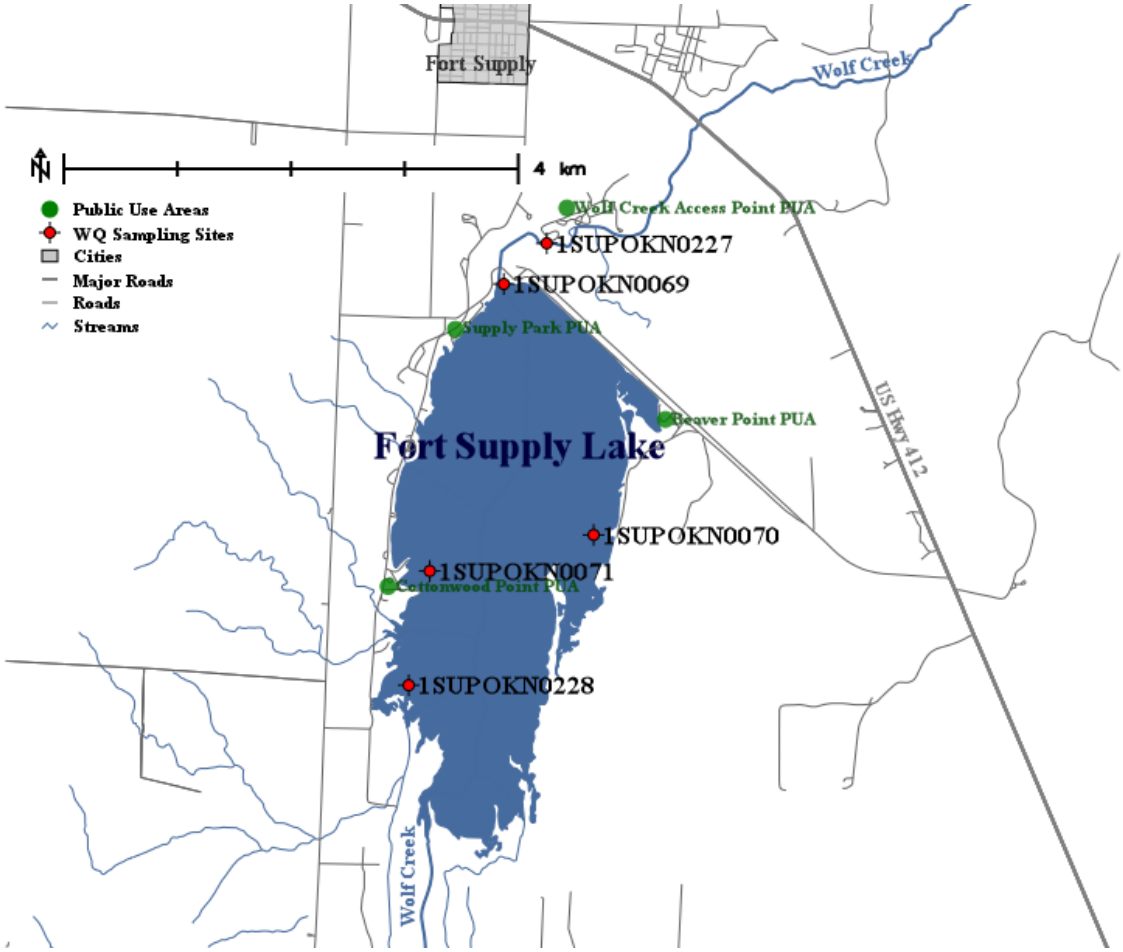

Figure 2. Locations of water quality sampling sites at Fort Supply Lake, OK, 2011.

The Fort Supply Lake pool was above conservation elevation (2004 feet) March through May, and below and decreasing June through September. During calendar year 2011, annual basin precipitation totaled 9.3 inches, about 36% of the 1981 – 2010 normal (26.02 inches). Total calendar year 2011 inflow to Fort Supply Lake was ~34% of the 1923 - 2010 water year average. Calendar year 2011 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.

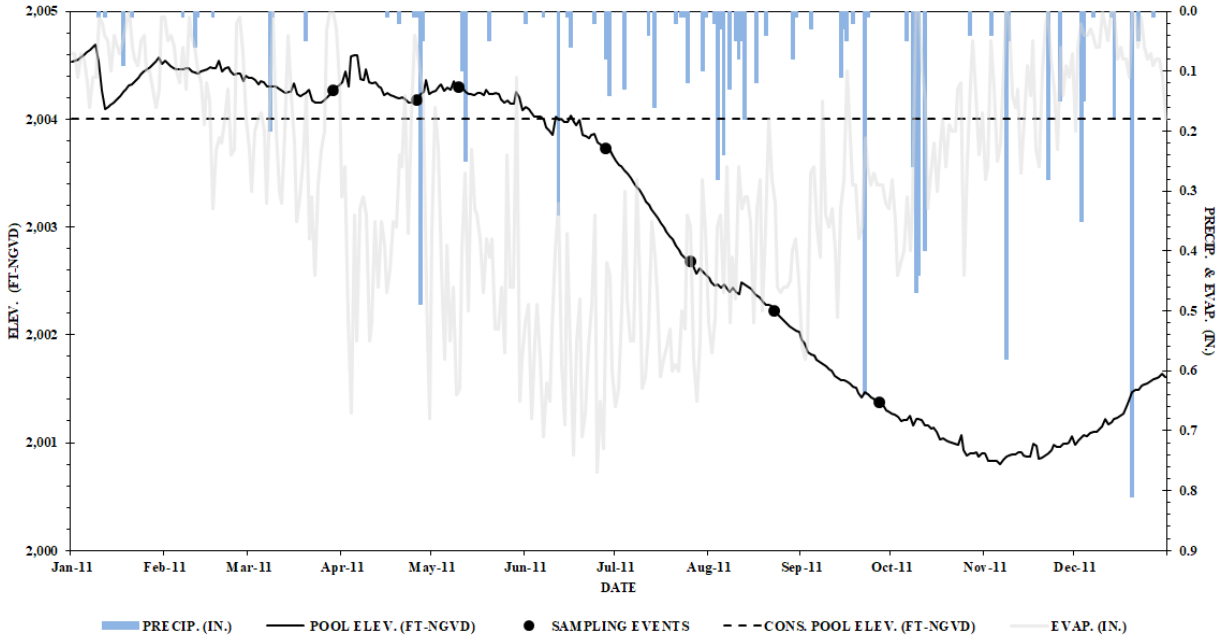

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Fort Supply Lake, OK, 2011.

Water temperatures varied seasonally (ranging from 8.45 to 30.41 ºC). Highest recorded water temperatures occurred in July with all recorded in-lake temperatures greater than 27.0 ºC. Water temperatures warmed progressively March through July but varied nominally from surface to bottom. Fort Supply is a relatively shallow reservoir, and no thermal stratification was noted. Lakewide median dissolved oxygen (DO) concentration was 8.35 mg/l, with concentrations revealing greatest variability (8.3 mg/l at the surface to 2.2 mg/l at 3 meters depth) during July when water temperatures were warmest. All in-lake observations of DO from March through May were >8.0 mg/l. Lakewide median total organic carbon concentration was 7.4 mg/l. Total organic carbon concentrations were lowest March through May (<7.0 mg/l) and steadily increased June through September. Median lakewide total organic carbon concentration in September was 11.2 mg/l.

Specific conductance (median 1,091.0 µS/cm) was high, consistent with regional geology. Total dissolved solids median concentration was 630.9 mg/l. High chloride and sulfate concentrations (medians 177.0 and 125.5 mg/l, respectively) were observed. Total dissolved solids, chloride, and sulfate concentrations increased from April through September. Alkalinity levels, lakewide study period median 170.0 mg/l as $CaCO_3$, decreased from April (200.0 mg/l) to September (160.0 mg/l), indicating a system capable of maintaining pH levels. Observed pH ranged from 8.15 to 8.64 standard units. Hardness levels, lakewide median 273.0 mg/l as $CaCO_3$, indicated ‘hard’ water.

Secchi depth (SD) at Fort Supply Lake during the study period ranged from 0.15 to 0.39 meters with a median value of 0.25 meters. SD observations were comparably low at each in-lake site on all sampling dates. In-lake median turbidity was 57.6 NTU, and all observations were greater than or equal to 25 NTU (minimum observed, 35.8 NTU). Total suspended solids concentrations, lakewide median 34.5 mg/l, were comparable at each in-lake site, with the median of surface concentrations (34.5 mg/l) slightly lower than the median bottom

concentration (45.2 mg/l). The euphotic zone at Fort Supply Lake ranged from <0.5 to ~1.0 meters with highest estimates occurring in May.

Lakewide ammonia concentrations, median 0.033 mg/l, were moderate ranging from less than the detection limit (0.013 mg/l) to 0.188 mg/l. Median lakewide bottom ammonia concentration was ~25% higher than surface concentration. Nitrite plus nitrate concentrations, median 0.01 mg/l, were low. Total Kjeldahl nitrogen concentrations, median 0.76 mg/l, were moderately high. Estimated lakewide median surface total nitrogen concentration during the 2011 study was 0.78 mg/l. Total phosphorus concentrations ranged between 0.07 and 0.24 mg/l (median 0.12 mg/l), with median sampling date concentrations in excess of 0.150 mg/l in June, August and September. Median dissolved ortho-phosphate concentration was 0.01 mg/l. The ratio of surface total nitrogen to total phosphorus concentrations (N:P ratio) suggested potential nitrogen limitation of algal growth. By sampling date, the lowest lakewide N:P ratio was observed in June (4.7) while the highest occurred in March (9.6). Lakewide median N:P ratio was 6.7.

Chlorophyll-*a* concentrations (CHLa) ranged from 7.3 to 45.1 µg/l, with a lakewide median concentration of 16.0 µg/l. Median in-lake site CHLa concentrations were comparable. Figure 4, below, shows sampling date distributions of lakewide CHLa observations. Consistent low water clarity and the resulting shallow euphotic zone likely limited algal growth. Also included in Figure 4, for comparison, is the Oklahoma Water Quality Standard CHLa criterion for Sensitive Public and Private Water Supply waterbodies (red line, 10 µg/l (OAC, 2023a)).

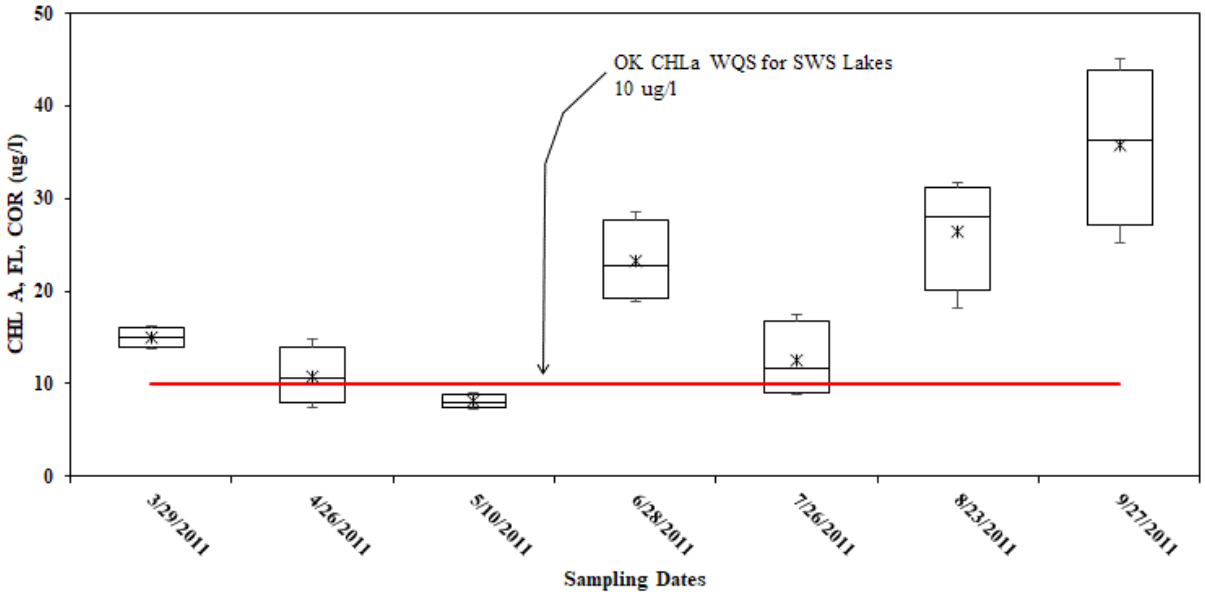

Figure 4. Chlorophyll-a concentration distributions by sampling date, at Fort Supply Lake, OK, March through September 2011. In the box-and-whiskers, '*' represents mean concentration, and the horizontal bar within each box represents median concentration.

Trophic status of Fort Supply Lake was assessed using all three metrics of Carlson's (Carlson, 1977) trophic state index (TSI) at each in-lake site. Shown in Figure 5, lakewide (LW) median TSI(SD) of 80.0 indicated eutrophy. The LW median based on total phosphorus [TSI(TP)] is lower, 71.7, but still indicated enhanced lake productivity. TSI(CHLa), with a LW median value of 57.7, also indicated eutrophy, moderated by water clarity.

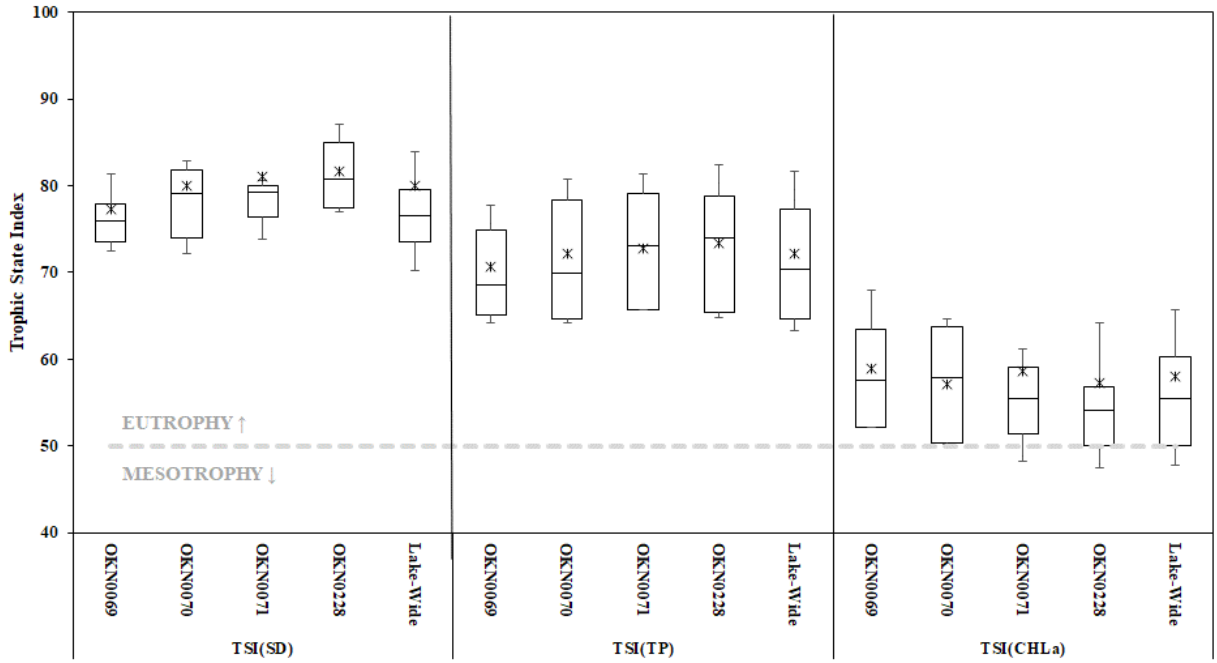

Figure 5. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Fort Supply Lake, OK, March through September 2011.

Total iron concentrations ranged from <0.02 to 0.67 mg/l with a median concentration of 0.42 mg/l. Total manganese concentrations ranged from 0.007 to 0.094 mg/l with a median concentration of 0.050 mg/l. Reportable concentrations of arsenic, chromium, copper, and nickel were found in all samples collected. Reportable concentrations of lead, zinc, and mercury were present in 29, 97, and 44%, respectively, of all samples collected.

Water samples were collected from the Fort Supply Lake tailwater (site 1SUPOKN0227) March through September. Generally, mean and median parameter results are comparable to in-lake data collected near the dam (1SUPOKN0069). Slightly lower turbidity, and slightly higher ammonia and nitrite plus nitrate concentrations were likely due to lack of releases from the lake through a significant portion of the sampling season.

USACE previously conducted water quality sampling at Fort Supply Lake, OK in 1995. That study indicated the lake did not thermally stratify, likely due to lake shallowness and persistent wind. Lake waters were found to be hard and total dissolved concentrations, chloride concentrations, and specific conductance were relatively high. Overall, the lake was turbid and Secchi depth transparency was low contributing to limited primary productivity. Based on 1995 CHLa measurements, the lake would be classified as hyper-eutrophic.