Lake Texoma Water Quality: 2019

The Lake Texoma Denison Dam is located on the Red River at river mile 725.9, 5 miles northwest of the city of Denison in Grayson County, Texas. The lake lies within Hydrologic Unit Codes 11130304 and 11130210. Construction began in August 1939 and final storage began January 1944. Power generation began in March 1945. Authorized purposes include flood damage reduction, regulation of flows on the Red River, water supply, hydropower, recreation, navigation, and other beneficial uses including fish & wildlife. The watershed above the Denison Dam encompasses ~39,719 square miles of which 33,783 square miles is contributing. Figure 1, below, identifies the region around Lake Texoma encompassed by the two Hydrologic Unit Codes identified above. Land use/cover in the region identified is dominated by grassland/pasture (~42%), forest (~33%), and open water (~14%). At the conservation pool elevation of 617.0 feet (NGVD 29), lake capacity, based on the most recent sediment survey conducted in 2002, has diminished by ~22.25%. The estimate suggests an annual conservation pool sedimentation rate of ~12,400 ac-ft/yr. Descriptive characteristics of Lake Texoma are included in Table 1.

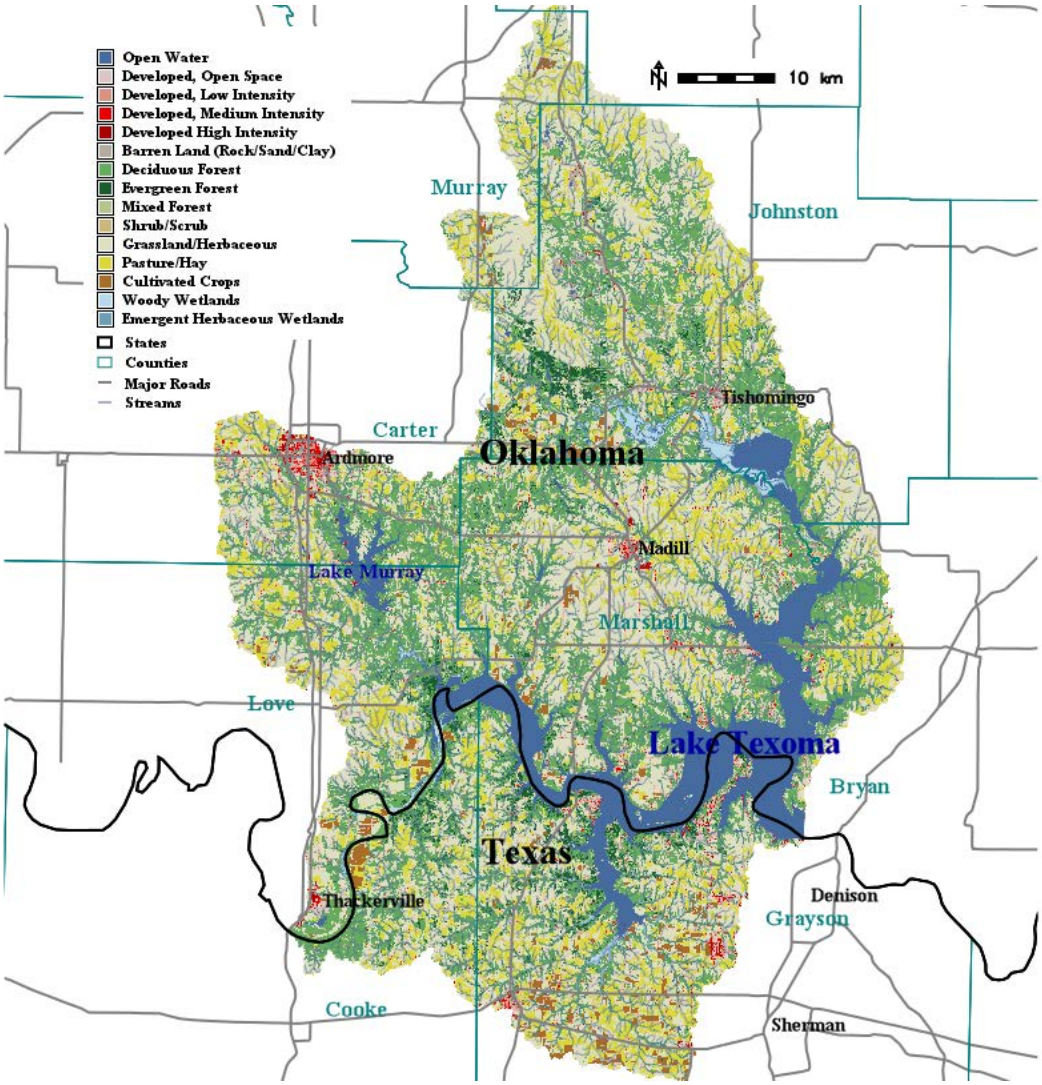

Figure 1. Lake Texoma Regional Watershed.

Table 1. Descriptive Characteristics of Lake Texoma.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	617.0 ft. [NGVD29]	188.06 m
Lake Surface Area (Conservation Pool)	*74,686 ac	30,224 ha
Lake Volume (Conservation Pool)	*2,516,425 ac-ft	$3.103*10^9$ m^3
Total Drainage Area (contributing)	33,783 mi^2	km^2
Mean Depth	*33.7 ft.	10.3 m
Maximum Depth (Conservation Pool)	112 ft.	34.1 m
Shoreline Length	*718 mi	1,115.6 km
Shoreline Development Index	*18.21	18.21
Total Annual Inflow, Average 1906 – 2019 [Water Years]	4,202,110 ac-ft	$5.183*10^9$ m^3
Total Annual Inflow, 2019 [Calendar Year]	7,960,609 ac-ft	$9.818*10^9$ m^3
Hydraulic Residence Time, 2019 [Calendar Year]	123.23 d	0.34 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2019 Annual Water Control Report (U.S. ACE - SWD RCC, 2020), and Tulsa District's Water Control page for Lake Texoma (U.S. ACE - Tulsa District, 2022), *Cumberland Pool excluded.

Lake Texoma lies within both the States of Texas and Oklahoma, and each assigns designated uses for assessment. State of Texas use designations (TCEQ, 2022) for Lake Texoma include primary contact recreational with significant risk of ingestion of water (PCR1), high aquatic life use (H), and domestic [public] water supply (PS). Based on the 2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d), (TCEQ, 2022), no Lake Texoma impairments are listed. The State of Oklahoma designated beneficial uses of the impoundment created by the Denison Dam include Public and Private Water Supply, Fish and Wildlife Propagation as a Warm Water Aquatic Community, Agriculture, Primary Body Contact Recreation, and Aesthetics (OAC 2020a). Assessment of Oklahoma designated beneficial uses at Lake Texoma divides the lake into five units including the Upper Washita River Arm, the Lower Washita River Arm, the Upper Red River Arm, the Lower Red River Arm, and Texoma Lake (main body below each arm). The 2022 Oklahoma Integrated Report (ODEQ 2022) documents impairment in the Lake Texoma Lower Washita River Arm of Fish and Wildlife Propagation as a Warm Water Aquatic Community due to low dissolved oxygen concentration, and Agriculture due to elevated chloride concentrations. Also identified is impairment of Fish and Wildlife Propagation as a Warm Water Aquatic Community in the Lake Texoma Upper Red River Arm due to turbidity.

Physical and chemical water quality data were collected in April, July, August, and September 2019 from eight in-lake sites. Water quality samples were not collected in May and June 2019 due to flood conditions. Sampled sites included TEXOKS0001, TEXOKS0004, TEXOKS0007, TEXOKS0013, TEXOKS0015, TEXOKS0019, TEXOKS0021, and TEXOKS0022. In-lake sites were accessed by boat, and samples were collected from locations over the deepest portion of the stream channel (thalweg). The number of sampling sites accessed each trip required collection of samples over two consecutive days in April, July, and August Sampling locations are identified in Figure 2.

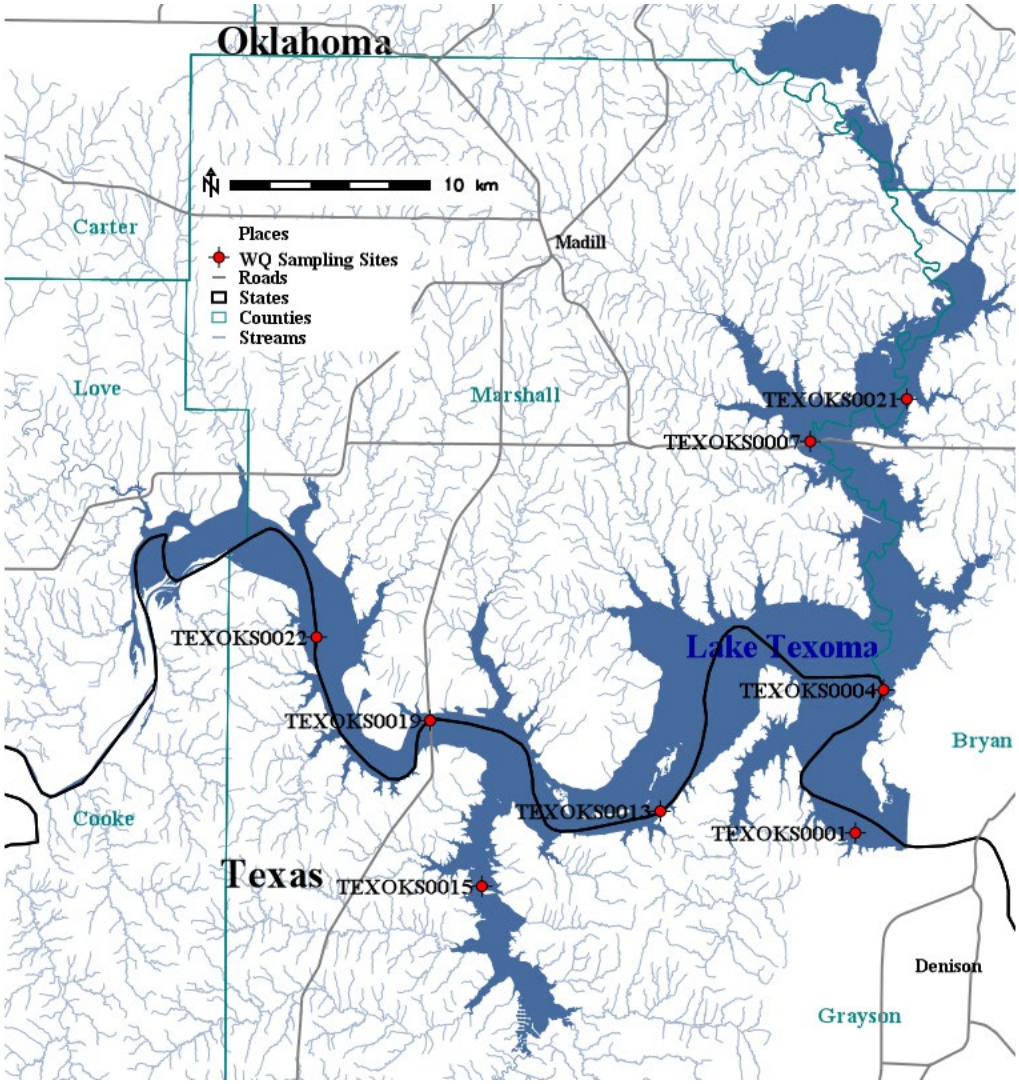

Figure 2. Locations of water quality sampling sites at Lake Texoma in 2019.

The Lake Texoma pool elevation rose above the conservation pool elevation of 617.0 feet in mid-April, continued to rise to greater than 629 feet in June, and returned to near conservation pool elevation in late August 2019. Calendar year 2019 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

In the following descriptions of Lake Texoma water quality, assessments are occasionally grouped by lake area. Data from sites TEXOKS0001 and TEXOKS0004 represent the Main Body (MB) of the lake. Sites TEXOKS0013, TEXOKS0015, TEXOKS0019, and TEXOKS0022 represent the Red River Arm (RRA) of the lake. Finally, data from sites TEXOKS0007, TEXOKS0021 represent the Washita River Arm (WRA) of Lake Texoma.

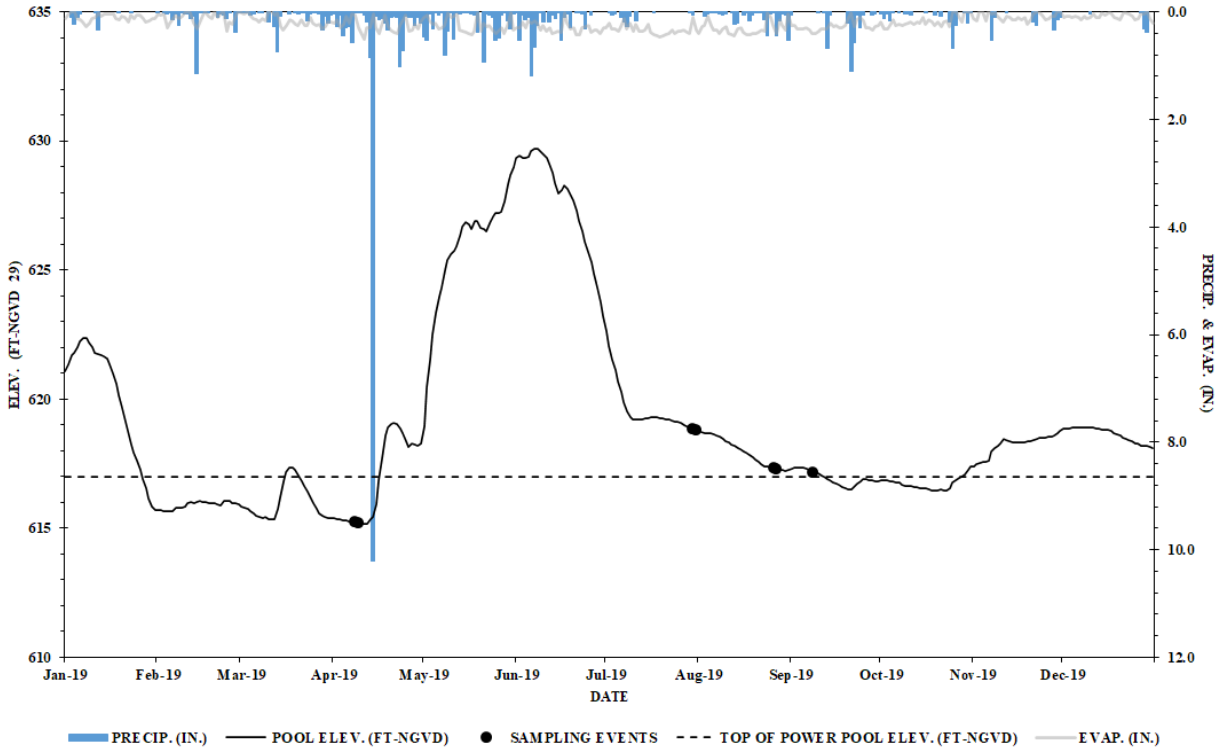

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at Lake Texoma in 2019.

Water temperatures ranged from 10.49 to 30.55 ºC peaking in August and September. Thermal stratification was observed in July and extending into September 2019 with significant temperature variation between surface and depth. The lake-wide median dissolved oxygen concentration was 7.14 mg/l. Hypoxia, dissolved oxygen concentration <2 mg/l, was observed at depth at all sites, except TEXOKS0022, July through September. Lake-wide total organic carbon concentrations were moderately high (median 6.92 mg/l), with highest concentrations in the Red River Arm (median 7.50 mg/l).

Specific conductance, lake-wide median 1,341.5 µS/cm, was highest in the Red River Arm (median 1,754 µS/cm) and lowest in the Washita River Arm (1,204 µS/cm). Total dissolved solids median concentration was 872 mg/l. Lake-wide median concentrations of calcium, magnesium, sodium, and potassium were 92.75, 34.1, 153, and 6.55 mg/l, respectively. Relatively high chloride and sulfate concentrations (lake-wide medians 241.5 and 266 mg/l, respectively) were observed, with highest chloride concentrations in the Red River Arm (median 349 mg/l) and highest sulfate concentrations in the Washita River Arm (median 293 mg/l). Alkalinity levels (median 146 mg/l as $CaCO_3$) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 370.5 mg/l as $CaCO_3$, indicate 'hard' water. Observed pH (6.97 to 8.58) ranged within regional norms. Lowest pH observations were recorded at depth in September (TEXOKS0001 &TEXOKS0013) with corresponding low (<0.5 mg/l) dissolved oxygen concentrations. Highest pH observations were observed in July and August in the Red River Arm corresponding with relatively high dissolved oxygen (and chlorophyll-*a*) concentrations indicating abundant algal activity.

Maximum recorded Secchi depth was 2.46 meters in the Main Body of the lake, and the lake-wide median was 1.18 meters. Lake-wide median turbidity was 11.9 NTU. Approximately 14% of all turbidity observations exceeded 25 NTU. Total suspended solids concentrations (lake-wide median 4.2 mg/l) were highest in the Red River Arm (median 7.34 mg/l). The euphotic zone at Lake Texoma was typically between 1.5 to 3.5 meters.

Observed lake-wide ammonia concentrations, median 0.09 mg/l, were highest in bottom samples (median 0.26 mg/l) corresponding with stratification and anoxic conditions at depth. Nitrite plus nitrate concentrations (lake-wide median 0.07 mg/l) were seasonally elevated with highest observations lake-wide in April. Total Kjeldahl nitrogen concentrations (lake-wide median 0.64 mg/l) were moderately high with highest observations in the Main Body at depth in September. Estimated lake-wide surface median total nitrogen concentration during the 2019 study was ~0.67 mg/l. Total phosphorus concentrations ranged between 0.10 and 0.50 mg/l (lake-wide median 0.15 mg/l). Lake-wide median dissolved ortho-phosphate concentration was 0.13 mg/l. Observations of dissolved ortho-phosphate concentrations at depth were significantly higher than surface observations. Surface nitrogen to phosphorus concentration ratios (N:P) were low (median 5.1), indicating potential nitrogen limitation of algal growth at Lake Texoma.

Chlorophyll-*a* concentrations ranged from 2.8 to 52.3 µg/l, with a lake-wide median concentration of 16.5 µg/l. Median observations were lowest in the Main Body of the lake (12.8 µg/l), and higher in the Washita River Arm (16.25 µg/l) and Red River Arm (23.0 µg/l). Figure 4, below, summarizes phytoplankton, by division, relative abundance and biovolume at select Lake Texoma sites (TEXOKS0001, TEXOKS0019, TEXOKS0013, and TEXOKS0007) in 2019. In April 2019 relative abundance generally reflected a broad distribution among phytoplankton divisions identified. In July through September 2017, relative abundance was dominated by Cyanophytes (blue greens). Biovolume was initially dominated by Cryptophytes (April), shifting to a more diverse biovolume representation in July, and transitioning to dominance by Cyanophytes in August and September 2019.

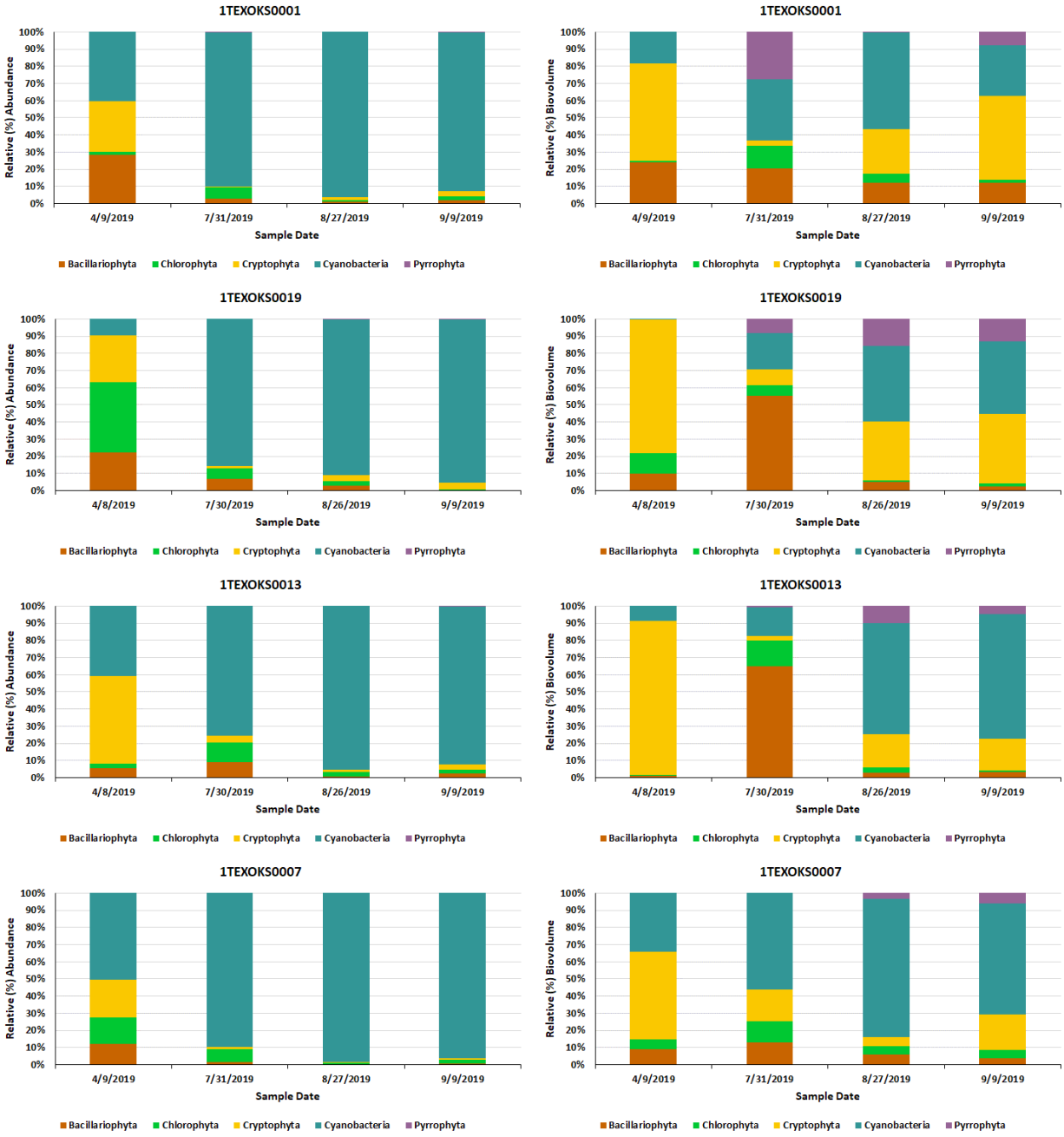

Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at selected sites in Lake Texoma, April, July, August, and September 2019.

The trophic status of Lake Texoma (lake-wide) in 2019, assessed using Carlson's trophic state index (TSI), indicated a moderately eutrophic lake as measured by Secchi depth (TSI(SD), 57.6) and chlorophyll-*a* concentrations (TSI(CHLa), 58.1). The index developed from total phosphorus concentrations (TSI(TP), 74.6) approaches a hypereutrophic classification (Figure 5).

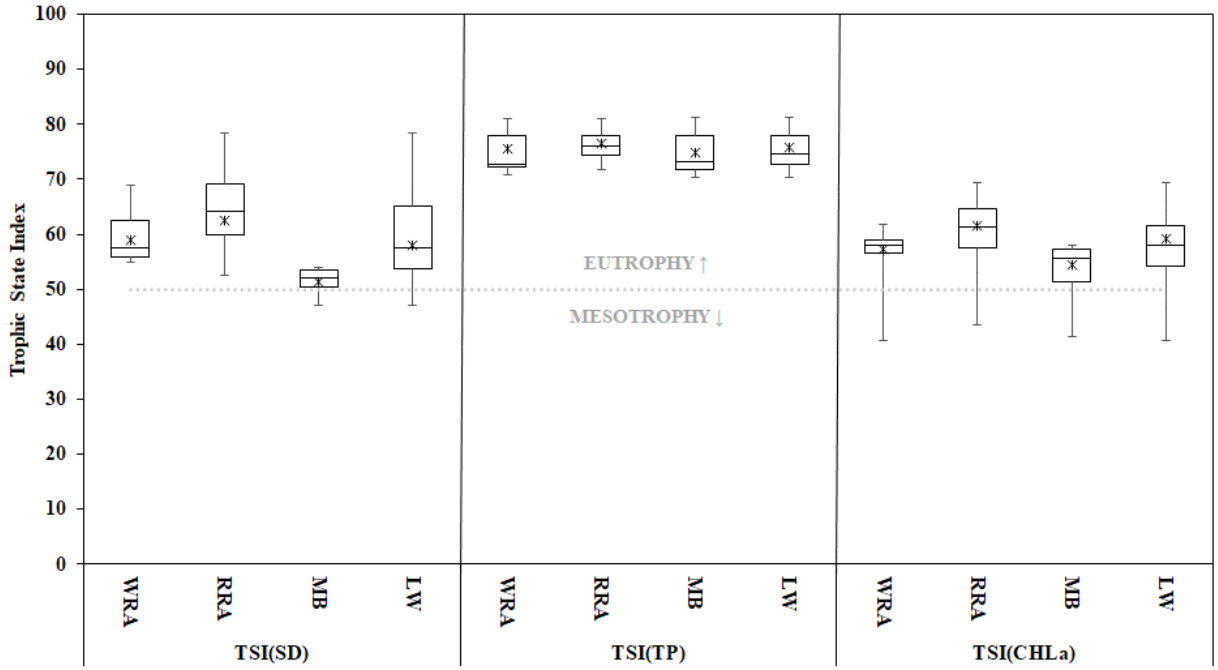

Figure 5. Distributions of Carlson's Trophic Sate Index (TSI), by lake area (WRA, RRA, MB, and LW [Lake-Wide]), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Lake Texoma.

Total iron (lake-wide median 0.07 mg/l) and manganese (lake-wide median 0.03 mg/l) concentrations were relatively low, although manganese concentrations were elevated at depth. Water samples from Lake Texoma were analyzed for total concentrations of select priority pollutant metals. Of the priority pollutant metal concentrations monitored, reportable concentrations of arsenic, mercury, chromium, copper, lead, nickel, selenium, silver, and zinc were noted at low levels.

USACE contracted a water quality study of Lake Texoma in 1977. Thermal stratification and anoxia within the hypolimnion was noted. Observations of conductivity, pH, calcium, sodium, chloride, and sulfate correspond with levels observed in 2019.