Hulah Lake Water Quality: 2005

The Hulah Lake dam is located at river mile 96.2 on the Caney River approximately 15 miles northwest of the city of Bartlesville, in Osage County, Oklahoma (OK). Hulah Lake is a multipurpose project for flood control, water supply, water quality, navigation, recreation, and fish and wildlife. The project was designed to provide maximum flood protection on the Caney and Verdigris Rivers when operated in conjunction with the Arkansas River Basin System. The impoundment extends north-northwest and west-southwest from the dam forming two arms. The arm trending west follows the channel of the Caney River and tributary Turkey Creek. The arm trending north extends to the confluence of Skull Creek and Hickory Creek. The lake and watershed are within Hydrologic Unit Codes 1107010602 (Upper Caney River) and 1107010601 (Headwaters Caney River). Construction of the Hulah Lake dam began in May 1946. Final storage began and the conservation pool was filled in September 1951. The total drainage area above the dam is reported as 732 square miles (Figure 1). Land use/cover (U.S. Geological Survey, 2011) in the basin is dominated by grassland/pasture (80%) and forest (12%). Based on a 2014 bathymetric survey (Wilson & Company, Inc., 2015), at the conservation pool elevation of 733.0 feet (NGVD 29), lake capacity has diminished by about 54% since construction. Descriptive characteristics of Hulah Lake are included in Table 1.

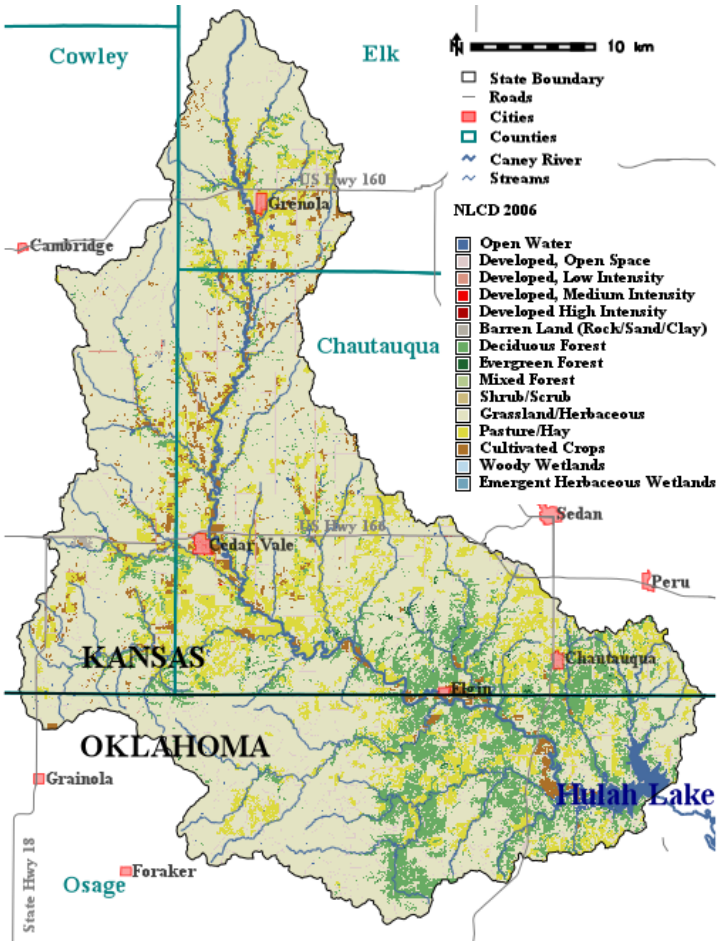

Figure 1. The Hulah Lake (Caney River) Watershed above the Hulah Lake Dam.

Table 1. Descriptive Characteristics of Hulah Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	733.0 ft NGVD	223.42 m
Lake Surface Area (Conservation Pool)	2,634 ac	1,066 ha
Lake Volume (Conservation Pool)	16,782 ac-ft	$20.7*10^6$ m^3
Total Drainage Area	732 mi^2	1,896 km^2
Mean Depth	6.4 ft	1.95 m
Maximum Depth (Conservation Pool)	21.5 ft	6.55 m
Shoreline Length	27.25 mi	43.85 km
Shoreline Development Index	3.79	3.79
Annual Inflow, Average 1918 – 2005 [Water Years]	331,100 ac-ft	$408.41*10^6$ m^3
Annual Inflow, 2005 [Calendar Year]	394,316 ac-ft	$486.38*10^6$ m^3
Hydraulic Residence Time, 2005 [Calendar Year]	29.15 d	0.08 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2021), the FY 2005 Annual Water Control Report (U.S. ACE - SWD, 2006), Tulsa District's Water Control page for Heyburn Lake (U.S. ACE - Tulsa District, 2024), and the 2014 bathymetric survey (Wilson & Company, Inc., 2015).

Designated beneficial uses of the reservoir created by the Hulah 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 a nutrient-limited watershed (designated beneficial use(s) adversely affected by excess nutrients (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 Hulah Lake water quality as impaired with respect to Fish and Wildlife Propagation as a Warm Water Aquatic Community, and Fish Consumption. Identified issues include turbidity and the presence of mercury, respectively.

Physical and chemical water quality data were collected monthly, April through September 2005, from four in-lake sites and the tailwater at Hulah 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 1HULOKN0118 (channel at dam), 1HULOKN0119 (mouth of Skull Creek), 1HULOKN0116 (near mouth of Turkey Creek), 1HULOKN0117 (near Caney River inflow), and 1HULOKN0226 (tailwater). 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.

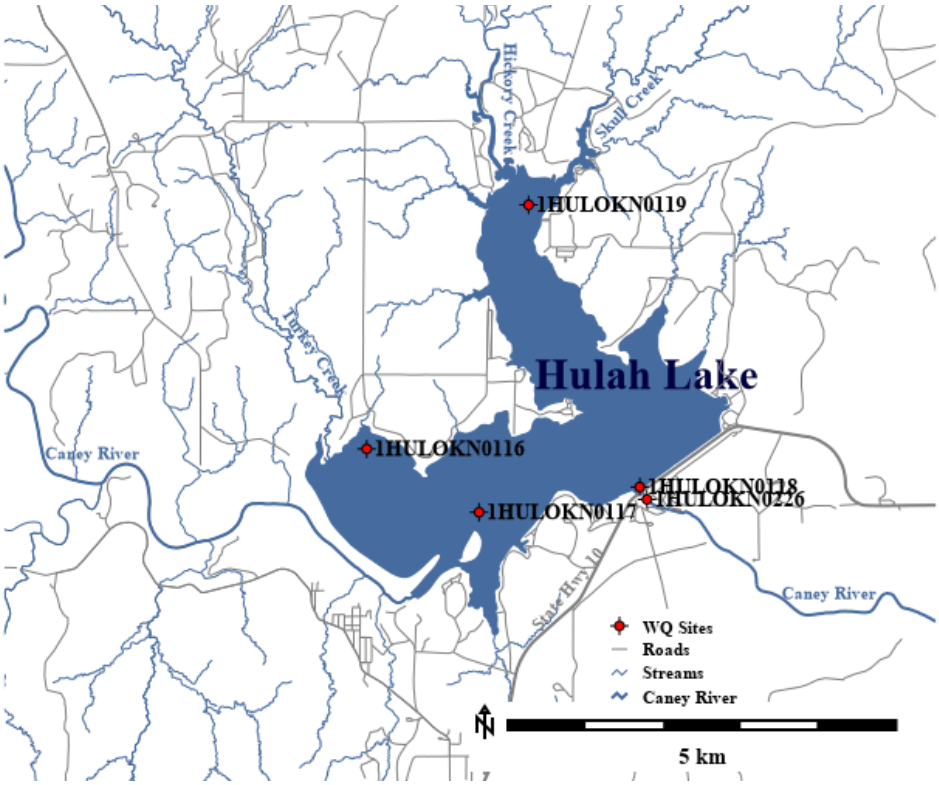

Figure 2. Locations of water quality sampling sites at Hulah Lake, OK, 2005.

The Hulah Lake pool was near conservation elevation (733.0 feet) in April, May, and July through September, but high in June. June was sampled twice, once prior to, and once following the peak pool elevation of 749.42 feet. During calendar year 2005, annual basin precipitation totaled 33.9 inches, 96% of the 1971 – 2000 normal. Calendar year 2005 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 4.

Figure 3. A photograph, lake side, of the Hulah Lake dam structure on 01-APR-2002.

Hulah Lake suffered a severe drought in 2002 losing all but 17 percent of its conservation pool. Recorded pool elevation dropped below 725 feet. During the critical stage of the drought all downstream flows and withdrawals from the lake had to be discontinued (Figure 3).

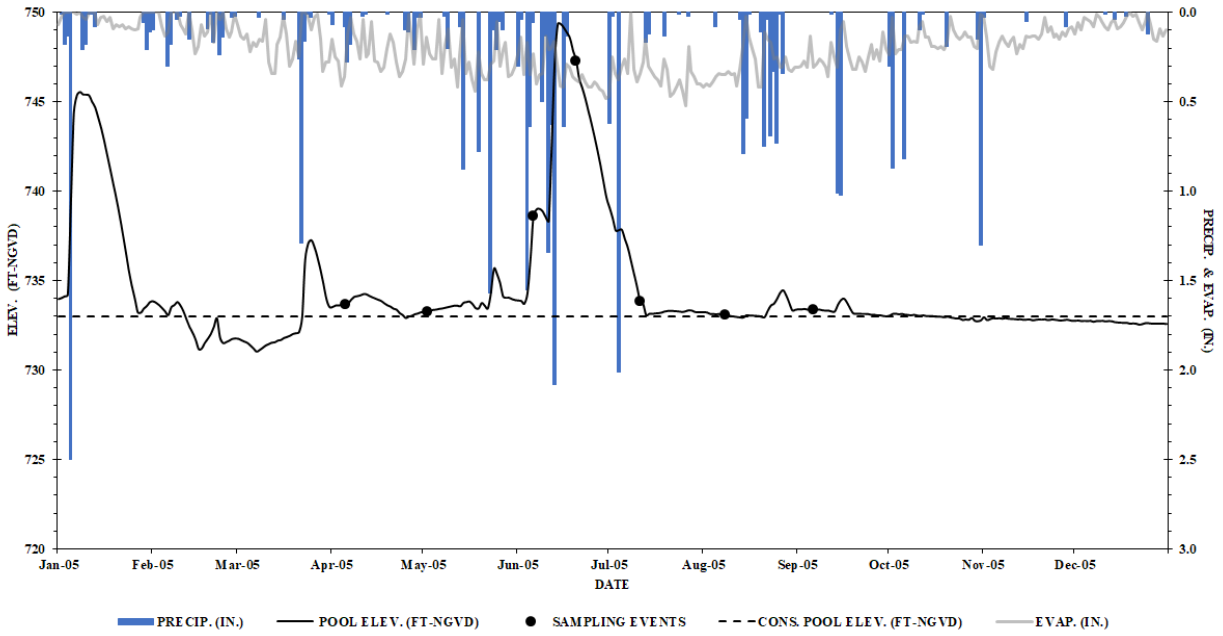

Figure 4. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Hulah Lake, OK, 2005.

Water temperatures varied seasonally (ranging from 15.00 to 31.09 ºC). Highest recorded water temperatures were noted in July and August at 1HULOKN0119 and 1HULOKN0116 where surface temperatures were greater than 30.0 ºC. Temporary vertical thermal stratification in Hulah Lake was observed from mid to late June. Hypoxia was noted at all in-lake sites 20-June at depths ranging from 2 to 5 meters below the surface. Median dissolved oxygen concentration was 5.8 mg/l with observations ranging from 0.33 to 9.85 mg/l. The lake was well-buffered (median alkalinity of 128 mg/l as CaCO3) and moderately hard (median hardness of 134 mg/l as CaCO3). Median chloride and sulfate concentrations were 12.0 and 11.0 mg/l, respectively. Hulah Lake was consistently turbid (median Secchi depth, turbidity, and total suspended solids concentration of 0.25 m, 55.9 NTU, and 36.0 mg/l, respectively) due in large part to suspended inorganic material. Nearly 80% of all turbidity measurements exceeded the 25 NTU Oklahoma turbidity standard for lakes (OAC, 2023a).

Nutrient levels in Hulah Lake were relatively high. The bulk of nitrogen in the system was in organic forms (total Kjeldahl nitrogen median of 0.67 mg/l). The median in-lake surface total nitrogen concentration was 0.75 mg/l. Total phosphorus concentrations (median 0.076 mg/l) indicated potential for a highly productive system, although a significant fraction of total phosphorus is likely bound to suspended sediments. The ratio of surface total nitrogen to total phosphorus concentrations (N:P ratio) ranged from 4.7 to 23.1, with a median of 9.9, suggesting potential phosphorus limitation of algal growth early in the sampled period trending toward nitrogen limitation during early summer. High concentrations of inorganic suspended materials influence light penetration and light availability for algal growth. Chlorophyll-a concentrations, an indicator of algal biomass, were relatively high (median 19.3 µg/l). The metals iron and manganese were observed at relatively high concentrations (medians 2.66 and 0.15 mg/l, respectively). Detectable concentrations of mercury were observed in 37% of samples collected. Six of seven bottom samples (85.7%) at 1HULOKN0118 contained detectable concentrations of mercury.

Trophic status of Hulah 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, the lakewide median TSI(SD) of 80.0 indicates eutrophy. The lakewide median based on total phosphorus [TSI(TP)] is lower, 66.3, but still indicates enhanced lake productivity. TSI(CHLa), based on chlorophyll-a concentrations, with a lakewide median value of 59.6, indicates eutrophy.

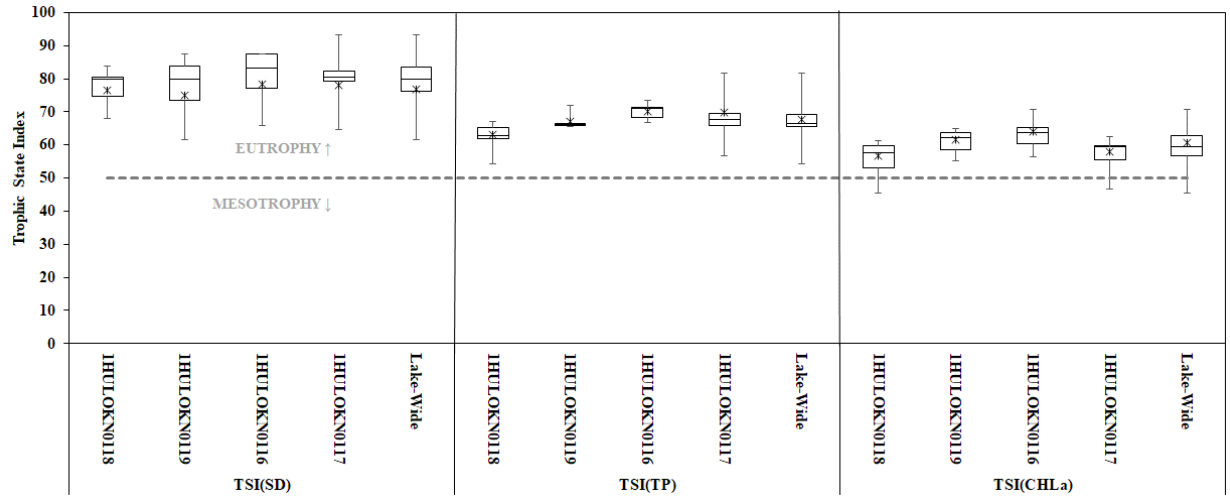

Figure 5. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Hulah Lake, OK, April through September 2005.

Mean and median parameter results from water samples collected from the Hulah Lake tailwater (1HULOKN0226) are comparable to in-lake data collected near the dam (1HULOKN0118).

A summary of the more recent water quality data collected by the Oklahoma Water Resources Board (OWRB, 2019) indicates 78% of observed turbidity levels exceeded the Oklahoma Water Quality Standards criterion for lakes of 25 NTU. Nutrient concentrations, including surface total nitrogen and total phosphorus, were seasonally elevated contributing to moderately high chlorophyll-a concentrations (16.77 µg/l) resulting in classification as a eutrophic waterbody. The lake experienced late summer stratification resulting in low dissolved oxygen concentrations (less than 2.0 mg/l) at depth. Specific conductance ranged from 258.3 to 418.8 µS/cm and pH ranged from 7.29 to 8.43 standard units, both consistent with regional norms.

USACE contracted a water quality investigation at Hulah Lake, OK in 1980, and performed sampling in 1994. The 1980 investigation found high suspended solids concentrations, and sedimentation within the conservation pool affecting safe boating activity. The 1994 effort reported fairly turbid, moderately hard water well-buffered against drastic pH changes. The lake was classified as eutrophic, and turbidity was identified as a likely factor limiting primary productivity.