

Hulah Lake

Hulah Lake was sampled for four quarters from October 2004 through July 2005. Water quality samples were collected from five (5) sites to represent the riverine, transition and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam site. The average lake-wide turbidity was 45 NTU (Plate 59), true color was 48 units and average secchi disk depth was 28 centimeters in sample year 2003. Based on these three parameters water clarity was poor at Hulah Lake in 2005, consistent with results from 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-*a*), was calculated using values collected at all sites for three quarters (n=15). Due to a post-processing error no samples were submitted to lab for analysis from the fall data collection efforts. The average TSI was 54 (Plate 59), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. Although based on only three quarters, this value is similar to the TSI in 2003 (TSI=55), indicating no significant change in productivity has occurred since the previous evaluation. The TSI values for all sites were mesotrophic in the winter and eutrophic during both spring and summer. The only exception was site 3, which was oligotrophic in the winter quarter. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in Figure 79a. Only one of the twenty values collected was below the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq 25\%$ of the samples exceed the WQS of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. With 95% of the collected values exceeding the numerical criteria of 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is not supported. Seasonal true color values are displayed in Figure 79b. True color values ranged from 25 to 84 units. Applying the same default protocol the Aesthetics beneficial use is considered as only 5% of the reported values exceeded the WQS of 70 units.



In 2005 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Hulah Lake ranged from 0.11 parts per thousand (ppt) to 0.23 ppt. This is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 242.3 $\mu\text{S}/\text{cm}$ to 358.3 $\mu\text{S}/\text{cm}$, indicating moderate concentrations of electrical current conducting compounds (chlorides and salts) in the lake system. The pH values ranged from 7.23 to 8.43 representing a neutral system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 184 mV in the hypolimnion during the fall to 487 mV during the spring quarter. All ORP values were positive indicating reducing conditions

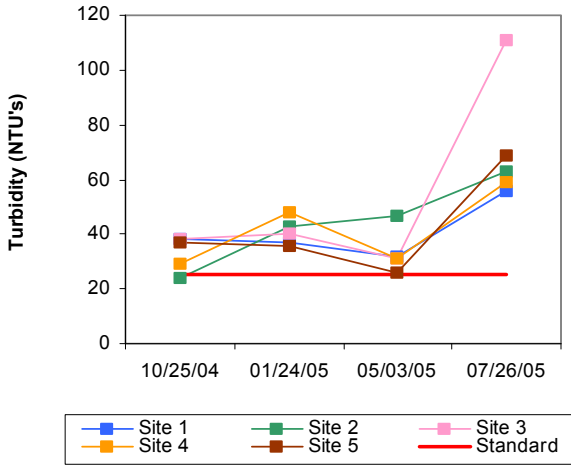
were not present in the lake. Thermal stratification was not present during the fall, winter and spring sampling intervals and the lake was well mixed (see Figure 79c-79e). In the summer dissolved oxygen (D.O) only fell below 2.0 mg/L at the sediment-water interface, which may be the result of the Hydrolab probe resting on the lake bottom (see Figure 79f). This lake is very shallow and generally stays well mixed due to wind and wave action. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered supported at Hulah Lake with only 1D.O. reading below 2.0 mg/L during the summer. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2004-2005 found the Agriculture beneficial use to be fully supported bases on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

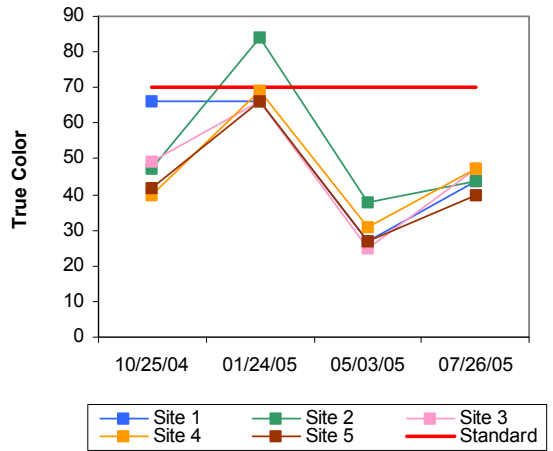
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.62 mg/L at the surface. Surface TN ranged from 0.31 mg/L to 1.44 mg/L, with the highest values seen in the summer and lowest in the spring quarter. The lake-wide total phosphorus (TP) average was 0.080 mg/L at the surface. Total phosphorus at the surface ranged from 0.056 mg/L to 0.129 mg/L. Similar to TN surface TP was highest in the summer and lowest during the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 8:1 for sample year 2004-2005. This is only slightly higher with the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Hulah Lake was eutrophic, indicative of high primary productivity and nutrient levels in 2004-2005. This is consistent with the evaluation in 2003, indicating no significant change in productivity has occurred since the lake was last sampled. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards. This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Water clarity was poor based on true color, turbidity and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and dissolved oxygen values, but not supporting based on high turbidity levels. With only 5% of the values exceeding the WQS of 70 units, the Aesthetics beneficial is considered supported based on true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Hulah Lake, located in Osage County, was constructed by the United States Army Corps of Engineers (USACE) for the purpose of flood control, water supply, low-flow regulation and conservation.

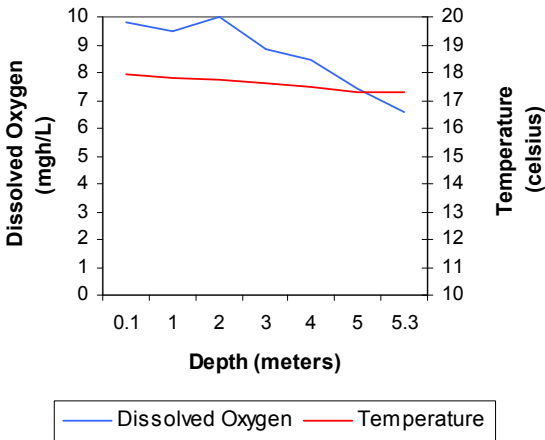
a. Seasonal Turbidity Values for Hulah Lake



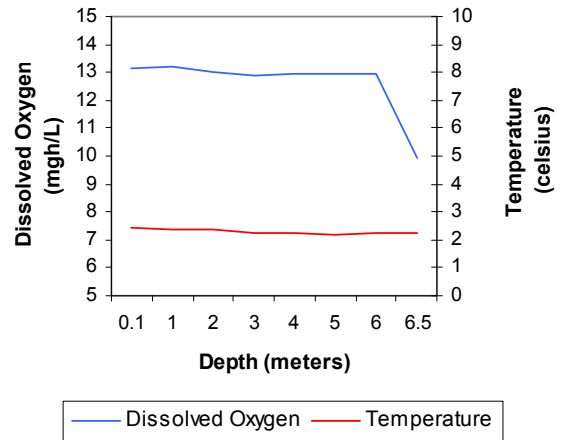
b. Seasonal Color Values for Hulah Lake



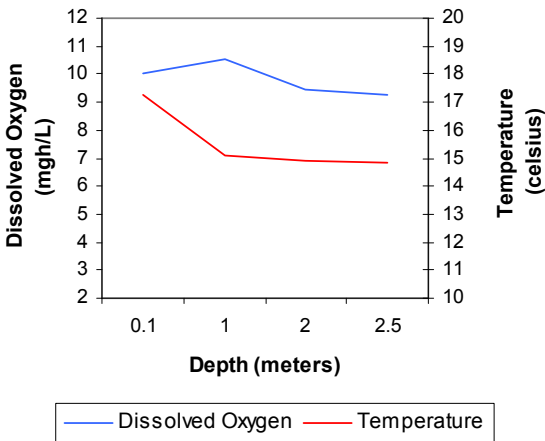
c. Profile of Hulah Lake
October 25, 2004



d. Profile of Hulah Lake
January 25, 2005



e. Profile of Hulah Lake
May 03, 2005



f. Profile of Hulah Lake
July 26, 2005

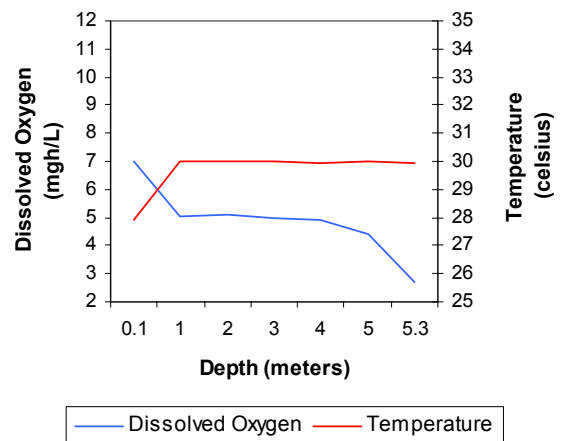


Figure 79a-79f. Graphical representation of data results for Hulah Lake.



Lake Data	
Constructed by	Corps of Engineers
County	Osage
Constructed in	1951
Surface Area	3,570 acres
Volume	31,160 acre/feet
Shoreline Length	62 miles
Mean Depth	9.64 feet
Watershed Area	732 square miles

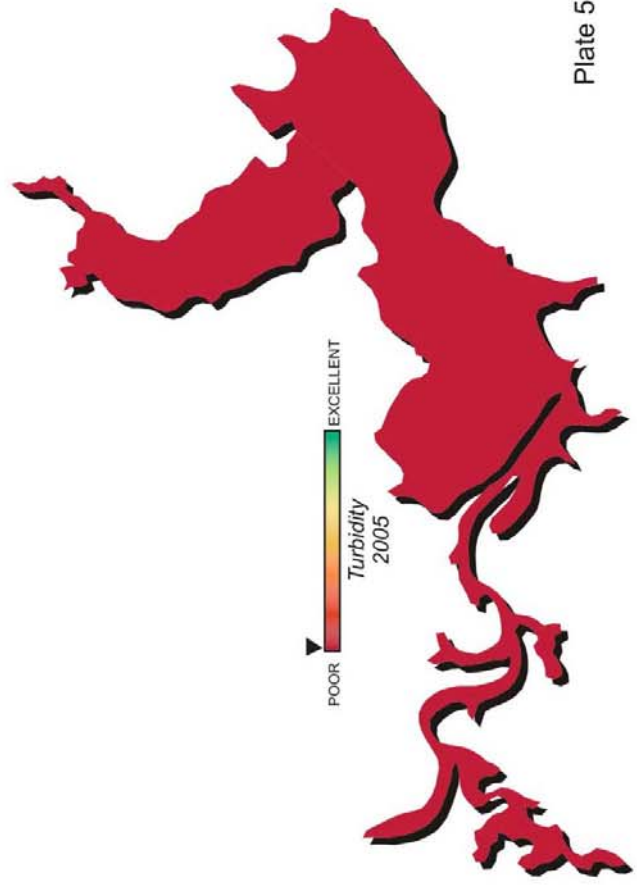


Plate 59 - Lake Water Quality for
Hulah Lake

LAKES MONITORING PROGRAM