Kaw Lake Water Quality: 2021

The Kaw Lake dam is located on the Arkansas River at river mile 653.7, about eight miles east of Ponca City, in Kay and Osage Counties, Oklahoma within Hydrologic Unit Code 11060001. The conservation pool of Kaw Lake was first filled in May 1977 after final storage began in April 1976. Authorized purposes include flood damage reduction, water supply, water quality, fish and wildlife, and recreation. The watershed above the Kaw Lake dam site extends to the headwaters of the Arkansas River near Leadville, CO. The total drainage area above the dam is ~48,300 square miles; however, the contributing area is ~38,771 square miles (Figure 1). Land use/cover in the basin is dominated by grassland/pasture (~44%) and cultivated cropland (~32%). Based on a 2020 bathymetric survey, at the conservation pool elevation of 1,010.0 feet (NGVD 29) lake capacity has diminished by about 20% since impoundment due to sedimentation. Descriptive characteristics of Kaw Lake are included in Table 1.

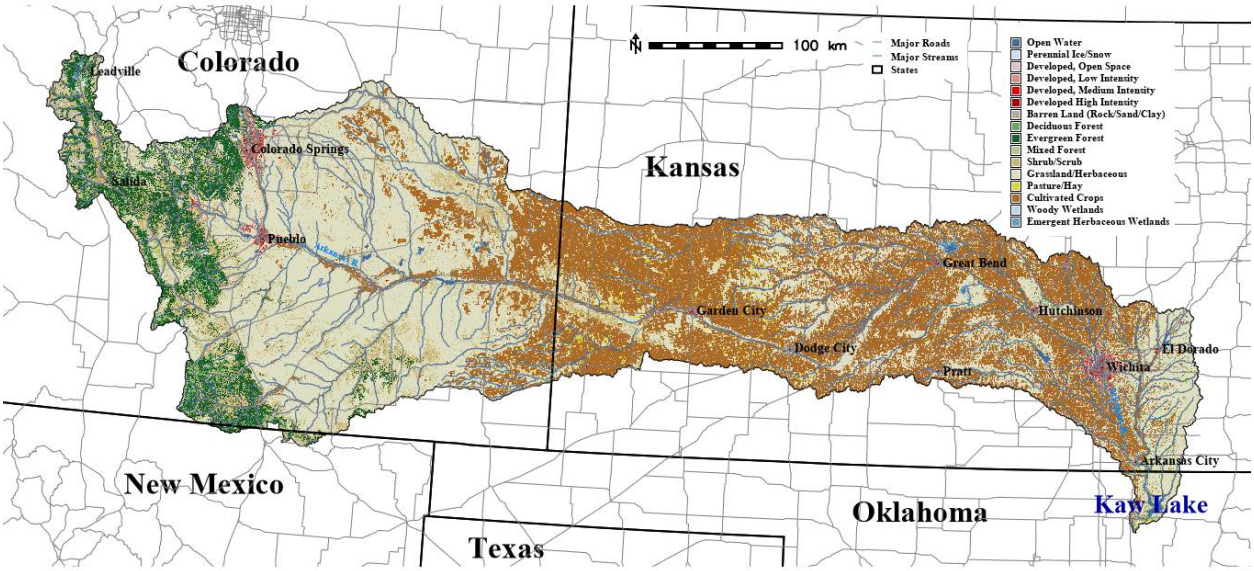

Figure 1. The Kaw Lake (Arkansas River) Watershed.

Table 1. Descriptive Characteristics of Kaw Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,010.0 ft. NGVD	307.85 m
Lake Surface Area (Conservation Pool)	14,260 ac	5,770 ha
Lake Volume (Conservation Pool)	344,043 ac-ft	$424.37*10^6$ m^3
Total Drainage Area (contributing)	38,771 mi^2	100,416 km^2
Mean Depth	24.1 ft.	7.35 m
Maximum Depth (Conservation Pool)	79 ft.	24.1 m
Shoreline Length	116.4 mi	187.3 km
Shoreline Development Index	6.5	6.5
Annual Inflow, Average 1922 – 2021 [Water Years]	2,047,370 ac-ft	$2.525*10^9$ m^3
Annual Inflow, 2021 [Calendar Year]	2,071,041 ac-ft	$2.554*10^9$ m^3
Hydraulic Residence Time, 2021 [Calendar Year]	70.38 d	0.19 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2021 Annual Water Control Report (U.S. ACE - SWD RCC, 2021), Tulsa District's Water Control page for Kaw Lake (U.S. ACE - Tulsa District, 2023), and the 2020 bathymetric survey (Seaworks Group, LLC, 2021).

Designated beneficial uses of the impoundment created by the Kaw Lake 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). Based on the 2022 Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ 2022), the upper portion of Kaw Lake is listed as impaired by turbidity affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community. Additionally, fish consumption (lake-wide) is impaired due to elevated mercury concentrations.

Physical and chemical water quality data were collected monthly by USACE from six in-lake sites and the stilling basin at Kaw Lake beginning 12 April and ending 14 September 2021 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 KAWOKN0096 (over channel at the dam), KAWOKN0097 (SW of Kaw City), KAWOKN0098 (channel W of Sarge Creek), KAWOKN0099 (Beaver Creek Arm at Furguson Road bridge), KAWOKN0101 (N of Kaw City), KAWOKN0102 (near mouth of Bear Creek), and KAWOKN0234 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.

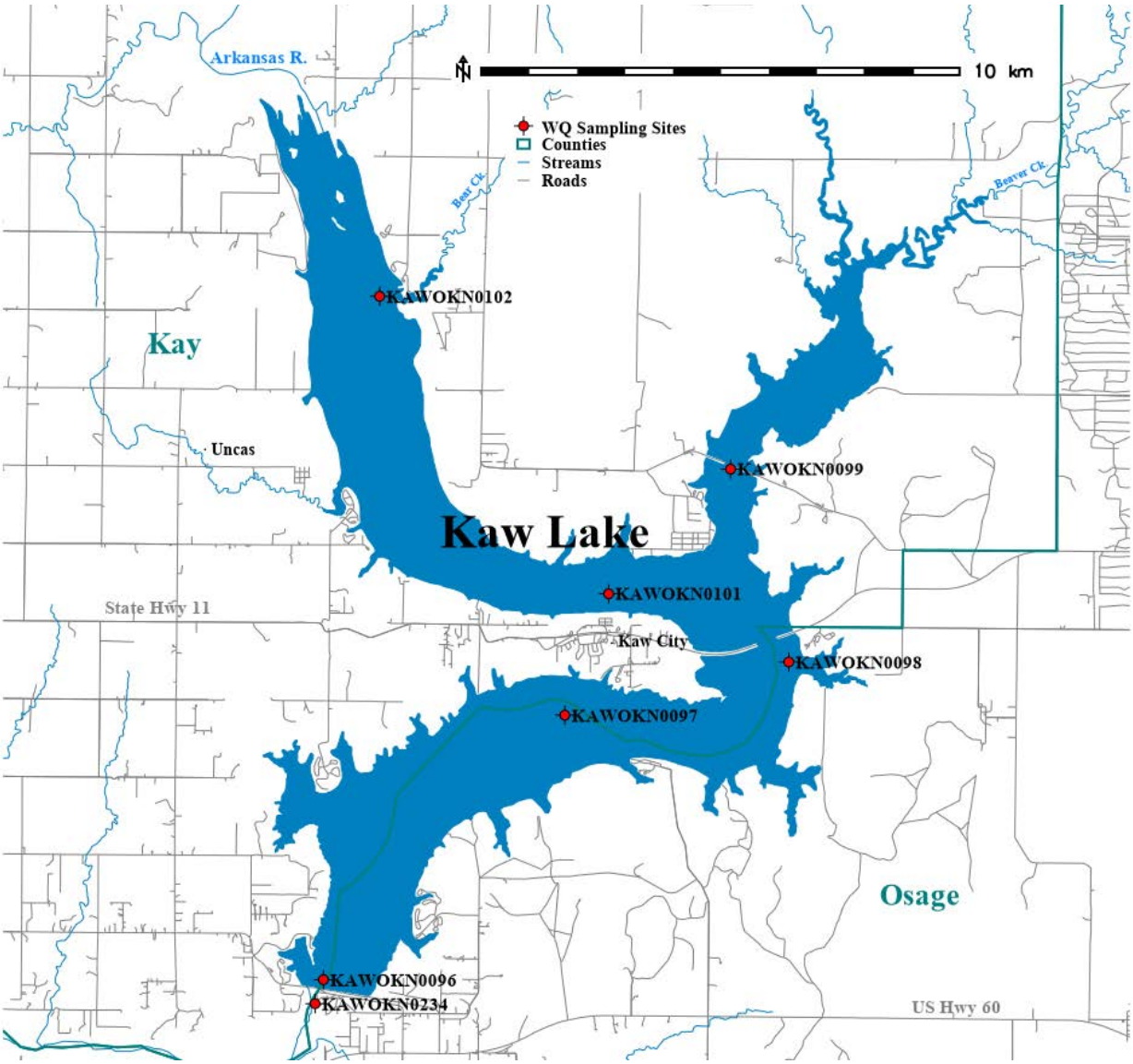

Figure 2. Locations of water quality sampling sites at Kaw Lake, OK, 2021.

The Kaw Lake pool elevation was at or above the conservation pool elevation throughout the sampling period in calendar year 2021. Calendar year 2021 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

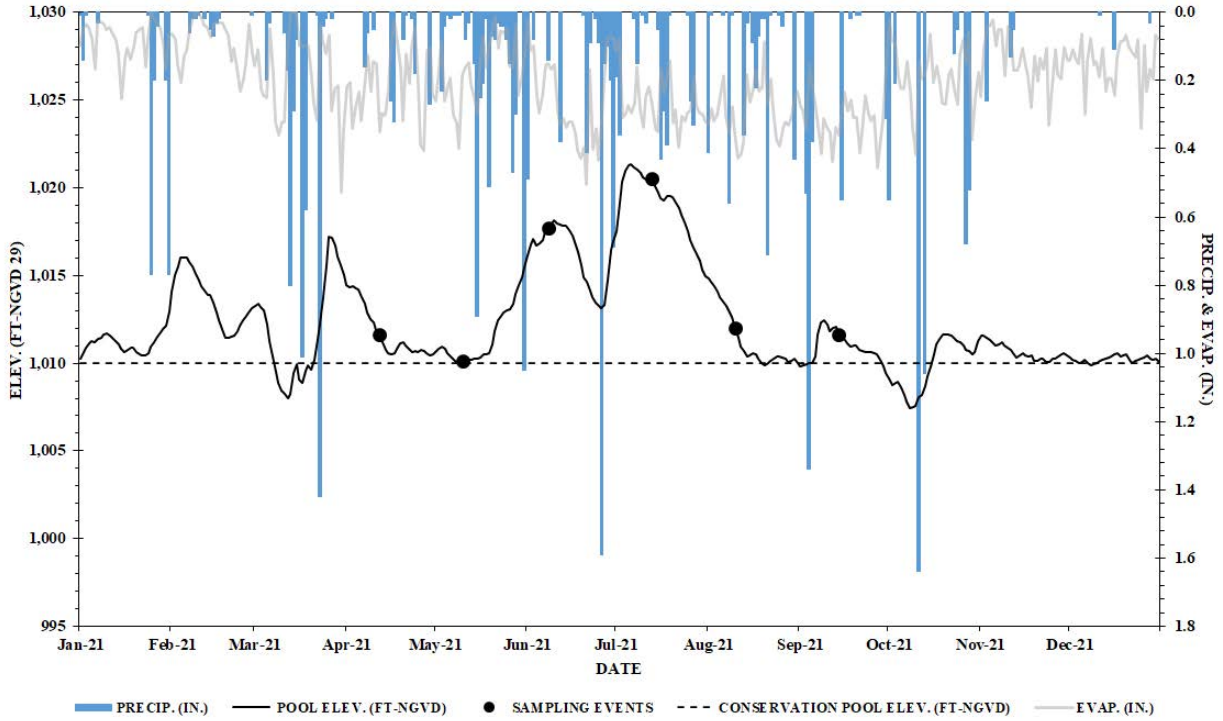

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), seasonal conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at Kaw Lake, OK, 2021.

Water temperatures varied seasonally (ranging from 14.80 to 28.34 ºC) peaking in August. Water temperatures, on individual sampling dates, displayed notable variation especially at sites KAWOKN0096 and KAWOKN0097 June through August. The reservoir did experience observable thermal stratification at lower lake sampling sites starting in June and ending before September. The study period in-lake median dissolved oxygen concentration was 5.30 mg/l. Observed in-lake dissolved oxygen concentrations ranged from 0.0 to 11.48 mg/l. Lowest dissolved oxygen concentrations were observed at the dam site (KAWOKN0096) in July and August when the bottom 10 and 14 meters of the water column, respectively, were hypoxic (dissolved oxygen concentration < 2 mg/l). Hypoxia at depth was also observed July and August at sites KAWOKN0097, KAWOKN0098, and KAWOKN0101. In-lake total organic carbon concentrations were high with a study period median of 6.92 mg/l. Observed median total organic carbon concentrations were highest at site KAWOKN0102 (8.39 mg/l) gradually diminishing down-lake to site KAWOKN0096 (6.20 mg/l).

Specific conductance (median 665 µS/cm) was moderately elevated, consistent with regional norms. Total dissolved solids median concentration was 423 mg/l. Moderately high chloride and sulfate concentrations (medians 88.45 and 54.40 mg/l, respectively) were observed indicating other components (minerals, cations) are contributing to dissolved solids. Alkalinity levels (median 134.0 mg/l as $CaCO_3$) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 172 mg/l as $CaCO_3$, indicate 'hard' water. Observed in-lake pH (7.06 to 8.46) ranged within regional norms. Highest pH was recorded near the surface at sites KAWOKN0096 and KAWOKN0097 in June, July, and August. Lowest pH was recorded in June at depth at site KAWOKN0101.

The lake was turbid through 2021. The study period median Secchi depth was 0.44 meters. Median Secchi depth increased from site KAWOKN0102 (0.20 m) down-lake to the dam site (KAWOKN0096, 0.88 m). In-lake median turbidity was 28.75 NTU, and 55% of all in-lake observations were greater than or equal to 25 NTU. Median total suspended solids concentrations (11.5 mg/l) decreased from the upper lake site (KAWOKN0102, 93.5 mg/l) down to the dam site (KAWOKN0096, 6.4 mg/l). The euphotic zone at Kaw Lake ranged from ~0.5 meters in the upper lake to ~2 meters near the dam.

Lake-wide ammonia concentrations were moderate (median 0.14 mg/l), and nitrite plus nitrate concentrations were moderate to high (median 0.60 mg/l). Total Kjeldahl nitrogen concentrations (median 0.74 mg/l) were moderately high. Estimated lake-wide median total nitrogen concentration during the 2021 study was 1.25 mg/l. Total phosphorus concentrations ranged between 0.24 and 0.70 mg/l (median 0.33 mg/l). Observations of dissolved ortho-phosphate, median 0.19 mg/l, were moderately elevated throughout the lake. Nitrogen to phosphorus ratios (N:P) in 2021 were <10 (median 3.9), indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-*a* concentrations (in-lake) ranged from 2.8 to 70.8 µg/l, with a median concentration of 10.75 µg/l. Highest concentrations were observed at upper lake sites (KAWOKN0101 and KAWOKN0102) in April 2021. Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton observed at Kaw Lake. Cyanophyte (blue-greens) abundance tended to increase through the sampled period while biovolume was mostly dominated by Bacillariophytes (diatoms).

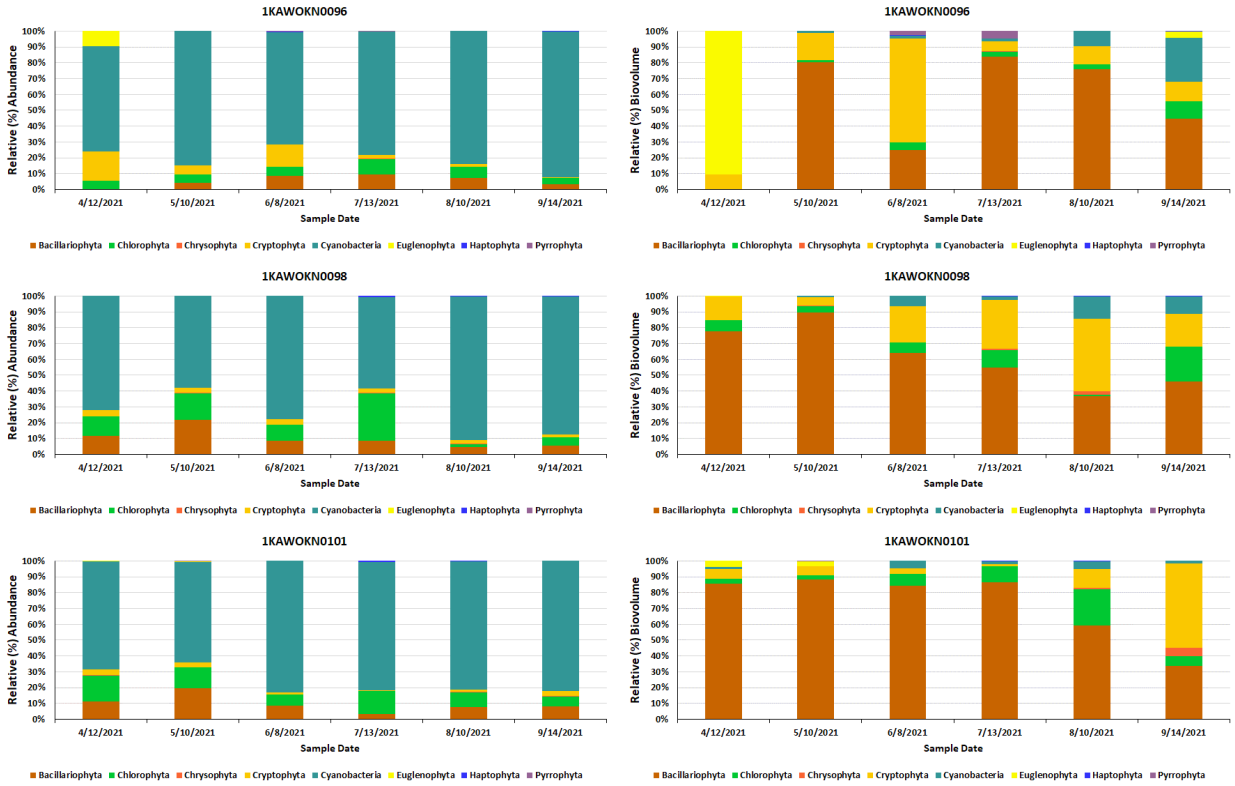

Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at KAWOKN0096, KAWOKN0098, and KAWOKN0101 April through September 2021.

The trophic status of Kaw Lake in 2021, assessed using Carlson's trophic state index (TSI), indicated a eutrophic lake as measured by Secchi depth (TSI(SD)), and hyper-eutrophic as assessed by total phosphorus concentrations (TSI(TP)). The index developed from chlorophyll-*a* concentrations (TSI(CHLa)) indicated a more moderate level of eutrophy (Figure 5).

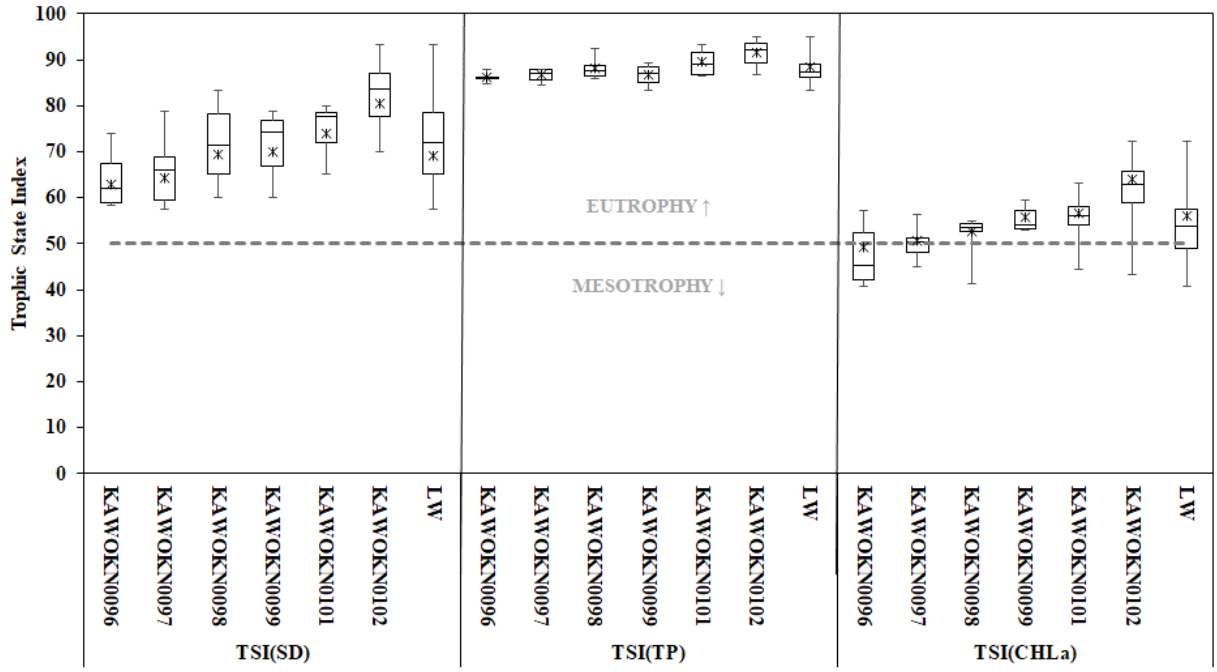

Figure 5. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lake-wide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Kaw Lake, OK, 12 April through 14 September 2021.

Total iron (median 0.31 mg/l) and manganese (median 0.07 mg/l) concentrations were moderately high. Reportable concentrations of arsenic were found in all in-lake samples collected with a median concentration of 0.0044 mg/l. Reportable concentrations of chromium, copper, nickel, and zinc were noted in all in-lake samples. Detectable lead concentrations were found in 92% of in-lake samples collected. One of 60 observations revealed a detectable concentration of mercury (KAWOKN0102, 14 September 2021, 0.00001 mg/l).

Water samples collected from below the dam at site KAWOKN0234 revealed constituent levels and concentrations nearly identical to samples collected at depth from the dam site (KAWOKN0096).

USACE conducted water quality sampling at Kaw Lake, OK in 1996 and 2008. Both efforts indicated concerns with respect to high nutrient concentrations, elevated trace metal concentrations, and reduced water clarity. The 2008 effort noted detectable mercury concentrations in 45% of samples analyzed.