

Arcadia Lake Water Quality: 2018

The Arcadia Lake dam is located at river mile 218.3 on the Deep Fork River, one of three principal streams flowing into Eufaula Lake, Oklahoma. Arcadia Lake is located about 12-miles northeast of Oklahoma City and 5-miles east of Edmond in Oklahoma County, Oklahoma. Arcadia Lake is a multi-purpose project authorized for flood control, water supply, recreation, and fish and wildlife. It is a unit of a multiple purpose system regulated for flood control, generation of hydropower, navigation, and other beneficial water uses on the Arkansas River and its tributaries. The impoundment extends southwest from the dam to near I-44, and the ~100 square mile watershed extends southwest into Oklahoma City. The lake and watershed are within Hydrologic Unit Code 1110030301. The conservation pool of Arcadia Lake was first filled in May 1987 after final storage began in November 1986. The total drainage area above the dam is ~100 square miles (Figure 1). Land use/cover (Dewitz, 2021) in the basin is dominated by developed (urban) areas (~58%), forested areas (~21%), and grassland/pasture (~16%). Based on a 2017 bathymetric survey (Bowen Engineering & Surveying, Inc., 2017), at the conservation pool elevation of 1,006.0 feet (NGVD 29), lake capacity had diminished by about 7.4% since a 2007 survey. Descriptive characteristics of Arcadia Lake are included in Table 1.

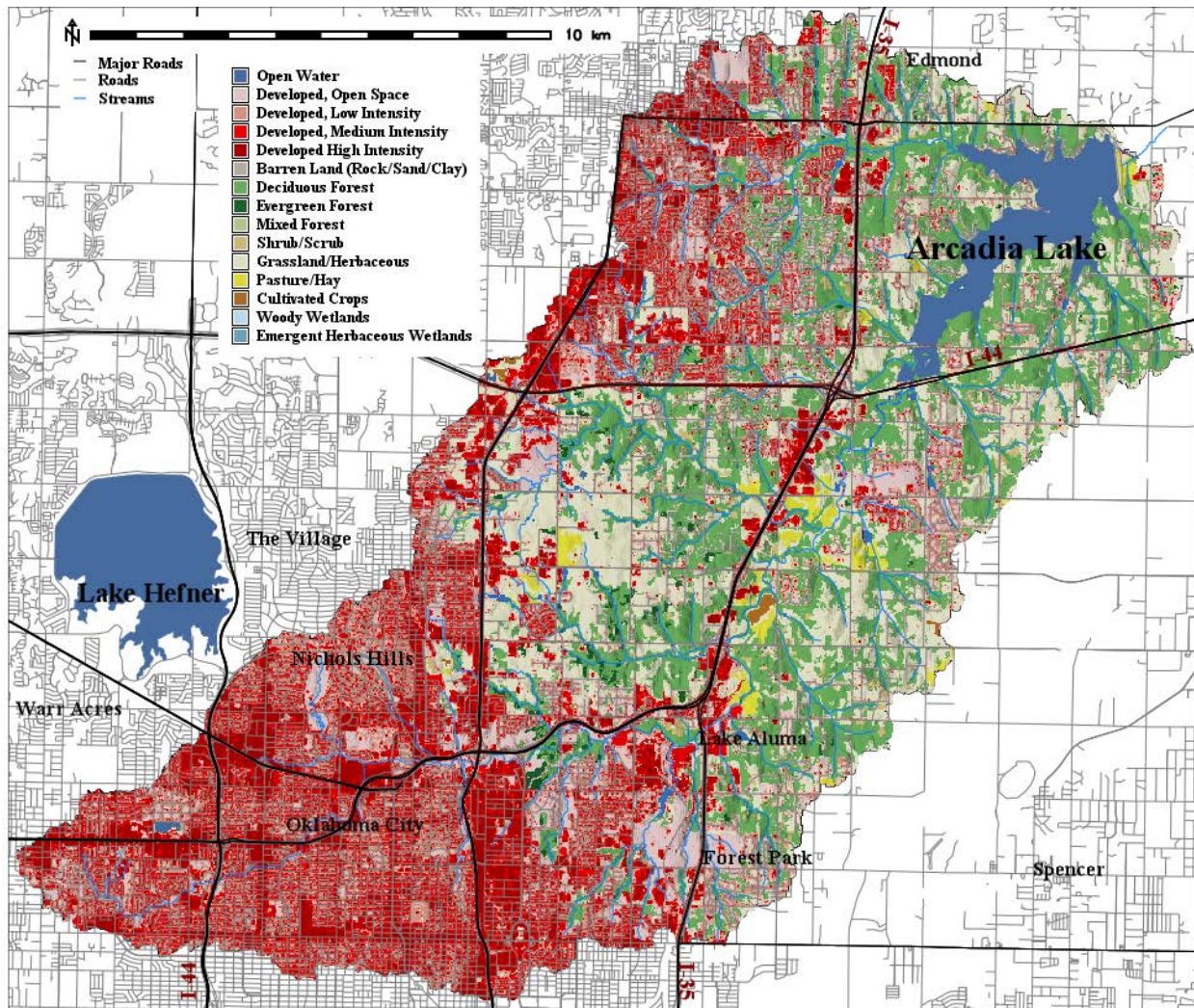


Figure 1. The Arcadia Lake (Deep Fork River) Watershed above the Arcadia Lake Dam.

Table 1. Descriptive Characteristics of Arcadia Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,006.0 ft. NGVD	306.63 m
Lake Surface Area (Conservation Pool)	1,570 ac	635.36 ha
Lake Volume (Conservation Pool)	27,380 ac-ft	33.77*10 ⁶ m ³
Total Drainage Area (contributing)	100.7 mi ²	260.8 km ²
Mean Depth	17.4 ft.	5.3 m
Maximum Depth (Conservation Pool)	50 ft.	15.24 m
Shoreline Length	26.5 mi	42.65 km
Shoreline Development Index	4.4	4.4
Annual Inflow, Average 1923 – 2018 [Water Years]	40,000 ac-ft	49.34*10 ⁶ m ³
Annual Inflow, 2018 [Calendar Year]	51,135 ac-ft	63.07*10 ⁶ m ³
Hydraulic Residence Time, 2021 [Calendar Year]	214.2 d	0.59 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2018 Annual Water Control Report (U.S. ACE - SWD RCC, 2019), Tulsa District's Water Control page for Arcadia Lake (U.S. ACE - Tulsa District, 2023), and the 2017 bathymetric survey (Bowen Engineering & Surveying, Inc., 2017).

Designated beneficial uses of the impoundment and watershed of the Arcadia 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 Sensitive Public and Private Water Supply (OAC, 2023). Based on the 2022 Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ 2022), Arcadia Lake is listed as impaired by turbidity, affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community, and by high algal concentrations affecting Public and Private Water Supply.

Physical and chemical water quality data were collected monthly by USACE from three in-lake sites at Arcadia Lake beginning 17 April and ending 11 September 2018 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 ARCOKN0212 (over channel near dam), ARCOKN0215 (mid-lake, E of Scissortail Campground), and ARCOKN0216 (upper lake near Turtle Island). 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.

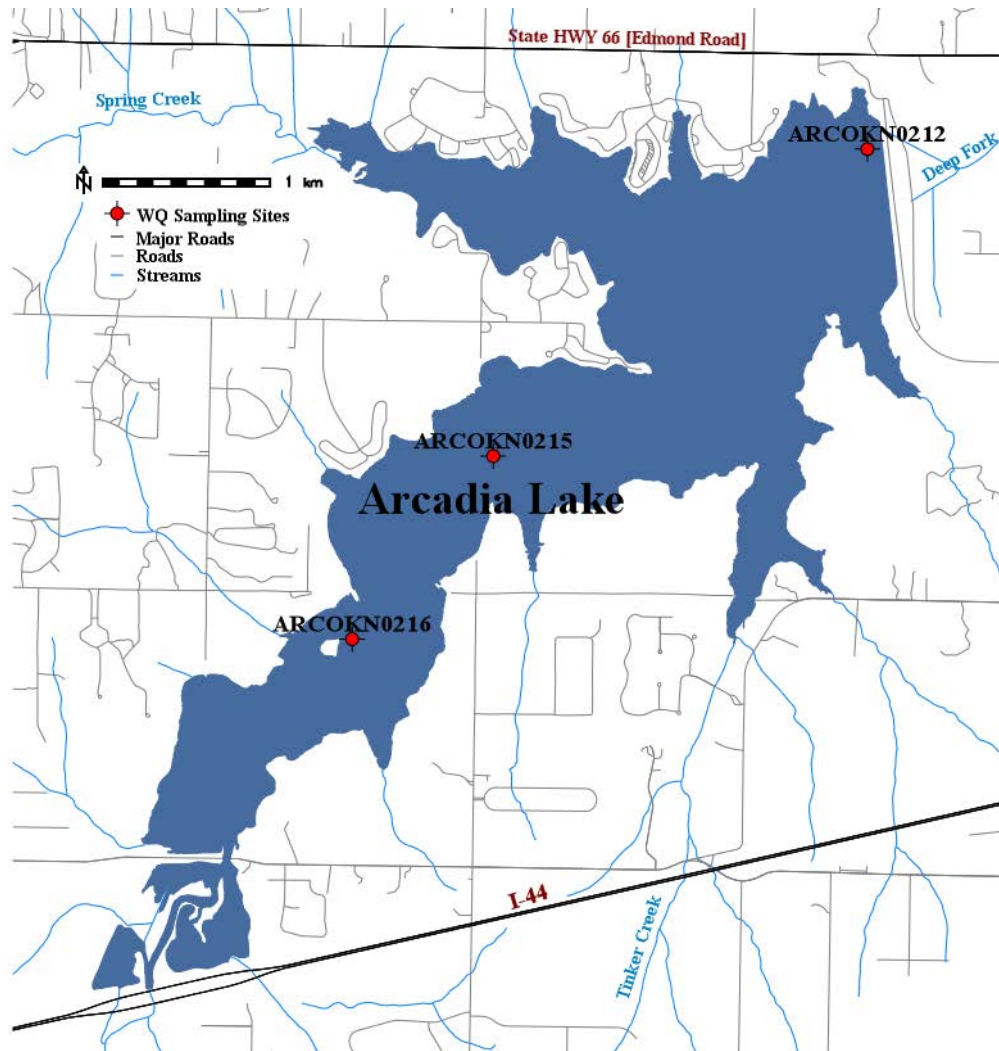


Figure 2. Locations of water quality sampling sites at Arcadia Lake, OK, 2018.

The Arcadia Lake pool elevation was at or above the conservation pool elevation throughout the sampling period in calendar year 2018. Calendar year 2018 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.

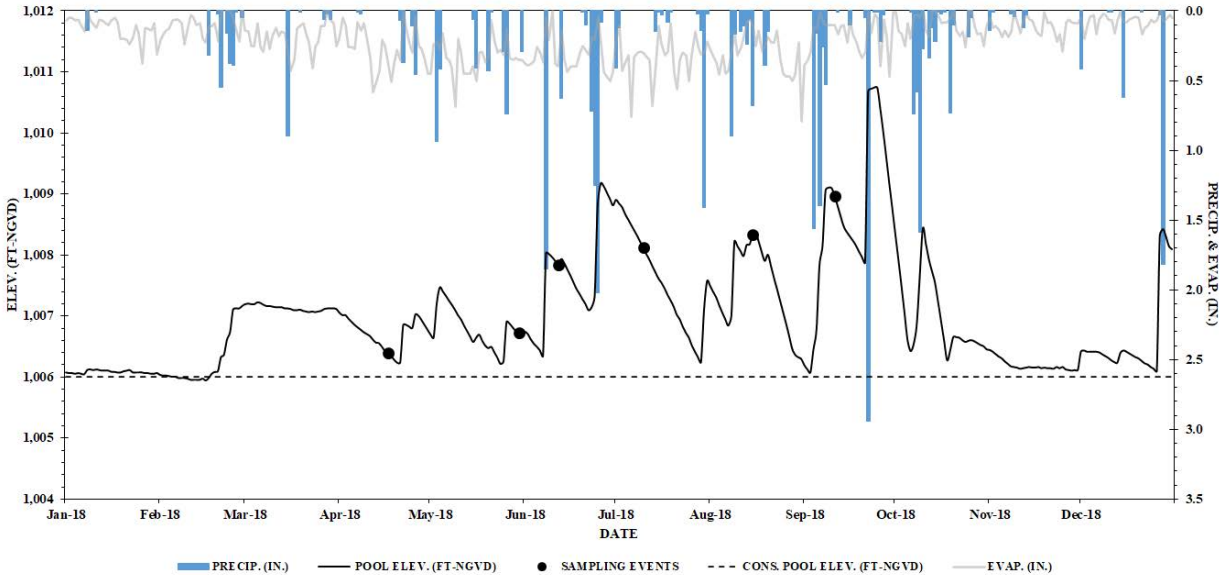


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at Arcadia Lake, OK, 2018.

Water temperatures varied seasonally (ranging from 12.81 to 32.02 °C) peaking in July. Water temperatures varied nominally from surface to bottom in April and September, while vertical profiles from May through August revealed more significant variation. Thermal stratification was observed at site ARCOKN0212 beginning in May and continuing through August 2018. The study period lakewide median dissolved oxygen concentration was 5.63 mg/l. Observed dissolved oxygen concentrations ranged from 0.10 to 11.30 mg/l. Dissolved oxygen concentrations at the dam site (ARCOKN0212) revealed hypoxia (concentrations less than 2 mg/l) from May through August at depths 5-meters below the surface. Hypoxia was also noted at the mid-lake site (ARCOKN0215 in May, July, and August) and the upper lake site (ARCOKN0216 in July). Highest dissolved oxygen concentrations were observed at sites ARCOKN0215 and ARCOKN0216 in April corresponding with coolest water temperatures. Lakewide total organic carbon concentrations were high with a study period median of 6.64 mg/l. Observed median total organic carbon concentrations were similar at all sites.

Specific conductance (median 387.5 $\mu\text{S}/\text{cm}$) was moderate, consistent with regional geology. Total dissolved solids median concentration was 238 mg/l. Moderate chloride and sulfate concentrations (medians 32.55 and 28.75 mg/l, respectively) were observed. Alkalinity levels (median 114 mg/l as CaCO_3) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 127.5 mg/l as CaCO_3 , indicate moderately 'hard' water. Observed pH (7.38 to 8.98) ranged within regional norms. Highest pH was recorded near the surface at sites ARCOKN0212 and ARCOKN0215 in July, and lowest pH was recorded in May, June, and July at depth at site ARCOKN0212.

The lake was moderately turbid through 2018. The study period median Secchi depth was 0.51 meters. Median Secchi depth increased from site ARCOKN0216 (0.46 m) down-lake to the dam site (ARCOKN0212, 0.88 m). Median turbidity was 24.85 NTUs, and 49% of all observations were greater than or equal to 25 NTUs. Median surface total suspended solids concentrations (9.20 mg/l) decreased from the upper lake site (ARCOKN0216, 11.1 mg/l) down to the dam site (ARCOKN0212, 6.94 mg/l), while bottom sample concentrations were

consistently higher (median 33.0 mg/l). The euphotic zone at Arcadia Lake ranged from 2.29 to 4.5 meters with highest estimates occurring in July.

Lakewide ammonia (median 0.11 mg/l) and nitrite plus nitrate (median 0.17 mg/l) concentrations were moderate to high. Total Kjeldahl nitrogen concentrations (median 0.67 mg/l) were moderately high. Estimated lakewide median surface total nitrogen concentration during the 2018 study was 0.70 mg/l. Total phosphorus concentrations ranged between 0.03 and 0.48 mg/l (median 0.08 mg/l). Observations of dissolved ortho-phosphate, median 0.03 mg/l, were low throughout the lake. Nitrogen to phosphorus ratios (N:P) in 2018 were <10 (median 9.7), indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-a concentrations ranged from 6.1 to 29.3 µg/l, with a median concentration of 22.05 µg/l. Concentrations were comparable, by date, at all sites throughout the sampling period. Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton observed at ARCOKN0212. Cyanophyte (blue-green algae) abundance progressively dominated most of the sampled period. Biovolume shifted through the period from domination by Bacillariophytes (diatoms) to greater representation of Cyanophytes, Cryptophytes, and Chlorophytes. Figure 5 displays zooplankton densities by sampling date at ARCOKN0212. Copepods and rotifers are consistently represented through the sampling period. Cladocerans showed moderate densities in May and September and low densities through summer months.

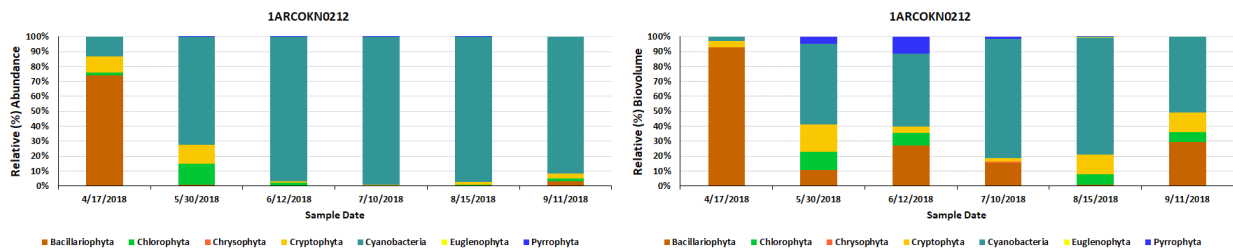


Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at ARCOKN0212 April through September 2018.

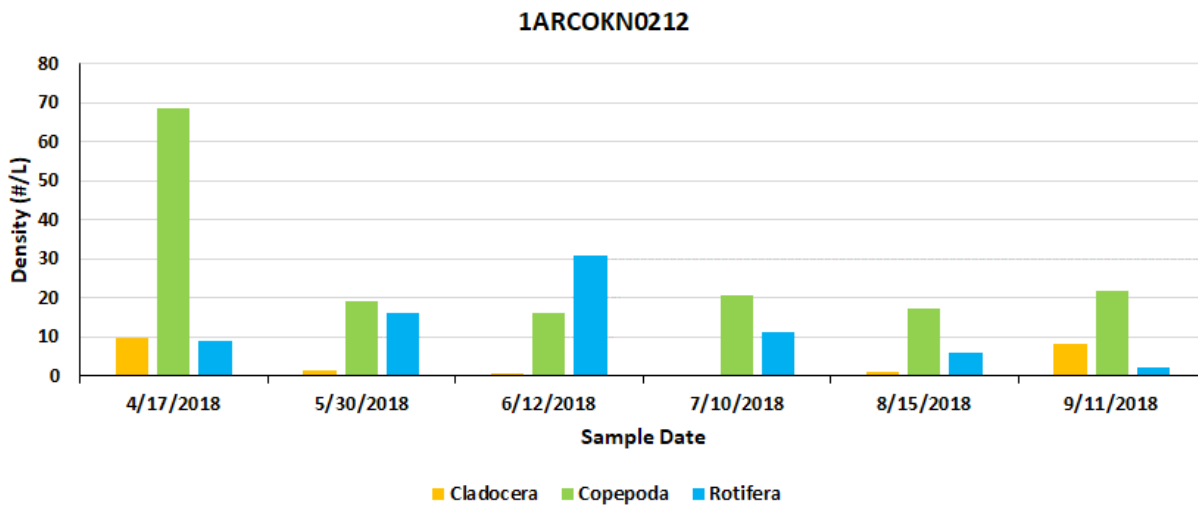


Figure 5. Zooplankton density by sampling date at ARCOKN0212 April through September 2018.

The trophic status of Arcadia Lake in 2018, assessed using Carlson's trophic state index (TSI), indicates a eutrophic lake (Figure 6) as measured by Secchi depth (TSI(SD)), total phosphorus concentrations (TSI(TP)), and chlorophyll-a (TSI(CHLa)).

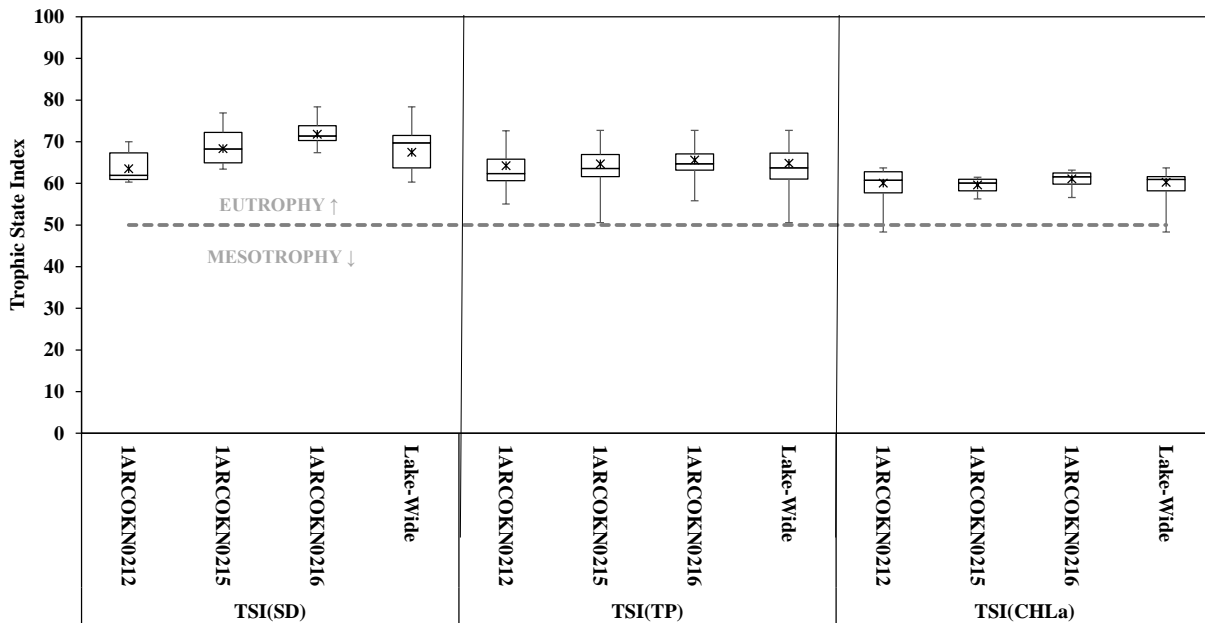


Figure 6. Distributions of Carlson's Trophic State Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHLa)) at Arcadia Lake, OK, 17 April through 11 September 2018.

Total iron (median 0.16 mg/l) and manganese (median 0.06 mg/l) concentrations were low to moderate. Reportable concentrations of arsenic were found in all samples collected, with a median concentration of 0.0038 mg/l. Reportable concentrations of copper, nickel, and zinc were noted in all samples. Detectable chromium and lead concentrations were found in 93 and 87%, respectively, of samples collected. One sample (of 30 total) revealed a reportable concentration of mercury.

USACE has previously conducted water quality sampling at Arcadia Lake, OK in 1989, 2001, and 2008. All prior efforts indicate generally well-oxygenated conditions with summer month thermal stratification and associated hypoxia at depth, moderately reduced water clarity, abundant nutrient concentrations, and high productivity. Assessment of priority pollutant metals indicates the consistent presence of arsenic and notable observations of other metals, usually below concentrations of concern.