

## Toronto Lake Water Quality: 2012

The Toronto Lake Dam is located at river mile 271.5 on the Verdigris River about three miles south of the city of Toronto in Woodson County, Kansas within Hydrologic Unit Code 11070101. Project construction began in November 1954 and the conservation pool first filled in March 1960. Authorized purposes of the lake include flood damage reduction, water supply, water quality, fish and wildlife, and recreation. The watershed above the Toronto dam site extends northwest ~45 miles up to I-35 and the Flint Hills in Kansas and encompasses ~730 square miles. Land use/cover is dominated by grassland and pasture. Basin elevations range from about 845 feet below the dam to 1,660 feet (Figure 1). At a conservation pool elevation of 901.5 feet (NGVD 29) the lake occupies about 2,210 acres with a mean depth of 7.5 feet, and a volume of 16,530 ac-ft. The project's designed sediment storage has been filled, and sedimentation now encroaches upon conservation pool storage. The most recent bathymetric survey conducted in 2010 indicated an annual conservation pool sedimentation rate of 212 ac-ft/yr since embankment closure, reducing the original conservation pool volume by 39.3%. Descriptive characteristics of Toronto Lake are included in Table 1.

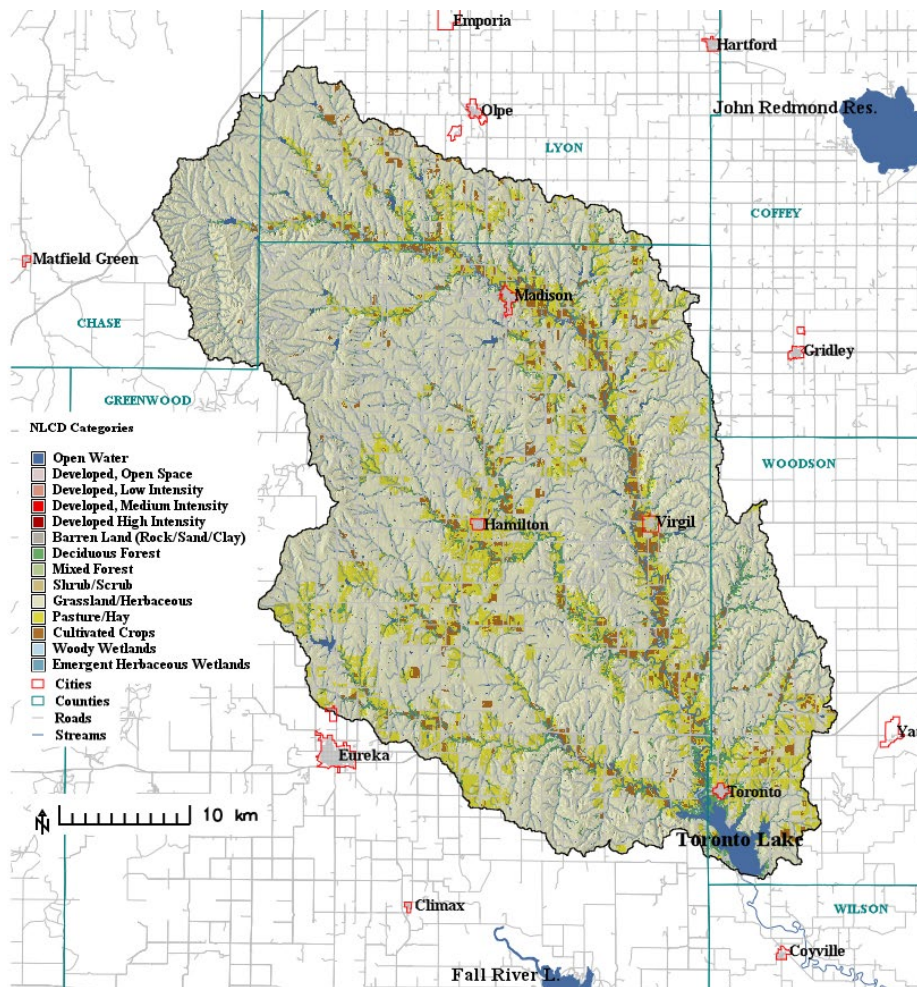


Figure 1. The Toronto Lake, KS Watershed above the Toronto Lake Dam.

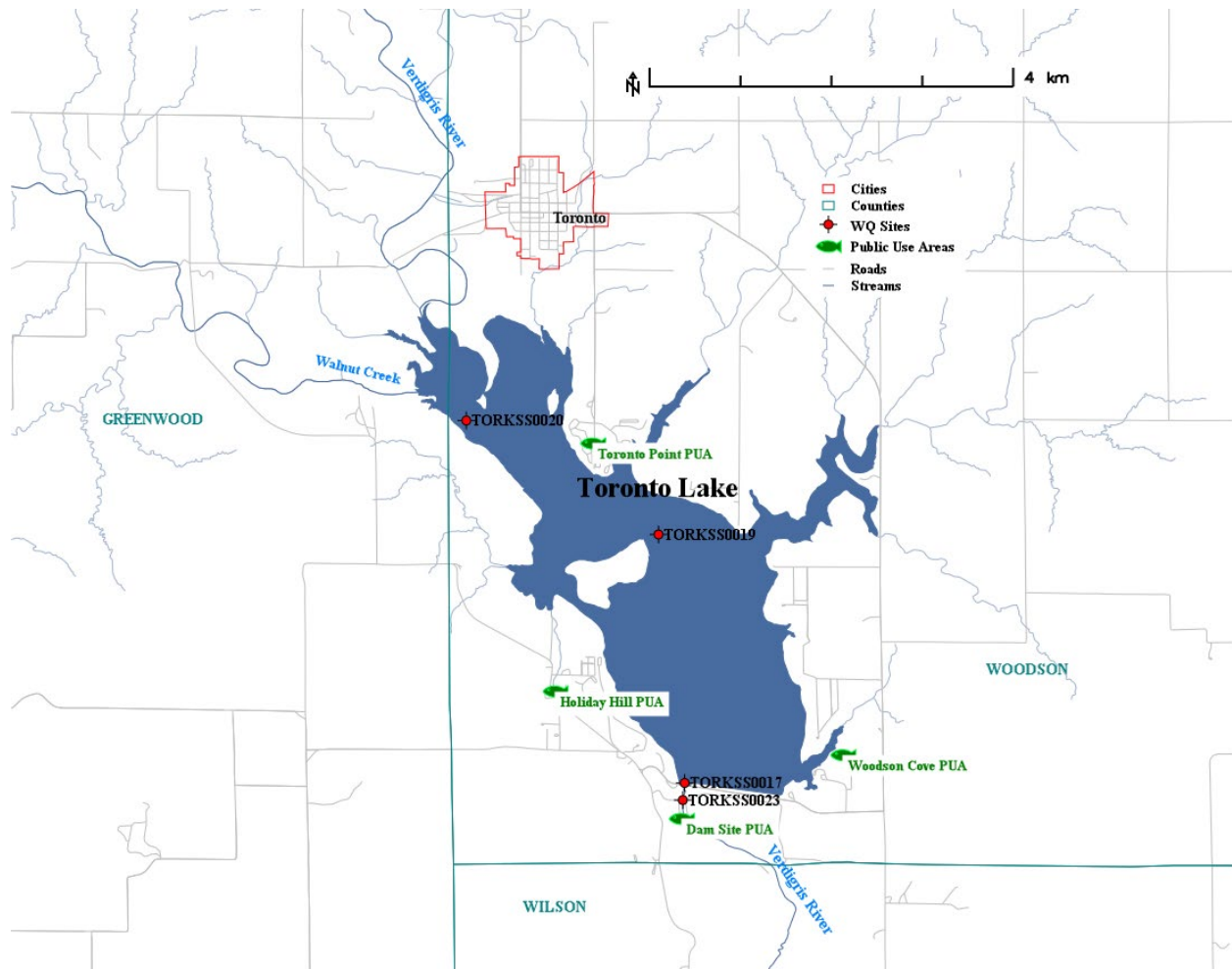
**Table 1. Descriptive Characteristics of Toronto Lake, KS (2012).**

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	901.5 ft. NGVD	274.78 m
Lake Surface Area (Conservation Pool)	2,210 ac	894.36 ha
Lake Volume (Conservation Pool)	16,530 ac-ft	20,389,455 m <sup>3</sup>
Total Drainage Area	730 mi <sup>2</sup>	1,890.69 km <sup>2</sup>
Mean Depth	7.5 ft.	2.3 m
Maximum Depth (Conservation Pool)	26.5 ft.	8.1 m
Shoreline Length	25.05 mi	40.32 km
Shoreline Development Index	3.47	3.47
Annual Inflow, Average 1922 – 2012 [Water Years]	345,300 ac-ft	425,921,278 m <sup>3</sup>
Annual Inflow, 2012 [Calendar Year]	82,604 ac-ft	101,890,534 m <sup>3</sup>
Hydraulic Residence Time, 2012 [Calendar Year]	75.92 d	0.21 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2012 Annual Water Control Report (U.S. ACE - SWD RCC, 2013), Tulsa District's Water Control page for Toronto Lake (U.S. ACE - Tulsa District, 2017), and the 2010 KBS Bathymetric Survey (Kansas Biological Survey, 2011).

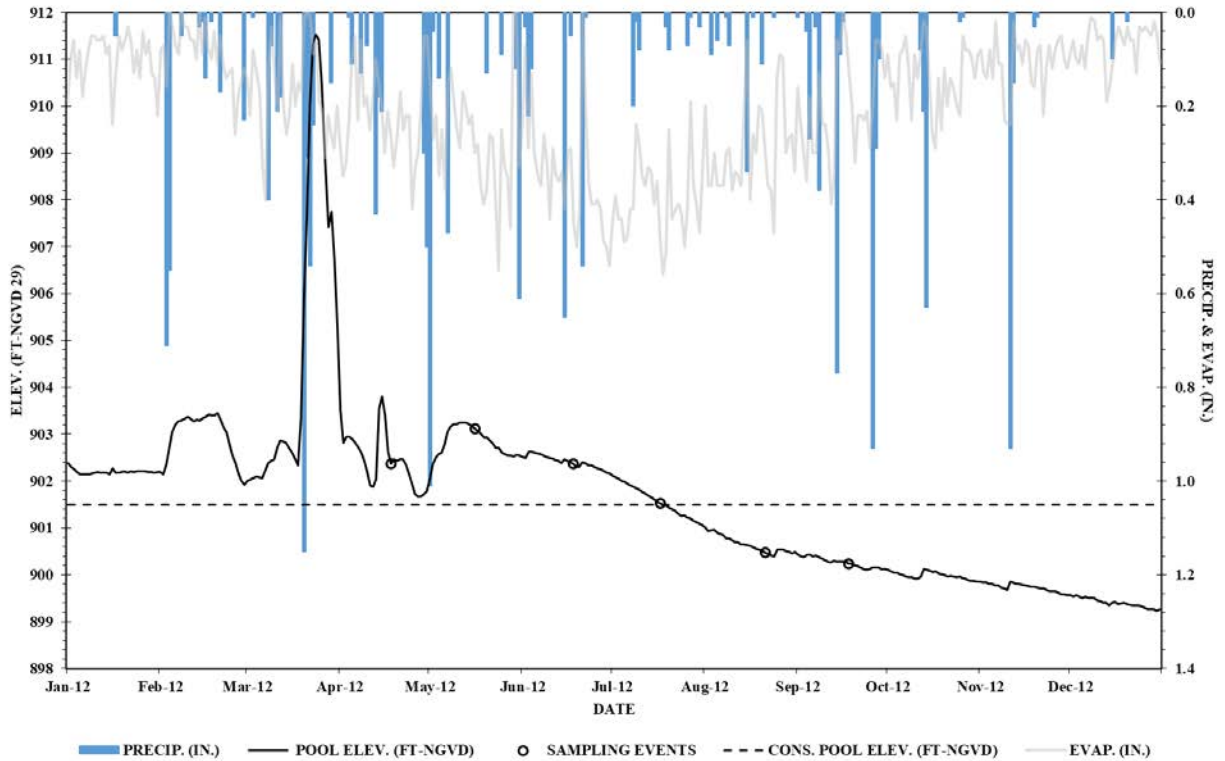
Use designations ( (KDHE 2013)) for Toronto Lake include expected aquatic life (AL), primary contact recreation (CR), domestic water supply (DS), food procurement (FP), ground water recharge (GR), industrial water supply (IW), irrigation use (IR), and livestock watering (LW). Based on the 2022 Kansas Integrated Water Quality Assessment (KDHE 2022), Toronto Lake is listed as impaired by lead (Pb), epilimnetic dissolved oxygen concentrations less than 5.0 mg/l, and eutrophication , all affecting aquatic life. Additionally, Toronto Lake is listed as impaired by siltation affecting water supply.

Physical and chemical water quality data were collected by USACE approximately monthly at Toronto Lake, KS, April through September 2012 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 TORKSS0017 (buoy line near outlet works), TORKSS0019 (channel east of Duck Island), and TORKSS0023 (stilling basin below dam). Historically, in-lake water quality samples were also collected from TORKSS0020 (upper lake, near the Verdigris River/Walnut Creek confluence). During the 2012 study, this site (TORKSS0020) was inaccessible by boat due to sedimentation and shallow conditions (Figure 2).



**Figure 2. Locations of water quality sampling sites at Toronto Lake, KS, 2012.**

Toronto Lake pool elevation was above normal early in the study period, but a combination of higher than normal air temperatures and lower than normal precipitation contributed to a consistently diminishing pool elevation drifting below conservation pool elevation in mid-July 2012. Calendar year 2012 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 29 at 0800 hours), conservation pool elevation (feet), basin precipitation (in.), evaporation rates, and water quality sampling dates at Toronto Lake, KS, 2012.**

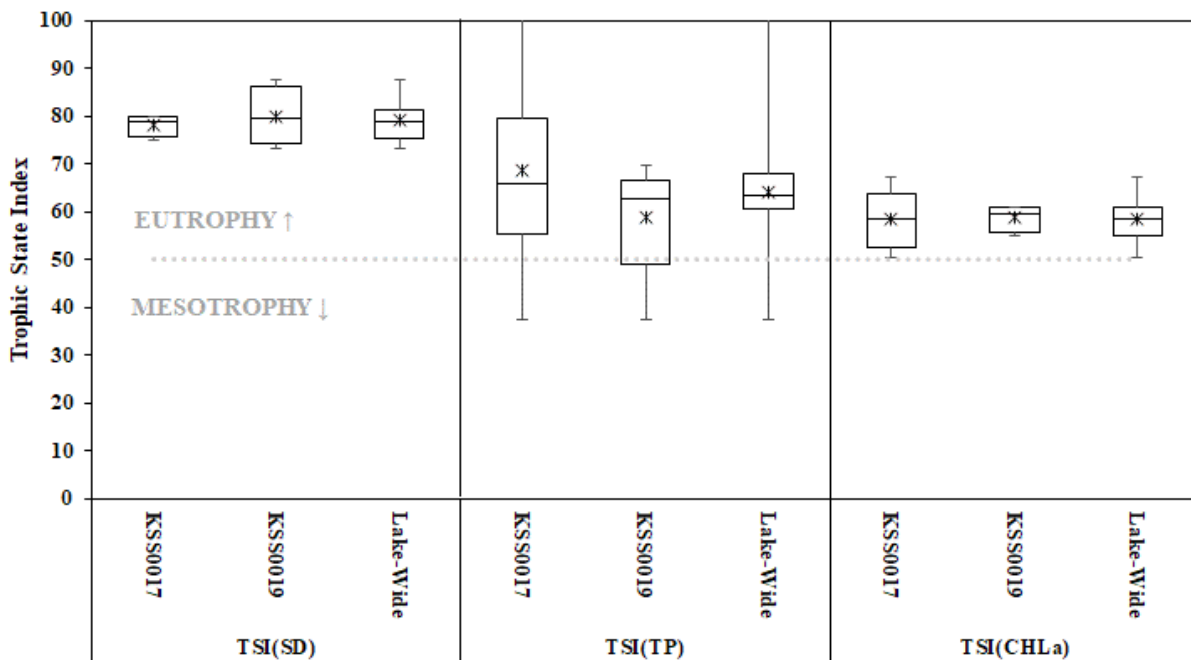
Water temperatures varied seasonally (ranging from 16.9 to 27.9 °C), peaking in July, but lake-wide water temperatures, on individual sampling dates, displayed nominal variation. The generally shallow reservoir did experience temporary thermal stratification in August near the dam site, although dissolved oxygen concentrations did not approach anoxia at depth. Median dissolved oxygen concentration for Toronto Lake through the study period was 7.67 mg/l. Five observations of dissolved oxygen concentrations below 3.0 mg/l were noted in May, June and July. Lake-wide total organic carbon concentrations were generally high (median 5.8 mg/l) peaking in July.

Specific conductance (median 387  $\mu\text{S}/\text{cm}$ ) and total dissolved solids (median 280 mg/l) were moderately elevated, consistent with regional norms. Moderate observed concentrations of chloride and sulfate indicate other components (minerals, cations) contributing to dissolved solids. Alkalinity levels (median 150 mg/l as  $\text{CaCO}_3$ ) imply a well-buffered system capable of maintaining pH levels. Hardness levels were consistently higher than 150 mg/l as  $\text{CaCO}_3$ , indicating 'hard' water. Observed pH ranged (7.58 – 8.50) within regional norms.

The lake remained consistently turbid through 2012 primarily due to suspended inorganic particles. The maximum recorded Secchi depth was 0.40 meters. All recorded turbidity measurements were greater than 25 NTUs (median 76.40 NTU). Total suspended solids concentrations (median 40.0 mg/l) were influenced by sediment laden inflows during runoff events, re-suspension of bottom sediment through wind and wave action, and shoreline erosion. The euphotic zone at Toronto Lake was typically  $\leq 1$  meter.

Ammonia concentrations were typically low (<0.20 mg/l), and nitrite plus nitrate concentrations were moderate to low (median 0.064 mg/l). Total Kjeldahl nitrogen concentrations were moderate to high (median 0.70 mg/l) indicating total organic nitrogen concentration in Toronto Lake is closely represented by TKN. Estimated mean total nitrogen concentration through the study period was 0.90 mg/l. The median total phosphorus concentration was 0.071 mg/l with a pronounced maximum (>2.0 mg/l) noted in August. Only one observation of dissolved ortho-phosphate was greater than the analytical detection limit of 0.05 mg/l. Nitrogen to phosphorus (N:P) ratios varied widely through the study period, with a lake-wide median of 12.7, indicating a transitional state of nutrient availability for algal growth.

Chlorophyll-a concentrations progressively increased through the study period and the median concentration of 17.3 µg/l indicates a moderately productive system. An algal bloom, potentially cyanobacterial, was noted in May at Woodson Cove, and a September concentration of 42.0 µg/l indicated high productivity. A temporally corresponding decrease in dissolved silica concentration from April through August suggests a significant diatom component of total phytoplankton. The trophic status of Toronto Lake during the 2012 study period, assessed by Carlson's trophic state index (TSI), based on chlorophyll-a concentrations (TSI(CHLa)), resulted in an index value of 58.5 indicates a moderately eutrophic lake (Figure 4).



**Figure 4. Distributions of Carlson's Trophic State Index (TSI), by sampling site and for the lake as a whole, based on observations of Secchi Depth [TSI(SD)], surface total phosphorus concentrations [TSI(TP)], and chlorophyll-a concentrations [TSI(CHLa)] at Toronto Lake, KS, 18-APR through 18-SEP-2012.**

Iron (median 0.756 mg/l) and manganese (median 0.122 mg/l) concentrations were relatively high, and concentrations observed could affect water taste and domestic uses. Approximately one-third of iron concentration observations exceeded the recommended criterion (1.0 mg/l) for protection of freshwater aquatic life. All observed manganese concentrations exceeded the recommended criterion (0.05 mg/l) for human health and consumption of water and organisms. No observations of priority pollutant metal (arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury) concentrations from water samples collected at Toronto Lake in 2012

exceeded current acute or chronic criteria for the protection of aquatic life, agriculture, or public health, although all 2012 samples collected revealed detectable concentrations of arsenic, chromium, nickel, and zinc.

Water samples were also collected in the stilling basin below the Toronto Lake dam at site TORKSS0023. Generally, mean and median parameter results are directly comparable to in-lake data collected near the dam (TORKSS0007).

USACE conducted a water quality study of Toronto Lake, KS in 1998 and noted reduced water clarity likely limiting lake productivity. Also noted were relatively high ammonia concentrations, and trace metals arsenic and mercury occasionally exceeded U.S. EPA criteria for the protection of human health and aquatic life. A comparison of parameter medians between the 1998 and 2012 study periods, both field and laboratory, revealed highly similar results. Notable differences include higher median dissolved oxygen concentration in 2012; slightly lower chloride and sulfate median concentrations in 2012; lower median ammonia, total Kjeldahl nitrogen, and total phosphorus concentrations in 2012; and higher median chlorophyll-a concentration in 2012.