Barr Lake and **Milton Reservoir**'s water quality has been sampled twenty times a year since 2003. These 420 trips to both reservoirs have produced an abundance of data and information. This is Part 8 of 8 of a water quality summary series for 2023 calendar year for both reservoirs. The first seven summaries focused on pH, chl-a, dissolved oxygen, water temperature, phosphorus, nitrogen, and water clarity; this one discusses alkalinity.

The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience "*cultural eutrophication*". This term means that water bodies become more productive and shallower much quicker (months to years) due to increased inputs of nutrients and sediments from human activities. This unnaturally accelerated aging of lakes causes a biological response – algae growth that usually leads to blue-green algal scums. This biological response then triggers chemical and physical changes within the water – pH, oxygen, water clarity and color, fish, water safety, plants, and aesthetics.

Alkalinity – It is the measure of water's ability to resist pH changes (buffers the effects of strong acids and bases to keep pH steady). Alkalinity is the sum of negatively charged compounds (bases) in the water. Most of these compounds come from weathered rock or calcium carbonate ($CaCO_3$). Calcium carbonate then dissolves into bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). Alkalinity is measured as $CaCO_3$ under the assumption that all the alkalinity is in carbonate or bicarbonate form. Bicarbonate has one negative charge and neutralizes one positive hydrogen (H^+) while carbonate has two negative charges and can neutralize two hydrogen ions.

"Bathtub ring" of calcium deposit at Barr Lake

Alkalinity is influenced by rocks, soils, and salts. Decomposition and the lack of dissolved oxygen can also increase alkalinity. Treated industrial and municipal wastewater can be sources of alkalinity to maintain effective biological activity and pH control. Reservoirs with high alkalinity and pH greater than 7.0 can precipitate calcium. This is how the "bathtub ring" is formed on reservoir dams. The water quality goal for alkalinity from the phased pH/DO TMDL is 95 mg/L during the growing season. A lower alkalinity will lower the background pH and allow room for pH increases caused by algal productivity.

Alkalinity can be lowered chemically by adding more H^+ ions. This can be accomplished by keeping the water aerated allowing for H^+ production. Alkalinity can also be reduced by dilution of water with less alkaline water. Rain and storm water are typically lower in alkalinity because of less contact time with rocks.

Water Quality Summary: Alkalinity
2023 Barr Lake & Milton Reservoir

2023 Alkalinity Data – Alkalinity data were collected from the one-meter depth during each visit. Samples were analyzed in a laboratory by titrating with a strong acid to see how many H^+ ions could be neutralized. For 2023, there were 20 alkalinity concentrations recorded for each reservoir (Table 1).

Table 1. Barr Lake and Milton Reservoir 2023 alkalinity data (as $CaCO_3$ mg/L). Bold values exceed the water quality target.

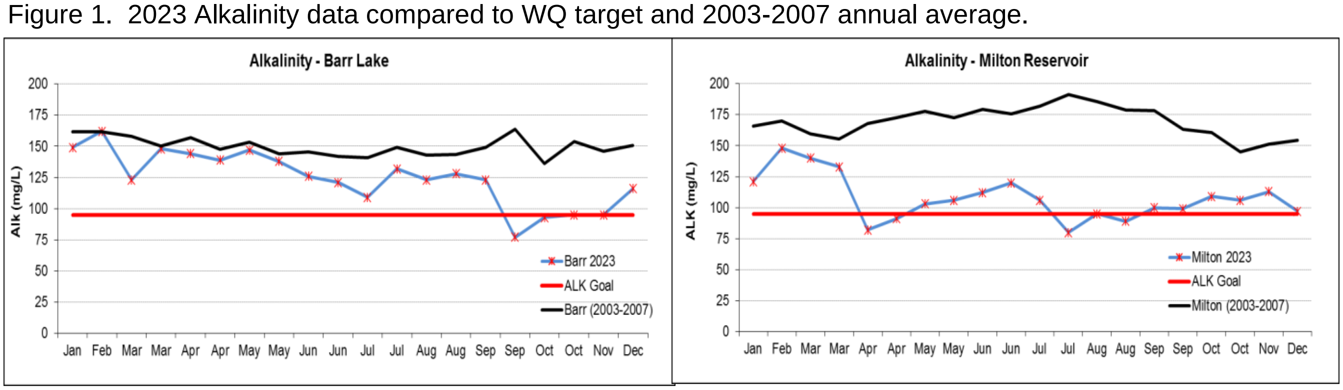
Month	Alk (Barr)	Alk (Milton)
Jan	**149**	**121**
Feb	**162**	**148**
Mar	**123**	**140**
Mar	**148**	**133**
Apr	**144**	82
Apr	**139**	91
May	**147**	**103**
May	**138**	**106**
Jun	**126**	**112**
Jun	**121**	**120**
Jul	**109**	**106**
Jul	**132**	80
Aug	**123**	95
Aug	**128**	89
Sep	**123**	**100**
Sep	77	**99**
Oct	93	**109**
Oct	95	**106**
Nov	95	**113**
Dec	**116**	**97**

The average alkalinity for **Barr Lake** in 2023 was 124 mg/L and 108 mg/L for **Milton Reservoir**. From sampling event to sampling event, the alkalinity does not change drastically. Barr remained below average for most of the year. Milton had a large decline in April and then remained well below the average for the year.

The growing season (July 1 – September 30) average for **Barr Lake** was 115 mg/L and 95 mg/L for **Milton Reservoir**. The annual and growing season averages are similar. Algal growth does change the pH and alter the overall ALK, but the cool-season algae and the warm-season cyanobacteria seem to both equally impact ALK.

Figure 1 shows the annual cycle, goal, and 2023 results for alkalinity. **Barr Lake** was impacted by storm water and this dilution may have caused the gradual decrease in 2023. **Milton Reservoir** typically has a higher alkalinity than Barr except for the last three years. Milton had lower alkalinity than Barr on 15 occasions in 2023. Besides being lower than Barr, Milton did experience a major drop in ALK in April. The only other parameter that was extreme during this timeframe was the chl-a level of 243.0 µg/ on 4/11/23. Clearly, algal growth was a factor.

Figure 1. 2023 Alkalinity data compared to WQ target and 2003-2007 annual average.



Water Quality Summary: Alkalinity

2023 Barr Lake & Milton Reservoir

Aquatic Chemistry – pH and alkalinity are important water quality parameters to understand. They both deal with positive hydrogens (acids) and negative oxides (bases). pH is the measurement of the concentration of H^+ ions, and alkalinity is the measurement of mostly HCO_3^-, CO_3^{2-}, and OH^-. As pH goes up, there is less H^+ (negative compounds attached to them) and more negatively charged compounds. From Figure 2 below, if reservoir water has a pH of just over 8.0, then most of the alkalinity is in the form of HCO_3^- . The higher the pH, the greater the buffering capacity because carbonate has a negative charge of 2. When bicarbonate is in large quantities, calcium will bond with it and precipitate out, forming the whitish bathtub ring along the dam (also called marl).

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

(Carbon dioxide) *(Carboic acid)*

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

(Bicarbonate)

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

(Carbonate)

$$Ca^{2+} + CO_3^{2-} \rightleftharpoons CaCO_3$$

(Calcium carbonate)

Figure 2.