Twenty times a year since 2003, **Barr Lake** and **Milton Reservoir** have been sampled for water quality. These 300 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 2017 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 to water bodies resulting in nuisance algae growth and sedimentation. This natural process usually occurs over a long geological period of time. Many lakes, reservoirs, and even estuaries and bays throughout the world experience "*cultural eutrophication*". This term means that water bodies tend to become more productive and shallower over relatively short periods of time due to increased inputs of nutrients and sediments from human activities. Accelerated aging of lakes causes a quick biological response – severe algae growth. This response then leads to other chemical and physical changes within the water – pH, oxygen, water clarity and color, fish, plants, and aesthetics can all change.


"Bathtub ring" of calcium deposit at Barr Lake

Alkalinity – This is the measurement of how much acid water can neutralize (buffers the effects of acid and keeps pH steady). Alkalinity is the sum of negatively charged compounds (bases) in the water. The majority of these compounds come from weathered rock or calcium carbonate ($CaCO_3$). Calcium carbonate then dissolves in water to bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). Alkalinity is measured as $CaCO_3$ under the assumption that all of 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.

Alkalinity is influenced by rocks, soils, and salts. Decomposition and the lack of dissolved oxygen can also increase alkalinity. Industrial waste and wastewater can be sources of alkalinity. Reservoirs with high alkalinity and high pH 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 closer to 8.0. This will allow room for pH to increase when there is algal productivity.

Alkalinity can be lowered chemically by adding more H^+ ions. This can be done by keeping the water aerated allowing for H^+ production. Alkalinity can also be reduced by dilution of water with less alkalinity. Rain and fast moving storm water are typically lower in alkalinity because of water moving rapidly through the watershed without time alkalinity because of biological activity in the treatment process.

2017 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 2017, there were 20 alkalinity concentrations recorded for each reservoir (Table 1).

Table 1. Barr Lake and Milton Reservoir 2017 alkalinity data (as $CaCO_3$ mg/L). Bold values exceed the water quality target.

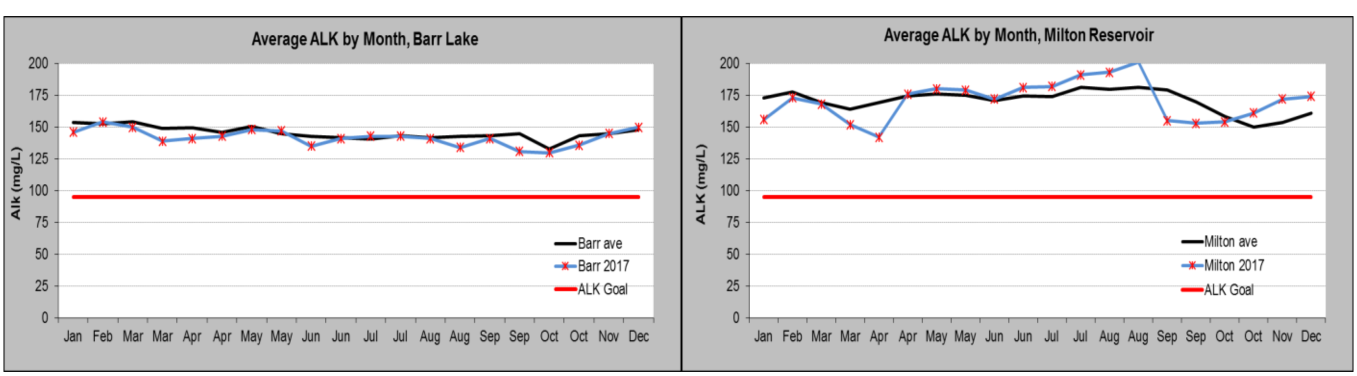
Month	Alk (Barr)	Alk (Milton)
Jan	146	156
Feb	154	173
Mar	150	168
Mar	139	152
Apr	141	142
Apr	143	176
May	148	180
May	147	179
Jun	134	172
Jun	141	181
Jul	**143**	**182**
Jul	**143**	**191**
Aug	**141**	**193**
Aug	**134**	**201**
Sep	**141**	**155**
Sep	**131**	**153**
Oct	130	154
Oct	136	161
Nov	145	172
Dec	150	174

The average alkalinity for **Barr Lake** in 2017 was 142 mg/L and 171 mg/L for **Milton Reservoir**. From sampling event to sampling event, the alkalinity does not change drastically. Barr remained near average for most of the year while Milton experienced bigger deviations from the average.

The growing season (July 1 – September 30) average for **Barr Lake** was 139 mg/L and 179 mg/L for **Milton Reservoir**. The growing season average was slightly lower than the annual average for Barr indicating that algae productivity was not so high. Typically, primary productivity will increase pH, which also increases alkalinity.

Figure 1 shows the annual cycle, goal, and 2017 results for alkalinity. **Barr Lake** had a normal year with a slight decline in alkalinity in August/September cause by inflows from storm water. **Milton Reservoir** typically has about 25 mg/L as $CaCO_3$ more alkalinity than Barr (compare the two average lines). The noticeable fluctuations in April and September were during times of inflows that may have diluted the alkalinity. Both reservoirs have a way to go to meet the alkalinity goal.

Figure 1. 2017 Alkalinity data compared to WQ target and 2003-2017 annual average



Water Quality Summary: Alkalinity

2017 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 attach to them) and more negatively charged compounds. From Figure 2 below, if reservoir water has a pH of 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.