Water Quality Summary: Phosphorus

2017 Barr Lake & Milton Reservoir

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 5 of 8 of a water quality summary series for 2017 calendar year for both reservoirs. The first four summaries focused on pH, chl-a, dissolved oxygen, and water temperature; this one discusses phosphorus.

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.

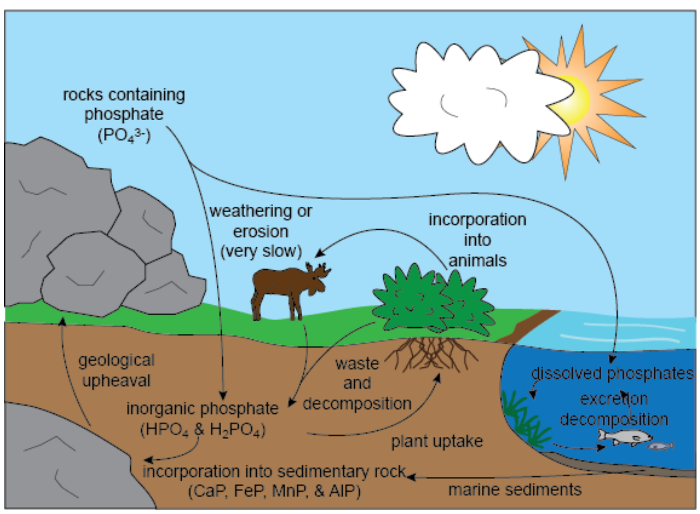
***Phosphorus* –** Phosphorus is a chemical element that is required by all living organisms. Phosphorus can be attached to soils (inorganic), dissolved in water (organic or inorganic), or be in the form of biomass (organic) (Figure 1). Phosphorus cannot be a gas. The most common form of phosphorus is the oxidized state, *phosphate* (PO_4^{-3}). Phosphates exist in three forms: orthophosphate, polyphosphate, and organically-bound phosphate. Orthophosphate is the compound that is available for algae/plant uptake.

Total phosphorus (TP) is the analysis that sums all of the phosphorus forms in a water sample (organic, inorganic, particulate, and dissolved). Soluble Reactive Phosphorus (SRP) or Orthophosphate is the analysis that includes the soluble, inorganic phosphates.

Phosphorus is a key nutrient that determines how much algae can grow in a lake. Concentrations are typically expressed in units of micrograms per liter (µg/L) or parts per billion (ppb). The two forms commonly analyzed are TP and SRP. Concentrations below 10 µg/L are considered low and values greater than 20 - 50 µg/L are considered high in general terms.

Excessive nutrient inputs are the main cause of *cultural eutrophication*. Too many nutrients

Figure 1.



lead to aesthetic issues, odor problems, cyanotoxins, large dissolved oxygen fluctuations, and lower water clarity. The TP goal that has been determined for **Barr Lake** and **Milton Reservoir** is 100 µg/L or less in the epilimnion (top mixing water, about three meters deep) during the growing season (July 1 – September 30).

2017 Phosphorus Data – Phosphorus data were collected from the one-meter depth and one meter from the bottom depth during each visit. For 2017, there were 40 phosphorus samples analyzed for each reservoir. Only top water data are shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2017 epilimnion phosphorus data (µg/L). Bold values exceed water quality target. Both reservoirs were sampled.

Barr Lake (µg/L)			Milton Reservoir (µg/L)		
Month	**TP**	**SRP**	**Month**	**TP**	**SRP**
Jan	190	100	**Jan**	920	870
Feb	350	210	**Feb**	880	780
Mar	280	-	**Mar**	690	480
Mar	250	140	**Mar**	650	400
Apr	260	100	**Apr**	520	280
Apr	330	310	**Apr**	510	450
May	380	-	**May**	520	-
May	340	260	**May**	500	450
Jun	200	230*	**Jun**	470	450
Jun	300	330*	**Jun**	690	450
Jul	**300**	230	**Jul**	**580**	470
Jul	**420**	330	**Jul**	**620**	550
Aug	**360**	310	**Aug**	**550**	530
Aug	**480**	390	**Aug**	**440**	390
Sep	**220**	210	**Sep**	**170**	150
Sep	**440**	-	**Sep**	**250**	130
Oct	340	240	**Oct**	290	200
Oct	320	210	**Oct**	310	270
Nov	290	180	**Nov**	220	200
Dec	260	-	**Dec**	140	100

*SRP cannot be greater than TP, analytical error

Units - microgram

µg/L or Parts Per Billion (ppb) is a really small concentration

Example:
1 drop in 2 tanker trucks

State defined "Growing Season" for Colorado Lakes and Reservoirs: this is the peak time for recreational use, irrigation, and when a waterbody is most productive.

The average TP for **Barr Lake** in 2017 was 316 µg/L and 510 µg/L for **Milton Reservoir**. This is up from 2016. Barr Lake had a narrow concentration range for most of the year except for the end of each summer month. In 2017, storm events created urban runoff inflows to Barr from the S. Platte River. These storms occurred on 7/21, 8/7, and 9/23. Barr Lake was at 8.5 meters deep by early October, above the average depth of 6 meters. Milton started the year with high TP values because of the complete refill in the fall of 2016. Then the concentrations steadily declined throughout the year.

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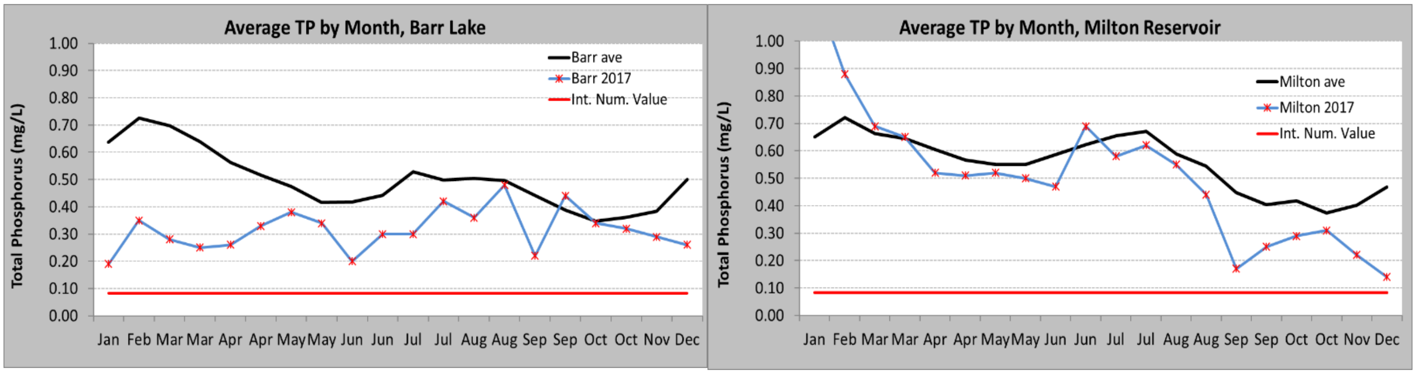
The growing season average for **Barr Lake** was 370 µg/L and 435 µg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average because of settling, uptake by algae, and water releases. Storm water runoff inputs during the summer months increased the TP concentrations for 2017.

Figure 2 shows the annual TP cycles, TP target, and 2017 data for both lakes. **Barr Lake** TP was below average for most of the year because no effluent was pumped to the lake during the winter months. **Milton Reservoir** started the year off significantly above average and then the TP declined for the year until late June and early fall.

Figure 2. 2017 Phosphorus data compared to WQ targets and 2003-2017 annual average



Internal Loading – Another way that phosphorus can enter lakes is from the lake sediment. This typically occurs when the bottom of a lake is anoxic (void of oxygen). No dissolved oxygen allows for a chain reaction to occur that results in a release of dissolved phosphorus from the sediments. This can happen during the winter or spring when the reservoirs are deeper than 7 meters. The other cause for internal loading is for sediments to be physically stirred up. This happens when the reservoirs are shallow in the late summer and winds can re-suspend sediments. Carp and other bottom feeders can also stir up the sediments. Carp are known to dig up to a foot in the sediments to get food. This is called "*bioturbation"* – when aquatic animals disturb the sediments.