2015 Water Quality Summary Series – Phosphorus

Twenty times a year since 2003, **Barr Lake** and **Milton Reservoir** have been observed and sampled for many water quality parameters. These 240 trips to both reservoirs have produced an abundance of data and information. This is Part 5 of a continuing series summarizing the 2015 water quality data. The first four summaries focused on pH, chl-a, dissolved oxygen, and water temperature; this one discusses phosphorus.

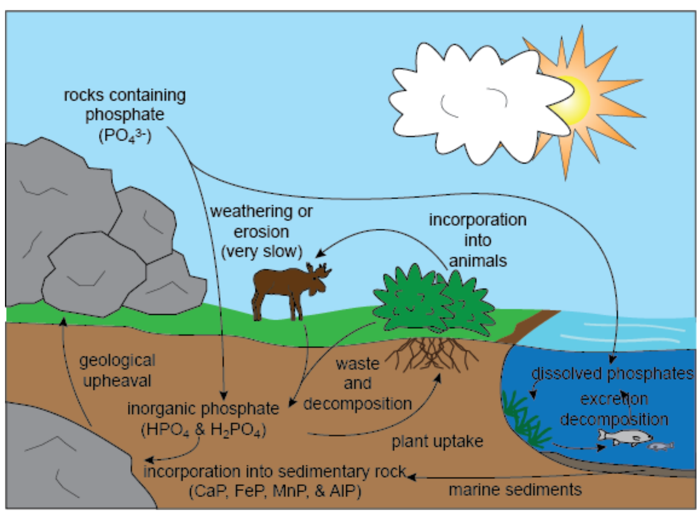
The Big Picture – Many lakes, reservoirs, and even estuaries and bays throughout the world experience "*cultural eutrophication*". This term means that water bodies tend to become more productive and shallower over relatively short periods of time due to increased inputs of nutrients and sediments from human impacts in the watershed. Eutrophication is a natural process, but it generally occurs over a much longer geological period. This 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 column – pH, oxygen, water clarity, water color, and aesthetics.

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 uptake.

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

Figure 1.



Excessive nutrients are the main cause of *cultural eutrophication*. Too many nutrients leads 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 during the growing season.

2015 Phosphorus Data – Phosphorus data are collected from the one meter depth and one meter from the bottom depth during each visit. For 2015, there were 40 phosphorus samples analyzed for each reservoir. Only top water data is shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2015 epilimnion phosphorus data (µg/L). Bold values exceed water quality target.

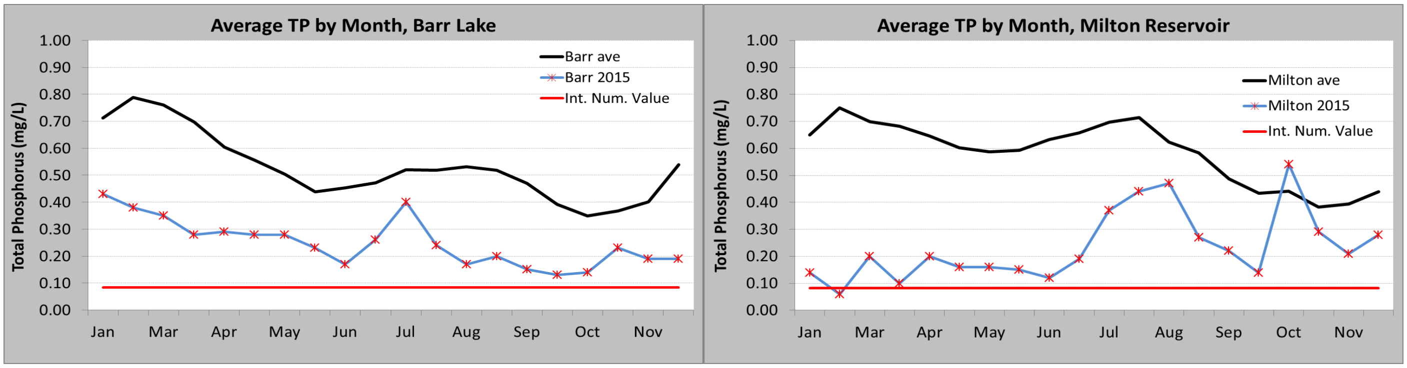
Barr Lake (ug/L)				Milton Reservoir (ug/L)		
Month	**TP**	**SRP**		**Month**	**TP**	**SRP**
Jan	430	390		**Jan**	140	140
Feb	380	300		**Feb**	60	70
Mar	350	230		**Mar**	200	80
Mar	280	200		**Mar**	100	70
Apr	290	190		**Apr**	200	170
Apr	280	260		**Apr**	160	140
May	280	240		**May**	160	130
May	230	180		**May**	150	NA
Jun	170	170		**Jun**	120	100
Jun	260	170		**Jun**	190	140
Jul	**400**	190		**Jul**	**370**	310
Jul	**240**	NA		**Jul**	**440**	380
Aug	**170**	NA		**Aug**	**470**	410
Aug	**200**	80		**Aug**	**270**	210
Sep	**150**	80		**Sep**	**220**	110
Sep	**130**	40		**Sep**	**140**	<30
Oct	140	40		**Oct**	540	150
Oct	230	120		**Oct**	290	<30
Nov	190	100		**Nov**	210	<30
Dec	190	<30		**Dec**	280	120

The average TP for **Barr Lake** in 2015 was 250 µg/L and 236 µg/L for **Milton Reservoir**. Barr Lake started the year high because of the winter fill season while Milton started low because inflows did not start until early March. Phosphorus increased periodically during the growing season because of inflows and Milton had internal loading in early October during the drawdown.

The growing season (July – September) average for **Barr Lake** was 215 µg/L and 318 µg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average but that only happened for Barr. Milton's TP was higher during the summer because of high inflows from the South Platte River in early July.

Figure 2 shows the annual TP cycles, TP target, and 2015 data for both lakes. Both reservoirs had below average TP for most of the year. **Barr Lake** TP was lower because no effluent was pumped to the lake during the winter months. **Milton Reservoir** was also lower than normal and only saw increases when major inflows occurred in March, April, and July and then internal loading in October. Clearly, there has been a major reduction in TP loading into both reservoirs in 2015.

Figure 2.



Internal Loading – Another way that phosphorus can enter lakes is from the bottom sediment. This typically happens when the bottom of a lake is anoxic. 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 way is for sediments to be physically stirred up. This happens when the reservoirs are very shallow in the late summer and winds can re-suspend phosphorus-rich 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.