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Water Quality Summary: Nitrogen

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 6 of 8 of a water quality summary series for 2017 calendar year for both reservoirs. The first five summaries focused on pH, Chl-a, dissolved oxygen, temperature, and phosphorus. This summary covers nitrogen (N).

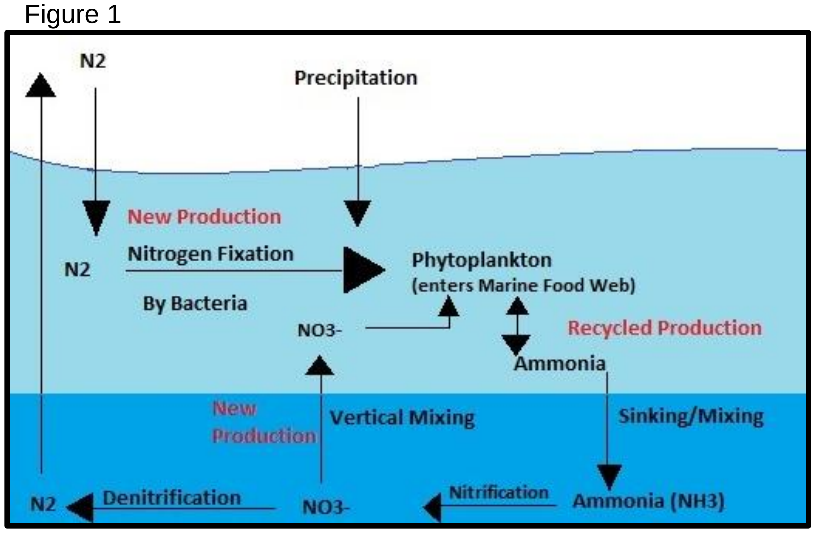
The Big Picture – Eutrophication is the addition of nutrients to water bodies resulting in nuisance algae growth and sedimentation. This natural process usually occurs over a long geological period of time. Many lakes, reservoirs, and even estuaries and bays throughout the world experience "*cultural 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.

Nitrogen – N is an element that is required by all living organisms and comes in many forms. N is the most abundant element in the atmosphere, comprising 78%. Typically, saltwater is nitrogen limited while freshwater is phosphorus limited. Under the right conditions, N can also be the limiting nutrient for lakes.

In water, N can occur in three forms: dissolved N gas, inorganic N, and organic N (Figure 1). Only a few blue-green algae can use dissolved N gas while other plants use inorganic N. Nitrogen fixation by blue-green algae is one reason why they grow so well; they are capable of fixing (assimilating) the dissolved N gas when there are no other forms of N in the water.

Organic N is the nitrogen that is in living, dead, or decomposing plants and animals. Examples of organic N are proteins, amino acids, and some humic compounds.

Figure 1



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The two main forms of inorganic N are ammonia (NH_3) and nitrate (NO_3^-). NH_3 is preferred by plants because it takes the least amount of energy to assimilate. NH_3 is released from decomposing organic N and ammonification of NO_3^- by bacteria when dissolved oxygen is not present. NH_3 is the most reactive form of N and can adhere to sediment particles. NH_3 in water is present primarily as ammonium (NH_4^+). Ammonia is toxic to aquatic organisms but NH_4^+ is not. Water temperature and pH determines the ratio of NH_3 and NH_4^+in the water.

Nitrification is the biological conversion of organic and inorganic N from a reduced state to a more oxidized state. NO_3^- is the next inorganic compound that plants use and is the most common inorganic form in lakes. NO_3^- can convert back to NH_3 by ammonification or convert back to dissolved N gas that will dissipate into the atmosphere. NO_3^- does not bind to soil but can leach into groundwater. Nitrite (NO_2^-) is the slightly reduced form of NO_3^- but is not as common.

Total nitrogen (TN) is the summation of all N in the water (organic, inorganic, particulate, and dissolved). Total Kjeldahl Nitrogen (TKN) is the measurement of organic N, NH_3, and NH_4^+. To calculate TN, nitrate and nitrite need to be added to TKN. Total inorganic N (TIN) is the summation of NH_4^+, NH_3, NO_3^-, and NO_2^-; this is what is readily available for plants. TN concentrations over 10 mg/L are considered high in general terms.

A TN standard has been established for **Barr Lake** and **Milton Reservoir** at 0.91 mg/L. This is the interim nutrient criteria value for warm water lakes. A ratio of TN:TP greater than 20 would result in a phosphorus limiting system and help control blue-green algae.

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

Table 1. Barr Lake and Milton Reservoir 2017 epilimnion nitrogen data (mg/L). Bold values exceed the interim nutrient criteria value.

	Barr Lake (mg/L)					Milton Reservoir (mg/L)				
Month	**NH_3**	**NO_{3+2}**	**TKN**	**TN**	**TN:TP**	**NH_3**	**NO_{3+2}**	**TKN**	**TN**	**TN:TP**
Jan	0.23	1.50	1.6	3.10	16	0.19	4.24	1.4	5.73	6
Feb	0.22	1.76	1.9	3.66	10	0.07	3.72	1.9	5.62	6
Mar	0.08	1.44	1.8	3.24	12	0.09	2.40	2.5	4.90	7
Mar	0.18	1.05	2.0	3.05	12	<0.05	1.97	2.6	4.57	7
Apr	0.13	0.85	2.1	2.95	11	0.05	1.36	2.4	3.76	7
Apr	0.71	0.69	1.9	2.59	8	**0.74**	1.11	2.1	3.21	6
May	0.16	0.76	2.1	2.86	8	**0.83**	1.10	2.1	3.20	6
May	0.47	0.57	1.5	2.07	6	0.91	0.99	1.9	2.89	6
Jun	0.18	0.14	1.5	1.64	8	0.37	0.83	1.4	2.23	5
Jun	0.11	0.21	1.4	1.61	5	0.05	0.64	2.3	2.94	4
Jul	<0.05	<0.02	1.2	**1.20**	4	<0.05	0.11	2.0	**2.11**	4
Jul	<0.05	<0.02	1.4	**1.40**	3	**0.24**	<0.02	1.3	**1.30**	2
Aug	0.18	0.05	1.3	**1.35**	4	0.25	0.02	1.4	**1.42**	3
Aug	<0.05	0.22	2.4	**2.62**	5	<0.05	<0.02	1.3	**1.30**	3
Sep	<0.05	0.08	2.7	**2.78**	13	0.07	<0.02	3.3	**3.30**	19
Sep	<0.05	0.04	2.6	**2.64**	6	0.40	0.06	2.5	**2.56**	10
Oct	0.09	0.84	1.6	2.44	7	0.17	1.08	1.3	2.38	8
Oct	<0.05	1.14	1.7	2.84	9	0.19	1.27	1.3	2.57	8
Nov	<0.05	1.18	1.4	2.58	9	0.33	1.15	1.3	2.45	11
Dec	0.25	0.91	1.2	2.11	8	0.34	0.75	1.2	1.95	14

The average TN for **Barr Lake** in 2017 was 2.44 mg/L and 3.02 mg/L for **Milton Reservoir**. TN tends to decrease through the growing season for both reservoirs until they begin to refill in the winter but this did not occur in 2017. NO_{3+2} and TKN increased in Barr in August and September.

The growing season (July 1 – September 30) average TN for both **Barr Lake** and **Milton Reservoir** was 2.0 mg/L. Typically, the growing season average is lower than the annual average because of the winter fill period and uptake, settling, and releasing of N during the summer.

The ammonia standard was met for Barr Lake but Milton Reservoir exceeded the chronic standard three times during the period when early life stages of fish are present (April 1 – August 31).

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Figure 2

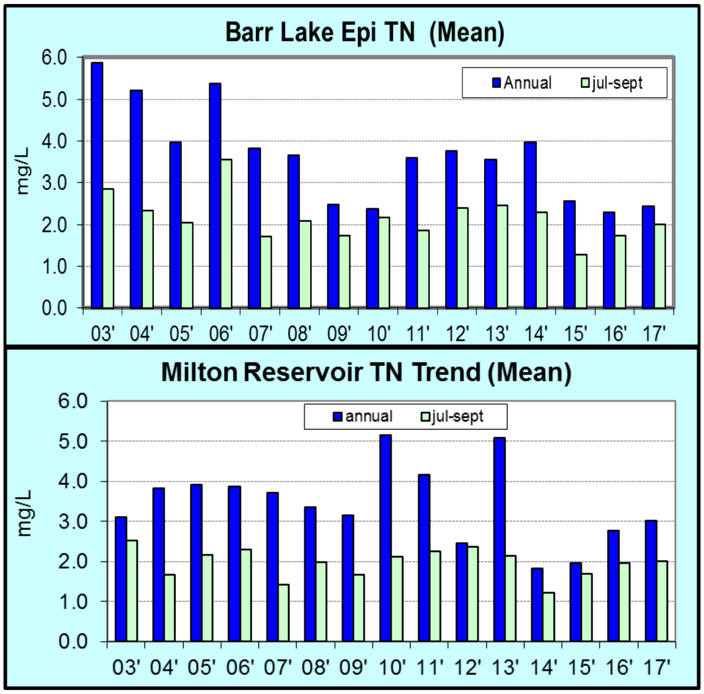
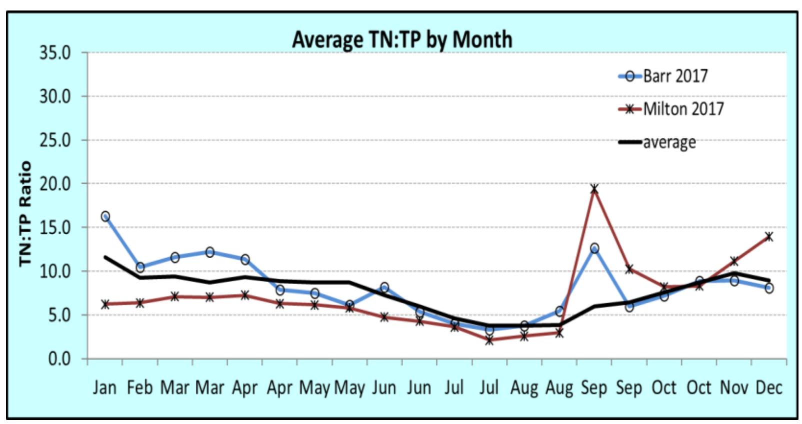


Figure 2 shows the annual and growing season averages since 2003. There was a downward trend in the annual average TN for Barr Lake until 2011. Then TN increased between 2011 and 2014. **Milton Reservoir** has slightly less TN on average than **Barr Lake.** There is a noticeable upward trend since 2014 for Milton.

TN:TP Ratio – In a complex reservoir system, there are multiple factors acting at once to influence algal growth. Both phosphorus and nitrogen are equally important. Other factors such as sunlight, water temperature, and even carbon play an important role.

N is much harder to control since blue-green algae and bacteria can assimilate the dissolved N gas that comes from an endless source, the atmosphere. Phosphorus, on the other hand, is more controllable and less abundant. For these reasons, it is more desirable to have a phosphorus limited reservoir.

Figure 3. 2017 TN:TP ratio compared to 2003-2017 annual average



A TN:TP ratio great than 20 is a desirable ratio that would indicate a phosphorus limited system. Blue-green algae blooms can be reduced when the ratio is kept high. Figure 3 shows the TN:TP ratio for 2017 for both reservoirs. **Barr's** ratio reflected the annual average except for January and early September. **Milton's** ratio remained slightly below average until September. Both reservoirs were not phosphorus limited for most of the year. Even though concentrations might be lower, it is important to understand that the ratio of N and P is just as critical as their concentrations.