

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 6 of 8 of a water quality summary series for 2023 calendar year for both reservoirs. The first five summaries focused on pH, chl-a, dissolved oxygen, temperature, and phosphorus. This summary covers nitrogen (N).

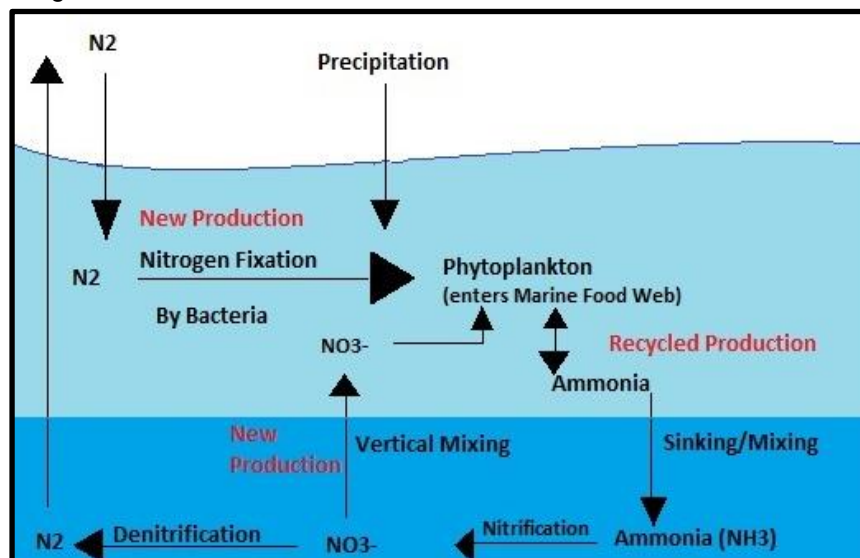
The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience "*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.

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 freshwater lakes.

In water, N can occur in three forms: dissolved N gas, inorganic N, and organic N (Figure 1). Some cyanobacteria can use dissolved N gas while other plants use inorganic N. Nitrogen fixation by cyanobacteria 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. Nitrogen limited waters then promote these N-fixing bacteria.

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



The two main forms of inorganic N are ammonia (NH_3) and nitrate (NO_3^-). NH_3 is preferred by plants. This form of N 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 to NH_3 by ammonification or convert 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's readily available for plants. TN concentration of 5 mg/L or more in freshwater is considered high in general terms.

A TN standard has been updated for **Barr Lake** and **Milton Reservoir** at 0.67 mg/L. This is the updated nutrient standard for warm water lakes that will be applied statewide in 2027. The ammonia standard for lakes is based on water temperature and pH. There are different ammonia standards. There are chronic and acute values for two different seasons, early life stages absent (September through March) and early life stages present (April through August). These standards are further applied to cold and warm waters to protect salmonids. Barr and Milton are warm water, and the salmonid values do not apply.

Water Quality Summary: **Nitrogen**

2023 Barr Lake & Milton Reservoir



2023 Nitrogen Data – Nitrogen data are collected from one-meter below the surface and one meter from the lake bottom during each visit. For 2023, there were 20 nitrogen sampling events for each reservoir. Only epilimnion (1-m) data are shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2023 epilimnion nitrogen data (mg/L). Bold values exceed the updated nutrient standard.

Month	Barr Lake (mg/L)					Milton Reservoir (mg/L)				
	NH ₃	NO ₃₊₂	TKN	TN	TN:TP	NH ₃	NO ₃₊₂	TKN	TN	TN:TP
Jan	0.09	1.03	1.9	2.93	8	0.76	3.16	2.4	5.56	19
Feb	0.76	1.64	1.9	3.54	10	0.67	4.30	2.6	6.90	18
Mar	0.04	1.79	2.5	4.29	12	0.15	3.57	2.4	5.97	18
Mar	0.16	2.09	1.8	3.89	14	0.04	2.97	2.3	5.27	20
Apr	0.23	1.99	1.7	3.69	17	0.03	2.01	3.5	5.51	20
Apr	0.58	1.76	2.2	3.96	14	0.11	1.79	2.4	4.19	28
May	0.65	1.70	1.6	3.30	12	0.51	1.63	1.5	3.13	28
May	0.46	1.24	1.6	2.84	9	0.57	1.36	1.9	3.26	22
Jun	0.40	0.81	1.3	2.11	10	0.09	0.96	1.9	2.86	16
Jun	0.02	0.60	1.0	1.60	8	0.49	0.81	1.9	2.71	18
Jul	<0.01	<0.02	1.2	1.20	8	0.02	0.31	1.1	1.41	20
Jul	0.06	<0.02	1.4	1.40	6	0.03	<0.02	2.2	2.20	16
Aug	0.06	<0.02	1.2	1.20	4	0.38	0.05	1.2	1.25	10
Aug	0.01	<0.02	1.1	1.10	5	0.01	<0.02	2.9	2.90	12
Sep	0.17	<0.02	1.2	1.20	7	0.05	<0.02	1.4	1.40	9
Sep	<0.01	<0.02	1.8	1.80	11	0.16	0.11	1.3	1.41	11
Oct	<0.01	<0.02	1.4	1.40	13	0.17	0.21	1.4	1.61	15
Oct	0.09	0.09	1.6	1.69	15	0.11	0.24	1.7	1.94	13
Nov	<0.01	<0.02	2.0	2.00	20	0.17	0.22	1.7	1.92	16
Dec	0.09	1.01	1.8	2.81	18	0.01	0.10	1.9	2.00	17

The average TN for **Barr Lake** in 2023 was 2.4 mg/L and 3.17 mg/L for **Milton Reservoir**. TN tends to decrease through the growing season for both reservoirs until they begin to refill in the fall/winter. TKN increased when there were the major algal blooms. Again, TKN is comprised of organic N and ammonia. For Barr and Milton, TKN increases are driven by the increase in organic N (i.e., algae growth). Ammonia is close to detection limits when TKN increases.

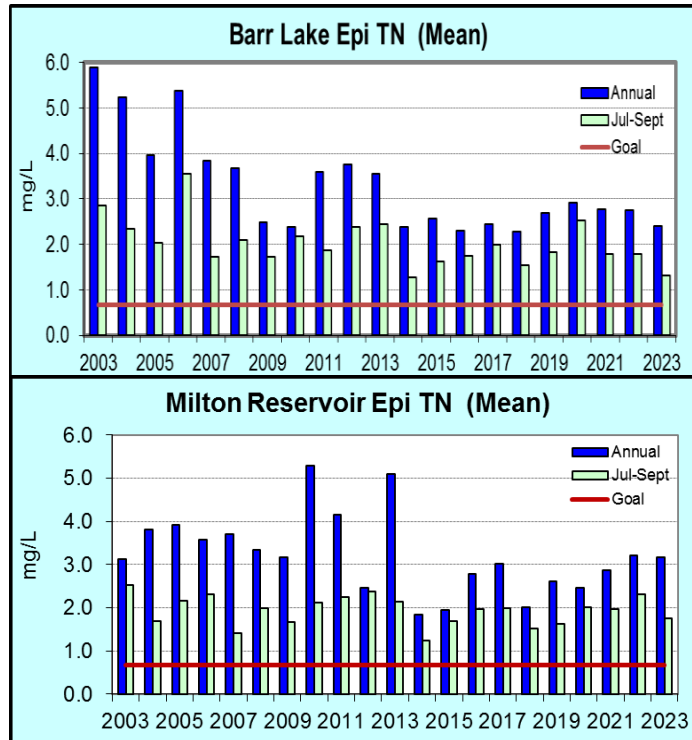
The growing season (July 1 – September 30) average TN for **Barr Lake** was 1.32 mg/L and 1.76 mg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average. The reservoirs do a good job of processing the nitrogen with biological uptake, physical settling to the sediments, and releasing of water out the dam.

The ammonia standard was met for both Barr Lake and Milton Reservoir in 2023 with no exceedances.



Figure 2 shows the annual and growing season averages since 2003. There is an overall downward trend in the annual average TN since 2003. **Milton Reservoir** has slightly increased TN over the past five years. There has been a noticeable shift in TN for both reservoirs since 2014.

Figure 2

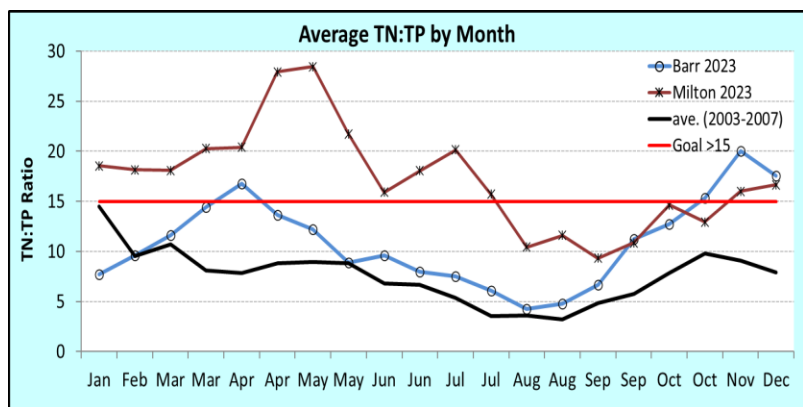


TN:TP Ratio – In a complex reservoir system, there are multiple factors acting at once to influence algal growth. Both phosphorus and nitrogen are equally important. Other factors such as sunlight, water temperature, and even carbon and silica play an important role.

N is much harder to control since cyanobacteria can assimilate the dissolved N gas that comes from 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.

A TN:TP ratio greater than 15 is a desirable ratio that would indicate a phosphorus limited system. Cyanobacteria blooms can be reduced when the ratio is kept high. Figure 3 shows the TN:TP ratio for 2023 for both reservoirs. Ratios are higher for most of the year for both reservoirs compared to the 2003-2007 average. **Barr and Milton**

Figure 3. 2023 TN:TP ratio compared to 2003-2007 annual average



were phosphorus limited in April and May and increased again in the fall. As TN declined over the course of the summer and TP remained steady, the ratio dropped well below 15 for most of the peak growing season. Milton's ratio was higher than Barr's until October which seems to have allowed for less cyanobacteria than Barr. Even though concentrations might be lower, it is important to understand that the ratio of N and P is just as critical as their individual concentrations.