Water Quality Summary: Dissolved Oxygen

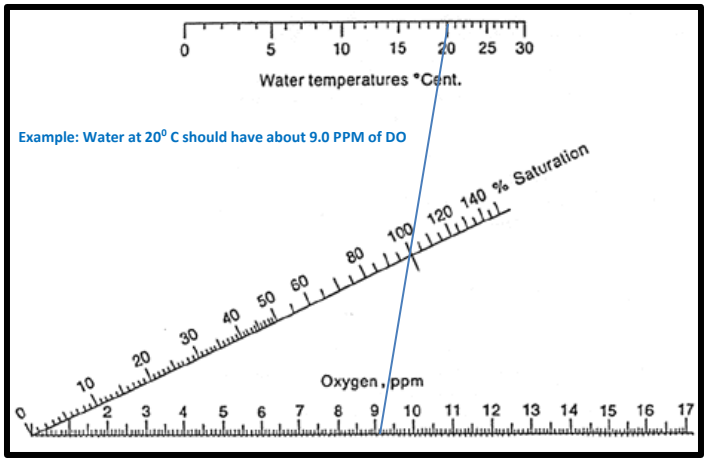
2024 Barr Lake & Milton Reservoir

Barr Lake and **Milton Reservoir**'s water quality has been sampled twenty times a year since 2003. These 440 trips to both reservoirs have produced an abundance of data and information. This is Part 3 of 8 of a water quality summary series for 2024 calendar year for both reservoirs. The first two summaries focused on pH and Chlorophyll-a; this one discusses dissolved oxygen (DO).

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.

DO – Oxygen is one of the most important parameters. All aquatic organisms, from fish to bacteria, need oxygen. DO is the measurement of how much oxygen gas is dissolved in water. The two mechanisms that control oxygen dissolution are diffusion from the atmosphere and photosynthesis. DO concentrations are typically expressed in units of milligrams per liter (mg/L) or parts per million (ppm). Concentrations below 1 mg/L are considered anoxic – void of oxygen and allowing internal loading of ammonia and dissolved phosphorus from the sediment.

Water temperature, pressure (atmospheric and hydrostatic), and dissolved salts determine the solubility of oxygen. The colder the water the more oxygen it can hold. At 32º F, one liter of water can hold about 14 mg of oxygen. The same liter of water at 80º F can hold about 8 mg – *lakes during the summer have less DO*. The higher the pressure, the less likely bubbles will form so it holds the oxygen in solution better – *lakes at higher elevation have less DO*. Water with more dissolved salts has less room for oxygen molecules – *lakes in drier areas have less DO*. At a given temperature, pressure, and salt content, there is a limited amount of DO that water can keep soluble. This is the 100% DO level. Percent DO saturation (%DO) is another way of looking at oxygen.



Quick Saturation Chart – draw a straight line from a water temperature to a DO concentration. The %DO is where the line crosses the % saturation line (note: this nonogram is for sea level).

Water Quality Summary: Dissolved Oxygen

2024 Barr Lake & Milton Reservoir

DO or %DO can change quickly and exhibit large differences between the top, middle, and bottom water in eutrophic lakes. Algae and wave action occur near the surface allowing for %DO to be 100% or more when in equilibrium. If it is >100%, it is often because of additional oxygen from photosynthesis. At the bottom of a lake there is no photosynthesis, and the water is not in contact with the atmosphere. At the same time, it is colder and there is more hydrostatic pressure. Bottom water DO can be less than 100% due to decomposition and chemical reactions. Fish can avoid low DO areas and swim to where there is an acceptable amount. Therefore, the DO water quality standard for Colorado lakes (deeper than 5 meters) only applies to the top water (0.5 – 2.0 meters). The DO standard for **Barr Lake** and **Milton Reservoir** is always 5.0 mg/L or higher. Both Milton and Barr met the DO standard for 2024.

2024 DO Data – DO profile data are collected throughout the entire water column in half meter increments during each visit. DO data from 0.5 to 2.0 meters are averaged for the top water. For 2024, there were 20 DO averages recorded for each reservoir (Table 1). Both reservoirs typically see a decrease in DO in the spring after the cold-water bloom, after large summer blooms, or after the reservoir mixes after a long period of thermal stratification.

Table 1. Barr Lake and Milton Reservoir DO data for 2024 (mg/L and %). Bold values exceed water quality target.

Month	DO (Barr)	DO (Milton)
Jan	15.1 (132.8%)	14.4 (131.6%)
Feb	20.7 (196.1%)	18.8 (176.4%)
Mar	13.6 (133.1%)	14.5 (142.2%)
Mar	13.3 (138.0%)	13.0 (132.4%)
Apr	6.9 (73.8%)	8.8 (95.9%)
Apr	5.6 (62.7%)	6.0 (68.3%)
May	8.5 (98.3%)	7.5 (85.3%)
May	6.2 (81.4%)	6.8 (87.7%)
Jun	6.3 (87.6%)	8.6 (120.6%)
Jun	6.5 (94.1%)	7.5 (105.0%)
Jul	6.0 (84.3%)	7.8 (109.2%)
Jul	13.4 (193.0%)	9.0 (126.2%)
Aug	8.1 (113.0%)	8.2 (113.9%)
Aug	10.3 (150.3%)	6.7 (93.4%)
Sep	9.5 (128.8%)	6.3 (83.8%)
Sep	12.9 (173.6%)	9.3 (116.5%)
Oct	9.1 (112.3%)	10.7 (132.4%)
Oct	7.4 (84.9%)	13.6 (154.3%)
Nov	12.2 (116.6%)	12.6 (117.4%)
Dec	6.1 (54.4%)	14.9 (127.3%)

Because of year-round algal growth, both reservoirs tend to have sufficient DO – 11 of the 20 averages in 2024 were over 100% DO for **Barr Lake** and 14 out of 20 for **Milton Reservoir**. Both reservoirs had their lowest oxygen levels in late April. This is after a productive winter, ice off in early February, thermal stratification, and during low algal productivity. The %DO levels above 100% are a direct result from higher chl-a numbers. Algae drives oxygen spikes (photosynthesis) as well as the declines (respiration and decompose).

DO is a response parameter similar to pH and chl-a. These reservoirs try to reach equilibrium during periods of extreme drawdowns, weather events, and sudden nutrient loads.

Water Quality Summary: Dissolved Oxygen

2024 Barr Lake & Milton Reservoir

8 O Oxygen 15.999

The growing season (July 1 – September 30) average for **Barr Lake** was 10.0 mg/L and 7.9 mg/L for **Milton Reservoir**. In general, there is plenty of oxygen except for isolated situations when consumption is faster than supply.

Figure 1. 2024 DO data compared to water quality standard and 2003-2007 annual average.

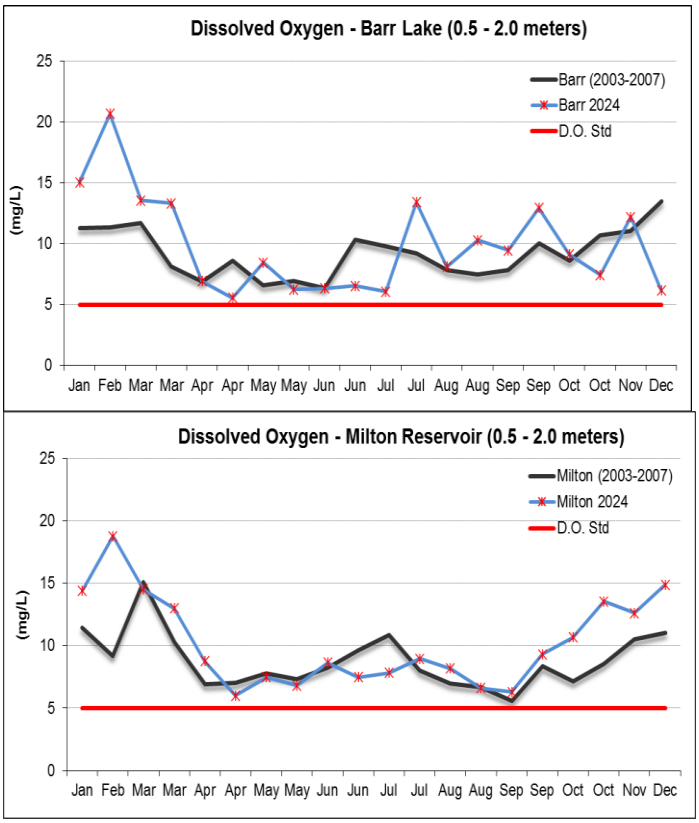


Figure 1 shows the average annual cycle of DO along with 2024 data for both reservoirs. **Barr Lake** followed the annual pattern of highs and lows. **Milton Reservoir** had a typical DO year as well. Both reservoirs had higher than average levels in the winter and fall.

Oxygen Deficit Rate – Figure 2 shows the average DO for each level in Barr Lake (top, middle, and bottom). The Oxygen Deficit Rate (ODR) is the slope of the line when DO declines. It tells you how many milligrams of oxygen are being consumed over a given time per unit area. The ODR for **Barr Lake** from April to June 2024 was 789 mg of DO/m^2-day. The oxygen consumption rate is the ODR applied to the sediment area of the bottom water (the bottom 2 meters). The consumption rate was 4,961 Kg of oxygen per day. Both the ODR and consumption rates were less than previous couple of years. This information is useful when considering aeration systems.

The reservoir is fully mixed when all three DO lines are the same. As soon as the bottom water is not mixing, respiration starts to consume the DO. When there is an increase in top water DO, this is caused either by photosynthesis or wave action. When middle and bottom water DO increases, this is usually caused by wind mixing or algal growth in shallow conditions. Barr was experiencing higher ODR in January, under ice cover conditions.

Figure 2