Bass Lake-St. Croix County WI water quality baseline summary-2021/22

Rationale

Historically, Bass Lake has periodically pumped water from the near bottom of the lake into the Willow River to manage high water levels (most recently in the 1990s). With recent high-water levels in the lake, there is interest in potential withdrawal in the future. The Wisconsin DNR requested that baseline water quality data be collected to determine how the Bass Lake water compares to the Willow River to not pump water into the Willow River that would degrade its water quality. These results will be used by the Wisconsin DNR to determine the potential permitting of a withdrawal from Bass Lake into the Willow River.

Water quality tests summary

The following were analyzed in both Bass Lake and Willow River simultaneously (2021-22) with a summary of what these analyses indicate:

Temperature: Temperature can become important in terms of the ability of oxygen to dissolve in the water. Warm water has a lower oxygen capacity, so as the water warms, dissolved oxygen will decrease. Warmer water can also speed up reactions in organisms, such as respiration, leading to higher BOD. Since these are fall/winter readings, the temperature is never likely to be an issue.

Dissolved oxygen: Dissolved oxygen (DO) concentration represents the amount of oxygen dissolved in the water. Respiration from organisms can decrease it as well as increasing temperatures. Photosynthesis, wave action, and flowing of the water can increase the DO. Reduced DO can adversely affect the survival of organisms. Different organisms have various tolerance to reduced DO depending on the type and species. Coldwater fish such as trout can be affected if DO gets below seven mg/L, while some organisms aren't affected until 2-3 mg/L. DO would be expected to decline during the winter in Bass Lake due to a lack of photosynthesis and mixing of the water. It will likely change little in the Willow River due to the water flowing.

Total phosphorus: Total phosphorus tests for all forms of dissolved phosphorus in the water. Phosphorus is typically the limiting nutrient in lakes and streams; therefore, small increases in phosphorus can lead to significant increases in algae and plant growth. In lakes, the threshold concentration for excessive productivity is 25 ug/L. In streams, that threshold is typically higher, around 100 ug/L. Phosphorus as phosphate can bind to sediments so that erosion can lead to increased phosphorus. Other common sources are fertilizers and animal and human waste (septic). Since the water withdrawn from Bass Lake is from the near bottom (hypolimnion), the near-bottom water may be higher in phosphorus than the surface due to sediment release. However, it would be unlikely to be as high as the Willow River phosphorus reaches during spring runoff.

Total nitrogen: Total nitrogen includes all forms of nitrogen dissolved in water. Increased nitrogen can lead to increased growth in plants and algae, although it is typically not the limiting nutrient. Various forms of nitrogen don't tend to be associated with sediments, so the sources are similar to phosphorus except for erosion. High ammonia (NH_3) can be toxic but is typically converted to the ammonium ion (NH_4^+) if the pH is not too high.

pH: This measures how acidic (low pH below 7) or alkaline (high pH above 7) the water is. Typically, water bodies in Bass Lake and Willow River are in the mid to upper 7s/low 8s. This is generally due to the bedrock that streams flow through, leading to enough mineral content to raise the pH slightly. Since rainfall is acidic, this buffering can be crucial. High organic matter can lead to bacterial breakdown with increased respiration, lowering the pH. Mining drainage can substantially lower pH in waterways, but this is not an issue here. Low pH can become a factor for the survival of various organisms in the low 6s. It would be unusual for the pH to be very high (9 or 10) without a pollution source. At high pH, toxic NH_3 won't convert to NH_4^+ (not toxic) as readily. Ammonia (NH_3) can be toxic to aquatic organisms in high amounts.

Alkalinity: Alkalinity indicates the buffer capacity of the water. If the water has high alkalinity, it is less susceptible to acidic conditions and will keep the pH higher. This is mainly due to calcium carbonate in the water. This keeps the waterway buffered from acidic sources such as precipitation.

Conductivity: Conductivity measures the ability of water to conduct electricity. It measures the number of dissolved ions in the water. Many of these ions are natural and good, but increased pollution can increase ions that are not naturally present and increase conductivity. This could include nutrient ions of phosphate and nitrate.

Total suspended solids (TSS): Small solids that don't dissolve and are small enough to stay suspended in the water contribute to this measurement. Runoff into lakes and rivers can lead to a high TSS. Mixed lakes can also have higher TSS due to small sediments becoming mixed in the water column from the bottom. High TSS is not typically desirable.

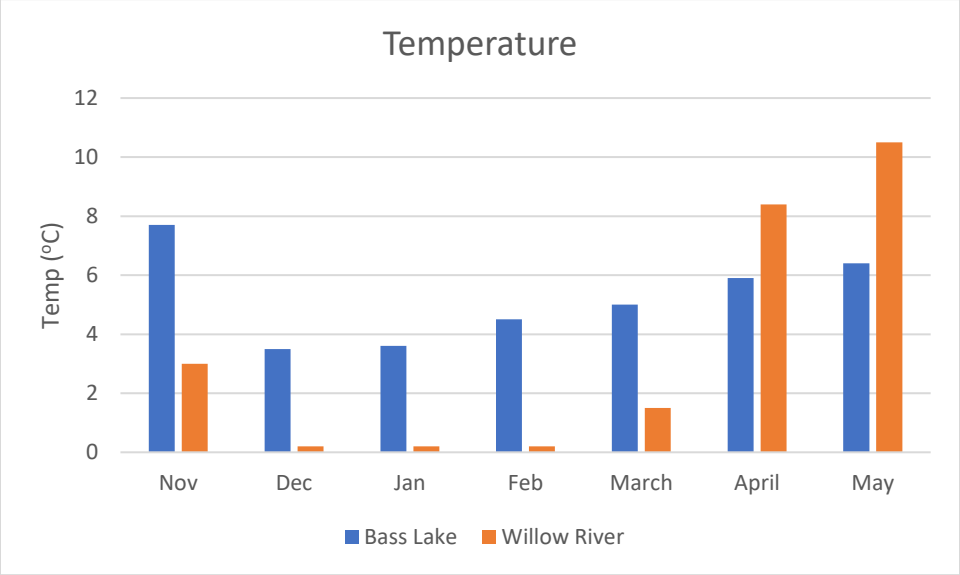
Chlorophyll-a: Chlorophyll is produced by plants and algae. Algae suspended in water can be represented by the chlorophyll concentration in the water. There are two forms of chlorophyll (*a* and *b*), with *a* being the form that is measured. High chlorophyll-a values indicate more algae growth in the water. Increased phosphorus (and sometimes nitrogen) can increase algae growth and, therefore, higher chlorophyll-a concentration.

Biological oxygen demand (BOD): When large amounts of organic pollution occur, such as animal waste, bacteria decompose this organic waste. During this process, the bacteria increase respiration and use oxygen to respirate. This lowers the oxygen dissolved in the water. This test measures the demand for oxygen that bacteria require while decomposing the organic matter. Therefore, the more organic matter in the water, the higher the oxygen demand. If high enough, the oxygen concentration of the water can become depleted. A high BOD is not desirable in waterways because it indicates a high amount of organic matter, such as animal waste in the water.

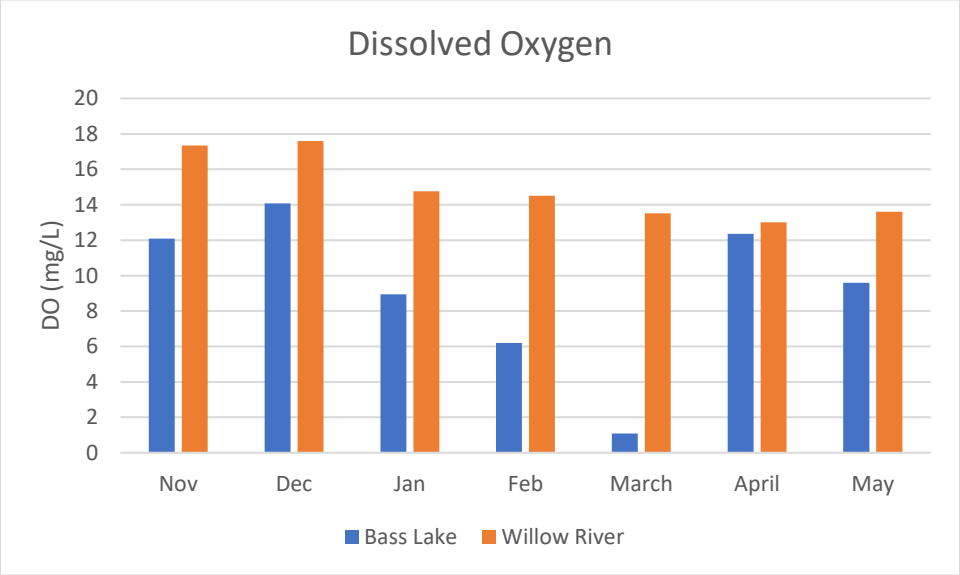
Analysis results/comparison of water bodies

The desirable outcome in the results that would allow permitted water pumping from Bass Lake to the Willow River is for the Bass Lake results to be of equal or better quality than the background water (Willow River) receiving the water. The following graphs compare each parameter that can provide a graphic comparison of the results. Not all tests were conducted each month since not all parameters will change in winter (chlorophyll-a).

Note: The January water samples arrived at the State Lab of Hygiene slightly frozen due to winter temperatures. The sample was discarded and not analyzed without informing us. If they had contacted us, we would have collected new samples, but there are no January samples since they did not contact us and we were completely unaware until informed in May 2022.

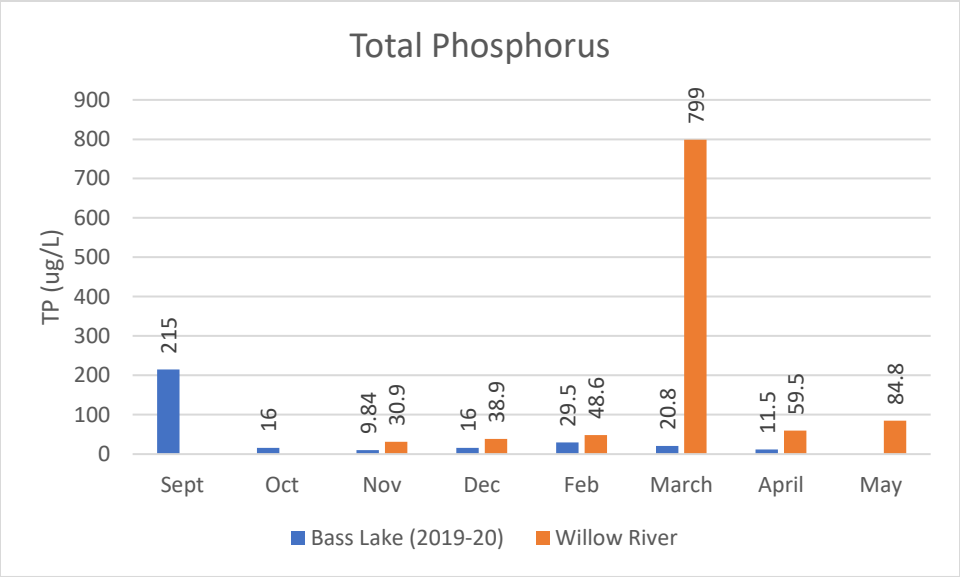


As expected, the Bass Lake water temperature is higher in all months except April. Although temperatures are higher, adding Bass Lake water below 8°C to the Willow River should have little effect on the temperature of the Willow River and is not likely a concern.

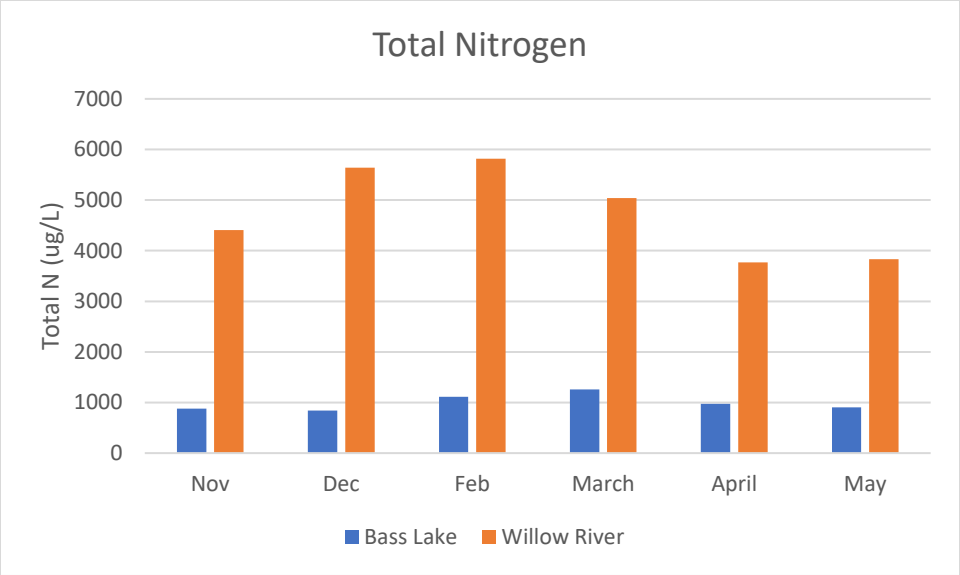


The DO of Bass Lake remained relatively high until March. This decline is expected, and it is likely that even in March, the cold Bass Lake water will increase in DO once exposed to the surface. The lake likely mixed in April, leading to higher DO in the lake. The Willow River DO is very high each month, making it less susceptible to reduction.

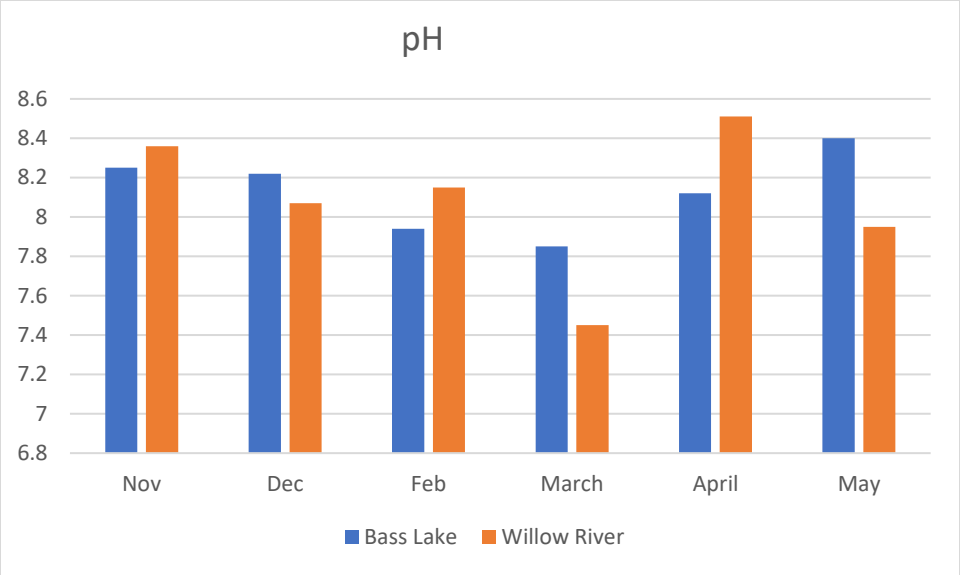
Phosphorus was collected in Bass Lake in 2019-20, so these analyses occurred at different times..



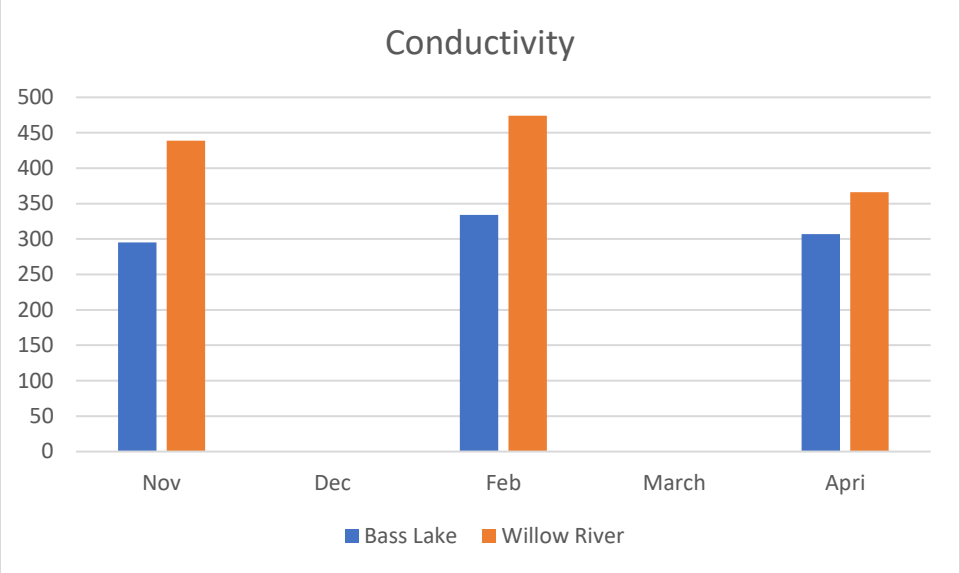
Total Phosphorus: The total phosphorus for the Willow River is relatively low for a river, likely due to limited runoff in the winter. The spike in March is likely due to snowmelt. The Bass Lake's total phosphorus is lower each month than the Willow River, which would be expected as lakes typically have less phosphorus. There was a spike in total phosphorus in September (2019), likely due to the internal loading of phosphorus that accumulated in the bottom layer during stratification. This is likely higher than the Willow River would have been, had a September analysis occurred. It is doubtful that Bass Lake would contribute phosphorus to the Willow River except for September or early withdrawal.



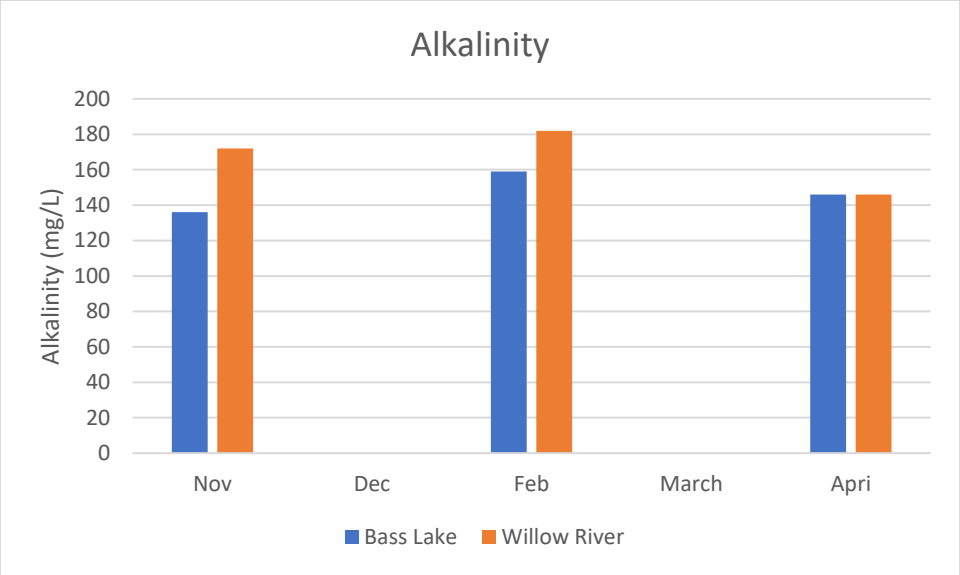
Total nitrogen: The nitrogen concentration of the Willow River was significantly higher in all months. This indicates that the Bass Lake water would not contribute to increased nitrogen in the Willow River.



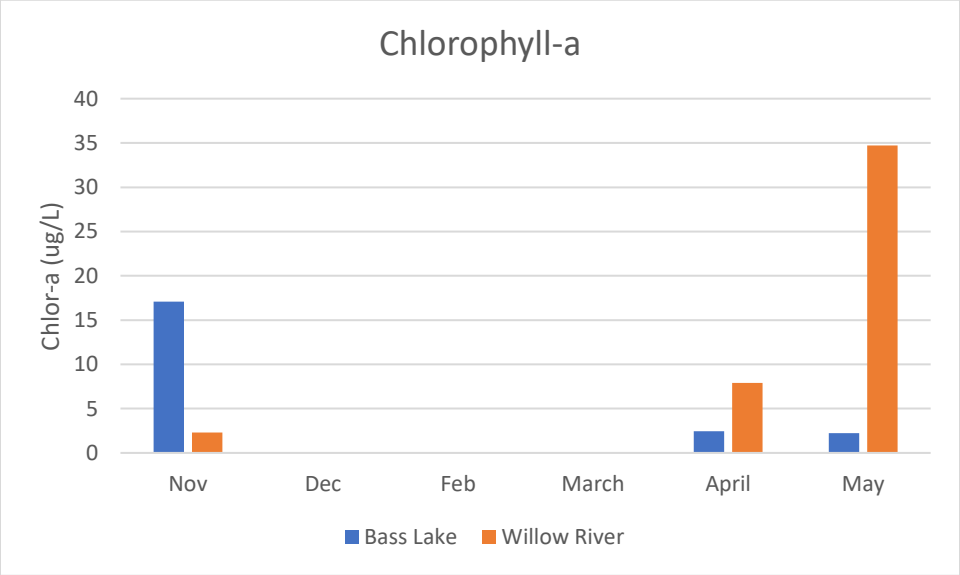
pH: The pH values each month were similar. Values indicate no pH issues within either water body (they are within an acceptable range). It is unlikely that Bass Lake water would affect the pH of the Willow River.



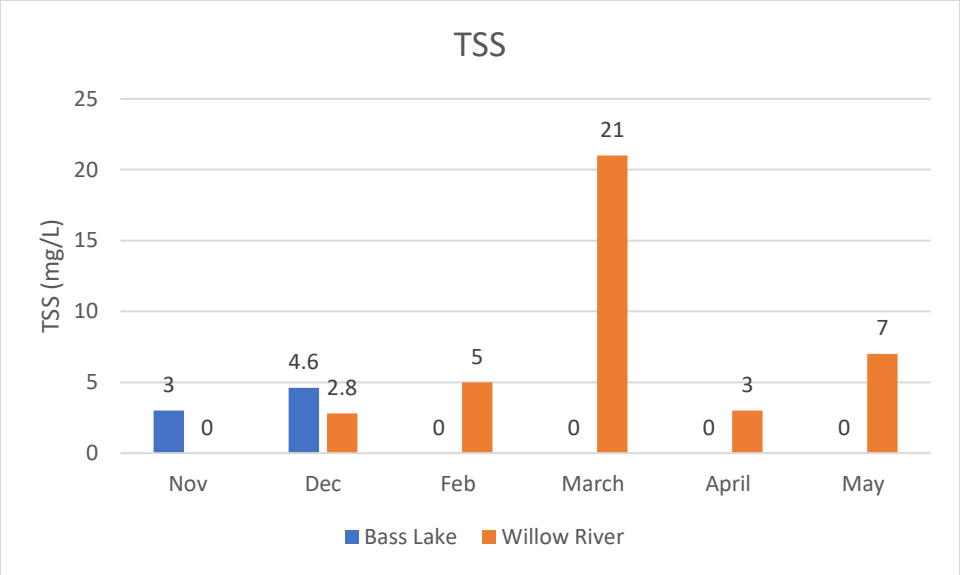
Conductivity: As expected, the Willow River (since it is flowing) has more dissolved ions than Bass Lake. Bass Lake would likely not affect the Willow River.



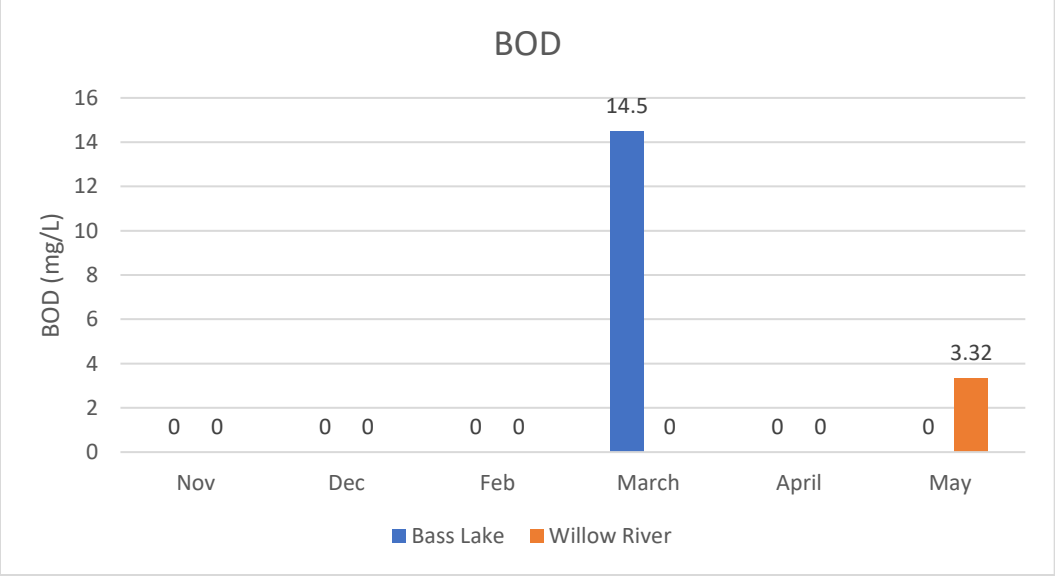
Alkalinity: Both water bodies have similar alkalinity values, and there appears to be no issue with this parameter.



Chlorophyll-a: As expected, the chlorophyll-a value in Bass Lake was higher in the fall. In the spring, it was higher in the Willow River. There should be no chlorophyll issues as long as the pumping occurs in the late fall to winter.



Total suspended solids (TSS): The TSS of the Willow River would be expected to be higher as the watershed is more significant, therefore more runoff. To have a TSS reading in Bass Lake near the bottom would be unlikely unless the lake is mixing. It may be that the higher values in Nov and Dec are due to that or the sampler disturbing the bottom. Bass Lake would not contribute to TSS in the Willow River. The spike in March in the Willow River is likely due to snowmelt. *(Note: The TSS values listed as zero may be slightly higher than zero. They were reported as ND (none detected), so the value is less than two mg/L)*



BOD: There would not be an expected BOD in Bass Lake near the bottom at any point unless organic sediments became mixed and the water warmed. The spike in BOD in the Willow River is likely due to snowmelt that contains organic matter such as animal waste. The results show that Bass Lake would not contribute organic pollution (waste) to the Willow River. *(Note: The BOD may not be zero, it was reported as ND (not detected), which means the value is less than the detection limit of 2 mg/L)*

Data Summary: (ND="not detected" and xxx="not tested that month")

Phosphorus (ug/L)								
	Sept	Oct	Nov	Dec	Feb	March	April	May
Bass Lake (2019-2020)	215	16	9.8	16	29.5	20.8	11.5	
Willow River			30.9	38.9	48.6	799	59.5	84.8
Nitrogen (ug/L)								
			Nov	Dec	Feb	March	April	May
Bass Lake			878	843	1110	1260	971	902
Willow River			4410	5640	5820	5040	3770	3830
pH								
			Nov	Dec	Feb	March	April	May
Bass Lake			8.25	8.22	7.94	7.85	8.12	8.4
Willow River			8.36	8.07	8.15	7.45	8.51	7.95
Conductivity (us/cm)								
			Nov	Dec	Feb	March	April	May
Bass Lake			295	xxx	334	xxx	307	xxx
Willow River			439	xxx	474	xxx	366	xxx
Alkalinity (mg/L)								
			Nov	Dec	Feb	March	April	May
Bass Lake			136	xxx	159	xxx	146	xxx
Willow River			172	xxx	182	xxx	146	xxx
Chlorophyll-a (ug/L)								
			Nov	Dec	Feb	March	April	May
Bass Lake			17.1	xxx	xxx	xxx	2.45	2.24
Willow River			2.32	xxx	xxx	xxx	7.91	34.7
TSS (mg/L)								
			Nov	Dec	Feb	March	April	May
Bass Lake			3	4.6	ND	ND	ND	ND
Willow River			ND	2.8	5	21	3	7
BOD (mg/L)								
			Nov	Dec	Feb	March	April	May
Bass Lake			ND	ND	ND	14.5	ND	ND
Willow River			ND	ND	ND	ND	ND	3.32