# SUMMARY REPORT OF CHEMICAL AND BIOLOGICAL CONDITIONS IN HIGGINS LAKE, SUMMER 2023

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I continued to assess the ecological conditions in Higgins Lake during summer 2023 and evaluated the trends based on my assessment. The major concerns continue to be the ongoing addition of nutrients, particularly phosphorus and nitrogen, the accumulation of organic sediments and decreased dissolved oxygen associated with those sediments, and increased depth of the thermocline. However, aquatic invasive species, particularly quagga mussels, have emerged as the greatest concern during 2023. I have outlined the status and trends of the most significant concerns.

Nutrients –

Phosphorus continues to occur at very low concentrations in the water column. Total phosphorus concentrations in the water column are typically <0.007 mg/L. Typically, lakes with low phosphorus levels are considered “healthy” and are classified as oligotrophic. However, the amount of biomass (the weight of living organisms in the lake) suggests that Higgins Lake is

much more productive than a lake that is classified as oligotrophic. The accumulation of organic matter at the bottom of the lake also indicates that Higgins Lake has become more productive in recent years.

I have already established that the zebra mussels associated with Eurasian watermilfoil spread over 20 acres accounts for more than 1 million mg of total phosphorus. During summer 2023, I estimated the amount of phosphorus contained in zebra mussels/quagga mussels in a rocky 14acre area in the North Basin of Higgins Lake. I calculated that there were approximately 74,486,911 zebra mussels/quagga mussels within that 14-acre area. At that density, zebra mussels/quagga mussels would account for approximately 968,329 mg of TP. It is reasonable to conclude that zebra mussels/quagga mussels are moving much of the phosphorus from the water column to the bottom of the lake where it would not be detected by sampling just in the open water areas.

Invasive Species –

There is no doubt that invasive species have significantly altered the ecology of Higgins Lake. As I noted for phosphorus, zebra mussels/quagga mussels have altered the distribution of nutrients in Higgins Lake.

Zebra mussels have been in Higgins Lake for at least two decades; I reported the presence of quagga mussels near the South State Park lagoon about 5 years ago. At that time, quagga mussels were only in the South Basin and in relatively small numbers. None the less, I predicted that quagga mussel populations would increase in density and have a substantial impact on Higgins Lake because they can occupy habitat that zebra mussels do not, particularly soft sediments. My prediction was based on reports in the literature and my work on Lake Michigan where I found quagga mussels living in soft sediments at depths over 500 feet. Since I first found quagga mussels in Higgins Lake, they have spread across both basins, and have mostly been found within zebra mussel beds. During summer 2023 I found quagga mussels have now reached high populations densities in soft sediments at deeper depths in some locations in the North Basin. For example, I recently collected a sediment sample from 55 feet and found large numbers of quagga mussels associated with a native alga that has also become abundant in deeper areas (Fig. 1)

Figure 1. Large numbers of quagga mussels associated with the algae *Nitella* collected at 55 feet. The sample was collected in September 2023.

The expansion of quagga mussels into deeper areas corresponds to the increase in water clarity during the past 2-3 years. Previously, water clarity (measured with a Secchi Disc) was generally at 33-35 feet. During the past 2-3 years I have consistently recorded Secchi depths of 42-44 feet. The dramatic increase in water clarity corresponds to the increase in quagga mussel populations.

A second species I have been monitoring in Higgins Lake is *Corbicula*, the Asiatic Clam. I first found *Corbicula* in the Northwest portion of the North basin about six years ago. Since then, they have spread to other areas of the North basin. At current densities, *Corbicula* may play a small role in the ecology of Higgins Lake. But studies have shown that at high densities *Corbicula* can increase water clarity and redirect nutrients to the bottom of a system where they may be used by organisms living on the bottom of a lake. As *Corbicula* spreads throughout Higgins Lake, it is likely they will also influence water clarity and the distribution of nutrients in the lake.

The increased water clarity appears to be having secondary impacts on the ecology of Higgins Lake. For example, the actual depth that light may travel in Higgins Lake is approximately double the Secchi depth. So, a Secchi depth of 42 feet may result in light travelling as deep as 84 feet, and the amount of light will be much greater in shallower areas. Increasing the amount of light in shallower areas may account, in part, for the increased plant growth in some parts of the lake, particularly along the drop off. It is likely the reason that the amount of macroalgal growth in deeper parts of the lake has become much more evident in the past few years (see Addendum).

As we become aware of the changes occurring in Higgins Lake due to the presence of invasive species, it becomes more apparent that it is critical to prevent the introduction of any additional invasive species.

**ADDENDUM – 10-30-2023**

I conducted a survey of the North Basin on 10-29-2023. My focus was on the area between Treasure Island and the West DNR Boat Launch, in approximately the same area I discovered quagga mussels associated with the macroalga *Nitella*(Fig. 1). I have learned that *Nitella* with associated quagga mussels (Fig. 2) covers an extensive area of the bottom ranging from the

45foot depth contour to the 70-foot depth contour, and for hundreds of yards along an East/West axis.

Figure 2. *Nitella* and attached quagga mussel collected from the North Basin of Higgins Lake at the 45-foot depth contour on October 29, 2023.

A simple rake toss recovered a surprising amount of *Nitella* (Fig. 3) and retrieving the anchor revealed an extraordinary amount (Fig. 4) of *Nitella*. Using a GoPro camera, I was able to record the *Nitella* bed and found that growth is between 1.5 to 2 feet thick. The thickness of the growth and the spatial extent of the growth suggests that the algal beds may constitute a significant amount of biomass. It is not unreasonable to suggest that this level of biomass is supported by the continued addition of nutrients and increased water clarity allowing more light to reach deeper depths.

Figure 3. *Nitella* collected from the North Basin of Higgins Lake using a weighted rake. The sample was collected from 45 feet on 10-29-2023.

The discovery of this large accumulation of algal biomass adds to the growing evidence that Higgins Lake supports a substantial amount of biological production/biomass. Together, the accumulation of organic sediments, the amount of plant biomass in some areas of the lake, the amount of algal biomass in shallow nearshore areas, and the recently discovered extensive growth of algae at deeper depths are all driven by the continued addition of nutrients into the lake.

Figure 4. *Nitella* accumulated on an anchor retrieved from 45 feet. The anchor had been deployed in the North Basin of Higgins Lake with very light wind conditions and no drifting. The photo was taken on 10-29-2023.

I also collected a sediment sample using a small Ponar dredge (Fig. 5) on October 28, 2023. The sample was collected from 60 feet, just East of the West DNR boat launch. The sediment was sand/fine sediment and had very little aquatic plant growth.

Figure 5. Hand winch and Ponar dredge used to collect deep sediment samples.

A total of 5 mussels were collected from an area of about 1 ft. sq. area. Although this density doesn't constitute a large amount of biomass, it does indicate that mussels have now colonized deeper offshore areas. As mussel densities increase, they will continue to alter the ecology of Higgins Lake.

Conclusion-

The current status of nutrient concentrations (low TP), chlorophyll a concentrations (low chlorophyll a), and water clarity (increasing) in open water replicate the conditions observed in Saginaw Bay in the early 1990s after zebra mussels became established (Nalepa and Fahnenstiel, 1995) and in other aquatic systems since then. These three parameters have been the primary metrics used to calculate the Trophic State Index (TSI) since the 1970s. However, when the TSI was initially developed, dreissenid mussels had not been introduced into North America. With their introduction, aquatic systems have changed significantly, and as stated in a position paper published by the North American Lake Management Society (NALMS), the TSI may not work for every lake. NALMS suggests that biomass may be a better indicator of trophic status for some lakes. The extensive growth of macroalgae in deeper areas along with the accumulation of biomass across several other groups of organisms and the buildup of organic matter in the sediments are strong evidence that Higgins Lake has become a much more productive lake than it was in the past. Because biomass and TP are both low in the open-

water areas of the lake but biomass of plants and macroalgae has increased, the trophic state index may no longer be a good measure of the trophic state of Higgins Lake.