Water Quality Monitoring and Analysis For Palmer Lake, Putnam County, NY

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September 24, 2008
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Palmer Lake In-situ Water Quality Data

During the 3 September 2008 sampling event, temperature, conductivity, dissolved oxygen (DO), and pH were measured and recorded at 0.5 meter intervals from surface to bottom at two in-lake stations on Palmer Lake (see Figure 1 for station locations) and the inlet and outlet. Deeper portions of the lake were selected for monitoring in order to assess the potential for thermal stratification and the associated depletion of DO.

Temperature

Temperature is one of the most important water quality parameters, since it controls the rate of all chemical and biological reactions and determines the physical structure of a lake or pond. As the air temperature increases through the growing season, the temperature of the surface waters increases. This results in the surface waters being warmer relative to the bottom waters. Once the temperature difference between the surface and the bottom waters is large enough, a waterbody becomes thermally stratified. These conditions substantially minimize the transfer of materials and gases between the surface waters (the epilimnion) and the bottom waters (the hypolimnion). For example, in productive waterbodies, once the hypolimnion is cut off from the epilimnion, DO can not enter the deeper waters. This can easily result in a depletion of DO in the bottom waters, a condition termed anoxia. Such conditions can have a substantial impact on the overall water quality of a lake.

Overall, the temperature varied by approximately 2° Celsius from the surface to the bottom at both in-lake stations, therefore Palmer Lake would not be considered thermally stratified during the 3 September 2008 sampling event. The relatively shallow depth of Palmer Lake generally prevents thermal stratification from occurring. Shallow waterbodies generally stay well mixed as a result of wind and wave action.

Dissolved Oxygen

Atmospheric oxygen enters water by diffusion from the atmosphere, facilitated by wind and wave action and as a by-product of photosynthesis. Adequate DO is necessary for acceptable water quality. Oxygen is a necessary element for most all forms of life. As DO concentrations fall below 5.0 mg/L, aquatic life is put under stress. DO levels that remain below 1.0 – 2.0 mg/L for a few hours can result in large fish kills and loss of other aquatic life. Although some aquatic organisms require a minimum of 1.0 mg/L of DO to survive, the NYDEC State criteria for DO concentrations in surface waters is 5.0 mg/L or greater, for a healthy and diverse aquatic ecosystem.

The DO concentrations at Station 1 were all above 6 mg/L, which indicates that this station was well-oxygenated from surface to bottom and meets NYDEC criteria. In

addition, the DO concentration at the inlet was also above 5 mg/L. However, the DO concentration at 1.5 meters at Station 2 declined to 3.99 mg/L, indicating that some process is utilizing oxygen near the bottom. Since large amounts of aquatic plant material were observed near the bottom of Station 2, it is reasonable to assume that decomposition is probably responsible for the reduced DO at this station. Furthermore, the lowest DO concentration (1.67 mg/L) was observed at the outlet station on the southern side of the dam. The low DO concentration at this station is probably caused by anoxic bottom water leaking through the dam and is exacerbated by the low water flow during this time of year.

pH and Conductivity

The optimal range of pH for most freshwater organisms is between 6.0 and 9.0. For waterbodies such as Palmer Lake, the NYS DEC has set pH limits of no less than 6.5 and no higher than 8.5. During the September sampling event, the pH for all stations and all depths were within these limits.

Conductivity is a measurement of the ability of water to carry an electric current. However, it can also be used as a measurement of the amount of dissolved substances (i.e. nutrients, minerals, salts) in water. Therefore, the higher the conductivity, the more dissolved substances present in the water. Through the course of the sampling event for Palmer Lake, conductance values were moderately high for all four stations and varied between 0.388 mS/cm and 0.396 mS/cm.

Water Clarity (as measured with a Secchi disk)

Water clarity or transparency, as measured with a Secchi disk, was generally acceptable at all of the in-lake sampling stations for Palmer Lake. Based on Princeton Hydro's in-house long-term database of lakes in the Mid-Atlantic States, water clarity is considered acceptable for recreational activities when the Secchi depth is equal to or greater than 1.0 m (3.3 ft). The Secchi depth was 1.5 and 1.6 meters for in-lake Stations #1 and #2, respectively.

Palmer Lake Discrete Water Quality Data

In addition to the *in-situ* data described above, a set of samples were collected for the analyses of total phosphorus (TP) at Station 1 and at the inlet and outlet stations. At Station 1, samples for TP were collected at the surface and near the sediment. Inlet and outlet samples were also collected for the analysis of TP. In addition, a sample for chlorophyll *a* was collected near the surface at Station #1.

Total Phosphorus (TP)

Phosphorus has been identified as the primary limiting nutrient for algae and aquatic plants in most freshwater lakes. Essentially, a small increase in the phosphorus load will result in a substantial increase in algal and aquatic plant growth. For example, one pound of phosphorus can generate as much as 1,100 lbs of wet algae biomass. The NYS DEC recommends a guidance value of 0.02 mg/L for drinking waterbodies. This fact emphasizes the continued need to reduce the annual phosphorus load entering lakes and streams.

In addition, based on Princeton Hydro's in-house database on Mid-Atlantic lakes, TP concentrations equal to or greater than 0.06 mg/L will typically result in the development of algal blooms / mats that are perceived as a nuisance by the layperson. Moreover, the USEPA identifies a eutrophic threshold of 0.03 mg/L while the New Jersey DEP's nutrient limit for lakes is 0.05 mg/L.

During this sampling event, Palmer Lake experienced elevated TP concentrations. The surface sample at the in-lake Station #1 had a TP concentration of 0.028 mg/L, while inlet and outlet TP concentrations were 0.039 mg/L and 0.068 mg/L, respectively. All of these concentrations exceed the recommended NYS DEC guidance value of 0.02 mg/L. Moreover, the deep water TP concentration at Station #1 was 0.104 mg/l, far exceeding any threshold value for nuisance algae and plant growth. However, it should be noted that large amounts of nuisance plant growth, mostly the submerged plant coontail (*Ceratophyllum demersum*) near the bottom of the lake may have contributed to the high TP concentration at this station through their decomposition. In addition, the relatively low surface water TP concentrations are at least partially due to the lack of recent rainfall.

Chlorophyll a

Chlorophyll *a* is a pigment possessed by all algal groups and used in the process of photosynthesis. Its measurement is an excellent means of quantifying algal biomass. In general, an algal bloom is typically perceived as a problem by the layperson when chlorophyll *a* concentrations are equal to or greater than 30.0 mg/m^3. In Palmer Lake chlorophyll *a* was sampled at a depth of 0.5 meters at Station 1.

The chlorophyll *a* concentration recorded at Station 1 was 9.2 mg/m^3. While this value indicates that algal densities were not at nuisance levels, according to the Carlson Trophic State Index it nevertheless is considered mildly eutrophic. In addition, total phosphorus and Secchi depth measurements and Trophic State Index results also describe the lake as being mildly eutrophic.

Palmer Lake Biological Water Quality Data

Surface and mid-depth whole water samples were collected at sampling station #1 for the analysis of phytoplankton. The samples were preserved with Lugol's solution and transported to Princeton Hydro's biological laboratory. The phytoplankton was identified to the taxonomic level of genus and cell abundance and biomass were also calculated.

Surface and deep water samples were also collected for zooplankton (micro-animals that live in the open waters of a lake or pond; some larger-bodied zooplankton are herbivorous, feeding on algae) with a plankton net at the same station where phytoplankton were collected. Similar to the phytoplankton, the zooplankton samples were preserved with Lugol's solution and transported to Princeton Hydro's biological laboratory. The zooplankton was identified to the taxonomic level of genus and animal abundance and biomass were calculated.

Phytoplankton

The composition of the phytoplankton community varied with depth in Palmer Lake. The biomass of the deeper sample (1.5 m) was dominated by diatoms, particularly the filamentous diatom *Melosira,* while the abundance of phytoplankton was dominated by green algae. Although diatoms can give lake water a brownish appearance, they are not considered to be a nuisance. In addition, green algae can serve as a source of food for other organisms such as zooplankton and unlike filamentous green algae, are not considered a nuisance.

The composition of the phytoplankton at the surface of Station 1 was dominated by green algae both in numbers and biomass. Again, this type of green algae is beneficial as a food source and is not considered a nuisance. It should be noted that no blue-green algae were identified in either sample. Blue-green algae are the leading cause of surface scums, taste and odor problems and production of cyanobacterial toxins. The abundance of blue-green algae generally increases as phosphorus concentrations increase. Thus, increases in TP loads and in-lake TP concentrations commonly result in water quality problems in freshwater ecosystems.

Zooplankton

The zooplankton community was low in abundance and biomass compared to other productive lakes. The deeper (1.5 m) sample at Station 1 contained several herbivores such as the copepod *Diaptomus* and the cladoceran *Diaphanosoma*. Herbivores can serve as a natural means of controlling nuisance algal growths and are therefore beneficial. The surface sample contained few zooplankton which is not surprising as zooplankton migrate downward during the day to avoid fish predation.

Palmer Lake Aquatic Plant Community

Excessive densities of aquatic plants are one of the primary water quality concerns associated with Palmer Lake. Given the impact aquatic plants have on the water quality and recreational use of Palmer Lake, detailed field observations were made on the aquatic plant community during the September 2008 monitoring event.

By far, the dominant aquatic plant in Palmer Lake was coontail (*Ceratophyllum demersum)*. This native submerged plant dominated the biomass of Palmer Lake and was observed throughout the lake in nuisance densities. Although coontail is a native plant, it can still attain nuisance densities and interfere with recreational activities such as fishing and boating. The coontail grew in patches which covered the lake bottom and reached the surface in several places around the lake. Because coontail is not deeply rooted in the sediments, it was found floating throughout the lake and obtains most of its nutrient requirements from the water and not the sediments.

Several other plants also grew in nuisance densities which affect the recreational value of Palmer Lake. White Water Lilly (*Nymphaea odorata*), watershield (*Brasenia schreberi*), and duckweed (*Lemna minor*) are floating-leaved plants that were found in high densities around the lake. The duckweed covered the entire water surface near the dam while the white water lilies and watershield covered the shallow portions of the lake along its perimeter. Duckweed covered approximately 1-2 acres around the dam area.

Finally, it should be noted that while the Trophic State Index values for Secchi depth, total phosphorus and chlorophyll *a* all indicate that Palmer Lake is mildly eutrophic, the abundance of submerged and floating aquatic vegetation clearly indicate that the lake is eutrophic. As with most shallow waterbodies, the majority of the primary productivity is being realized in aquatic plants and not algae.

Conclusions

In summary, Palmer Lake is a eutrophic waterbody that has the potential, and periodically does, experience nuisance water quality conditions. These nuisance conditions are primarily excessive densities of aquatic plants, especially the species coontail (*Ceratophyllum demersum*). In fact, most of the primary productivity in Palmer Lake is contained within the biomass of submerged vegetation. Furthermore, since coontail obtains most of its nutrients from the water column, an increase in phosphorus loading is likely to increase nuisance densities of this plant and/or algae, particularly blue-green algae.

During the hot, dry conditions of late summer, surface water total phosphorus (TP) concentrations tend to be reduced by the settling of particulate material and the assimilation of this nutrient into algal / plant biomass. Although blue-green algae were not identified in Palmer Lake, these lowered TP concentrations may have limited their growth and occurrence in early September.

While blue-green algal blooms or surface scums were not experienced in Palmer Lake during the early September 2008 sampling event, an increase in its current phosphorus load would result in a higher probability of such conditions. According to Carlson's Trophic State Index, Palmer Lake is considered mildly eutrophic for chlorophyll *a*, total phosphorus (TP) and Secchi depth. An increase in TP loading to the surface waters of a eutrophic lake will increase the amount of algae as well as change the composition of the dominant algal group. For instance, as a eutrophic lake becomes more phosphorus enriched, it shifts from being phosphorus limited to being more nitrogen limited. Such a shift favors the growth of blue-green algae that can generate their own nitrogen through nitrogen fixation. Therefore, increased phosphorus loading is likely to cause an increase in blue-green algae which produce such undesirable effects as surface scums, taste and odor problems, and cyanobacterial toxins.

Palmer Lake In-situ Data 9/3/2008

Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(C°)	mS/cm	(mg/L)	(units)
In-Lake #1	1.8	1.5	Surface	25.27	0.394	6.9	7.75
			0.5	23.83	0.389	6.84	7.44
			1	23.46	0.389	6.6	7.6
			1.5	23.55	0.389	6.6	7.45
In-Lake #2	1.8	1.6	Surface	25.72	0.388	7.85	7.81
			0.5	23.85	0.388	7.98	7.77
			1	23.33	0.388	6.25	7.61
			1.5	23.06	0.388	3.99	7.43
Inlet	0.9	0.9	0.5	23.6	0.395	5.33	7.67
Outlet	0.4	0.4	0.2	20.42	0.396	1.67	7.32

Total Phosphorus for Palmer Lake for the 3 September 2008 Monitoring Event

Station	Total Phosphorus (mg/L)
#1 In-Lake (Surface)	0.028
#1 In-Lake (1.5m)	0.104
Inlet	0.039
Outlet	0.068