9 LAKE HIAWATHA

HISTORY

Lake Hiawatha was acquired by the Minneapolis Park & Recreation Board (MPRB) in 1923 at a cost of $555,000. Originally a shallow wetland called Rice Lake (because of the wild rice growing along its shores), Lake Hiawatha was renamed after Henry Wadsworth Longfellow's poem "Song of Hiawatha" in 1925.

Major changes were made to the shape and depth of Lake Hiawatha in the early part of the 20th century to make it more desirable to build and live near the lake. Over 1.25 million cubic yards of material were dredged and relocated beginning in 1929, with the fill being used to create the Hiawatha Golf Course that opened in 1934. Lake Hiawatha is part of the Lake Nokomis - Lake Hiawatha regional park which is currently the fifth most visited park in the State of Minnesota (Metropolitan Council, 2006).

Lake Hiawatha has an extremely large watershed due to the fact that Minnehaha Creek runs through the lake on its way to the Mississippi River. The watershed area changes depending on whether water is released at Gray's Bay dam from Lake Minnetonka into Minnehaha Creek. Figure 9A shows the bathymetric map of Lake Hiawatha. Table 9A shows the morphometric data of Lake Hiawatha. The watershed of the lake includes 115,840 acres and the large volume of runoff associated with this area (~97% of the water and ~88% of the phosphorus input to the lake) reduces the residence time of the water in the lake to an average of 11 days or less. The flushing time is short compared to most other lakes in Minneapolis that have residence times in the range of years (Table 18A). The limited amount of time the water spends in the lake affects the biology of the system. The most obvious effect is the generally less than expected level of algae in the water, based on the amount of phosphorus present. The converse of this occurs during seasons with low creek flow, increasing the residence time and allowing nuisance conditions of algae to develop.

The flow from the creek also has physical repercussions for Lake Hiawatha. Sediment in the water column, contributed by the creek, is higher than what is typically found in a lake. This decreases the water clarity in Hiawatha and contributes to sediment deltas. Additionally, the creek inflow can have a destabilizing effect on the thermal stratification of the lake during the summer months.

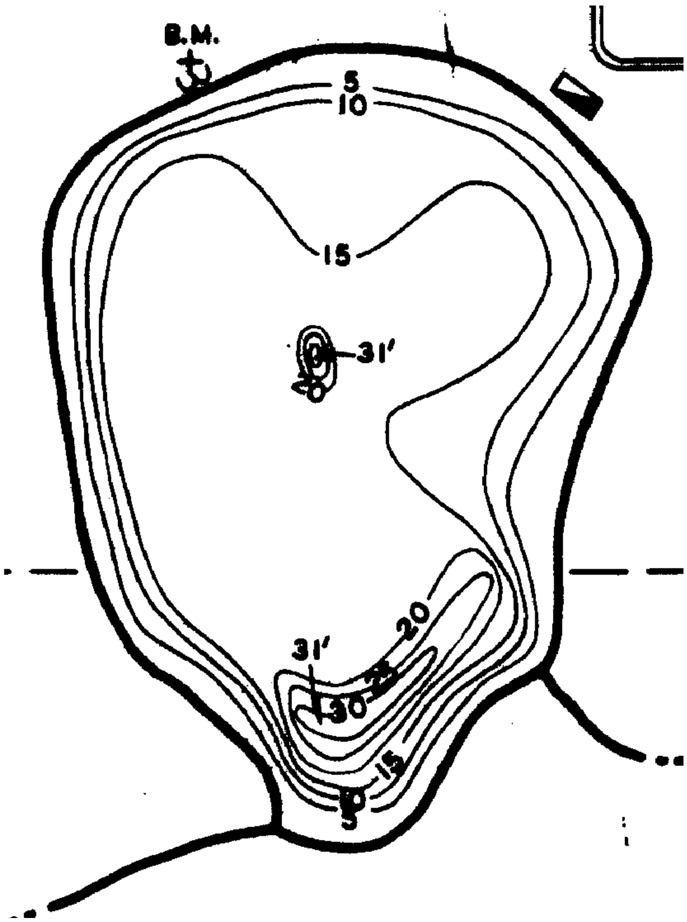

Figure 9A. Bathymetric map of Lake Hiawatha. Map courtesy of the Minnesota Department of Natural Resources (MDNR).

Table 9A. Lake Hiawatha morphometric data. *Littoral area defined as less than 15 feet deep

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
54	4.1	7.0	26%	8.95×10^5	115,840	2145	0.03

Lake Level

Lake levels for Lake Hiawatha are recorded weekly. The historical lake levels for Lake Hiawatha are shown in Figure 9B for the entire period of record. Mean sea level elevation can be calculated by adding the city datum (710.3 feet) to the elevations shown in Figure 9B. A significant bounce can be seen in Hiawatha lake levels due to the influence of Minnehaha Creek.

See Section 18 for a comparison between other MPRB lake levels.

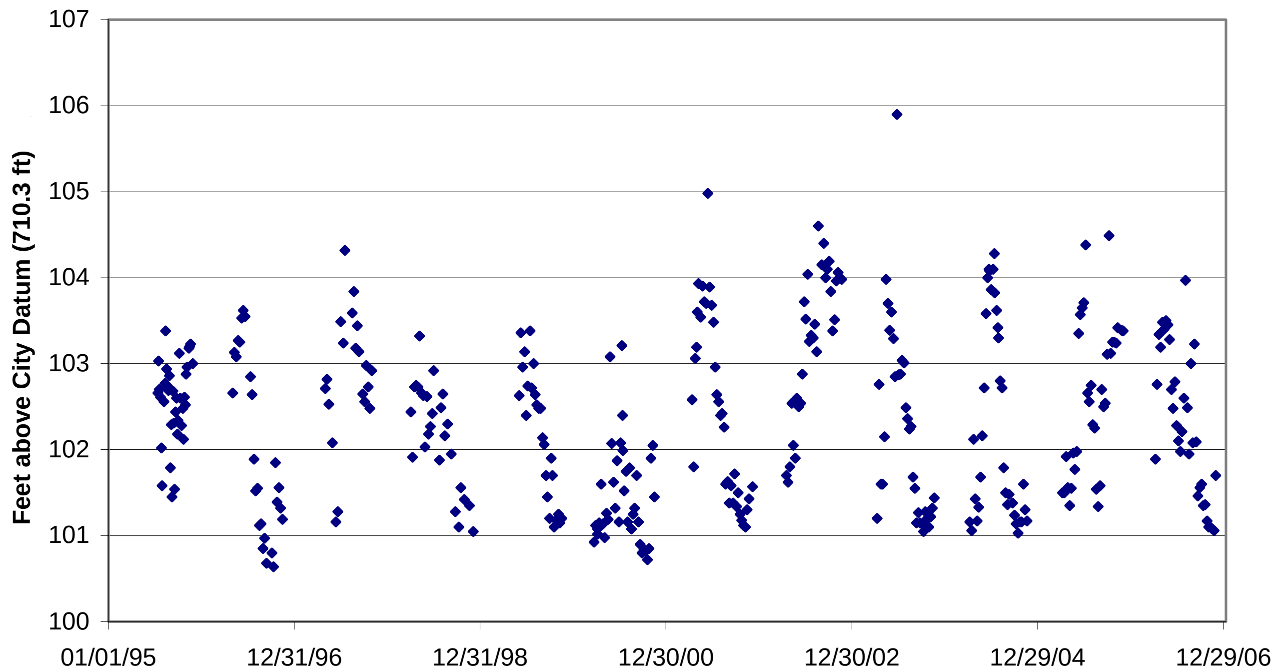

Figure 9B. Historical lake levels for Lake Hiawatha.

WATER QUALITY TRENDS (TSI)

Figure 9C shows the Lake Hiawatha linear regression to be stable as the TSI score remains relatively unchanged. A detailed explanation of TSI can be found in Section 1.

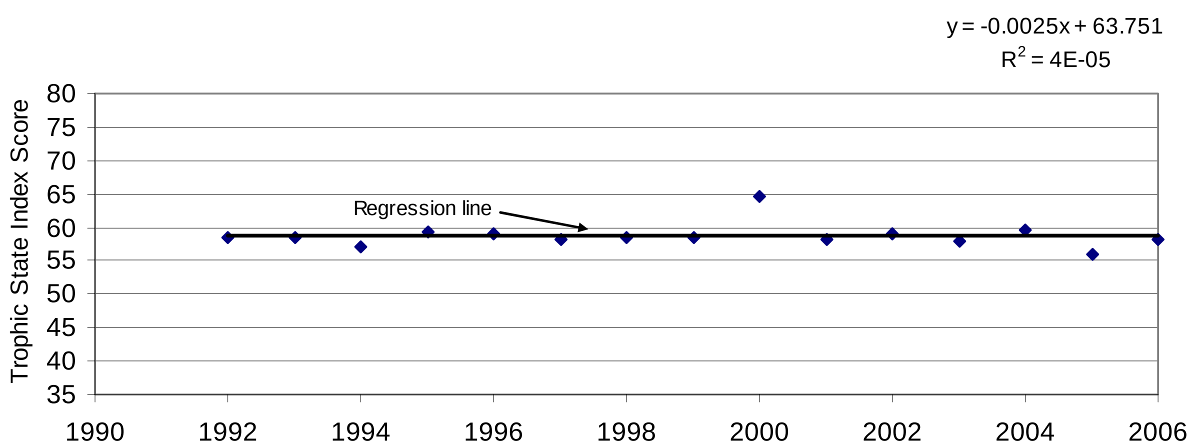

Figure 9C. Lake Hiawatha TSI scores and regression analysis.

The TSI score of Lake Hiawatha reflects the inputs from Minnehaha Creek. The 2006 score is in line with past years showing the strong influence of the creek. The only outlier in the TSI scores is the year 2000, which was a dry year. Water was not released from Lake Minnetonka and Minnehaha Creek went dry for parts of the year. Water quality decreased in the lake, which may be attributed to less flow from Lake Minnetonka. This may explain the significant TSI change in year 2000. Currently, Lake Hiawatha has a TSI score that is average for this ecoregion. It falls near the 50th percentile category for lakes in this ecoregion (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004).

Box and Whisker Plots

The box and whisker plots show in more detail the scatter within the years data set for the Secchi, chlorophyll-*a* and total phosphorus data. Long-term lake monitoring is necessary to evaluate the seasonal and year-to-year variations seen in each lake and predict trends. A detailed explanation of box and whisker plots can be found in Section 1. Figure 9D shows the box and whisker plots of the Lake Hiawatha TSI data.

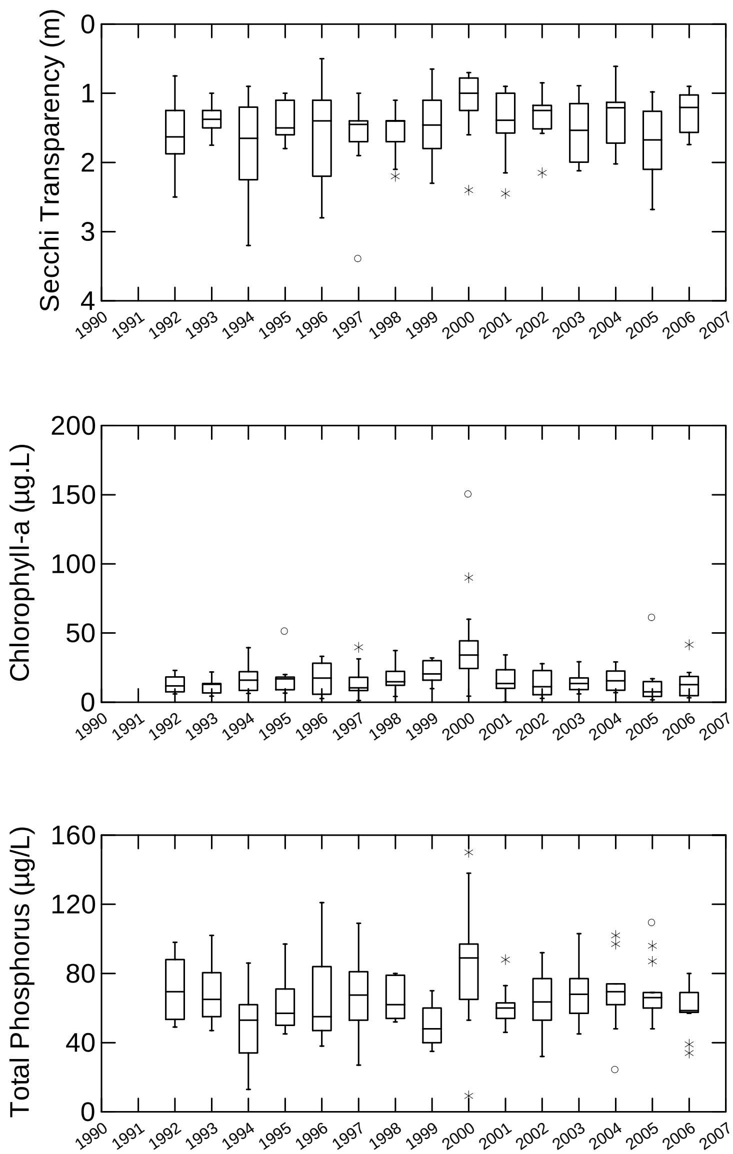

Figure 9D. Box and whisker plots of Lake Hiawatha TSI data.

2006 was an average year for Lake Hiawatha. The system is stable due to the short flushing times and influence of Minnehaha Creek. Changes in water quality or quantity in Minnehaha Creek influence Lake Hiawatha more than other lakes in the system.

BEACH MONITORING

The public beach on Lake Hiawatha was closed in 2004. This decision was made by the Board of Commissioners due to budgetary constraints and *E. coli* bacteria issues at the beach. Due to concern about this issue, monitoring was continued at this site. Further details on MPRB beach monitoring can be found in Section 19.

E. coli levels were sampled at one location on the east side of Lake Hiawatha. As can be seen from Table 9B, the season long geometric mean for *E. coli* was 104, the highest value out of all MPRB beaches. If the beach at Lake Hiawatha had been open for the 2006 season, it would have been closed five out of nine weeks. Figure 9E illustrates the box and whisker plot of *E. coli* sampling results (per 100 mL) for 2003 – 2006. The box and whisker plot shows in more detail the scatter, within the years, of the data set.

Table 9B. Summary of *E. coli* (per 100 mL) results for the site on Lake Hiawatha in 2006.

Statistical Calculation	Hiawatha Site
Minimum Value	15
Maximum Value	2300
Median Value	70
Geometric Mean	104
Standard Deviation	527
Number of Samples Taken	41

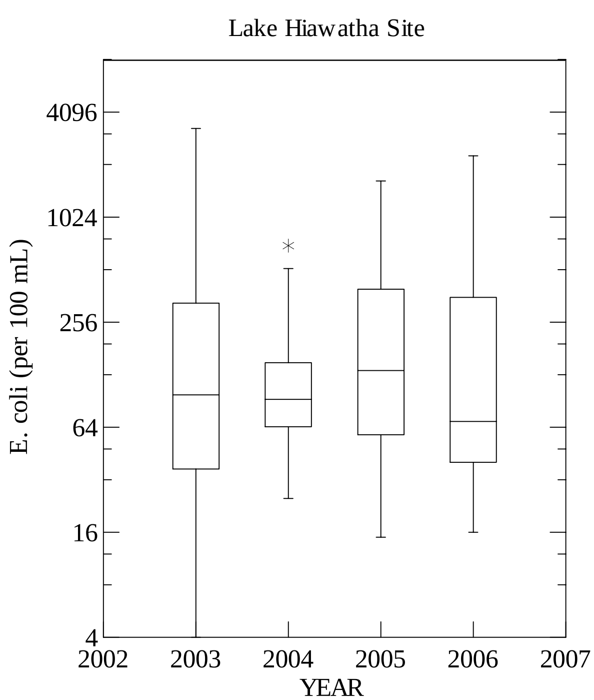

Figure 9E. Box and whisker plot of *E. coli* results (per 100 mL) for the Lake Hiawatha site, 2003 to 2006. Note the log scale on the Y-axis.

Figure 4F illustrates the 30-day geometric mean for *E. coli* values from 2003 – 2006 for the Lake Hiawatha site. According to the graph, higher 30-day geometric means can be seen during the month of June and decreases throughout the remainder of the beach season. A slight spike occurred in the beginning of August which may be attributable to rain and stormwater runoff because it rained a total of 3.88 inches on the 1st and 2nd of August. In 2006, the 30-day geometric mean was higher than in the year 2004, but lower than the geometric means in 2005 and 2003. The 30-day geometric means for 2004 were fairly and consistently low for most of the season. This was probably due to 2004 having a dry summer.

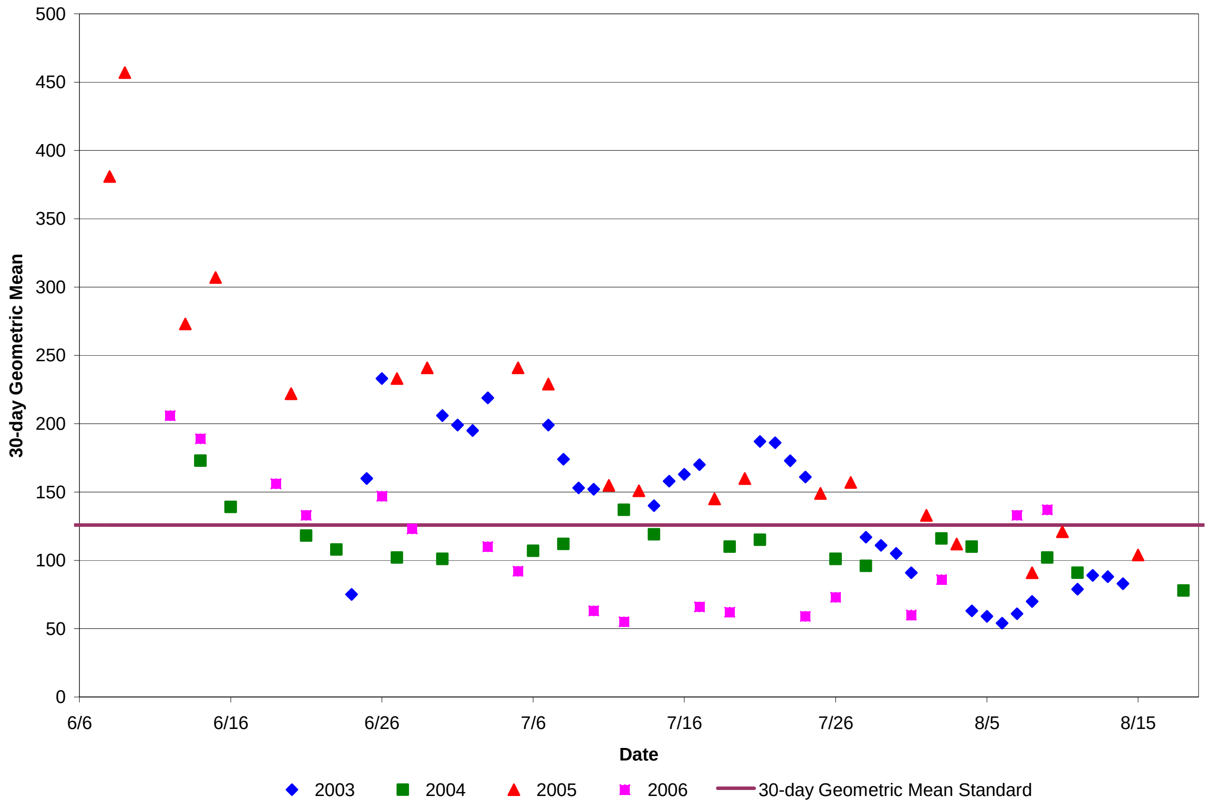

Figure 4F. Graph of 30-day geometric means for Lake Hiawatha site from 2003-2006. Note the 30-day geometric mean standard is 126 per 100 mL (solid line).

Table 9C shows *E. coli* correlations with selected variables at the Lake Hiawatha site. Very strong positive correlations exist with rainfall amount, rainfall duration and intensity, lake elevation and birds. Very strong negative correlation exists with dissolved oxygen, percent dissolved oxygen, pH and specific conductivity.

Table 9C. Selected correlations (r) between *E. coli* (per 100 mL) and select variables at the Lake Hiawatha site in 2006.

Variables	Lake Hiawatha Site
Birds	0.466
Dissolved Oxygen	-0.557
Lake Elevation	0.929
Percent Dissolved Oxygen	-0.519
pH	-0.624
Rainfall	0.888
Rainfall Duration	0.818
Rainfall Intensity	0.906
Specific Conductivity	-0.784

In an effort to ascertain the nature of the bacterial contamination at the Lake Hiawatha beach site, two samples were collected on September 12, 2006 and shipped on ice to Source Molecular Corporation in Miami, FL. Concurrently, two samples were collected for *E. coli* determination and taken to the City of Minneapolis Public Health Lab. There was 0.01 inches of rain in the preceding 24 hours before sample collection. The *E. coli* results were 145 colonies per 100 mL and the *Enterococci* results were 148 colonies per 100 mL. Two analytical schemes were completed by Source Molecular Corporation on the samples. The Human *Enterococcus* "Quantification" ID™ involves the detection and quantification of the *Enterococcus faecium* human gene biomarker for human fecal contamination by real-time Quantitative Polymerase Chain Reaction (qPCR) DNA analytical technology. Both samples gave the same results, the human biomarker was below detection and the analytical results were negative. The Human *Bacteroidetes* "Quantification" ID™ involves the detection and quantification of the fecal *Bacteroidetes* human gene biomarker for human fecal contamination by real-time Quantitative Polymerase Chain Reaction (qPCR) DNA analytical technology. Both samples were below detection for the human fecal *Bacteroidetes*, however, one sample had a faint band in the internal quality control while the other sample did not and was negative. This may indicate a trace amount of residual human fecal pollution. But the overall results point to animal sources of pollution as the bacterial contamination at the Lake Hiawatha beach site.

DNA source tracking of bacterial issues is very expensive. This effort, even though the results were slightly ambiguous, tells us that the bacteria levels we are seeing at the beach site are most likely not due to leaking sanitary sewer lines and that non-point sources are the most probable sources.

Lake Aesthetic and User Recreation Index (LAURI)

The LAURI for Lake Hiawatha is shown in Figure 9G. Lake Hiawatha scored "excellent" in aesthetics and in aquatic plant growth and "good" in water clarity. Lake Hiawatha does not have a swimming beach and was not scored for public health. Details on LAURI can be found in Section 1.

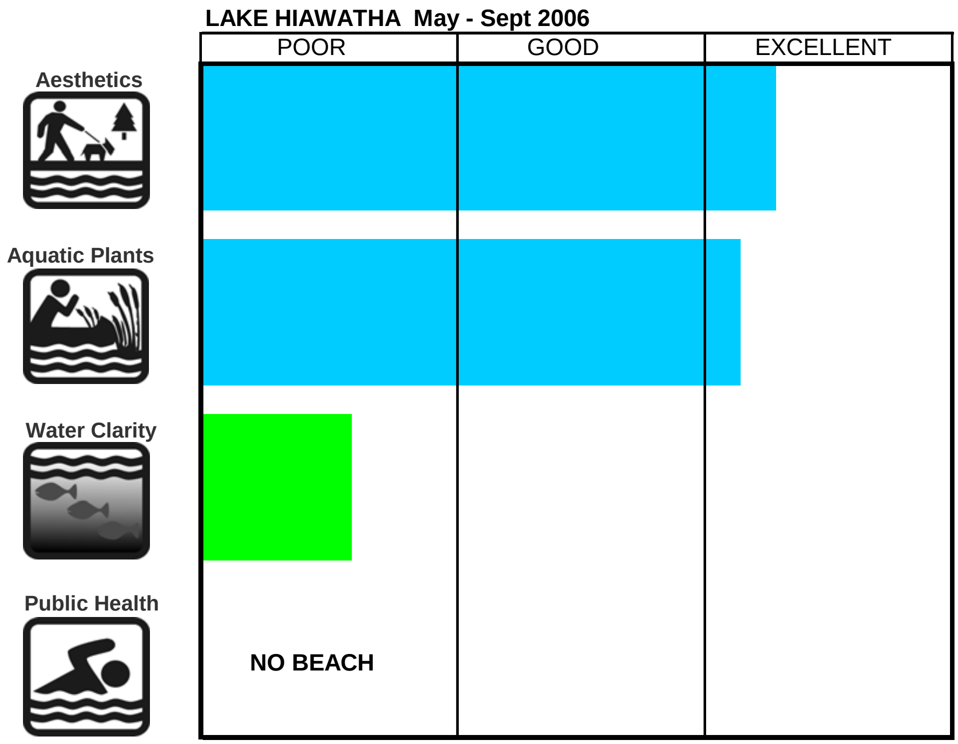

Figure 9G. The 2006 LAURI for Lake Hiawatha.

WINTER ICE COVER

Ice came off Lake Hiawatha on April 6, 2006, which is the average and median date. Ice was not on the lake for the winter until Jan 31, 2007. This is the latest date of ice on ever recorded for Lake Hiawatha or for any other MPRB lake. See Section 1 for details on winter ice cover records and Section 18 for a comparison with other lakes.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the basic food web of lake ecology. The greenness of a lake is measured by chlorophyll-*a* (chl-*a*) as an expression of the phytoplankton present. Figures 9D and 9E show the phytoplankton and chlorophyll-a data, respectively. The relative abundance of phytoplankton refers to the total (division) community. During the 2006 monitoring period the phytoplankton community had several shifts of dominance. Unlike the other lakes in the system, bacillariophyta (diatoms) dominated in Lake Hiawatha during the majority of the sampling season. The phytoplankton community may change quickly as the residence time in Lake Hiawatha is roughly 11 days, due to the effect of Minnehaha Creek, which flows through Lake Hiawatha. During 2006, the highest recorded chl-*a* value was approximately 42 µg/L (Figure I). Pyrrhophyta (dinoflagellates), cyanophyta (blue-green algae), and chlorophyta (green algae) had peaked about two weeks prior to the chl-*a* peak, and bacillariophyta (diatoms) were dominant during the chl-*a* peak. It is likely that the chl-*a* concentration reflects a combination of both the productivity in Lake Hiawatha and in Minnehaha Creek. Figure 9F shows the zooplankton distribution for the 2006 sampling season. Rotifers dominated in the May sample and arthropods were more prevalent for the rest of the collection period. Zooplankton numbers throughout the sampling season were comparatively higher than in the larger lakes. This may be due to the prevalence of diatoms and green algae throughout the growing season, since these species are more easily eaten by zooplankton, and are more nutritious.

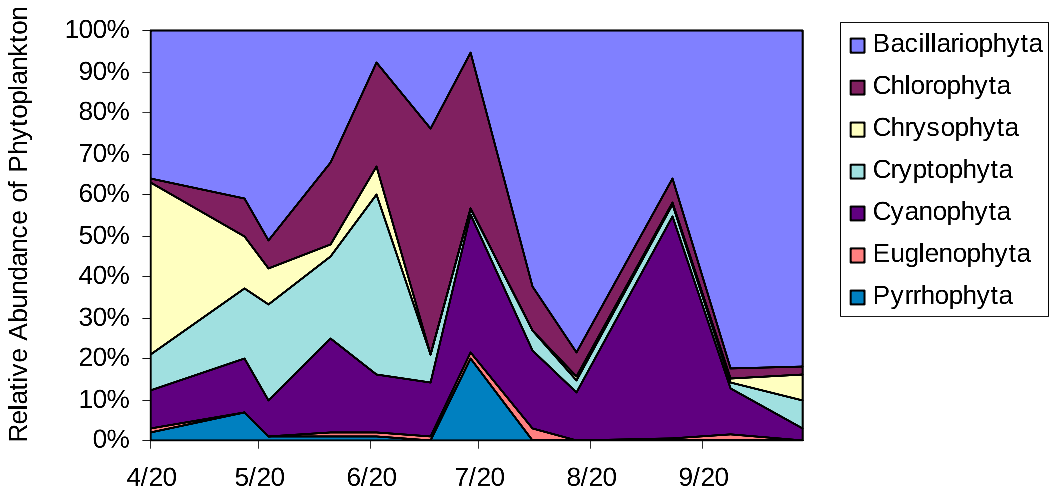

Figure 9H. Lake Hiawatha 2006 relative abundance of phytoplankton divisions.

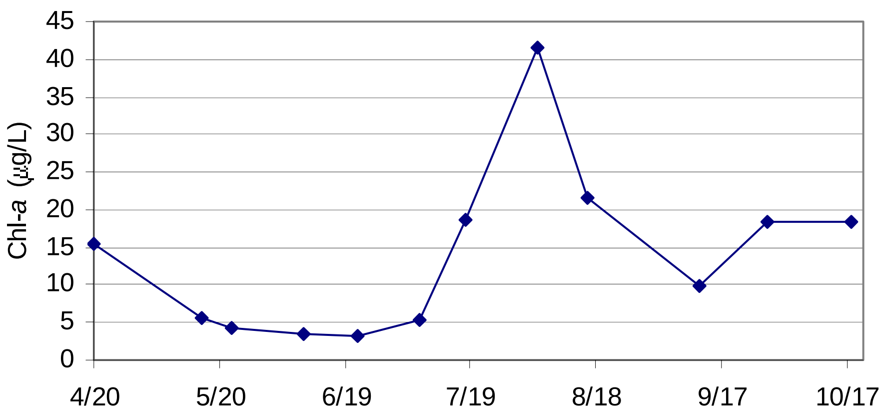

Figure 9I. Lake Hiawatha chlorophyll-*a* data from the 2006 sampling season.

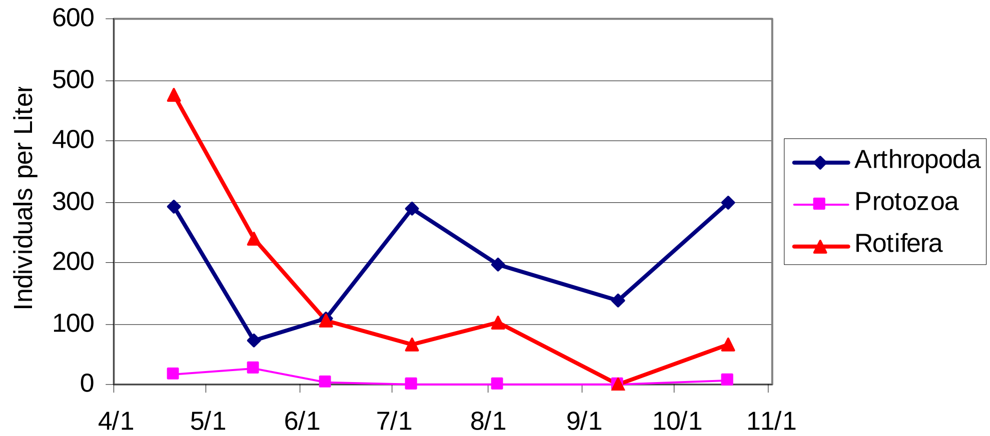

Figure 9J. Lake Hiawatha zooplankton distribution during the 2006 sampling season.