2011 Baseline Water Quality Monitoring and Assessment of Pemaquid Pond

At the request of the Pemaquid Watershed Association, LWRMA conducted baseline sampling of Pemaquid Pond in August, 2011. The purpose of this project was to gather lake water quality data for the pond to evaluate present conditions, and to compare the information with historical data for the waterbody.

In addition to the samples and readings that we collected on August 18, water clarity data were gathered throughout the summer by certified volunteer lake monitor Mike Cahill, who has been trained to collect lake data by the Maine Volunteer Lake Monitoring Program. The volunteer data have been included in our analysis. Data obtained in 2011 were also compared to similar results from several hundred lakes throughout Maine that were sampled during the same period.

The primary focus of sampling Pemaquid Pond was to obtain water quality information that reflects the extent to which development pressures in the watershed may be influencing the lake system. Watershed development is generally considered to be the most pervasive threat to the health of Maine's lakes and ponds.

The primary effect of watershed development on lakes and ponds is increasing biological productivity, caused by the inflow of the nutrient phosphorus in stormwater runoff from areas that have been altered from their naturally occurring state. Phosphorus stimulates the growth of algae, which in turn reduces water clarity. Water clarity has consistently been identified in public surveys as the most valued attribute of lakes and ponds. Shorefront property values have been strongly linked to the clarity of Maine lakes.

Over time, excess algal growth can also result in a decline in oxygen levels in lake water during the warm summer months. Oxygen loss can stress the fishery, especially coldwater (salmonid) species. According to the Maine Department of Inland Fisheries and Wildlife, Pemaquid Pond supports, and is managed for both warm and coldwater fish. However, recent late summer temperature and dissolved oxygen profiles for the lake, including the profiles that we took on August 18, 2011, for sampling stations 01 and 02, indicate that there is very little habitat available for coldwater fish during the late summer due to oxygen depletion in a significant percentage of the water column.

Baseline sampling was conducted on two historically determined sampling stations on Pemaquid Pond, designated 01 and 02. Sample station 01 is the deepest point in the lake basin; sample station 02 is situated in a somewhat shallower area of the lake to the north of the deep station. Lake water quality indicators monitored included a measurement of water transparency (an indirect indication of the amount of algae in the water) at the deepest point in the pond. Samples were also collected to determine the concentration of the nutrient phosphorus, and the plant pigment chlorophyll-a, in order to determine the potential for algae growth, as well as the actual concentration of algae at the time of sampling. Surface to bottom profiles were taken for water temperature and dissolved oxygen. The natural color of the water was measured as well as the pH, and the alkalinity (a measure of the capacity of the water to resist, or buffer a change in pH).

Indicators of lake water quality vary considerably from season to season and year to year, and baseline sampling represents a "snapshot" of conditions in the lake at the exact time that samples and readings were taken. The natural variability of lake ecosystems creates a significant challenge to interpreting lake data, and to identifying actual changes (trends) in the condition of individual lakes and ponds.

Sampling Results for Pemaquid Pond:

Station 01: Monitoring took place at the deepest point in the pond, where the water depth measured 18.0 meters (~59 feet). At that time, water clarity measured 5.2 meters (~17 feet) in depth. Additional readings, taken by the volunteer lake monitor during the season, averaged 4.7 meters, ranging from a low reading of 4.1, to a high of 5.7 meters over a period of four months. The historical average for station 01 is 4.8 meters, over a period of 36 years. During that period, readings as low as 3.1 meters, and as high as 7.7 meters have been recorded. A fair amount of seasonal and annual variability in water clarity has been documented for Pemaquid Pond, with annual water clarity averages varying as much as 2 meters during nearly four decade monitoring period. On the whole, the clarity of the water in Pemaquid Pond is about average for Maine lakes.

A total phosphorus sample taken from the lake surface to a depth of 5.5 meters (integrated core) measured 7 parts per billion (ppb). The next most recent sample, taken in 2010, measured 10 ppb, and one taken in 2008 measured 8 ppb. The historical average for station 01, which is based on 11 samples over the long term monitoring period, is 9 ppb. Phosphorus samples have ranged from 6-17 ppb during the period. The 2011 sample was one of the two lowest concentrations measured during the historical monitoring period.

Based on the very low concentrations of dissolved oxygen measured in the deep area of the water column at station 01, two additional samples were taken at deeper points in the water column to determine if phosphorus was being released from the bottom sediments and being "recycled" to the surface. A sample taken at 11 meters depth measured 9 ppb, only slightly higher than the core sample closer to the surface. However, a phosphorus sample taken at 17 meters (one meter from the bottom) measured 33 ppb, indicating that

the low oxygen conditions measured in the deepest area of the lake is likely causing the release of phosphorus from the sediments. There was no indication on August 18 that phosphorus from the bottom sediments was being entrained to the surface by internal lake currents. However, the depth profile for Pemaquid Pond is such that this phenomenon could occur under certain circumstances. The potential for this to occur in Pemaquid Pond is moderate to high, which raises the risk for the lake to experience a significant increase in algal growth over time.

Chlorophyll-a (CHL), measured 4.4 ppb on August 18, compared to 4.3 ppb in 2010, and 5.1 ppb in 2008. The long-term average for station 01, based on 9 historical samples taken during the past 36 years, is 4.2 ppb. The 2011 CHL sample was somewhat consistent with the phosphorus sample value that was taken on the same day. With so few historical samples, it is difficult to determine whether or not CHL levels may be increasing in the lake. However, the 2011 "snapshot" was close to the historical average.

The temperature and dissolved oxygen profile taken from the surface to the bottom of the lake at 18.0 meters depth showed a severe loss of dissolved oxygen from a depth of 8 meters to the bottom of the pond. The 2011 temperature and dissolved oxygen profiles were similar to historical profiles taken at approximately the same time of year. The loss of oxygen in Pemaquid (01) during the late summer is somewhat in contrast with average water clarity and relatively low concentrations of phosphorus and chlorophyll. However, changes in late summer dissolved oxygen concentrations in lakes and ponds may precede more directly observable changes, such as water clarity. The loss of oxygen in Pemaquid Pond may be causing the release of phosphorus from the bottom sediments, which, under certain weather conditions, could stimulate algae growth in the lake, causing a downward trend in water quality.

The level of natural water color measured 32 (standard platinum-cobalt units) SPU, compared to the historical average for the lake of 26 SPU. The moderate level of water color in Pemaquid is caused by the leaching of humic acids from vegetation in surrounding wetlands, and it may, at times, be high enough to affect water clarity readings, as well as phosphorus concentrations. Color can be a significant natural influence on a number of indicators of lake water quality, and should be considered in the analysis of lake data.

The August 18 pH sample measured 6.7, compared to the historical average of 6.7. Total alkalinity measured 7.0 mg/l, compared to the historical average of 7.3. Both are within the range of values that are typical for Maine lakes and ponds. However, alkalinity values for Pemaquid are on the low end of normal for Maine lakes, indicating that the pH of the water is marginally buffered against a downward shift in pH. The moderate natural color component of the water may be an influence on alkalinity levels in Pemaquid.

Station 02: Monitoring took place at the deepest point in the north end of the pond, situated close to the public boat landing on Route 1, where the water depth measured 13.0 meters (~42 feet). At that time, water clarity measured 4.7 meters (~15 feet) in depth.

Additional readings, taken by the volunteer lake monitor during the season, averaged 4.2 meters, ranging from a low reading of 3.2, to a high of 4.7 meters over a period of four months. The historical average for station 02 is also 4.2 meters, over a period of 30 years. During that period, readings as low as 2.6 meters, and as high as 6.5 meters have been recorded. A fair amount of seasonal and annual variability in water clarity has been documented for Pemaquid Pond at station 02, but somewhat less than at station 01. On the whole, the clarity of the water in Pemaquid Pond at station 02 is slightly below average for Maine lakes.

A total phosphorus sample taken from the lake surface to a depth of 4.5 meters (integrated core) measured 11 parts per billion (ppb). The next most recent sample, taken in 2000, also measured 11 ppb. The historical average for station 02, which is based on only 5 samples over the long term monitoring period, is 12 ppb. Phosphorus samples have ranged from 9-14 ppb during the period. The average phosphorus concentration at station 02 is higher than at station 01, possibly due to a number of factors, including the flushing rate of the two locations, the difference in depth, and the watershed for each.

Based on the very low concentrations of dissolved oxygen measured in the deep area of the water column at station 01, an additional sample was taken at a deeper point in the water column to determine if phosphorus was being released from the bottom sediments and being "recycled" to the surface. A sample taken at 12 meters depth measured 92 ppb, very substantially higher than the core sample closer to the surface, suggesting that the low oxygen conditions measured in the water column is likely causing the release of phosphorus from the sediments. There was no indication on August 18 that phosphorus from the bottom sediments was being entrained to the surface by internal lake currents. However, the depth profile for Pemaquid Pond at station 02 is such that this phenomenon could occur under certain circumstances. The potential for this to occur in Pemaquid Pond at station 02 is moderate to high, which raises the risk for the lake to experience a significant increase in algal growth over time, including the possibility of a nuisance algal bloom.

Chlorophyll-a (CHL), measured 4.1 ppb on August 18, compared to 5.2 ppb in 2000, and 5.8 ppb in 1999. The long-term average for station 01, based on 9 historical samples taken during the past 30 years, is 4.6 ppb – somewhat higher than at station 01. The 2011 CHL sample was somewhat consistent with the phosphorus sample value that was taken on the same day. With so few historical samples, it is difficult to determine whether or not CHL levels may be increasing in the lake. However, the 2011 "snapshot" was close to (slightly lower than) the historical average.

The temperature and dissolved oxygen profile taken from the surface to the bottom of the lake at 13.0 meters depth showed a severe loss of dissolved oxygen from a depth of 6 meters to the bottom of the pond. The 2011 temperature and dissolved oxygen profiles were similar to historical profiles taken at approximately the same time of year. The loss of oxygen in Pemaquid (02) during the late summer is somewhat in contrast with average water clarity and relatively low concentrations of phosphorus and chlorophyll. However, changes in late summer dissolved oxygen concentrations in lakes and ponds may precede

more directly observable changes, such as water clarity. The loss of oxygen in Pemaquid Pond may be causing the release of phosphorus from the bottom sediments, which, under certain weather conditions, could stimulate algae growth in the lake, causing a downward trend in water quality.

The level of natural water color measured 22 (standard platinum-cobalt units) SPU, compared to the historical average for the station of 23 SPU. The moderate level of water color in Pemaquid is caused by the leaching of humic acids from vegetation in surrounding wetlands, and it may, at times, be high enough to affect water clarity readings, as well as phosphorus concentrations. Color can be a significant natural influence on a number of indicators of lake water quality, and should be considered in the analysis of lake data.

The August 18 pH sample measured 6.7, compared to the historical average of 6.7. Total alkalinity measured 7.0 mg/l, compared to the historical average of 7.3. Both are within the range of values that are typical for Maine lakes and ponds. However, alkalinity values for Pemaquid are on the low end of normal for Maine lakes, indicating that the pH of the water is marginally buffered against a downward shift in pH. The moderate natural color component of the water may be an influence on alkalinity levels in Pemaquid.

Summary

All lake water quality indicators measured at stations 01 and 02 in Pemaquid Pond were close to historical averages in 2011. Overall, the lake experienced an average to slightly above average year, based on comparisons to historical data for the lake.

Based on historical data for several hundred Maine lakes, Pemaquid Pond is average, in terms of water clarity, the concentration of the nutrient phosphorus and the amount of algae in the water. However, the extreme loss of oxygen during late summer should serve as a warning that the pond is sensitive, and could experience a relatively rapid decline under certain conditions, characterized by a substantial increase in the growth of algae and reduced water clarity. The use of watershed conservation practices to protect the pond from additional phosphorus and sediment in stormwater runoff from developed areas can reduce the potential for a negative change over time.

Attached to this report is a summary of the findings for several hundred lakes that were monitored throughout Maine in 2011. This information is provided to help put the results of the monitoring of Pemaquid Pond in perspective. The information shows that overall, Maine lakes were slightly less clear in 2011, compared to the previous year, but were approximately average, compared to the long-term data for all Maine lakes.