The Lakes of Sammamish

A Report on Water Quality Monitoring Results for Water Year 2010 at Pine and Beaver Lakes

Pine Lake

Prepared for the City of Sammamish
by the King County Lake Stewardship Program

February 28, 2011

King County

OVERVIEW

The King County Lake Stewardship Program and its predecessor programs have worked with volunteer monitors for more than 18 years on Pine Lake and the two basins of Beaver Lake within the city of Sammamish. The water quality data indicate that in general, Pine Lake and Beaver-2 are low to moderate in primary productivity with good water quality, while Beaver-1 has been and continues to be highly productive, indicative of the input from the nearby wetland that constitutes its major surface water source.

Both Beaver Lake and Pine Lake have public access boat launches and parks with beach front, where members of the public are able to access the lake. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae that could be produced in the lake. A second measure is the nitrogen-to-phosphorus ratio (N:P), which is used to predict what groups of algae may become dominant in the lake during certain periods. Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The discussion in this report focuses on the 2010 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Or can be provided in the form of Excel files upon request.

BEAVER LAKE

In the mid-nineties, residents at both basins of Beaver Lake (Figure 1: smaller north basin referred to as Beaver-1 and large main basin referred to as Beaver-2) began monitoring water quality through participation in the King County Lake Stewardship Program (KCLSP). Volunteer monitoring efforts continued through 2010. Physical and chemical data collected through many years of monitoring suggest that this lake in the city of Sammamish is moderate (Beaver-2) to high (Beaver-1) in primary productivity (mesotrophic-eutrophic), with good to fair water quality.

Figure 1. Aerial photo of Beaver Lake showing both monitored basins. A third small basin that contains the outlet is located in the bottom left of the figure

Physical Parameters

Excellent precipitation and water level records for the main basin (Beaver-2) were compiled for the 2010 water year. Water levels in Beaver Lake increased in response to high winter storm events, but the outlet allowed water to drain quickly from the lake until spring, when levels rose dramatically during June and stayed high (Figure 2). It was determined that beaver activities in the park were responsible and city staff dismantled the dam, allowing water levels to recede by early July. After that, the water level dropped slowly through the summer and early fall, similar

to the pattern established in previous years and characteristic of the regional pattern of winter high–autumn low stands. Precipitation and lake level data show the lake does rise with the onset of autumn rains and remains elevated through the winter and into spring. However, the highest lake levels don't usually persist longer than a few days to a week when the outlet is flowing freely.

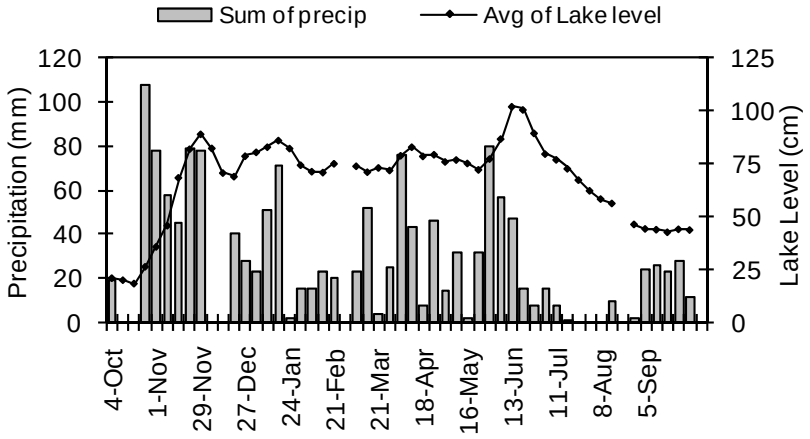

Figure 2. WY 2010 Beaver-2 Lake Level and Precipitation

Residents on Beaver-1 did not collect daily precipitation or lake level information, but the channel between the two lakes rarely shows any perceptible flow between the water bodies. Continuous lake level measurements made by the King County hydrology group for the Beaver Lake Management District have shown that water levels are generally equivalent between the two basins.

Beaver-2 "Level I" volunteers collected weekly temperature and Secchi transparency data throughout the year in 2010 (Figure 3). A different "Level II" volunteer collected water samples for laboratory analyses from early May through late October, and at the same time made temperature and Secchi measurements. Secchi transparency measured by the Level I volunteer ranged between 1.2 m and 2.4 m, with an annual average of 2.1 m, and a summer average of 2.2 m. The data from the Level II volunteer, measuring from May through October only, ranged from 2.3 to 3.2 m, with a summer average of 2.6 m.

Observers can vary in how they read the endpoint of the Secchi test, depending on their ability to differentiate subtle changes and how their vision reacts to glare off the water surface, the type of boat they are using, and how close to the water surface they can safely view the disk. Therefore, it is not surprising that there is a small systematic difference between the two observers, which even occurs among professionally trained field crews. It is important to be consistent in examining one observer's measurements over time and, if at all possible, to calibrate differences by collecting concurrent measurements between observers for comparison.

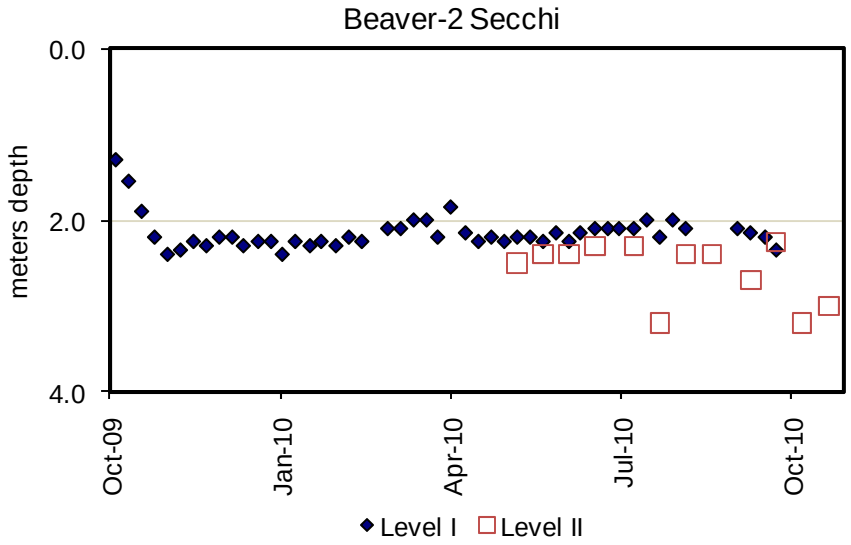

Figure 3. 2010 Beaver-2 Lake Secchi Transparency

Surface water temperatures ranged between 3.5 to 24.0 degrees Celsius over 2010 with an annual average of 12.4 and a summer average of 18.3 degrees Celsius (Figure 4). The recorded maximum temperature was in the midrange of values reported among the group of monitored lakes.

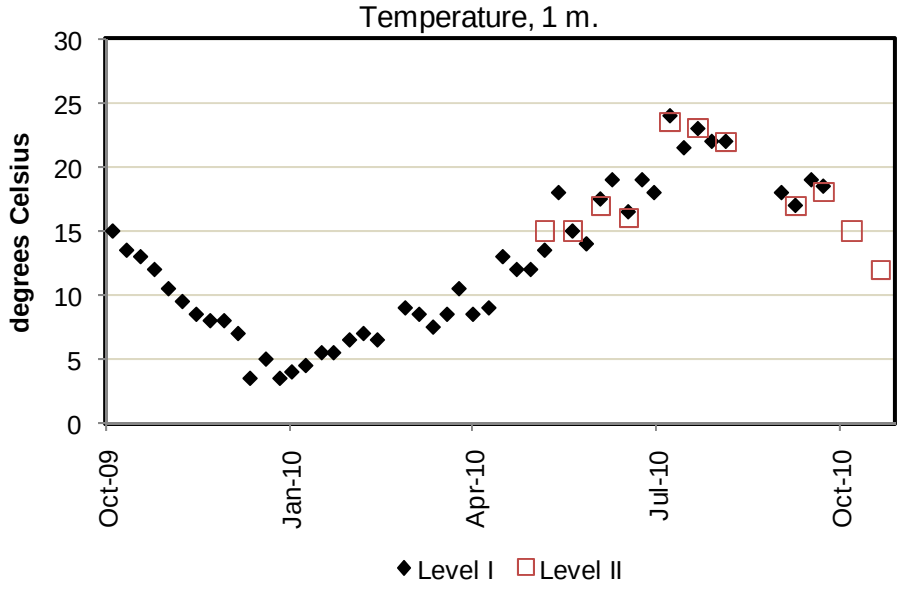

Figure 4. 2010 Beaver-2 Lake Water Temperatures

The north basin (Beaver-1) was monitored for Secchi transparency and water temperature during the Level II monitoring season from early May to the end of October 2010. Transparency ranged from 0.6 m to 1.5 m with an average of 1.3 m (Figure 5). Beaver-1 is at the lower end of clarity for the lakes monitored by the KCLSP in 2010, due to the tea-colored water coming from wetland ELS 21 that drains directly into the basin.

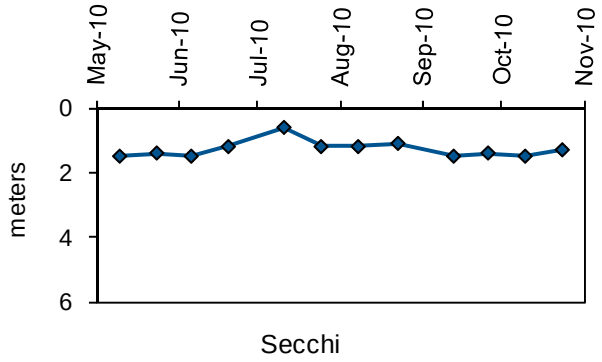

Figure 5. 2010 Beaver-1 Secchi Transparency

Temperatures for Beaver-1 ranged from 12.0 degrees Celsius to 24.0 degrees Celsius with an average of 17.4 (Figure 6) that ranks the north basin of Beaver Lake as one of the cooler lakes measured for the 2010 water year.

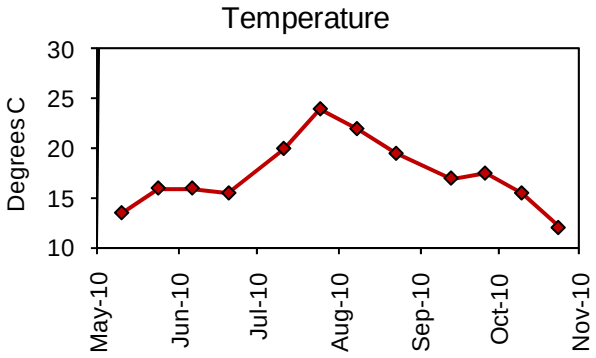

Figure 6. 2010 Beaver-1 Lake Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms–a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

During the monitoring period for Beaver-2, TN values were relatively stable with small fluctuations through the season. TP was highest in the mid-June sampling event and was relatively stable throughout the rest of the season (Figure 7).

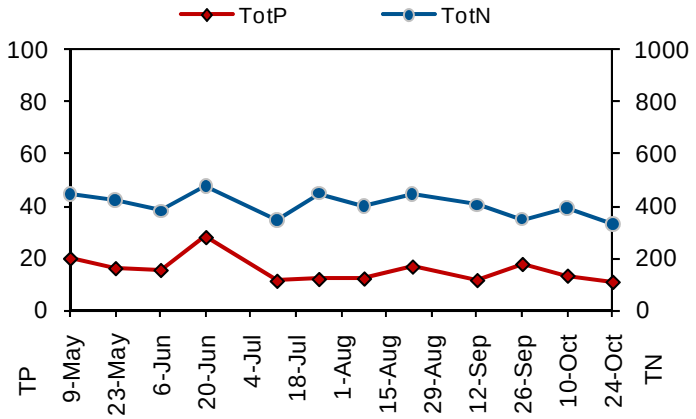

Figure 7. 2010 Beaver-2 Total Phosphorus and Total Nitrogen Concentrations

Beaver-1 had much higher levels overall of both TP and TN. TN had a major spike in early July that was echoed subtly in the TP, after which both declined. A slight increase in the fall was observed for both parameters (Figure 8).

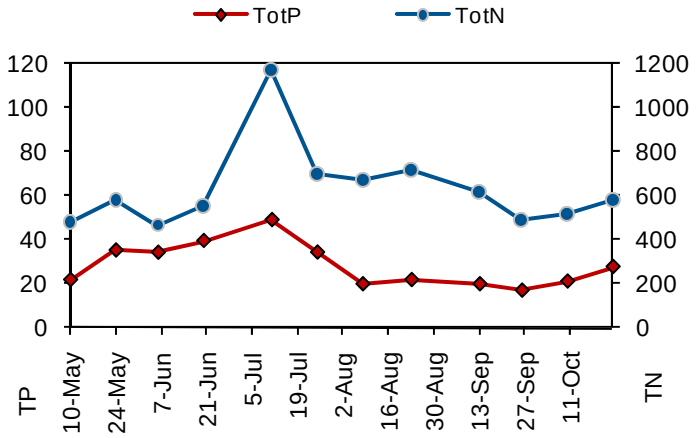

Figure 8. 2010 Beaver-1 Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen to phosphorus (N:P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air.

In Beaver-2, total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 17 to 37 with an average of 27, which suggests that conditions in the lake were generally not favorable for nuisance bluegreen growth. Beaver-1 ranged from 14 to 34 with an average of 24. There were three low values consecutively

in May and June in Beaver-1, which suggested that there were times in the spring when conditions were favorable for nuisance bluegreen algae growth.

Chlorophyll concentrations relate to the amount of algae present in lake water. All algae must have chlorophyll in order to fix energy from sunlight, so higher amounts of chlorophyll denote more abundant algae. However, some of the cyanobacteria (bluegreen algae) also use other pigments to capture light, so their relative amounts of chlorophyll may be smaller than for other groups of algae. Pheophytin is a degradation product of chlorophyll, and large amounts present in a sample can indicate that the presence of sediment or other sources of old chlorophyll in addition to that contained in vibrant, living algae. Some of these sources include wind and rain storms, sediment disturbance, bank erosion, or wash-in from watershed activities.

Chlorophyll *a* concentrations in Beaver-2 seesawed between low and moderate levels throughout the season, with an overall increase toward late summer and fall. Pheophytin (degraded chlorophyll) levels were above detection levels, but remained low with the exception of one date in June (Figure 9).

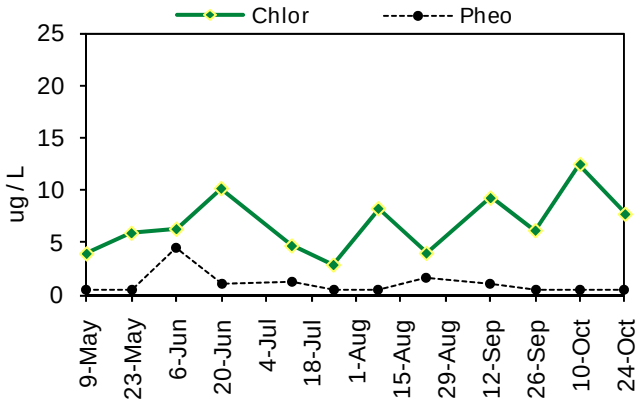

Figure 9. WY 2010 Beaver-2 Chlorophyll *a* and Pheophytin concentrations

In Beaver-1 chlorophyll *a* concentrations were moderate with one very high peak in early July that was not sustained in the following sample, which may have been caused by a large algal colony or clump of plant material getting into the sample (Figure 10). Chlorophyll also increased again in the fall. The majority of the pheophytin levels were below detection levels throughout the period.

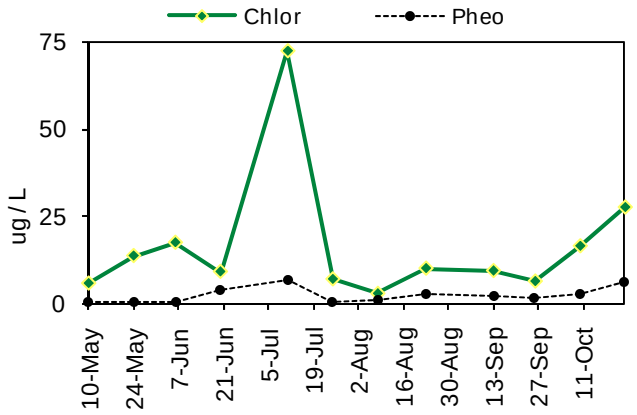

Figure 10. WY 2010 Beaver-1 Chlorophyll *a* and Pheophytin concentrations

Profile data on Beaver-2 indicates that thermal stratification was present from early summer and likely persisted through late summer, although the thermometer failed during the second profile event. Higher concentrations of total phosphorus were found in deep water in May, suggesting that anoxia could have triggered a release of phosphorus from the sediments as shown by the OPO4 values. However, these high values did not persist through the summer, as phosphorus did not appear to be particularly elevated in the deep water by the end of August. Ammonia concentrations, which are another indicator of low oxygen conditions in the deep water, were not very high on either date and did not support hypoxia development over the summer in the hypolimnion (Table 1).

Table 1. 2010 Beaver-2 Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Beaver-2	5/23/10	2.4	1	15.0	5.9	<MDL	0.424	0.016	0.0162	<MDL	0.233	13.7
			7	9.0	3.0	1.2	0.477		0.0150			
			14	6.0			0.774	0.017	0.0730	0.0092		
Beaver-2	8/23/10	2.4	1		4.0	1.6	0.448	<MDL	0.0168	0.0022	0.258	13.9
			7		1.4	2.1	0.317		0.0265			
			14				0.356	0.015	0.0236	0.0044		

The UV254 value shows that some tea coloration is present in the water of Beaver-2 and represents a moderate level of dissolved organic carbon, while the total alkalinity represents soft water that is not well buffered against pH change.

Chlorophyll *a* profile data indicated that the highest concentrations of phytoplankton are in the surface of the lake on each of the profile dates, while both dates have low chlorophyll concentrations overall, suggesting the lake does not have an abundance of phytoplankton and low biological productivity.

Profiles on Beaver-1 (Table 2) showed that thermal stratification set up in the lake in early spring and lasted through late summer. The high TP and TN levels, accompanied by significant ammonia concentrations, found in the deep water are representative of a general buildup in the anoxic waters that develops each year near the bottom of Beaver-1.

The high UV254 values are indicative of the marked tea color of the water coming from dissolved organic carbon leached from the upstream wetland, and the low alkalinity value shows that the lake water is very soft and poorly buffered against pH change.

Table 2. 2010 Beaver-1 Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Beaver-1	5/24/10	1.4	1	16.0	13.6	<MDL	0.584	<MDL	0.0351	<MDL	0.489	9.4
			7	5.5	2.6	<MDL	0.502		0.0293			
			14	5.0			0.659	0.079	0.0975	0.0564		
Beaver-1	8/23/10	1.1	1	19.5	10.0	2.9	0.719	0.090	0.0218	<MDL	0.364	11.0
			7	6.0	2.6	6.2	0.536		0.0520			
			14	5.5			0.675	0.247	0.1740	0.0799		

Chlorophyll *a* data suggest the most algae are found in the surface waters rather than spread throughout the upper water column.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*. A value of 50 or higher indicates eutrophy, or a highly productive lake in terms of algae, while values below 40 indicate oligotrophy, or low rates of productivity. Values between 40 and 50 are considered moderate or mesotrophic.

The 2010 Beaver-2 TSI indicators for chlorophyll *a* and Secchi were close to each other in the high range of mesotrophy, down from 2009 when there was an *Anabaena* bloom, while the TSI-TP indicator was lower than the other two indicators (Figure 11). The average of TSI indicators in 2010 was slightly lower than 2009, but the trend overall is static and Beaver-2 remains mesotrophic.

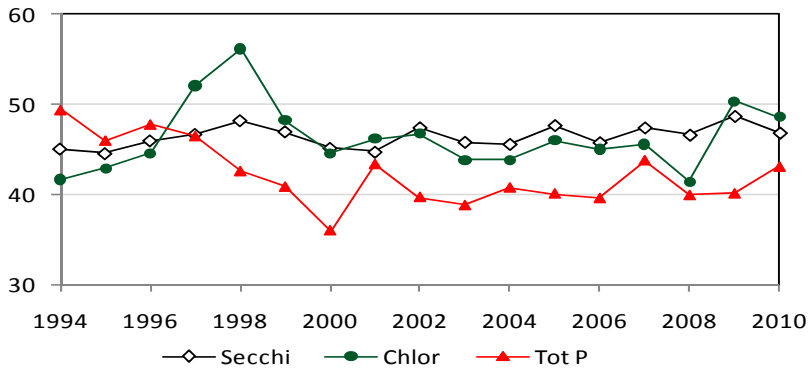

Figure 11. Beaver-2 Trophic State Indicators through 2010

In 2010, all three Beaver-1 TSI indicators were close to each other in the lower range of eutrophy, and the TSI-Secchi indicator was not higher than the other two for the first time since

1997 (Figure 12). Chlorophyll increased considerably in 2010 due to the impact of the anomalously high value in early July on the calculation. Phosphorus also increased, bringing it to the highest value since 1998. If a trend line is drawn through the entire series, there is no significant change over time. However, a slight, but steady increase has been seen in this basin since 2002, and a close watch should be kept on phosphorus as development proceeds in the upper watershed.

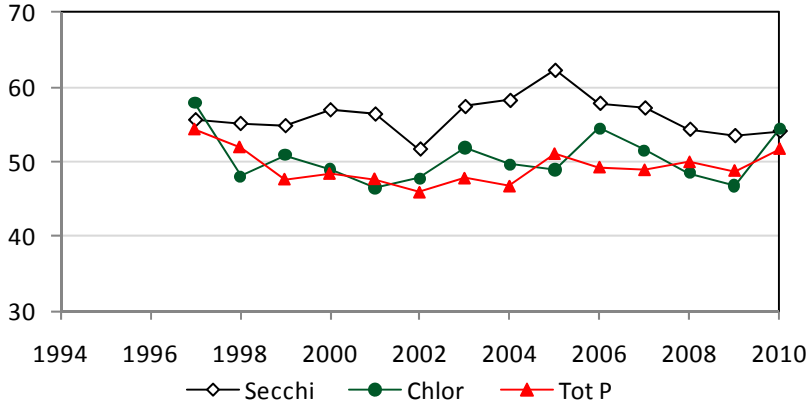

Figure 12. Beaver-1 Trophic State Indicators through 2010.

Conclusions and Recommendations

Based on monitoring data, water quality in Beaver-2 appears to be stable over the period measured, and the steady TN:TP ratio is not conducive to nuisance bluegreen algae blooms, although the bloom in 2009 shows that some species can occasionally predominate without a favorable N:P ratio. In Beaver-1, there has been a slow but steady increase in phosphorus since 2002, and the TN:TP ratio is lower, which suggests nuisance bluegreen algae blooms may be an issue more often. It is recommended that continued monitoring of nutrient and chlorophyll concentrations be done to assess these conditions into the future as development proceeds.

PINE LAKE

Physical Parameters

Excellent precipitation and water level records for Pine Lake were compiled for the 2010 water year. Water levels in the lake responded to winter storm events, but remained relatively steady until late June when the water level slowly decreased over the remainder of the water year. Overall, the lake follows the regional pattern of winter high–autumn low stands. Precipitation and lake level data collected since 1995 suggest the lake rises with the onset of autumn rains and remains somewhat elevated through the winter and into spring. However, the highest lake levels do not usually persist longer than a week or two (Figure 1).

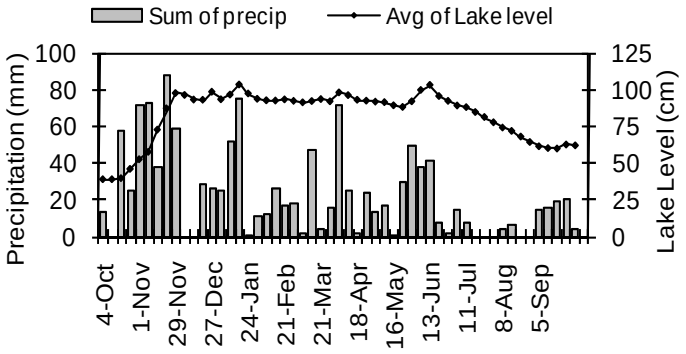

Figure 1. WY 2010 Pine Lake Level and Precipitation

Pine Lake volunteers collected weekly temperature and Secchi transparency data throughout the 2010 water year in addition to values collected during the "Level 2" monitoring season from early May through late October. Secchi transparency ranged between 1.4 and 6.0 m (Figure 2). The annual average was 4.1 m and the summer average was 4.6 m, which placed it in the higher range for monitored small lakes in 2010. A couple of unusual low transparency values were recorded in July, but the condition did not persist.

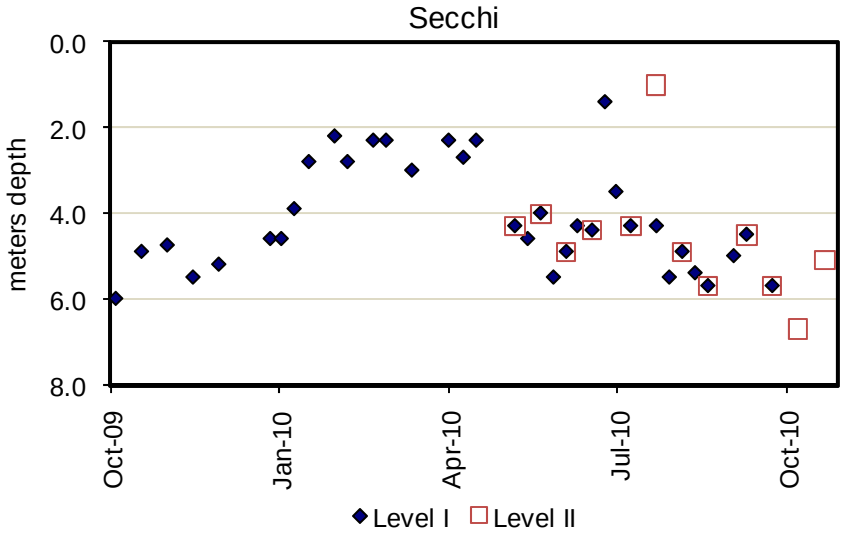

Figure 1. Pine Lake Secchi Transparency

Surface water temperatures ranged between 3.0 to 25.0 degrees Celsius over 2010 with an annual average of 13.4 and a summer average of 19.1 degrees Celsius (Figure 3). The recorded maximum temperature was in the midrange of values reported among the group.

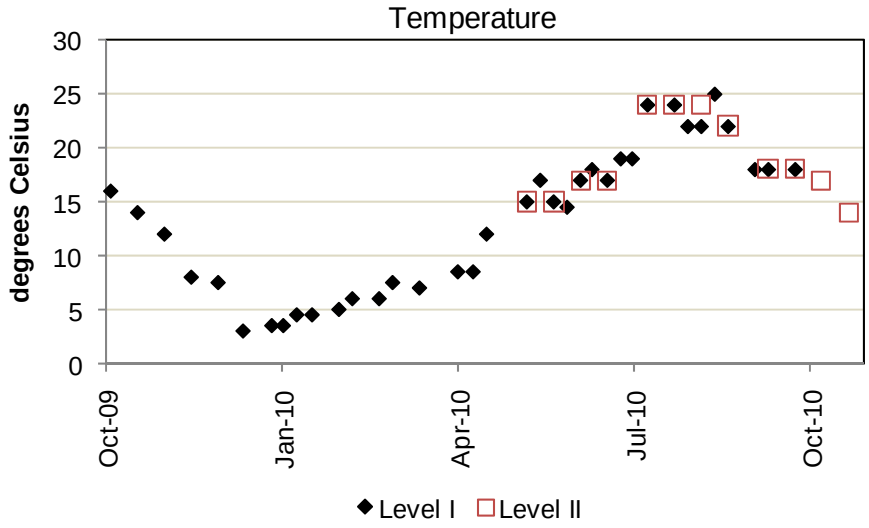

Figure 3. Pine Lake Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms–a nuisance to residents and lake users, and a potential

safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

During the monitoring period for Pine Lake, TN and TP values remained fairly consistent throughout the sampling season, with little variation over time (Figure 4).

The ratio of nitrogen to phosphorus (N:P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air. In Pine Lake, total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 24 to 60 with an average of 45, which suggests that conditions in the lake were not favorable for nuisance bluegreen blooms.

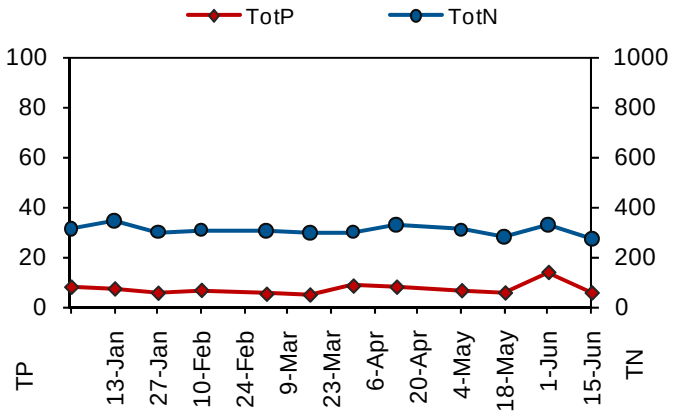

Figure 4. 2010 Pine Lake Total Phosphorus and Total Nitrogen Concentrations in µg/L

Chlorophyll concentrations relate to the amount of algae present in lake water. All algae must have chlorophyll in order to fix energy from sunlight, so higher amounts of chlorophyll denote more abundant algae. However, some of the cyanobacteria (bluegreen algae) also use other pigments to capture light, so their relative amounts of chlorophyll may be smaller than for other groups of algae. Pheophytin is a degradation product of chlorophyll, and large amounts present in a sample can indicate that the presence of sediment or other sources of old chlorophyll in addition to that contained in vibrant, living algae. Some of these sources include wind and rain storms, sediment disturbance, bank erosion or wash-in from watershed activities.

Chlorophyll *a* concentrations in Pine Lake also remained low throughout the period with no significant peak periods observed (Figure 5). Pheophytin (degraded chlorophyll) levels remained below detection levels throughout the season except for late June and the last sampling date in October.

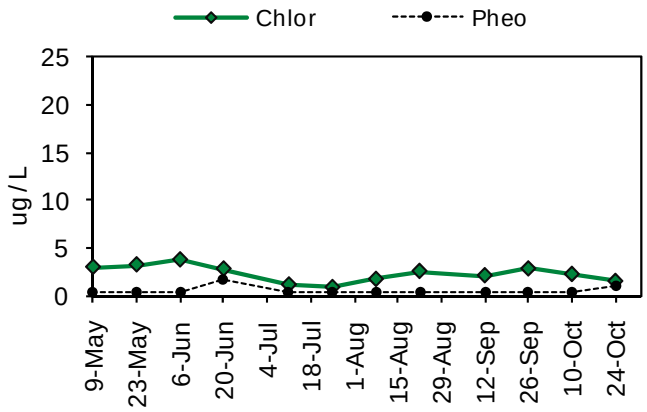

Figure 5. WY 2010 Pine Lake Chlorophyll *a* and Pheophytin concentrations

Profile data on Pine Lake indicates that thermal stratification was present in early summer and persisted through late summer. Higher concentrations of phosphorus were found in deep water in both May and August, and ammonia was detected on both dates, which confirmed the lack of oxygen in the deep water (Table 1). However, the OPO4 values remained fairly low, as did the chlorophyll values, suggesting that phosphorus recycling back to the deep water from the sediments was not having a major effect on the phytoplankton.

Table 1. Pine Lake Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Pine	5/23/10	4.0	1	15.0	3.3	<MDL	0.346	0.008	0.0074	<MDL	0.058	21.0
			5	13.0	2.2	<MDL	0.335		0.0071			
			10	8.0			0.380	0.081	0.0502	0.0141		
Pine	8/22/10	5.7	1	22.0	2.6	<MDL	0.326	<MDL	0.0081	<MDL	0.073	21.1
			5	20.0	2.0	<MDL	0.308		0.0080			
			10	9.0			0.885	0.152	0.0856	0.0020		

The UV254 values are indicative of clear water, unlike the tea color of the water in Beaver Lake that is evidence of dissolved organic carbon. The alkalinity value, while still low, is higher than those derived for the Beaver Lake basins, and it may relate to the higher degree of development and soil disturbance in the Pine Lake watershed. However, Pine Lake water is fairly soft and not well buffered against pH change.

Both profile dates have low chlorophyll concentrations at both shallow and mid-depths, showing that the lake has very little phytoplankton in the zone that sunlight penetrates, with generally low biological productivity.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the “trophic state index” (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*. A value of 50 or higher indicates eutrophy, or a highly productive lake in terms of algae, while

values below 40 indicate oligotrophy, or low rates of productivity. Values between 40 and 50 are considered moderate or mesotrophic.

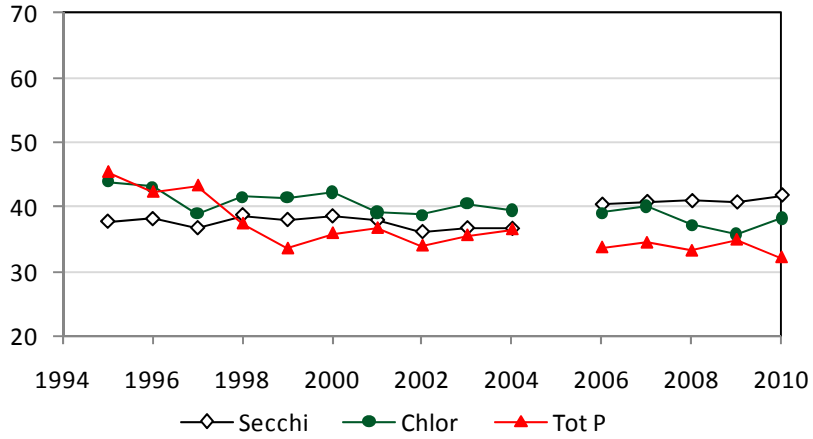

Figure 6. Pine Lake Trophic State Indicators through 2010

The 2010 Pine Lake TSI indicators for chlorophyll *a* and Secchi were fairly close to each other on either side of the threshold between oligotrophy and mesotrophy, while the TSI–TP indicator was in the lower end of the oligotrophic range (Figure 6). The average of all three TSI indicators in 2010 was consistent with previous years, suggesting that conditions in Pine Lake are stabilized in the upper ranges of oligotrophy.

Conclusions and Recommendations

Based on monitoring data, water quality in Pine Lake appears stable over the period measured with a low rate of productivity in the summer months. High average N:P ratios could indicate conditions are generally not favorable for nuisance bluegreen algae blooms. Continued monitoring of nutrient and chlorophyll concentrations will assess future conditions and track any changes.