Lake Sawyer Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2009 at Lake Sawyer

Lake Sawyer

Prepared for the City of Black Diamond
by the King County Lake Stewardship Program

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King County

Overview

The King County Lake Stewardship Program (KCLSP) collaborated with citizen volunteers to monitor Lake Sawyer between 1993 and 2004. In 2006, the City of Black Diamond contracted with KCLSP to continue monitoring Lake Sawyer. Water quality monitoring is done on a schedule of once per month, versus the typical every other week for other lakes in the program. The water quality data indicate that currently the lake has moderate to low productivity (mesotrophic – oligotrophic) with good water quality.

There is a public boat launch and several public parcels adjacent to the lake that allow members of the public to access for recreation and to launch boats. Lake users should track aquatic plants growing near shore to monitor Eurasian watermilfoil and to catch early infestations of 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 2009 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.

Physical Parameters

Secchi clarity and water temperatures were gathered by the volunteer from May through October 2009. Physical parameters were recorded each time water samples were collected through the sampling season.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

For Lake Sawyer, Secchi transparency values ranged from 3.1m to 4.7m, averaging 4.0m (Figure 1). Compared to data collected in previous years, the Secchi transparency values exhibited normal and expected variability through the season.

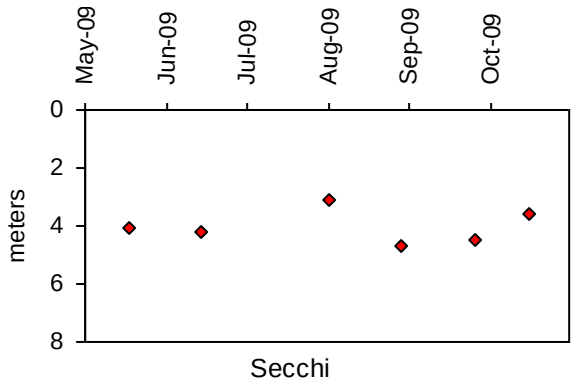

Figure 1. Lake Sawyer Secchi Transparency

Water temperatures during the sample period followed a pattern similar to other lakes in the region, with temperatures warming to summer maximum temperatures occurring between mid-July and mid-August, and temperatures cooling in the fall. The temperatures through the sampling season ranged from 13.0 degrees Celsius to 27.5 degrees Celsius with an average of 19.9 (Figure 2). The maximum temperature was considerably higher than normal, reflecting the very hot weather experienced in the region during late July.

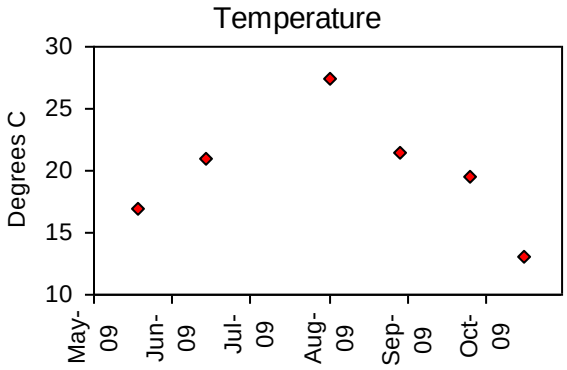

Figure 1. Lake Sawyer Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many activities 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.

Total phosphorus (TP) and total nitrogen (TN) concentrations followed a pattern throughout the May – October sampling period similar to previous years (Figure 3). In 2009, the TN started higher and decreased, stabilized in August and then again decreased slightly through fall. TP values varied only slightly throughout the season, with the lowest value at the beginning of sampling in May.

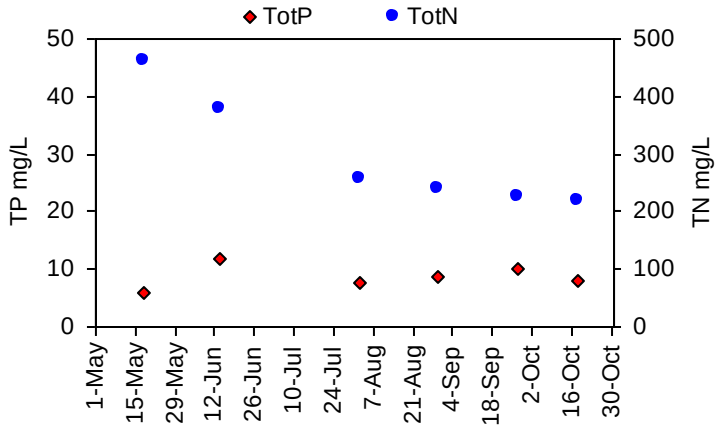

Figure 3. Lake Sawyer Nutrients

The ratio of nitrogen (N) to phosphorus (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. Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 22.8 to 79.7 with an average of 37.2, which suggests that conditions were generally unfavorable for nuisance bluegreen growth. However, the N:P ratios in the low 20s occurred in fall, suggesting that if a nuisance bluegreen algae bloom were to occur it would be during that period.

Chlorophyll *a* values varied very little throughout the monitoring season in Lake Sawyer (Figure 4). The low levels suggest low phytoplankton volumes in the surface water mid-lake. Pheophytin (degraded chlorophyll) remained near the level of detection throughout the majority of the season. Because the measurement is made in the middle of the lake, it will not reflect short term algae accumulations that may occur along the shorelines resulting from wind movement.

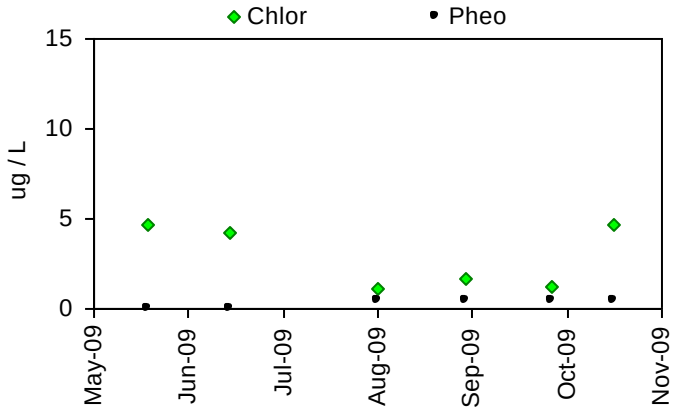

Figure 4. Lake Sawyer Chlorophyll *a* and Pheophytin Concentrations

Profile temperature data indicate that thermal stratification was present early in the season and persisted through the summer (Table 1). In the bottom samples in both May and August there were elevated levels of TN and TP, as well as ammonia, indicating that the hypolimnion (bottom water) of Lake Sawyer becomes anoxic over the summer, causing release of phosphorus from the sediments. This internal loading was apparent in the August bottom sample, in which TP was nearly 3-fold higher than it was in May.

Table 1: Lake Sawyer Profile Sample Analysis

		meters	meters		ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	abs	mg/L
Lake name	**Date**	**Secchi**	**Depth**	**DegC**	**Chlor-a**	**Pheo**	**Total N**	**NO2-3**	**NH3**	**Total P**	**OPO4**	**UV254**	**Total Alk**
Sawyer	5/18/09	4.1	1	17.0	4.7	**<MDL**	0.462	0.286	0.013	0.0058	**<MDL**	0.091	59.1
			8	6.5	2.4	1.3	0.613			0.0080			
			16	6.0			0.621	0.424	0.023	0.0209	0.0037		
Sawyer	8/30/09	4.7	1	21.5	1.6	**<MDL**	0.241	**<MDL**	**<MDL**	0.0086	**<MDL**	0.065	59.5
			7.5	9.5	5.9	**<MDL**	0.383			0.0175			
			15	6.0			0.573	**<MDL**	0.434	0.1450	0.0363		

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 values predict the biological primary productivity of the lake based on measurements of water clarity (Secchi) and concentrations of TP and chlorophyll *a*. There are 3 categories of productivity: oligotrophic (low productivity, below 40 on the TSI scale); mesotrophic (moderate productivity, between 40 and 50); and eutrophic (high productivity, above 50).

TSI-indicators are created by averaging all 1m data collected for May through October. for Lake Sawyer was lower than the other two indicators, placing in the mid oligotrophic range, similar to 2008 (Figure 5). TSI-chlorophyll and TSI Secchi also decreased, with TSI-chlorophyll dropping below the oligotrophic threshold for the first time since 1994. The decrease is TSI-Secchi was less dramatic, remaining just above the threshold. The indicators in 2009 continued the decline in values (increasing water quality) since 2007, with the average of the three TSI values in the high oligotrophic range.

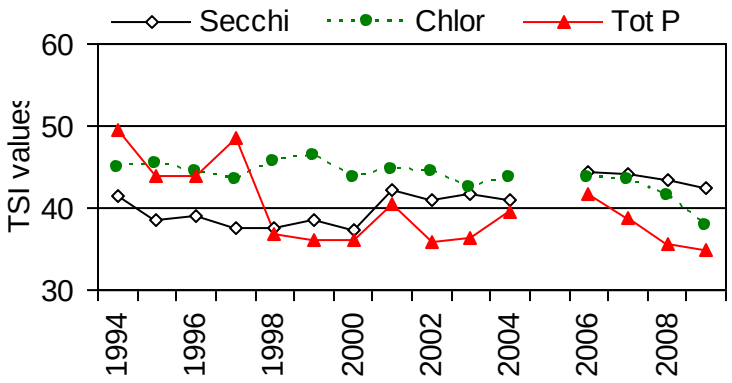

Figure 5. TSI Values at Lake Sawyer

TMDL

The Total Maximum Daily Load for Lake Sawyer set by the Washington Department of Ecology in 1993 defined a goal of an average of 16 ug/L total phosphorus concentration for the lake, but did not include the time period or water volume for which this was to be calculated. A wasteload allocation of zero was set in accordance with the removal of the Black Diamond wastewater treatment plant discharge to Rock Creek. A total annual influx of 715 kg phosphorus was estimated to meet the 16 ug/L average concentration target. Load allocations for tributary input was set at 511 kg/yr and internal loading input at 124 kg/yr, with 80 kg/yr allowed for other sources such as direct runoff and dust fall.

Onwumere (WDOE publication 02-02-054 December 2002) assumed that the standard June-September period should apply to the calculation and used the 1m values taken between May and October by the King County Lake Stewardship Program monitoring program to look at TMDL effectiveness. He found that Lake Sawyer appeared to be meeting the TMDL target as a long term average, but noted that it might not be meeting a maximum in-lake mean summer target. However, because no time period or summer maximum appears to have been set by the original TMDL, so it is hard to know what standard should be applied to the Lake Sawyer data to reach such a conclusion.

The long term data set collected by King County and trained volunteer monitors begins in 1985 and continues to the present, with a one year gap in the data. Average June – September 1m values (Figure 6) show that there was a series of years around the time of the decommissioning of the sewage treatment plant when summer average phosphorus concentrations were higher than previously measured and generally above the TMDL goal. However, since 1998 the values have been similar to the late 1980s and have shown no increasing trends or cause to believe that the lake is not meeting the standard set in the TMDL.

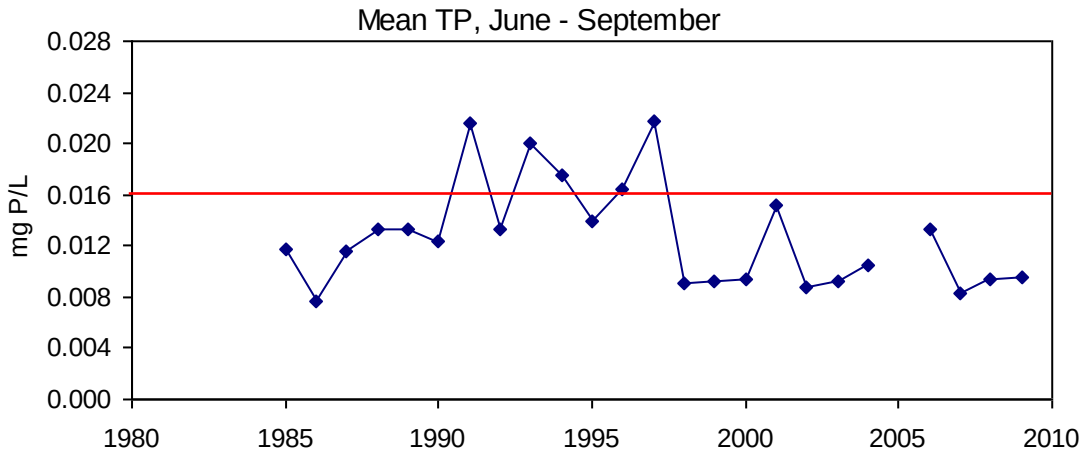

Figure 6. Summer average total phosphorus at 1m depth at Lake Sawyer

This data is encouraging because it suggests that currently Lake Sawyer is meeting the TMDL and has been doing so for at least 10 years, if Onwumere's interpretation of how to calculate the average target value is correct. However, because significant land development is expected to occur in the watershed in the future, it is important to keep

monitoring to look for changes as it proceeds, as well as for some time afterwards, in order to be sure that the permit controls imposed as development proceeds are meeting water quality goals and targets.

Inlet Water quality

A second monitoring effort focused on the water quality of the major streams flowing into Lake Sawyer: Rock Creek (LSIN1) and Ravensdale Creek (LSIN9). Beginning in January 2006, a program was initiated of sampling once a month at the creek mouths during the wet season (generally November through May) when both creeks are flowing heavily. At the same time, water flowing from the lake at the outlet weir was also sampled (LSIN10). An additional goal was set of sampling one storm a year if possible, but this has not been accomplished in all years.

Volunteers were trained to take the routine samples and were provided with prepared sample bottles and equipment. Samples were submitted to the King County Environmental Laboratory for analysis. Parameters measured included specific conductivity and total alkalinity as indicators of development, total phosphorus and orthophosphate for TMDL monitoring, total suspended solids, temperature and water stage for flow calculations.

Total alkalinity and Specific Conductivity

Specific conductivity measures the amount of dissolved salts in water that can carry an electrical current at 25 degrees Celsius. Total alkalinity, also known as acid neutralizing capacity, measures the amount of calcium carbonate equivalents in the water that act as a buffer, thus moderating pH changes. It is closely related to the "hardness" of the water.

In general, both specific conductivity and total alkalinity are tied to the soil types and rocks found in the drainage basin. Both parameters usually increase as a basin is developed because of soil uncovering and disturbance, as well as concrete emplacement. Because of this, they can be used as indicators of development over time.

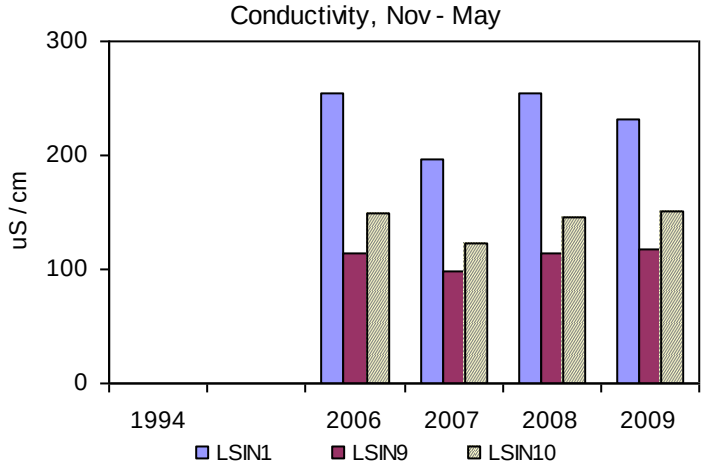

Figure 7. Wet season average of specific conductivity for Lake Sawyer and inlets

Rock Creek (LSIN1) is higher in specific conductivity than Ravensdale each year (Figure 7), while water from Lake Sawyer at the outlet appears to be a mixture of the two, but is closer to Ravensdale in value. The hydrological model constructed in the 1990s for the

Lake Management Plan assigned more inflow from Ravensdale than Rock Creek, based on the measurements taken in 1993-1994. Therefore, the more dilute water from Ravensdale would have a greater effect on the specific conductivity in the lake than the smaller inflow from Rock Creek, and this is reflected in the water from the lake being between the two inlets in value. This is also consistent with present land use in the two basins; in particular it should be noted that Rock Creek drains an inactive coal mining site with bare soils and rock outcroppings. Unfortunately, specific conductivity and total alkalinity appear not to have been measured in 1993-94, so a long term comparison cannot be made.

Total alkalinity follows the same pattern as specific conductivity (Figure 8). Alkalinity in the lake is higher than in Ravensdale Creek, but significantly lower than Rock Creek.

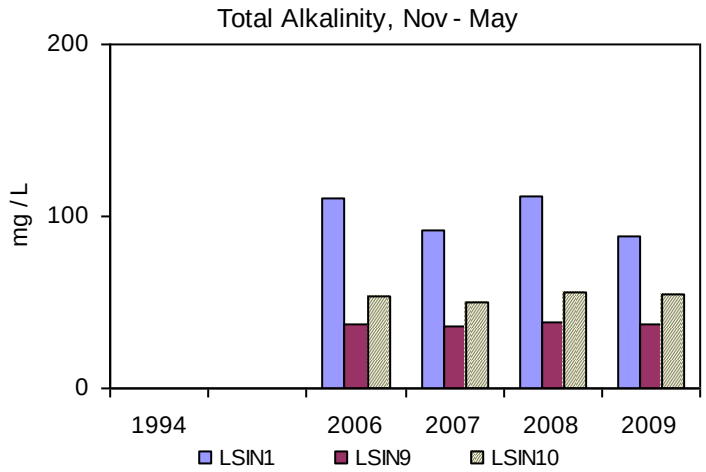

Figure 8. Wet season average of total alkalinity for Lake Sawyer and inlets

Phosphorus

Inputs of both total phosphorus and orthophosphate were also measured on a monthly basis from November through May. Total phosphorus is a measure of all phosphorus in a sample, in both dissolved and particulate form, while orthophosphate is dissolved, inorganic phosphate that is readily available for uptake as a nutrient for algae and aquatic plants.

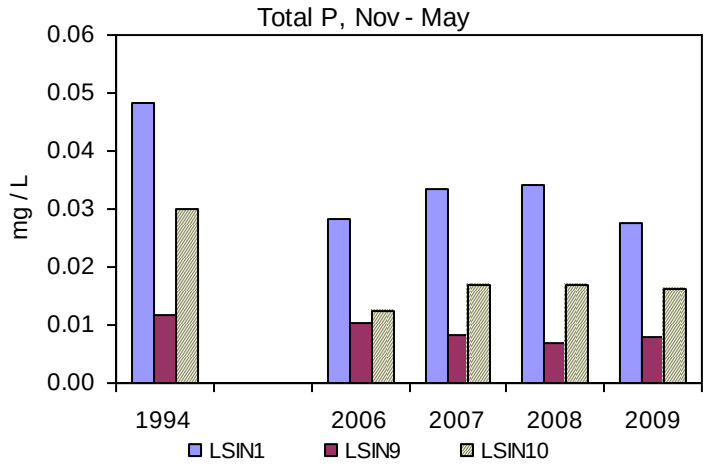

Figure 9. Wet season average of total phosphorus for Lake Sawyer and inlets

Total phosphorus has clearly declined at all three sampling sites since the 1994 water year (Figure 9), with the most dramatic decline occurring in Rock Creek, consistent with the diversion of sewage effluent from the wetland as called for in the TMDL for phosphorus reduction. However, it must be kept in mind that this data represent winter flows and lake concentrations, while the adopted TMDL is does not detail the time period to be used, with the implication that it might be annual, although Ecology chose to use the standard June-September period in the effectiveness monitoring study.

There is a lag time for most Pacific Northwest lakes between when the most phosphorus enters lakes (winter) and when it is utilized (summer). This is due to the climate, which delivers most inflow to water bodies during the winter, while summer tends to produce very low base flows with little water delivery to lakes. The results is that summer nutrient inputs may actually be very small though the concentrations in the inlet water may be high. Therefore, there is often a good correlation between winter phosphorus inputs and summer algae production. Thus, the decrease in winter phosphorus is a good indicator for Lake Sawyer that algae may be reduced as a result.

A similar pattern was found for orthophosphate (OPO4, Figure 10). The apparent increase over the 3 years 2006-2008 should not cause alarm, as variation exists between years based on flows and the randomized nature of sampling. Trends generally cannot be reliably calculated until a minimum of 8 years of data has been collected. In 2009, the OPO4 average was a little lower than in 2008 for both Rock and Ravensdale Creeks, while the value at the outlet was a little higher.

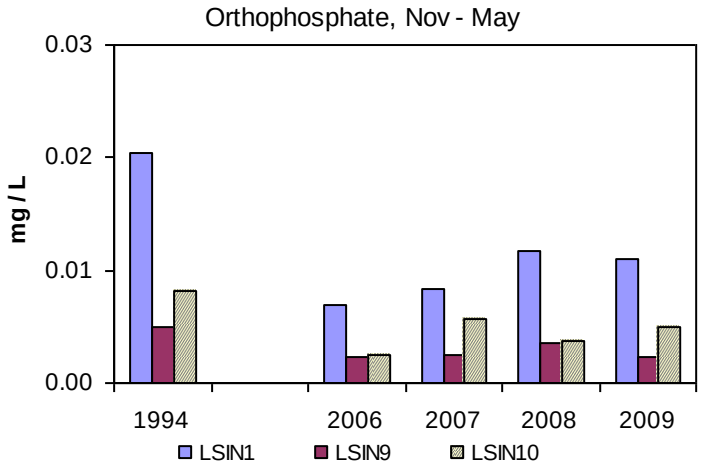

Figure 10. Wet season average of orthophosphate for Lake Sawyer and inlets

Conclusions and Recommendations

Based on monitoring data, water quality in Lake Sawyer has appeared to be relatively stable over the last decade. The nutrients in the lake varied a small amount during the sampling season and the N:P ratios were generally greater than 20 in 2009, which indicated that conditions in the lake are usually unfavorable for bluegreen algae blooms, but there might be times of the year when they can be found in the lake, particularly if concentrated against a shoreline by wind.

The inlets have showed a decline in phosphorus since the 1990s, but insufficient data has been collected as yet to calculate long term annual trends. Baseline values of total alkalinity and specific conductivity have been set to use as references as development in the watershed occurs. Continued monitoring should be carried out to assess conditions and to ensure that water quality remains consistent in Lake Sawyer as the area continues to be developed.