

Monitoring Report

Lacamas Lake Annual Data Summary for 2007

Background

Since the original settlement of Clark County, land use changes have dramatically altered Lacamas Lake and resulted in conditions that reduce the lake's suitability for fishing, swimming, and aesthetic enjoyment. High nutrient inputs (primarily phosphorus but also nitrogen) from the watershed have been identified as a major contributing factor.

Ongoing problems include summertime dissolved oxygen depletion, poor water clarity, high levels of algae growth, nuisance blue-green algae blooms, and dense beds of aquatic plants.

Grant-funded activities implemented by Clark County and other agencies between 1987 and 2001 reduced agricultural phosphorus sources and increased public awareness of lake issues. Water quality monitoring indicated that phosphorus concentrations in the lake and its major tributary, Lacamas Creek, were substantially reduced during this period. Despite these improvements, however, water quality problems persist in Lacamas Lake.

Since the conclusion of grant-funded work in 2001, Clark County's Clean Water Program has continued routine monitoring of this resource to provide information for future lake management decisions.

This report summarizes monitoring activities and data collected from May through October 2007. Historical lake data and nutrient loading were most recently summarized following data collection in 2003. The April 2004 report Lacamas Lake Nutrient Loading and In-Lake Conditions may be viewed at <http://www.clark.wa.gov/water-resources/documents.html>. Summaries of grant-funded activities from 1987 through 1998 are also available.

Lake Description

Location

Lacamas Lake and Round Lake are located in Clark County, Washington, on the northern boundary of the city of Camas. Though named separately, Round Lake is part of Lacamas Lake

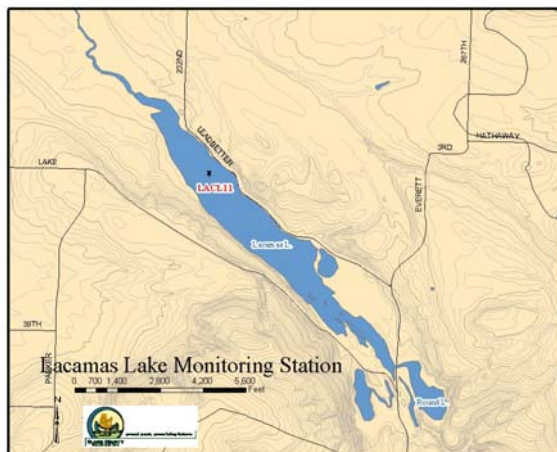
Lacamas Watershed



connected by a small channel flowing under SE Everett Road. In a county with few lakes, Lacamas Lake is recognized as an important community resource. Fishermen, swimmers, boaters, and hikers utilize the lake and its shores year-round.

Size and morphology

Lacamas Lake is 2.4 miles long and has a maximum width of one quarter mile.



The lake is relatively deep, about 60 feet at its deepest, and covers approximately 330 acres. Water level is controlled by a dam originally constructed in the late 1800s to provide industrial water supply and a means to float logs to the mill in Camas.

Watershed

The Lacamas Creek watershed includes 67 square miles of forest, farm, residential, commercial, and industrial land. The Lacamas watershed extends from Hockinson in the north to Camas in the south. Its western border is approximately 162nd Avenue, and the eastern border is formed by Elkhorn and Livingston mountains (Clark County, 2004).

Lacamas Creek has five major tributaries: Matney Creek, Shanghai Creek, Fifth Plain Creek, China Ditch, and Dwyer Creek. There are also many smaller streams. Lacamas Creek flows about 12.5 miles, from relatively undisturbed forest headwaters through rural, agricultural, and residential areas, into Lacamas and Round Lakes. Below the lakes, Lacamas Creek drops through a series of waterfalls, and finally into the Washougal River (Clark County, 2004).

Monitoring activity summary

Methods

The details of the Lacamas Lake monitoring project are described in the project's quality assurance project plan (QAPP). Staff and volunteer monitors use standardized procedures for performing environmental measurements (Clark County, June 2002).

Monitoring is conducted on a monthly basis from May through October each year. Samples are collected at a single location over the deepest portion of the lake. This station has been utilized for monitoring since the early 1980s and provides a consistent location for long-term data collection.

Field measurements include vertical profiles for water temperature, dissolved oxygen, pH, and conductivity, as well as a single measurement of turbidity and Secchi depth. Water samples collected from the epilimnion (near the surface) and hypolimnion (near the bottom) are analyzed for total phosphorus, total Kjeldahl nitrogen, and nitrate + nitrite nitrogen. Chlorophyll *a* samples are obtained by compositing three grab samples equally spaced through the photic zone. The photic zone is the depth to which light penetrates, and is estimated as 2 times the measured Secchi depth.

The 2007 sampling was performed with the assistance of volunteers, as the project continues a transition to a volunteer project administered under Clark County's Clean Water Program.

Data management and analysis

Field observations and measurements are recorded with electronic field meters and backed up with hard copy forms. Field and analytical data are reviewed to ensure the data are complete and meet the quality control objectives for the project. Data are stored in hard-copy form in three-ring binders until the completion of each sampling season, after which they are entered into the county's water quality database.

The level of data analysis and reporting varies according to a five-year schedule. Brief data summaries such as this one are produced following each sampling year. A technical report is completed following year five sampling, focusing on long-term trends in lake condition. The next technical report is scheduled for completion following 2008 monitoring.

Data analysis focuses on the assessment of lake conditions, specifically on the level of algal growth and related parameters. Basic summary statistics showing central tendency and variability

of the data are calculated on seasonal datasets and summarized in tables. Data are also displayed using simple graphical techniques, such as time series and possibly box-and-whisker plots.

A Trophic State Index (TSI) is used to describe the level of productivity of a lake, or the amount of algal matter produced by photosynthesis. Indices are used to integrate complex datasets, provide a common reference point to describe lake conditions, and help track changes over time. A single measurement of TSI does not indicate whether a lake's health is deteriorating, nor does it imply where a lake *should be* in terms of the current health.

Lake conditions

Based on a series of investigations dating back to the early 1980s, Lacamas and Round Lakes are categorized as “eutrophic” (see Table 1 at the conclusion of this report for summary water quality values). The terms oligotrophic, mesotrophic, and eutrophic are often used to characterize lakes according to a low, medium, or high level of algal production, respectively. Over time, lakes naturally move slowly along this continuum in the direction toward eutrophic conditions (high algal production). In some cases, however, this movement can be dramatically accelerated due to human activities in a lake or watershed.

Trophic categories are not meant to convey value judgments. Oligotrophic conditions do not necessarily imply “good” water quality or a “healthy” lake. Conversely, eutrophic conditions do not always mean a lake is impaired or has “bad” water quality. Rather, trophic categories describe the amount of nutrient enrichment and biological productivity in a lake, whereas terms like “healthy” and “impaired” refer to the condition of a lake relative to its desired uses or natural condition (Snohomish County, 2003).

In the case of Lacamas Lake, accelerated eutrophication has dramatically altered the lake from its natural historical condition and resulted in conditions that may impair current desired uses such as fishing, swimming, and aesthetic enjoyment. Water quality monitoring during 2007 supports previous conclusions regarding the eutrophic condition of the lake.

Water clarity

Lacamas Lake has low water clarity. In general, an average summertime Secchi disk depth of less than 2.0 meters is indicative of eutrophic conditions. From May through October 2007, Secchi depth averaged 1.8 m and ranged from 0.9 to 3.0 m. Turbidity values were generally low, averaging 5.6 NTU and ranging from 1.5 to 10.4 NTU.

Water clarity in Lacamas Lake is impacted primarily by algal cells during the summer months. The lake often takes on a green tint when algal populations are high, and these algal blooms limit light penetration.



Secchi Disk

Nutrients

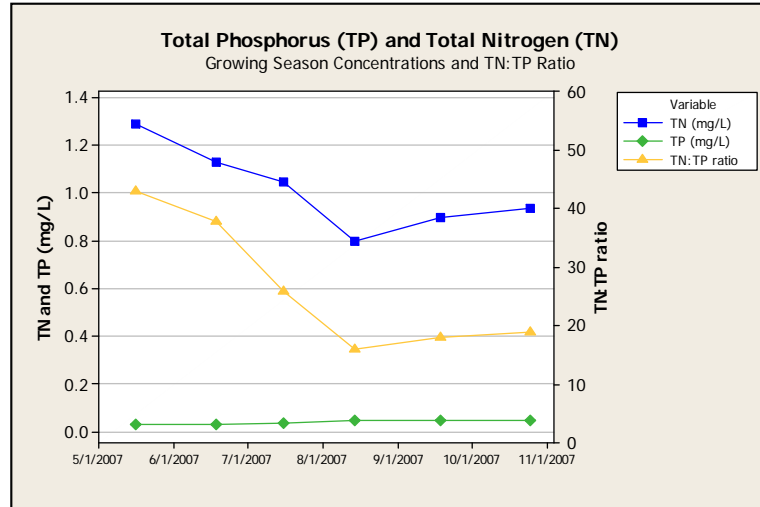
The total phosphorus criterion for preventing nuisance algal blooms and controlling eutrophication is 25 $\mu\text{g/L}$ (EPA, 1986). Lacamas Lake had moderate surface phosphorus levels somewhat above this criterion throughout the summer, averaging 42 $\mu\text{g/L}$ and ranging from 30 to 50 $\mu\text{g/L}$.

Total nitrogen concentrations were fairly high, averaging 1.02 mg/L and ranging from 0.80 to 1.29 mg/L .

Nutrient availability to algae is an important aspect of nutrient dynamics in lakes. The ratio of TN to TP is often used to interpret the availability of nutrients relative to one another. Low ratios

indicate an abundance of phosphorus and a relatively low amount of nitrogen. Higher ratios indicate a scarcity of phosphorus relative to nitrogen. In these cases we say that the nutrient in shorter supply is “limiting” algal growth. In some cases, the ratio may indicate the potential for either phosphorus or nitrogen to be limiting.

Similar to recent years, TN:TP ratios in the lake were very high during 2007, ranging from 16 to 43. This suggests that phosphorus was the limiting factor for algal growth throughout the summer. This situation may have a positive impact on algal blooms because in a nitrogen-limited system nuisance blue-green algal species can have a competitive advantage.



(Above) Total Nitrogen and Total Phosphorus concentration and ratio, summer 2007

Temperature/Oxygen

Vertical profiles of temperature and oxygen indicate that Lacamas Lake typically stratifies, or separates into layers by temperature. Stratification occurs when solar energy warms the surface water, while the deeper water tends to remain colder because the sun’s rays only penetrate a short distance.

The resulting temperature gradient is often strong enough to confine water, nutrients, dissolved oxygen, and suspended materials to a discrete layer, playing a key role in the movement of materials within lakes.

Summer surface water temperatures are typically quite warm in Lacamas Lake. In 2007, surface temperatures almost reached 25 degrees Celsius, about 77 degrees Fahrenheit. Temperatures in this range are sufficient to promote algal growth throughout the summer, and often favor certain species of algae, such as blue-green algae, that may increase to nuisance levels. These temperatures are also above the acceptable range for cold-water fish species such as trout (generally <18 degrees Celsius). Suitable water temperatures were present throughout the summer at depths greater than approximately 5 meters. However, these cold-water areas were often uninhabitable by fish due to extremely low dissolved oxygen concentrations.

Oxygen depletion results from the decomposition of biological material that settles to the lake bottom. Thermal stratification does not allow fresh oxygen from the atmosphere to reach the deeper layer and the oxygen is eventually depleted. The oxygen is only replenished when the stratification breaks down and vertical mixing of the water column occurs during fall.

In Lacamas Lake there is generally insufficient oxygen for most aquatic life uses (<5 mg/L) at depths greater than 4-5 meters from July through September, with essentially no oxygen at all below 6 meters from July through September. This historical pattern was again observed in 2007.

The combination of dissolved oxygen depletion in deeper cool water and elevated surface temperatures in shallower water forces fish and other aquatic life to survive in a very restricted, and sometimes non-existent, band of suitable habitat.

pH

Typically, aquatic life criteria require that pH levels remain close to neutral (6.5) to slightly basic, not to exceed a value of 8.5-9.0 units (EPA, 1986). Lacamas Lake has relatively high pH levels and 2007 data indicated values were highest (~9.0 units) during July and August, most likely due to intense algal growth at these times. By-products of the photosynthetic reactions in algal cells cause a net increase in pH.

Algae

Chlorophyll-a, a pigment present in algae utilized for photosynthesis, is often used to estimate the amount of algae in lakes. The average chlorophyll-a concentration for the May – October 2007 period was 11 $\mu\text{g/L}$ and ranged from 1 to 23 $\mu\text{g/L}$. Eutrophic lakes typically have maximum chlorophyll-a concentrations ranging between 20 and 200 $\mu\text{g/L}$ (Holdren and others, 2001).

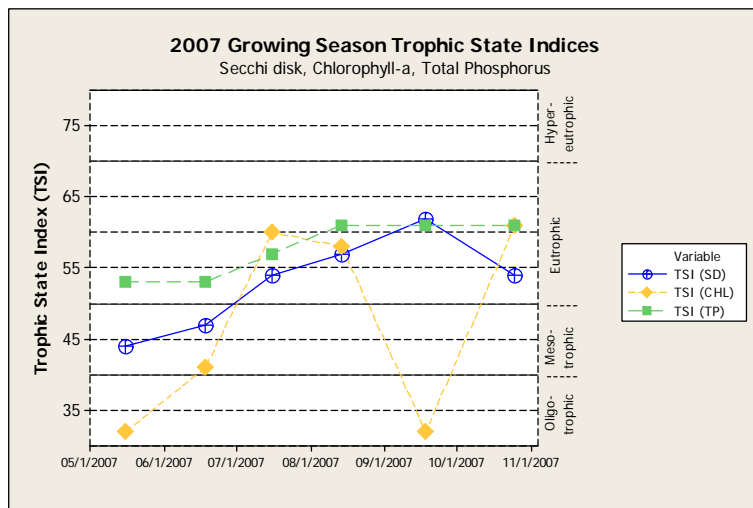
The average chlorophyll-a value for the May-October 2007 period was substantially lower than for the same period in 2005 (excluding comparison with partial data period for 2006).

Algal cell counts were most recently summarized following sampling in summer 2003. The phytoplankton community biovolume was then dominated by species commonly associated with eutrophic conditions. The average biovolume and a general pattern of dominance by the diatom *Fragilaria crotonensis* and blue-green algal species were consistent with results from earlier studies in 1984 and 1995. However, a significant increase in the blue-green alga *Aphanizomenon flos-aquae* since 1984 is a likely indication of advancing eutrophication.

Trophic State

Trophic state indices (TSI) calculated from Secchi disk, chlorophyll-a, and total phosphorus values generally indicated that the lake was eutrophic during much of the summer, meaning the lake is enriched with nutrients and algae. Using all three TSI characteristics on a scale of 0-100, the overall average monthly TSI value for summer 2007 was 53 with individual monthly TSI values ranging from 32 to 62. Values between

50 and 70 are associated with eutrophic lakes. Periodically, monthly Secchi disk and chlorophyll-a TSI estimates suggested short periods for Lacamas Lake that were more similar to mesotrophic or even oligotrophic conditions that may have been associated with zooplankton grazing of algae.



(Above) Trophic State Index (TSI) values, summer 2007

Aquatic Plants

Lacamas Lake is characterized by extensive aquatic plant growth. Based on surface and scuba surveys, scientists in 1984 concluded that at least 97% of the potential colonizable area in Lacamas Lake was populated with aquatic plants. Results from the most recent Washington State Department of Ecology survey in 1999 indicated increasing dominance of the plant community by Brazilian waterweed (*Egeria densa*), an aggressive exotic species (photo). Since 1984, *Egeria densa* has largely displaced more desirable native species in the shallow-water areas (Parsons, 1999).



Egeria densa

Fish

The most recent Lacamas Lake fish population study was conducted in 1997 by the Washington Department of Fish and Wildlife. Lacamas Lake supports self-sustaining populations of warm-water fish (e.g. perch, bluegill, and largemouth bass).

The native cutthroat trout historically found in the lake are thought to be non-existent. Brown and rainbow trout are introduced through an annual stocking program and support a well-used fishery (Mueller and Downen, 1999).

The 1997 investigation concluded that warm-water species in Lacamas Lake exhibit signs of an unbalanced community, including slow growth, poor condition, and low recruitment. There appeared to be an overpopulation of small, slow growing fish with key size classes lacking.

Food availability did not appear to be a factor in causing the poor fish growth. Rather, the report concluded that poor water quality (primarily dissolved oxygen depletion) causes stress, limits habitat, and may be the greatest impediment to both the cold and warm-water fisheries (Mueller and Downen, 1999).

Summary

Overall conditions in Lacamas Lake were similar in 2007 to those observed over the past several years. Phosphorus levels were slightly higher than EPA's aquatic life criteria to avoid nuisance algal blooms, and nitrogen levels were relatively high. Elevated surface water temperatures combined with low dissolved oxygen conditions in the deeper areas limited summer cold-water fish habitat. Light penetration was consistently low due to abundant algal growth. Trophic state indices for Secchi disk, total phosphorus, and chlorophyll-a all indicated Lacamas Lake was eutrophic.

Algal growth was strongly phosphorus-limited during 2007. This pattern has been noted for the past several years and represents a change from historical conditions that have seen the lake typically shift to nitrogen limitation during late summer. The consistently elevated nitrogen values, compared with relatively low phosphorus inputs could indicate increased nitrogen sources in the watershed and/or an increased role of nitrogen in the ecology of Lacamas Lake.

Consistent limitation of algal growth by phosphorus could be a positive development for the lake, maintaining conditions favorable to desirable algal species. However, despite the limitation by phosphorus in 2007, current phosphorus levels are still easily sufficient to allow high levels of plant and algal growth and maintain a trophic status well into the eutrophic range.

Recommendations

Continued monitoring during the summer season is recommended to track long-term changes in lake conditions and inform future management efforts. Successfully decreasing phosphorus inputs may help limit blue-green algal blooms and, if the decrease was significant enough, potentially move the lake toward a lower trophic status.

Public and agency activities to improve Lacamas Lake have diminished since the major grant-funded restoration effort concluded in 2001. Renewed community interest and support would encourage further measures by state and local agencies to build on earlier successes in improving Lacamas Lake. Focused management efforts within the lake aimed at maintaining beneficial uses, such as mechanically introducing oxygen during the summer, would require consistent funding sources and broad public support.

Acknowledgements

The assistance of Frances Foley for her 2007 Lacamas Lake volunteer monitoring was greatly appreciated.

This report was originally written by Jeff Schnabel and updated by Robert Hutton in June 2008 based on 2007 Lacamas Lake data.

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Or, visit the Clean Water Program website:
www.clark.wa.gov/water-resources/index.html

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Table 1. Average values for Lacamas Lake monitoring projects; values in parentheses are ranges for the period

Data Source	Date Range	Maximum Surface water temperature (deg-C)	Minimum water column oxygen concentration (mg/L)	Surface water pH (units)	Secchi Depth (meters)	Turbidity (NTU)	Total phosphorus (mg/L-P)	Total nitrogen (mg/L-N)	Chlorophyll-a (ug/L)
Beak and SRI, 1984	Dec 1983 to Nov 1984	23.2	<0.1	7.7 (6.6 - 9.4)	1.3 (0.6 – 2.0)	7.3	0.070	1.16	19 (0.4 – 65)
Clark County, 1994 (Lafer)	July 1991 to Nov. 1992	23.0	<0.1	8.5 (7.5 – 9.6)	1.7	--	0.030 (0.015 – 0.063)	0.8 (0.4 – 1.6)	25 (est) 64 (max)
E&S, 1996	April to Nov. 1995	25.0	<0.1	7.9 (6.4 – 9.9)	1.4 (0.9 – 2.8)	4.3 (2.0 – 8.5)	0.041 (0.030 – 0.066)	1.13 (0.8– 1.4)	--
E&S, 1997	February to May, 1996	15.2	<0.1	6.4 (6.2 – 6.7)	1.1 (0.9 – 1.3)	6.8 (4.0 – 9.3)	0.102 (0.026 – 0.310)	1.5 (1.1 -1.9)	--
Clark County, 2000 (Schnabel)	Oct. 1998 to Sept. 1999	22.1	<0.1	7.5 (6.7 – 8.9)	1.6 (0.9 -2.1)	--	0.033 (0.018 – 0.050)	--	--
Clark County, 2002 (Schnabel)	Oct. 1999 to Sept. 2001	23.2	<0.1	--	1.4 (0.6 – 3.0)	--	0.030 (0.010 – 0.053)	1.2 (0.6 – 2.3)	--
Clark County, 2004 (Schnabel)	Oct. 2001 to Sept. 2003	25	<0.1	7.9 (6.8 – 9.3)	1.7 (0.5 – 3.0)	--	0.036 (0.010 – 0.079)	1.3 (0.4 – 2.4)	(May-Oct 2003 data unreliable)
Clark County (unpublished)	Oct. 2003 to Oct. 2004	24	<0.1	8.1 (6.9 – 9.0)	1.7 (1.2 – 2.5)	3.5	0.041 (0.023 – 0.144)	1.2 (0.5 – 2.2)	29 (18 – 35)
Clark County, 2006 (Schnabel)	May to Oct. 2005	23.6	<0.1	8.6 (8.0 – 9.0)	1.5 (1.1 – 2.0)	6.0	0.036 (0.021 – 0.58)	1.09 (0.7 – 1.3)	37 (15 – 82)
Clark County, 2007 (Schnabel)	May to Oct. 2006	22.9	<0.1	8.2 (6.6 – 9.2)	1.7 (1.3 – 2.6)	3.6 (1.4 – 6.9)	0.037 (0.023 – 0.060)	1.13 (0.8 – 1.6)	(July-Oct only) 13 (10-13)
Clark County, 2008 (Hutton & Schnabel)	May thru Oct. 2007	24.8	0.13	7.9 (6.5-9.1)	1.8 (0.9-3.0)	5.6 (1.5-10.4)	0.042 (0.030-0.050)	1.02 (0.8-1.29)	11 (1-23)