BC Lake Stewardship and Monitoring Program

Green Lake 2005 - 2007, 2009

A partnership between the BC Lake Stewardship Society and the Ministry of Environment

BRITISH COLUMBIA
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The Importance of Green Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics, and recreational opportunities. When these features are not apparent in our local lakes, people begin to wonder why. Concerns often include whether the water quality is getting worse, if the lake has been impacted by land development or other human activities, and what conditions will result from more development within the watershed.

The BC Lake Stewardship Society (BCLSS), in collaboration with the Ministry of Environment, has designed a program, entitled *The BC Lake Stewardship and Monitoring Program*, to address these concerns. Through regular water sample collections, we can come to understand a lake's current water quality, identify the preferred uses for a given lake, and monitor water quality changes resulting from land development within the lake's watershed. There are different levels of lake monitoring and assessment. The level appropriate for a particular lake depends on the funding and human resources available. In some cases, data collected as part of a Level I or II program can point to the need for a more in-depth Level III program. This report gives the 2005 - 2007 and 2009 results of a Level I program for Green Lake.

Looking towards Wedge Mountains (from Green Lake)

The BCLSS can provide communities with both lake-specific monitoring results and educational materials on general lake protection issues. This useful information can help communities play a more active role in the protection of the lake resource. Finally, this program allows government to use its limited resources efficiently with the help of local volunteers and the BCLSS.

A **watershed** is defined as the entire area of land that moves the water it receives into a common waterbody. The term watershed is misused when describing only the land immediately around a waterbody or the waterbody itself. The true definition represents a much larger area than most people normally consider.

Watersheds are where much of the hydrologic cycle occurs and play a crucial role in the purification of water. Although no "new" water is ever made, it is continuously recycled as it moves through watersheds and other hydrologic compartments. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution.

Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately surrounding a waterbody. Poor land use practices in a watershed can eventually impact the water quality of the downstream environment.

Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g. waste discharge outfalls, spills, etc). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alterations. However, modifications to the landscape and increased levels of pollution impair this ability.

Green Lake is located in the Coastal Mountain region and falls within Resort Municipality of Whistler boundaries. The lake has a surface area of 205.2 ha, shoreline perimeter of 10.9 km and lies at an elevation of 634 m. The average depth of Green Lake is 14.2 m, while the deepest spot is 40.2 m. Only about 20% of the lake is deeper than 20 m.

The inputs to Green Lake are three main creeks near the west end of the lake: Nineteen Mile Creek, Alta Creek, and Fitzsimmons Creek. The lake contains bull trout, kokanee, cutthroat trout, prickly sculpin, and rainbow trout (FISS, 2010). Locals also report the presence of stickleback (Burrows, 2010). Both kokanee and rainbow trout populations have been augmented with hatchery stocks. The lake is bound on the northeast side by Highway 99 and on the southwest side by the CN railway. There are two subdivisions along Green Lake, Emerald Estates along the northern edge and Nicklaus North at the southern tip. At Nicklaus North there is a golf course between residences and the lakefront. It is difficult to determine the number of year-round or strictly seasonal residents as Whistler often serves as a second home/vacation property for many and has a large transient community (Rebellato, 2005).

What's Going on Inside Green Lake?

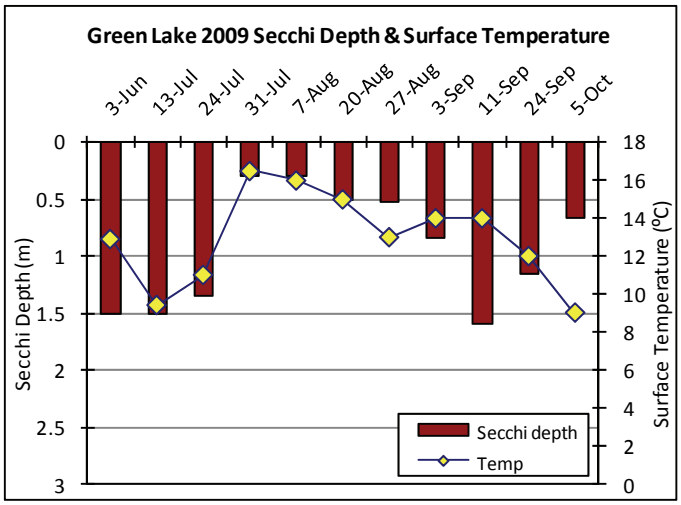
Temperature

Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water at the bottom. Because colder water is more dense, it resists mixing into the warmer upper layer for much of the summer. In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4 °C) near the bottom. These lakes are called dimictic lakes because they turn over twice per year. They are the most common type of lake in British Columbia. Green Lake is classified as a dimictic lake.

Coastal lakes in BC are more often termed warm monomictic lakes because they turn over once per year. These lakes have temperatures that do not fall below 4°C. Warm monomictic lakes generally do not freeze and circulate freely in the winter at or above 4°C, and stratify only in the summer.

Ice-on and ice-off dates for BC lakes are important data for climate change research. Local residents report that Green Lake freezes every year and have been submitting ice on and off dates to the BCLSS office since 2004. By comparing these dates to climate change trends, we can examine how global warming is affecting our lakes.

Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. Surface temperature helps to determine much of the seasonal oxygen, phosphorus, and algal conditions.



Surface temperature and Secchi depth (water clarity) were measured on Green Lake from 2005 to 2007 and in 2009. The adjacent graph illustrates the 2009 Secchi and temperature data for Green Lake from June to October. The maximum surface temperature was 16.5°C (Jul. 31st) and the minimum surface temperature was 9.0°C (Oct. 5th). The maximum surface temperatures measured in 2005, 2006 and 2007 were 16.2°C (Jun. 23rd), 15.6°C (Aug. 21st & 23rd), and 14.3°C (Aug. 28th), respectively. Minimum surface temperatures were 10.0°C (Jul. 7th), 8.2°C (May 9th), and 8.5°C (Jul. 20th) in 2005, 2006 and 2007, respectively. It is important to note that the data were not evenly spaced from spring overturn (immediately following ice-off) through early fall in 2006, 2007, and 2009. For this reason, the data collected in those years may not accurately represent fluctuations in water clarity and surface temperature throughout the season. Additionally, surface temperatures can be influenced by seasonal climate variation and glacial melt.

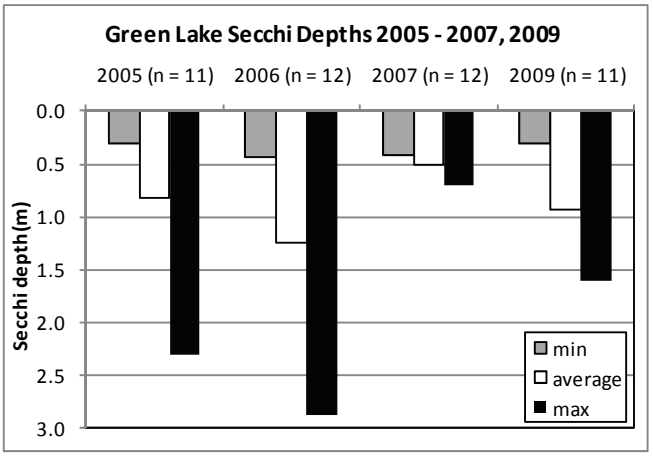
Trophic Status and Water Clarity

The term *trophic status* is used to describe a lake's level of productivity and depends on the amount of nutrients available for plant growth, including tiny floating algae called phytoplankton. Algae are important to the overall ecology of the lake because they are food for zooplankton, which in turn are food for other organisms, including fish. In most lakes, phosphorus is the nutrient in shortest supply and thus acts to limit the production of aquatic life. When in excess, phosphorus accelerates growth and may artificially age a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities.

Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels, sparse plant life and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life because of higher nutrient levels. Lakes with an intermediate productivity are called ***mesotrophic*** and generally combine the qualities of oligotrophic and eutrophic lakes.

One measure of productivity is water clarity. The more productive a lake, the higher the algal growth and, therefore, the less clear the water becomes. The clarity of the water can be evaluated by using a Secchi disc, a 20 cm diameter black and white disc that measures the depth of light penetration.

Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. In general, as temperatures increase during the summer months, Secchi depth decreases. As the temperature of the lake increases, so do some species of algae. Due to the increase in algae, the water clarity can decrease. This general trend can be observed in the 2009 data (above graph), however previous water quality reports on Green Lake mention that there are large water inputs and suspended fine sediments originating from the glacial headwaters of Fitzsimmons Creek, that contribute to high turbidity, and therefore low Secchi readings, during the summer months (McKean & Nordin 1982, Schiefer 2004).



The graph on the right illustrates the minimum, average and maximum Secchi readings from 2005 to 2007 and 2009, as well as the number of readings taken each year (n). The maximum reading for all sampling years, 2.9 m, occurred on May 9th, 2006. The lowest Secchi depth, 0.3 m, was measured several times in

2005: Aug. 4th & 22nd, and Sep. 8th & 18th, and in 2009: Jul. 31st and Aug. 7th. The average Secchi readings for Green Lake ranged from 0.5 m (2007) to 1.2 m (2006). Based on these Secchi values, Green Lake was exhibiting eutrophic conditions, however Schiefer (2004) notes that Secchi depths for Green Lake are greatest (deepest) during early spring and fall, and in 2005, 2007 and 2009 spring sampling was missed. McKean & Nordin (1982) note that phosphorus levels are high in Green Lake due to these large water and suspended fine sediment inputs. Despite these high levels of phosphorus, Green Lake experiences low productivity of plankton due to the high turbidity levels that reduce sunlight penetration in the summer, and thus retains its oligotrophic status (McKean & Nordin, 1982).

The flushing rate, another factor that affects water quality, is the rate of water replacement in a lake and depends on the amount of inflow and outflow of a lake. The higher the flushing rate, the more quickly excess nutrients can be removed from the system. McKean and Nordin (1982) estimate the flushing rate of Green Lake to be very high at 9 times per year.

Dissolved Oxygen

Oxygen is essential to life in lakes. It enters lake water from the air by wind action and also through plant photosynthesis. Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels. Lakes that are less productive (oligotrophic) typically will have sufficient oxygen to support life at all depths throughout the year. The dissolved oxygen (DO) profiles (0 - 15 m) for Green Lake show that temperature and DO are uniform throughout the sampled depths and that DO is high in the top 15 m of water column. For example, on July 30, 2007, DO was 11.7 mg/L at the surface and 11.6 mg/L at 15 m, and temperature was 12.2 °C at the surface and 11.7 °C at 15 m. This reinforces the oligotrophic status as there is little phytoplankton growth, resulting in minor decomposition and, therefore, little oxygen demand. The profiles for all sample dates are similar, with uniform DO and temperature, indicating that Green Lake did not stratify, likely due to the large inflows throughout the summer.

Land Use and Pollution Sources

Generally, point source pollution originates from municipal or industrial effluent outfalls. Other pollution sources exist over broader areas and may be hard to isolate as distinct effluents. These are referred to as non-point sources of pollution (NPS). Shoreline modification, urban stormwater runoff (which may contain contaminants such as: fertilizers from golf courses, lawns and gardens, road salt, or oil and fuel leaks), onsite septic systems, agriculture, and forestry are common contributors to NPS pollution.

With a golf course situated on the edge of Green Lake and the lake being bound by a highway on one side and railroad track on the other, there is potential for impact on Green Lake due to land uses. To minimize other potential impacts, local residents are encouraged to ensure their septic systems are up to standard and that their land use activities are following good environmental practices. Further information can be found on the following page.

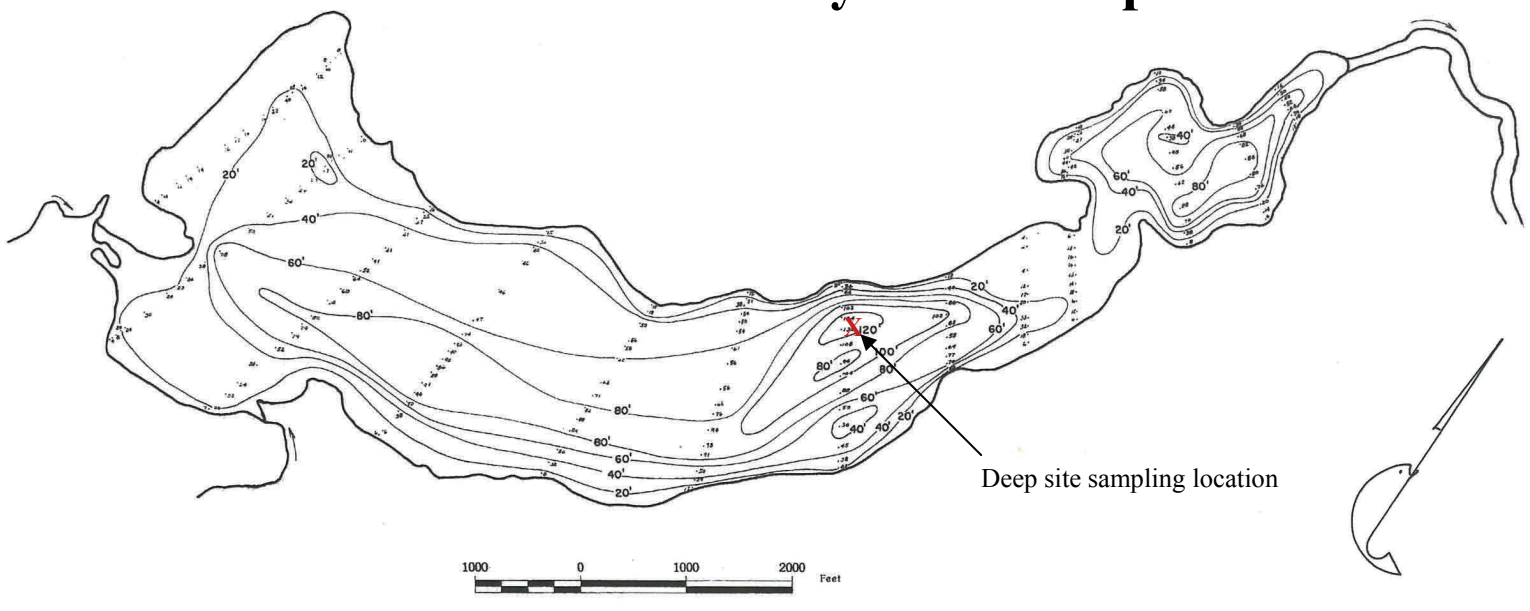
Should Further Monitoring be Done on Green Lake?

The data collected on Green Lake from 2005 to 2007 and in 2009 indicates fluctuation due to inputs of glacial flour and sediments from tributary streams. Dissolved oxygen/temperature profiles taken from 2005 - 2007 indicate the lake remains well-mixed during the sampling season, with high oxygen levels throughout the water column. This, combined with little phytoplankton growth, suggests oligotrophic conditions. Low Secchi readings are likely due to large water inputs and high volumes of fine sediments from glacial headwaters.

If volunteers are willing to continue monitoring Green Lake, a minimum of twelve Secchi and surface temperature readings taken at evenly spaced intervals during the spring, summer and early fall will provide valuable data. Long-term collection of Secchi and surface temperature data could help identify early warning signs should there be a deterioration in water quality.

Temperature data is also valuable for climate change studies. As well, freeze-up and break-up of ice should continue to be recorded for climate change studies.

Green Lake Bathymetric Map



Tips to Keep Green Lake Healthy

Onsite Sewage Systems

- Inspect your system yearly, and have the septic tank pumped every 2 to 5 years by a septic service company. Regular pumping is cheaper than having to rebuild a drain-field.
- Use phosphate-free soaps and detergents.
- Do not put toxic chemicals (paints, varnishes, thinners, waste oils, photographic solutions, or pesticides) down the drain because they can kill the bacteria at work in your on-site sewage system and can contaminate waterbodies.
- Conserve water: run the washing machine and dishwasher only when full and use only low-flow showerheads and toilets.

Yard Maintenance, Landscaping and Gardening

- Minimize the disturbance of shoreline areas by maintaining natural vegetation cover.
- Minimize high-maintenance grassed areas.
- Replant lakeside grassed areas with native vegetation. Do not import fine fill.
- Use paving stones instead of pavement.
- Stop or limit the use of fertilizers and pesticides.
- Do not use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.
- Do not apply fertilizers or pesticides before or during rain due to the likelihood of runoff.
- Hand pull weeds rather than using herbicides.
- Use natural insecticides such as diatomaceous earth. Prune infested vegetation and use natural predators to keep pests in check. Pesticides can kill beneficial and desirable insects, such as ladybugs, as well as pests.
- Compost yard and kitchen waste and use it to boost your garden's health as an alternative to chemical fertilizers.
- Pick up after your pets, as pet waste can lead to bacterial contamination of lake water.

Boating

- Do not throw trash overboard or use lakes or other water bodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals
- Conduct major maintenance chores on land.
- Keep motors well maintained and tuned to prevent fuel and lubricant leaks.
- Use absorbent bilge pads for minor leaks or spills.
- Recycle used lubricating oil and left over paints.
- Check for and remove all aquatic plant fragments from boats and trailers before entering or leaving a lake.
- Do not use metal drums in dock construction. They rust, sink and become unwanted debris. Use blue or pink closed -cell extruded polystyrene billets or washed plastic barrel floats. All floats should be labelled with the owner's name, phone number and confirmation that barrels have been properly maintained.

Who to Contact for More Information

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Acknowledgements

Volunteer Monitoring by:
Karen and Chuck Blaylock

Data Compiling by:
Kristi Carter

Brochure Produced by:
Kristi Carter
BC Lake Stewardship Society

Photo Credit:
www.sharphooks.com

Bathymetric Map:
Fish Wizard (www.fishwizard.com)