B.C. Volunteer Lake Monitoring Program

SUMMIT LAKE 1998 - 2000

The Importance of Summit Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunity. When we don't see these features in our local lakes, we want to know why. Is water quality getting worse? Has the lake been polluted by land development? What uses can be made of the lake today? And, what conditions will result from more development within the watershed?

The Ministry's Volunteer Lake Monitoring Program (VLMP), in collaboration with the non-profit B.C. Lake Stewardship Society, is designed to help answer these questions. 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.

Through regular status reports, the VLMP can provide communities with monitoring results specific to their local lake and with educational material on lake protection issues in general. This useful information can help communities play a more active role in the protection of the lake resource. Finally, the VLMP allows government to use its limited resources efficiently thanks to the help of area volunteers and the B.C. Lake Stewardship Society.

Summit Lake's VLMP program began in 1998 and was conducted by resident volunteers of Summit Lake. This status report summarizes information derived from the 1998 to 2000 sampling programs. Quality of the data has been found to be acceptable. Data quality information is available on request.

A **watershed** is defined as the entire area of land that moves the water it receives to 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. Summit Lake's watershed is shown on the next page.

Watersheds are where much of the ongoing hydrological cycle takes place and play a crucial role in the purification of water. No "new" water is ever made - water is only cleansed through its continuous natural recycling in watersheds. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution.

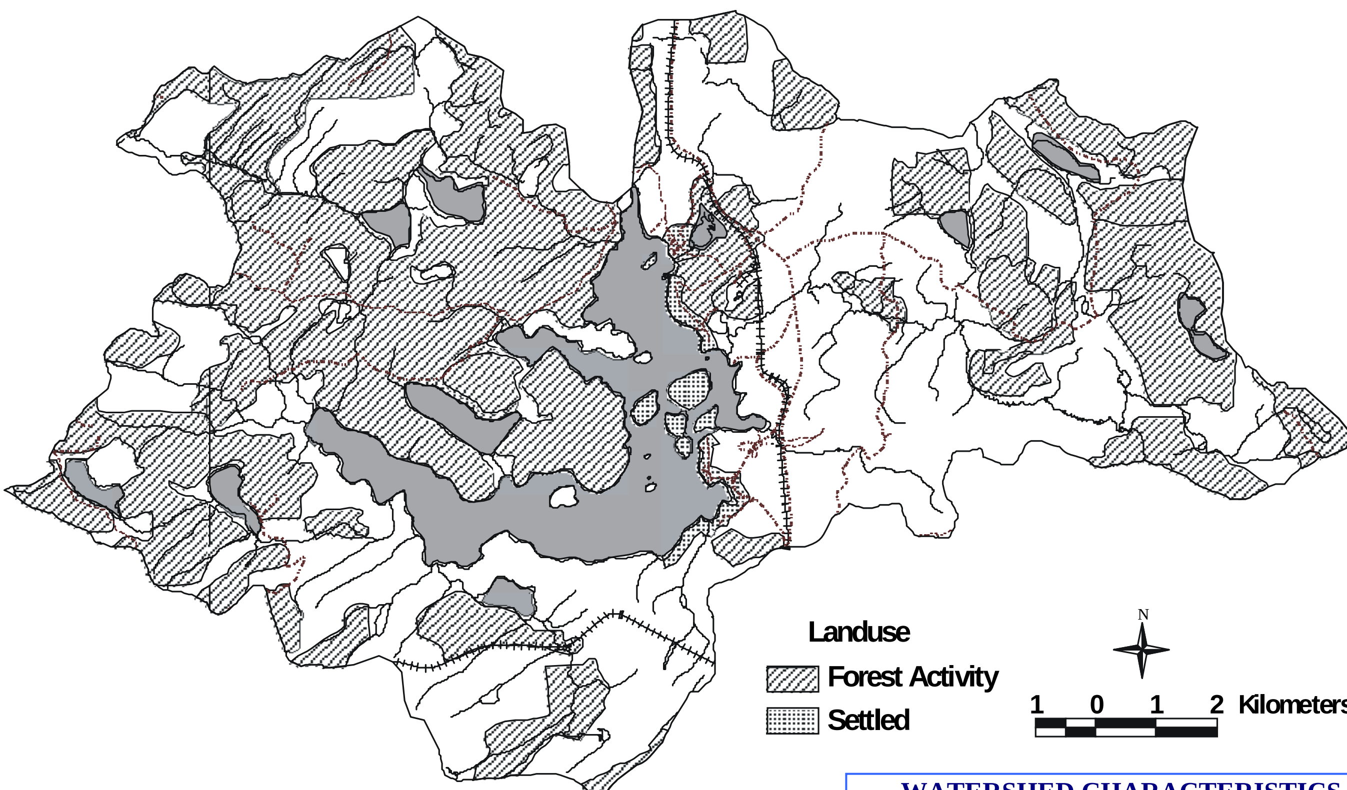
Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately surrounding a water body. Poor land-use practices anywhere 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. outfalls, spills, etc.). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alteration. However, modifications to the landscape and increased levels of pollution impair this ability.

Summit Lake is located… in the Omineca-Peace region near Hwy 97, 50 km north of Prince George, B.C.. This U-shaped lake is roughly 12 km long, with a complex shoreline, several islands and three basins. Maximum lake depth is 16 m. Its surface area is 1384 hectares and it has a shoreline perimeter, including islands, of 53.5 km. The lake contains the following sport fish: rainbow trout *(Oncorhynchus mykiss)*, mountain whitefish (Prosopium williamsoni), lake whitefish *(Coregonus clupeaformis)*, lake char *(Salvelinus namaycush)* and bull trout *(Salvelinus confluentus)*. Extensive surveys for northern pike (*Esox lucius*) have determined that the species does not inhabit the lake. Refer to http://www.FishWizard.com for more Summit Lake mapping information.

Land use in the watershed includes some 175 residential lakeshore lots, 139 of which are currently developed. Forest harvesting is also conducted. Roughly 16 of the residences are believed used on a full time basis. It is thought that 42 residences use surface water as a potable supply. The lake is used for general recreational purposes and provides good public access. Two forestry camps and one scout camp exist on shore. Summit is also the most southerly lake in the arctic drainage along Hwy 97. The greatest challenge to the lake is likely the control of phosphorus (nutrient) loading, which can promote summer algal blooms and the spread of aquatic plants. However, no reports of algal blooms or aquatic plant problems exist in B.C. Environment files. The aquatic plant *Elodea canadensis* (canadian pondweed) has not been identified in the lake. Some extensive areas of aquatic vegetation were noted during a 1979 fisheries inventory and several residents believe aquatic plant numbers are increasing.

Summit Lake Watershed and Land Use Map



THEORETICAL PHOSPHORUS SUPPLY

Spring Overturn TP (ug/L):	18
Sedimentation Rate Coefficient:	(0.5)
Flushing Rate (#/yr):	0.51
Yearly P Loading (gm/m^2/yr):	0.116

WATERSHED CHARACTERISTICS

Area: 158 km^2

Percent Land Usage:

1.5 % Residential (Settled)

42.8 % Forest Activity

0.1 % Mining

Non Point Source Pollution and Summit Lake

"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, onsite septic systems, agriculture and forestry are common contributors to NPS pollution. One of the most detrimental effects of NPS pollution is phosphorous loading to water bodies.** The amount of total phosphorus (TP) in a lake can be greatly influenced by human activities. If local soils and vegetation do not retain this phosphorus, it will enter watercourses where it will become available for algal production.

Onsite Septic Systems and Grey Water

Onsite septic systems effectively treat human waste water and wash water (grey water) as long as they are properly located, designed, installed, and **maintained**. When these systems fail they become significant sources of nutrients and pathogens. Poorly maintained pit privies, used for the disposal of human waste and grey water, can also be significant contributors.

Boating

Oil and fuel leaks are the main concerns of boat operation on small lakes. With larger boats, sewage and grey water discharges are issues. Other problems include the spread of aquatic plants and the dumping of litter. In shallow water operations, the churning up of bottom sediment and nutrients is a concern.

Forestry

Timber harvesting can include clear cutting, road building and land disturbances which alter water flow and increase sediment and phosphorous inputs to water bodies.

Stormwater Runoff

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles and boats, road salt, and litter can all be washed by rain and snowmelt from properties and streets into watercourses. Phosphorus and sediment are of greatest concern, providing nutrients and/or rooting medium for aquatic plants and algae. Pavement prevents water infiltration to soils, collects hydrocarbon contaminants during dry weather and increases direct runoff of these contaminants to lakes during storm events.

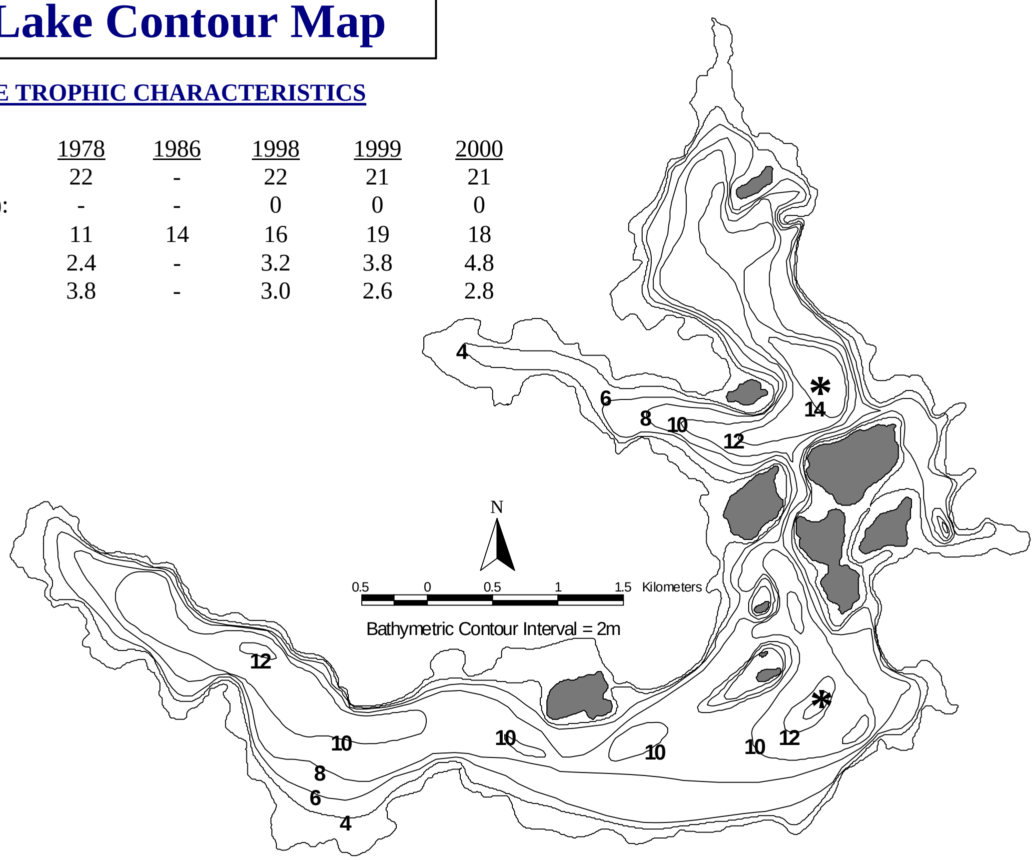
Summit Lake Contour Map

SUMMIT LAKE TROPHIC CHARACTERISTICS

	1978	1986	1998	1999	2000
Max. Surface Temp (°C):	22	-	22	21	21
Min. Near-bottom Oxygen (mg/L):	-	-	0	0	0
Spring Overturn TP (ug/L):	11	14	16	19	18
Avg. Chlorophyll a (ug/L):	2.4	-	3.2	3.8	4.8
Avg. Secchi Depth (m):	3.8	-	3.0	2.6	2.8

LAKE CHARACTERISTICS

Area: 1 384 ha
Volume: 89 006 000 m^3
Maximum Depth: 16 m
Mean Depth: 6.4 m
Shoreline Length: 53. 5 km
Elevation: 706 m
* = water quality sampling sites



What's Going on Inside Summit Lake?

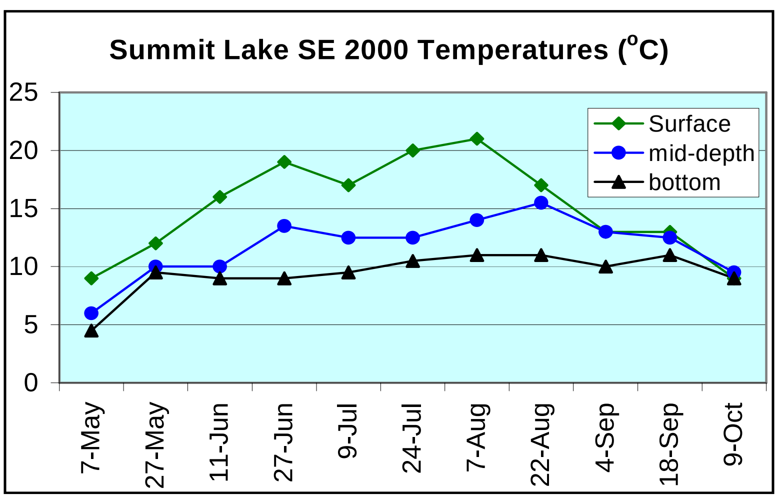
Temperature

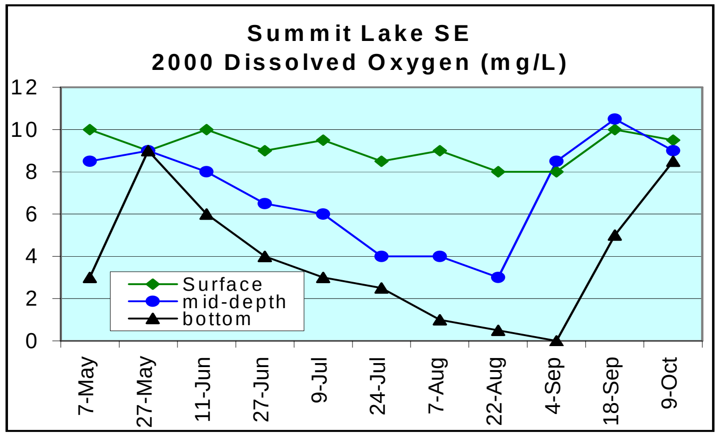
Lakes show a variety of annual temperature patterns based on each lake's location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because colder water is denser, it resists mixing into the warmer, upper layer for much of the summer. In spring and 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 most dense water (4°C) near the bottom.

Lakes of only a few metres depth tend to mix throughout the summer or layer only temporarily, depending on wind conditions. In winter, the temperature patterns of these lakes are similar to deeper lakes.

Temperature stratification patterns are very important to lake water quality. They determine much of the seasonal oxygen, phosphorus and algal conditions. When abundant, algae can create problems for most lake users.

The figure below illustrates Summit Lake's southeast basin temperature patterns for 2000. The north and SE basins displayed similar patterns in both 1999 and 2000. Given its moderate depth the lake did stratify each year, usually in early May. Surface temperatures were at least 2 ^{o}C lower than in 1998 over most of the summer. Greatly reduced (and below normal) hours of daily sunshine, air temperatures that averaged 3 ^{o}C cooler and wind speeds 1 km/h higher than 1998 were the likely causes. The maximum temperature at surface did reach 21 ^{o}C in the SE basin. Shorter days and cooling air temperatures through September caused a loss of stratification by October 9th of each year, leaving water temperature nearly uniform with depth.





Dissolved Oxygen

Oxygen is essential to life in lakes. It enters lake water from the air by wind action and 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 unproductive (oligotrophic) will have sufficient oxygen to support life at all depths through the year. But as lakes become more productive (eutrophic), and increasing quantities of plants and animals respire and decay, more oxygen consumption occurs, especially near the bottom where dead organisms accumulate.

In productive lakes oxygen in the isolated bottom layer may deplete rapidly (often to anoxia), forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 20% saturation). Fish kills can occur when decomposing or respiring algae use up the oxygen. In summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing.

The figure above shows the oxygen patterns of the SE basin for 2000, which are comparable to the N basin and to both basins in 1999. Surface water oxygen remained near saturation, not dropping below 8 mg/L. Both basins displayed gradual declines in mid-depth and bottom oxygen to 3 and 0 mg/L, respectively. Bottom anoxia would not support fish and facilitated phosphorus release from bottom sediments (as in 1998). It was reached later and existed for a shorter period than in 1998 (two versus eight weeks). This was likely due to the lower number of sunlight hours experienced in 1999 and 2000. Increased wind speed may also have been a factor. Oxygen saturation was regained by October 9th.

What's Going on Inside Summit Lake?

Trophic Status and Phosphorus

The term "trophic status" is used to describe a lake's level of productivity and depends on the amount of nutrient available for plant growth, including tiny floating algae called phytoplankton. Algae are important to the overall ecology of a 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. As mentioned earlier (page 3), total phosphorus (TP) in a lake can be greatly influenced by human activities.

The trophic status of a lake can be determined by measuring productivity. The more productive a lake is the higher the algal growth and therefore the less clear the water becomes. Water clarity is measured using a ***Secchi disc***. Productivity is also determined by measuring nutrient levels and ***chlorophyll*** (the green photosynthetic pigment of algae). Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity.

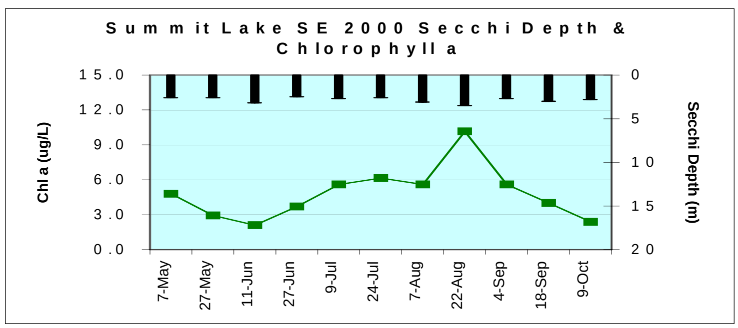
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels, sparse plant life, and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life, including algae, because of higher nutrient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

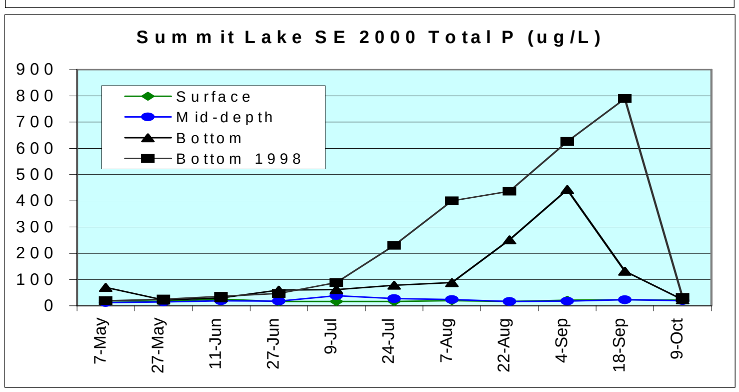
Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This "internal loading" of phosphorus can be natural but is often the result of phosphorus pollution. Lakes displaying internal loading have elevated algal levels and may lack recreational appeal.

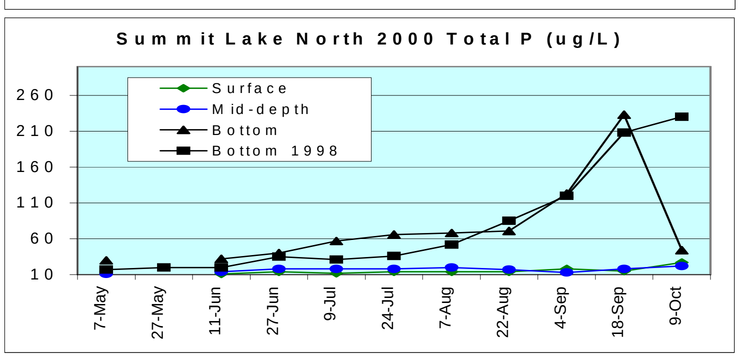
Summit Lake spring overturn TP levels (page 3) have remained fairly stable in recent years (18 ug/L) **but do suggest a shift from oligotrophy to mesotrophy since 1978** (11 ug/L), implying increased summer algal growth and declining water quality. Algal chlorophyll data mirror these results, with averages increasing from 2.4 ug/L in 1978 to a recent three year average of 3.9 ug/L. Average Secchi depths responded, declining from 3.8 m to 2.8 m for the same period. The two lake basins produced similar average chlorophyll levels and Secchi readings in 2000.

For each year and lake basin Secchi readings (water clarity) do not correspond well with a fairly consistent chlorophyll pattern (see figure below). Summit Lake's natural brown colour may have affected the reliability of Secchi readings.

The latter diagrams below display 2000 total phosphorus cycling in Summit Lake. Whereas near bottom internal loading occurred each year and peaked in September, concentrations were variable for both site and year. Total phosphorus near bottom in the SE basin increased from 20 to 440 ug/L in 2000 versus a peak of 790 ug/L in 1998. This phosphorus is brought to surface during September mixing, where it can promote the growth of algae. Internal loading on Summit Lake is related to the duration of deep water anoxia (see page 4), itself likely dependent on hours of sunshine, and so could be variable from year to year. The North basin did not display the same sort of variability in bottom phosphorus between 1998 and 2000, and produced much lower concentrations overall. Reasons for this are unknown but may be related to the greater number and older history of housing developments in the South East basin.







Problems and Solutions

Lake Coring; What does it Mean?

The Summit Lake VLMP was initiated well after local land development and possible impacts to the lake began. So, although this monitoring program can accurately document current lake quality, it cannot reveal historical "baseline" conditions or long term water quality trends. Here lies the value in coring lake sediments. Past changes in water quality can be inferred by studying the annual deposition of algal cells on the lake bottom.

Summit Lake was cored and sectioned by BC Environment in 1999. The 39 cm, 300 year core was analysed by Dr. Brian Cummings of Queen's University. His report is available on request.

Historical changes in relative abundance of diatom algae were measured directly by microscopy. By knowing the age of various core sections and the phosphorus preference of the specific algae types in each section, historical changes in lake phosphorus, chlorophyll, and water clarity can be estimated.

The core indicates that Summit Lake has undergone only minor changes in types and amount of diatom algae, and has maintained a relatively low estimated phosphorus concentration, over the past 200 years. Increases did occur to many sediment metal concentrations circa 1950, perhaps as a result of completing and using the Hart Highway.

Lakeshore Land Use Survey of Summit Lake

In 1999, BC Environment commissioned a photo survey of lakeshore development practices that may impair Summit Lake water quality. The following table summarizes the findings, the related problems and solutions. Pollution Prevention Branch may correspond directly with a number of property owners, requesting that alternatives designed to limit aquatic impairment be undertaken. **All residents should consider the potential impacts of their land use practices.**

LAND USE	IMPACT	ALTERNATIVE
Riparian Clearing (removing natural vegetation within 15 m of the lake) **49% Of Properties**	Reduces terrestrial nutrient uptake leading to **increased uptake and growth by aquatic plants and algae.** Fertilizers can increase toxins and nutrients. Increases erosion and bank instability. Disrupts fish habitat and production.	Practice strategic clearing for partial view and pathway to lakeshore, rather than "clean-sweep" approach. Leave patches or strips of native plants. Leave or add vegetation between septic fields or pit privies and the lakeshore to increase the uptake of nutrients before they reach the water. Disturbed areas within the riparian zone should be revegetated as soon as possible with native species such as alder, black cottonwood, willow and red-osier dogwood. The use of fertilizers should be avoided.
Outhouse (30 m or less from lake) **&** **Cabin** (within 15 m of the lake) **Encroachment** **7%**	**Increases the rate of erosion, nutrient loading and fecal bacterial loading to water.** Reduces foreshore vegetation cover, damaging habitat and water quality. Lakeshore view is often altered and left undesirable for other lake users.	Lots should be clustered together in an area away from the shoreline to increase the amount of shoreline available for common use and for habitat conservation. During construction, all debris should be kept away from the water. Cabins should be a minimum of 15 m from the lakeshore and outhouses 30-60 m, depending on soil type and depth to water table. This will allow for maximum foreshore area and natural vegetation, reducing the rate of erosion and nutrient loading. Natural vegetation should be replanted as soon as possible.
Breakwaters (Concrete, Cobble or Pressure treated wood) **and Beach Creation** **17%**	Fill may erode, covering natural lake substrate **with fine textured rooting medium for aquatic plants.** It may also promote algae. Impacts fish habitat, migration and feeding.	Build a small dock for swimming and lake access. Use public beaches for swimming. Do not construct beaches or import fill within 15 m of the shore. If adding fills outside the 15 m buffer, the fill should be low in phosphorus and should be placed in a manner which minimizes erosion. It is best to avoid fills and breakwaters whenever possible. Maintain natural soils and vegetation for soil stability and nutrient uptake.

SUMMARY

Recent VLMP and sediment coring results suggest that Summit Lake has a fair to good recreational water quality that has remained relatively stable over past decades of watershed development. A three year sampling program should be repeated in five to ten years, depending on volunteer availability and Ministry resources. Regardless, all residents and land developers within the watershed are advised to practice good land management such that nutrient or sediment addition to the lake and its tributaries are minimized.

Household Tips to Keep Summit Lake Healthy

Yard Maintenance, Landscaping & 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.
- Don't 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.

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.
- Don't 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 onsite 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.

Boating

- Do not throw trash overboard or use lakes or other waterbodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
- Conduct major maintenance chores on land.
- Use 4 stroke engines, which are less polluting than 2 stroke engines, whenever possible. Use an electric motor where practical.
- Keep motors well maintained and tuned to prevent fuel and lubricant leaks.
- Use absorbent bilge pads to soak up minor oil and fuel 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 styrofoam or washed plastic barrel floats. All floats should be labeled with the owner's name, phone number and confirmation that barrels have been properly emptied and washed.

Auto Maintenance

- Use a drop cloth if you fix problems yourself.
- Recycle used motor oil, antifreeze, and batteries.
- Use phosphate-free biodegradable products to clean your car. Wash your car over gravel or grassy areas, but not over sewage systems.

Who to Contact for More Information

Ministry of Water, Land and Air Protection
Contact: Bruce Carmichael
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Derek Smith (On-site Sewage)
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The BC Lake Stewardship Society
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