B.C. Volunteer Lake Monitoring Program

WEST (NADSILNICH) LAKE
1994, 1995 and 2002

The Importance of West 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 of Environment'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.

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. West Lake's watershed, shown on the next page, is 208 square kilometers.

Watersheds are where much of the ongoing hydrological cycle takes place and play a crucial role in the purification of water. Although no "new" water is ever made, it is continuously cleansed and 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.

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.

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 down stream environment.

West Lake's VLMP program began in 1994 and was continued in 2002 by the West Lake Volunteer Water Testing Group. This status report summarizes information derived from this program and compares it to government data from throughout the 1980s and 1990s. Quality of the data has been found to be acceptable. Data quality information is available on request.

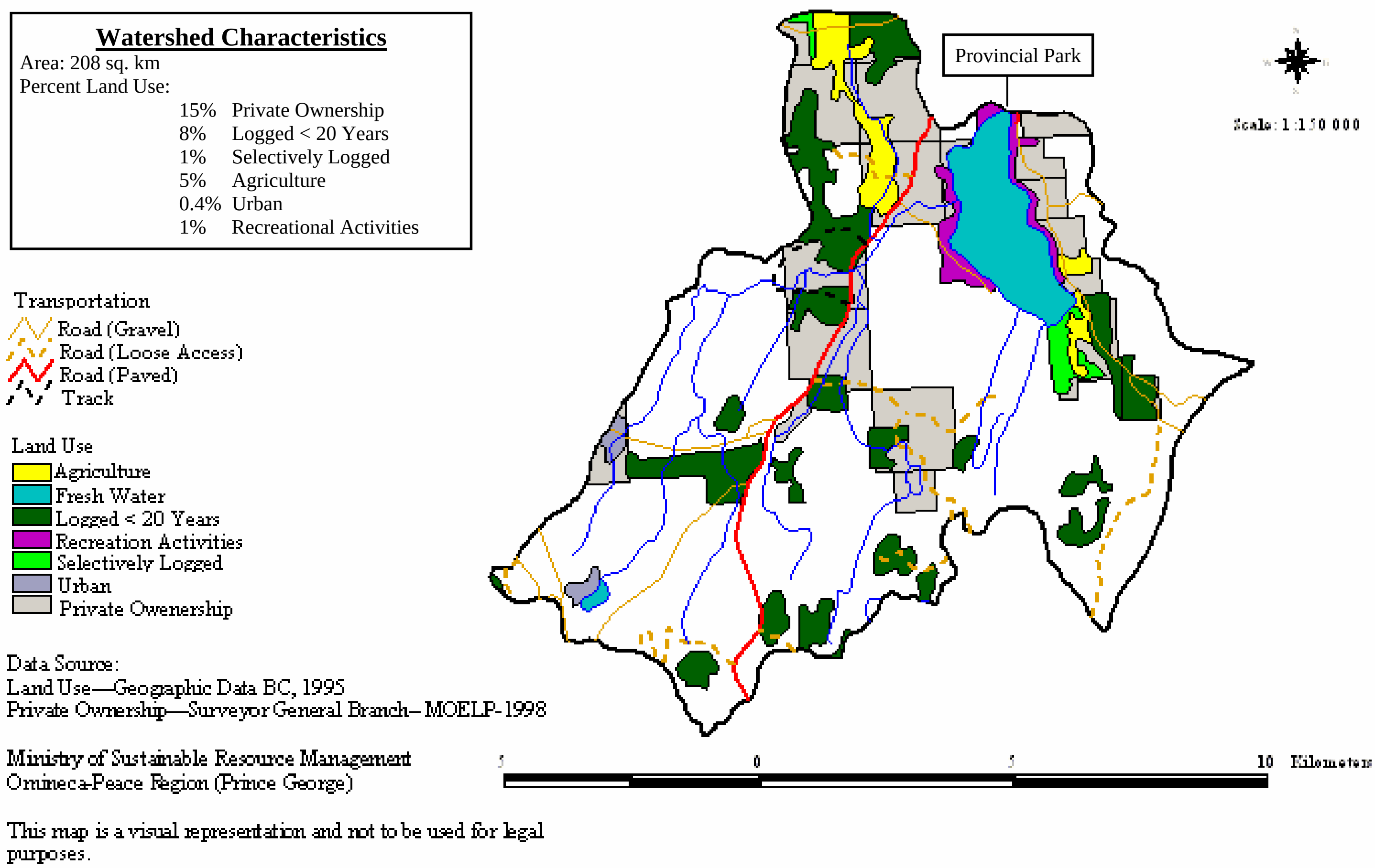
Human activities that impact water bodies range from small but widespread and numerous "non-point" sources throughout the watershed to large "point" sources of concentrated pollution (e.g. outfalls, spills, etc.). Undisturbed watersheds have the ability to purify water and repair small amounts of damage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

West Lake is located...in the Omineca Peace region approximately 20 km southwest of Prince George, B.C. This lake is roughly 5.75 km long, with maximum and mean depths of 15.2 m and 7.9 m, respectively. Its surface area is 5.03 km^2 and it has a shoreline perimeter of 10.7 km. The map below shows the West Lake watershed and its associated land use practices. It is believed that land use practices in the West Lake watershed are integral to the health of the lake. The close proximity of West Lake to Prince George likely has an influence on water quality, as the lake is a highly popular recreational area.

West Lake contains the following sport fish: rocky mountain whitefish (*Prosopium williamsoni)*, rainbow trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), and burbot (*Lota lota*). The largest tributary entering West Lake is St. George Creek, where significant natural rainbow trout reproduction occurs every year. Because of heavy fishing pressure and popularity on the lake, there is also an annual stocking of rainbow trout additional to the natural reproduction.

Land use within the watershed includes lakeshore development (approximately 110 private residential lots), recreation (including a Provincial Park), forestry and agriculture. The lake has good public access and is used for general recreational purposes by residents of West Lake and surrounding communities. The greatest challenge to lake management is likely the control of phosphorus (nutrient) loading. This loading promotes summer algal blooms and the spread of aquatic plants. Reports exist in Ministry files of aquatic plant infestations, with *Elodea canadensis* being the dominant species. A survey by the Ministry in 1996 also found this species covering much of the littoral area of West Lake Park. This species may have been a local introduction, and may still be spreading throughout the lake. There have also been reports of algal blooms with the *Oedogonium sp*. and an unidentified Blue Green Algae (cyanobacteria) species being the most noted. Complaints regarding sewage discharge to the lake are also on file, as well as concerns with the modified outlet. There is possibility that this outlet may affect the natural flushing rate of the lake, with potential to retain excess nutrients that may now be available for summer algal production.

West Lake Watershed and Land Use Map



Non-Point Source Pollution and West 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 phosphorus 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.

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.

Tree Harvesting

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

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 litter, the spread of aquatic plants, and the churning up of bottom sediments and nutrients in shallow water operations.

West Lake Contour Map

THEORETICAL PHOSPHORUS SUPPLY

Spring Overturn TP (ug/L): 38.9
Sedimentation Rate Coefficient: (0.55)
Flushing Rate (#/yr): 0.21
Yearly P Loading (gm/m^2/yr): 2.34

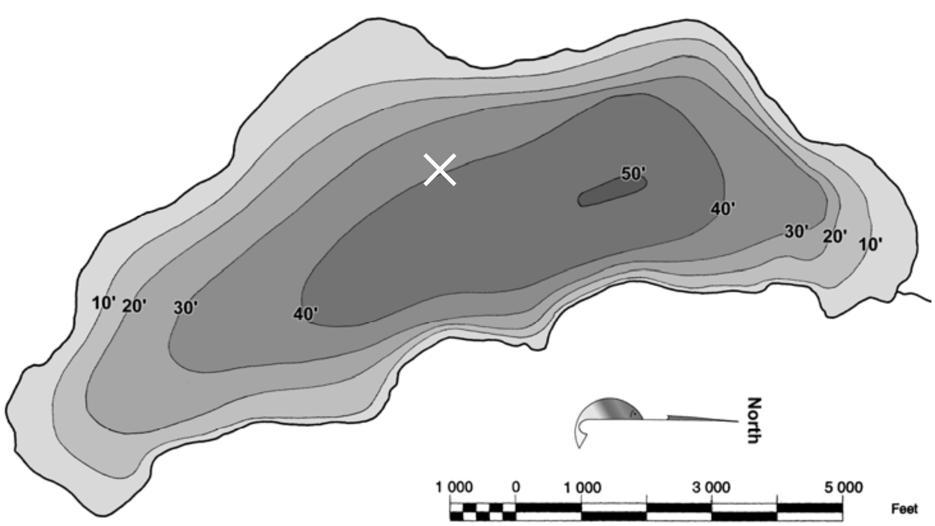
WEST LAKE TROPHIC CHARACTERISTICS

	1985	1987	1990	1991	1994	1995	2002
Max. Surface Temp (°C):					24		21
Min. Near-bottom Oxygen (mg/L):					0.4		1
Spring Overturn TP (ug/L):	**37.7**	**43.0**		**45.7**	**29.3**		
Avg. Chlorophyll a (ug/L):			6.04	5.81	5.08	3.68	4.93
Avg. Secchi Depth (m):			3.22	2.97	3.4		3.42

LAKE CHARACTERISTICS

Area: 5.03 km^2
Volume: 40,500,000 m^3
Max. Depth: 15.2 m
Mean Depth: 7.9 m
Shoreline Length: 10.7 km
Elevation: 610 m
X = water quality sampling site

mg/L = 1 part per million
ug/L = 1 part per billion



What's Going on Inside West Lake?

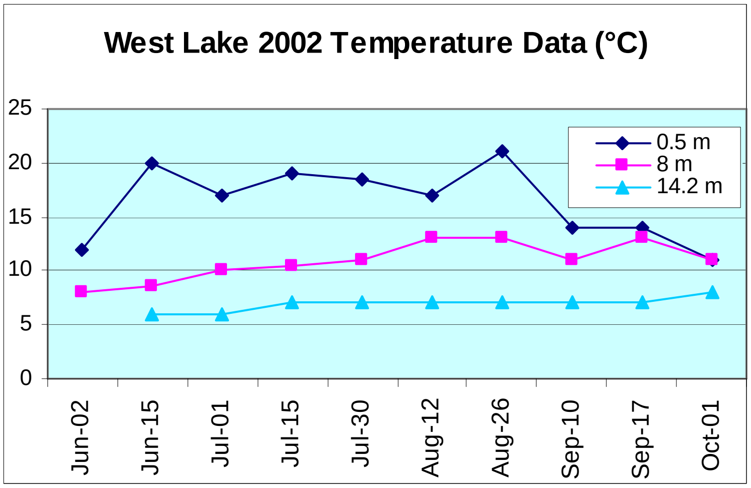
Temperature

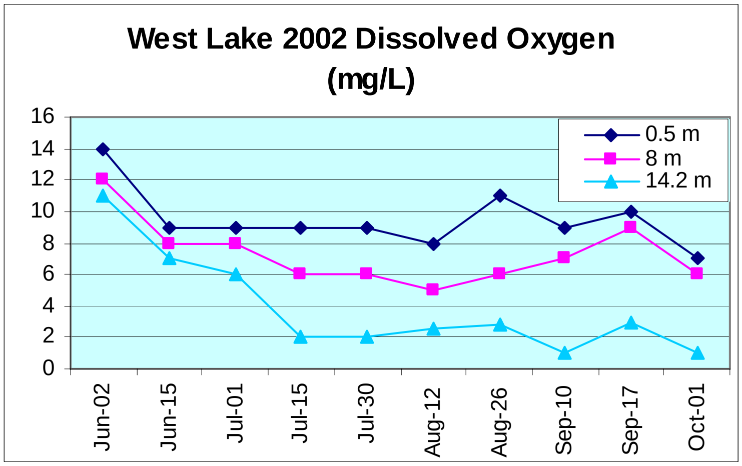
Lakes show a variety of annual temperature patterns based on each lake's location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because colder water is denser, it resists mixing into the warmer, upper layer for much of the summer. In spring and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

Temperature was measured in the deep station of West Lake during 2002. The lake appears to stratify in early May, which is indicated by data collected in previous years. The lake had already stratified by June 2nd, the first day of sampling in 2002 by the VLMP. This stratification appears to hold throughout the summer, indicating a strong temperature/density gradient between the water layers. This strong gradient is due to the depth of the lake, as the deeper water is less affected by strong wind activity and water turbulence which do affect stratification patterns in shallow lakes. The maximum surface temperature, reached by late August, was 21 ^{o}C. Shorter days and cooling air temperatures through September caused a loss of lake stratification, leaving the water temperature nearly uniform with depth, and decreasing water temperatures throughout late fall.





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 - no oxygen), 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 for West Lake in 2002. Surface water oxygen remained near saturation for most of the summer and fall, only dropping to 7 mg/L on the October 1st sampling date. Oxygen concentrations differed between the three sample depths for most of the summer, likely due to the stratification within the lake. Bottom water oxygen levels dropped significantly throughout the summer, with lows of 1 mg/L on more than one occasion. This is consistent with oxygen data collected in previous years. This bottom anoxia existed for approximately three months, which would likely void the zone of fish. Fish are not usually found in waters with less than 4 mg/L of oxygen. These prolonged low oxygen levels also contribute to internal phosphorus loading within the lake (refer to page 5). Vertical mixing and the aeration of bottom waters occurred with the onset of cooler fall temperatures. This is not seen in the 2002 profile, however does occur during late October of previous years.

What's Going on Inside West 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 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. As mentioned earlier (page 3), total phosphorus (TP) in a lake can be greatly influenced by human activities.

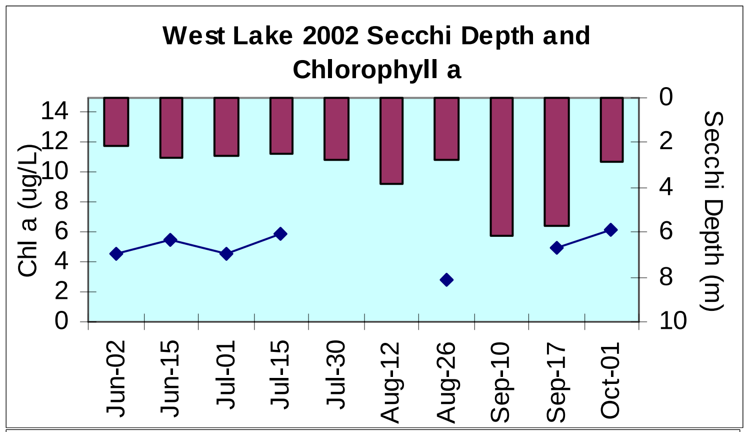
The trophic status of a lake can be determined by measuring productivity. The more productive a lake is the higher the algal growth and therefore the less clear the water becomes. Water clarity is measured using a ***Secchi disc***. Productivity is also determined by measuring nutrient levels and ***chlorophyll***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

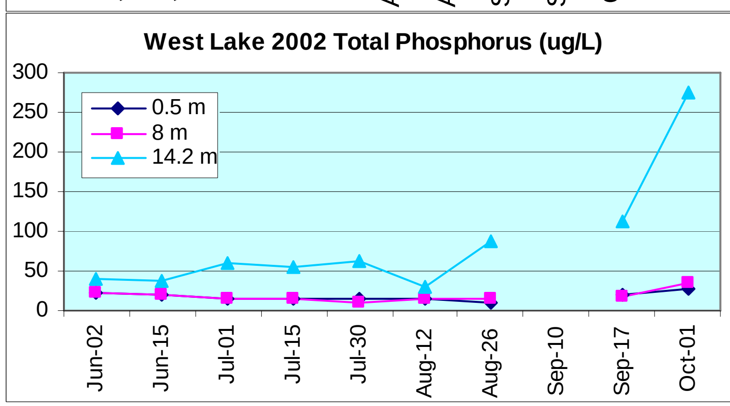
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 ug/L TP), sparse plant life (0-2 ug/L Chl. a), and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 ug/L Chl. a), including algae, because of higher nutrient levels (>30 ug/L TP). Lakes with an intermediate productivity are called ***mesotrophic*** (10-30 ug/L TP and 2-7 ug/L Chl. a) and generally combine the qualities of oligotrophic and eutrophic lakes.

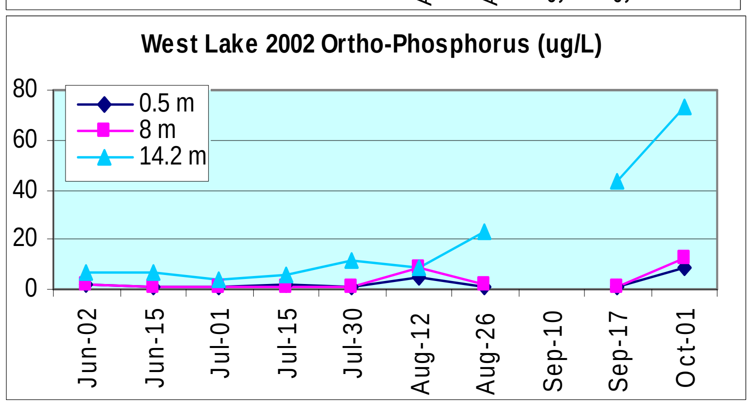
Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This "internal loading" of phosphorus can be natural but is often the result of phosphorus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

West Lake spring TP levels (page 3) have fluctuated since 1985 (average of 38.9 ug/L), but have remained in the eutrophic category. Spring TP data are missing for many of the sample years, as data collection had begun after spring turnover. Caution must be taken however, as spring TP levels are often not a good indicator of the following summer's trophic condition in lakes that exhibit internal phosphorus loading. Therefore to assess the changing conditions of West Lake we need to evaluate the history of summer phosphorus, chlorophyll a and secchi disc changes. Although there are holes throughout the historical data sets, summer TP values do appear to be similar during the past two decades, with only minor fluctuations. The data also suggest that summer algal densities have changed, but have remained within the mesotrophic range. This contrast in algal vs. TP nutrient classifications may be due to dissolved organic matter binding with available phosphorus, as well as decreased light levels which algal cells use for photosynthesis. These decreases in available TP and lower light levels likely result in lower algal densities. The top figure below displays West Lake chlorophyll concentrations and visibility, as measured by Secchi disc. Secchi was a reasonable indicator of chlorophyll in 2002, however the data set does have missing collection dates.

The latter diagrams below display 2002 total and ortho-phosphorus cycling in West Lake (these graphs are representative of the other study years). Average summer total phosphorus (TP) in the deep station was 18 ug/L at the surface. This basin displayed an increase in near bottom TP throughout the summer, with a peak of 275 ug/L on the October 1st sampling date. This rise and peak in TP is also indicated in the ortho-phosphorus profile during the same time period (which results from internal phosphorus loading). Approximately 28% of peak TP in the central basin was ortho-P, with the remainder of the peak likely due to the deposition of algae.







What's Around West Lake?

Lakeshore Land Use Survey of West Lake

In 2003, the Regional District of Fraser-Fort George completed a survey of lakeshore development practices that may impair West Lake water quality. The following table summarizes the findings, the related problems and solutions. The Regional District/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.**

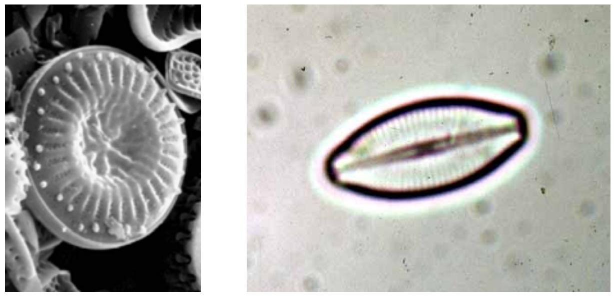
LAND USE	IMPACT	ALTERNATIVE
Riparian Clearing (removing natural vegetation within 15 m of the lake) **50% Of Properties**	Reduces terrestrial nutrient uptake leading to **increased uptake and growth by aquatic plants and algae.** Fertilizers can increase toxins and nutrients. Increases erosion and bank 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** **9%**	**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 (e.g. deep-rooted plants) should be replanted as soon as possible to help control erosion problems.
Breakwaters (Concrete, Cobble or Pressure treated wood) **and Beach Creation** **15%**	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 (trying to keep treated woods out of the water). Consider using the public boat launch rather than building a private boat launch. 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.

Historical Look at West Lake

Lake Coring; What does it Mean?

The West 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 (in this case diatoms) on the lake bottom.

West Lake's deep station was cored and sectioned by the Ministry, with help from the VLMP, during the winter of 2002/2003. The 20.5 cm, 200-year core, was analyzed by Dr. Brian Cummings of Queen's University. His report is available on request.



Diatoms are a type of phytoplankton (algae) commonly found in lake environments. Their glass-like shell (known as a frustule) is composed of silicon. This frustule leaves a permanent record of diatom history in lake bottoms.

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

Dating processes indicated that the lead 210 activity of the West Lake core was low and did not show an expected exponential decay with core depth. This suggests that there has either been variations in sediment deposition over time and/or mixing of the core had occurred. Additionally, there was some uncertainty in the core analysis that may affect the chronology of the core by 10 years.

The deep station core indicates that West Lake has undergone only minor changes in diatom assemblage during the past 200 years. The inferred total phosphorus concentration has fluctuated between 18 and 24 ug/L, with a low point around 1820. This range is characteristic of a mesotrophic lake, which has also been indicated by the summer VLMP algal and TP samples.

The core also suggests that sedimentation rates have increased since the 1950s, with pronounced increases since the 1980s. However, because sedimentation rates can vary across a lake basin, caution must be taken when interpreting the results from just one core. The core also shows a small organic matter increase in the sediments since the 1960s. This increase is small (~2%), however before the 1960s, the organic matter content was stable indicating some change has occurred.

SUMMARY

Previous VLMP and government data suggest that West Lake has had slight changes in nutrient levels during the past two decades. Future VLMP sampling is recommended for this lake, as the continuously changing water quality parameters, as well as its high recreational value near Prince George, put it at risk. The lake core collected during the winter of 2002/2003 suggests that West Lake is, and has been slightly less productive than current spring TP results indicate; however, because recent chlorophyll data also suggest mesotrophic conditions (as discussed on page 5), the results from the core (using algal cells), may in fact give conditions different from those inferred by spring TP, perhaps due to the lake's coloured nature and internal phosphorus loading. 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 West 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 lady bugs, as well as pests.
- Compost yard and kitchen waste and use it to boost your garden's health as an alternative to chemical fertilizers.

Agriculture

- Locate confined animal facilities away from waterbodies. Divert incoming water and treat outgoing effluent from these facilities.
- Limit the use of fertilizers and pesticides.
- Construct adequate manure storage facilities.
- Do not spread manure during wet weather, on frozen ground, in low-lying areas prone to flooding, within 3 m of ditches, 5 m of streams, 30 m of wells, or on land where runoff is likely to occur.
- Install barrier fencing to prevent livestock from grazing on streambanks.
- If livestock cross streams, provide gravelled or hardened access points.
- Provide alternate watering systems, such as troughs, dugouts, or nose pumps for livestock.
- Maintain or create a buffer zone of vegetation along a streambank, river or lakeshore and avoid planting crops right up to the edge of a waterbody.

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.

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.

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.

Who to Contact for More Information

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