BC Lake Stewardship and Monitoring Program

Horn Lake 1986, 2003 - 2008

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

The Importance of Horn Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunities. When these features are not apparent in recreational lakes, questions arise. People begin to wonder if the water quality is getting worse, if the lake has been affected by land development, and what conditions will result from more development within the watershed.

The BC Lake Stewardship Society, in partnership with the Ministry of Environment, has designed a program, entitled *The BC Lake Stewardship and Monitoring Program*, to help answer these questions. Through regular water sample collections, we can begin 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 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 1986 and 2003 - 2008 results of a Level II program for Horn Lake.

Through regular status reports, this program 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, this program allows government to use its limited resources efficiently thanks to the help of area volunteers and the BC Lake Stewardship Society.

The watershed area of Horn Lake is approximately 46.7 km^2. 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.

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 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 water body. Poor land-use practices anywhere in a watershed can eventually impact the water quality of the downstream environment.

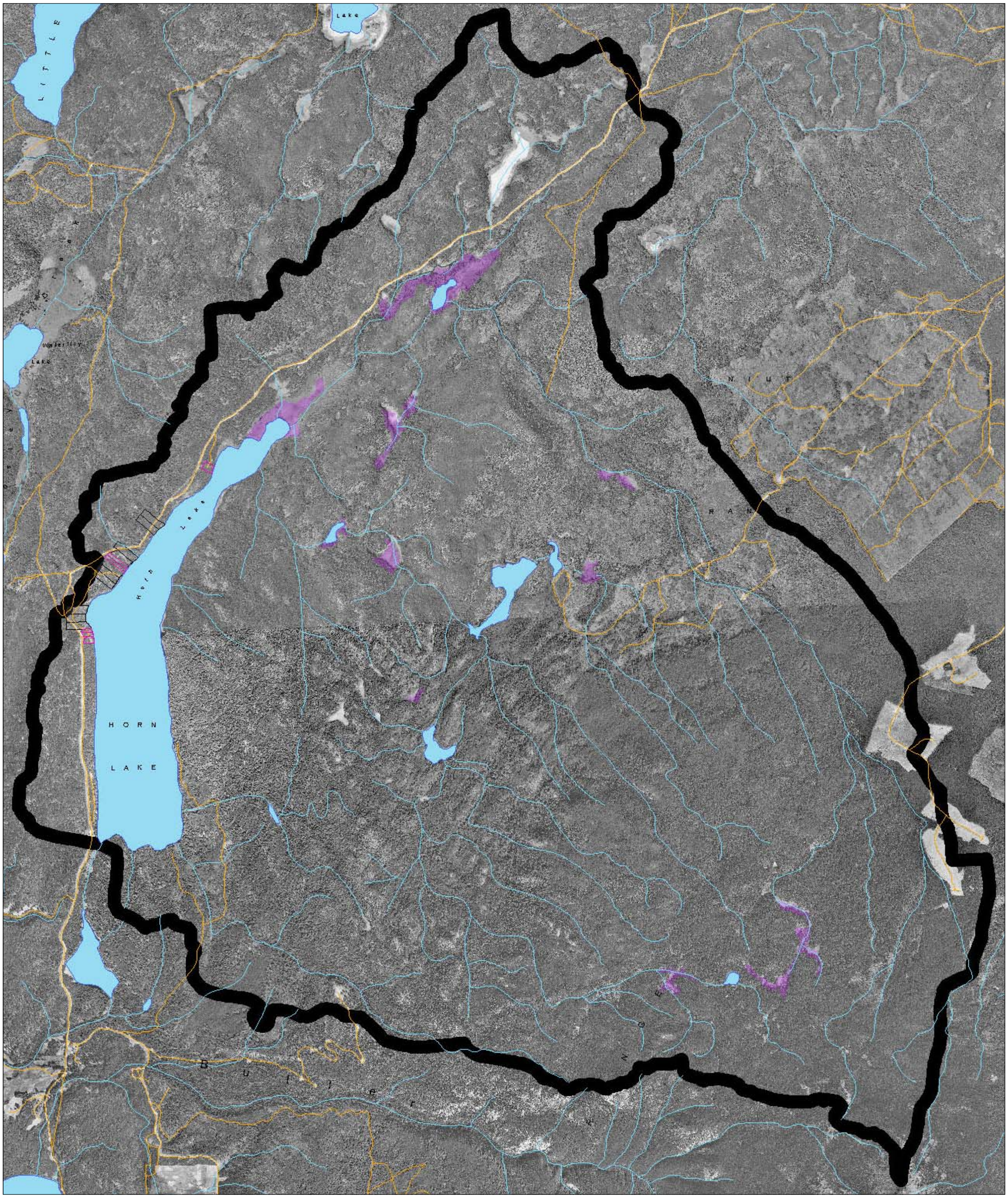
Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g. waste discharge outfalls, spills, etc). Undisturbed watersheds have the ability to purify water and repair small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

Horn Lake is located south of Highway 20 between Williams Lake and Bella Coola in the Chilcotin region. The lake has maximum and mean depths of 39.6 m and 18.5 m, respectively. Its surface area is 1.7 km^2 and the shoreline perimeter is 9.6 km. Horn Lake lies at an elevation of 940 m. Horn Lake contains bull and rainbow trout, and sucker (general). The lake is stocked annually with rainbow trout.

The flushing rate is a measure of time that inflow replaces the lake water volume. It is important because the longer the retention time, the less the lake has the ability to assimilate additional nutrients, and therefore avoid unnatural eutrophication. There is no information for the flushing rate of Horn Lake.

The map below shows the Horn Lake watershed and its associated land use practices. The majority (91%) of the land around the lake consists of productive forest base. 12 ha of the watershed is private with lakeshore lots located on the north west side of the lake. There are 53 ha (1%) of wetlands in the watershed, with a large wetland at the north end of the lake. The lake is approximately 4% of the watershed size.

Horn Lake Watershed Map



Category	Area (ha)	% of Watershed
Productive Forest Land Base (PFLB)	4288	91
Not In Productive Forest Land Base	382	8
Non Productive	349	7
Lake	218	4
Early Seral	183	3
Wetland	53	1
Private Land <= 1ha within 100m of Lake Shore	2	0
Other Private Land	12	0
Watershed Area	4670	

Private <= 1ha in 100m of lake
Wetland
Grazing Lease
Private

British Columbia Ministry of Agriculture and Lands
Integrated Land Management Bureau

W:\srm\nr\arcproj\wl\wl_07_0020_wtrshed_runoff\wrk
June 25, 2008

1:52,314

Non-Point Source Pollution and Horn 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.

Agriculture

Agriculture is economically and culturally important. When practices are improperly managed, however, there can be significant NPS impacts, such as nutrients and pathogens from manure and damage to shorelines from livestock access.

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 or located pit privies, used for the disposal of human waste and grey water, can also be significant contributors.

Stormwater Runoff

Over-fertilizing of lawns and gardens, oil and fuel leaks from vehicles, snowmobiles and boats, road salt, and litter are all washed by rain and snowmelt from our yards and streets. Pavement increases runoff of surface water and the amount of contaminants entering water bodies. Pavement collects contaminants during dry weather, and prevents water from soaking into the ground during storm events. Phosphorus and sediment are of greatest concern, providing nutrients and/or a rooting medium for aquatic plants and algae.

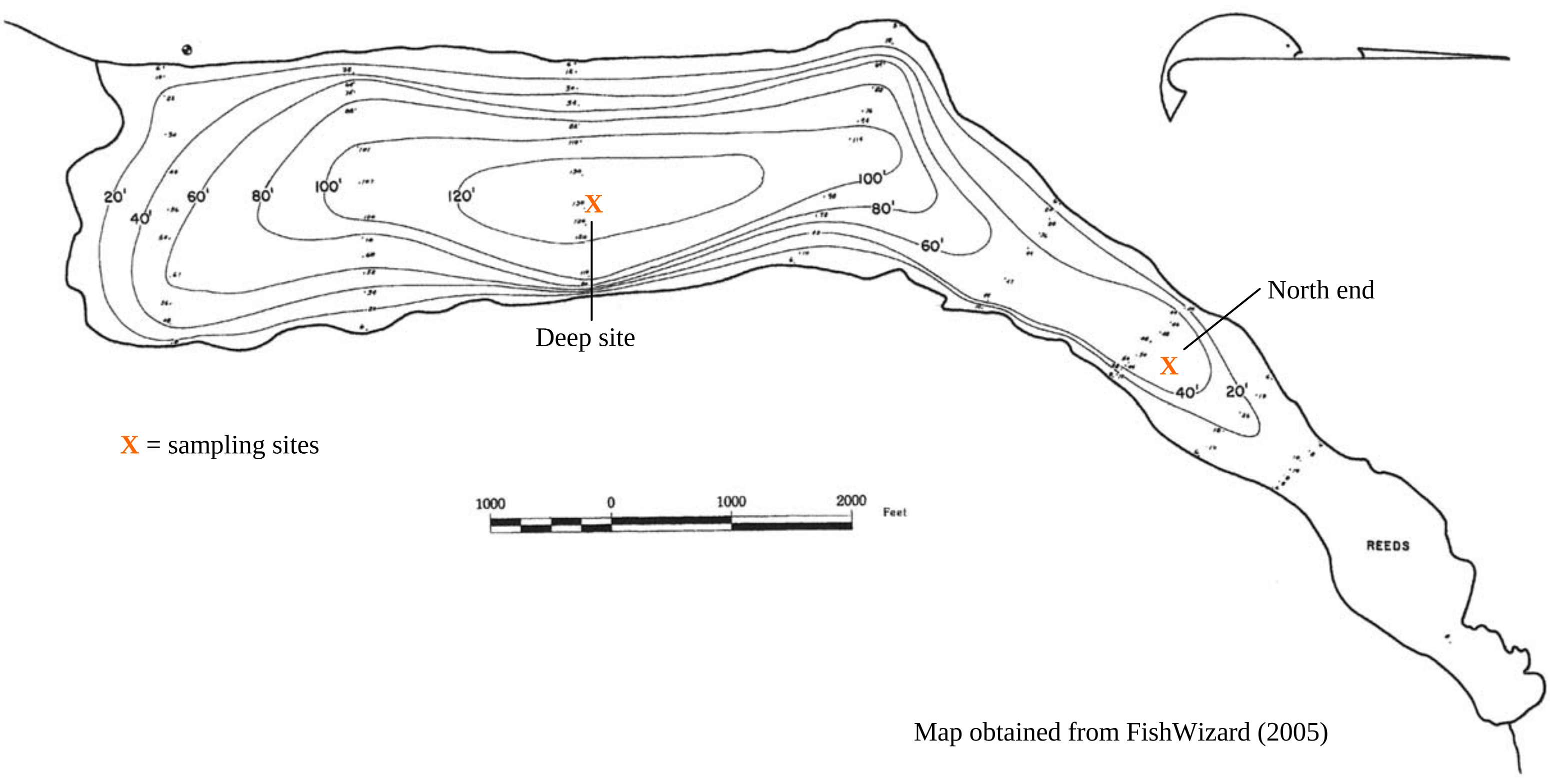
Forestry

Forestry, which includes clear cutting, road building and other land disturbances is essential to the economy, however it can increase sediment and phosphorus, and alter water flow.

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 sediments and nutrients is a concern.

Horn Lake Bathymetric Map



Map obtained from FishWizard (2005)

What's Going on Inside Horn 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 near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen rich surface water distinctly separates from the cold, often oxygen poor water in the deeper parts of the lake, it is said to create a thermocline, a region of rapid temperature change between the two layers.

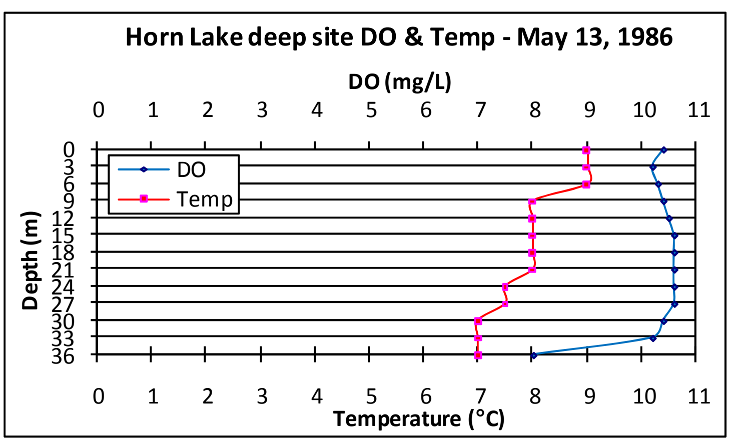
In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4°C) near the bottom. Because these types of lakes turn over twice per year, they are called dimictic lakes. These are the most common type of lake in BC. Horn Lake is a dimictic lake.

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

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

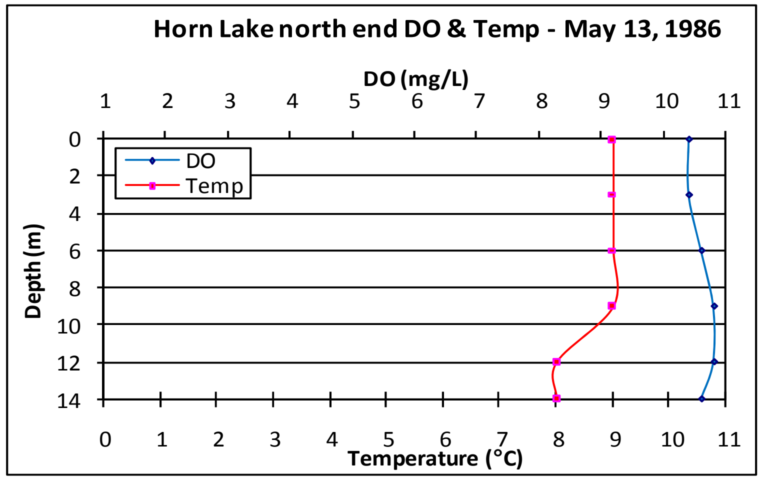
The timing of freeze-up and break-up of BC lakes is important information for climate change research. Volunteers at Horn Lake began recording ice on/off dates in winter 2008. If this information has been recorded in the past, please send the information to the BCLSS for incorporation into climate change studies.

Dissolved oxygen (DO) and temperature data was collected at 2 sites on Horn Lake in 1986 and between 2004 and 2006.



The two sites sampled are the deep and north end sites, shown on the bathymetric map on page 3.

The previous graph shows the DO and temperature data collected on May 13, 1986 at the deep site. The high DO levels indicate that the lake was completely mixed at spring overturn. Thermal stratification is just beginning as shown by the slight warming of surface temperatures, indicating the lake was sampled after the lake underwent spring overturn. The profile from the north end (shown below) on the same date indicates isothermal conditions throughout the water column to 14 m depth.



Profiles from the deep site in 2004, 2005 and 2006 also indicate that the lake was sampled after spring overturn as thermal stratification had begun.

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 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) will have sufficient oxygen to support life at all depths throughout 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 (salmonids are stressed when oxygen levels fall below about 20% saturation) where temperatures may be too warm. Fish kills can occur when decomposing or respiring algae use up the oxygen. In the summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing because oxygen has been depleted under winter ice.

As mentioned, the previous graph from the deep site indicates that spring overturn had recently occurred, as the lake appears to have been thoroughly mixed. Spring overturn is a good time to get a representative sample as chemicals in the water column are uniform. Nutrient concentrations can be compared each spring to determine trends.

Trophic Status

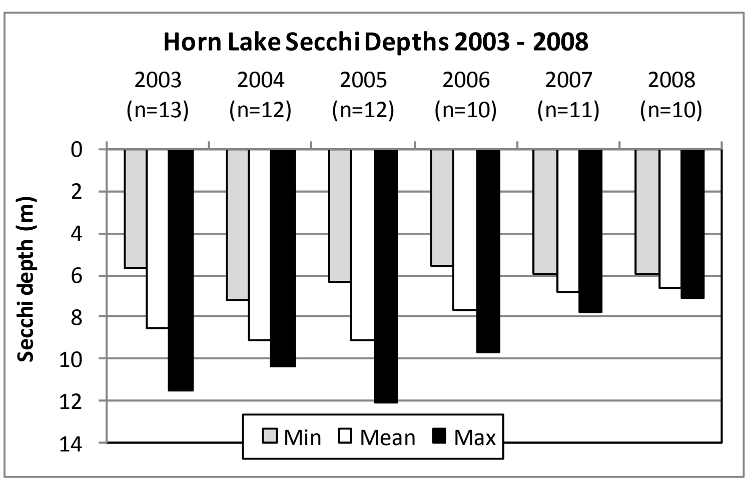
The term *trophic status* is used to describe a lake's level of productivity and depends on the amount of nutrients available for plant growth, including tiny floating algae called phytoplankton. Trophic status is often determined by measuring levels of phosphorus (TP), algal chlorophyll *a* (chl. *a*) and water clarity. The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in that same water and is directly related to the Secchi depth. Establishing the trophic condition of a lake allows inter-lake comparisons and general biological and chemical attributes of a lake to be estimated.

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

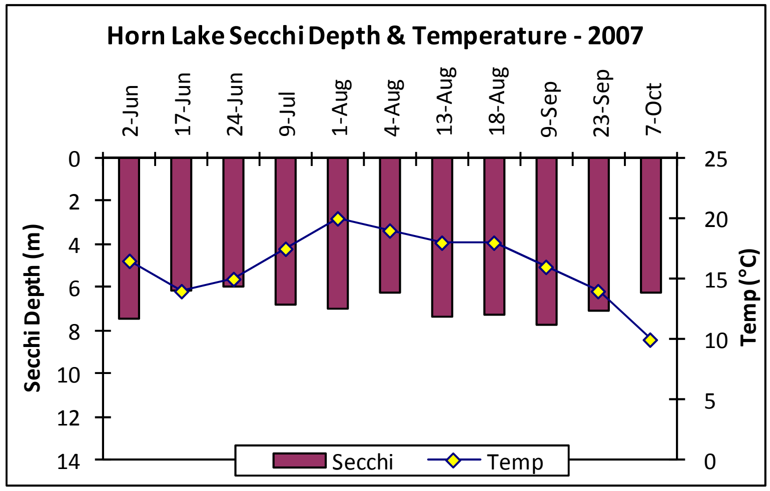
Water Clarity

As mentioned in the previous section, one method of determining productivity is water clarity. The more productive a lake is, the higher the algal growth and, therefore, the less clear the water becomes. The clarity of the lake water can be evaluated by using a Secchi disk, a black and white disk that measures the depth of light penetration.

The graph below shows the minimum, mean and maximum Secchi readings recorded on Horn Lake from 2003 to 2008, as well as the number of readings each year (n). The Secchi depths for all years were taken at the deep site. Mean summer Secchi depth measurements ranged from 6.6 m (2008) to 9.1 m (2004 & 2005). Since all readings are greater than 5 m, Horn Lake is classified as an oligotrophic (low productivity) lake.



Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. The following graph, for 2007, shows that the temperature increased to a maximum on August 1st and then declined, while the Secchi depth varied slightly throughout the sampling season. Generally, as temperature increases, so do some species of algae. Due to the increase in algae, the water clarity can decrease and the Secchi depth decreases as well. This particular trend is not seen in the Horn Lake data.



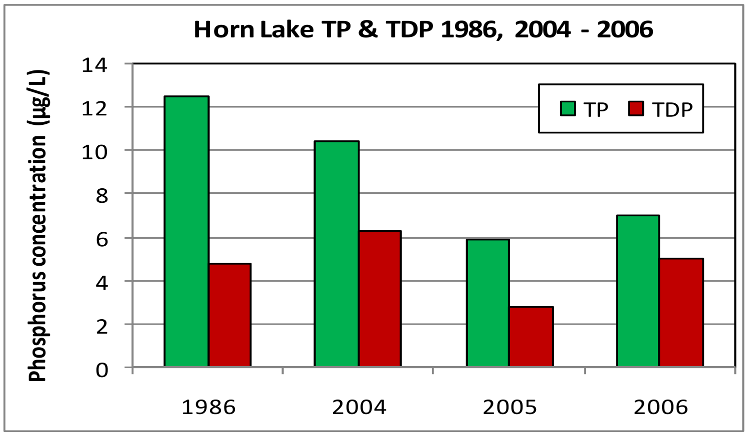
It is interesting to note that the maximum Secchi readings recorded in 2007 and 2008, 7.8 m (September 9th) and 7.1 m (September 1st), respectively, are much shallower than the maximum values in previous years (11.6 m, 10.4 m, 12.1 m, and 9.7 m in 2003, 2004, 2005, and 2006, respectively). The lower values caused a lower mean Secchi value than other sampling years. An analysis of water and weather conditions did not provide an explanation for the decreased clarity, therefore this is assumed to be within natural variability for this lake.

Phosphorus

As mentioned previously, productivity can also be determined by measuring phosphorus levels. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity. Productivity is dependant on the amount of nutrients (phosphorus and nitrogen) in a lake, which are essential for plant growth, including algae. Algae are important to the overall ecology of a lake because they are the food for zooplankton, which in turn are the 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, however, phosphorus accelerates growth and artificially ages a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities.

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.

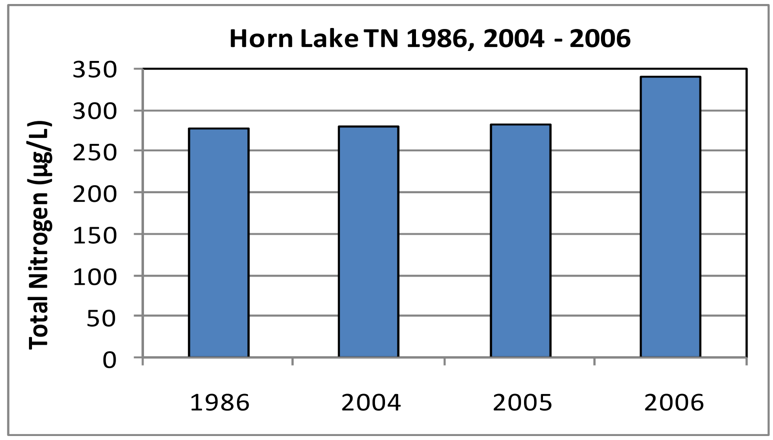
Chemistry sampling was conducted at the 2 sampling sites on Horn Lake in 1986 and 2004 to 2006. In 1986 samples were taken from the surface and bottom only, whereas in 2004, 2005, and 2006 samples were collected at multiple depths throughout the water column. As the graph on the following page shows, the chemistry data indicates that the total phosphorus (TP) levels declined slightly in Horn Lake, but this likely reflects natural variability. Total dissolved phosphorus (TDP) values are less variable than TP, and appear to be stable. Although the 1986 TP value falls in the lower mesotrophic range the 2004 to 2006 values classify the lake as oligotrophic, consistent with the Secchi disc readings.



Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the limiting nutrient for algae growth (see phosphorus). In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the N:P is less than 5:1, nitrogen becomes limiting to algae growth and can have major impacts on the amount and species of algae present.

The N:P ratio is approximately 37:1, which means the lake is a phosphorus limited system. Although an increase in nitrogen should not increase algae biomass, it could result in a change to the species of algae present, possibly to a less desirable species.



The average spring overturn total nitrogen (TN) concentrations were 278 µg/L, 281 µg/L, 282 µg/L, and 340 µg/L in 1986, 2004, 2005, and 2006, respectively, likely reflecting natural variability. As the above graph displays, the TN concentrations have remained relatively stable since 1986. All TN values classify Horn Lake as mesotrophic (Nordin, 1985).

Chlorophyll a

Chlorophyll *a* is the common green pigment found in almost all plants. In lakes, it occurs in plants ranging from algae (phytoplankton) to rooted aquatic forms (macrophytes). Chlorophyll captures the light energy that drives the process of photosynthesis. While several chlorophyll pigments exist, chlorophyll *a* is the most common. The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in that same water.

Mean summer chlorophyll *a* values were calculated from spring overturn phosphorus values and were 2.9 µg/L in 1986, 2.4 µg/L in 2004, 1.4 µg/L in 2005, and 1.6 µg/L in 2006, indicating oligotrophic to borderline mesotrophic conditions.

Aquatic Plants

Aquatic plants are an essential part of a healthy lake. Factors that affect the type and amount of plants found in a lake include the level of nutrients (i.e. phosphorus), temperature, and introduction of invasive species.

Plant species have not been surveyed in Horn Lake

Aquatic plants play an important role in the lifecycle of aquatic insects, providing food and shelter from predators for young fish, and also providing food for waterfowl, beavers and muskrats.

Aquatic plant species can spread between lakes via boaters. Be sure to check for and remove all aquatic plant fragments from boats and trailers before entering or when leaving a lake.

Should Further Monitoring Be Done on Horn Lake?

The data collected on Horn Lake indicates that the water quality has remained relatively stable for the last 20 years in terms of nutrients. The Secchi disc readings and phosphorus levels classify Horn Lake as oligotrophic while the nitrogen values place the lake in the mesotrophic rating. The data does not indicate further water chemistry monitoring is necessary at this time. However, the Ministry of Environment believes it is worthwhile to continue with the summer Secchi disc program considering the lower mean Secchi values in 2007 and 2008 compared to previous years.

Tips to Keep Horn 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.
- 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 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 and lakeshore.
- If livestock cross streams, provide graveled 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 absorbent bilge pads to soak up minor leaks or spills.
- 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 labeled with the owner's name, phone number and confirmation that barrels have been properly emptied and washed.
- Remember: when within 150 m of shore adjust your speed accordingly to prevent waves from eroding banks.
- Adhere to British Columbia's Universal Shoreline Speed Restriction which limits all power-driven vessels to 10 km/hr within 30 m of shore. Exceptions to this restriction include:
  - vessels traveling perpendicularly to shore when towing a skier, wakeboard, etc.
  - rivers less than 100 m wide
  - buoyed channels

Who to Contact for More Information

Ministry of Environment - Cariboo Region
Suite 400 - 640 Borland St.
Williams Lake, BC V2G 4T1

Phone: 250.398.4530
Fax: 250.398.4214

Horn Lake
Joe Cortese & Deborah Kannegiesser
P.O. Box 15
Tatla Lake, BC V0L 1V0

Business Telephone / Fax: 250.476.1125
Home Phone: 250.476.1258
Email: jcortese@xplornet.com

The BC Lake Stewardship Society
#203 - 1889 Springfield Rd.
Kelowna, BC V1Y 5V5

Phone: 250.717.1212
Toll Free: 1.877 BC LAKES
Fax: 250.717.1226
Email : info@bclss.org
Website: www.bclss.org

Acknowledgements

Volunteer Monitoring by:
Joe Cortese
Deborah Kannegiesser

Data Compiling by:
Carrie Dillman & Kirsten Heslop (MoE-Williams Lake)
Carolyn Johns (BCLSS)

Lake Report Produced by:
Carolyn Johns
BC Lake Stewardship Society

Technical Review by:
Chris Swan (MoE)

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

Land Use Map:
Integrated Land Management Bureau - Williams Lake

Photo Credit:
Chris Swan (MoE)

References

Nordin, R.N. 1985. Water Quality Criteria for Nutrients and Algae. Water Quality Unit, Resource Quality Section. Ministry of Environment, Lands and Parks. Victoria, B.C.

O'Keeffe, J., Zirnhelt, N., and J. Savege. 2000. Cariboo Region Lake Water Quality 1998-99. Ministry of Environment, Lands, and Parks. Williams Lake, BC.