BC Lake Stewardship and Monitoring Program

# Timothy Lake 1984, 2004 - 2006

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

# The Importance of Timothy 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 1984 and 2004 - 2006 results of a Level II program for Timothy 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 Timothy Lake is approximately 125 $km^2$. 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.

Timothy Lake is located 13 km east of Lac La Hache in the Cariboo region of BC. The lake has a maximum depth of 23.2 m and a mean depth of 13.5 m. Its surface area is 4.4 $km^2$ and the shoreline perimeter is 17.7 km. Timothy Lake lies at an elevation of 928 m and contains rainbow trout, largescale sucker, northern pikeminnow, peamouth chub and redside shiner. The lake was stocked annually with rainbow trout until 2006and now relies on natural production of rainbow trout from Timothy Lake.

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 Timothy Lake.

The map below shows the Timothy Lake watershed and its associated land use practices. Land use around the lake is approximately 88% forested, 7% non-productive, and the lake is approximately 4% of the watershed size.

# Timothy Lake Watershed Map

| Category | Area (ha) | % of Watershed |
|---|---|---|
| | | |
| Productive Forest Land Base (PFLB) | 10973 | 88 |
| Not In Productive Forest Land Base | 1494 | 11 |
| Non Productive | 948 | 7 |
| Lake | 541 | 4 |
| Early Seral | 5146 | 41 |
| Wetland | 293 | 2 |
| Private Land <= 1ha withing 100m of Lake Shore | 35 | 0 |
| Other Private Land | 615 | 4 |
| Watershed Area | 12467 | |

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

Integrated Land Management Bureau

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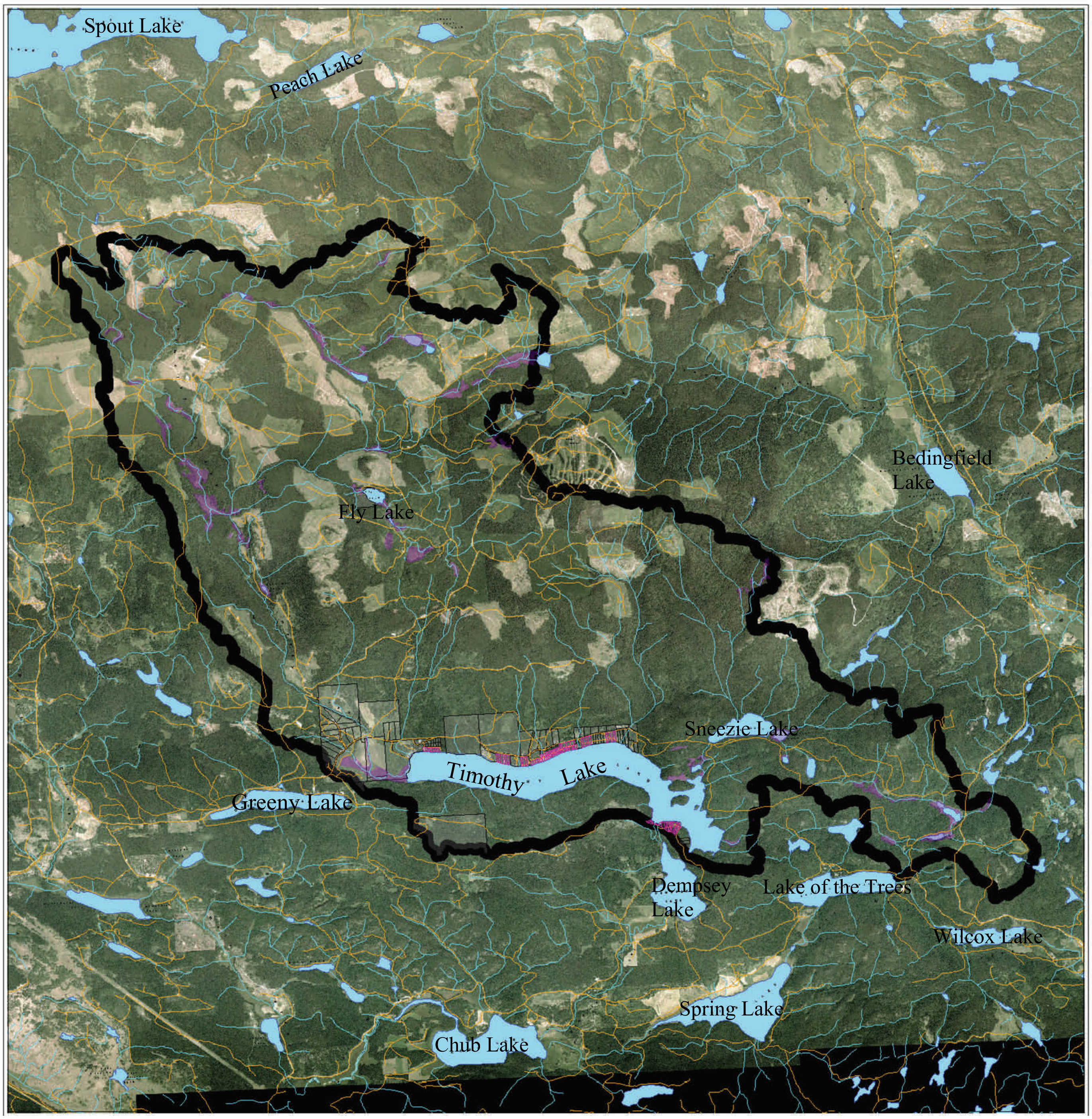
June 25, 2008

1:106,587



# Non-Point Source Pollution and Timothy 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.

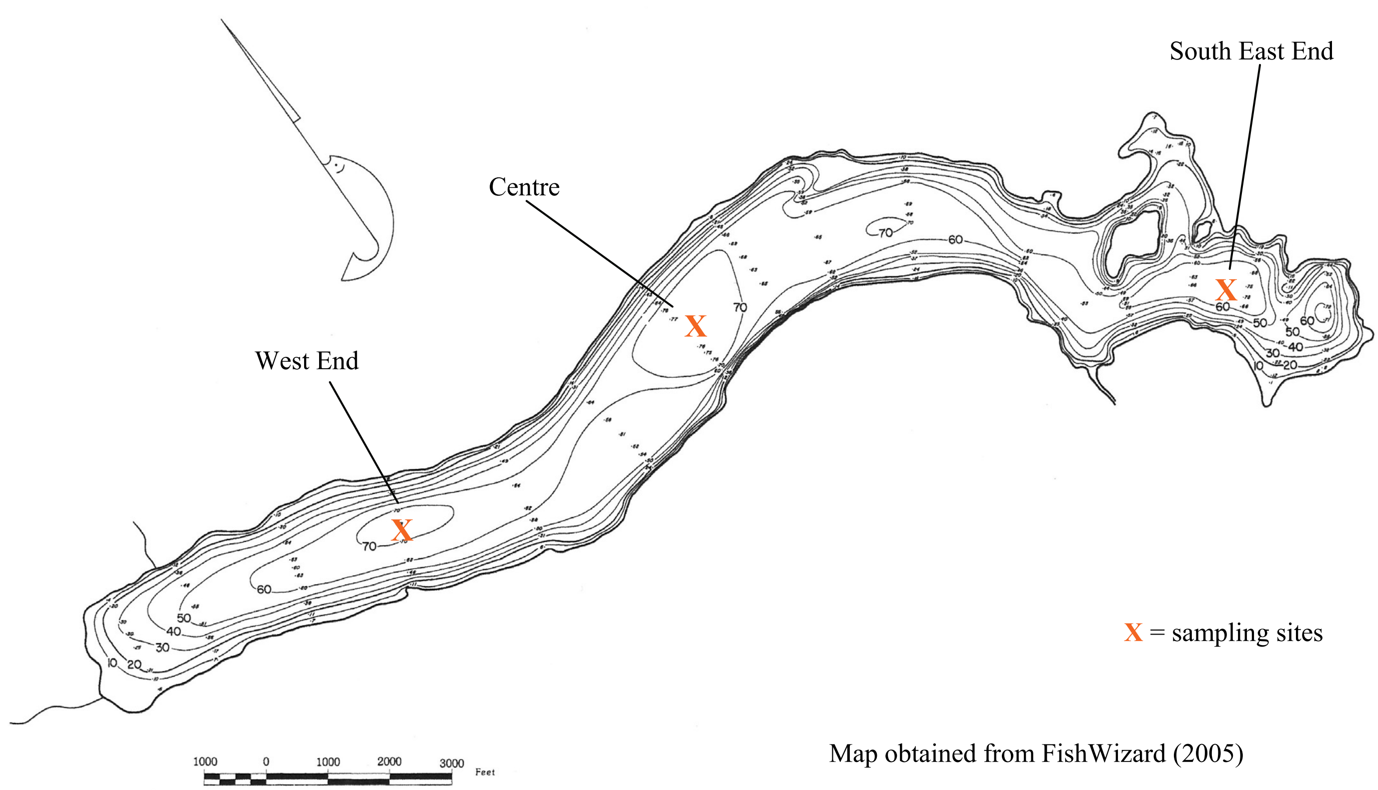
### *Forestry*

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 serious concern.

## Timothy Lake Bathymetric Map




Map obtained from FishWizard (2005)

# What's Going on Inside Timothy Lake?

## *Temperature*

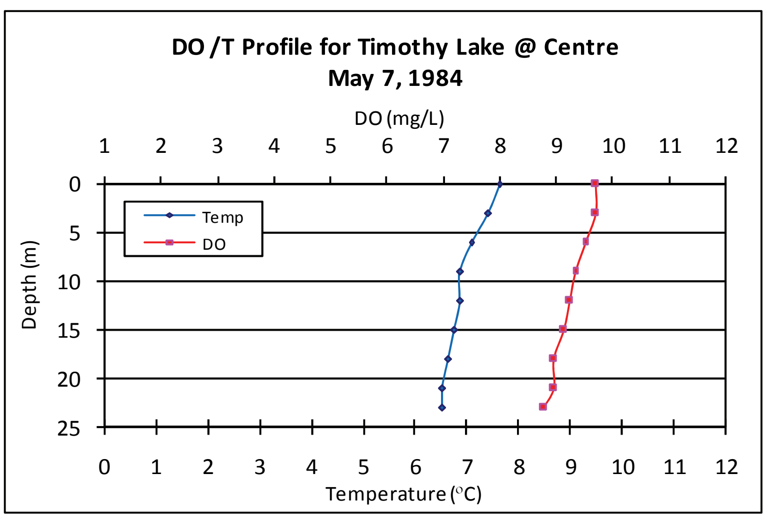
Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen rich surface water distinctly separates from the cold 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. Timothy 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.

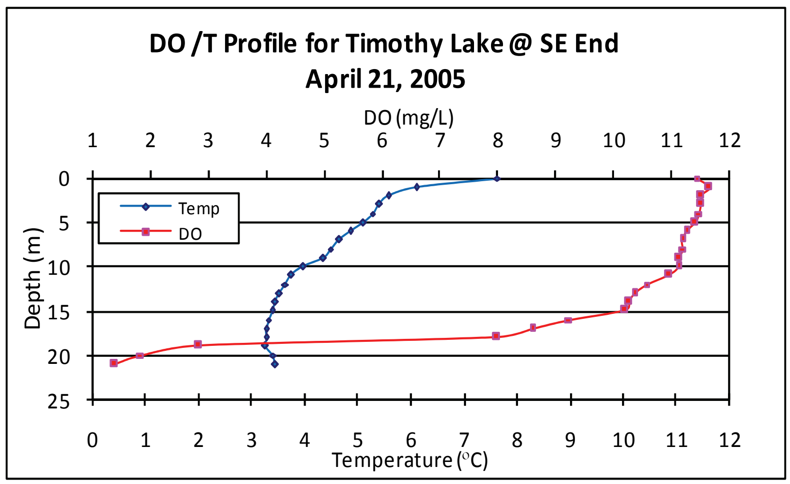
Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. Temperature stratification patterns are also very important to lake water quality. They determine much of the seasonal 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. The BCLSS is interested in this information. If these dates have been recorded in the past, please send the information to the BCLSS so that it can be incorporated into climate change studies.




Dissolved oxygen (DO) and temperature (T) data was collected at 3 sites on Timothy Lake between 2004 and 2006. The three sites sampled were the centre, the south east end, and the west end sites, shown on the bathymetric map on page 3. In 1984, 2 of the 3 sites were sampled, the centre and south east end sites.

The previous graph shows the DO and temperature data collected on May 7, 1984 at the centre site. The DO levels and temperature readings indicate that the lake was well mixed at spring overturn. The profile taken on April 21, 2005 (shown below) at the south east end site indicates thermal stratification is just beginning as shown by the slight warming of surface temperatures. DO levels in this profile indicate the lake had not completely turned over as the water was well oxygenated from the surface to the 18 m level, and then oxygen levels drop off quickly. The south end area of the lake is a smaller sheltered bay that may not get enough exposure to wind to completely turn the lake over at that site. This is likely not a common event, however, as profiles from this site in 1984, 2004 and 2006 indicate the lake was mixed, though thermal stratification had begun..




Profiles from the west end 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 centre site indicates that spring overturn had recently occurred, as the lake appears to have been thoroughly mixed. For this reason, 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. 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.

Secchi readings were recorded at spring overturn on Timothy Lake in 1984, 2004, 2005, and 2006. Only one reading was taken each year at each site, with no reading taken in 1984 at the west end site, and no reading at the centre site in 2004. Secchi depth measurements ranged from 2.3 m (1984) to 5.3 m (2005). To attain an adequate baseline of data, a minimum of 12 Secchi readings taken at regular intervals throughout the spring and summer for a minimum of three years is be required for Timothy Lake. Later in this report, trophic status is classified using spring overturn nutrient data, however, a good baseline of Secchi depth measurements would be useful in verifying this classification.

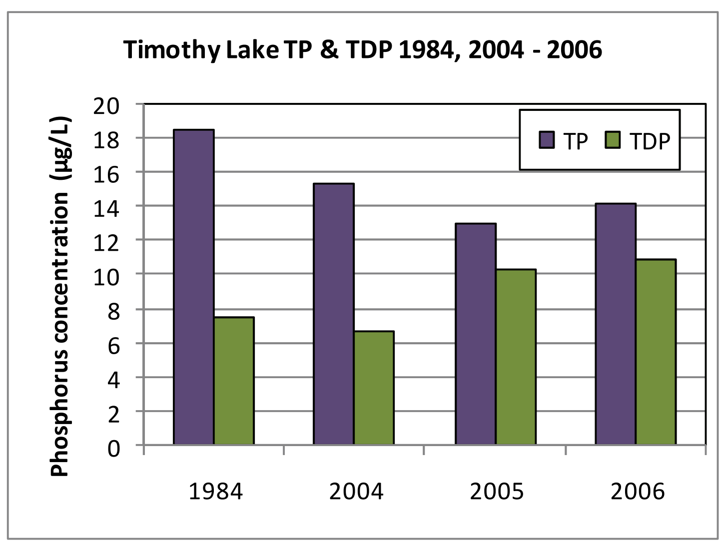
Secchi data is very useful in evaluating annual and inter-annual variability. Lakes are very dynamic, often on a weekly scale, and water chemistry and chlorophyll *a* samples collected monthly (or more frequently) is an expensive and time-consuming approach to identify trends in water quality. The Secchi disk serves this purpose very well (Nordin, 2008).

Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. In order to interpret this, surface temperature readings should be recorded with the Secchi readings throughout the spring and summer.

## *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.

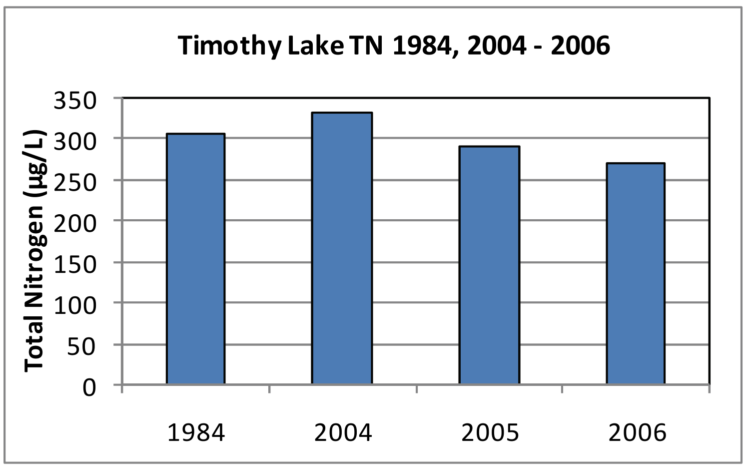



As seen in the previous graph, data collected from 1984 and 2004 - 2006 indicates that the total phosphorus (TP) levels appear to be quite stable in Timothy Lake, with the values likely reflecting some natural variability. Total dissolved phosphorus (TDP) values appear to be increasing slightly, but this also likely reflects natural variability as 2004 values were similar to those in 1984. The TP values for all sampling years fall in the mesotrophic range.

### *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 19.1:1, 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 305 μg/L, 331 μg/L, 290 μg/L, and 271 μg/L in 1984, 2004, 2005, and 2006, respectively, likely reflecting natural variability. As the previous graph displays, the TN concentrations have remained relatively stable since 1984. All TN values indicate place Timothy Lake in the mesotrophic range (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 4.2 μg/L in 1986, 3.5 μg/L in 2004, 3.0 μg/L in 2005, and 3.3 μg/L in 2006, indicating 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.

The plant species that have been documented in Timothy Lake include only *Myriophyllum* (watermilfoil) species, however it is likely a larger number of species are present.

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 Timothy Lake?

The data collected on Timothy Lake indicates that the water quality has remained relatively stable for the last 20 years. According to nutrient data, Timothy Lake is classified as a mesotrophic lake. In order to verify this trophic status classification, it is important to establish a good baseline of Secchi and surface temperature data. This involves collecting a minimum of 12 evenly spaced readings, starting at spring overturn and continuing through the summer, for a minimum of three years. To do this, the BCLSS and MoE requires some willing volunteers to collect data on Timothy Lake. Interested volunteers can find more information at www.bclss.org or by calling the BCLSS office (contact information on the back page).

If volunteers are willing, freeze-up and break-up of ice should be recorded for climate change studies.

# Tips to Keep Timothy 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

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A volunteer is needed for Timothy Lake

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**Bathymetric Map:**
FishWizard
(www.fishwizard.com)

**Land Use Map:**
Ministry of Sustainable Resources Management, Business Solutions Branch - Williams Lake

**Photo Credit:**
Chris Swan (MoE)

# References

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