B.C. *Volunteer Lake Monitoring Program*

NUKKO LAKE

2003-2005

The Importance of Nukko 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.

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.

Nukko Lake's VLMP program began in 2003 and has been conducted by the dedicated Nukko Environmental Lake Weed Society. This group has undertaken numerous activities around their lake, including VLMP monitoring of water quality for three years, as well as fundraising to purchase a plant harvester to combat the *Elodea canadensis* problem. This status report summarizes information derived from the VLMP. 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. Nukko Lake's watershed is ~ 38 km^2 and 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. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution. This buffering capacity can be decreased by degrading land use activities.

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.

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.

This study is one part of a broader water quality management program being carried out by the Environmental Quality Section in MOE's Omineca-Peace Region. The overall objectives of this program are to monitor water quality so as to identify problems, to determine causes, and to work with local governments, landowners and other interested parties to improve or otherwise protect water quality and aquatic life.

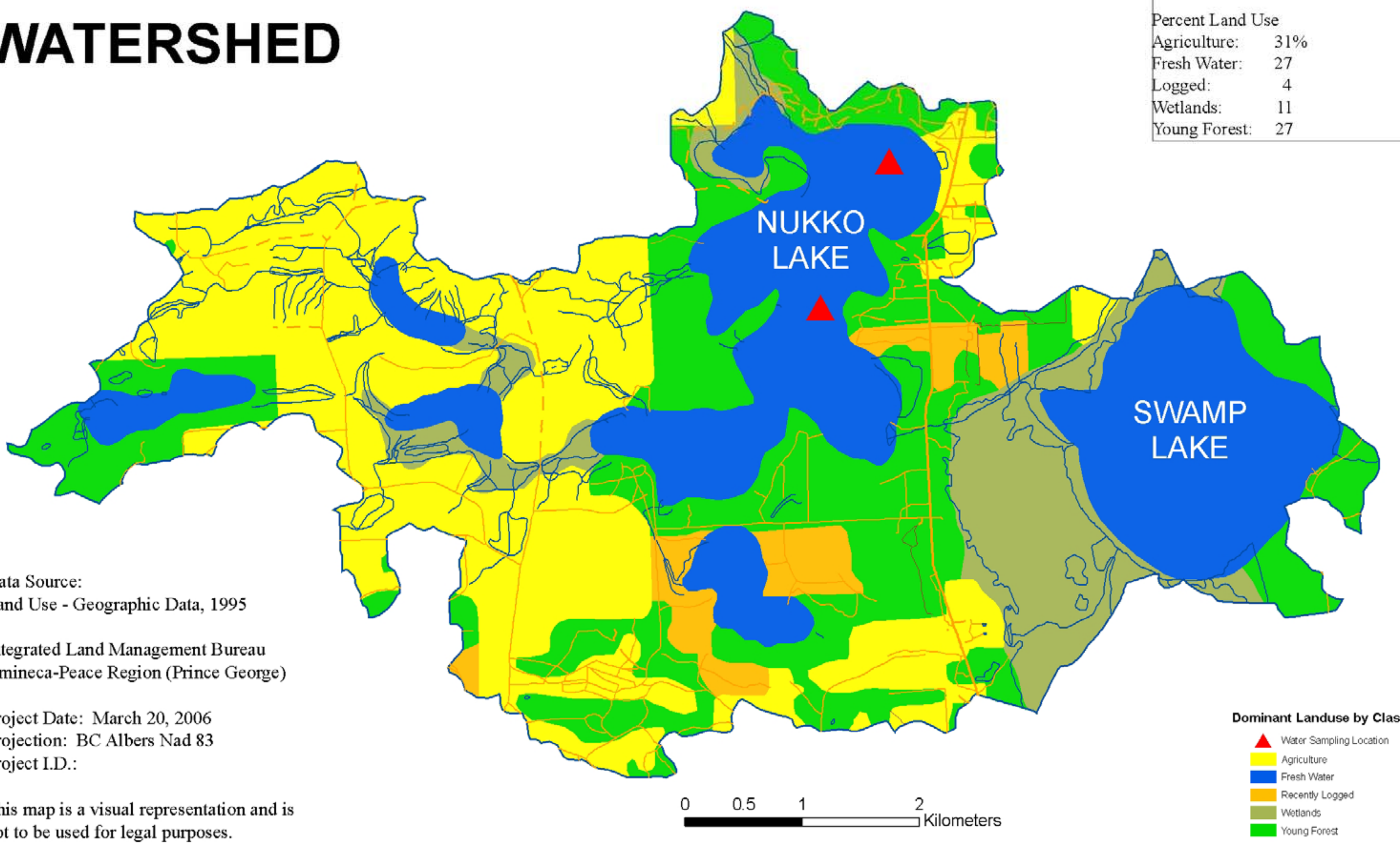
The information gained through this study will be applied to the protection of water quality through various means, including education of property and land owners, development of watershed management plans, or the enforcement of provincial and local regulatory controls, where applicable.

NUKKO LAKE WATERSHED

WATERSHED CHARACTERISTICS

Watershed Area: 38 sq. km

Percent Land Use	
Agriculture:	31%
Fresh Water:	27
Logged:	4
Wetlands:	11
Young Forest:	27



Data Source:
Land Use - Geographic Data, 1995

Integrated Land Management Bureau
Omineca-Peace Region (Prince George)

Project Date: March 20, 2006
Projection: BC Albers Nad 83
Project I.D.:

This map is a visual representation and is not to be used for legal purposes.

Nukko Lake is located in the Omineca region approximately 25km northwest of Prince George, B.C. The lake is roughly 4km long with maximum and mean depths of 17.1m and 7.2m, respectively. It has a surface area of 4.15km^2 and a shoreline perimeter of 17.4km. The map on the previous page shows the approximate Nukko Lake watershed. Land use activities include agriculture, forestry, range and residential development. It is of note that the watershed is very flat, and most streams are ephemeral (seasonal). There are some small drainages that enter the lake in the south end, with the outlet being in the north basin. Named tributaries include Nukko Creek, Crocker Creek and Shell Creek.

Nukko Lake contains the following sport fish: rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis)*, mountain whitefish (*Prosopium williamsoni*) and lake whitefish (*Coregonus clupeaformis)*. The lake was stocked from 1934 until 1963 with both rainbow trout and brook trout. Nukko Lake has not been stocked in recent years.

Land use around the lake includes lakeshore development (~47 developed lots) and agriculture. There is a small community park, and a few small, but not easily accessible, public boat launches. The greatest challenge to lake management is likely the control of phosphorus (nutrient) loading (although the nitrogen/phosphorus ratio was not calculated during this program, historical results have shown Nukko Lake to be phosphorus limited). This loading can promote summer algal blooms and the spread of aquatic plants. However, as will be discussed later in the brochure, much of the phosphorus input to Nukko Lake is not from external sources, but from Nukko Lake itself (internal phosphorus loading from lake sediments, page 7).

Nukko Lake has faced challenges in recent years regarding dense mats of Canadian pondweed (*Elodea canadensis)*, which prompted concern among area residents. This concern resulted in the formation of the Nukko Environmental Lake Weed Society, a group that has promoted stewardship and awareness on their lake. After three years of dedicated fundraising, the group purchased a weed harvester in 2004. This harvester is now used each summer to combat the *Elodea* problem, so that residents and people from surrounding communities can enjoy recreational activities, without interference from problematic weeds.

Non-Point Source Pollution and Nukko 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 may 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.

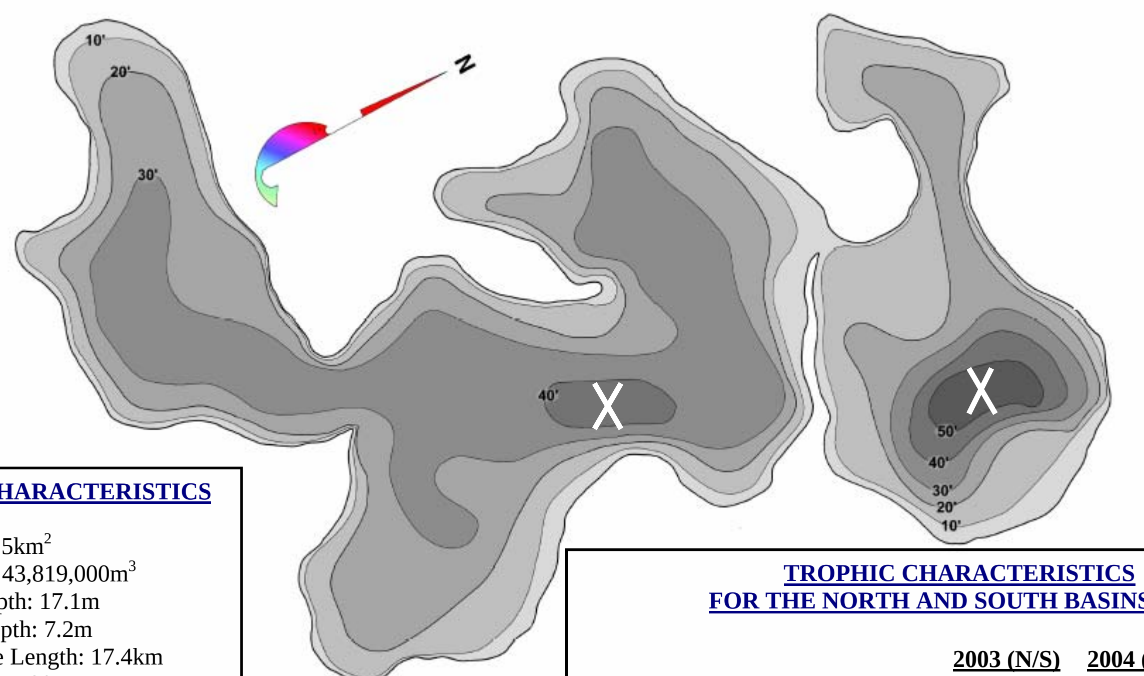
Agriculture

Agriculture includes grain, livestock and mixed farming. These practices can alter water flow and increase sediment and chemical/bacterial/parasite inputs to water bodies.

Boating

Oil and fuel leaks are the main concerns with 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.

Nukko Lake Contour Map



LAKE CHARACTERISTICS

Area: 4.15km^2
Volume: 43,819,000m^3
Max. Depth: 17.1m
Mean Depth: 7.2m
Shoreline Length: 17.4km
Elevation: 790m
X = water quality sampling site

TROPHIC CHARACTERISTICS FOR THE NORTH AND SOUTH BASINS (N/S)

	2003 (N/S)	2004 (N/S)	2005 (N/S)
Max. Surface Temp (^{o}C):	20/20	21/21	20/20
Min. Near-bottom Oxygen (mg/L):	0/0.2	0/0	0/0
Spring Overturn TP (µg/L):	16/26	11/23	13/27
Avg. Chlorophyll *a* (µg/L):	8.2/6.4	4.6/5.9	2.8/4.3
Avg. Secchi Depth (m):	2.8/2.4	3.2/2.7	3.4 /2.9

What's Going on Inside Nukko Lake?

Temperature

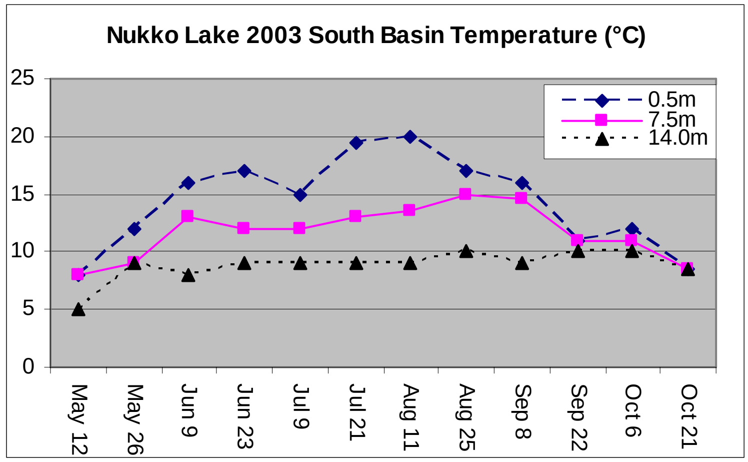
Lakes show a variety of annual temperature patterns based on each lake's location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because cold water is more dense, it resists mixing into the warmer, upper layer for much of the summer. In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the most dense water (4°C) near the bottom.

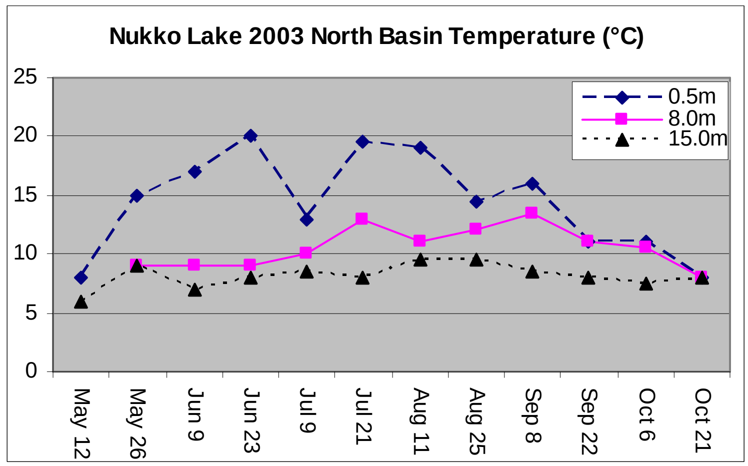
Lakes of only a few metres depth tend to mix throughout the summer or layer only temporarily, depending on wind conditions. In winter, the temperature pattern of these lakes is similar to that of deeper lakes.

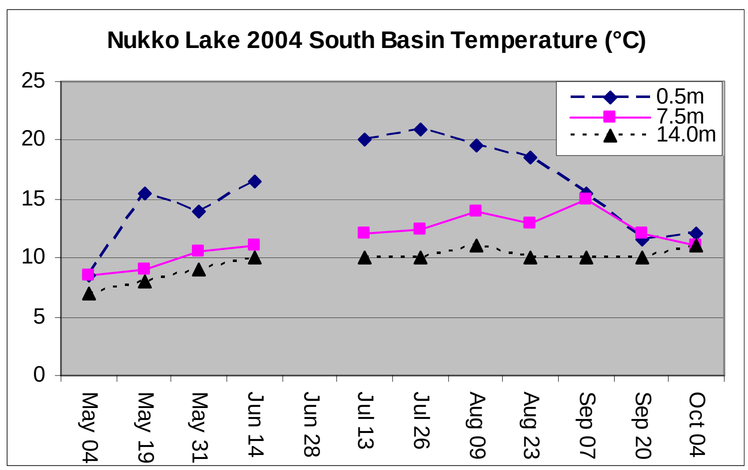
Temperature stratification patterns are very important to lake water quality. They determine much of the seasonal oxygen, phosphorus and algal conditions. When abundant, algae can create problems for most lake users.

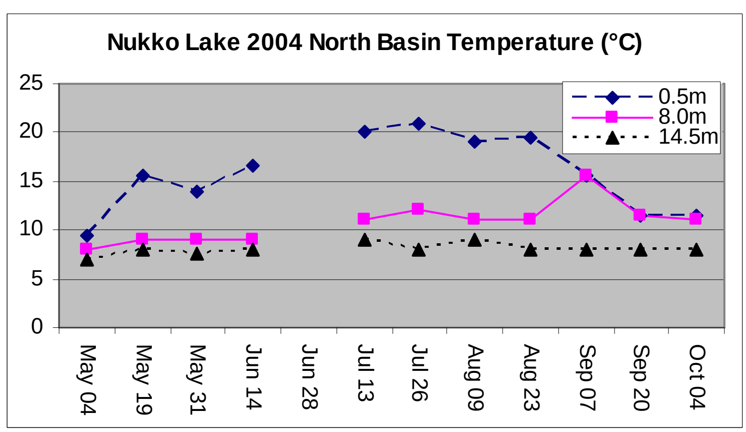
Temperature was measured in both the north and south basin of Nukko Lake between 2003 and 2005. The figures on the next column illustrate representative profiles of the program. All three years, in both basins, show the lake beginning to stratify in early May. This stratification is held throughout the summer, typically until late September/early October when shorter days and cooling temperatures caused a loss of lake stratification, leaving the water temperature nearly uniform with depth. Because the lake maintains this stratification during the summer, and experiences two turnover events (one in the spring and one in the fall), it is termed a dimictic lake. The profiles also show distinct thermal layers in the lake, with mid-depth reaching above 10-15°C during most years. Bottom depths typically remained below 10°C; however, did exceed this mark on four dates during the program. Surface water temperatures reached the 20°C mark in late May 2005. This maximum did not occur in 2003 and 2004 until late June. Maximum water temperatures were similar between the two basins for all three years. Temperatures reached a high of 20°C in both 2003 and 2005, and a high of 21° in 2004.

It is of note that the volume and quality of data collected during this program was excellent, extending from spring turnover to fall turnover in most years. This complete set of data is very useful when doing any sort of interpretation and trend analysis.









What's Going on Inside Nukko Lake?

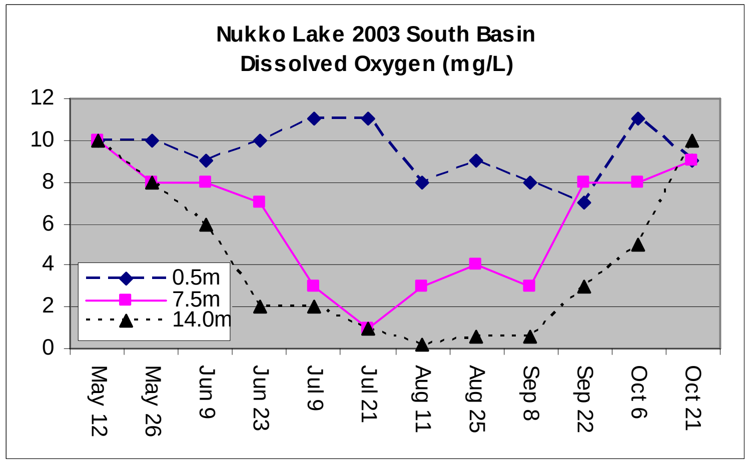
Dissolved Oxygen

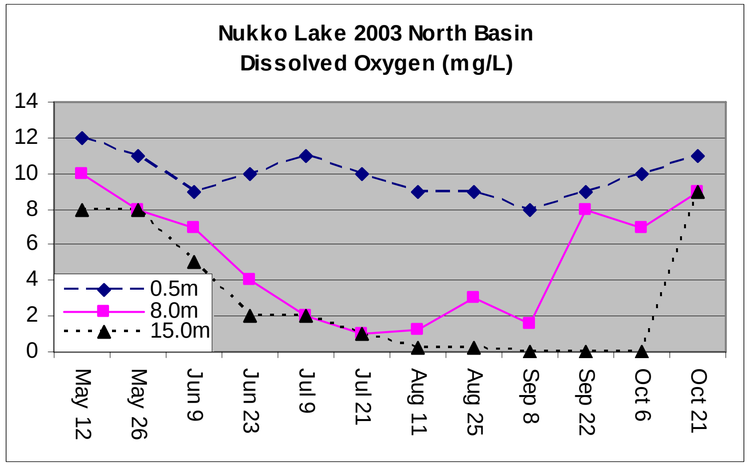
Oxygen is essential to life in lakes. It enters lake water from the air by wind action and plant photosynthesis. Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels.

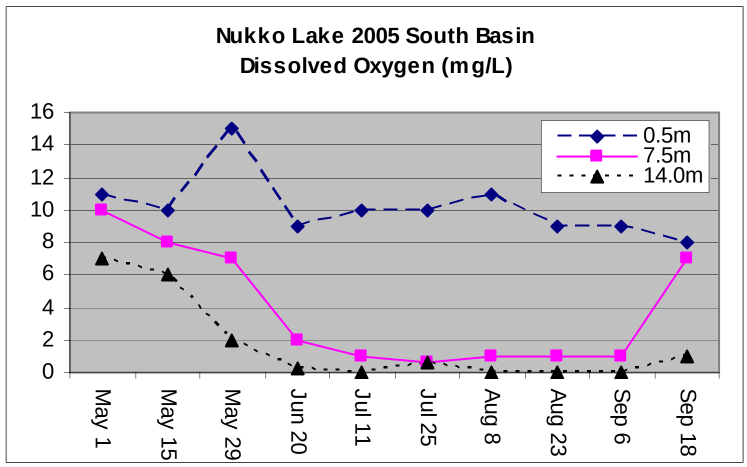
Lakes that are unproductive (oligotrophic) will have sufficient oxygen to support life at all depths through the year. But as lakes become more productive (eutrophic), and increasing quantities of plants and animals respire and decay, more oxygen consumption occurs, especially near the bottom where dead organisms accumulate.

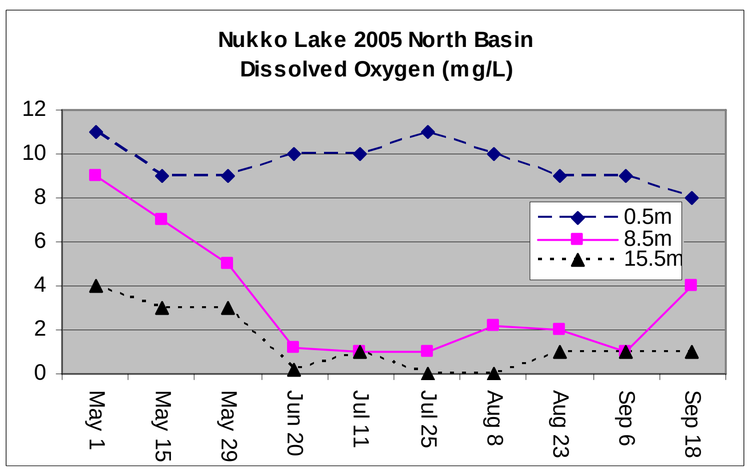
In productive lakes oxygen in the isolated bottom layer may deplete rapidly (often to anoxia), forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 20% saturation). Fish kills can occur when decomposing or respiring algae use up the oxygen. In summer, this can happen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

The figures on the next column display oxygen patterns for the north and south basins of Nukko Lake for 2003 and 2005. Similar patterns were observed in each basin during the three years, showing common trends and consistency in field collection by volunteers. Surface water oxygen ranged between 8 and 12mg/L in both basins during all three years, while bottom oxygen typically went to anoxia (no oxygen) in early July (mid June in 2005). Furthermore, the mid-depth oxygen concentrations dropped to below 4mg/L during mid-summer. The water with less than 4 mg/L oxygen (especially the lake bottom), would not have supported fish for a period of roughly three months. This bottom level anoxia was likely the result of a strong temperature density gradient, and the lack of vertical mixing between the surface and bottom. Furthermore, bacterial decomposition of settled organic matter, which uses up oxygen from deeper waters, probably had some influence. There was an extended period of anoxia in 2005, compared to both 2003 and 2004, which likely influenced internal phosphorus loading from the bottom sediments (refer to page 7). This extended period was likely influenced by the very warm temperatures during the spring of 2005, which warmed the lake much faster than in 2003 or 2004.









What's Going on Inside Nukko Lake?

Trophic Status and Phosphorus

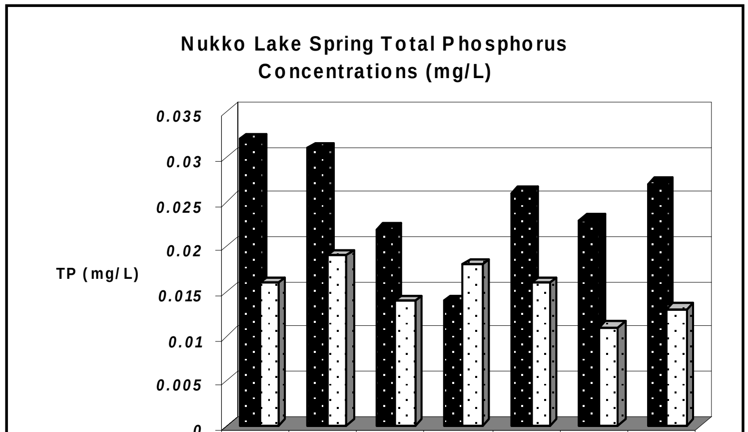
The term "trophic status" is used to describe a lake's level of productivity and depends on the amount of nutrient available for plant growth, including tiny floating algae called phytoplankton. Algae are important to the overall ecology of lakes because they are food for zooplankton, which in turn are 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 4), 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 algae productivity.

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.

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.

Nukko Lake spring TP levels in both the north and south basins averaged between 10 and 30µg/L in 2003 through 2005, indicating mesotrophy. Furthermore, as displayed in the historical spring TP figure to the upper right, most samples between 1985 and 2005 also show mesotrophy. It is of note that although the spring TP concentration is often used to predict summer productivity levels, it may be difficult to do so when the lake exhibits internal phosphorus loading. This loading, which is dependant on the bottom level dissolved oxygen concentration, can influence algal productivity when bio-available (ortho) phosphorus is released. Nukko Lake exhibits internal loading for over two months each summer.



	1985	1986	1993	1995	2003	2004	2005
Central (South) Basin	0.032	0.031	0.022	0.014	0.026	0.023	0.027
North Basin	0.016	0.019	0.014	0.018	0.016	0.011	0.013

Most samples collected during the 20 year Nukko sampling history indicate the south basin had much higher spring TP concentrations than the north basin. One of the main factors might be the amount of internal phosphorus loading occurring within the two basins. From the 2003-2005 data, it is evident that higher concentrations of ortho-phosphorus was released in the south basin compared to the north. Furthermore, because the south basin is much larger than the north and releases more ortho-phosphorus, this should eventually lead to higher average TP concentrations, as seen in the data. Another possible factor might include the lake's numerous inflowing tributaries in the south basin and one outflowing tributary in the north. Finally, land use activity around the lake, as shown on page 2, may be a factor.

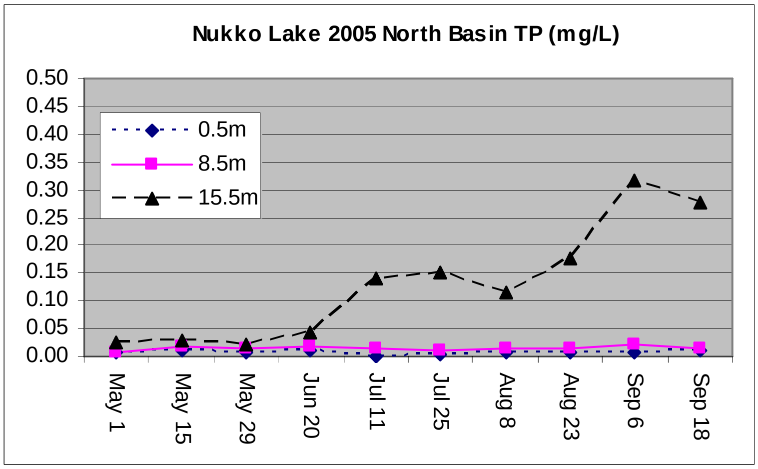
Total phosphorus trends were similar between 2003 and 2005, with summer and mid-depth levels remaining relatively stable from spring through fall, and bottom level concentrations increasing substantially by late June. This trend is consistent between the two basins; however, concentrations do vary. More specifically, the south basin TP levels are much higher than the north, as previously discussed. Bottom level TP generally decreases in October, when fall overturn mixes the lake water, diluting the high levels initially found in the hypolimnion.

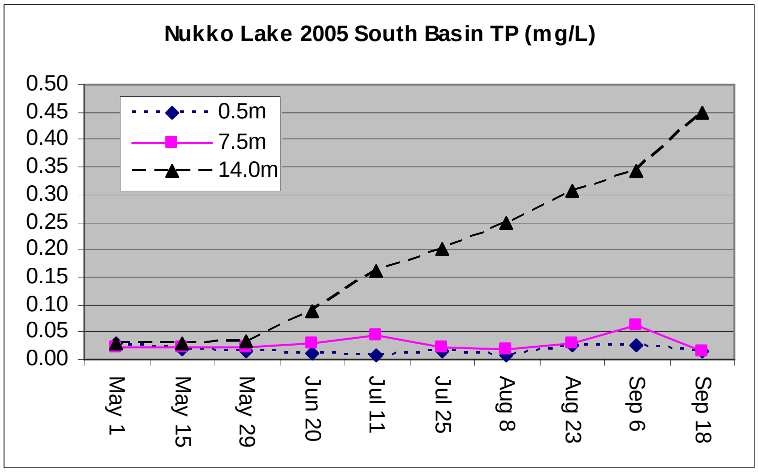
The large peak in bottom level TP is largely influenced by internal phosphorus loading, with late summer ortho-phosphorus contributing 50-90% of the TP. This percentage does vary between years, however the trends are similar. The remaining TP not originating from ortho-phosphorus is likely the result of organic (plankton, weeds, etc.) and inorganic (sediment) settling.

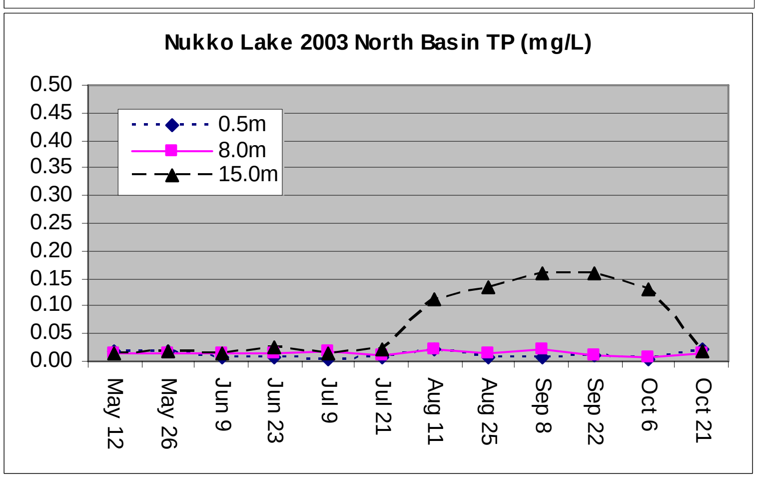
What's Going on Inside Nukko Lake?

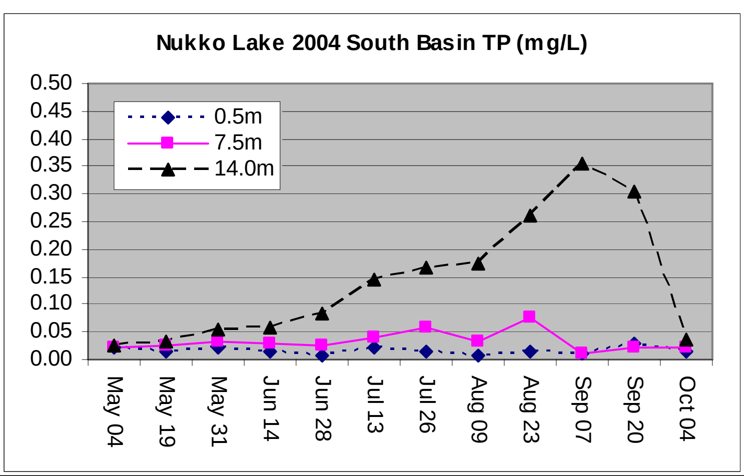
Chlorophyll *a* data, seen in the graphs for both the north and south basin, show similar trends between 2003 and 2005 with a three year summer average of 5.5µg/L in the south and 5.2µg/L in the north, further supporting a mesotrophic designation. All three years showed an increase in chlorophyll *a* in the spring, followed by a decline and stabilization throughout the summer, and then a final peak in the late summer/early fall. The initial peak is probably due to the abundance of available nutrients and warmer temperatures after ice off and lake turnover. Productivity in the lake is low in winter because of the ice and snow cover, and these available nutrients are not used. When the lake opens up, warm water, high light levels and an abundance of ortho-phosphorus promotes algal growth. The bloom in the late summer/early fall is probably due to excess nutrients moving up to the epilimnion from bottom waters during the fall turnover. Again, these bio-available nutrients would be taken up quickly by algae, promoting a bloom.

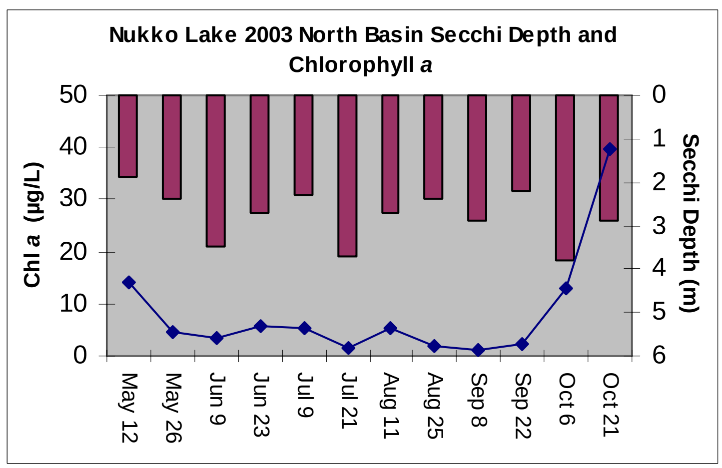
Water visibility, which is measured by Secchi disc (seen in the same figure), is used as an indicator for summer chlorophyll *a* concentrations. Secchi appeared to be a relatively good indicator of chlorophyll *a* during this program, with a three year average of 2.7m in the south basin and 3.1m in the north. Summer Secchi depth average actually increased in both basins during the sampling period, indicating water clarity actually improved slightly during the three year program. This trend was also seen in the chlorophyll *a* data, where summer averages decreased each year from 2003-2005. Future measurements of just Secchi depth should be a good indicator of algal density, and will be useful in evaluating long term productivity trends in Nukko Lake.

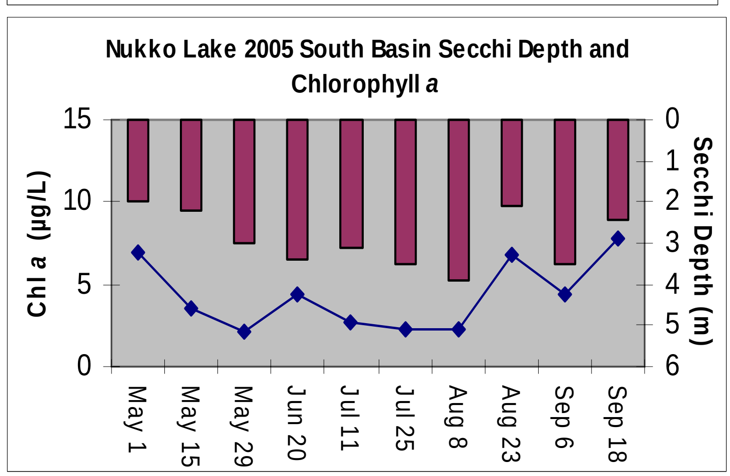












Nukko Lake Lakeshore Survey Summary

Nukko Lake's shoreline is approximately 30% developed. This includes approximately 47 lots developed with wither permanent residents or summer cabins. There is also an agricultural field paralleling a small portion of the lake and a small community park with both picnicking and swimming facilities.

A lakeshore land-use survey was conducted on Nukko Lake during the fall of 2005 by MOE. This survey was conducted using a motorized boat, with a photograph taken at each residence or developed area (a copy of the full lakeshore survey report is available on request). Notes were taken regarding riparian buffer classification, encroachment of buildings and livestock, visible erosion and questionable land-use practices.

Shoreline Survey Results	Number of Residences	% of Total
Total number of residences	47	100
Encroaching[1] outhouse	1	2.2
Encroaching house	6	13.0
Encroaching cattle pasture	0	0
Complete riparian[2] buffer	7	15.2
High riparian buffer	11	23.9
Moderate riparian buffer	15	32.6
Low riparian buffer	9	17.4
No riparian buffer	5	10.9
Private boat launches	4	8.7
Visible shoreline erosion	11	23.9
Retaining walls\breakwaters	5	10.9
Treated wood structures	0	0
Imported material on shore (gravel/sand)	2	4.3
Large effluent-type pipes	0	0

[1]According to the Regional District of Fraser Fort George, encroaching is defined as less than 15m (house), 30m (outhouse) and 15m (livestock).
[2]Refer to the Nukko Lake Shoreline Survey (2005) for a definition of the buffer classification system.

As seen in the above table, 13% of houses or cabins were encroaching the shoreline. The range for other lakes in the Omineca Peace region has been 2.5%-22%. Furthermore, there appeared to be one encroaching outhouse; however, it is thought to be no longer in use.

Although approximately 30% of Nukko Lake's shoreline is developed, most lots are large enough that they have retained substantial amounts of natural, forested shoreline. In addition, most lots (72%) had riparian buffers classified as moderate or higher. The agricultural field paralleling the east side of Nukko Lake is also well-buffered. Consequently, only 23.9% of lots were experiencing visible, human induced erosion.

Breakwaters were installed at approximately 11% of the residences. Although these breakwaters are useful in preventing erosion where they are installed, they can often deflect currents to adjacent lots increasing erosion there. Furthermore, these unnatural breakwaters can destroy or damage fish and wildlife habitat, compared to the more natural approach of vegetated riparian buffers.

Overall, the shoreline of Nukko Lake is in a relatively natural state, with the majority of developed lots retaining good riparian buffers. However, many residences could still improve their shoreline and help reduce erosion by simply planting or allowing the regeneration of additional vegetation, and avoiding the use of breakwaters.

Historical Look at Nukko Lake

Lake Coring; What does it Mean?

The Nukko 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.

Nukko Lake's north basin was cored and sectioned by the Ministry in 2005. The 31.5 cm core, which represents hundreds of years of sedimentation, was analysed by Dr. Brian Cumming of Queen's University. His report is available on request.

Historical changes in relative diatom abundance were measured directly by microscopy. By knowing the age of various core sections (using a lead 210 profile) and the phosphorus preference of the specific diatom in each section, historical changes in lake phosphorus concentrations, chlorophyll *a*, and water clarity can be inferred. Furthermore, sedimentation rates of both organic and inorganic material were determined.

Diatoms are a type of phytoplankton commonly found in lake environments. Their glass-like shell (known as a frustule) is composed of silicon and is their primary characteristic. There are two main types of diatoms, the Centrales which have radial symmetry (e.g. *Cyclotella stelligera* seen in the left photo) and the Pennales which have bilateral symmetry (e.g. *Navicula miniscula* seen in the right photo).

The lead 210 activity of the Nukko north sediment core was surprisingly low, only allowing date estimation in the top 10cm, or approximately since 1900. One hundred and thirty diatom species were found in the Nukko core, with results suggesting two major shifts in diatom assemblage. Prior to 1900, the diatom assemblage is dominated by the benthic mesotrophic indicator *Fragilaria pinnata*, *Fragilaria construens* and *Fragilaria brevistriata.* After this period, there is a distinct shift in the assemblage to the more oligotrophic planktonic *Cyclotella stelligera*, as well as smaller increases in mesotrophic and eutrophic planktonic taxa. After 1960, *Cyclotella stelligera* continued to increase along with small the eutrophic planktonic taxon *Stephanodiscus parvus.* A distinct increase in chrysophytes (golden algae) relative to diatoms is seen in the sediment record after 1900, with the largest increase occurring after 1960.

Diatom inferred TP levels indicate mid-summer mesotrophic conditions that vary between 9 and 14µg/L since approximately 1900. This estimation agrees with the current VLMP north basin program, which found similar mid-summer concentrations between 2003 and 2005.

The large increase in *Cyclotella stelligera* may not be an indication of decreasing productivity, but more likely suggesting an increasing degree of stratification. This is corroborated by the increase in chrysophytes/diatom ratio after 1900, and especially after 1960. These chrysophytes are exclusively planktonic (free floating algae) and do much better in stratified conditions compared to diatoms. This increased stratification could also affect overall productivity in the lake and increases in green and blue-green algae. The reason for this increased length of stratification is thought to be climate change during the past 100 years, which has been especially strong during the past 40 years in the Prince George region.

Sedimentation rates and percent organic matter were also determined from the sediment core. The main disturbance found was a large decrease in percent organic matter (~15%), thought to occur just after 1900. This magnitude of change is usually associated with a major watershed disturbance that would result in changes to the sediment accumulation rate. Because of the low lead 210 activity, a more specific date can not be determined. Since this disturbance (the last 100 years), the percent organic matter has increased by approximately 8%.

SUMMARY

Recent VLMP water quality results suggest that Nukko Lake is mesotrophic, with the south basin having much higher nutrient concentrations compared to the north. The north basin results agree with the lake sediment core collected in 2005. The sediment core also suggested there has been an increase in the duration of stratification since approximately 1900, which has in turn increased the chrysophyte concentrations and possibly green and blue-green algae. This increased stratification is thought to be due to climate change during the past 100 years and especially the past 40 years in the Prince George region, according to Queen's University. The VLMP data also show that both the north and south basin have a strong stratification throughout the summer, with very low oxygen conditions in both the middle and bottom depths. This suggests that most aquatic life (i.e. fish) would be confined to the top few meters of the lake for large durations of the summer. Furthermore, this lack of oxygen in the hypolimnion promotes internal phosphorus loading each summer, which has substantial impacts on algal blooms in the spring and fall, as seen in the chlorophyll *a* data.

The Nukko Lake data collected in 2003-2005 suggests that further sampling under the VLMP is not immediately required. However, because such a good relationship was found between chlorophyll *a* and Secchi depth, future Secchi readings are recommended, which will help expand the dataset and identify trends. Regardless, all residents and land developers within the watershed are encouraged to practice good land management such that nutrient and/or sediment addition to the lake and its tributaries is minimized.

Household Tips to Keep Nukko 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 and treat outgoing runoff 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

Public Feedback Welcomed

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