BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

Diver Lake 2008

Water Quality Monitoring Program

(September 2011)

The Importance of Diver Lake and its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunity. When we do not see these features in our lakes, we want to know why. Through regular monitoring programs the Ministry of Environment (MoE) can come to understand a lake's current water quality, identify the designated uses for a given lake, and monitor changes resulting from land development within the lake's watershed. The MoE can work in partnership with local government, land owners, and the BC Lake Stewardship Society (BCLSS) to develop lake specific monitoring programs and provide educational materials on general lake protection issues. This useful information can help communities play a more active role in the protection of the lake resources.

Monitoring data for Diver Lake was first collected in 2008. This status report focuses on the results from the data and outlines seasonal changes in the physical, chemical and biological makeup of the lake. The main focus of this study is to determine the overall health of the lake, its suitability as fish habitat and to identify potential threats that may compromise the integrity of the lake and its watershed. Recommendations for future monitoring are also provided.

Diver Lake lies within the Coastal Douglas-fir biogeoclimatic zone and is located on Vancouver Island, in the northwest region of the City of Nanaimo, at an altitude of 108 m. The lake's surface area is approximately 12.3 hectares, its perimeter 1600 m (FIDQ, 2011a), and its bathymetry is relatively concentric with a mean and maximum depth of 3.35 m, and 7.01 m, respectively (FIDQ, 2011b).

According to the Freshwater Atlas (GeoBC, 2011), Diver Lake's watershed (defined as the entire area of land that moves water it receives to a common water body) drains an area of 3.42 km2 (Figure 1). Watersheds are a crucial component in the hydrological cycle and, when intact, support proper maintenance of ecosystem functions. Water is continuously cleansed and recycled as it moves through watersheds and other hydrological 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. However, poor land-use practices anywhere in a watershed can eventually impact the water quality of the downstream environments.

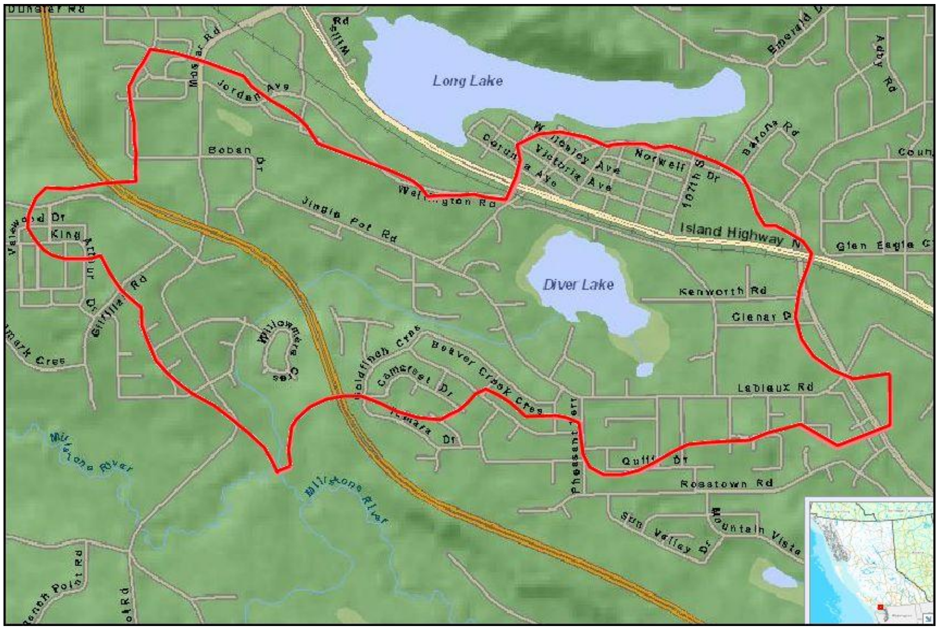


Figure 1. Diver lake with its watershed outlined in red (2011).

Diver Lake lies approximately 500 m south of Long Lake. Although the two lakes are located on opposite sides of Island Highway 19A, they are connected by a heavily channelized watercourse that flows from Long Lake, the larger of the two, into Diver Lake. The watercourse is thick with vegetation, particularly from Long Lake to the highway, at which point, the water is directed under the highway, through a culvert over 50 m in length. The channel then re-emerges as a roadside ditch for approximately 50 m until it passes through another culvert under Shenton Rd (~ 10 m in length). The lowermost 100 m of the channel flows directly into Diver Lake, becoming thick with plant life as it approaches the lake shore. This last section may be the most suitable natural habitat within the watershed to support rearing trout. The watercourse from Long Lake is the primary inflow to Diver Lake; however, the lake receives drainage from residential, commercial, industrial and park land surrounding the lake (Griffith, 1986).

Primarily on the southeast side of Diver Lake, located 15 to 25 m from the shore line, extends a variable band of wetland vegetation including reed canary grass, bulrushes, horsetail, and pink spiraea. Residential homes are located to the south and southeast of the lake and are separated from the lake by a border of apple and alder trees. Other trees on the upland include a few mature big leaf maple trees to the south of the lake, clusters of arbutus trees on the east side, and hawthorns scattered around the southern perimeter of the lake. The near shore and uplands to the north of the lake are disturbed or heavily urbanized areas where vegetation is limited or has been eradicated completely by development. Primarily to the east and north of the Diver Lake you can find the invasive species scotch broom and European blackberry dominating smaller patches of land (Holland, 1991).

The wetlands and upland grasses and trees around Diver Lake are potentially suitable habitat for a variety of birds and small mammals. It is not uncommon to see racoons and rabbits around the lake. Birds commonly found at Diver Lake include starlings and robins, while waterfowl such as mallards, Canada geese, mergansers and redwing blackbirds have been observed utilizing the wetlands. The wetland vegetation is also important in that it stabilizes the lake shore, helps filter stormwater runoff, and provides nesting sites and food sources for birds, as well as habitat for juvenile fish and their food organisms.

Diver Lake is frequented by anglers and is considered to have a high recreational value as an urban fishery. It is one of the most heavily used lakes in the region with respect to recreational fishing. A MoE fish survey conducted in December of 1995 reported presence of sculpin, stickleback, pumpkinseed, and crayfish. The fish were determined to be healthy with a good conditioning factor. Aside from releasing 69 steelhead trout in 1999, stocking efforts at Diver Lake have entailed the release of either rainbow or cutthroat trout. Diver Lake was first stocked with cutthroat trout in 1926. It was not stocked again until 1961, at which point, stocking activities involved releasing both cutthroat and rainbow trout. The last release of cutthroat trout occurred in 2004 and the lake has been stocked exclusively with rainbow trout since then, with the Freshwater Fisheries Society of BC (FFSBC) releasing 21,508 catchable sized rainbow trout into Diver Lake from March, 2004 to June, 2011. Currently, Diver Lake is stocked in the early spring and fall; it is not stocked during the summer as lake characteristics at this time diminish fish survival rates (Silvestri, pers. comm., 2011). In 2011, the FFSBC sponsored the installation of a new fishing pier on Diver Lake. The 400-square foot pier was built in conjunction with the Habitat Conservation Trust Fund and the City of Nanaimo and could further increase the popularity of Diver Lake as an urban angling site. Figure 2 shows a bathymetric map of Diver Lake, including the approximate locations for the Ministry of Environment (MoE) water monitoring site, the new fishing dock and primary inflow and outflow streams.

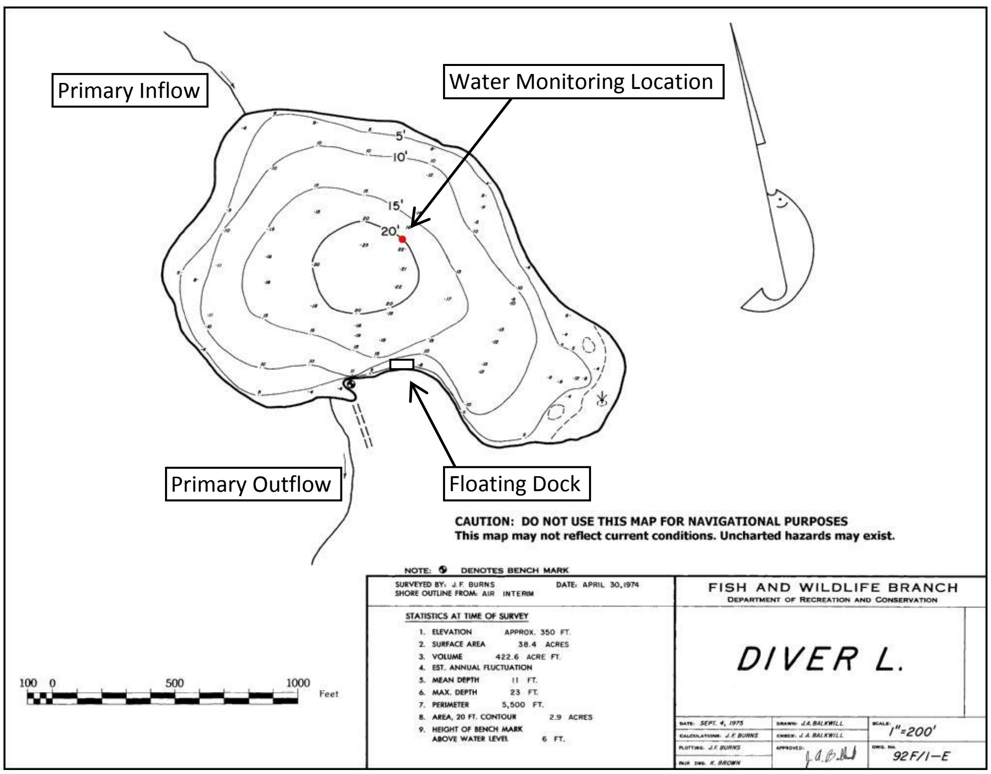


Figure 2. Bathymetric map of Diver Lake including water monitoring location, inflow and outflow points, and public fishing dock.

Challenges to water quality management on Diver Lake include phosphorous loading from non-point sources, shallow depths, warm temperatures and low oxygen levels, particularly in the summer months. Excess phosphorous can cause spring and summer algal blooms and support the growth of aquatic vegetation. When the vegetation and blooms die off and settle to the bottom, this can lead to oxygen depletion in the lake which can affect aquatic life, such as fish. Nutrient loading is compounded by the lake's shallow depth, which provides favourable temperatures and photic opportunities for algae growth deep into the water column. Furthermore, as oxygen levels decrease near the bottom, internal nutrient loading occurs, whereby phosphorous is released from the sediment and enters the water column, exacerbating an already nutrient rich environment.

Diver Lake is surrounded by residential housing, commercial and industrial facilities, and a heavily used highway (Figure 3), making urban pollution and encroachment a constant threat to the health of the lake and the integrity of its watershed. Conserving the remaining fish and wildlife habitat within the watershed is another considerable challenge. Preventing excessive nutrient loading and pollution from entering Diver Lake is important for supporting good water quality and preserving the lake's biological community. This may become particularly challenging given the lake's urban surrounding, small size and shallow depth that make it more susceptible to inputs of nutrients, pollutants or sediment.

Figure 3. Aerial view of Diver Lake, (2004).

Land use designations play a key role within a lakes watershed and for Diver Lake, and particular urban activities may pose unique challenges to upholding ecological integrity. An extensive portion of Diver Lake's watershed has been covered with impermeable surfaces such as roadways and parking lots. Decreasing a watershed's permeability can greatly diminish its natural capacity to filter runoff and offset pollution. Figure 3 shows a large commercial community, primarily composed of automotive dealerships, that has developed to the east of the lake, with more recent developments to the northwest. The use of oil, gasoline and other industrial fluids at these facilities could seriously degrade the water quality at Diver Lake if the proper precautions are not taken to prevent rainwater from flushing the pollutants into the waterbody. Educating business owners regarding the ecological needs of Diver Lake is important in safeguarding the lake from exposure to industrial chemicals. Business operators should be encouraged to implement comprehensive and progressive transport, handling, storage and spill response protocols to ensure risks are minimized. In the past, the Nanaimo Business Stewardship Project (NBSP) and Nanaimo Area Land Trust (NALT) have championed better management practices for automotive businesses in hopes to educate and motivate business operators to minimize their environmental impact. By performing environmental surveys and providing businesses with resource guides, the program accredited those facilities that showed improvements towards running their business more sustainably. However, due to funding issues, the program was ended in 2003, and no follow-up was ever conducted (Adrienne, pers. comm., 2011).

Non-Point Source Pollution and Diver 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 (NPS) of pollution (Figure 4). Shoreline modification, urban stormwater runoff, onsite septic systems, agriculture and forestry are common contributors to NPS pollution.

One of the most detrimental effects of NPS pollution is phosphorous loading to water bodies. The amount of total phosphorous (TP) in a lake can be greatly influenced by human activities. If local soils and vegetation do not retain this phosphorous, it will enter water courses where it will become available for algal production. Watersheds have the ability to buffer against pollution in time but the ability is impeded with landscape modification and/or significant increases in pollution.

Figure 4. Non-point sources of pollution in a watershed.

Land Use

Lakeshore property owner's rights and increasing land values can promote high land use expectations at the expense of lake-shore riparian areas. Residential development generally includes clear-cutting and other vegetation removal for placement of structures. This can be limited to just the building site requirements or can include removal of riparian vegetation, land clearing for lawns or agricultural activities, shoreline protection structures, and docks. All of these land disturbance activities can alter water flow, and potentially increase sediment and phosphorous inputs to water bodies.

Agriculture

Agriculture, including livestock, the production of grains, and mixed farming can alter water flow and increase sediment, chemical, bacterial, and parasitic input into water bodies. Agricultural runoff is a potential source of freshwater eutrophication – a process where organic and inorganic compounds such as nitrogen and phosphorous, not normally present in such abundance, are introduced to a lake. The usual result of eutrophication is an overabundance of algae growth on the lake surface.

Onsite Septic Systems and Grey Water

As long as onsite septic systems are properly located, designed, installed and maintained, they can effectively treat human waste water and wash water (grey water). Failure of onsite septic systems can cause significant nutrient and pathogenic waste to enter the water body and can be dangerous to human and animal health.

Storm Water Runoff

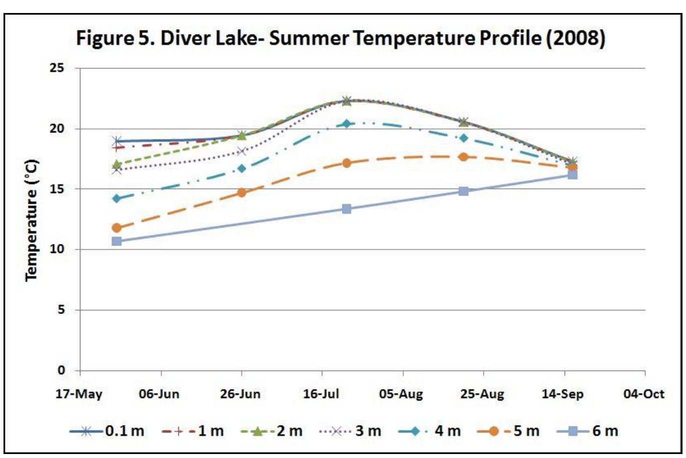
Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, lawn chemicals, oil and fuel leaks from vehicles and boats, road salt, and litter can all be washed by rain and snowmelt from properties and streets into water courses. Phosphorous and sediment are of greatest concern, providing nutrients, and/or rooting medium for aquatic plants and algae. Paved structures prevent infiltration of water to soils, collect hydrocarbon contaminants during dry weather, and increase direct runoff of these contaminants to lakes during heavy rain events. Severe stormwater runoff can cause soils to erode and can result in property loss. As a common resource, it is the responsibility of everyone to ensure that the freshwater resources remain clean. The control of runoff pollution, at the source, is vital to the protection of this precious resource.

What's Going on Inside Diver Lake?

Temperature

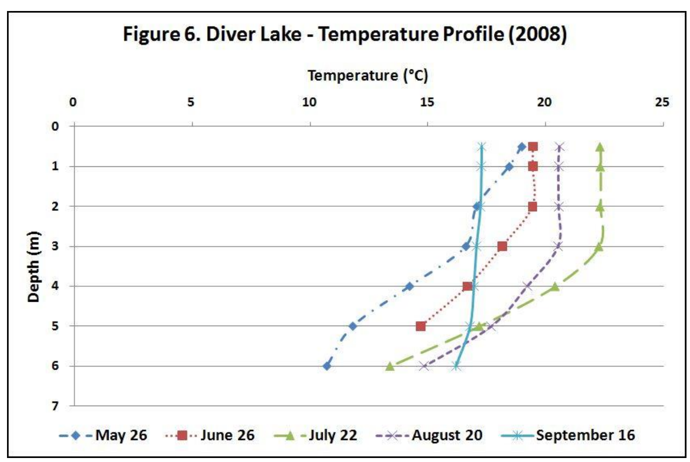
Temperature can affect the solubility of many chemicals and can therefore influence the effect of pollutants on aquatic life. If lake temperature drops more than 1°C over an increase in depth of 1 m, a thermocline develops, effectively layering (stratifying) the water body and preventing overturning (mixing from top to bottom). Colder water is denser and heavier and lies on the bottom overlain by subsequent warmer, less dense layers. Temperature stratification patterns are important to lake water quality because they determine much of the seasonal oxygen, phosphorous, and algal conditions. Most Vancouver Island lakes stratify in the summer and, like coastal lakes, are typically monomictic, overturning once during late winter or spring as wind energy overcomes the differences in temperature and density between layers within the water column. Without adequate wind agitation, shallow lakes may exhibit heightened temperatures, which in turn, elevate the metabolic oxygen demand of aquatic organisms while reducing the solubility of oxygen in the water.

The absorption of solar radiation and its conversion into heat have profound effects on the thermal structure, stratification and circulation pattern of lakes (Wetzel, 2001). Based on a 2008 seasonal temperature profile (Figure 5 (n=34)), Diver Lake began to weakly stratify by late May.



Stratification became relatively stable on July 22nd, with temperatures of 20.40, 17.18 and 13.39 °C measured at 4, 5 and 6 m deep, respectively. A maximum temperature of 22.32 °C was also recorded on July 22nd at 1 m deep. In 2008, the lowest recorded temperature at Diver Lake was 10.70 °C, measured at 6 m deep on the 26th of May.

Diver Lake became isothermic (its temperature relatively uniform from top to bottom) by the fall of 2008, with surface and bottom temperatures of 17.28 and 16.19 °C, respectively, on September 16th (Figure 6). Surface temperatures began to drop dramatically in September due to the cooler seasonal temperatures and less exposure to solar radiation. Bottom temperatures, however, stayed relatively stable because, although solar radiation became less intense into the late summer and fall, the available sun light could now penetrate deeper into the clearer water column as algal blooms died off and receded. This caused Diver Lake to become isothermic in the fall, with surface and bottom temperatures separated by only 1.09 °C on September 16th, represented by the vertical nature of the solid line in Figure 6.



Dissolved Oxygen

The availability of oxygen in water is critical to the maintenance of aquatic life. Oxygen enters the water as dissolved oxygen (DO) from many sources including air, wind action, and through plant photosynthesis. Oxygen is consumed by the respiration of plants and animals and through the decomposition of dead organic material by bacteria (Carter & Roumiew, 2008).

Lakes that are low in productivity (oligotrophic) typically have sufficient levels of oxygen to support life at all depths. As lakes become more productive (eutrophic) and more organisms consume oxygen, its availability becomes increasingly limited and sufficient quantities to accommodate new life may only be found at certain depths. Fish, for example, can become stressed when oxygen levels fall below 5 mg/L, the instantaneous minimum level recommended for the protection of aquatic life (MoE, 2001). However, sufficient amounts of oxygen may not be at depths that correspond with the optimum temperature ranges that support certain species.

Multi-Depth DO data was collected once a month at Diver Lake from March to September, 2008 (Figure 7). A maximum DO value of 10.21 mg/L was recorded at depths equal to or less than 1 m on May 26th and a minimum value of 0.29 mg/L was recorded at 6 m deep on August 20th. From late spring to early fall, sufficient DO levels (≥5 mg/L) could only be found at depths of 3 m or less. At 4 m deep, otherwise anoxic during mid-late summer, there is a brief increase in DO in late July to just above the recommended instantaneous minimum. This is likely due to an algal bloom approximately 4 m deep that supplied the water with oxygen produced through photosynthesis and corresponds with the warmest average water temperature during the sample period of 20.02 °C on July 22nd.

Comparing summer DO levels to temperature patterns in Diver Lake shows the effect stratification can have on the chemical properties within the lake. On June 26th, 2008, temperature was relatively uniform from surface waters to 2 m deep (0.5 m = 19.46 °C, 1 m = 19.45 °C, 2 m = 19.44 °C), and so, with adequate mixing occurring between these depths, DO values were also similar (0.5 m = 9.75, 1 m = 9.73, 2 m = 9.70 (mg/L)). As depth continued to increase temperature dropped more sharply, from 19.44 °C at 2 m to 18.15, 16.69 and 14.70 °C at 3, 4 and 5 m, respectively. The mixing that had occurred in the epilimnion (the upper layer of the water column) contributing to similar DO concentrations was facilitated by uniform temperatures. The cooler, denser layer at 3 m exhibited a much lower concentration of DO (5.95 mg/L), as it was unable to mix with the epilimnion to receive oxygen from wind agitation.

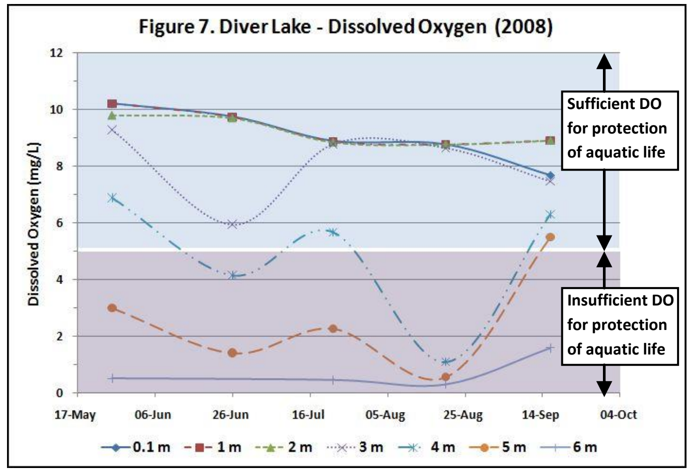


Figure 7. Diver Lake - Dissolved Oxygen (2008)

For all sample dates in 2008, DO begins to drop at 3 m depth, steadily diminishing towards insufficient levels for the protection of aquatic life. In June, depths of 2 m or less have relatively high DO levels (Figure 8), likely from wind agitation and biological activity that was confined to warmer, more shallow waters due to less intense incoming solar radiation.

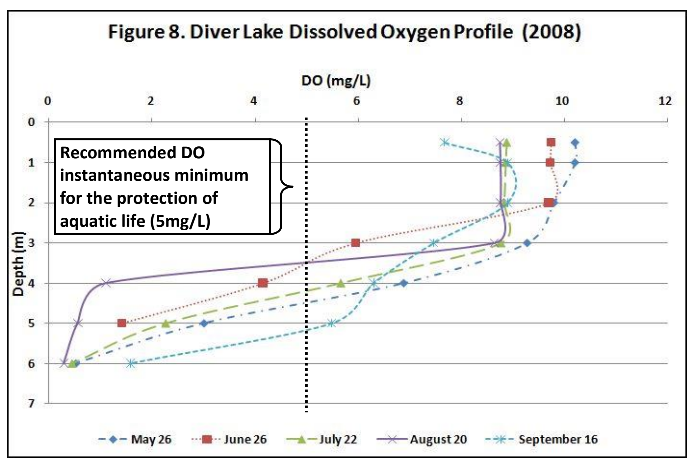


Figure 8. Diver Lake Dissolved Oxygen Profile (2008)

By July and into August, with warming temperatures and the photic zone expanding downwards, algal species started to inhabit and photosynthesize in deeper waters, and thus, higher DO was found at depths ≥ 3 m. In September, temperatures began to diminish and become more uniform throughout the water column and the former thermocline began to weaken, allowing for more thorough mixing from surface waters to approximately 5 m deep. This allowed mixing to circulated and redistributed oxygen to deeper waters, thus the range of values decreased and levels became more similar throughout Diver Lake. Furthermore, cooler waters could now store higher concentration of DO and exhibited sufficient DO levels for the protection of aquatic life up to 5 m deep.

Trophic Status and Phosphorous

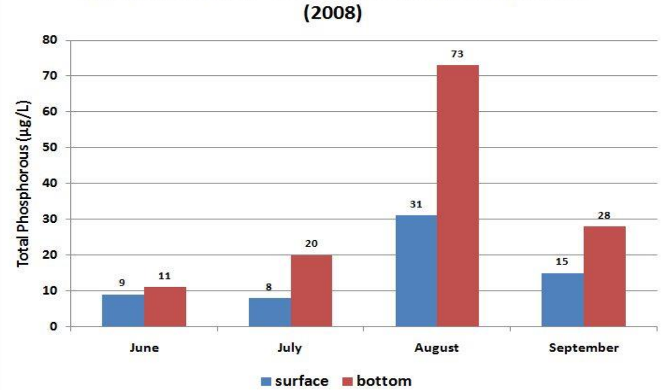
The term trophic status is used to describe a lake's level of productivity and depends upon the amount of nutrients available for plant growth, including tiny floating algae called phytoplankton. Algae are important to the overall ecology of the lake because they are food for zooplankton, which in turn are food for other organisms, including fish. In many lakes, as is the case with Diver Lake, phosphorous is the nutrient in shortest supply, acting as the nutrient limiting aquatic life production. When in excess, phosphorous accelerates growth and can artificially advance a lake towards a higher trophic status. As mentioned on Page 4, TP in a lake can be greatly influenced by human activities.

The trophic status of a lake can be detected by measuring productivity, as determined by measuring nutrient levels and chlorophyll (the green photosynthetic pigment in plants). The more productive a lake is the higher the algal growth and the less clear the water. Phosphorous concentrations measured during spring overturn are often used to assess current productivity and predict summer algal productivity. Lakes of low productivity, referred to as oligotrophic, 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 called eutrophic. They have abundant plant life (> 7 µg/L chl. a), including algae, due to 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. α) (Nordin, 1985). Mesotrophic lakes tend to encompass the characteristics 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. The release of TP from sediments can cause algal blooms and lead to further oxygen depletion when algae die. This internal loading of phosphorus can be natural but is often the result of phosphorus pollution. Lakes displaying internal loading usually have elevated algal levels and typically lack recreational appeal. The phosphorus guideline recommended for the protection of aquatic life is 5-15 µg/L TP and for recreational utility, phosphorous levels should not exceed 10 µg/L (MoE, 2001).

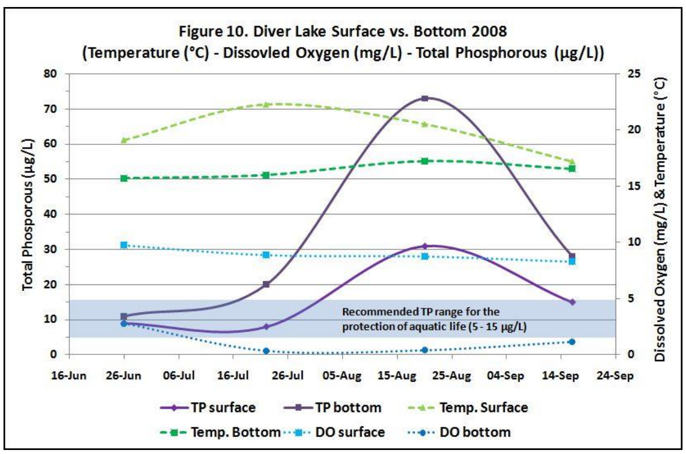
Total phosphorous (TP) data was collected for Diver Lake once a month in 2008 from June to September. Figure 9 separates TP into surface and bottom concentrations. In general, the levels of bottom phosphorous are far greater than those at the surface, indicating that during the summer and early fall of 2008; the majority of total

Figure 9. Diver Lake - Surface and Bottom Phosphorous (2008)



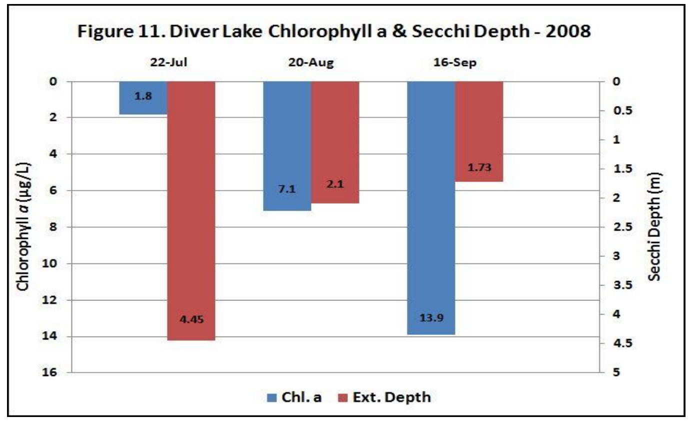
phosphorous in the lake was a result of internal nutrient loading. The largest recorded concentrations for both surface and bottom concentrations were measured in August, with surface values reaching 31 µg/L while bottom levels measured 73 µg/L.

In June, TP levels in the hypolimnion began to increase, likely due to temperature stratification and algal die off. Comparing TP measurements to the average temperature of the hypolimnion (the bottom layer, ≥ 4 m deep) indicates that the warming of bottom waters initially decreased the concentration of DO in the hypolimnion and stimulated a chemical reaction in the substrate of Diver Lake. The result was the release or remobilization of phosphorous formerly trapped in bottom sediments (Figure 10) and a much sharper increase in bottom TP into July and August. Although surface values also rise during this time, the increase is relatively modest as temperature stratification prevents internally loaded bottom nutrients from mixing with the epilimnion (surface layer). Furthermore, biological uptake during this time was continually removing phosphorous from shallower water. By late August, TP and temperature throughout the water column began to decline. Surface concentrations of DO also decreased slightly, largely the result of algal die off. Conversely, bottom DO concentrations rose slightly as the lake began to cool, decreasing aquatic organisms' metabolic demand for Oxygen.



Summer plant life samples, as measured by chlorophyll *a*, were collected in 2008 on July 22nd, August 20th and September 16th in the epilimnion of Diver Lake. Chlorophyll *a* concentrations are shown with Secchi depth readings in Figure 11. Secchi depth is an indicator of water clarity and is measured by submerging a 20 cm diameter, black and white disc into the lake and recording the depth at which the disc is no longer visible.

Generally, Secchi depth displays a negative correlation to concentrations of chlorophyll *a* because algal blooms reduce water clarity. In June, biological uptake in Diver Lake was limited and chlorophyll *a* concentrations were relatively low (1.8 µg/L). With low chlorophyll *a* levels, the lake was fairly clear, indicated by a secchi depth reading of 4.45 m. As summer progressed, warmer temperatures increased biological activity, perpetuating algal blooms and by late July, chlorophyll *a* concentrations had increased nearly fourfold (7.10 µg/L), in turn obscuring the water and decreasing the secchi depth reading to 2.10m.



In the fall, biological activity peaked and chlorophyll *a* was measured at 13.9 µg/L on September 16th. As biological activity accumulated over the late summer, chlorophyll *a* values almost double from August 20th to September 16th. The mounting biological activity in Diver Lake corresponds with a decrease in secchi depth from 2.1 m to 1.73 m over the same time span.

Hardness, Metals & Polycyclic Aromatic Hydrocarbons (PAHs)

Hardness is commonly considered an aesthetic quality of water and is usually a symptom of relatively high concentrations of calcium and magnesium in a waterbody. Although these minerals may not be a direct threat to the health of a lake and its biological community, monitoring water hardness can help indicate an aquatic ecosystems tolerance for certain toxins (MoE, 2001). Higher concentrations of calcium and magnesium, measured as calcium bicarbonate, can buffer the impacts of potentially harmful metals such as aluminum, cadmium, copper, lead, manganese and zinc. It is therefore important when measuring metals that water hardness is concurrently monitored. Many of these metals are commonly used in industrial process, some of which are automotive. For example, the electroplating of metals and alloys to protect against corrosion, as well as tire fillers and many lubricants, are potential sources of cadmium (Bonar, 2003).

PAHs are organic compounds, non-essential for the growth and survival of plants and animals, yet they are widespread in the environment. When sufficient quantities are present, certain PAHs become toxic and carcinogenic to plants and animals (Nagpal, 1993). Major sources of PAHs into aquatic environments include petroleum spillage, wastewater and surface water runoff. Concentrations in fresh water lakes can vary widely and largely depend on such factors as source type and proximity to source, as well as, the size and flushing rate of the affected lake (Nagpal, 1993).

Considering Diver Lake's relatively small size along with its close proximity to sources of metals and PAHs, there is potential for the health of the lake to be degraded by such toxins and chemicals. In 2003, in conjunction with the Better Management Practices program, NALT performed an assessment that measured levels and attempted to identify possible sources of metals and PAHs within the industrial area of Diver Lake's watershed. The previously listed metals, along with PAHs including; Anthracene, Benzo(a)antrhracene, Benzo(a)pyrene, Fluoranthene, Phenanthrene and Pyrene, were measured along storm drains which flowed into the lake (Figure 12).

Figure 12. Sample sites for NALTs Water Quality Data Report (2003).

The resulting report, *Water quality data report (2003): Diver Lake tributary (Kenworth Road)* (Bonar, 2003*)*, identified aluminum, cadmium, copper and zinc as metals with relatively high concentrations which exceeded background levels. Likewise, Fluoranthene and Pyrene concentrations were found to exceed background levels at several sites. Although the report does recognize the presence of these potentially harmful substances within Diver Lake's watershed, determining their environmental affect requires follow up.

Recommendations for Water Quality Management at Diver Lake

Diver Lake is a eutrophic lake with the potential to become hyper eutrophic. It is a relatively small and shallow lake, making it more vulnerable to inputs of pollutants, sediment and nutrients. Its watershed is dominated by residential and urban areas with light industrial facilities located in close proximity to the lake. This environment may contribute to the accumulation of metals, PAHs and phosphorous in the lake and the remaining vegetation within the watershed may be insufficient to buffer against excess pollutants and external nutrient loading. Water quality monitoring to date has been limited and does not provide for analysis of long term trends of physical, biological and chemical characteristics. It is recommended that water quality monitoring at Diver Lake resume with the development of a comprehensive watershed management plan, including a nutrient budget, to assess the progression of the lakes trophic status and help guard against hyper-eutrophication. The high recreational value of Diver Lake, especially as an urban fishery, further increases the importance of lake water quality monitoring and watershed management, including reducing potential sources of nutrients, metals and PAHs.

In July and August of 2008, Diver Lake had insufficient levels of DO to support aquatic life in the hypolimnion. However, these relatively anoxic depths exhibited temperatures more favourable to fish life than the overlying, warmer waters with higher DO levels. This effectively limited the habitat range of fish to a small band, more or less near mid-depth, where temperature and DO may not be favourable but tolerable. Heightened levels of phosphorous can exacerbate this condition, further decreasing the range of suitable habitat and increasing physical stress on fish. During the summer, this layer is crucial for the survival of fish, however, if wind agitation overturns lake waters, the dispersal of DO throughout the water column can result in insufficient levels at all depths and ultimately cause fish kills. To support the biological community at Diver Lake and maintain its value as an urban fishery, nutrient inputs must be mitigated.

Educating and motivating home owners and business operators within the Diver Lake watershed is an important step towards reducing the levels of unnatural external inputs into the lake. This should be addressed in a watershed management plan for Diver Lake. A program similar to NALT's past better management practices initiative should be implemented to make businesses aware of basic watershed dynamics and their potential impacts on the ecological integrity of the watershed and lake, while providing specific guidelines and options on how to moderate their influence on the aquatic environment. Such a plan should be long term and include follow up assessments to gauge commitment levels and determine the level of progress towards improved stewardship.

---------------------------------Tips to Keeping Diver Lake Healthy----------------------------------

Yard Maintenance, Landscaping & Gardening

- Minimize the disturbance of shoreline areas by maintaining natural vegetation cover
- Minimize high-maintenance grassed areas
- Replant lake-side 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 apply fertilizers or pesticides before or during rain due to the likelihood of runoff
- Compost yard and food waste and use it to boost your garden's health as an alternative to chemical fertilizers
- Use natural insecticides such as diatomaceous earth

- Prune infested vegetation and use natural predators to keep pests in check. Pesticides can kill beneficial and desirable insects such as ladybugs

Agriculture

- Locate confined animal facilities away from water bodies and 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 stream banks and lake-shores
- 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 stream bank, river or lake-shore and avoid planting crops right up to the edge of a water body

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
- Conserve water: run the washing machine and dishwasher only when full and use only low-flow showerheads, faucets, and toilets.
- Don't put toxic chemicals (paints, varnishes, thinners, waste oils, photographic solutions, or pesticides) down the drain. They can kill the bacteria at work in your on-site sewage system and can contaminate water bodies

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 and wash your car over gravel or grassy areas, but not over sewage systems

Boating

- Do not throw trash overboard or use lakes or other water bodies as toilet
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals
- 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. Eurasian milfoil is an aggressive invasive aquatic weed. Be sure to familiarize yourself with this plant and remove and discard any fragments
- 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 and label them with owner's name and phone number in case they wash away.

Who to Contact for More Information

Ministry of Environment
2080-A Labieux Road
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Phone: (250) 751-3100
Fax: (250) 751-3103

The BC Lake Stewardship Society
#4-552 West Ave.
Kelowna, BC V1Y 4Z4
Phone: 1-877-BC-LAKES or
(250) 717-1212
Fax: (250) 717-1226
Email: bclss@shaw.ca
Website: www.bclss.org

Regional District of Nanaimo,
Water and Wastewater Services
6300 Hammond Bay Road
Nanaimo, BC V9T 6N2
Phone: (250) 390-6560
Email: wwsrv@rdn.bc.ca

City of Nanaimo,
Engineering & Public Works:
Tom Hickey, Director of Engineering & Public Works
Phone: (250) 756-5301
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