WATER QUALITY SURVEY OF BLACKSTONE, CRANE, HEALEY AND KAPIKOG LAKES, 2008

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1.0 INTRODUCTION

1.1 Purpose

Good water quality and healthy aquatic ecosystems are generally the most important concerns expressed by those living on or using recreational lakes and rivers in Ontario. Without clean and safe water, many of our favoured summer recreational activities are jeopardized and our sense of enjoyment in being in a natural and relatively pristine environment is quickly lost. Unfortunately, our increasing demands for more cottages, more boats, more roads, more marinas and other “economic development” activities can seriously stress our efforts to protect and preserve natural water quality and aquatic ecosystems.

It is well recognized that human activities on or near the water can have a significant effect on water quality. Land use activities can involve shoreline development for year-round or seasonal residences, campgrounds, trailer parks, marinas, and other private or commercial facilities. Water quality effects can include nutrient leaching from septic systems, shoreline erosion, runoff of fertilizers, herbicides and pesticides from lawns, spills of solvents or other toxic materials, oil and gasoline spills, etc. Water based activities include recreational boating and the water-transport of various goods and materials. Water quality effects can result from spills, combustion residues from marine engines and the discharge of contaminated water (termed “greywater” for washwater and “blackwater” for sewage system effluent).

Bacterial contamination can come from various sources related to these human activities. Where such contamination is excessive, the safe use of these waters for drinking or recreational use can be jeopardized. Unfortunately, it is often difficult for water users to assess or measure bacterial levels to determine safety of use.

The Township of the Archipelogo is fortunate to have some of the most outstanding freshwater environments on the continent. This includes the central portion of the Thirty Thousand Island coastline of Georgian Bay and a series of interior lakes and watersheds which remain in a relatively natural condition. This is worth protecting! Recent experience in Sturgeon Bay demonstrates that protecting water quality is preferable to trying to remediate it at some later date.

A water quality monitoring program for Blackstone, Crane, Healey and Kapikog Lakes was initiated by the Township in 2000, with the results presented in the “Water Quality Monitoring Report – 2000, Township of the Archipelogo” (Schiefer, March 2001).

This report provides the results of a water quality monitoring program carried out during 2008 on these same four lakes in the Township of the Archipelago. Its general purpose was to assess current water quality conditions in Blackstone, Crane, Healey and Kapikog Lakes, and to continue the development of a longer-termed database which will be instrumental in future efforts to manage and protect water quality and aquatic ecosystems in these lakes.

1.2 Water Quality Parameters

The 2008 water quality study focused on a number of water quality parameters which are most commonly used to indicate the present status of water quality and aquatic ecosystem health in freshwater lakes.

The Limnological process of greatest concern is **eutrophication**, or the enrichment of lake waters by nutrients such as phosphorus and nitrogen, and their associated effects. In an extreme condition, eutrophication can lead to extensive algal blooms and problems with toxic blue-green algae as has occurred recently on Sturgeon Bay. **Acidification** is also of concern, especially on Healey and Kapikog Lakes which occur in a sensitive geological area for acidification. Ecological effects related to **climate change** and global warming are of increasing concern for many areas.

To assess the present condition and track future trends of water quality and ecological processes in these lakes, the following physical, chemical and biological parameters are measured. The value of measuring each parameter and the typical natural range for each is also provided to assist in the interpretation of results.

Water Conductivity

Water conductivity is a measurement of the ability of a water sample to conduct a current of electricity using a conductivity meter. The conductivity of water is directly related to levels of total dissolved solids (TDS), including minerals, in that water. Soft water, having less dissolved minerals, has a lower conductivity while hard water, with more dissolved minerals, has a higher conductivity. Waters running off of the granite shield are typically low in dissolved minerals (soft) and have a low conductivity value, usually in the range of 30 to 80 µS/cm. Waters draining the limestone bedrock of Southern Ontario have higher levels of dissolved minerals (hard) and a resulting higher conductivity, often in the 200 to 500 µS/cm range. Georgian Bay waters have conductivity around 200 µS/cm while tributaries draining off of the shield are usually 40 to 60 µS/cm.

Measuring water conductivity has two primary benefits. First, as discussed above, it provides an indication of the relative hardness (quantity of total dissolved solids) of the water. Secondly, it provides a good indicator of water sources and mixing patterns in lakes and Georgian Bay coastal waters. A lake with good mixing of surface waters throughout its basin will have similar water conductivity readings in all locations. A lake with more isolated bays which do not mix readily with waters of the main basin will often have different water conductivity readings, depending on tributary influences. Water conductivity measurements can also indicate the degree of isolation of deeper, cold waters below the thermocline from warmer surface waters during the summer period of thermal stratification.

pH

The level of acidity in the water is measured as pH. A pH of 7 is neutral, with lower values being acidic and higher values basic. Natural waters in Southern Ontario and the Great Lakes typically have a pH of 7.5 to 8.5. Waters draining the granite shield are more acidic, especially if they drain bogs and small marshy lakes. The pH of these waters is typically in the range of 6.0 to 7.0. In more extreme cases, the pH of small tributary streams can drop below 5.5, which is a level of acidity that is harmful to aquatic life, including some fish species.

Acidification of surface waters is a concern in some areas, mainly because of atmospheric sources of acidic inputs, including acidic rainfall. This is particularly true where the bedrock geology is more sensitive to acidification, as in the case near Kapikog and Healey Lakes. This is discussed further in Sections 4.0 and 5.0.

Alkalinity

Alkalinity refers to the capability of water to neutralize acid, often expressed as buffering capacity. A buffer is a solution to which an acid can be added without changing the pH appreciably. It essentially absorbs the excess H^+ ions and protects the waterbody from fluctuations in pH.

Alkalinity is often related to the hardness of water since the main source of alkalinity is from carbonate rocks, such as limestone. Granite bedrock has little carbonate, so most lakes on the granite shield have reduced levels of alkalinity. The alkalinity level of a lake is important as it determines the sensitivity of that lake to future acidification potential.

For protection of aquatic life the buffering capacity (alkalinity) of a lake should be above 20 mg/L. If alkalinity is naturally low, less than 20 mg/L, it should not be allowed to drop by more than 25%.

Total Phosphorus

Total phosphorus concentrations are generally used to interpret the nutrient status of a lake since phosphorus is the element that controls the growth of algae in most Ontario lakes. Increases in phosphorus in the surface waters of lakes can typically result in the following effects:

- a stimulation of algae growth in the lake, including a green slimy growth on lakeshore rocks and green plankton blooms in surface waters.
- a decrease in water clarity because of the increased algae (plankton)
- a decrease in deepwater dissolved oxygen levels (below the thermocline) due to bacterial activity on dead algae as it sinks to the bottom of the lake. As lakes become more nutrient enriched (euthrophic), it is this loss of oxygen in the deep

coldwater zone which often results in the loss of lake trout, whitefish and other sensitive fish species.
- in extreme cases, algal blooms will affect the aesthetics of a lake and could cause taste and odour problems in the water. If blue-green algal blooms occur, as in the case of Sturgeon Bay, the water can become unusable for recreational or domestic purposes.

Many limnologists place lakes into three broad categories with respect to nutrient status. Lakes with less than 10 µg/L total phosphorus (TP) are considered oligotrophic. These are dilute, low productivity lakes that rarely experience nuisance algal blooms. Lakes with TP between 10 and 20 µg/L are termed mesotrophic and are in the middle with respect to trophic status. These lakes show a broad range of characteristics and can be clear and unproductive at the bottom end of the scale or susceptible to moderate algal blooms at concentrations near 20 µg/L. Lakes over 20 µg/L are classed as eutrophic and may exhibit persistent, nuisance algal blooms.

Most lakes in the Township of the Archipelago would have natural background levels of total phosphorus below or around 10 µg/L. The goal should be to keep total phosphorus levels below 10, with 12 to 15 as a trigger point for remedial action. For reference purposes, Sturgeon Bay commonly has TP levels above 25, and sometimes above 30.

The Ministry of Environment (MOE) typically measures total phosphorus in the spring, just after ice-out and spring turnover in the water column. Recent measurements from the MOE Lake Partner Program, where available, have been provided for each lake. These tend to be single measurements in the centre of the lake. The 2008 sampling program included six or seven surface samples in various locations on each lake.

The 2008 program also included phosphorus sampling in the deeper, cold water zone (below the thermocline) of each lake. Where a lake had more than one deep basin, sampling was carried out in each of these. Deep water phosphorus sampling in late summer is important to assess whether phosphorus is being released from lake sediments under conditions of thermal stratification. Phosphorus release from organic sediments can reach very high levels when these deep waters become anoxic. Anaerobic bacterial activity releases phosphorus to the water. Under these conditions, phosphorus levels can build up below the thermocline and be released to surface waters in the fall when the thermocline breaks down. It is this process of phosphorus release from lake sediments under anoxic conditions which has been identified as the primary cause of extensive blue green algae blooms in Sturgeon Bay in September or early October. This process does not occur if oxygen levels remain high enough in these deeper waters throughout the summer. Kapikog and Healey Lakes both show symptoms of deep water phosphorus cycling under low oxygen conditions in late summer (Figure 4.3 and 5.3). This is discussed in Sections 4.0 and 5.0.

Another indicator of anoxic conditions in the release of small suspended bubbles of hydrogen sulphide (H_2S) gas in the water above these deep sediments. These show as small black dots on the sonar charts, generally 2 to 4 m from the bottom. Water samples collected from these deeper areas have a strong sulphur smell because of the hydrogen sulphide gas bubbles. This condition is evident on Healey and Kapikog Lakes, but not on Blackstone or Crane Lakes.

Water Clarity

Water clarity is typically measured using a Secchi disc, which is a black and white weighted disc which is lowered into the water until it is no longer visible from the surface. The depth at which it ceases to be visible is the Secchi depth of visibility. In clear lakes, the visibility (Secchi depth) may be 5 to 8 m while in other lakes, typically with greater plankton blooms, visibility may be reduced to 1 or 2 m. In Sturgeon Bay, plankton blooms can reduce water visibility to less than 1 m.

Water clarity is a simple feature to measure but can be very useful to track changes that might be occurring in the lake over time, which monitoring TP alone might not be noticed.

Temperature Profile

Because most deeper lakes thermally stratify during the summer and because this stratification can have a major influence on the limnological and biological processes occurring in the lake, it is important to understand where and how this stratification is occurring in a lake. This is done by measuring the water temperature at 1 m intervals from the surface of the lake to the bottom, unusually in the deepest part of the lake basin. When a lake stratifies, it typically develops a thermocline, or zone of rapid temperature change, at a depth of 6 to 10 m. The actual thermocline depth will vary from lake to lake. One important feature of the thermocline is that it prevents surface waters from mixing with the deeper, colder and denser water below it. This, in effect, isolates the water column below the thermocline for the entire period that the thermocline is in place. When the thermocline breaks down in the fall, mixing can occur from top to bottom at similar water temperatures, a process called “fall turnover”.

The location of the thermocline is illustrated for each of the four lakes in Figure 2.3, 3.3, 4.3 and 5.3. Its location is defined by the temperature profiles (red line) to the right and superimposed on a sonar chart across the deep basin of that lake.

Another benefit of measuring and recording this thermal profile is that it provides one of the better indicators of potential climate change within a lake. If summers become warmer and extend over a longer time period, the thermocline could be expected to form earlier in the summer, last for a longer time period in the fall and be pushed deeper into the water column because of the increased volume of warm water on the lake’s surface. This can have a major effect on other lake processes, including the amount of dissolved oxygen left in these deep waters. This is discussed in the next section.

Dissovled Oxygen Profile

Adequate levels of dissolved oxygen in the water are critical to the health of aquatic ecosystems, including most fish species. While oxygen is produced by aquatic plants and absorbed into surface waters from the atmosphere, dissolved oxygen levels can drop sharply in the deeper, colder waters below the thermocline during the summer period. Typically, dissolved oxygen levels below the thermocline reach their lowest levels by late summer, which is why this is the best time to monitor oxygen levels. The rate and degree of oxygen decline is usually related to lake productivity and the amount of algae produced in the water. As dead algae sinks to the bottom of the lake, it is decomposed by bacteria which consume oxygen in the process. The more algae, the greater the degree of oxygen depletion. Because the thermocline prevents water mixing with the more oxygen-rich waters above the thermocline, this deoxygenated condition (anoxia) can persist until the thermocline breaks down in the fall. This loss of oxygen in the deep coldwater zone is a primary cause for the disappearance of lake trout, whitefish and other sensitive fish species in many lakes.

Dissolved oxygen is measured at 1 m intervals from the lake surface to the bottom at the same time that temperatures are measured. The resulting dissolved oxygen profile is illustrated in Figures 2.3, 3.3, 4.3 and 5.3 with the blue line. On some lakes, dissolved oxygen levels drop rapidly thought the thermocline and are at very low levels below it. Dissolved oxygen levels above 5 mg/L (or ppm) are adequate to support all aquatic life while levels below 3 mg/L become stressful and lethal for many species, especially fish.

Sonar Transect

To help illustrate the effects of many of the water chemistry and limnological processes occurring in a lake basin, a sonar transect can be very useful. The sonar images provided in Figure 2.3, 3.3, 4.3 and 5.3 were recorded in the deep basins of each lake. The corresponding temperature and oxygen profiles are provided for each lake and the location of the thermocline indicated. As well, total phosphorus measurements for surface and deep water samples are also provided.

For those less familiar with the interpretation of sonar recordings such as these, the following will provide a general guide:

- the water surface is shown as a grey band across the top with a depth indicator of 0.0 feet;
- the grey and black scatter-band below the surface to around 8 to 10 feet of depth is caused largely by plankton in these surface waters;
- the bottom of the lake is shown as a black line with grey band of various widths near the bottom of the chart;
- the depth scale printed on each chart indicates the water depth in feet;

- individual larger fish are shown as a small arch, while schools of small fish such as smelt or yellow perch are shown as a black and grey cluster in the water column;
- a yellow band has been added to the recording to indicate the general location of the thermocline (area of rapid temperature change); and
- the sonar transducer used here had a 29° cone; therefore the chart recordings shown in each figure represent only a narrow slice of water being sampled within each basin

These lakes demonstrate a broad range of conditions illustrated on the sonar chart recordings. Blackstone and Crane Lakes have higher oxygen levels below the thermocline and support an abundance of coldwater fish (Figure 2.3 and 3.3). Healey Lake has adequate oxygen below the thermocline, and supports coldwater fish, in basin 1 (Station 1), but not in basins 2 and 3 (Figure 4.3). Kapikog Lake has little oxygen below the thermocline and lacks coldwater fish (Figure 5.3). The sonar profiles on Healey Lake and Kapikog Lake also show a black stippling in the lower water column near the bottom. This is small gas bubbles suspended in the water column above the lake sediments. Water samples collected from these deep zones confirmed these to be hydrogren sulphide (H_2S), which imparts a strong sulphur smell to the water sample. Hydrogen sulphide is a product of anaerobic decomposition of the deep organic sediments found in these basins, and indicates the severity of oxygen depletion here. This anaerobic activity in the sediments also releases soluble phosphorus to the water above it. This accounts for the higher phosphorus levels below the thermocline in these lakes (Figures 4.3 and 5.3).

The presence and condition of this coldwater fish community provides an excellent biological indicator of overall water quality and ecological health of these lakes. This is due to their requirements for clean, cold, well-oxygenated waters. The decline or disappearance of these species is usually a direct indicator of deteriorating water quality and a decline in the ecological integrity of freshwater ecosystems.

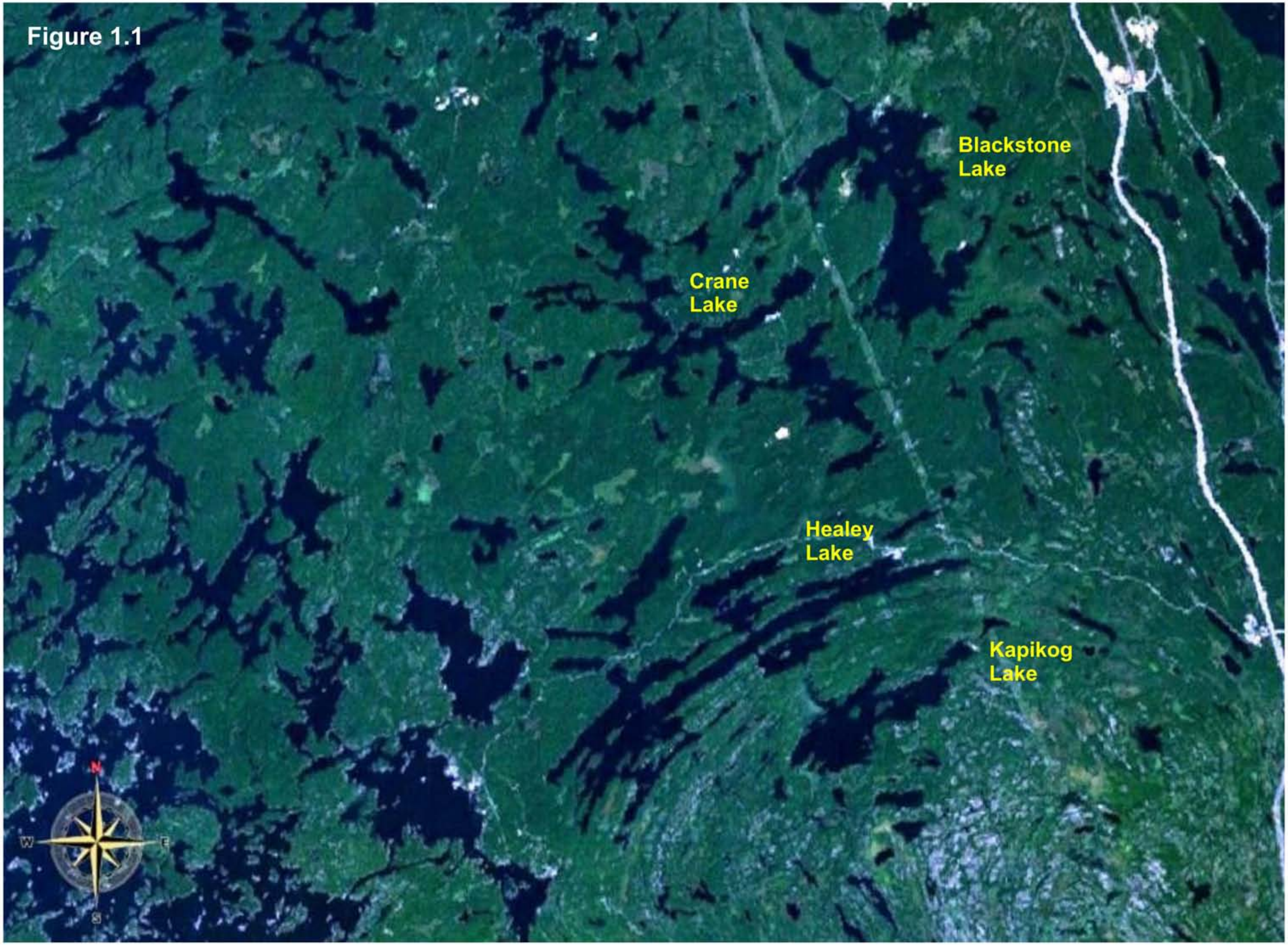


Figure 1.1
Blackstone Lake
Crane Lake
Healey Lake
Kapikog Lake
N
W
E
S

2.0 BLACKSTONE LAKE

2.1 Physical Features

Surface Area:	516 hectares (1,274 acres)
Maximum Depth:	58 m (190 feet) – Figure 2.2 Bathymetry
Average Depth:	20 m (66 feet) – Figure 2.2 Bathymetry
Lakeshore Perimeter:	34.9 km
Littoral Zone:	23%
Water Level:	regulated by Crane Lake Dam
Watershed:	Blackstone River (to Georgian Bay)

2.2 Lakeshore Development

Access:	extensive road access (Figure 2.1)
Crown Land:	approx. 20% of shoreline
Private Development:	2008 – 119 developed lots, 30 vacant, 2 resorts, 1 marina
	1999 – 102 developed lots, 42 vacant, 2 resorts, 1 marina

2.3 Water Quality

Water Clarity: (Secchi depth)	5.6 m (2008), 5.0 m (2000), 5.5 m (1973)
Water Colour:	slight yellow
Alkalinity:	27.4 mg/L – Level 3 moderate sensitivity (MOE, 1989)
pH:	7.1 (2000), 7.1 (2001)
Total Phosphorus:	8 µg/L (Table 2.1) MOE Lake Partner Program – Spring Sampling 6.4 (2003), 7.5 (2004), 8.2 (2005), 7.2 (2006)
Conductivity:	87 µS/cm (Table 2.1)
Thermal Profile:	Figure 2.3

Dissolved Oxygen: Figure 2.3

Sonar Transect: Figure 2.3

Table 2.1 Blackstone Lake Water Quality, 10 September 2008 (Sampling Stations in Figure 2.1)

Sampling Station	Secchi Depth (m)	Water Conductivity (µS/cm)	Total (µg/L) Phosphorus
1	5.6	87	10
1 (15 m depth)		86	10 and 12
2	5.4	86	9
3	5.1	86	8
4	5.1	88	11
5	4.6	86	8
6	5.5	87	6

2.4 Biological Features

Fish Species:

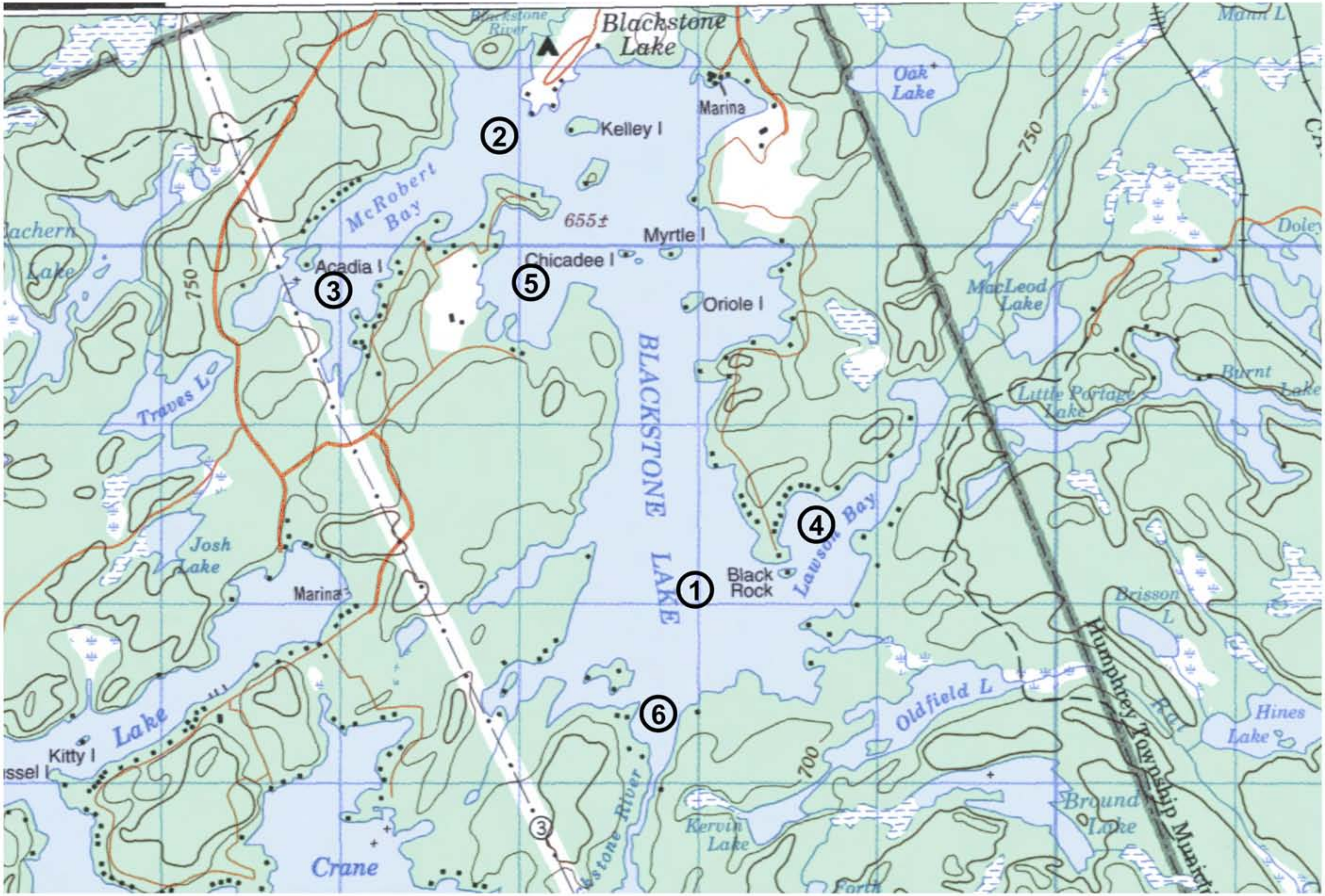
Lake Trout (stocked)
Walleye (natural and stocked)
Smallmouth Bass
Largemouth Bass
Northern Pike
Muskellunge
Yellow Perch
Black Crappie
Cisco
White Sucker
Brown Bullhead
Burbot
Rock Bass
Pumpkinseed
8 Forage Species (minnows, shiners, darters, etc.)

Information on fish population and management programs for Blackstone Lake are found in the following reports:

McIntyre, E. 2005. Blackstone Lake 2005 Spring Littoral Index netting (SLIN) Survey Reports. 15 p.

McIntyre, E. 2005. Blackstone Lake Synoptic Trapnet Survey, 2005.

McIntyre, E. 2005. Blackstone Lake Index Walleye Spawners Survey, Spring 2005.

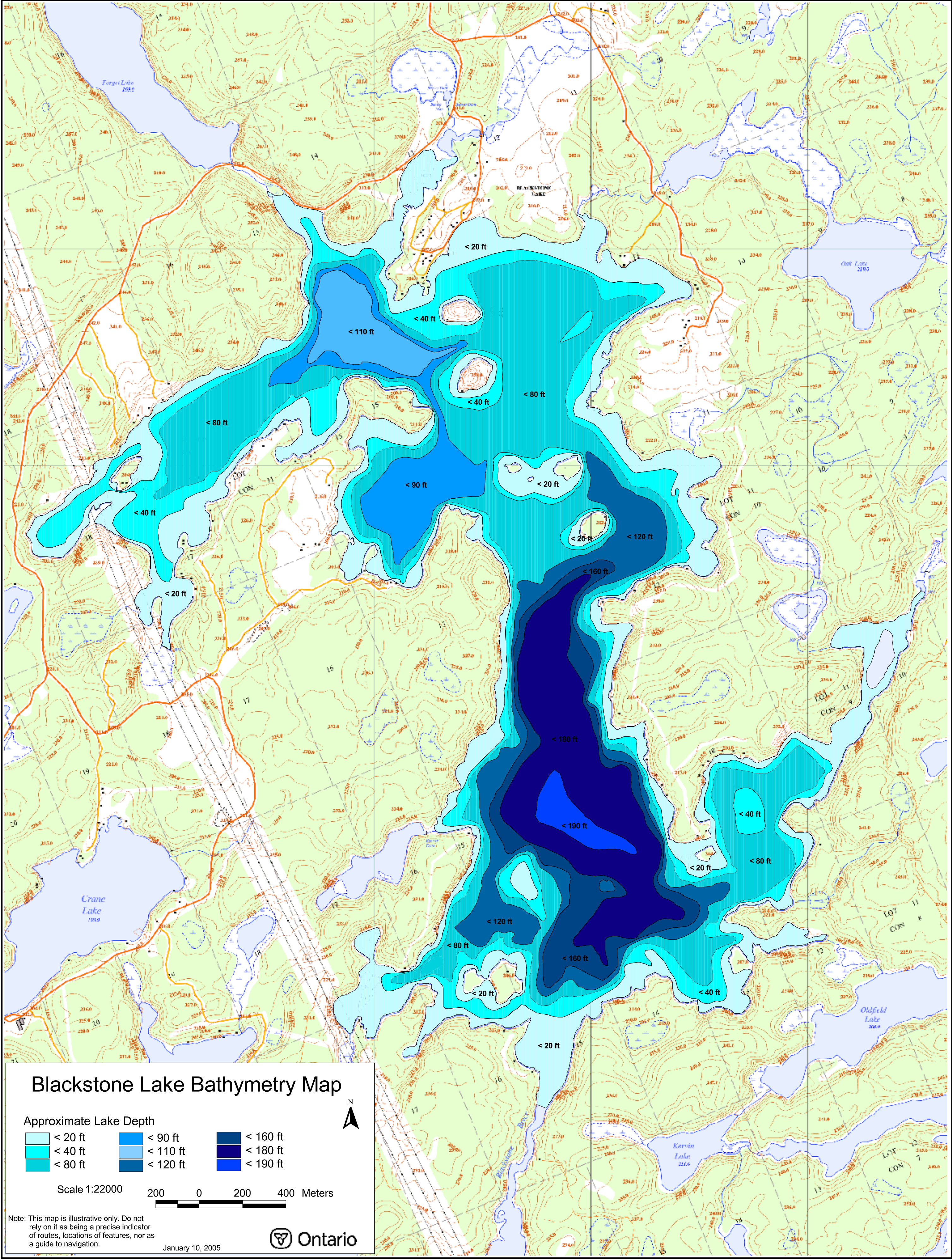


① Water quality sampling stations

Blackstone Lake

Figure 2.1

December 2008



Blackstone Lake Bathymetry Map

Approximate Lake Depth

< 20 ft	< 90 ft	< 160 ft
< 40 ft	< 110 ft	< 180 ft
< 80 ft	< 120 ft	< 190 ft

Scale 1:22000

200 0 200 400 Meters

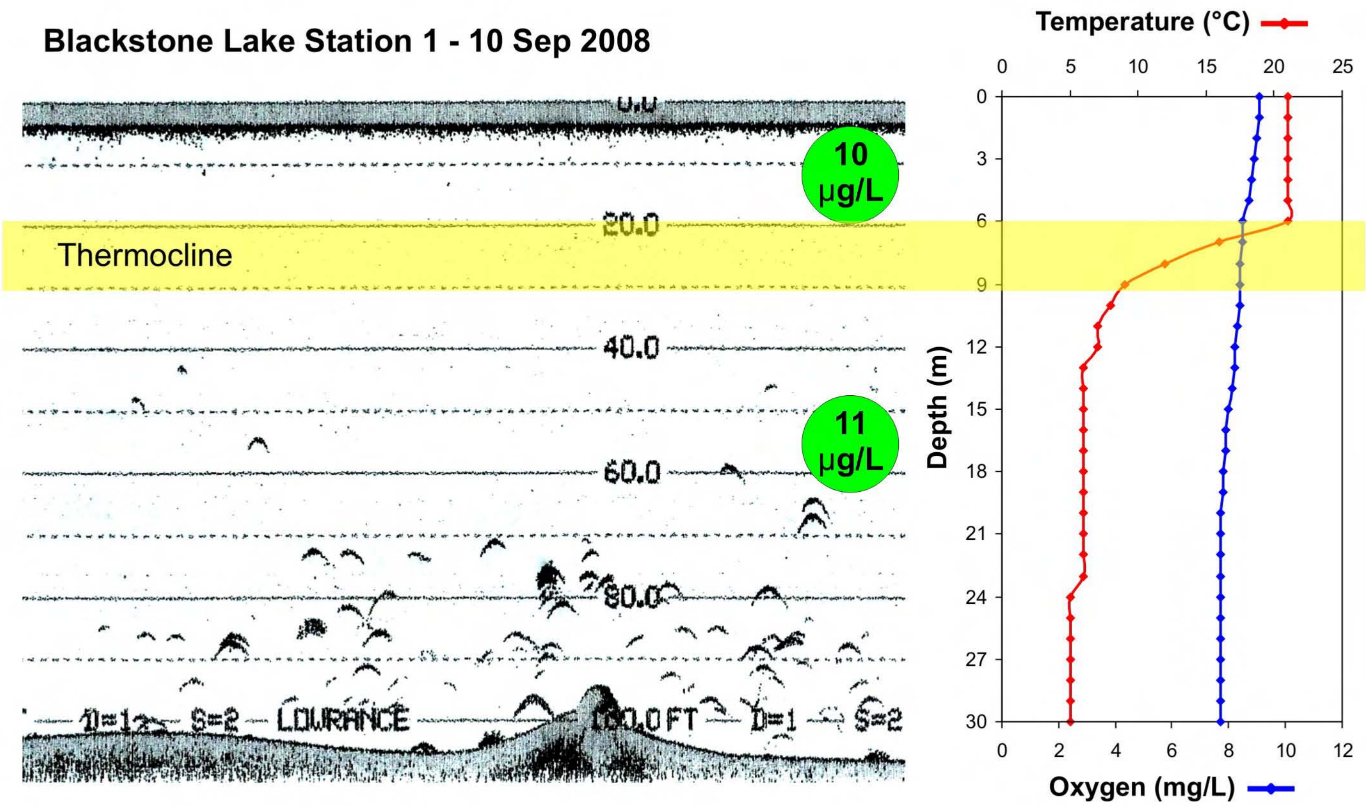
N

Note: This map is illustrative only. Do not rely on it as being a precise indicator of routes, locations of features, nor as a guide to navigation.

January 10, 2005

Ontario

Blackstone Lake Station 1 - 10 Sep 2008



Sonar Transects and Temperature-Dissolved Oxygen Profiles

Figure 2.3	December 2008

Total Phosphorus

Township of Archipelago, 2001. Water Quality and Aquatic Assessment for Blackstone Lake – August 2000.

McIntyre, E. 1996. Walleye (Spawning Adults) Index Netting Progress Report.

OMNR, 1994. Winter Creel 1994.

Thurston, L., 1993. Walleye Rehabilitation Chronological Events.

Thurston, L., Pepper, R., Janoki, K., 1993. Trapnet Survey.

Thurston, L. 1991. Summary of Electrofishing Surveys 1987-1991.

Rusk, M., 1975. Blackstone Lake Spawning Grounds Improvement Project.

Thurston, L., 1975. Summer and Winter Creel Census on Selected Lake Trout lakes in the Parry Sound District.

2.5 Water Quality and Ecological Overview

Blackstone Lake is a moderate-sized, relatively deep **headwater lake** with several small tributary inflows, including the Blackstone River. Figures 1.1, 2.1 and 2.2 (bathymetry) illustrate many of the topographic features of Blackstone Lake.

With several **deep basins** (58 m depth) and an average depth of 20 m, Blackstone Lake has a high depth to surface area ratio compared to other similar sized lakes in this region of Parry Sound/Muskoka. Also, typical of deeper headwater lakes with limited drainage basins, water retention time in Blackstone Lake has been estimated to be a comparatively high three years.

Because of its considerable depth and naturally-low nutrient levels, Blackstone Lake would be classified as **oligotrophic** (low levels of biological productivity), which helps account for the very clear waters and high dissolved oxygen levels below the thermocline (Figure 2.3).

Water quality is excellent with a near neutral pH (7.1) high water clarity (5 m transparency), moderate alkalinity (low sensitivity to acids), low total phosphorus (average below 10 µg/L) and high dissolved oxygen levels at all depths. Water conductivity measurements indicate a high degree of surface water mixing between the various basins and bays in the lake. Phosphorus measurements below the thermocline indicated no deepwater phosphorus releases (Figure 2.3), which would be expected given the high dissolved oxygen levels at all depths.

Three **tributary inflows** were found to have pH levels of 6.1, 6.5 and 6.3 and total dissolved solids levels of 29, 18 and 18 mg/L in 2000 (Schiefer, 2001). This is typical of localized drainage from small lakes, beaver ponds and acidic bogs on the granite bedrock of the Canadian Shield. Fortunately, Blackstone Lake appears to have adequate natural buffering capacity to neutralize these acidic tributary inflows.

Because of its considerable depth and high water quality, Blackstone Lake is **thermally stratified** through the summer with high dissolved oxygen levels at all depths. When measured in early September, 2008, surface waters were 22°C, a sharp thermocline (zone of rapid temperature change) occurred at 6 to 8 m depth, and water temperatures below 12 m were 5°C. (Figure 2.3). Dissolved oxygen levels exceeded 7 mg/L (ppm) at all depths. This is similar to thermal and dissolved oxygen conditions found in 2000 (Schiefer, 2001).

Blackstone Lake has a good **diversity of fish species** with healthy populations of both warmwater and coldwater fish communities. The coldwater fish community is represented by cisco (lake herring), burbot (freshwater-cod) and lake trout, while the warmwater community is quite diverse, including walleye (yellow pickerel) smallmouth and largemouth bass, northern pike, muskellunge, rock bass, pumpkinseed (sunfish), white sucker, brown bullhead (catfish), and others. Figure 2.3 shows a broad distribution of coldwater fish sonar images throughout the water column in a deep basin of Blackstone Lake in early September of 2008. See Section 1.2 to assist in the interpretation of these results. These would be primarily cisco and lake trout. Because of favourable water temperatures and dissolved oxygen conditions, these species are able to utilize the entire coldwater zone of Blackstone Lake.

Although the fish population is quite diverse for a small to medium-sized headwater lake, it is important to recognize that natural **biological productivity** in Blackstone Lake is comparatively low, meaning that fish populations must be managed carefully and conservatively to avoid levels of exploitation that exceed the natural biological capacity of the lake. Without this, Blackstone Lake fish stocks are highly vulnerable to overfishing because of the lake's road accessibility and considerable shoreline development (numbers of anglers resident on the lake or having ready access to it).

The existing degree of **lakeshore development** and associated human activity on Blackstone Lake could be considered relatively high for an oligotrophic headwater trout lake on the Precambrian Shield. The lake has easy road accessibility from Highway 400 with local roads now circling much of the eastern, northern and western sides of the lake. With 30 existing undeveloped lots on the lake, an increase in lakeshore development and human activity of approximately 25% above current levels can be expected over the next several decades as these lots are developed. This could continue to change the character of Blackstone Lake from a more natural Shield lake to an increasingly urbanized shoreline with higher intensity of human activity.

2.6 Recommendations

Water Quality: Water quality in Blackstone Lake should be protected as a priority, both because of its relatively high natural quality for recreational use and because of its excellent lake trout habitat. Long-term monitoring of nutrient levels, water clarity (Secchi disc depth), dissolved oxygen and bacterial levels should be continued. A water quality survey similar to that carried out in 2008 should be repeated at least every 5 years.

Fishery Resources: As discussed in Section 2.5, natural biological productivity in Blackstone Lake is low (oligotrophic). This, combined with the easy road accessibility and considerable shoreline development, makes Blackstone Lake a very good candidate for special fishing regulations to protect fish stocks and enhance fishing quality. This could include reduced catch limits, maximum or slot size limits, the possible use of spawning sanctuaries and open season changes to protect critical brood stock or excessively vulnerable fish populations. These types of special fishing regulations have proven very successful at protecting fish stocks and improving fishing quality in many similar circumstances.

Lakeshore Development: It is strongly recommended that no further building lots be created on Blackstone Lake. As discussed in Section 2.5, future development of the 30 existing vacant lots already on the lake will increase the density of shoreline development and levels of human activity on the lake by 25% above existing levels, which could be considered high for this type of headwater shield lake.

Future lakeshore development capacity should be determined based on a comprehensive long-term vision of the ecosystem, landscape and human environmental features to be protected on the lake. Those residing on the lake should be directly involved in developing this vision through the “lake plan” or “community plan” process now occurring on many lakes.

As well, the extension of road access to presently inaccessible shorelines on this lake should be restricted to preserve the natural character and ecosystem features in these areas. Circling of the lake with roads inevitably leads to the undesirable linear urbanization of lakeshores.

Lake Stewardship: Because of the relatively high density of lakeshore development and sensitive nature of water quality and aquatic ecosystems in Blackstone Lake, all residents on the lake should practice a high level of lake stewardship on their properties, including a well-operating septic system, low water use practices, maintenance of natural vegetation on the lake shores, restricted use of fertilizers and pesticides, and phasing out of two-cycle outboard motors for the much cleaner four-cycle engines.

3.0 CRANE LAKE

3.1 Physical Features

Surface Area:	513 hectares (5,267 acres)
Maximum Depth:	32 m (105 feet) – Figure 3.2 Bathymetry
Average Depth:	9 m (30 feet) – Figure 3.2 Bathymetry
Lakeshore Perimeter:	50.4 km
Littoral Zone:	
Water Level:	regulated by Crane Lake Dam
Watershed:	Blackstone River (to Georgian Bay)

3.2 Lakeshore Development

Access:	extensive road access (Figure 3.1)
Crown Land:	approx. 50% of shoreline
Private Development:	2008 – 217 developed lots, 32 vacant, 1 resort, 1 marina
	1999 – 210 developed lots, 48 vacant, 1 resort, 1 marina

3.3 Water Quality

Water Clarity: (Secchi depth)	5.8 m (2008), 6.0 m (2000)
Water Colour:	slight yellow
Alkalinity:	20.5 mg/L – Level 3 moderate sensitivity (MOE, 1989)
pH:	6.9 (2000), 6.8 (2005)
Total Phosphorus:	8 µg/L (Table 3.1) MOE Lake Partner Program – Spring Sampling 6.5 (2002), 5.2 (2003), 4.3 (2004), 3.4 (2005), 3.5 (2006), 3.6 (2007)
Conductivity:	80 µS/cm (Table 3.1)
Thermal Profile:	Figure 3.3

Dissolved Oxygen: Figure 3.3

Sonar Transect: Figure 3.3

Table 3.1 Crane Lake Water Quality, 10 September 2008 (Sampling Stations in Figure 3.1)

Sampling Station	Secchi Depth (m)	Water Conductivity (µS/cm)	Total (µg/L) Phosphorus
1	5.8	80	8
1 (15 m depth)		81	15
2	4.7	50	9
2 (15 m depth)		41	15
3	5.1	71	11
4	5.4	80	8
5	6.1	68	6
6	6.2	74	7
7	5.2	55	8

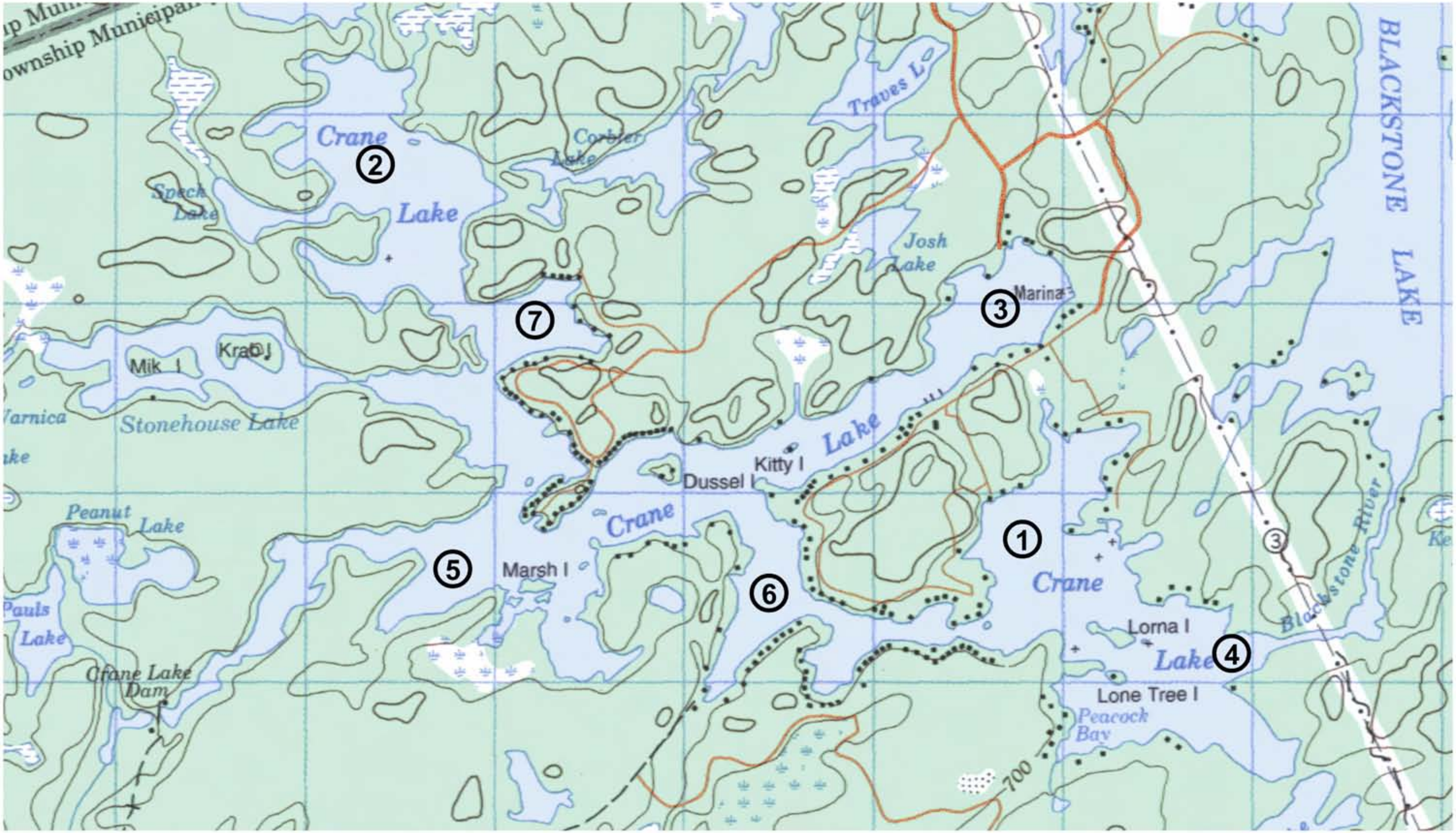
3.4 Biological Features

Fish Species:
Lake Trout (stocked)
Walleye (natural and stocked)
Smallmouth Bass
Largemouth Bass
Northern Pike
Muskellunge
Yellow Perch
Black Crappie
Cisco
White Sucker
Brown Bullhead
Burbot
Rock Bass
Pumpkinseed
8 Forage Species (minnows, shiners, darters, etc.)

Information on fish population and management programs for Blackstone Lake are found in the following reports:

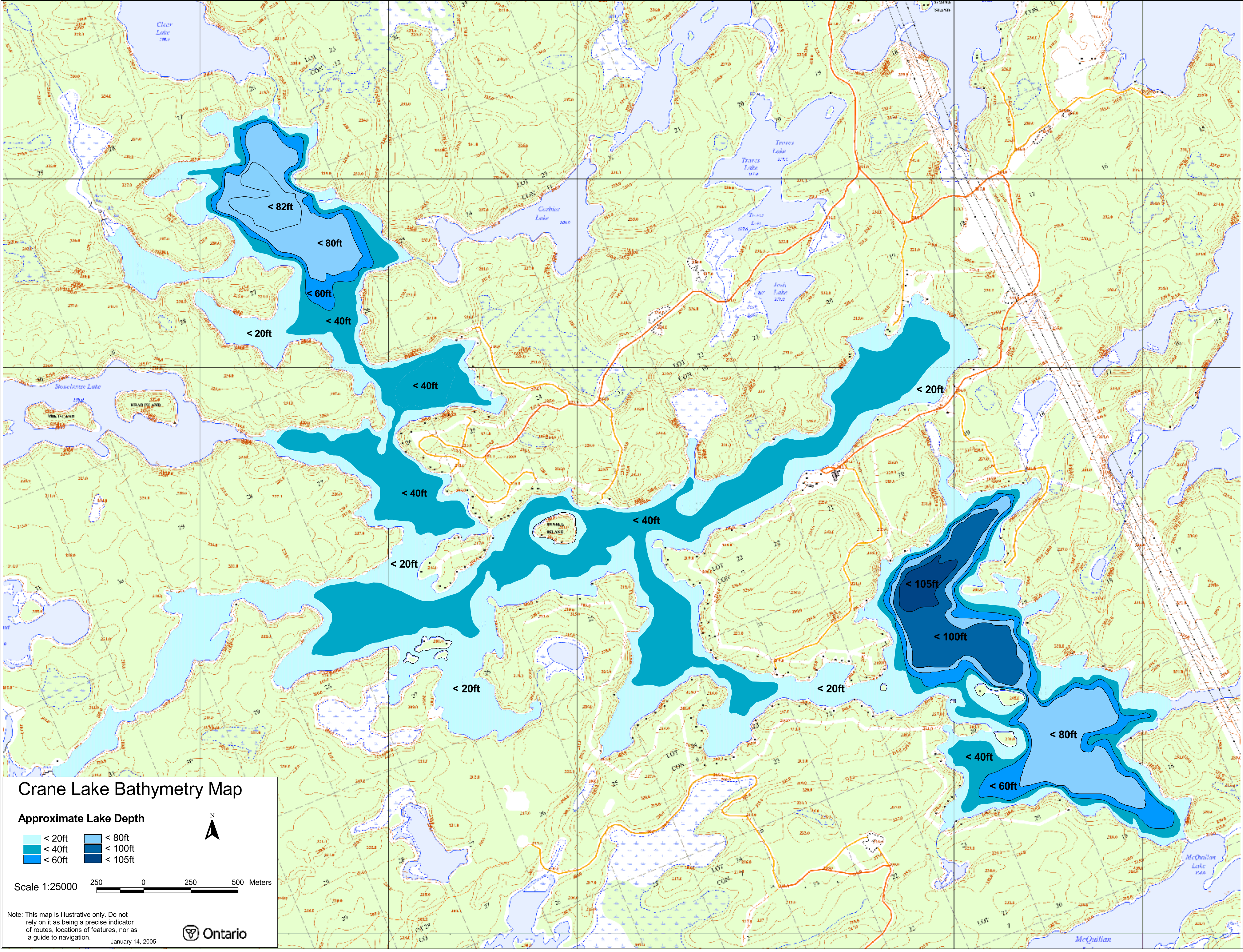
McIntyre, E. 2005. Crane Lake 2005 Trapnet Survey Report. 19 p.

McIntyre, E. 2002. Parry Sound Area 2001 Fall Walleye Index Netting (FWIN) report.



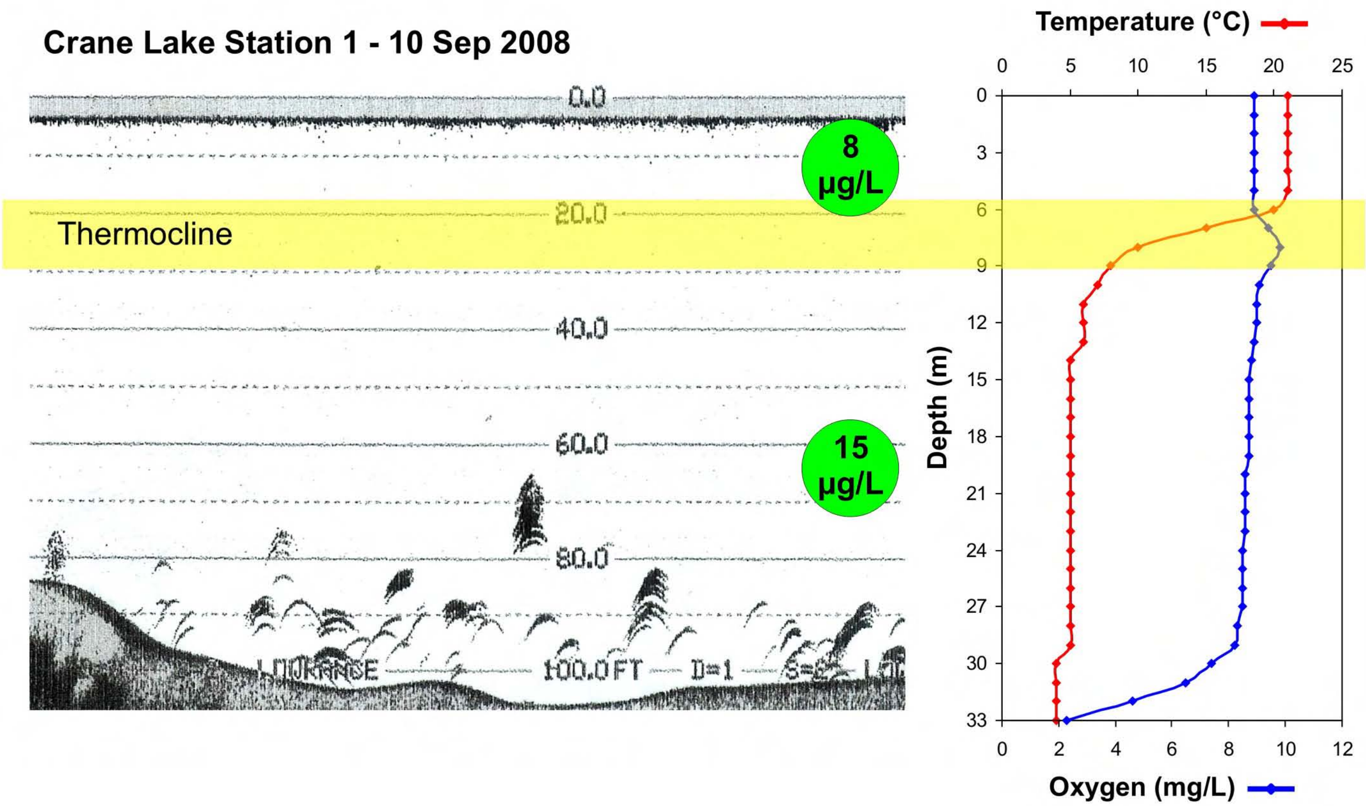
① Water quality sampling stations

Crane Lake	
Figure 3.1	December 2008

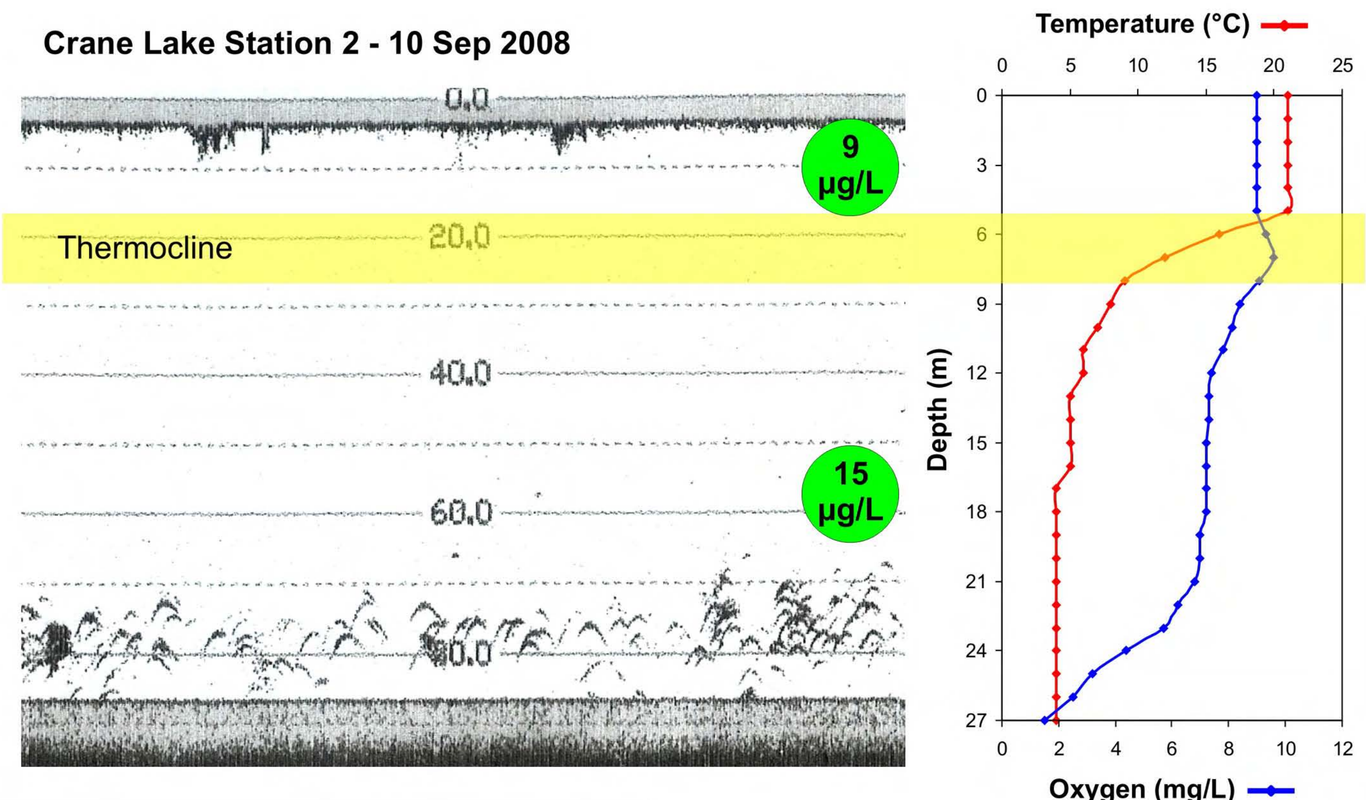


Crane Lake Bathymetry Map
Approximate Lake Depth
< 20ft
< 40ft
< 60ft
< 80ft
< 100ft
< 105ft
N
Scale 1:25000
250 0 250 500 Meters
Note: This map is illustrative only. Do not rely on it as being a precise indicator of routes, locations of features, nor as a guide to navigation.
January 14, 2005
Ontario
< 82ft
< 80ft
< 60ft
< 40ft
< 20ft
< 40ft
< 40ft
< 20ft
< 40ft
< 20ft
< 20ft
< 20ft
< 105ft
< 100ft
< 80ft
< 40ft
< 60ft

Crane Lake Station 1 - 10 Sep 2008



Crane Lake Station 2 - 10 Sep 2008



Sonar Transects and Temperature-Dissolved Oxygen Profiles

Figure 3.3	December 2008

Total Phosphorus

Township of Archipelago, 2001. Water Quality and Aquatic Ecosystem Assessment for Crane Lake – August 2000.

Blythe & Associates Biological Services, 1998. Crane Lake Synoptic Trap-net Survey Report.

1994 Crane Lake Winter Creel Survey (No report – Creesys analysis only).

1993 Crane Lake Trap-net Survey (Summary only available).

Thurston, L. 1993. Walleye Rehabilitation.

Deary Environmental Consultants, 1990. Summary Report for Lake Trout (*Salvelinus namaycush*) Assessment of thirteen Lakes in the Parry Sound District).

Microbiological Survey – Crane Lake 1989.

Thurston, L. 1981. A Historical Review of native Versus Non-native Lake Trout Lakes in the Parry Sound District.

1979 Creel Census Raw Data.

Thurston, L. 1977. Summary of two years (1976-77) of lake trout assessment work Parry Sound District.

Thurston, L. 1976. Assessment of Lake Trout Plantings Parry Sound District.

3.5 Water Quality and Ecological Overview

Crane Lake is a **moderate-sized, moderately deep lake** with several small localized tributary inflows and the Blackstone River flowing through the eastern and central basins of the lake (Figure 3.1). With Blackstone Lake upstream, Crane Lake is less of a headwater lake and is strongly influenced by water quality from Blackstone Lake. A very irregular lake with numerous long bays and arms, Crane Lake has an exceptionally high ratio of shoreline perimeter to lake surface area. Figures 1.1, 3.1 and 3.2 illustrate many of the topographic features of Crane Lake.

With two **deeper basins** (to 32 m depth) and an average depth of 9 m, Crane Lake has a moderate depth to surface area ratio compared to other similar sized lakes in this region. For instance, it has a lower depth to area ratio than upstream Blackstone Lake, but higher than nearby Healey Lake or Kapikog Lake. Because Crane Lake is less deep than Blackstone Lake and lower in the Blackstone River watershed (higher river volume flow-through), water retention time in Crane Lake has been calculated at 0.9 years compared with 3 years for Blackstone Lake. This means that the entire volume of water in Crane Lake is replaced by inflow water each year compared to every three years in Blackstone Lake.

Because of its considerable depth and naturally-low nutrient levels, Crane Lake would be classified as **oligotrophic** (low levels of biological productivity), which helps account for the very clear waters and high dissolved oxygen levels below the thermocline (Figure 3.3).

Water quality in Crane Lake reflects localized shield runoff and the influence of water quality in Blackstone Lake a short distance upstream on the Blackstone River.

Water quality is generally excellent with a near neutral pH (6.9), adequate alkalinity, very low total dissolved solids and high water clarity (6 m transparency). Water conductivity measurements indicate that the eastern and central portions of Crane Lake have water chemistry which is strongly influenced by the Blackstone River which flows through these basins; while the north western bays of the lake (Stations 2 and 7) are less well mixed with waters from the rest of the lake (Figure 3.1). Water chemistry here is more strongly influenced by local watershed drainage (conductivity 50 to 55 compared to 70 to 80 in the rest of the lake). Total phosphorus measurements were below 10 in surface waters and only slightly elevated, to 15, in deeper waters below the thermocline (Figure 3.3). Very little phosphorus cycling from deep sediments is occurring because of the high dissolved oxygen conditions in the deeper basins. This is a very favourable condition for a longer term water quality protection.

Similar to Blackstone Lake upstream, smaller local **tributaries** draining small lakes, beaver ponds and acidic bogs on the granite bedrock were found to have lower pH levels ranging from 6.4 to 6.9. However, Crane Lake appears to have adequate natural buffering capacity (alkalinity) to neutralize these more acidic tributary inflows.

Because of its depth to 32 m (105 ft), Crane Lake is **thermally stratified** in both its eastern and western basins through the summer, with high dissolved oxygen levels at all depths. When measured in early September of 2008, surface waters were 21°C, a sharp thermocline (zone of rapid temperature change) occurred at 6 to 8 m depth, and water temperatures below 14 m were 5°C (Figure 3.3). Dissolved oxygen levels exceeded 8 ppm at all depths in both basins. Dissolved oxygen levels above 5 ppm are required to support healthy populations of coldwater fish species such as lake trout, whitefish and cisco. This is similar to the thermal and dissolved oxygen conditions found in 2000 (Schiefer, 2001)

Crane Lake has a good **diversity of fish species** with a healthy population of warmwater fish species and a more limited coldwater fish community. The coldwater fish community is represented by cisco (lake herring), burbot (freshwater cod) and a small population of stocked lake trout, while the warmwater community is quite diverse, including walleye (yellow pickerel), smallmouth and largemouth bass, northern pike, muskellunge, rock bass, pumpkinseed (sunfish), white sucker, brown bullhead (catfish), and others. The sonar charts provided in Figure 3.3 illustrate a considerable abundance of coldwater fish, largely cisco, throughout the deeper portions of the water column where temperature and dissolved oxygen conditions are favourable. See Section 1.2 to assist in the interpretation of these results. The presence of these species is a good biological indicator of overall water quality in Crane Lake.

Although the fish population is quite diverse for a small to medium-sized headwater lake, it is important to recognize that natural **biological productivity** in Crane Lake is comparatively low, meaning that fish populations must be managed carefully and conservatively to avoid levels of exploitation that exceed the natural biological capacity of the lake. Without this, Crane Lake fish stocks are highly vulnerable to overfishing because of the lake's road accessibility and considerable shoreline development (numbers of anglers resident on the lake or having ready access to it).

The existing degree of **lakeshore development** and associated human activity on Crane Lake could be considered relatively high for a moderate-sized oligotrophic headwater lake on the Precambrian Shield. In 2008, the lake had 217 cottages and homes, one resort and 32 undeveloped vacant lots. These residences are concentrated in areas of high density shoreline development around the central basin of the lake which is ringed with access roads. The eastern basin has more scattered shoreline development with fewer access roads, while the western basin of the lake remains in a natural condition. With 32 existing undeveloped lots on the lake, an increase in shoreline development and human activity of approximately 15% above current levels can be expected over the next several decades as these lots are developed.

3.6 Recommendations

Water Quality: Water quality in Crane Lake should be protected as a priority, both because of its relatively high natural quality for recreational use and because it contains lake trout habitat. Long-term monitoring of nutrient levels, water clarity (Secchi disc depth), dissolved oxygen and bacterial levels should be continued. A water quality survey similar to that carried out in 2008 should be repeated at least every 5 years.

Fishery Resources: As discussed in Section 3.5, natural biological productivity in Crane Lake is low (oligotrophic). This, combined with the easy road accessibility and considerable shoreline development, makes Crane Lake a very good candidate for special fishing regulations to protect fish stocks and enhance fishing quality. This could include reduced catch limits, maximum or slot size limits, the possible use of spawning sanctuaries and open season changes to protect critical brood stock or excessively vulnerable fish populations. These types of special fishing regulations have proven very successful at protecting fish stocks and improving fishing quality in many similar circumstances.

Lakeshore Development: It is strongly recommended that no further building lots be created on Crane Lake. As discussed in Section 3.5, future development of the 32 existing vacant lots already on the lake will increase the density of shoreline development and levels of human activity on the lake by 15% above existing levels, which could be considered relatively high for this type of headwater shield lake.

Future lakeshore development capacity should be determined based on a comprehensive long-term vision of the ecosystem, landscape and human environmental features to be protected on the lake. Those residing on the lake should be directly involved in developing this vision through the "lake plan" or "community plan" process now occurring on many lakes.

One of the other factors which should be considered on Crane Lake is the very high ratio of shoreline perimeter to either lake surface area or lake water volume. Lakes such as this are particularly vulnerable to excessive shoreline development if only shoreline availability is considered rather than lake surface area and water volume. This is because water-based recreational activities such as boating, water-skiing and fishing must all be accommodated on the surface area of the lake, while the water volume in the lake is what is available to assimilate or dilute various discharges and contaminants related to shoreline development. This would include nutrient leaching from septic systems, fertilizer and pesticide runoff from lawns and gardens, gasoline and oil residues from two-cycle outboard motors, etc. A loss in aesthetic values of the lake environment due to excessive boating activity or noise levels is at risk on smaller surface area lakes with long narrow arms and bays, while a deterioration in water quality is likely for lakes with high shoreline development but comparatively small water volume.

As well, the extension of road access to presently inaccessible shorelines on this lake should be restricted to preserve the natural character and ecosystem features in these areas. Circling of the lake with roads inevitably leads to the undesirable linear urbanization of shorelines.

Crane Lake is fortunate that the western basin of the lake and several other bays have remained undeveloped with natural shoreline landscapes and ecological functions. These areas should be protected from any future shoreline development as an essential element to achieving and sustaining a diverse and ecologically balanced Crane Lake ecosystem.

Lake Stewardship: Because of the relatively high density of lakeshore development and sensitive nature of aquatic ecosystems in Crane Lake, all residents on the lake should practice a high level of lake stewardship on their properties, including a well-operating septic system, low water-use practices, maintenance of natural vegetation on the lake shores, restricted use of fertilizers and pesticides, and phasing out of two-cycle outboard motors for the much cleaner four-cycle engines.

4.0 HEALEY LAKE

4.1 Physical Features

Surface Area: 762 hectares (1,883 acres)

Maximum Depth: 23 m (75 feet) – Figure 4.2 Bathymetry

Average Depth: 6 m (19 feet) – Figure 4.2 Bathymetry

Lakeshore Perimeter: 55.7 km (Island shoreline additional 19 km)

Littoral Zone: 61%

Water Level: controlled by outlet dam

Watershed: short drainage connection to Georgian Bay

4.2 Lakeshore Development

Access: extensive road access (Figure 4.1)

Crown Land: approx. 65% of shoreline

Private Development: 2008 – 365 developed lots, 4 vacant, 3 resorts with marinas

4.3 Water Quality

Water Clarity: 3.8 m (2008), 3.8 m (2000), 5.5 (1973)

(Secchi depth)

Water Colour: light yellow

Alkalinity: 13.7 mg/L – Level 3 moderate sensitivity (MOE, 1989)

pH: 7.1 (2000), 6.5 (1973)

Total Phosphorus: 13 µg/L (Table 4.1)

MOE Lake Partner Program – Spring Sampling

9.4 (2004), 8.5 (2006)

Conductivity: 46 µS/cm (Table 3.1)

Thermal Profile: Figure 4.3

Dissolved Oxygen: Figure 4.3

Sonar Transect: Figure 4.3

Table 4.1 Healey Lake Water Quality, 9 September 2008 (Sampling Stations in Figure 4.1)

Sampling Station	Secchi Depth (m)	Water Conductivity (µS/cm)	Total (µg/L) Phosphorus
1	3.8	46	13
1 (18 m depth)		46	25 and 31
2	3.8	36	12
2 (20 m depth)		37	18 and 20
3	4.2	33	6
4	3.3	37	10
5	1.4	30	15
6	3.3	37	10

4.4 Biological Features

Fish Species:

- Largemouth Bass
- Smallmouth Bass
- Northern Pike
- Yellow Perch
- Black Crappie
- Cisco
- White Sucker
- Brown Bullhead
- Rock Bass
- Pumpkinseed
- Forage Species (minnows, shiners, darters, etc.)

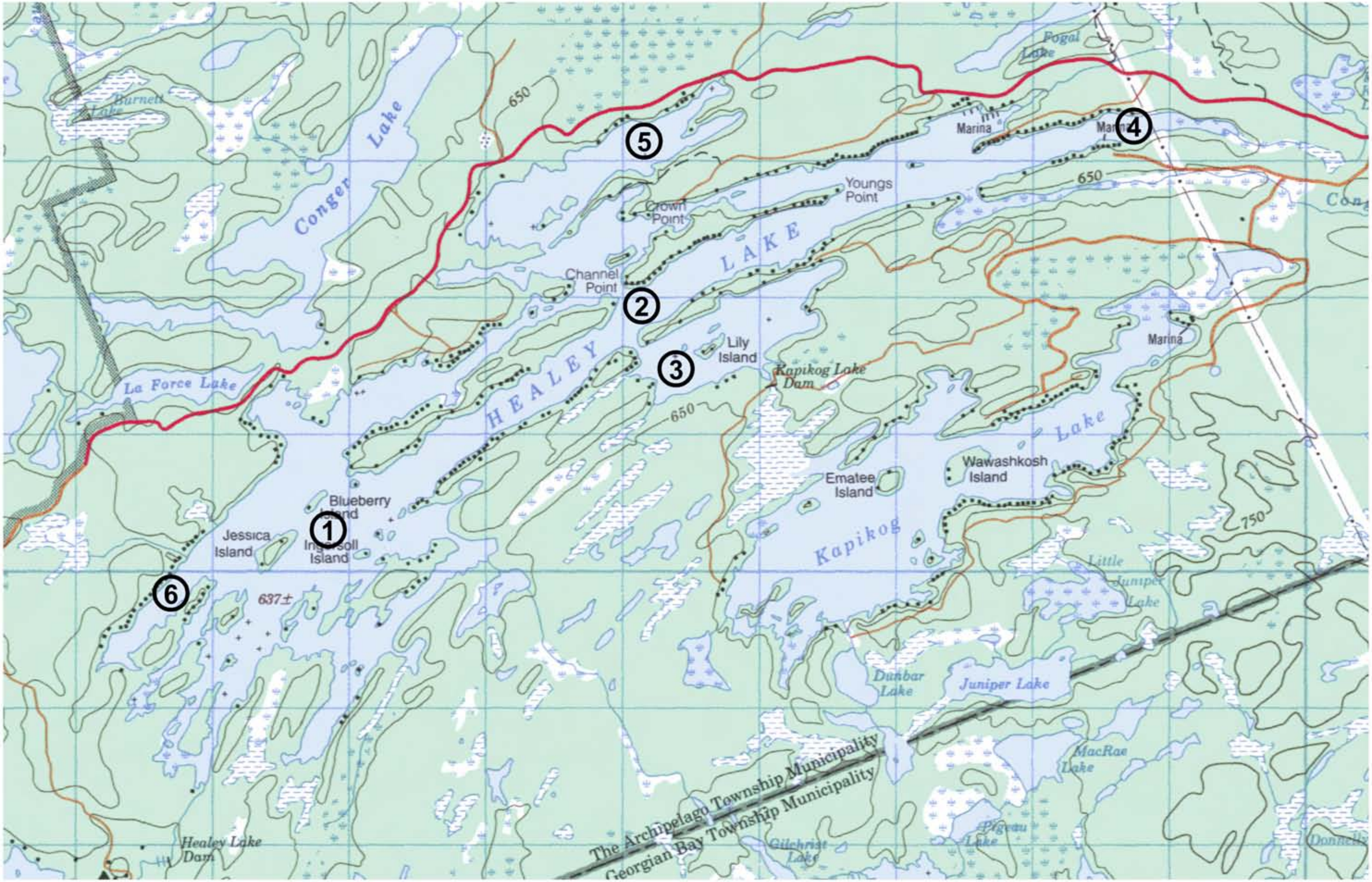
Information on fish population and management programs for Healey Lake are found in the following reports:

Paus, R.M. 1983. 1983 Inland lake fishery assessment program: Healey Lake. 49 p.

MNR. 1973. Raw Creel Data (Winter, 1973).

MNR. 1973, 1974, 1977. Intensive Creel Survey (Summer).

Lee, T. 1973. Interpretation of Limnological Data collected on Healey, LaForce and Conger Lake.

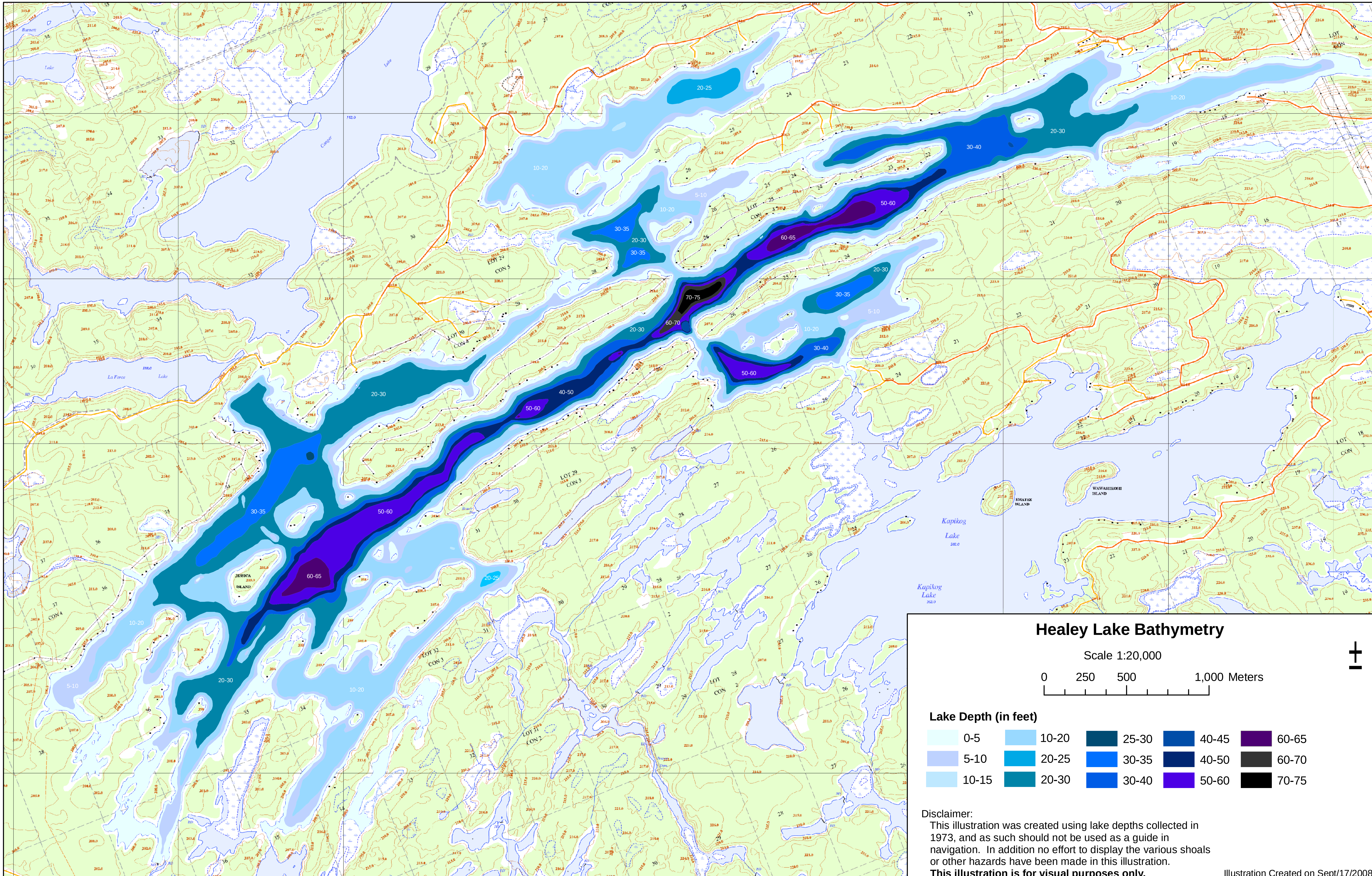


① Water quality sampling stations

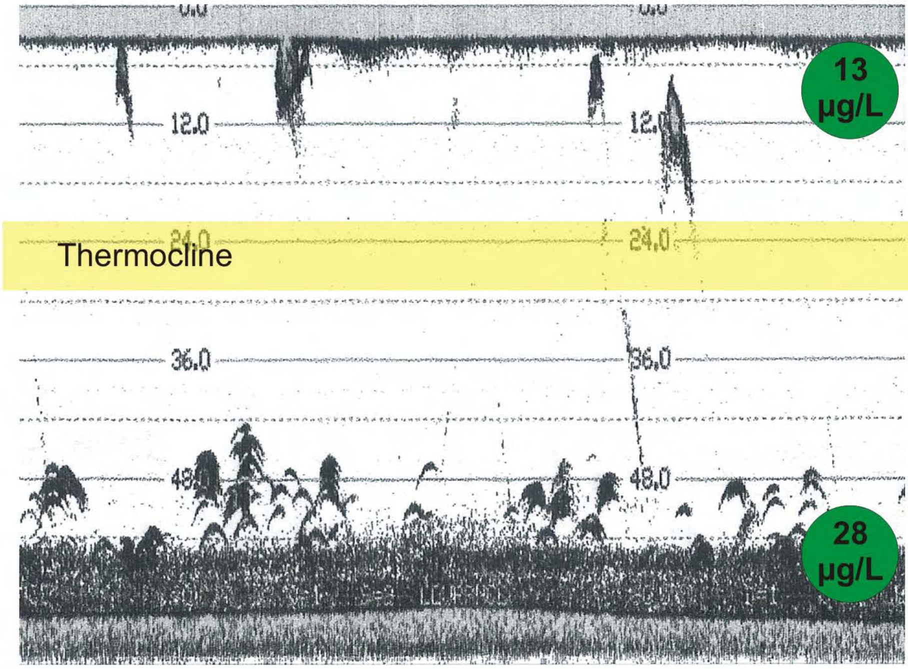
Healey Lake

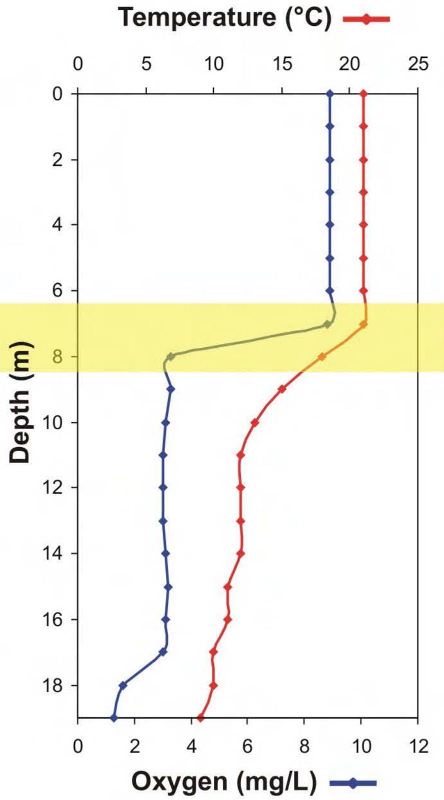
Figure 4.1

December 2008

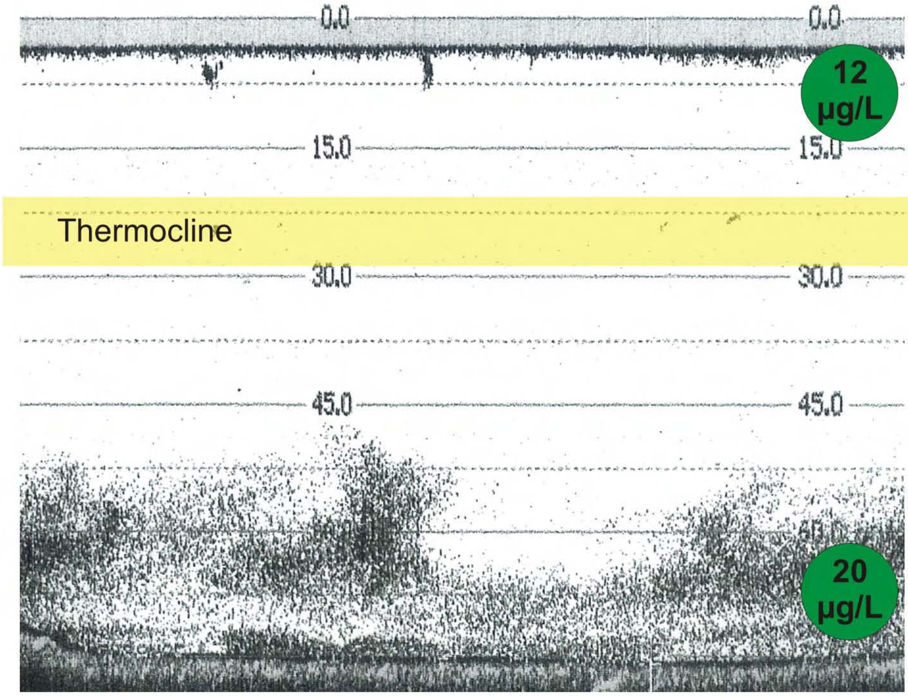

Healey Lake Bathymetry
Scale 1:20,000
0 250 500 1,000 Meters
Lake Depth (in feet)
0-5
5-10
10-15
10-20
20-25
20-30
25-30
30-35
30-40
40-45
40-50
50-60
60-65
60-70
70-75
Disclaimer:
This illustration was created using lake depths collected in 1973, and as such should not be used as a guide in navigation. In addition no effort to display the various shoals or other hazards have been made in this illustration.
This illustration is for visual purposes only.
Illustration Created on Sept/17/2008
Kapikog Lake
JESSICA ISLAND
WAWASHKOSH ISLAND
La Force Lake
Lake

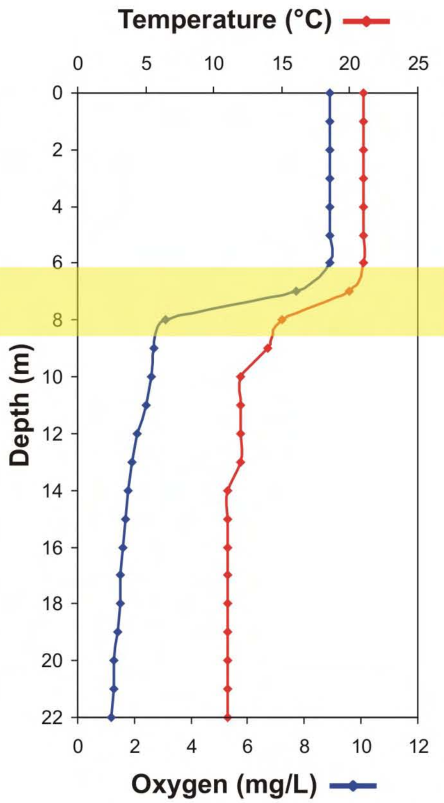
Healey Lake Station 1 - 09 Sep 2008





Healey Lake Station 2 - 09 Sep 2008

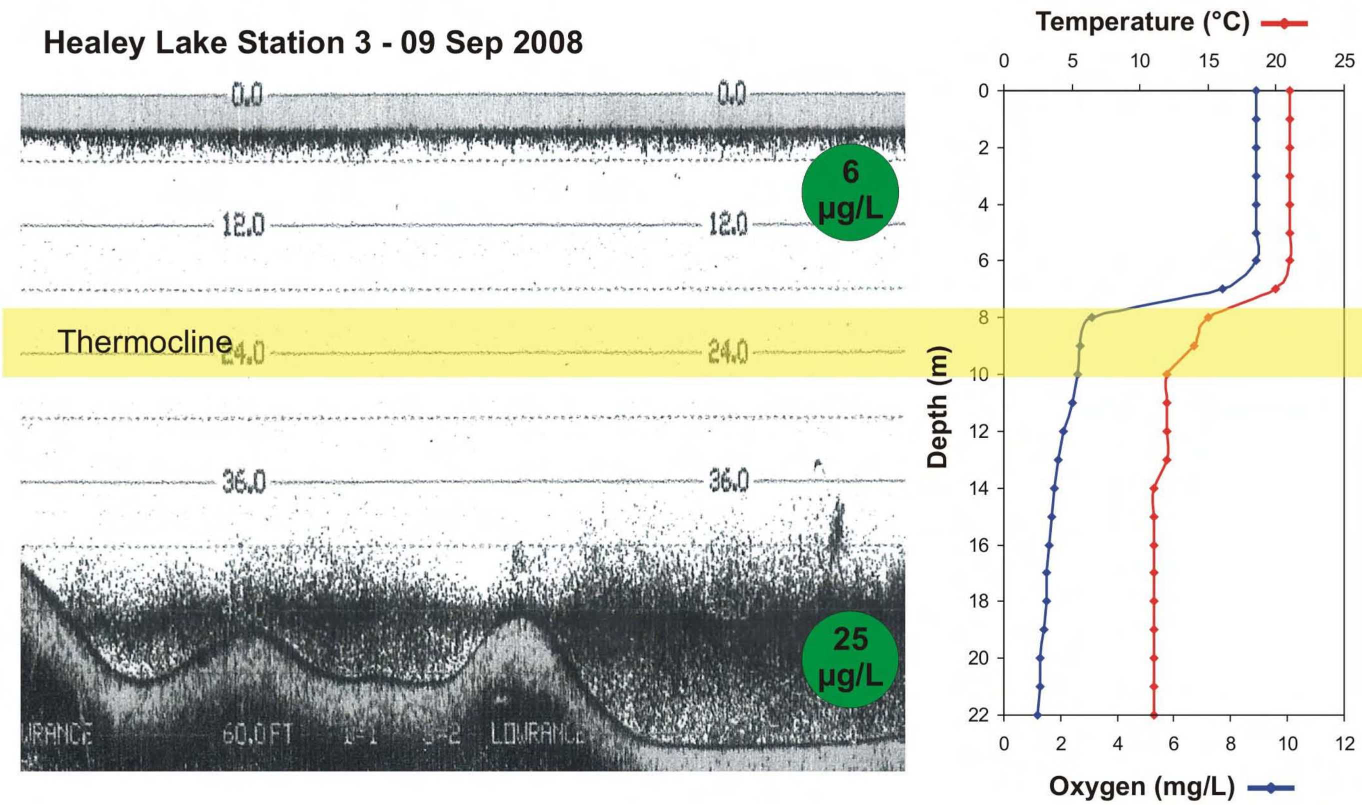




Sonar Transects and Temperature-Dissolved Oxygen Profiles	
Figure 4.3	December 2008

● Total Phosphorus

Healey Lake Station 3 - 09 Sep 2008



Sonar Transects and Temperature-Dissolved Oxygen Profiles	
Figure 4.3	December 2008

Total Phosphorus

4.5 Water Quality and Ecological Overview

Healey Lake is a moderate-size, moderately-deep **headwater lake** with several small localized tributary inflows. This includes the drainage from Kapikog Lake into Healey Lake. Figures 1.1, 4.1 and 4.2 illustrate many of the topographic features of Healey Lake.

Healey Lake is **moderately-deep** with an average depth of 6 m and a maximum depth of 23 m. The lake has a relatively low water volume to shoreline perimeter ratio and low water surface area to shoreline perimeter ratio. This is largely due to its irregular, elongated shape with numerous islands and bays.

The low total dissolved solids levels, low to moderate total phosphorus levels, and fair to good water clarity would suggest that Healey Lake is **oligotrophic** (low levels of biological productivity), but tending to mesotrophic. The fact that there is a high degree of oxygen depletion below the thermocline by late summer suggests sufficient nutrient loading to cause this effect (Figure 4.3). This may be a result of the high level of shoreline development on the lake over the past four decades (43 cottages in 1955, 324 cottages and 3 marinas by 1973, 365 cottages by 2008). Earlier temperature and oxygen data (prior to 2000) are not available. However, the presence of a population of cisco (lake herring), a coldwater species, suggests that coldwater fish habitat with higher dissolved oxygen levels may have occurred in the past. These fish are now confined to the deeper basin at Station 1 where dissolved oxygen conditions are marginal at 3 mg/l (ppm) below the thermocline. These fish are absent from the deep basins at Stations 2 and 3 because of low oxygen levels (Figure 4.3).

Water quality is good with a near neutral pH (7.1), low but likely adequate alkalinity, very low total dissolved solids, and good water clarity (3.8 m transparency). Water conductivity measurements indicate a lower degree of water mixing between the various bays and arms of Healey lake, as might be expected given the complex nature of this lake basin (Figure 4.1) and its lack of a major tributary system flowing through it. The northern bay of Healey Lake is most isolated from the remainder of the lake (Station 5) and appears to have some different water chemistry features. At 30 µS/cm water conductivity (Table 4.1), this is the softest water in the lake. It is also much more stained in colour (dark brown), has a reduced water clarity (1.4 m), and a higher phosphorus level (15). These all suggest a strong influence from local acid bog drainage to this bay and reduced mixing with the rest of Healey Lake.

Total phosphorus levels in surface waters averaged around or slightly above 10 in Healey Lake by late summer. This is tending toward the mesotrophic level and is likely higher than would be expected as a natural background condition. Some of this phosphorus appears to be originating from deep basin releases due to the anoxic conditions found here. All three basins (Stations 1, 2 and 3) had low dissolved oxygen and higher phosphorus levels (28, 20 and 25, respectively). This is illustrated in Figure 4.3. All three basins also had hydrogen sulphide (H_2S) gas bubbles in these deeper waters, as is indicated by the black stippling of the water column near the bottom on the sonar charts in Figure 4.3. See Section 1.2 for assistance in interpreting these results.

Several **tributary inflows** were found to have pH levels of 5.5 to 6.1, with Kapikog Lake outflows at 6.5. This is typical of localized drainage from small lakes, beaver ponds and acidic bogs on the granite bedrock of the Canadian shield. Healey Lake and Kapikog Lake lie within a geological zone called the Moon River synform. If viewed on an aerial photograph or satellite image, the synform shows as a circular swirl just to the north of the Moon River between Georgian Bay and Lake Joseph (see Figure 1.1). The semi-circular shape of Healey Lake is part of the synform structure. The synform consists largely of a type of granite called alaskite. This granite is of volcanic origin, pink in colour because of its high content of quartz and feldspar, and very hard and weather-resistant. Because of this underlying geology, surface waters in this region tend to be very acidic with little natural buffering capacity. Some small lakes to the south of Healey Lake and Kapikog Lake are so acidic that they support little fish life. Fortunately, Healey Lake appears to have adequate natural buffering capacity to at least partially neutralize these acidic inflows. Nevertheless, Healey Lake may be vulnerable to longer-termed acidification stresses.

Healey Lake is deep enough in its three basins to be **thermally stratified** through the summer but exhibits a high degree of oxygen depletion below the thermocline by late summer (Figure 4.3). When measured in early September of 2008, surface waters were 21° C, a moderately-sharp thermocline (zone of rapid temperature change) occurred at 7 to 8 m depth, and water temperatures below 10 m were 10 to 12 °C. Dissolved oxygen levels fell from 8.9 ppm above the thermocline to 3 ppm or lower below it. Oxygen levels below 3 to 4 ppm will not support coldwater fish species such as lake trout, whitefish and cisco.

Healey Lake has a good diversity of **warmwater fish species** but only a small population of cisco representing the coldwater fish community. The warmwater fish community is quite diverse, including populations of smallmouth and largemouth bass, northern pike, white sucker, yellow perch, rock bass, pumpkinseed (sunfish) and brown bullhead (catfish). A remnant population of cisco was found in the deeper basin at Station 1 where dissolved oxygen conditions were marginal at 3 mg/L (see sonar charts in Figure 4.3). The deep basins at Stations 2 and 3 also appear to have suitable coldwater habitat for cisco but have oxygen levels which are too low to support this species (below 2 mg/L). Any further reduction of late summer dissolved oxygen in Basin 1 will likely result in the elimination of this fish species from Healey Lake. As discussed in Section 1.2, the presence and condition of this cold water fish species can be a good biological indicator of overall lake health and water quality.

Although the fish population is quite diverse for a moderate-sized headwater lake, it is important to recognize that natural **biological productivity** in Healey lake is comparatively low, meaning that fish populations must be managed carefully and conservatively to avoid levels of exploitation that exceed the natural biological capacity of the lake. Without this, Healey Lake fish stocks are highly vulnerable to overfishing because of the lake's road accessibility and considerable shoreline development (numbers of anglers resident on the lake or having ready access to it). The comparative abundance of perch, rock bass, pumpkinseed, white sucker and bullheads suggests that the large predator species (bass and pike) may be excessively depleted, shifting the normal equilibrium which occurs between these species. Early reports on Healey Lake suggest that game fish were very abundant until an access road was built in 1949, after which fishing quality declined as cottage development density increased. Unfortunately, fishery management and catch regulations on Healey Lake were not adjusted to account for this increased fishing pressure. Fishery regulation specific to the needs of Healey Lake should be considered.

The existing level of **lakeshore development** and associated human activity on Healey Lake could be considered high for a moderate-sized, oligotrophic headwater lake on the Precambrian Shield. Environmentally sensitive planning in the past would likely have limited shoreline development well below that which currently exists on Healey Lake. As discussed above, the depletion of dissolved oxygen below the thermocline by late summer may be related to nutrient loadings from shoreline development.

There are over 400 residences on Healey Lake. These residences occur in highest density along the northern, eastern and southern shores of the lake where access roads follow the shoreline. There are only limited areas on the lake which retain a totally natural shoreline landscape without human alteration.

Healey Lake has easy road accessibility from Highway 400 with local access roads now circling much of the eastern, northern and southern sides of the lake. Only the extreme southwestern shore of the lake remains roadless.

4.6 Recommendations

Water Quality: Water quality in Healey Lake should be protected as a priority, both because of its relatively high natural quality for recreational use and because of its potential sensitivity to acidification within the watershed and possible early stage eutrophication effects. Long-term monitoring of nutrients levels, water clarity (Secchi disc depth), dissolved oxygen, pH and bacterial levels should be continued. A water quality survey similar to that carried out in 2008 should be repeated at least every 5 years.

Fishery Resources: As discussed in Section 3.0, natural biological productivity in Healey Lake is low (oligotrophic). This, combined with the easy road accessibility and considerable shoreline development, makes Healey Lake a very good candidate for special fishing regulations to protect fish stocks and enhance fishing quality. This could include reduced catch limits, maximum or slot size limits, the possible use of spawning sanctuaries and open season changes to protect critical brood stock or excessively vulnerable fish populations. These types of special fishing regulations have proven very successful at protecting fish stocks and improving fishing quality in many similar circumstances. In Healey Lake, it should also improve the species population equilibrium, which requires healthy populations of the larger predator species. The population of cisco in this lake could be used as a biological indicator of environmental conditions, since any additional nutrient loading (eutrophication) would likely further deplete dissolved oxygen levels in deeper portions of the lake and have a negative effect on cisco population levels and ultimate survival in Healey Lake.

Lakeshore Development: It is strongly recommended that no further building lots be created on Healey Lake. As discussed in Section 4.5, this lake is already at or above the optimum shoreline development capacity if a broad spectrum of environmental factors is considered.

Shoreline development capacity should be determined based on a comprehensive long-term vision of the ecosystem, landscape and human environmental features to be protected on the lake. Those residing on the lake should be directly involved in developing this vision through the “lake plan” or “community plan” process now occurring on many lakes.

One of the other factors which should be considered on Healey Lake is the very high ratio of shoreline perimeter to either lake surface area or lake water volume. Lakes such as this are particularly vulnerable to excessive lakeshore development if only shoreline availability is considered rather than lake surface area and water volume. This is because water-based recreational activities such as boating, water-skiing and fishing must all be accommodated on the surface area of the lake, while the water volume in the lake is what is available to assimilate or dilute various discharges and contaminants related to shoreline development. This would include nutrient leaching from septic systems, fertilizer and pesticide runoff from lawns and gardens, gasoline and oil residues from two-cycle outboard motors, etc. A loss in aesthetic values of the lake environment due to excessive boating activity or noise levels is at risk on smaller surface area lakes with long narrow arms and bays, while a deterioration in water quality is likely for lakes with high shoreline development but comparatively small water volume.

As well, the extension of road access to presently inaccessible shorelines on this lake should be restricted to preserve the natural character and ecosystem features in these areas. Circling of the lake with roads inevitably leads to the undesirable linear urbanization of shorelines. In particular, a very high level of protection should be given to the several large wetlands on Healey Lake.

Lake Stewardship: Because of the high density of lakeshore development and sensitive nature of aquatic ecosystems in Healey Lake, all residents on the lake should practice a high level of lake stewardship on their properties, including a well-operating septic system, low water-use practices, maintenance of natural vegetation on the lake shores, restricted use of fertilizers and pesticides, and phasing out of two-cycle outboard motors for the much cleaner four-cycle engines.

5.0 KAPIKOG LAKE

5.1 Physical Features

Surface Area:	317 hectares (783 acres)
Maximum Depth:	16 m (53 feet) – Figure 5.2 Bathymetry
Average Depth:	6 m (20 feet) – Figure 5.2 Bathymetry
Lakeshore Perimeter:	23.3 km (Island shoreline an additional 6.8 km)
Littoral Zone:	57%
Water Level:	regulated by Kapikog Lake Dam
Watershed:	Drains to Healey Lake and Georgian Bay

5.2 Lakeshore Development

Access:	extensive road access (Figure 5.1)
Crown Land:	approx. 50% of shoreline
Private Development:	2008 – 125 developed lots, 1 resort and marina

5.3 Water Quality

Water Clarity:	4.2 m (2008), 4.2 m (2000), 4.0 (1998)
(Secchi depth)	
Water Colour:	light yellow
Alkalinity:	13.7 mg/L – Level 3 moderate sensitivity (MOE, 1989)
pH:	6.5 (2000), 6.5 (1989)
Total Phosphorus:	14 µg/L (Table 5.1)
	MOE Lake Partner Program – Spring Sampling
	7.0 (2002), 9.1 (2004), 5.3 (2005), 5.5 (2006)
Conductivity:	22 µS/cm (Table 5.1)
Thermal Profile:	Figure 5.3
Dissolved Oxygen:	Figure 5.3
Sonar Transect:	Figure 5.3

Table 5.1 Kapikog Lake Water Quality, 9 September 2008 (Sampling Stations in Figure 5.1)

Sampling Station	Secchi Depth (m)	Water Conductivity (µS/cm)	Total (µg/L) Phosphorus
1	4.2	22	14
1 (15 m depth)		53	31
2	4.2	22	14
3	4.1	22	8
4	4.0	22	15
5		22	12
6	3.8	22	11

5.4 Biological Features

Fish Species:
- Largemouth Bass
- Smallmouth Bass
- Northern Pike
- Yellow Perch
- Cisco
- Brown Bullhead
- Rock Bass
- Pumpkinseed
- Forage Species (minnows, shiners, darters, etc.)

Information on fish population and management programs for Kapikog Lake are found in the following reports:

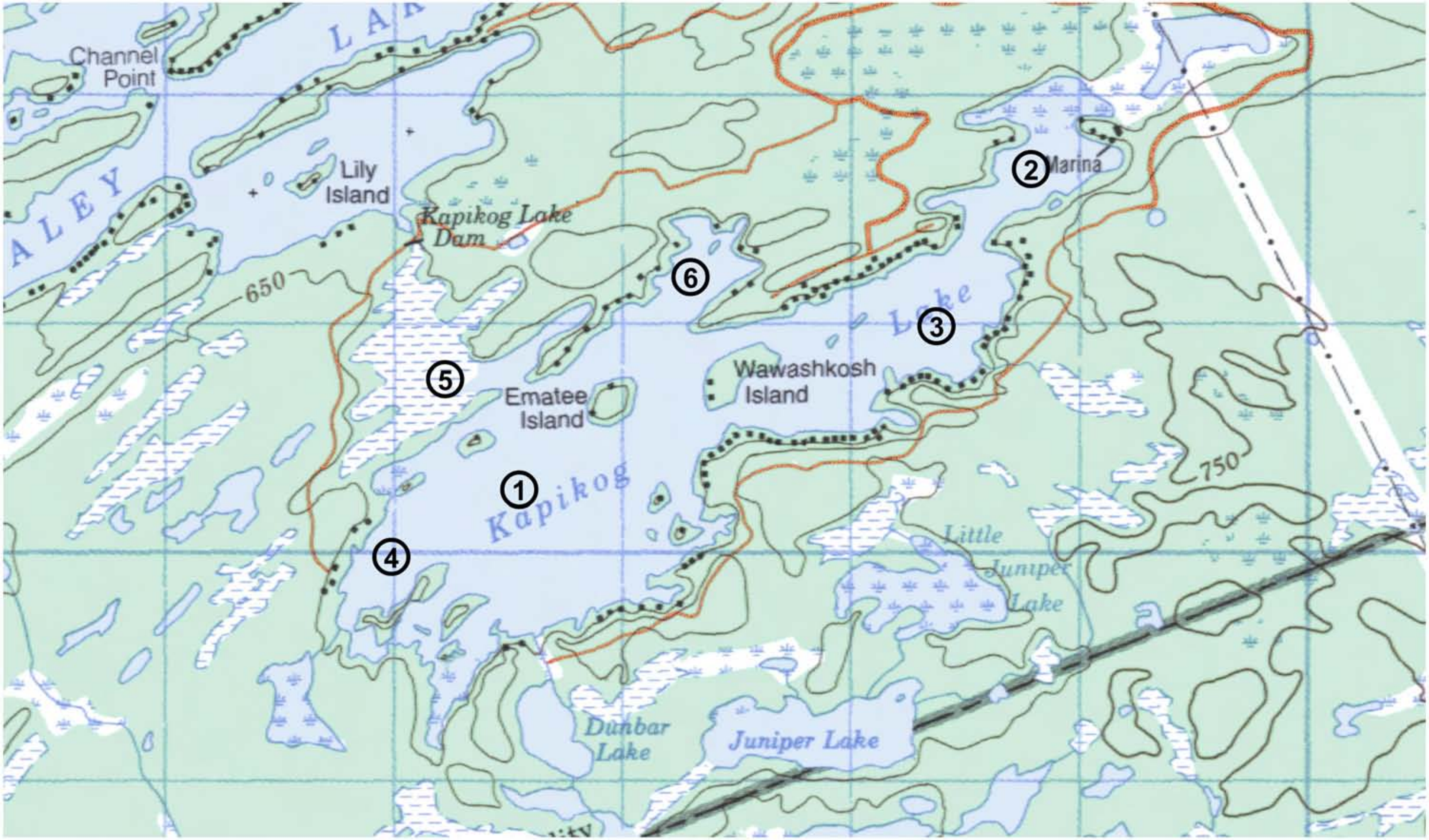
Paus, M. 1984. Results of a Trapnet and Gill net Survey conducted on Kapikog Lake During 1983.

McIntyre, E. 1981. Pre-stocking Assessment and Transfers of Largemouth Bass in the Parry Sound District 1981.

5.5 Water Quality and Ecological Overview

Kapikog Lake is a small, relatively shallow **headwater lake** with several very small tributary inflows. Figures 1.1, 5.1 and 5.2 (bathymetry) illustrates many of the topographic features of Kapikog Lake.

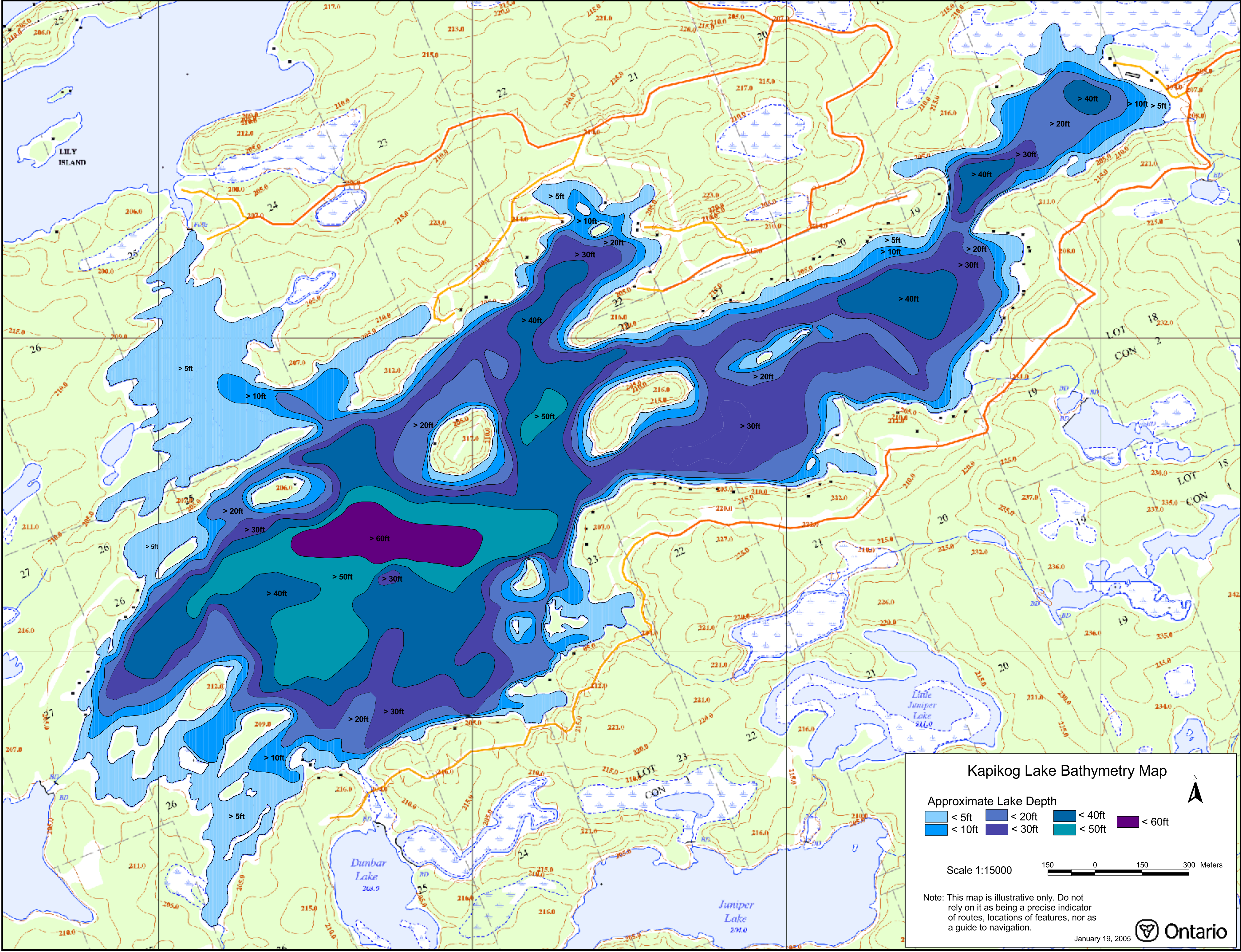
Kapikog Lake is **comparatively shallow** with an average depth of 6 m and a maximum depth of 16 m. The lake has a relatively low water volume to shoreline perimeter ratio and low water surface area to shoreline perimeter ratio. The former is largely due to its relative shallowness while the latter is due to its irregular, elongated shape.

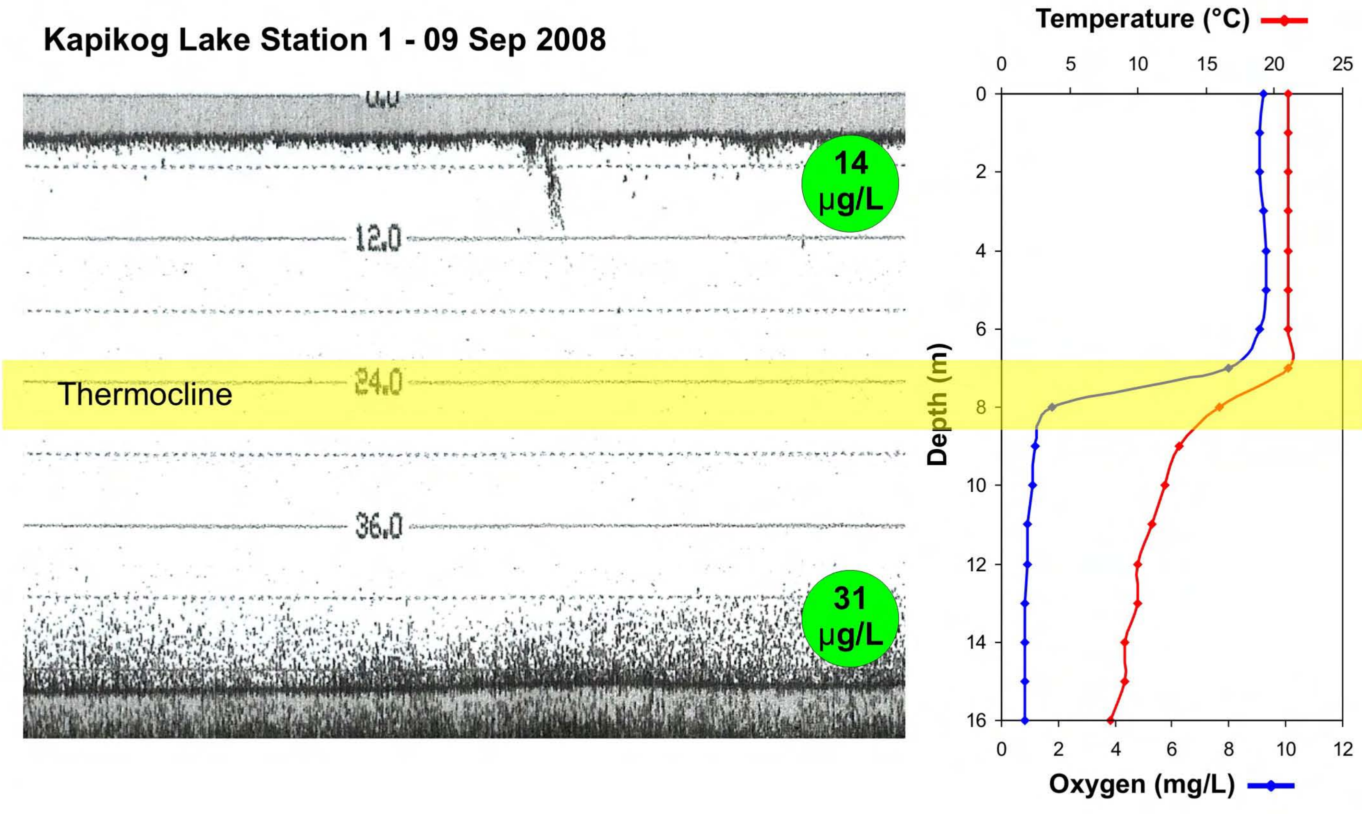


① Water quality sampling stations

Kapikog Lake

Figure 5.1	December 2008


Kapikog Lake Bathymetry Map
Approximate Lake Depth
< 5ft
< 10ft
< 20ft
< 30ft
< 40ft
< 50ft
< 60ft
Scale 1:15000
150 0 150 300 Meters
Note: This map is illustrative only. Do not rely on it as being a precise indicator of routes, locations of features, nor as a guide to navigation.
January 19, 2005
Ontario
LILY ISLAND
Dunbar Lake
Juniper Lake
Little Juniper Lake
> 5ft
> 10ft
> 20ft
> 30ft
> 40ft
> 50ft
> 60ft



Sonar Transects and Temperature-Dissolved Oxygen Profiles

Figure 5.3	December 2008

Total Phosphorus

The low total dissolved solids levels and good water clarity would suggest that Kapikog Lake is **oligotrophic** (low levels of biological productivity), a typical classification for other lakes in this region. However, the fact that there is almost total oxygen depletion below the thermocline by late summer suggests sufficient nutrient loading to cause this effect. A similar condition was found in 2000 (Schiefer, 2001). This may be a result of considerable shoreline development on the lake over the past three decades or a longer-termed natural condition. However, the documented presence of a remnant population of cisco (lake herring), a coldwater species, in 1973 suggests that coldwater fish habitat with higher dissolved oxygen levels may have occurred in the past.

Water quality is good with a somewhat acidic pH (6.5), low to moderate alkalinity, very low total dissolved solids, and good water clarity (4.2 m transparency).

Water conductivity measurements indicate that surface waters are well mixed throughout Kapikog Lake. Total phosphorus levels are somewhat elevated at 8 to 15 µg/h across the lake in early September, likely due to some contribution by deepwater phosphorus cycling from anoxic sediments (see Section 1.0). Phosphorus measurements below the thermocline were 31 µg/L (Table 5.1). This is illustrated in Figure 5.3. The sonar image also indicates the presence of hydrogen sulphide gas bubbles in the bottom several metres of water, which was confirmed by the strong sulphur smell of the water sample collected here. Hydrogen sulphide in a result of the anoxic condition found in these deeper, colder waters, which is also responsible for the elevated phosphorus levels.

Two **tributary inflows** were found to have pH levels of 6.1 and 5.6 in 2000 (Schiefer, 2001), the latter being the bog drainage at the east end of the lake. In 2008, the pH of these tributaries was 5.6. This is typical of localized drainage from small lakes, beaver ponds and acidic bogs on the granite bedrock of the Canadian shield. Kapikog Lake and Healey Lake lie within a geological zone called the Moon River synform. If viewed on an aerial photograph or satellite image, the synform shows as a circular swirl just to the north of the Moon River between Georgian Bay and Lake Joseph (see Figure 1.1). The semi-circular shape of Healey Lake is part of the synform structure. The synform consists largely of a type of granite called alaskite. This granite is of volcanic origin, pink in colour because of its high content of quartz and feldspar, and very hard and weather-resistant. Because of this underlying geology, surface waters in this region tend to be very acidic with little natural buffering capacity. Some small lakes to the south of Kapikog Lake are so acidic that they support little fish life. Fortunately, Kapikog Lake appears to have adequate natural buffering capacity to at least partially neutralize these acidic inflows. Nevertheless, Kapikog Lake may be vulnerable to longer-termed acidification stresses.

Kapikog Lake is deep enough in its central basin to be **thermally stratified** through the summer but exhibits almost total oxygen depletion below the thermocline by late summer. When measured in early September of 2008, surface waters were 21°C, a sharp thermocline (zone of rapid temperature change) occurred at 7 to 8 m depth, and water temperatures below 10 m were 9°C (Figure 5.3). Dissolved oxygen levels fell from over 8 mg/L (ppm) above the thermocline to below 1 mg/L (ppm) below it. Oxygen levels below 3 to 4 ppm will not support coldwater fish species such as lake trout, whitefish and cisco.

Kapikog Lake has a good **diversity of warmwater fish species** but appears to lack a coldwater fish community. The warmwater fish community is quite diverse, including populations of smallmouth and largemouth bass, northern pike, yellow perch, rock bass, pumpkinseed (sunfish) and brown bullhead (catfish).

A lake survey in 1973 indicated the presence of a small population of cisco, a coldwater fish species. In 2000 and 2008, dissolved oxygen levels in the coldwater zone below the thermocline were extremely low, below 1 mg/L, a level which would not support a population of cisco. The sonar reconnaissance carried out in 2008 showed an absence of any fish below the thermocline (Figure 5.3). Compare this with the results found in Healey Lake (Figure 4.3), Crane Lake (Figure 3.3) or Blackstone Lake (Figure 2.3). Deep water dissolved oxygen levels were higher in each of these lakes, supporting the coldwater fish communities observed in these sonar images. The possible disappearance of cisco in Kapikog Lake over the past 3 decades could be linked to higher phosphorus levels and associated oxygen depletion of deeper waters though the summer. This is typically considered a symptom of increasing eutrohication, or nutrient enrichment of a lake.

Although the fish population is quite diverse for a small headwater lake, it is important to recognize that natural **biological productivity** in Kapikog Lake is comparatively low, meaning that fish populations must be managed carefully and conservatively to avoid levels of exploitation that exceed the natural biological capacity of the lake. Without this, Kapikog Lake fish stocks are highly vulnerable to overfishing because of the lake's road accessibility and considerable shoreline development (numbers of anglers resident on the lake or having ready access to it). The comparative abundance of perch, rock bass, pumpkinseed and bullheads suggests that the large predator species (bass and pike) may be excessively depleted, shifting the normal equilibrium which occurs between these species.

The existing degree of **lakeshore development** and associated human activity on Kapikog Lake could be considered high for a small, oligotrophic headwater lake on the Precambrian Shield. There are over 125 cottages and homes on Kapikog Lake. These residences occur in highest density along the northern, eastern and southern shores of the lake where access roads follow the shoreline. There are only limited areas on the lake which retain a totally natural shoreline landscape without human alteration. The lake has easy road accessibility from Highway 400. Only the extreme western shore of the lake remains roadless. As discussed above, the depletion of dissolved oxygen below the thermocline by late summer may be related to nutrient loadings from shoreline development.

5.6 Recommendations

Water Quality: Water quality in Kapikog Lake should be protected as a priority, both because of its relatively high natural quality for recreational use and because of its potential sensitivity to acidification within the watershed and possible early-stage eutrophication effects. Long-term monitoring of nutrient levels, water clarity (Secchi disc depth), dissolved oxygen and bacterial levels should be continued. A water quality survey similar to that carried out in 2008 should be repeated at least every 5 years.

Fishery Resources: As discussed in Section 5.5, natural biological productivity in Kapikog Lake is low (oligotrophic). This, combined with the easy road accessibility and considerable shoreline development, makes Kapikog Lake a very good candidate for special fishing regulations to protect fish stocks and enhance fishing quality. This could include reduced catch limits, maximum or slot size limits, the possible use of spawning sanctuaries and open season changes to protect critical brood stock or excessively vulnerable fish populations. These types of special fishing regulations have proven very successful at protecting fish stocks and improving fishing quality in many similar circumstances. In Kapikog Lake, it should also improve the species population equilibrium which requires healthy populations of the larger predator species. The small population of cisco in this lake could be used as a biological indicator of environmental conditions, since additional nutrient loading (eutrophication) would likely further deplete dissolved oxygen levels in deeper portions of the lake and have a negative effect on cisco population levels and ultimate survival in Kapikog Lake. As discussed in Section 5.5, cisco may have already been exterminated from Kapikog Lake.

Lakeshore Development: It is strongly recommended that no further building lots be created on Kapikog Lake. As discussed in Section 5.5, this lake is already at or above the optimum shoreline development capacity if a broad spectrum of environmental factors were considered.

Shoreline development capacity should be determined based on a comprehensive long-term vision of the ecosystem, landscape and human environmental features to be protected on the lake. Those residing on the lake should be directly involved in developing this vision through the “lake plan” or “community plan” process now occurring on many lakes.

As well, the extension of road access to presently inaccessible shorelines on this lake should be restricted to preserve the natural character and ecosystem features in these areas. Circling of the lake with roads inevitably leads to the undesirable linear urbanization of shorelines. In particular, a very high level of protection should be given to the several large wetlands on Kapikog Lake.

Lake Stewardship: Because of the high density of lakeshore development and sensitive nature of aquatic ecosystems in Kapikog Lake, all residents on the lake should practice a high level of lake stewardship on their properties, including a well-operating septic system, low water-use practices, maintenance of natural vegetation on the lake shores, restricted use of fertilizers and pesticides, and phasing out of two-cycle outboard motors for the much cleaner four-cycle engines.

6.0 DISCUSSION

These four lakes generally have good to excellent water quality and apparently relatively healthy aquatic ecosystems. They also illustrate a range of conditions for various water quality criteria, from deep, well-oxygenated Blackstone Lake, which supports lake trout, to smaller Kapikog Lake which experiences oxygen depletion and does not support coldwater fish species. As is the case with all lakes, each of these lakes is somewhat unique in its geology, basin morphology, hydrology, water chemistry, biology and recreational features. As such, each has its own distinct sensitivities and priorities with regard to protecting and managing water quality, and the aquatic ecosystem as a whole.

There is considerable scope for better managing the fish populations in these lakes, but this requires a commitment among the majority of residents on the lake and a coordinated effort with the Ontario Ministry of Natural Resources.

With regard to lakeshore development, comments have been provided for each lake which generally suggest that additional waterfront development be discouraged or prevented. This stems from a number of factors:

- Each lake already has a significant level of lakeshore development at this time. Further development risks eroding the natural character and peaceful enjoyment of the environment found on these lakes.

- Numerous studies have demonstrated a direct linkage between lakeshore development and the long term decline in water quality and reduced health and diversity of aquatic ecosystems. This is especially true when access roads are constructed around a lakeshore, because of the increased density and intensity of human activities which roads promote.

- Lakeshore development tends to be a uni-directional, irreversible change to the lake environment. It is difficult, if not impossible, to restore an earlier, and often more desirable, condition once excessive lakeshore development has occurred. For this reason, a cautious and environmentally conservative approach to lakeshore development is suggested.