CHANDOS LAKE CAPACITY UPDATE AND PROPOSED PLANNING POLICY DIRECTIONS

Prepared for:

Chandos Lake Property Owners' Association

Prepared by:

Michalski Nielsen Associates Limited
and
Anthony Usher Planning Consultant

June 2008 (Revised May 2009)

Michalski Nielsen
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May 21, 2009

Mr. William Rasberry
4 Fieldstone Road
Toronto, Ontario
M9C 2J6

Re: Chandos Lake Capacity Review/Update; Our File 2104

Dear Mr. Rasberry:

Michalski Nielsen Associates Limited is pleased to provide you with our report entitled **CHANDOS LAKE UPDATE AND PROPOSED PLANNING POLICY DIRECTIONS** (June 2008 [Revised May 2009]).

Should you have any questions or comments, please do not hesitate to call.

Yours truly,

MICHALSKI NIELSEN ASSOCIATES LIMITED
Per:

Michael Michalski

MM/be

Enc.

c.c.: Mr. Jim O'Shea

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Letter of Transmittal

1 INTRODUCTION

1.1 Background

In 1991, the then Township of Chandos retained Michael Michalski Associates (now Michalski Nielsen Associates Limited) and Anthony Usher Planning Consultant to:

- evaluate the capacities of Chandos Lake (as well as other lakes in the Township) to support development with respect to lake trophic state, shoreline development, sports fisheries and boating; and

- recommend changes to the Township of Chandos' Official Plan and Zoning Bylaw that might be needed to maintain the quality and sustainability of the lake's environment, while encouraging uses and development desired by Township residents.

For the most part, the work program was based on data already available. Key new information related to surveys of boating activity, boat populations, numbers of shoreline residences, and a biophysical analysis of six undeveloped stretches of private shoreline. As well, the Ministry of Municipal Affairs and Housing's (MMAH) 1986 Lake Trophic State model was applied to Chandos Lake and determined how chlorophyll *a* (i.e., the green photosynthetic pigment in algae that is governed primarily by levels of phosphorus which is a nutrient considered to be in limiting supply in lakes, rivers and streams) would respond to various development scenarios including:

1. Pre-development;
2. Development of approved vacant lots only;
3. Scenario 2, with 33 a% of residences principal;
4. Scenario 3, with 10% increases in residences and commercial accommodation; and
5. Scenario 4, with 50% reductions in phosphorus loads per development unit.

Key findings from **Chandos Township Lake Carrying Capacities** which was submitted to the Township in 1993 included lake capacity summaries and recommendations; these are reproduced in **Appendix A**.

Michalski Nielsen Associates Limited and Anthony Usher Planning Consultant recognized the limitations of the 1993 report very early in the document. While it addressed aspects of the physical capacity of lakes to support development, the authors explained that lake capacity is determined by economic and social factors as well as physical considerations. The features used to assess lake capacity did incorporate some of these other dimensions. For example, the recommendations regarding water quality objectives, and the capacity standards used in the analysis of boating, reflected to some degree social acceptability as well as physical considerations. However, in general, the study did not directly address social and economic concerns such as aesthetics, the density and type of development desired, recreational crowding, noise, "antisocial" behaviour, and so on. It was the opinion of the authors that it is up to the residents and Council of the then Township of Chandos to decide how they wanted to integrate social, economic and physical concerns in determining the lake planning and management policies they wished to adopt. Further information relating to lake capacity and shoreline development standards is presented in **Appendix B**.

As matters progressed, the results of the 1993 report were never incorporated as policy into the Township of Chandos Official Plan. Several other important changes should be noted that significantly altered the policy environment in which the original recommendations were developed.

- The Township of Chandos was merged with the Township of Burleigh and Anstruther into the Township of North Kawartha (1968). Chandos Lake was no longer the predominant focus of the amalgamated municipality.

- What constitutes "good planning" in Ontario became much more explicitly directed by the Province, through the adoption of the *Comprehensive Set of Policy Statements* (1995) and its successor *Provincial Policy Statement* (1996, 2005). Peterborough County is now also subject to the *Greater Golden Horseshoe Growth Plan* (2006).

- The County of Peterborough Official Plan came into force (1994) and has since been substantially strengthened, including with respect to shoreline development (2006).

- It was decided that new local planning policies for North Kawartha, to replace the Chandos and Burleigh and Anstruther Official Plans, would be developed and incorporated into the Peterborough County Official Plan. The new North Kawartha policies were approved by the Ministry of Municipal Affairs and Housing approval in October 2008.

In the spring of 2004, Michalski Nielsen Associates Limited was contacted by the Chandos Lake Property Owners' Association to (CLPOA), to discuss the possibility of completing an update of the original 1993 work, particularly with a view to taking a fresh look at policy direction based on cottagers' opinions and attitudes on important environmental questions. Through discussions with Jim O'Shea and other members of CLPOA, it was decided to revisit/update four key matters.

1. **New water quality information**. Sampling was undertaken at five locations on two occasions (i.e., immediately after ice-out and in mid-August). At each station, water temperature and dissolved oxygen was measured every metre of depth, surface to bottom; as well, Secchi disc measurements were obtained. Concentrations of total phosphorus were also determined from 3.0 metres (m) of depth. The data are integrated with other information collected from Ministry of the Environment (MOE) and Ministry of Natural Resources (MNR) files, as well as from the MOE's Lake Partner Program; of some interest is that the collection of long term data on trophic state parameters was a recommendation of the 1993 report.

2. **New information on cottage use for seasonal and permanent residences**. The information on such data were obtained from a questionnaire return (**Appendix C**), similar to a 1992 survey included in the 1993 report. In addition to incorporating the data into an updated version of the 1986 Lake Trophic State Model, the responses provided new factual information on seasonal versus permanent residency, boat numbers/types at cottages, and significant direction on policy matters, which are presented later in this report. As well, updated information on numbers of lots was obtained by CLPOA, using guidelines provided by the consultants (**Appendix D**).

3. **Revisions to 1986 Lake Trophic State Model**. There have been a number of alterations made to the 1986 version of the Lake Trophic State Model, the most recent of which are described in "A Review of the Components, Coefficients and Technical Assumptions of Ontario's Lakeshore Capacity Model" (2006). Also, new information on numbers of shoreline lots and use were computed using findings of the recent questionnaire, and were incorporated into the updated model, which is also presented in this report.

4. **Policy direction**. A number of the policies proposed in the 1993 report are still relevant; these are included in the final section of this update dealing with direction on planning policies, as are policy directions resulting from our analysis of 2004 questionnaire returns.

1.2 Acknowledgements

Anthony Usher, Planning Consultant, reviewed draft copies of the user questionnaire, summarized and interpreted lot development information compiled by CLPOA for use in an updated Lake Trophic State Model, prepared planning and development policies based on interpretation of questionnaire responses, and generally contributed to the production of this update report. Brent Parsons (Aquatic Ecologist) summarized historical water temperature and dissolved oxygen profiles for Chandos Lake and its embayments, and Gilmour Bay, and made revisions to the 1986 Lake Trophic State model. Michael Michalski, Limnologist and Senior Advisor, prepared sections on water quality in relation to policies on phosphorus and dissolved oxygen, and integrated the individual components of this report, and undertook revisions resulting from new data and discussions with CLPOA.

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2 CHANDOS LAKE
WATER QUALITY CONDITIONS

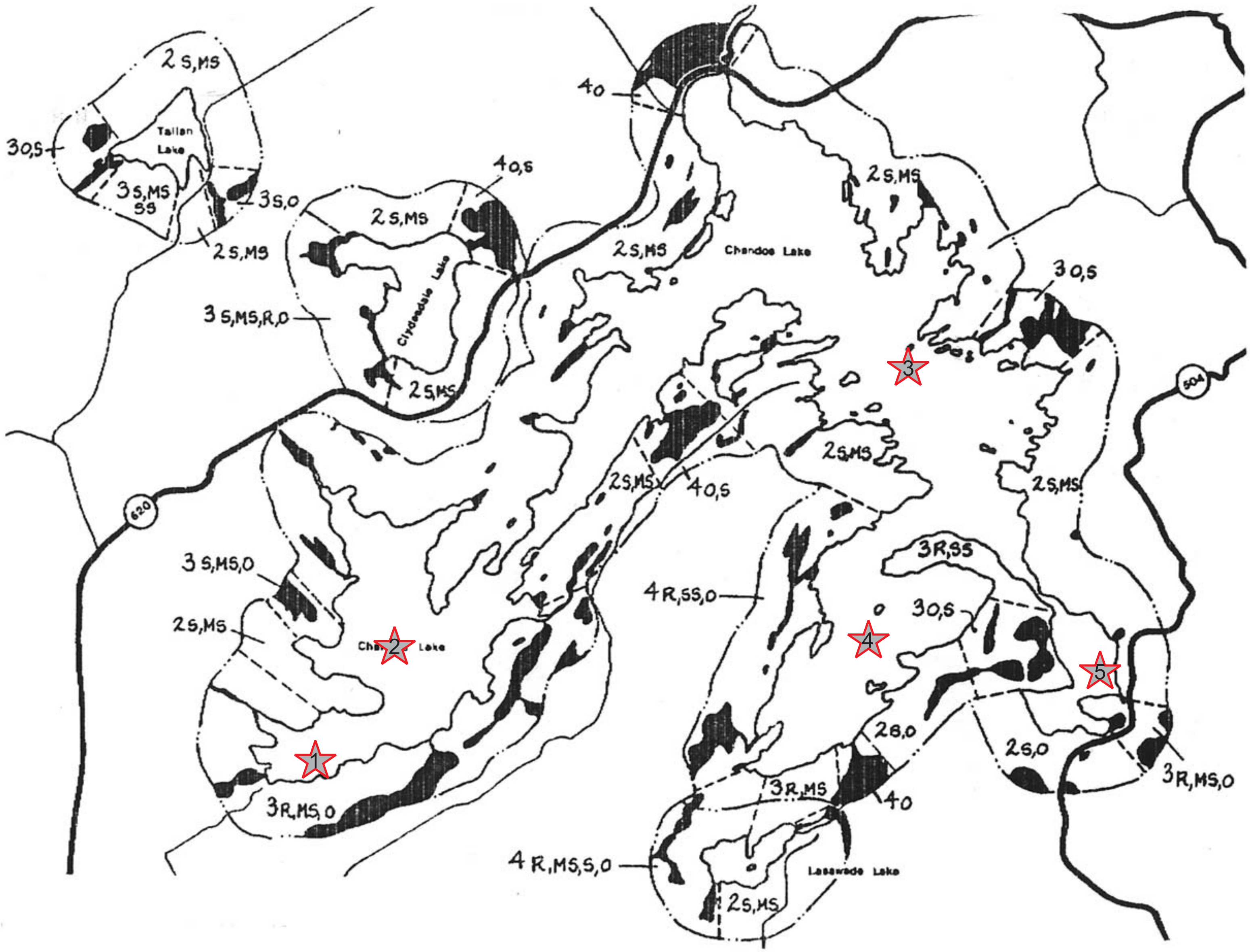
2.1 Introduction

Much can be learned about water quality and more specifically information on lake trophic state from just a few parameters collected at the correct time and location. For this update, it was decided to focus on water temperature and dissolved oxygen with depth, water clarity as determined from Secchi disc measurements, and concentrations of total phosphorus determined on samples collected from 3.0 m of depth. The sampling was undertaken on two occasions, April 30 and September 14, 2004; samples from five stations were obtained (**Figure 1**); two of the five stations are considered to be in relatively shallow water (i.e., Stations 1 and 2), while three are deep water sites (i.e., Stations 3, 4 and 5). Stations 1 through 4 are all in Chandos Lake, while Station 5 is in Gilmour Bay.

2.2 Water Temperature

In lakes located in temperate zones, water temperatures during mid-summers follow two common patterns. In shallow lakes, well exposed to wind, temperatures are practically constant from top to bottom, typically varying less than three degrees to four degrees Celsius between surface and bottom. Variables other than climatic that govern the lake's internal structure include: volume of inflow and outflow in relation to the volume of the basin; basin configuration; surface area of the lake; position of the basin in relation to wind action, etc. Typically, lake depth is insufficient to maintain strong thermal stratification throughout the entire summer and fall. This uniformity of temperature indicates that the waters are well-mixed throughout. The near-shore waters of shallow basins may contain weed beds of submergent and emergent vascular aquatic plant material, and produce relatively high yields of warm water species of game fish. Water temperature at Station 1 (West Bay) was uniform surface to bottom on the two sampling dates in 2004 (**Figure 2**), while a slight temperature gradient was apparent in the lower depths of Station 2 (Hawkes Bay) on April 30th.

The other common pattern occurs in water bodies having maximum depths generally in excess of about 15 m. In this case, three characteristic layers are present: an upper zone of water in which the temperature is more or less uniform throughout; an intermediate zone in which the temperature declines gradually with depth; and a lower zone of cold water in which temperature is again fairly uniform throughout. These three layers are termed the epilimnion, metalimnion, and hypolimnion respectively, and are depicted schematically in **Figure 3**.



Project Name: Chandos Lake	Prepared For: CLPOA	Date Initiated: 2004	Filename: 2104 Water Sample Locations	**FIGURE 1**

Michalski Nielsen ASSOCIATES LIMITED

Scale: NTS	Drawn By: CM
Rev. No:	Project Number: 2104

Water Sampling Stations for August 30 and September 14, 2004 for Chandos Lake

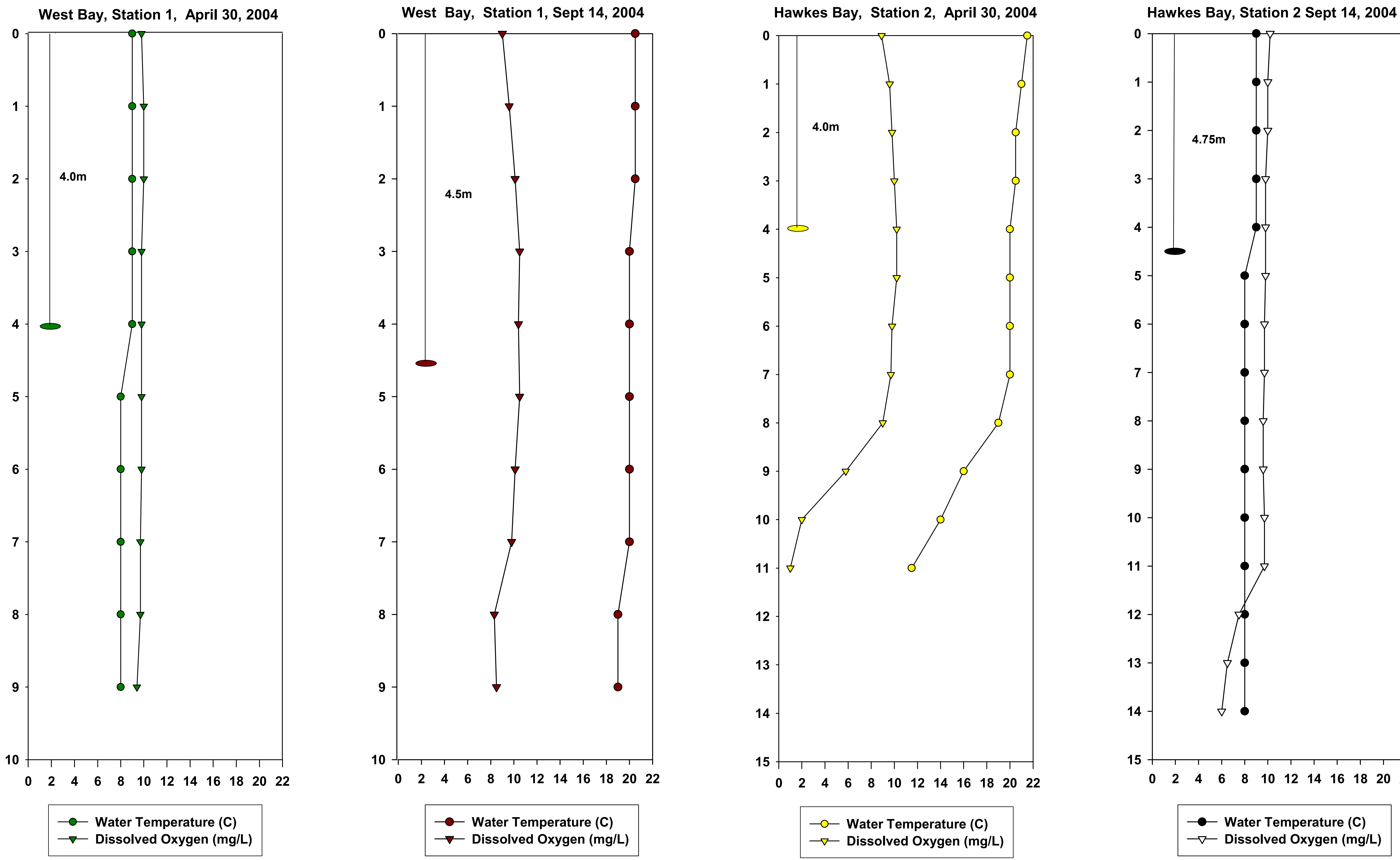
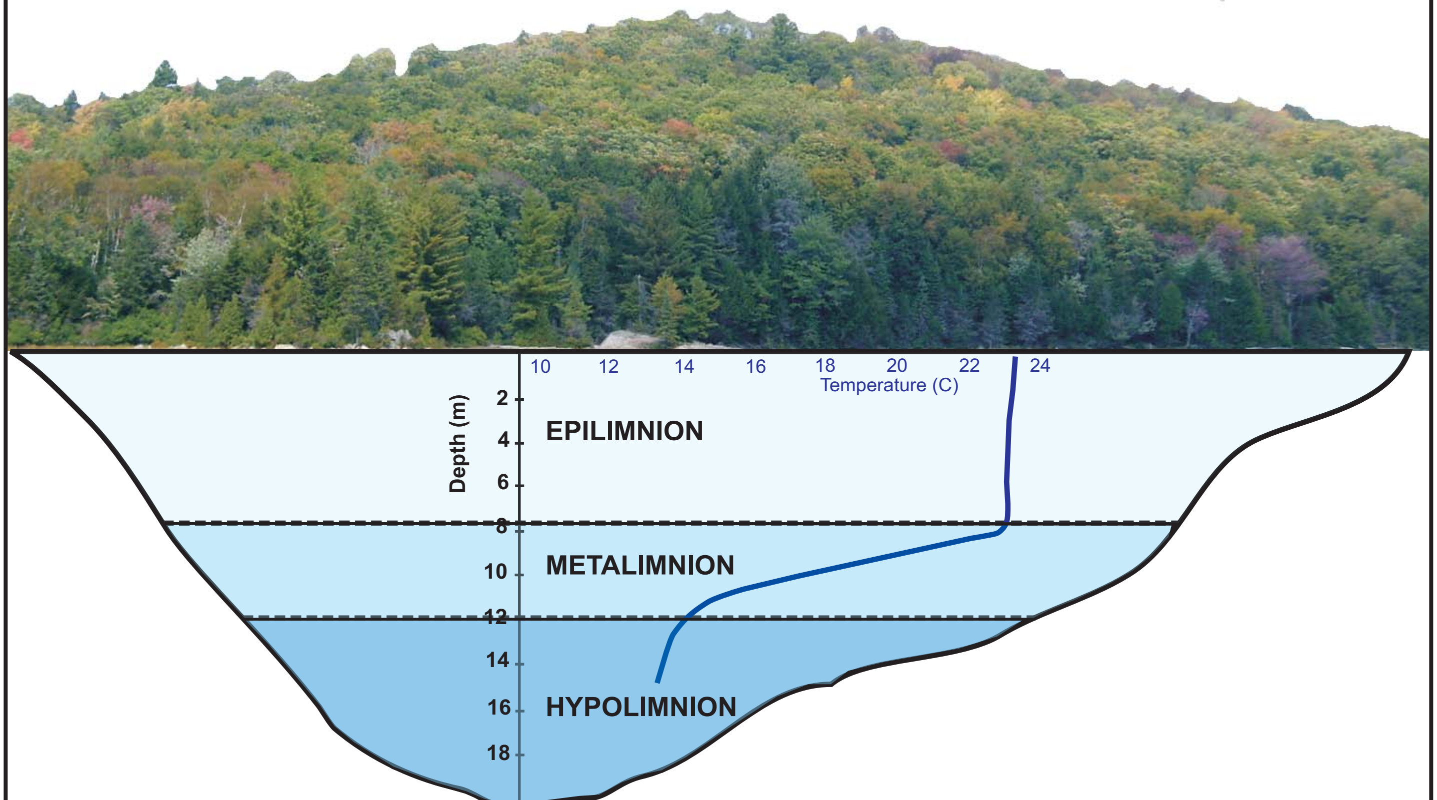


Figure 2. Temperature and dissolved oxygen profiles in Chandos Lake at Stations 1 and 2 on April 30, 2004 and on Sept 14, 2004. Secchi disc values are also shown in top left. Data were collected by Michalski Nielsen Associates Limited.



Project Name: Chandos Lake Update	Date Initiated: June 2008	Filename: Chandos Lake	**FIGURE 3**
Prepared For: Chandos Lake Property Owners' Association	Thermal stratification in a deep, north temperate zone lake in mid-summer		
Michalski Nielsen ASSOCIATES LIMITED	Rev. No: 1	Drawn By: JN	Scale: 1:250,000	Project Number: 2104

The profiles in **Figure 4** for Stations 3 and 4 and **Figure 5** for Gilmour Bay indicate strong stratification during the summer. The rate of temperature decline in the metalimnion approximated 3°C per metre of depth. On the basis of the available data, Chandos Lake including Gilmour Bay was not characterized by any peculiar features that would suggest an annual heat regime different from those of any other lake of similar area, maximum depth, and latitude (see Schindler [1971] for a discussion of factors affecting heat budgets of Precambrian Shield lakes in northwestern Ontario).

2.3 Dissolved Oxygen

Changes in dissolved oxygen concentrations with depth and season depend, for the most part, on the depth of the lake. In very shallow lakes which remain well-mixed owing to wind and wave action, the entire volume will be well-oxygenated at all depths. This occurs at Station 1 and partly at Station 2 (**Figure 2**). However, in deeper basins of the lake and in Gilmour Bay, the warm surface, epilimnetic waters float on the cooler, more dense hypolimnetic waters during the summer months. The difference in density creates a resistance to mixing by wind action; in fact, many lakes do not become fully mixed again until the surface waters cool in the fall, when the lake undergoes its "fall turnover". During the summer stratification period, the surface waters are constantly being mixed by wind action and supplied with oxygen through photosynthesis; as a result, they usually have high concentrations of dissolved oxygen. In contrast, the bottom waters are limited in their ability to replenish their oxygen supply, and must rely on oxygen derived during the "spring turnover" (the second period in a year when a lake's oxygen resource is naturally replenished) to offset respiration and decomposition of sedimented and sedimenting organic material. Depending on a number of biotic and abiotic factors, a lake's deep water oxygen resource can be depleted, in some cases only marginally, while in others substantially. As indicated by the MOE and Ministry of Natural Resources (1977):

> ". . . In many lakes which exhibit thermal stratification between spring and fall turnover, the decomposition of organic matter utilizes the total oxygen supply of the bottom waters of the lake. This is a natural phenomenon and is not confined to lakes which support shoreline development. It is not unusual or unexpected to discover severe oxygen depletion in the bottom waters of totally undeveloped lakes. . . In addition to the natural conditions of lakes, it is recognized that cultural enrichment resulting from human activities within a lake's drainage basin can influence its water quality conditions."

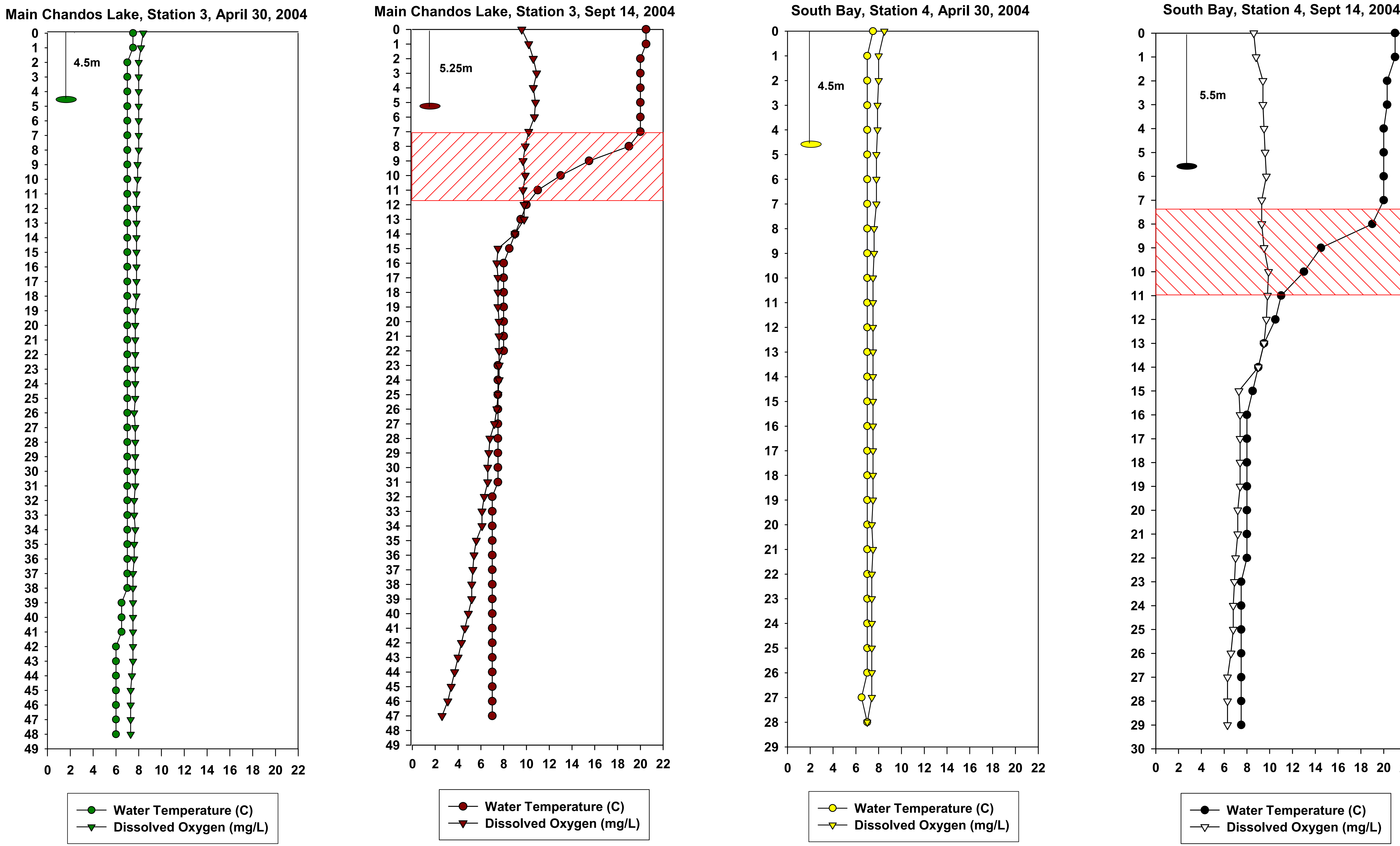


Figure 4. Temperature and dissolved oxygen profiles in Chandos Lake at Stations 3 and 4 on April 30 and September 14, 2004. Secchi disc values are also shown in top left. Locations of metalimnia are shown in hatched areas. Data were collected by Michalski Nielsen Associates Limited.

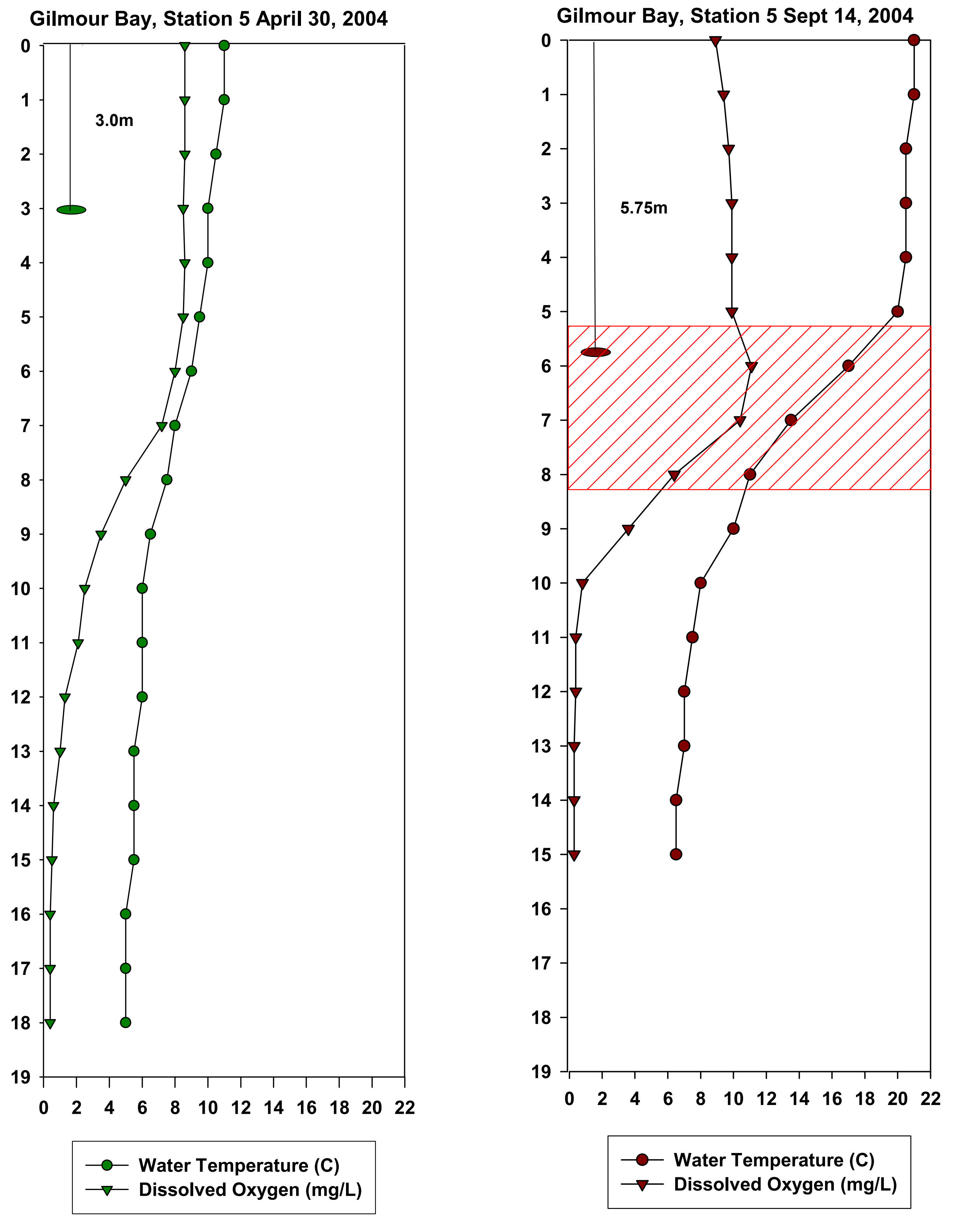


Figure 5. Temperature and dissolved oxygen profiles in Gilmour Bay at Station 5 on April 30 and September 14, 2004. Secchi disc values are also shown in top left. Location of metalimnion is shown in hatched area. Data were collected by Michalski Nielsen Associates Limited.

At Station 3, the deepest sampling site at 49.0 m, dissolved oxygen was near constant with depth on April 30th (**Figure 4**). In contrast, on September 14th, the vertical distribution was slightly clinograde or diminishing with depth, particularly below about 26 m; however, anaerobic or near-anaerobic conditions did not materialize in bottom waters. In this regard, concentrations below the lower limit of the metalimnion (i.e., 11.0 m) were above 6.0 milligrams per litre (mg/L) to about 36 m of depth, and were never lower than 3.7 mg/L at 46.0 m. Excellent oxygen conditions prevailed on both sampling dates, at Station 4 (South Bay); during summer stratification, concentrations were always above 6.0 mg/L, even at 29 m of depth (**Figure 4**). In contrast, dissolved oxygen profiles at Station 5 (Gilmour Bay) diminished with depth on both sampling dates; below about 9.0 m, very little oxygen was present, with anaerobic conditions developing in bottom waters.

Fisheries managers in Ontario recognize that the most critical water quality conditions for lake trout materialize late in the summer. At this time, water temperature and dissolved oxygen combine to restrict that portion of the lake having suitable habitat for lake trout. In this regard, MacLean *et al*. (1990) reported that for all life history stages for this species, individuals are generally distributed below an upper temperature of 15°C, and above a lower concentration of dissolved oxygen of 4.0 mg/L. This zone is defined as usable habitat. As lakes warm from the surface downward, they lose oxygen from the bottom upward, and the usable habitat generally becomes restricted to a mid-depth zone. While lake trout can survive quite well under the above-noted temperature and dissolved oxygen conditions, optimal conditions for this species are generally considered to be temperatures of 10°C or cooler (Scott and Crossman 1973 and MacLean *et al*. 1990) and dissolved oxygen concentrations of 6 mg/L or greater (Ministry of Environment and Energy 1994 and MacLean *et al*. 1990). Accordingly, within the zone containing usable lake trout habitat, there is a second zone, defined as optimal lake trout habitat.

As indicated in the temperature and dissolved oxygen profiles seen in **Figure 4**, useable and optimal habitat constitute a considerable portion of Chandos Lake's depth. For example, on September 14th at Station 3, the usable habitat was between about 9.0 m and 43.0 m, while the optimal habitat was between 12.0 m and 34.0 m.

In an attempt to better evaluate lakes with potential lake trout habitat, the MNR's Fisheries Assessment Unit has been using a Mean Volume Weighted Hypolimnetic Dissolved Oxygen (MVWHDO) criterion (**Appendix E**). This approach scores each hypolimnetic layer by combining its dissolved oxygen concentration with the percentage hypolimnetic volume represented for that stratum. In this way, each stratum represents a portion of lake trout habitat based on late summer temperature and oxygen regimes. The sum of the scores is then used as an index to determine the quality of lake trout habitat. A value of 7.0 mg/L or greater is considered as acceptable for lake trout communities; in fact, this value is now the MNR's policy. Calculations of MVWHDO for South Bay, Chandos Lake, and Gilmour Bay are presented below.

Bay	**Date**	**MVWHDO (mg/L)**[1]	**Average**
Chandos	August 28, 1991	7.2	
Chandos	August 19, 2002	9.0	
Chandos	August 30, 2004	7.4	
Chandos	September 7, 2007	7.9	7.9
South Bay	August 28, 1991	7.3	
South Bay	August 30, 2004	8.1	
South Bay	September 7, 2007	8.3	7.9
Gilmour Bay	August 28, 1991	2.9	
Gilmour Bay	August 19, 2002	5.5	
Gilmour Bay	August 30, 2004	3.2	
Gilmour Bay	September 7, 2007	3.7	3.7

1 All calculations determined from profiles provided by the Ministry of the Environment, except for 2004 data, which was obtained by Michalski Nielsen Associates Limited.

As indicated above, Chandos Lake and South Bay have an excellent supply of dissolved oxygen in their colder deeper waters in late summer, and are well suited for coldwater fish species such as lake trout. In contrast, the average MVWHDO for Gilmour Bay is 3.7 mg/L, well below the MNR's 7.0 mg/L criterion; accordingly, Gilmour Bay cannot sustain lake trout during the summer stratification period. In fact, it is unlikely that the Bay's hypolimnion can sustain any fish species during the summer and fall months of the year. West Bay and Hawkes Bay do not provide habitat for lake trout in late summer, not because dissolved oxygen is insufficient, but because their deep layers have temperatures that are too high for such species.

2.4 Water Clarity

Water clarity means the depth to which one may see into the water; obviously, this is subject to conditions of the day and the eyesight of the observer. In Chandos Lake, including Gilmour Bay but excluding Sharpe's Bay, Secchi disc values have historically ranged between 4.8 m and 5.4 m (**Table 1**). Some comments on the relevancy of the data are appropriate at this time.

In order that the Secchi disc measurements be undertaken to provide consistency and accuracy, the following conditions should be met.

- Ideally, the same person should take all readings, since sharpness of vision varies from person to person.
- The readings should be taken on the same day of the week, or at least not more than one day before or after the same day of the week.
- All measurements should be taken between 10:00 a.m. and 4:00 p.m. so that the light rays from the sun are at a relatively similar angle each time the reading is taken.
- The readings should not be taken when the lake is overly choppy or rough, and to every extent possible, measurements should be taken on the shaded side of the boat to reduce the effects of reflecting light.

In general, non-coloured lakes which have Secchi disc readings ranging between 1.0 m and 1.9 m are enriched or eutrophic, and frequently experience problems owing to algal growths and/or extensive weed beds. Lakes which have Secchi disc measurements exceeding 4.0 m are unenriched or oligotrophic, and are highly valued for their clear water appearance and aesthetic appeal. Lakes having Secchi disc readings between 2.0 m and 3.9 m are moderately productive or mesotrophic; that is, they have a moderate level of nutrients, plant growth, and biological production. On the basis of these criteria, Chandos Lake including Gilmour Bay, with annual average Secchi disc readings exceeding 4.0 m is oligotrophic. Also of interest is that the lake is somewhat coloured owing to concentrations of dissolved organic carbon (see **Section 2.5**) owing to natural inputs of decomposing and/or decomposed plant material from wetlands, marshes and ponds within the watershed. This colouring would tend to reduce light visibility above that resulting from other

Table 1. Historical Secchi disc (m) and total phosphorus (µg/L) data for five locations (**Figure 1**) in Chandos Lake, expressed as annual averages. Information is primarily from Ministry of the Environment's Lake Partner Program; 2004 spring and early fall data collected by Michalski Nielsen Associates Limited have been incorporated into the data base.

	Station									
Year	**West Bay**		**Hawkes Bay**		**Chandos Lake**		**South Bay**		**Gilmour Bay**	
	SD	**TP**	**SD**	**TP**	**SD**	**TP**	**SD**	**TP**	**SD**	**TP**
1996	5.2	7.0	–	–	5.2	–	–	–	–	–
1997	4.5	6.0	–	–	4.0	–	–	–	–	–
1998	4.8	12.0	–	–	5.5	–	–	–	–	–
1999	5.3	8.0	–	–	5.3	–	–	–	–	–
2000	4.4	8.0	–	–	5.5	–	–	–	–	–
2001	5.0	10.0	4.8	12.8	5.0	14.0	5.0	12.0	–	–
2002	5.0	12.0	4.8	12.0	5.5	10.7	6.1	14.2	6.3	16.3
2003	4.9	9.7	5.3	8.0	–	12.5	–	11.4	–	11.6
2004	4.7	9.0	5.3	12.5	4.9	8.9	5.0	10.6	4.4	12.2
2005	4.9	7.1	–	6.5	–	8.9	–	–	–	12.5
2006	4.8	7.0	–	15.3	–	11.0	–	–	–	–
2007	–	9.5	–	6.0	–	12.9	–	–	–	11.6
2008	–	10.4	–	11.5	–	18.9	–	–	–	11.7
Average	**4.9**	**8.9**	**5.1**	**10.6**	**5.1**	**12.2**	**5.4**	**12.1**	**5.4**	**12.7**

suspended particles such as phytoplankton and zooplankton, meaning that absolutely firm conclusions on the trophic status of the lake cannot be made on the basis of Secchi disc readings alone.

2.5 Phosphorus

Phosphorus is the element in shortest supply to plant and algal growths, and is the principal nutrient causing eutrophication[1]. It is present in many organic and inorganic forms. The primary form of phosphorus that plants can absorb is dissolved inorganic phosphate, also known as *dissolved reactive phosphorus*. The concentration of this form is determined by filtering the sample through a very fine filter (e.g., 0.45 µm) and analyzing for phosphorus. However, the most common form of reported phosphorus is *total phosphorus*, which includes both dissolved and particulate forms. The latter is analyzed by digesting an unfiltered sample and analyzing for phosphorus. The amount of organic phosphorus is determined by subtracting the dissolved reactive phosphorus from the total phosphorus. The latter is the most useful form because in lakes and rivers, it is very dynamic. This means that phosphorus is readily transformed from one form to another.

There are many ways for phosphorus to enter a lake; external loadings come from the lake's watershed, that is, from streams and groundwater, or via wind, precipitation and snowfall. Many human activities increase the amount of phosphorus (i.e., the rate of supply) that runs off a landscape. In Ontario's recreational lakes country, effluent from sewage treatment systems also contains large amounts of phosphorus, which in many cases are loaded to downgradient surface waters. As well, untreated stormwater runoff from shoreline residential development can have quite high annual loadings, often to the detriment of surface water quality. Finally, it is not surprising in some enriched lakes and rivers that phosphorus is contributed from sediments, which is very difficult to control. This is not the case with Chandos Lake, although it may be occurring in the bottom waters of Gilmour Bay, where anaerobic conditions (i.e., zero or near-zero concentrations of dissolved oxygen) prevail. As noted above, phosphorus is the principal nutrient linked to eutrophication of lakes, rivers and streams. Accordingly, environmental protection agencies are particularly concerned about permitting uncontrolled loadings to enter lakes.

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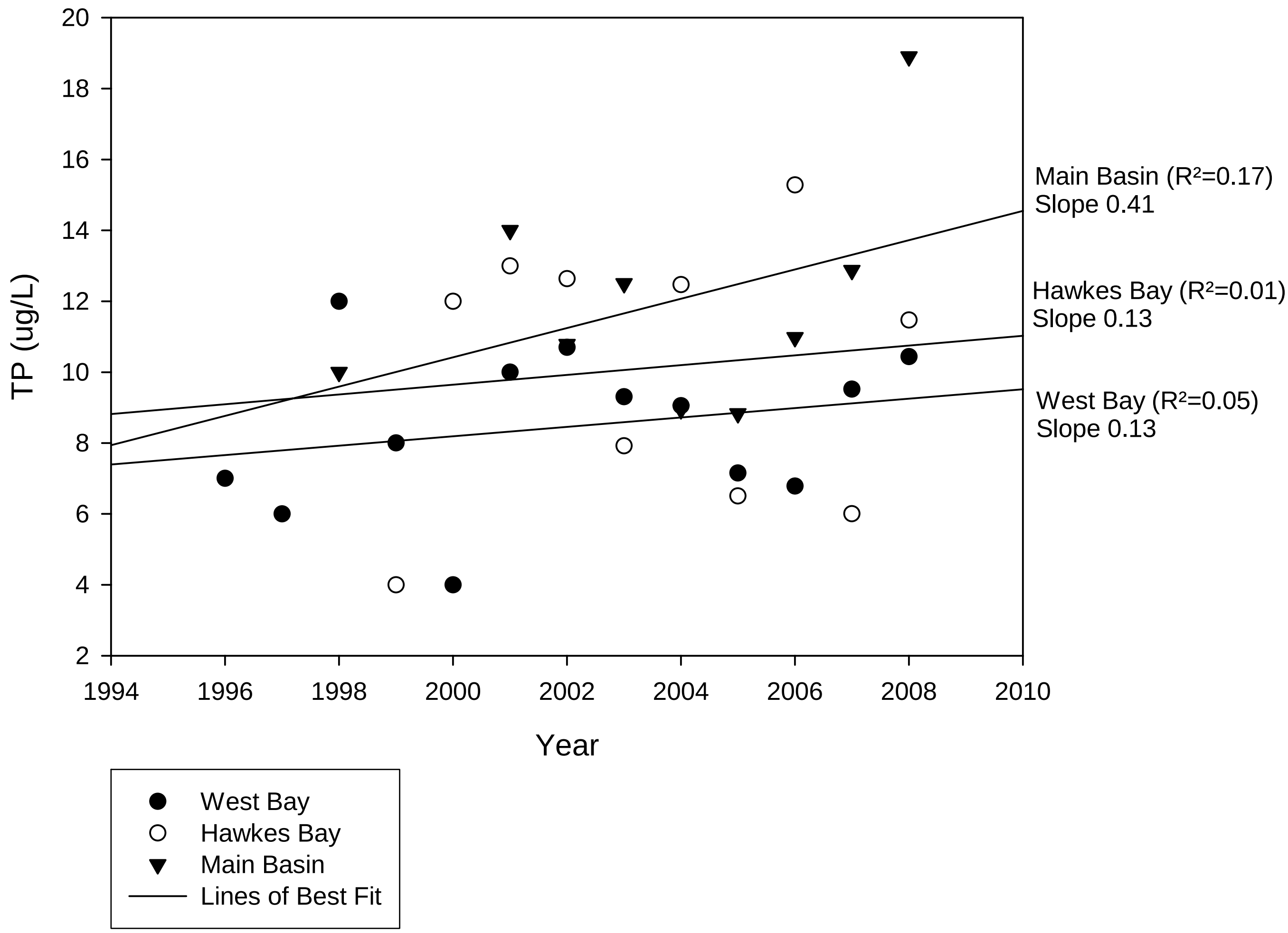
1 Eutrophication is the natural aging of a body of water caused by the inflow of too much nutrients. Although all lakes and rivers age from a young, productive state, in nature this eutrophication takes many thousands of year. European settlement and development have caused many lakes including the Lower Great Lakes and portions of the Upper Great Lakes, the Bay of Quinte, and some of the lakes within the Kawartha/Trent/Rideau waterway to age much faster over the last two centuries.

Figure 6. Trends in concentrations of total phosphorus in surface waters of West Bay, Hawkes Bay and the Main Basin of Chandos Lake (1996-2008).



The most obvious effects of increased levels of phosphorus in lakes are more algae and weeds, less clear water, and in the case of lake trout lakes, reduced habitat for cold water fish species. These changes are generally considered to be undesirable, although it should be emphasized that native aquatic plants are part of a healthy, productive lake ecosystem, and, like much else in nature, should not be viewed as intrinsically bad, even though they may physically interfere with certain recreational activities such as swimming, boating, and fishing. The effects of increased phosphorus loadings are generally not detectable from one year to the next, but if they are permitted to increase unabated, they can be noticed from one decade to the next, and can be very significant over a generation or a lifetime.

The MOE does not have a firm objective for phosphorus for surface waters; instead, it has set an Interim Provincial Water Quality Objective (PWQO) for it which is as follows:

> "Current scientific evidence is insufficient to develop a firm objective at this time. Accordingly, the following phosphorus concentrations should be considered as general guidelines which should be supplemented by site specific studies:
>
> To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 micrograms per litre (μg/L); A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 μg/L or less. This should apply to all lakes naturally below this value;
>
> Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 μg/L."

Table 1 presents historical data on concentrations of phosphorus and Secchi disc transparency at five locations in Chandos Lake. Of importance is that the average concentration in Hawkes Bay, Chandos Lake, South Bay and Gilmour Bay all exceed 10 μg/L, meaning these systems are on the borderline between oligotrophy (i.e., nutrient poor) and mesotrophy (i.e., lakes having a moderate quantity of nutrients). More importantly, these waters would be considered overcapacity in terms of phosphorus concentration, because, as policy, the MOE does not want to see lakes that naturally have concentrations less than 10.0 μg/L increase their loadings to the point where phosphorus concentrations exceed 10.0 μg/L. As indicated in **Table 1**, this has happened in Hawkes Bay, Chandos Lake, South Bay and Gilmour Bay.

In **Figure 6**, the long term average concentrations were plotted for the West Basin, Hawkes Bay and Chandos Lake (Main Basin), and lines of best fit determined for each. Although the regression analysis is statistically significant only for Hawkes Bay, it is apparent that phosphorus is increasing throughout the lake, with the greatest increase evident in Chandos Lake (i.e., Main Basin).

In the opinion of Michalski Nielsen Associates Limited, what the above data are saying is that every practical and reasonable effort should be taken to reverse the trend to ensure that higher annual loadings of phosphorus do not occur. In fact, the trend through time data clearly indicate that measures need to be implemented to reduce existing loadings from artificial sources.

In 2008, the MOE placed on the Environmental Registry the results of a fifteen-year-long review of phosphorus management in recreational lakes on the Precambrian Shield. This resulted in a proposed revision of the Interim PWQO, from this existing two-tiered objective of 10 µg/L or 20 µg/L to an objective of a 50% increase from the modeled background or pre-development concentration of total phosphorus. Although not yet formally adopted by the Ministry, this objective has been accepted as a quality threshold for lakes in the District Municipality of Muskoka, and the Township of Seguin.

2.6 Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) from terrestrial and wetland marsh sources contributes the primary source of external organic carbon to fresh waters. It is the most abundant dissolved substance entering boreal lakes (Schindler *et al*. 1997), and is extensively modified by microbial metabolism in soils, streams, wetlands, and littoral areas as it flows towards downgradient lakes, eventually forming dissolved fulvic and humic acids (Wetzel 2001). DOC affects the acid-base chemistry which in turn can affect the concentration and availability of some forms of nitrogen and phosphorus. Highest concentrations typically occur in surface soil horizons (i.e., the organic layer and A horizon) as a result of inputs from vegetation layers and decomposition of surface particulate organic carbon (POC). DOC tends to be much greater in soils that are within coniferous vegetation than amongst hardwoods.

Nearly all of the organic carbon of natural waters consists of DOC and POC; the ratio of DOC to POC is typically between 2.5:1 and 10:1, both in lacustrine and running water ecosystems, as tabled below.

Habitat	Dissolved organic carbon (mg/L)	Particulate organic carbon (mg/L)	DOC:POC ratio
Groundwater	0.65	0.05	13
Precipitation	1	0.1	10

Habitat	Dissolved organic carbon (mg/L)	Particulate organic carbon (mg/L)	DOC:POC ratio
Oligotrophic lakes	2	0.2	10
Rivers	5	2	2.5
Eutrophic lakes	10.3	1.7	6
Wetlands – marshes	15.3	1.7	9
Bogs	30.3	2.7	11

Reproduced in part from Wetzel (2001), as median organic carbon value for various natural aquatic ecosystems.

Concentrations of DOC in the epilimnetic waters of Chandos Lake ranged between 4.6 mg/L and 5.7 mg/L on April 30 and September 14, 2004. These values are between the values cited above for oligotrophic and eutrophic lakes, and confirm the presence of wetlands in the watershed of Chandos Lake.

2.7 Lake Carrying Capacity Update (Trophic State Model)

2.7.1 Amendments to Input Parameters/Coefficients

In our 1993 report, the 1986 Trophic State Model was applied to Chandos Lake, partitioned into its main basin and Gilmour Bay. Since that time, a number of technical modifications have been recommended by Hutchinson (2002) and Paterson *et al*. [2006]). These, together with refined estimates of shoreline development densities and use estimates determined as part of this update, were incorporated into a revised Lake Trophic State Model for Chandos Lake and Gilmour Bay. The model variables, their symbols, units and roundings for each variable, the model's equations, and input variables can be found in Appendix 3 of the 1993 report, except for the following.

- Phosphorus loadings from wetlands were estimated using the equation:

  kg total phosphorus = catchment area (km^2) x (0.47 x % wetland area + 3.82),

  with the percentage of wetland within the watershed of Chandos Lake equal to 4%.

- A per-capita phosphorus contribution of 0.66 kg/capita years/year was applied instead of 0.8 kg/capita years/year which has conventionally been used (Paterson *et al*. 2006). Consistent with the MOE's practice, we have taken the conservative approach of assuming that all private sewage systems are septic tank tile fields, even though some may be holding tanks, which if properly used, should have no phosphorus impacts.

- Paterson *et al*. (2006) recognizes some attenuation of septic tank derived phosphorus where native soils are greater than 3.0 m in depth. For example, attenuation is 34% if the tile field is greater than 100 m from the lake's shoreline, 67% if it is greater than 200 m, and 100% retention if the tile field is greater than 300 m. In the questionnaire analysis, it was determined that only 10.8% of respondents have sewage treatment systems that are greater than 100 m from the shoreline. This means that 89.2% have tile beds that are less than 100 m from the lake. Assuming a 34% attenuation for 10.8% of the respondents, then the aggregate attenuation is 3.7%, meaning that 96.3% of all sewage-related phosphorus eventually enters Chandos Lake or Gilmour Bay. There was little benefit to be derived from re-analyzing the questionnaire data to find out how many tile fields were greater than 200 m from the lake's shoreline; for example, if we were to go through such an exercise, it is unlikely the aggregate attenuation would exceed 5%. Accordingly, a phosphorus retention coefficient of 0.037 was applied to determine how much of the sewage-related phosphorus is eventually loaded to the lake.

- Numbers of developed and residential lots on Chandos Lake and Gilmour Bay were derived from an evaluation of data collected by members of CLPOA using the "Shoreline Development Data Collection and Analysis" methodology in **Appendix D**. The lot data are summarized in **Table 2**.

- The most recent update of the Lake Trophic State Model (Paterson *et al*.) recommends usage data for various shoreline properties as shown in **Table 3**. The seasonal usage value derived from the questionnaire returns was calculated to be 0.60 capita years/year, which very closely approximates the Paterson *et al*. estimate of 0.69 capita year/year. However, there is a considerable difference in the permanent residential use factors, that is, 2.56 capita years/year in **Table 3**, versus 1.62 capita years/year for Chandos Lake and Gilmour Bay. What appears to be happening is that even though about 10% of Chandos Lake residents claim permanent residency, it is likely they are "at the lake" on an extended seasonal basis, rather than year round basis. In the analysis reported on herein,

Table 2. Development characteristics of Chandos Lake (Main) and Gilmour Bay, determined from shoreline development data collection and analysis by Chandos Lake Property Owners' Association, with review by Anthony Usher Planning Consultant.

	Chandos Lake (Main)		**Gilmour Bay**	
	Shoreline	**Inland** [1]	**Shoreline**	**Inland** [1]
Total Conveyable and Developable Lots	1,029	66	81	19
Total Developed Residential	935	33	78	8
Principal Residential	103	6	14	4
Seasonal Residential	832	27	64	0
Vacant	72 [2]	29 [2]	1 [2]	10 [2]
Other uses, developed	22	4	2	1

[1] Within 300 m of the shoreline.

[2] Excludes undevelopable lots: seven for Chandos shoreline; eight for Chandos inland; and one each for Gilmour shoreline and inland.

Table 3. Usage values for shoreline properties (modified from Downing 1983 and reproduced from Paterson *et al.* 2006).

Development type	**Usage (capita years/year)**
Seasonal residence	0.69
Extended seasonal residence [1]	1.27
Principle residence	2.56
Resorts (services, housekeeping cabins, or meal plan) [2]	1.18
Trailer parks	0.69
Youth camps	125 grams per capita/year
Campgrounds/tent trailers/RV parks [3]	0.37

[1] Extended seasonal included residences that are non-principle, but have reliable year round access.

[2] If staff members are included, usage per resort unit is estimated using the extended seasonal value of 1.27.

[3] Includes recreational campgrounds with septic systems servicing pump outs, comfort and wash stations.

values of 0.60 capita years/year and 1.62 capita years/year for seasonal and permanent occupancy were applied.

- As indicted by Paterson *et al*. (2006), shoreline development may also contribute phosphorus to a lake when forests are removed for lot development. For lakes located on the Precambrian Shield, the export from individual lots may be calculated using the export coefficient for forest pasture (i.e., forested areas with 15% cleared land), multiplied by the mean size of surveyed lots (Euler 1983):

  Export from lots = 9.8 milligrams per square metre per year X 3,789 square metres per lot
  = 0.04 kilograms total phosphorus per lot per year

- Commercial accommodation use was estimated from information provided by CLPOA, as follows.

  – **Camp Ke-Mon-Ova**, also known as Chandos Outdoor Education Centre, in West Bay, operates for seven weeks in the summer, five days each week. There are no campsites, only cabins, with 70 children and 20 staff. The camp also operates for 14 weeks during the spring, fall and winter, five days each week; occupancy during this period is 25 children and five staff each week. This amounts to 18.8 capita years/year of use.

  – **Harbour Hills** (cabins only), which is in Gilmour Bay, has an occupancy of 30 people per week, July and August. On weekends only in May, June, September and October, the occupancy is 20 to 30 people per weekend day. This use translates into 9.7 capita years/year.

  – **Lakeview Cottages and Marina** in the main basin of Chandos Lake has four cabins. During July and August, the occupancy is four people per cabin per day. In June and September, there is only weekend use, with four people per cabin. The usage factor for this resort is 8.75 capita years/year.

2.7.2 Alternative Development Scenarios

In our 1993 report, we prepared a number of scenarios to show the impacts of different levels of land use and development options. The purpose of this exercise was to help Township officials, other government agencies, and residents of Chandos Lake to appreciate the present and potential impacts of development on water quality (i.e., lake trophic state), and to better inform those who would be participating in developing planning policies for the subject lakes. Herein, we present five realistic scenarios which similarly achieve these objectives.

Scenario 1 – pre-development

- This scenario is intended to indicate as a base line what conditions would be in the absence of any development. It is roughly, though not entirely, representative of conditions in, say, 1783.

- A major difference from "1783" conditions is that we have assumed no change in rates of phosphorus deposition from the atmosphere. These rates were undoubtedly lower 200 years ago, though we don't know by how much. However, airborne phosphorus comes from a wide range of sources inside and outside Ontario, and cannot be controlled by policy makers at a local or regional level.

Scenario 2 – existing development

- This scenario reflects existing development around Chandos Lake and Gilmour Bay based on the input values and coefficients used in our 1993 report, with the exceptions described in **Section 2.7.1**.

- It includes all developed residential properties, both shoreline and inland, with the latter defined as residences not directly on the shoreline, but within 300 m of the lake/bay. As well, loadings were included from commercial accommodation units.

Scenario 3 – development of existing vacant lots considered to be developable

- This scenario is intended to suggest the lowest level of change from the present situation that could be expected.

- We amended existing conditions by developing one residence on each existing vacant and developable shoreline lot within 300 m of the lake/bay. There would be no growth of any other kind. No special mitigation measures would be applied to retain or otherwise reduce phosphorus.

Scenario 4 – phosphorus reductions

- This scenario is intended to show what could happen if all lots were developed as in Scenario 3, but that 20% of the resident shoreline population would decrease its sewage-related phosphorus by reconstructing drain fields with "B" Horizon Precambrian Shield soils that have a high capability to retain phosphorus by adsorption (i.e, electrostatic binding), and mineralization (i.e., with reactive iron and reactive aluminum), which is a permanent reaction. The extent of reduction is 99%, as per the results of six years of monitoring at the Branson property on South Kushog Lake in the Township of Algonquin Highlands (**Section 3.1.2**).

Scenario 5 – phosphorus reduction to achieve Interim PWQO of 10.0 µg/L

- This proposal illustrates the level of effort needed in terms of the percentage of shoreline residences that would need to reduce their sewage-related phosphorus by 99% in order to achieve the MOE's Interim PWQO for phosphorus. The starting point is Scenario 3.

To undertake the above calculations, we re-arranged the basic steady-state equation for calculating phosphorus concentrations in lakes to back-calculate its annual load.

$$L = \frac{([P] \times A_o)(0.956\ q_s)}{(1 - R)}$$

where:

L is the annual load of phosphorus (kilograms/year);

[P] is the existing concentration of phosphorus (µg/L);

A_o is the area of the lake ($10^6 m^2$);

q_s is the areal water load determined from $Q \div A_o$; and

R is the lake phosphorus retention determined from the equation $12.4 \div (12.4 + q_s)$.

Once the annual load is determined, it was altered, as per the prescriptions set out in the above-described scenarios.

Results of applying the development scenarios to Chandos Lake and Gilmour Bay are provided in **Table 4**. Highlights are as follows.

- Ice-free concentrations of total phosphorus in a pre-development state (Scenario 1) are 8.0 µg/L for Chandos Lake, and 5.6 µg/L for Gilmour Bay. Such values indicate nutrient-poor or oligotrophic conditions for both systems.

- For Chandos Lake, concentrations of total phosphorus appear to have increased by 41% over the last two centuries (i.e., from 8.0 µg/L to 11.3 µg/L). In contrast, the increase in Gilmour Bay has been much greater, that is from 5.6 µg/L to 12.7 µg/L, which amounts to an increase of 127%. Applying the MOE's proposed 50% above background policy to Chandos Lake would mean there is some shoreline development capability remaining, as the increase in concentration of phosphorus is only 41% above background. In contrast, the phosphorus increase in Gilmour Bay far exceeds the proposed 50% increase above background; accordingly, this embayment would be deemed to be at capacity, and no further development would be approved, unless it could be carried out such that any impacts would be zero to near-zero.

- By developing all currently approved but vacant lots, concentrations of total phosphorus would be elevated from 11.3 µg/L to 11.4 µg/L in Chandos Lake, an overall increase from pre-development times of 43%. The overall increase in phosphorus concentrations for Gilmour Bay would be quite small, but nonetheless, cumulative.

Table 4. Calculations to demonstrate changes in concentrations of phosphorus (µg/L) for a variety of land use changes as set out in Scenarios 1 through 5 for Chandos Lake and Gilmour Bay.

Scenario		Chandos Lake	Gilmour Bay
1.	Pre-development	8.0	5.6
2.	Existing development	11.3	12.7
3.	Existing development plus build out of existing vacant lots	11.4	12.8
4.	20% of residential shoreline population with 99% reduction of sewage-related phosphorus[1]	10.9	11.5
5.	Percentage of shoreline residents required to retain 99% of sewage-related phosphorus[1]	85% (9.94)	78% (9.99)

[1] Includes the development of vacant lots to seasonal usage.

- The reductions in phosphorus loading in the fourth scenario would generate lower concentrations in both Chandos Lake and Gilmour Bay, but not to the point of reaching the MOE's Interim PWQO of 10.0 μg/L. This includes all of the currently vacant but approved lots being fully developed.

- As suggested by Scenario 5, if it is desired to reduce concentrations to achieve the MOE's Interim PWQO for total phosphorus, the choice will be:

  – applying very stringent reductions in phosphorus loads from new development;
  – retrofitting existing development to reduce their existing phosphorus loads; or
  – a combination of meaningful elements of both.

Apart from the Lake Trophic State Model, the MOE places great weight when determining whether a lake is or is not at capacity by comparing measured concentrations of total phosphorus with the Interim PWQOs for this parameter. As indicated in **Section 2.5**, if pre-development or natural concentrations are less than 10 μg/L, development is permitted subject to applying a high level of protection. However, if natural concentrations are elevated above 10 μg/L, the MOE takes a position of no further increase in phosphorus loading, which in most circumstances translates into a no-further-development policy. Also are the longer term trends that are emerging which show that phosphorus concentrations throughout the lake are increasing. In contrast, concentrations of MVWHDO for Chandos Lake and South Bay are well in excess of 7.0 μg/L, meaning that from a lake trout habitat perspective, these basins can sustain some additional development. However, in our opinion, there would be no ambiguity about Chandos Lake and Gilmour Bay; no further shoreline development would be permitted, because phosphorus concentrations have been elevated from less than 10.0 μg/L to in excess of this threshold. As well, Gilmour Bay's MVWHDO is much less than 7.0 mg/L, meaning that it cannot sustain lake trout during the summer stratification period; by this criterion alone, the MNR supported by the MOE, would judge the bay to be at-capacity, and would endorse a no-further-lot-creation policy.

In summary, it is our opinion that both Chandos Lake and Gilmour Bay are at-capacity, but for different reasons. For Chandos Lake, even though concentrations of MVWHDO are more than sufficient for sustaining coldwater fish species in late summer, both absolute concentrations of total phosphorus and the increasing trend through time analysis reported herein are concerning. For that reason, we conclude that additional development can proceed on Chandos Lake, but only subject to implementing stringent phosphorus control measures. For Gilmour Bay, it is at capacity for two reasons; first, its existing concentration of total phosphorus is in excess of the Interim PWQO of 10 µg/L, and second, its MVWHDO is less than the MNR's objective of 7.0 µg/L.

We are also of the view that the long term data presented herein clearly point to the importance of the MOE's Lake Partner's Program as an early warning approach to detecting signs of advancing enrichment; in this regard, it is our recommendation that this initiative be continued, and if possible, expanded to ensure a more thorough coverage of the entire Chandos Lake including Gilmour Bay.

3 CHANDOS LAKE SHORELINE DEVELOPMENT POLICIES

3.1 Preamble

This section of the update reviews the advances (i.e., both in policy and technically) made in protecting water quality of Precambrian Shield lakes over the past 10 – 15 years, and summarizes some of the initiatives taken by leading municipalities in this regard. As well, the 14 candidate policies on which opinion was sought in the shoreline residents' survey are reviewed. However, before getting into details of the policies, it is important to appreciate the related technical and planning underpinnings.

In our 1993 report, planning policy directions were proposed which would ensure that lake capacity considerations were fully taken into account in reflecting environmental concerns of Township residents. These are summarized in **Appendix A**, and included direction on water quality, resource protection and recreational boating. Most of the proposed policies on water quality resulted from applying the Lake Trophic State Model to Township lakes, and determining how conditions in the lake would change under a variety of development scenarios.

When we were retained by the CLPOA in 2004, it was clearly our intent to revisit the model and either modify or supplement our initial recommendations with more up-to-date state of the art directions. However, two factors changed our thinking in terms of updating policies driven primarily by the Lake Trophic State Model. First was the 2002 publication of "Limnology, Plumbing and Planning: Evaluation of Nutrient-Based Limits to Shoreline Development in Precambrian Shield Watersheds" by Dr. Neil Hutchinson (**Appendix F**), coupled with the extensive research by scientists at the University of Waterloo and others on mobility and persistence of phosphorus in septic system plumes (**Appendix G**). Second, was a shift in policy direction set out in numerous official plans from a phosphorus-based limiting approach, as was taken in our 1993 report, to meaningful and practical mitigation measures that could be implemented on individual properties that would have the beneficial impact of retaining phosphorus on site (i.e., this aquatic plant nutrient would not move through the soils to the lake), thereby eliminating water quality as a constraint to lakeshore development.

3.1.1 Limnology, Plumbing and Planning: Evaluation of Nutrient-based Limits to Shoreline Development in Precambrian Shield Watersheds

The above publication (**Appendix F**) presents the results of Dr. Hutchinson's re-evaluation of nearly 25 years of data from over 125 lakes in the District Municipality of Muskoka, and provides constructive comments on some of the basic assumptions that are at the very core of the Province's trophic state lakeshore capacity model including the following:

- that 100% of the phosphorus loaded to a shoreline septic system will ultimately be expressed as increased trophic state in downgradient lakes. In this regard, the MOE has historically recommended septic retention coefficients of zero for phosphorus uptake by soils. This is considered to be a worst case scenario, that in our opinion does not represent reality, but a precautionary approach. The Ministry's assumption, ". . . has only been tested indirectly as a function of the fit of predicted with measured phosphorus in study lakes . . . Recent investigations of septic system geochemistry and the mechanisms of phosphorus mineralization in soil suggest that this assumption is debatable where soils are present between a septic system and a waterbody and that 100% phosphorus export is, in fact, unlikely"; and

- that all anthropogenic phosphorus sources within 300 m of the lakeshore, or any inflowing tributary, must be included in the lake's phosphorus budget. " . . . Although the assumption is based on the need to place boundaries on the inclusion of phosphorus sources, the distance of 300 m is arbitrary and has neither been substantiated nor tested."

As indicated by Hutchinson,

> ". . . Since the publication of the original models, direct monitoring studies and mechanistic understanding of soil and phosphate interactions have provided evidence that conflicts with the original assumptions. Mechanistic evidence (Stumm and Morgan, 1970; Jenkins *et al*. 1971; and Isenbeck-Schroter *et al*. 1993) and direct observations made in septic systems (Willman *et al*. 1981; Zanini *et al*. 1997; Robertson *et al*. 1998(all show strong adsorption of phosphate on charged soil surfaces and mineralization of phosphate with Fe and A1 in soil. The mineralization reactions, in particular, appear to be favored in acidic and mineral-rich groundwater in Precambrian Shield settings (Robertson *et al*. 1998), such that over 90% of septic phosphorus may be immobilized. The mineralization reactions appear to be permanent (Isenbeck-Schroter *et al*. 1993), and direct observations suggest that most septic phosphorus may be stable within 0.5 m of the tile drains in a septic field on the Precambrian Shield (Robertson *et al*. 1998) . . . The mechanistic and geochemical evidence is supported, in part, by trophic status modeling. Dillon *et al*. (1974) reported that only 26% of the potential loading of phosphorus from septic systems around Harp Lake, Muskoka, could be accounted for as measured phosphorus in the lake. The authors attributed the variance

> between measured and modeled estimtes of phosphorus to retention of septic phosphorus in thick tills in the catchment of Harp Lake. Although the Muskoka watershed is frequently characterized as an area of thin to no soils over bedrock, this description is in no way universal. The central corridor of the watershed (i.e., in which Harp Lake is located) occupies a glacial outwash plan of alluvial sands and gravels, and many catchments contain substantial soil deposits. Western and southwestern Muskoka represent the more typical topography of thin soils and granite ridges and outcrops (Figures II.17.5). Even in these areas, however, tile fields are often by necessity, built on imported fill and so some attenuation is possible. . . Revisions to trophic status models should use the findings of these recent studies to improve the positive bias (i.e., over-prediction of measured phosphorus) in the model by accounting for a 74% retention of septic phosphorus for those lakes with suitable soils in their ctchments (Dillon *et al*. 1974)."

Because the matter of the eventual mobilization of sewage-related phosphorus from drain fields to lakes continues to be a major concern, **Table 5** was prepared. It summarizes the research undertaken over the past 25 years or so insofar as the movement of phosphorus from small scale systems is concerned (i.e., producing less than 10,000 litres per day of sewage), and the ability of Precambrian Shield "B" Horizon soils to negate the movement. Of importance is that Part 8 of the **Ontario Building Code** is silent on the matter of impacts of sewage-related phosphorus (and nitrogen) on lakes, rivers and streams; accordingly, Ontario's provincial approval agencies have no legal authority to deal directly with phosphorus outflows from small scale systems. As a result, any initiatives to address phosphorus migration from small sewage treatment units must by default become the responsibility of municipal governments.

The District Municipality of Muskoka is one agency that has carefully reflected on and ultimately accepted the new science on soil retention of phosphorus, and incorporated it into Official Plan Amendment 32, which was approved by the Ontario Municipal Board in June 2007. The amendment was subsequently consolidated into the District Official Plan in November 2007 (**Appendix H**). Historically, the District relied on application of the MOE's trophic state lake capacity model to determine limits to shoreline growth, that is, that lake X has the ability to accommodate for example Y additional shoreline lots. However, after a number of years of study on matters relating to model error, the scientific research undertaken at the University of Waterloo and elsewhere on direct measurements of phosphorus retained in shoreline-based sewage treatment systems, and the natural variability in phosphorus measurements in lakes, the District's advisors informed it that it would not be advisable to continue a policy of lake specific capacities. Essentially, estimates of capacity were too coarse to defend from a scientific perspective. Instead, there are other approaches than lake carrying capacity, which, when applied to shoreline development, would be just as restrictive if not more so, than phosphorus loadings. Not only would they protect water quality and related cold water fish habitat

Table 5. Sewage effluent, phosphorus and soils literature review, modified from Riverstone Environmental Solutions Inc. (2008).

Date	Author(s)	Summary
1976	Viraraghaven and Warnock[1]	Most groundwater samples below a septic tile field operating for three years showed phosphate concentrations lower than background levels.
1976	Reneau and Pettry[1]	No soluble phosphorus in a slowly moving water table below a four and fifteen year old septic system in sandy loam soils, and orthophosphate concentrations below 0.2 µg/L at points 3 m from the tiles.
1977	Sawhney and Starr[1]	Sampling tubes installed below and downgradient from a tile field showed that soil 15 cm – 30 cm from the tiles was removing most of the outflow phosphate after six years of use. Also showed that wetting/drying (alternate operation of two trenches) "regenerated" the soils phosphorus removal capacity.
1979	Reneau[1]	Studied transfer of effluent from 10 domestic septic tank systems all greater than 12 years old, to an agricultural tile drain. Varying soil phosphorus attenuation was found, with 99% removal within 8 m to 30 m from the outflows
1979	Jones and Lee[1]	Concluded, "no evidence for phosphate transport from septic tank effluent was found in any of the monitoring wells" after sampling 15 points within 10 m – 100 m from a four year old septic tile field.
1981	Aulenbach *et al.*[1]	According to the Scope Newsletter, "estimated 85% overall removal of phosphorus from sewage in septic tank systems (including soil retention and assuming 5% of systems failing) around Lake George, New York State."
1983	Gilliom and Parmont[1]	Concluded, "movement of more than 1% effluent phosphorus to the lake was rare" from a study of eight septic systems ranging between 20 and 40 years of age adjacent to a small lake.
1988	Chen[1]	Found that, "of 45 groundwater sampling points situated 0 m to 3 m below the surface, and up to 100 m from 17 different septic tank systems situated near the shores of lakes in northern and eastern New York State, only four showed phosphate concentrations >0.1 mg P/L".
1988	Johnson and Atwater[1]	Showed, "96% to 99% removal of soluble phosphate with three different soil types (three loamy sands, three sands) in 3 m long channels.

Date	Author(s)	Summary
1989	Alhajjar *et al.*[1]	Compared phosphorus contamination of groundwater for nine septic systems and concluded, "there was zero probability of more than 5% of phosphate reaching groundwater in all cases, with mean phosphate transfer < 0.1 mg P/L in all cases".
1989	Reneau, Hagedorn and Degan[1]	Concluded, "most field studies indicate that P contamination is limited to shallow groundwater adjacent to on-site waste water disposal systems and that P sorption continues under saturated conditions".
1991	Robertson *et al.*	On the Muskoka River near Bracebridge, from a septic system in operation for one year on a poorly buffered, carbonate-depleted sand aquifer, and in Cambridge from a septic system in operation for over twelve years on a carbonate-rich sand aquifer, tests showed high levels (about 10 mg/L) of phosphorus in the septic tank effluent, while concentrations were substantially attenuated immediately below the tile field, with no detectable phosphate phosphorus (<0.02 mg/L) observed in the groundwater zone.
1992	Wieskel and Howes[1]	Looked at nutrients from four different 10 – 75 year old septic tank systems situated close to Buttermilk Bay, Massachusetts, and concluded that approx 0.3% of the effluent phosphorus would reach the bay.
1993	Wood	In research undertaken as part of a Master's of Science degree, phosphorus levels from a septic system installed in 1962 to serve a shoreline seasonal residence on Harp Lake, northeast of Huntsville were analysed. The septic system was located 0.66 metres above the water table and 15.8 metres from the shoreline of the lake. Between 1962 and 1992, there was no maintenance to either the tile field or the steel septic tank. Wood reported slightly elevated phosphorus in the groundwater of the terrestrial and aquatic zones, and most of the phosphorus from 30 years of use was found directly under the tile field (within 14 cm of the drains). Soil phosphorus concentrations below and downgradient from this horizon were at background levels.

Date	Author(s)	Summary
1995	Robertson[1]	Reported further monitoring results from the Cambridge domestic septic tank site (see 1991 above). Phosphate levels stabilized at 1 mg P/L in the septic plume, and "analysis of dilution factors led to the conclusion that around 25% of septic tank effluent P continued to be attenuated in the vadose zone"; the attenuation is most likely the result of mineral precipitation, and higher attenuation values are obtained at lower pH levels (acidic waste water or soil conditions).
1995	Robertson and Blowes[1]	A septic tank system serving a seasonal cottage was studied for four years after installation in Sudbury. The native soil was poorly buffered silt, and an acid contamination plume developed in the ground, but with limited phosphate mobility. There was no phosphate migration significantly beyond the infiltration bed gravel layer over the study period.
1996 1999	Harmon *et al.*[1] Robertson and Harman[1]	These two studies looked at effluent plumes from three septic systems serving a 200-pupil school for nearly 50 years and a seasonal 200-person campsite for five and for 25 years (two outflows). Following this extended use, approximately 85% of phosphate was being retained in the first 30 cm past the tiles. Phosphate above background levels was detectable up to 75 m away from the older system (mobile groundwater), but not beyond. They concluded that over long periods of use of septic tanks, long-term migration of phosphorus in the groundwater zone may occur.
1998	Zanini, Robertson *et al.*	Studies continued on the school plume (as above) and on three domestic septic tank systems also in Ontario: Cambridge (operational approx 20 years), Muskoka (10 years), and Harp Lake (30 years). Results showed high phosphorus removal within the first 10 cm – 30 cm of soil around infiltration pipes. Based on soil iron content, they estimated that it would take approximately 35 years to saturate the first 25 cm around the infiltration pipes.

Table 5. (Cont'd.)

Date	Author(s)	Summary
1998	Robertson *et al.*	Studied phosphate distribution in ten mature septic system plumes, and revealed that in six cases (primarily those on calcareous sands, and south of the southern limit of the Precambrian Shield), relatively large plumes were present (>10 m in length), and phosphate concentrations of 0.5 mg/L to 5.0 mg/L were higher than normally found in uncontaminated aquatic ecosystems. At the other four sites, on acidic and on Precambrian Shield non-calcareous sands and silt- and clay-rich sediments, high phosphate concentrations occurred only within three metres of the infiltration pipes. Concentrations of phosphorus in the Precambrian Shield plumes appeared to be strongly controlled by mineral precipitation reactions that occur in close proximity to the infiltration pipes. Concluded that results open up the possibility of modifying septic system design to achieve improved phosphate attenuation.
1998	Ptacek[1]	Studied an effluent plume situated on sand and found, "phosphate concentrations higher than background (but low at <0.02 mg P/L) up to 60 m away from the septic tank in part of the soil groundwater (non-surface groundwater with low oxygen levels). This shows that septic tank outflows can contribute phosphate to surface waters where septic tanks are relatively close to surface waters (<100 m) and in sand substrate (rather than soil) over an impermeable layer".
2000	Robertson[1]	Research, "in a two-year field experiment using a lysimeter containing natural sandy soils, showed that septic tank effluent soluble phosphate levels were brought down below the detection limit (<0.005 mg P/L). Only around 0.2% of soil iron had been used, forming stable coatings on the soil particles, suggesting that the system would remain effective for many years".
2003	Robertson	Robertson's fundamental conclusion that phosphorus is strongly attenuated in acidic soils remained consistent. The data show that under acidic conditions, permanent phosphorus attenuation is carried out by high levels of aluminum combining to produce an aluminum/phosphate complex on sand grains below the infiltration bed.
2005	Zhang	The author used path analysis and multiple regression to examine the relationships between phosphorus adsorption and levels of iron and aluminum in different soils and found that extractable (acidified aluminum ammonium oxalate) aluminum and iron were the two most important properties related to the adsorption of phosphorus in soil.

Date	Author(s)	Summary
2002	Hutchinson	Presents results of a re-evaluation of nearly 25 years of data from over 125 lakes in the District Municipality of Muskoka. The assumption that 100% of the phosphorus entering a septic system will ultimately be expressed as increased trophic state in downgradient lakes, "has only been tested indirectly" and that, "recent investigations of septic system geochemistry and the mechanisms of phosphorus mineralization in soil suggest that this assumption is debatable where soils are present between a septic system and a waterbody and that 100% phosphorus export is, in fact, unlikely". Dr. Hutchinson recommends that the phosphorus contribution from sewage septic systems be reduced by 74% for those lakes with suitable soils in their catchments.
Aug 2003 through Oct 10, 2008	Branson property (Michalski Nielsen Associates Limited)	In a site plan agreement with Mr. Branson and the County of Haliburton, monitoring was undertaken on concentrations of phosphorus in the sewage before entering the tile field, and concentrations after treatment. The concentrations after treatment were captured in five permanent sampling wells installed to bedrock when the tile field was constructed, four in each of the corner areas and one in the centre. The phosphorus capacity of soil used to construct the tile field ranged between 75 mg and 150 mg of phosphorus/100 grams of soil. Nineteen sets of results show a very significant reduction in total phosphorus (i.e., continuously greater than 99%).
2006	Paterson *et al.*	The position of the Ministry of Environment differs from the recent science regarding the sewage-related phosphorus attenuating ability of soils. This publication updates the approach in that it recognizes that phosphorus attenuation may occur in some watersheds and probably increases with distance from the lake's shoreline. The publication notes, "First, in watersheds (or portions of watersheds) with shallow (generally <3 m) or absent soils, and with exposed or fractured bedrock, the existing assumption of zero retention is applied . . . Second, at sites where deeper (generally >3 m), non-calcareous native soils are present, the modeller may use the coefficients outlined in Table 3. Here, the degree of attenuation increases with distance from the shoreline, with an assumption of zero export at distances of >300 m (Hutchinson 2002). Third, in cases where site-specific characteristics demonstrate that retention of septic system phosphorus may occur over the long term, attenuation factors may be developed for consideration by local planning authorities and plugged into the model.

Date	Author(s)	Summary
No date	Lacosse and Fanfan	Monitoring of the Ecoflow Biofilter followed by 12 inches of soil demonstrated that the former reduces total phosphorus by 12% on average. The combination of the biofilter and drain field provides an overall removal of 98% of the total phosphorus present in the septic tank effluent. The monitoring covered a period of 40 months, and no influence was noted with respect to soil permeability. It was concluded that the phosphorus fixation related to the adsorption on the surface of metallic elements, particularly iron and aluminum. The life span of the treatment train insofar as phosphorus retention is concerned was estimated to be about 20 years, without accounting for the contribution in iron, aluminum, humic and fulvic acids associated with the peat-based filtering media.

[1] Information referenced from Scope Newsletter January 2006.

to a high standard, but they would maintain other attributes of recreational lakes such as shoreline habitat for wildlife, and lakeshore aesthetics. Potential measures include: zoning provisions for minimal lot frontages; protection of environmentally sensitive areas; enhanced natural buffers and setbacks from the lakeshore; policies to encourage shoreline naturalization; and application of stormwater management and new technologies to reduce phosphorus from sewage treatment systems.

Lakes in the District Municipality are now classified as being responsive or sensitive to phosphorus loadings (i.e., high, medium and low) based on the mobility of phosphorus in soils within their watersheds. Where a lake has surpassed an acceptable threshold for phosphorus concentrations, and where appropriate native soils exist (i.e., those having a high potential for irreversibly retaining phosphorus through mineralization with reactive iron and aluminum), it is possible to allow new development, provided strict requirements are imposed (i.e, stormwater management, proving that soil conditions are not only suitable from the perspective of Ontario Building Code requirements, but have a high capability to retain phosphorus through electrostatic binding and mineralization with iron and aluminum, increased natural shoreline buffers and setbacks, installation of enhanced sewage systems that have a demonstrated ability to retain phosphorus, and on-site monitoring).

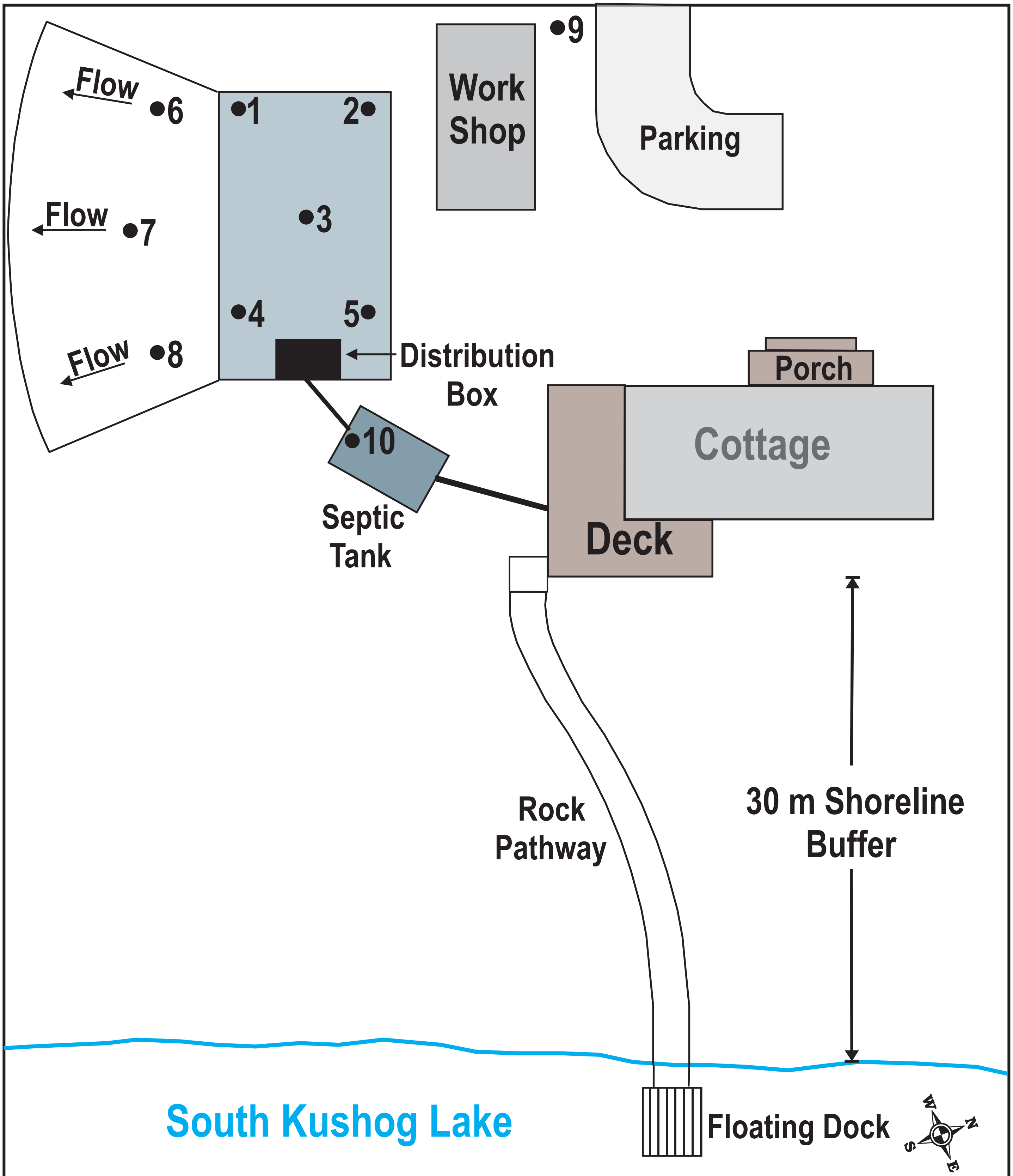
3.1.2 The Branson Matter

In advancing Official Plan Amendment 32, the District was aware of the emerging new technologies, including the use of “B” Horizon Precambrian Shield soils in constructing tile fields and filter beds. In this regard, the Branson matter is informative and important. As background, Mr. William Branson (now deceased) applied to the Land Division Committee, County of Haliburton, to sever a 3.5 hectare parcel from about 24.3 hectares which front on South Kushog Lake, a Ministry of Natural Resources designated lake trout lake. The proposed lot exceeded the township’s minimal area and frontage requirements of 2,800 square metres and 45 m respectively; in this regard, the lot has an area of 34,800 m^2 and a frontage of 110 m.

The single-lot application was appealed to the Ontario Municipal Board by the MNR; the appeal was denied after an extended hearing. In permitting the application, the Board required ongoing monitoring of the tile field, which was to be constructed with “B” Horizon Precambrian Shield soil because of its high capability to retain phosphorus through mineralization or precipitation with aluminum and iron. The monitoring commenced in 2003, after five years of extended seasonal use by the landowners. Five permanent sampling wells were installed in the leaching bed when it was constructed, four in each of the corner areas, and one in the centre (**Figure 7**). The depth of the wells to bedrock ranged between 1.75 m and 2.0 m. As an objective, staff of the MOE determined prior to the monitoring commencing that phosphorus concentrations following treatment by the soils would need to be reduced by 90% relative to concentrations at the outlet of the septic tank (i.e., in the distribution box).

At this point, there are 19 sets of monitoring data collected between August 12, 2003 and November 3, 2008; the information is presented in **Table 6**. The results show a very significant reduction in total phosphorus, typically greater than 97%, and in 16 data sets out of the 18, greater than 99%. It is our conclusion that the high retention was a result of mineralization of iron and aluminum with sewage related phosphorus, which as mentioned earlier, is a permanent reaction. To put matters in perspective, there is no municipal sewage treatment plant in Ontario that is achieving the same high degree of reduction as is being attained at the Branson site; in this regard, the Bradford sewage treatment plant is achieving concentrations in treated effluent between about 0.070 mg/L and 0.090 mg/L on a continuing basis, which is one of the best treatment systems in the Province in terms of phosphorus reduction.

Before leaving this issue, it is important to consider "Evaluation of the absorption bed's efficiency under the Ecoflow Biofilter" by Roger Lacasse and Naider Fanfan (i.e., the final inclusion in **Table 5**). This paper reported that the Ecoflow Biofilter reduced phosphorus by 12% on average. However, the combination of the biofilter with a drain field composed of a layer of at least 12 inches of native soil, removed 98% of the phosphorus present in the septic effluent. The findings were reported from installations in operation for more than 40 months. The main difference between the sewage treatment systems described by Lacasse and Fanfan and that at the Branson site is that the raw sewage at the former receives a better level of pre-treatment by the Ecoflow Biofilter (i.e., tertiary treatment according to the 1997 **Ontario Code and Guide for Sewage Systems**) than does the raw sewage at the South Kushog Lake site. There, it receives only a primary level of treatment. However, the overall effectiveness of the soils is similar for both systems; the reduction of phosphorus is primarily by adsorption to the surface of iron and aluminum particles which are naturally present in the soil.



Project Name: Chandos Lake Planning Policies	Date Initiated: June 2008	Filename: 2104 Figure 6	**FIGURE 7**

Prepared For: CLPOA

Michalski Nielsen
ASSOCIATES LIMITED

Sketch of developed portion of Sanderson lot on western shore of South Kushog Lake, showing location of tile field sampling wells

Rev. No:	Drawn By:	Scale:	Project Number:
0	JN	Not to scale	2104

Table 6. Sewage related phosphorus reduction at Branson/Sanderson site, South Kushog Lake. Values for raw sewage and the samples from each piezometer are shown as milligrams of phosphorus per litre.

Date	Raw	Piezometer Numbers					Average % Reduction
		1 (NE)	2 (NW)	3 (Centre)	4 (SW)	5 (SE)	
August 12, 2003	9.1	0.04	1.30	0.02	0.01	0.02	97.0
December 2, 2003	9.2	0.36	0.05	0.07	0.03	0.05	98.8
June 10, 2004	10.9	0.2	–	0.01	0.03	0.07	99.4
May 16, 2005	9.5	0.04	0.02	0.01	0.01	0.01	99.8
May 31, 2005	8.7	0.02	0.13	0.005	0.01	0.01	99.6
August 26, 2005	10.4	0.85	0.06	0.06	0.06	0.04	97.9
November 11, 2005	9.6	0.01	0.17	0.02	0.02	0.01	99.6
November 14, 2005	9.6	0.01	0.01	0.01	0.01	0.01	99.9
April 18, 2006	11.4	0.007	0.011	0.012	0.008	0.007	99.9
October 11, 2006	8.5	0.005	0.052	0.005	0.056	0.017	99.7
May 17, 2007	13.9	0.011	0.042	0.006	<0.005	<0.005	99.9
May 22, 2007	10.1	0.012	0.051	0.011	<0.005	0.008	99.8
September 6, 2007	22.8	0.043	0.114	0.450	0.263	0.026	99.4
October 4, 2007	7.9	0.059	–	–	0.107	0.023	99.3
October 10, 2007	8.03	0.020	0.023	–	0.005	0.005	99.9
April 28, 2008	9.14	0.013	0.030	–	0.011	0.006	99.9
May 22, 2008	9.53	0.012	0.051	0.011	<0.008	0.008	99.9
June 6, 2008	8.60	0.020	0.012	0.019	0.006	<0.005	99.9
July 10, 2008	7.90	<0.005	0.008	<0.005	<0.005	0.005	99.9
November 3, 2008	9.60	0.008	0.018	0.010	<0.005	0.009	99.8

3.1.3 The Municipality of Dysart et al

The Municipality of Dysart et al is another jurisdiction that has been a leader in this regard, basing its shoreline development policies not on a phosphorus based limitation to growth principle, but on practical mitigation measures that can significantly reduce phosphorus loadings from new lot creation as well as re-development. In this jurisdiction, Council recognizes that there are some lake trout lakes that have been identified by the MOE and MNR as lakes in which naturally reproducing lake trout are highly sensitive to phosphorus inputs from further shoreland development, and other lake trout lakes where further research is warranted to confirm whether the stocks are at risk. However, even for such systems, Council does not completely rule out development potential. As indicated in section 5.2.2 of the **Dysart et al Official Plan** (approved 2004),

> " . . . Council will not consider any application that involves the creation of a new lot, the development of new medium density, lifestyle, or cluster residential units, or any non-residential development, on the shorelands of a lake listed in Tables 1 or 1A [i.e., sensitive or potentially sensitive lake trout lakes] unless at least one of the following applies:
>
> - The subject lands are within the Haliburton Village Service Area and the development is or will be provided with full municipal sewage services.
> - Tile fields on the lots created will be located outside the shorelands, or if in the shorelands will be located so that their drainage flow to the lake will be greater than 300 metres (984 feet) or so that they will drain into a lake not listed in Tables 1 or 1A.
> - Each created and retained lot has an existing functioning dwelling and tile field, and its use is and will remain residential.
> - If the proposed development is residential, the development is eligible for an approved pilot program of the Ministry of Municipal Affairs and Housing to evaluate alternative phosphorus removal technologies, and the applicant and the Municipality are prepared to enter into the agreements required by the pilot program to the satisfaction of the Ministry.
> - If the proposed development is non-residential, the development does not involve or require any new individual on-site or communal sewage disposal systems, or expansion of existing systems.
> - Any new individual on-site or communal sewage disposal systems, or expansion of existing systems, will use technologies recognized by the Ministry of the Environment as causing no increase in phosphorus inputs over those existing before development."

3.1.4 Township of Galway-Cavendish-Harvey

Other municipalities are taking similar approaches; for example, the proposed **Official Plan for the Township of Galway-Cavendish-Harvey** which reflects the policies of the parent **Peterborough County Official Plan**, deals with the at-capacity issue as follows.

> 5.1.10.9 Coldwater Lake Trout Lakes
>
> (i) Highly Sensitive Lake Trout Lakes
>
> Beaver Lake, Pencil Lake, Fortescue Lake, Crystal Lake and Cavendish Lake within the Township of Galway-Cavendish and Harvey have been designated as highly sensitive or "at capacity" Lake Trout Lakes.
>
> The creation of new lots by consent or plan of subdivision/condominium shall be prohibited on highly sensitive "at-capacity" lakes. This policy applies to all lands within 300 metres of the normal high water marks of such capacity reached lakes, whether or not the subject lands are in a land use designation that permits residential development or other forms of development.
>
> Notwithstanding this policy, Council may consider the creation of new lots in unique or special circumstances where it can be demonstrated, in consultation with the Ministries of Environment and Natural Resources that one or more of the following conditions exist:
>
> - Drainage of the proposed lot flows to a separate, non-sensitive watershed as a result of the physical features of the property;
> - Detailed site-specific hydrogeological studies show that the drainage of the sewage effluent will effectively result in a circuitous flow path that extends for at least 300 metres before reaching the lake;
> - That new technologies in sewage disposal systems intended to serve any proposed development have been accepted by the Ministry of the Environment and will result in no adverse effects on lake water quality;
> - That any conventional sewage disposal system designed to serve a new development will be set back a minimum of 300 metres from the high water mark;
> - That a detailed site-specific hydrogeological and soil study which assesses phosphorus distribution, mitigation velocity and long-term soil retention capabilities.
>
> Existing lot of record (existing at the date of approval of this Official Plan) may be issued a building permit for uses permitted by the Zoning By-law. The greatest development setback achievable shall be provided for existing lots of record on highly sensitive lake trout

lakes in order to minimize negative impacts on water quality. At a minimum, a 30-metre development setback with maintenance of the natural vegetative cover should be provided.

3.2 Chandos Lake Candidate Policies

This section reviews the 14 candidate policies on which opinion was sought in the 2004 shoreline residents survey. The candidate policies are reproduced below in *italics*. Each is followed by a brief discussion, in which we assess the policy against:

- the survey results,
- actions/comments provided by the CLPOA Steering Committee established to oversee and direct this assignment,
- the County-wide policies of the Peterborough County Official Plan,
- the North Kawartha policies incorporated into the County Official Plan in 2008,
- other best-practice policies in cottage country official plans and zoning bylaws.

Where planning documents are quoted, section references are in parentheses. At the end of our assessment of each policy, we provide our recommendation. No recommendations are warranted for a number of the candidate policies.

We have not generally assessed the policies against the existing, antiquated Chandos Comprehensive Zoning Bylaw. Under new provisions of the *Planning Act*, the Township will be required to bring its zoning bylaws into conformity with the County-wide and North Kawartha Official Plan policies within the next few years. No doubt the Township will want in any case to amalgamate and update the Burleigh-Anstruther and Chandos zoning bylaws in the not too distant future.

The Official Plan encourages lake associations to develop lake plans. "The implementation of Lake Plans may involve amendments to this plan and may incorporate policies that are unique to a specific lake" (Section 7.29.1). A Chandos Lake lake plan may be the most appropriate vehicle for seeking implementation of the recommendations below, that is, in the Official Plan and/or zoning bylaw.

As described in **Section 1.1** of this report, there have been several important changes in the planning environment in recent years, including the following since the 14 candidate policies were put forward in late 2004:

- The stronger *Provincial Policy Statement* under the *Planning Act* that came into effect on March 1, 2005.
- The stronger County-wide policies of the County Official Plan, particularly with regard to shoreline development, that came into effect in March 2006; almost all the County Plan policies quoted below only came into effect at that time.
- The North Kawartha policies of the County Official Plan that came into effect in October 2008.

1. ***Require that no development take place unless it can demonstrate that its phosphorus impact on the lake will be the same as or less than the existing impact from the property.***

Survey results: For, 82%; against, 7%; undecided and no response, 11%.

Discussion: The County Plan requires:

> "Creation of new lots shall be prohibited on capacity reached lakes . . .
>
> "Local plans will implement [this policy] by . . . restricting new development on 'at capacity' lakes. Generally, the creation of new lots within 300 metres of the shoreline of an 'at capacity' lake . . . will not be considered. Council may consider the creation of new lots in unique or special circumstances where it can be demonstrated . . . that one or more of the following conditions exist:
>
> - [one of those conditions being] that new technologies in sewage disposal systems intended to serve any proposed development have been accepted by the Ministry of the Environment and will result in no adverse affects on lake water quality." (4.4.3.)

The County Plan designates Gilmour Bay as an "at capacity" water body, and provides appropriate implementing policies.

Therefore, the above candidate policy is already met with respect to Gilmour Bay, but not for the rest of the lake.

The District Municipality of Muskoka Official Plan requires that:

> "new lot creation, development or redevelopment will only be permitted where it is determined that phosphorus impacts on water quality can be effectively eliminated" (F.20).

The Muskoka Plan then goes on to prescribe specific approaches and techniques to ensure that happens.

However, Muskoka's and other best-practice official plans do not specifically prohibit development, or require any permitted development to be zero-impact, unless the water body is considered at or over capacity. Because of the importance of District's new approach to protecting water quality while at the same time permitting new lot creation, but under very strict rules and standards, the relevant policies are reproduced in **Appendix H**.

Given the above, we recommend the following.

- **That CLPOA advocate that the Township of North Kawartha move away from a phosphorus limiting approach to one that focuses on the biophysical capabilities of a landscape to sustain development, coupled with the implementation of site specific and practical mitigation measures**.
- **That CLPOA advocate that the Township of North Kawartha require that no development take place on any basin of Chandos Lake unless the applicant can demonstrate that the future phosphorus impact from the subject land will be the same as or less than the existing impacts**.

In moving away from a phosphorus limiting approach to evaluating new development and re-development applications to one that focuses on the biophysical capabilities of a landscape, coupled with the implementation of site specific and practical mitigation measures, we urge CLPOA to advocate the following, which if meaningfully implemented and enforced will result in near-zero or zero phosphorus impacts.

- **To every extent possible, on-site "B" Horizon soils be incorporated into the construction of new drain fields, owing to their high capability to irreversibly complex phosphorus.**
- **Any imported soils should have a high capability to retain phosphorus (i.e., adsorption capacity greater than 50 milligrams phosphorus per 100 grams of soil)**.
- **Soak-away pits or french drains be used for retaining and treating stormwater from hard surfaces (i.e., rooftops), as an additional method of decreasing any potential impacts to downgradient surface water**.
- **During the period of land clearing, grubbing and construction, sedimentation and erosion control works, in the form of silt fencing and straw bales, be located along the downgradient edges of building envelopes**.

- **The above erosion and sediment control measures be maintained in good working order until the exposed soils have been greened up**.

In addition, for resort development or redevelopment (i.e., where sewage treatment facilities generate in excess of 10,000 litres per day), we recommend the following.

- **Sewage and stormwater treatment systems be required to have zero to near-zero impacts on downstream water quality insofar as artificial loadings of phosphorus are concerned**.

With respect to the MOE's Lake Partner Program and other stewardship matters relating to improving water quality of Chandos Lake, we recommend the following.

- **The CLPOA continue, and if possible expand, its monitoring efforts to ensure thorough and consistent coverage year to year of the entire Chandos Lake, including Gilmour Bay**.
- **The CLPOA arrange to have prepared meaningful and practical guidelines for the care of littoral, riparian and upland habitats, inclusive of shoreline rehabilitation through principles of site naturalization**.

Development setbacks from water are addressed under candidate policy 10. Maintenance of natural conditions within development setbacks are addressed under policy 11.

2. ***Require that no development approval or transfer of title take place without septic system reinspection and, if required, upgrading to current standards*.**

Survey results: For, 77%; against, 12%; undecided and no response, 12%.

Discussion: We are not aware of any cottage country municipality requiring septic system reinspection or upgrading as a prerequisite to transfer of title and in any case, this may be beyond municipal powers under the *Planning Act*.

With regard to development approval, the Township of Seguin Official Plan requires that:

> "the approval of the appropriate agencies that the septic system servicing the dwelling unit conforms to the standards is required . . . before certain types of improvements can be made to a lot or dwelling unit in [the Shoreline Area designation]. These improvements are . . .:
>
> i) The enlargement, renovation or addition to a dwelling unit requiring a [building permit];
>
> ii) The development of an accessory building requiring a [building permit]; and,
>
> iii) The development of a deck or accessory building in the same yard as the septic system." (C.3.1.3.1.a.)

Although the above policy was introduced partly because the new Seguin Official Plan now permits both seasonal and permanent occupancy throughout Seguin's shoreline residential areas, it seems to us equally applicable in a shoreline environment such as that of Chandos Lake which is intended as seasonal, but where expansion and extension of seasonal use and some conversion to permanent occupancy can be expected to continue.

Given the above, we recommend the following.

- **The CLPOA advocate an official plan policy for Chandos Lake similar to the above Seguin policy**.

3. *Increase minimum lot frontage for all new lots created.*

Survey results: For, 57%; against, 15%; undecided and no response, 28%.

Discussion: Minimum lot frontage is left entirely to the discretion of the Township of North Kawartha through its zoning bylaw. The current standard minimum lot frontage on Chandos Lake is 46 m.

There is no "right" frontage. Beyond the base distance necessary to accommodate dwellings and tile fields and provide for some minimum spacing between development and lot lines, minimum frontage is part of a social decision about what kind of development the community desires.

Typical minimum frontages for mainland, road-accessible shoreline development in recent cottage country planning documents include:

- Municipality of Dysart et al: 45 m
- City of Kawartha Lakes (draft Official Plan): 60 m, 30 m if infill
- Township of Rideau Lakes: 60 m
- Township of Muskoka Lakes: 60 m, 90 m on Lake Joseph
- Township of Seguin: 90 m, exceptions 60 m to 200 m for various lakes.

Current practice is that the minimum frontage be specified in general terms in the Official Plan as well as prescribed in the zoning bylaw, so as to better support the zoning regulation if it is contested.

Input from the CLPOA Steering Committee suggests that for Chandos Lake, a modified City of Kawartha Lakes model for minimum frontages for new lots would be an improvement. In this regard, new lots should have a minimum frontage of 60 m.

Given the above discussion, we recommend the following.

- **The CLPOA advocate as an official plan policy and zoning regulation for Chandos Lake, a minimum lot frontage of 60 metres for shoreline residential development, except in infill situations. "Infill situations" should be defined as the creation or development of vacant shoreline lots, where the closest abutting developed shoreline lots on each side of the vacant lots are not more than 100 metres apart**.

4. ***Require site evaluation reports as part of development/redevelopment approval on sites that have development constraints across much of the property.***

Survey results: For, 65%; against, 12%; undecided and no response, 23%.

Discussion: The County Plan requires:

> "The development of lots [in Shoreland Areas] where possible shall be undertaken using a 'best management' approach. Biophysical information for the siting of the building, septic system and any buffer area should take into account the soil type, depth and slope of the land when determining the best location for any such buildings." (4.4.3.)

The Plan also requires that any new plan of subdivision or condominium,

> "shall have an impact assessment completed which addresses issues such as the nature of development, servicing, location of septic systems, setbacks from the high water mark and clearing of trees and vegetation" (4.4.3.)

Therefore, major development already must meet or exceed the candidate policy. Minor development involving existing lots or severances implicitly should also meet the candidate policy, but the requirement is not explicit.

The Dysart et al Official Plan requires that in the Waterfront Areas designation:

- development of an existing vacant lot that has substantial development constraints and less than 150 m frontage,
- creation of a new lot,
- higher-density residential development,
- non-residential development,

be supported by a site evaluation report (5.2.4, 9.2, 22.4.2). The Plan contemplates that the requirements for this report be tailored to the scale of development.

The Seguin Official Plan requires site evaluation reports for all development within the Shoreline Area designation (C.3.1.3.3).

The Muskoka District Official Plan includes a terms of reference for the type of work it wants to see in support of shoreline applications on high sensitivity and over threshold lakes. Although the objective is lake system health and the required study is called a Water Quality Impact Assessment, the terms of reference is another useful site evaluation model, and is included in **Appendix H**.

Given the above, we recommend the following.

- **The CLPOA advocate that site evaluation reports be required as part of the development/redevelopment approval process**.

5. ***Encourage alternative residential development styles such as cluster development, where it can be shown that they will have less impacts per unit and per metre of frontage than traditional shoreline development.***

Survey results: For, 11%; against, 66%; undecided and no response, 24%.

Discussion: The County Plan requires that local official plans include policies addressing "backlot and/or cluster development" (4.4.3).

The North Kawartha policies state the following, although in the context of the rest of the policies, prohibition of traditional ribbon development does not appear to be intended:

> "Seasonal Residential areas shall be developed in groupings in order to avoid, where possible, ribbon or strip development along the lake frontage. Such groupings will be designed to improve accessibility to the lake and water-oriented activities for a greater number of cottage users and tourists by providing desirable open space areas." (6.2.5.3.d.)

It's clear that Chandos Lake residents strongly oppose cluster and other nontraditional development styles. However, applicants for such development, provided they can demonstrate impacts that are acceptable and do not exceed those of traditional development, will find strong support for their proposals in the above Official Plan policies. Typically, proponents of new backshore development or redevelopment of existing resorts or trailer parks, will need to address many more issues than just servicing and phosphorus management. These include but are not limited to: protection of fish and wildlife habitat; recreational activities, primarily boating; shoreline buffer and development setbacks; privacy issues; communal docking and boat launching; etc. In our opinion, many of the concerns raised by cottagers in relation to such developments can be effectively mitigated; in fact, for redeveloping properties, there are typically considerable opportunities for making improvements, particularly to sewage treatment systems and related impacts, and shoreline naturalization.

6. ***Permit beds and breakfasts and other home businesses where they can demonstrate minimum impact on neighbours.***

Survey results: For, 27%; against, 55%; undecided and no response, 18%.

Discussion: The Official Plan describes home occupations (e.g., professional office, music teaching, private home day care, etc.) as compatible within any residential zone provided basic standards regulated through the zoning bylaw are complied with. The policies leave to the discretion of the municipality whether a zoning bylaw amendment would be required (7.30). Home industries and beds and breakfasts do not appear to be permitted in the Seasonal Residential designation that applies to Chandos Lake.

7. ***Control lot coverage on the portion of the lot nearer to shore.***

Survey results: For, 58%; against, 19%; undecided and no response, 23%.

Discussion: Several cottage country municipalities now set two maximum lot coverage percentages for shoreline lots, one for the entire lot or rear of the lot, and one for the area nearer the shore. Some of the systems used are quite complex, aside from the fact that in some municipalities, there are multiple applicable lot coverage percentages depending on lake or lot characteristics. As well, municipalities vary in whether and to what extent they include accessory structures in lot coverage.

Leaving those complexities aside, for shoreline residential development, Dysart et al, Muskoka Lakes, and Seguin all establish additional lot coverage maximums based on development within 60 m or 61 m of shore, relative to lot area within the same distance from shore. These concepts are specified in general terms in the Official Plan (except in Dysart et al), as well as prescribed in the zoning bylaw. For Chandos Lake, the CLPOA Steering Committee pointed out that most lots are of limited depth (± 100 m), and typically back onto a municipal or private road; therefore, a single lot coverage approach is sufficient.

8. ***Include outside decks, stairways, etc. in lot coverage calculations.***

Survey results: For, 30%; against, 49%; undecided and no response, 20%.

Discussion: This candidate policy is not supported by Chandos Lake residents and there is nothing in the Official Plan policies requiring such a policy. However, the current Chandos zoning bylaw does include decks and stairways in lot coverage calculations.

9. *Limit maximum size of the main dwelling.*

Survey results: For, 52%; against, 30%; undecided and no response, 18%.

Discussion: The cottage country municipalities now restrict the maximum gross floor area of the main dwelling on shoreline lots:

- Dysart et al: a percentage cap on gross floor area relative to lot area, such that for minimum size lots (the zoning bylaw provides for several different shoreline lot types), the cap is around 475 m^2 – 500 m^2; to provide further restriction on larger lots, no single storey can exceed 280 m^2
- Muskoka Lakes: 697 m^2
- Seguin: 700 m^2.

These concepts are specified in general terms in the Official Plan (except in Dysart et al), as well as prescribed in the zoning bylaw.

Based on input from the CLPOA Steering Committee, the following is recommended.

- **The CLPOA advocate as a zoning regulation for Chandos Lake, that the maximum gross floor area of a main dwelling be 500 square metres, with no single storey to exceed 280 square metres**.

10. *Require that all buildings (except boathouses, pumphouses, etc.) and tile fields be set back at least 30 m from shore.*

Survey results: For, 47%; against, 37%; undecided and no response, 16%.

Discussion: The County Plan states that:

> "[by March 2009] local plans and zoning by-laws will require that all new development and sewage disposal systems be set back at least 30 metres from the ordinary high water marks of all waterbodies. Excepted from this requirement are marina facilities, docks and other water access facilities, pumphouses, and minor accessory buildings and structures as defined in zoning by-laws . . . ." (4.4.3). The Plan contemplates some flexibility, indicating that minor variances may be granted on existing lots and for additions to existing buildings.

The North Kawartha policies implement the 30 m requirement. They also state that any replacement building closer to water must not exceed its original footprint, and that on existing vacant lots, tile fields must meet or come as close as possible to the 30 m requirement (6.2.5.3.h).

Therefore, for all practical purposes the Official Plan implements this candidate policy, despite its lukewarm endorsement by Chandos Lake residents.

11. *Prohibit vegetation clearing and site alteration, and require planting in cleared areas, in much of the required shoreline natural buffer or setback.*

Survey results: For, 50%; against, 32%; undecided and no response, 19%.

Discussion: The County Plan states:

> "Tree cover and vegetation is encouraged to be retained along the shoreline to uphold the visual and environmental integrity of waterfront areas. Where development is proposed along shoreline areas, local official plans should contain policies relating to the incorporation of a natural undisturbed buffer between the water's edge and the development. Any such buffer shall be stipulated as being a specific depth from the water's edge and be represented as a percentage of the water frontage." (4.4.3.).

The North Kawartha policies do not, however, go any farther.

More stringent policies elsewhere in cottage country planning documents include the following (required setbacks are 30 m except as noted, and some exceptions are allowed for pathways, shoreline-related accessory buildings, etc.):

- Muskoka (District Official Plan): On newly created and vacant lots, no disturbance within, and natural restoration of, the first 15 m of the setback, except that for up to 25% of the shoreline length this restriction does not apply.
- Muskoka Lakes (Official Plan and zoning bylaw): No disturbance within, and natural restoration of, a 16 m setback.
- Kawartha Lakes (draft Official Plan): No disturbance within the setback, except that for up to 25% or 9 m of the shoreline length (whichever is less) this restriction only applies to the first 8 m of the setback. No explicit restoration requirement.

Of all the recommendations to protect water quality, in our opinion, the most important one relates to maintaining a natural shoreline buffer, and where that buffer has been fragmented or otherwise sacrificed, it should be restored through landscape naturalization. The functions of the natural buffer relate not only to attenuating pollutants associated with stormwater runoff, but to ensuring the ecological integrity of the riparian vegetation in terms of fish and wildlife (i.e., mainly birds and small mammals) habitat, and maintaining shoreline aesthetics. For certain, most shoreline residents acknowledge that a natural shoreline buffer is a good thing; the problems are that such a feature can be difficult to define in policy, and municipalities typically do not want to get involved in enforcing shoreline buffers. However, in our opinion, they are critical to health of lakes, and they need to be in place and enforced.

The CLPOA Steering Committee clearly sees the importance of maintaining natural shoreline vegetation and prefers the Muskoka District approach, as outlined above. It also advocates a tree cutting bylaw, but that is beyond the mandate of our assignment. With respect to its request that a minimum three metre natural buffer be maintained where grass is grown to the water's edge, we point out that this matter can be handled through our recommendation to prepare guidelines for restoring lakeshore riparian habitat (refer to candidate policy 1).

Given all of the above, we recommend the following.

- **The CLPOA advocate that the 30 metre development setbacks from water required by the Official Plan (see candidate policy 10) be maintained or restored as natural shoreline buffers. Activities in the setbacks/buffers should be restricted through zone, site plan agreements, or any other development or servicing agreements to be executed between the Township of North Kawartha and the applicant(s). These restrictions**

should require that the setbacks/buffers be disturbed as little as possible, consistent with access to the shoreline, safety, and provision of views.

12. *Require that docks etc. can only be developed along a portion of shoreline frontage.*

Survey results: For, 60%; against, 19%; undecided and no response, 21%.

Discussion: Several cottage country municipalities now restrict the extent of shoreline structure development on residential lots; examples include:

- Dysart et al: not more than 30% or 12 m (whichever is less) of shoreline length,
- Muskoka Lakes: not more than 25% or 23 m (whichever is less) of shoreline length, more stringent restrictions on smaller or more sensitive lakes,
- Seguin: not more than 25% or 23 m (whichever is less) of shoreline length.

These concepts are specified in general terms in the Official Plan (except in Dysart et al), as well as prescribed in the zoning bylaw. The CLPOA Steering Committee prefers the Dysart et al model above.

Accordingly, the following is recommended.

- **The CLPOA advocate as a zoning regulation for Chandos Lake, that shoreline structures not be permitted to occupy more than 30% or 12 metres, whichever is less, of a residential lot's shoreline frontage**.

13. *Restrict nearshore lighting so that its light pollution impacts are minimized.*

Survey results: For, 66%; against, 18%; undecided and no response, 15%.

Discussion: The County Plan requires:

> "In approving site plans, municipalities shall ensure that lighting fixtures that are not owned, operated or managed by a public agency or entity and designed for exterior illumination shall be designed so as to direct light downward and deflected away from adjacent properties. Private exterior lighting should be located so that it does not interfere with the

night vision of those using the waterways, the habitat of nocturnal animals and the privacy of area properties." (4.4.3.)

The proposed North Kawartha policies will subject plans of subdivision or condominium to site plan control, but as is usual planning practice, single-lot development or redevelopment will generally be exempt.

Other cottage country official plans include general statements such as Seguin's: [In the Shoreline Area designation], "lighting shall be designed to minimize light trespass onto adjacent lands and the water" (C.3.1.3.14.d). However, without site plan control, these statements can only be implemented through moral suasion unless they are also reflected in the zoning bylaw. Dysart et al's zoning bylaw has such a provision:

> "Despite any structure height provision of this By-law, no light standard shall be constructed on any lot with a structure height of more than 9 metres, and no exterior light shall be affixed to any structure at a height of more than 9 metres above average finished grade. All exterior lighting fixtures shall direct light downwards and not towards abutting lots, streets, or water bodies. These requirements do not apply to traffic signals and light standards serving streets." (3.12.)

Given the above, the following is recommended.

- **The CLPOA advocate a "dark sky" nearshore lighting approach, similar to the above policies of Seguin and Dysart et al, that would be applicable to all development including single lot development and re-development, as an official plan policy and zoning regulation for Chandos Lake**.

14. *Prohibit development in valued natural areas beyond what is required by provincial policy.*

Survey results: For, 77%; against, 8%; undecided and no response, 15%.

Discussion: The County Plan, section 4.1.3.4, encourages municipalities to protect valued natural areas beyond *Provincial Policy Statement* requirements. The *PPS* was itself considerably strengthened in 2005.

The proposed North Kawartha policies do not designate any significant natural heritage on or near Chandos Lake. Most of the lake's shoreline is designated Seasonal Residential, with substantial areas designated Environmental Constraint (hazardous lands) and the rest Rural.

The only significant natural heritage features that the proposed policies would designate in North Kawartha Township are provincially significant wetlands. Presumably the proposed map schedule is correct in not showing any identified provincially significant wetlands on or near Chandos Lake; however, that could reflect the fact that on the Precambrian Shield, there are many wetlands that have never been evaluated which might prove provincially significant if evaluated.

As to whether there is other provincially or locally significant natural heritage on or near the lake that should be designated for protection, that is beyond the mandate of this report and we do not have the information to express any opinion.

4 SHORELINE RESIDENT RESPONSES

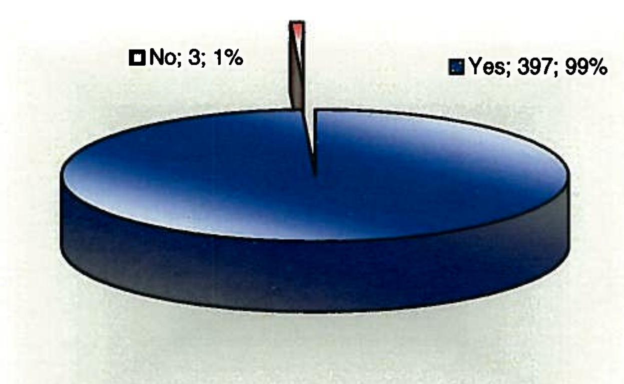
The 2004 shoreline shoreline residents survey was designed to collect information on residential use for the Lake Trophic State Model, types and conditions of sewage treatment systems, water quality perceptions, and opinions on 14 candidate planning policies. The survey form is in **Appendix C**. A total of 1,030 questionnaires were distributed; 402 were returned, for a response rate of 39.0%.

Responses to each of the questions are reproduced in the following pages.

Total Surveys	1030	Response rate of 39.03%
Responses	402	
	39.03%	

Question 1: Do you own a property with a built private residence <u>and</u> shoreline on Chandos Lake?

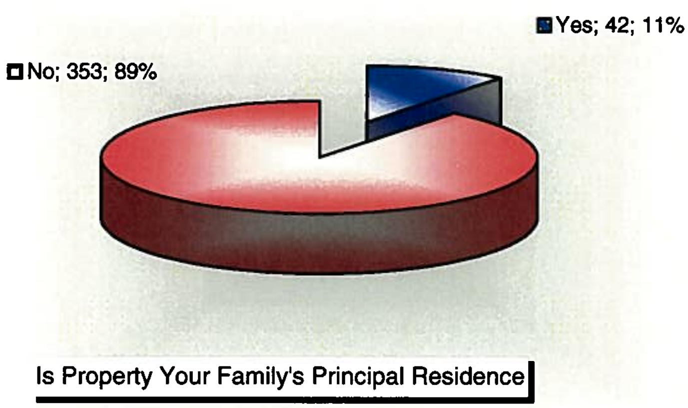
Response	*Frequency*	*Percentage*
Yes	397	99.3%
No	3	0.8%
Subtotal	**400**	
No Response	2	
Total	**402**	



Property With a Built Private Residence and Shoreline

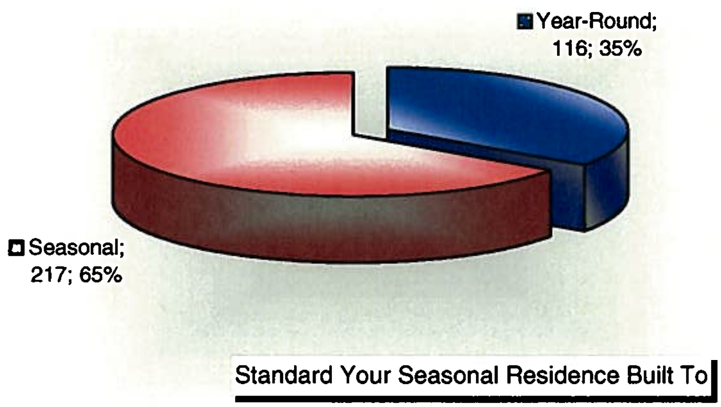
Question 4: Is this property your family's principal residence?

Response	***Frequency***	***Percentage***
Yes	42	10.6%
No	353	89.4%
Subtotal	**395**	
No Response	2	
Total	**397**	



Question 5: If you answered No, this is not a principal residence, to what standard is your residence built?

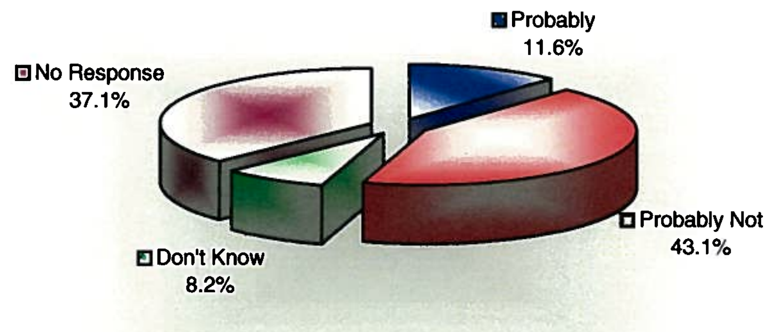
Occupancy Standards	*Frequency*	*Percentage*
Year-Round	116	34.8%
Seasonal	217	65.2%
Subtotal	**333**	
No Response	20	
Total	**353**	



Question 6: If you answered No, this is not a principal residence, do you expect to do either of the following to your residence over the next 10 years?

(a) Improve/rebuild to year-round occupancy standards so that it could be lived in as a year-round residence, or sell/leave it to someone who will.

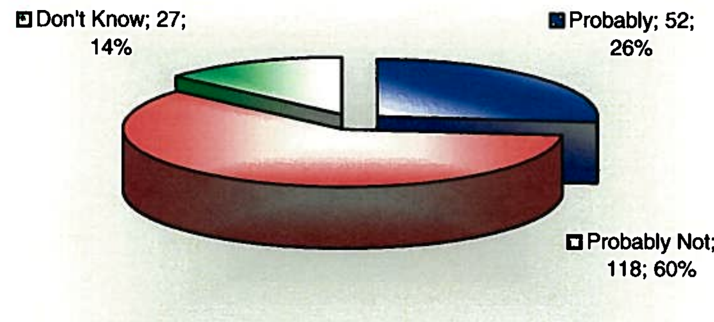
Response	***Frequency***	***Percentage***
Probably	41	11.6%
Probably Not	152	43.1%
Don't Know	29	8.2%
No Response	131	37.1%
Total	**353**	**100.0%**



Improve/Rebuild Searsonal Residence to Year-Round Occupancy Standards Within 10 Years

(b) Keep it seasonal occupancy standards, but improve/rebuild so that it will accommodate significantly more people, or sell/leave it to someone who will.

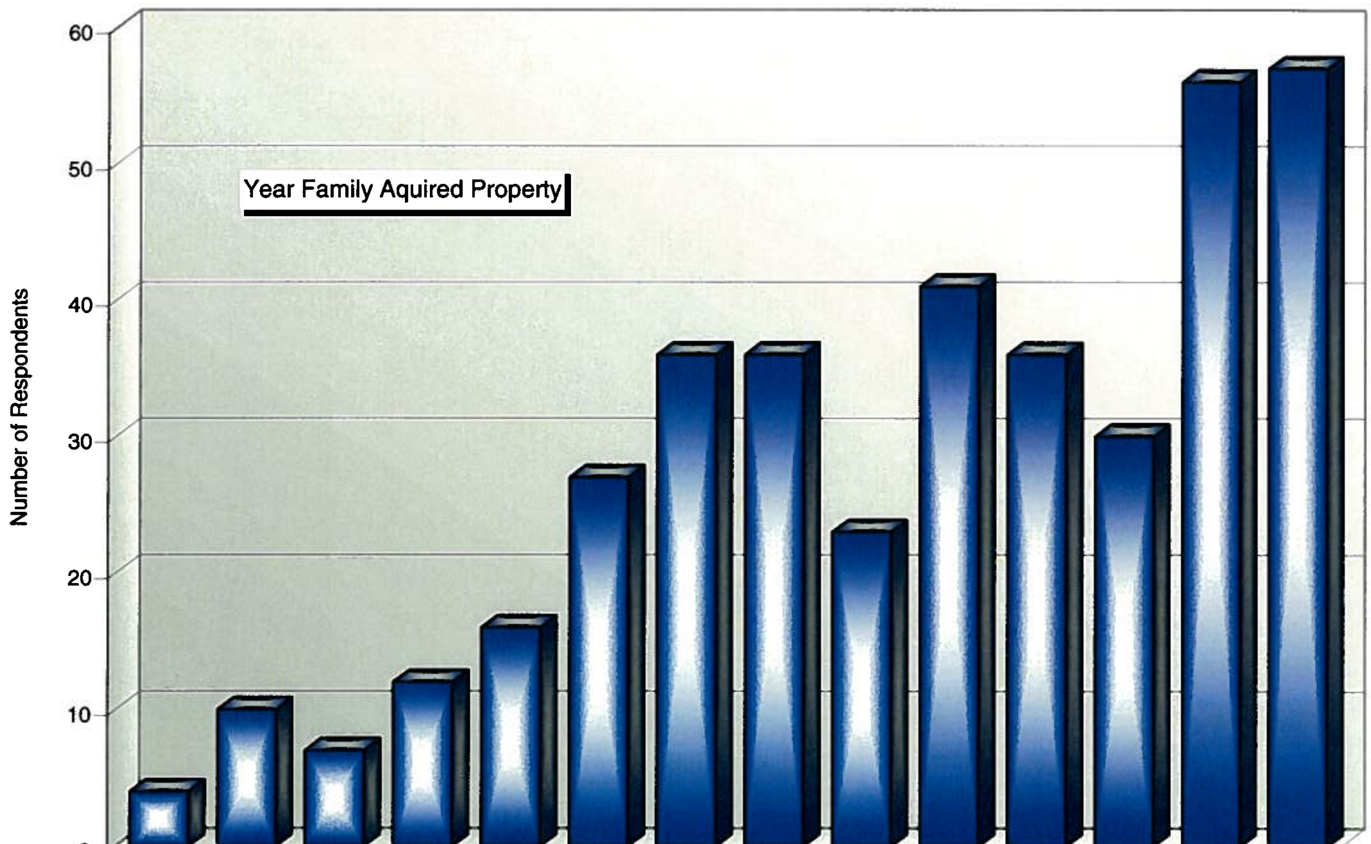
Response	***Frequency***	***Percentage***
Probably	52	26.4%
Probably Not	118	59.9%
Don't Know	27	13.7%
Subtotal	**197**	
No Response	156	
Total	**353**	



Maintain Seasonal Occupancy - Improve/Rebuild To Accommodate More People Within 10 Years

Question 7: In what year did you or your family acquire the property?

Years	*Frequency*	*Percentage*
1920 - 1929	4	1.0%
1930 - 1939	10	2.6%
1940 - 1949	7	1.8%
1950 - 1954	12	3.1%
1955 - 1959	16	4.1%
1960 - 1964	27	6.9%
1965 - 1969	36	9.2%
1970 - 1974	36	9.2%
1975 - 1979	23	5.9%
1980 - 1984	41	10.5%
1985 - 1989	36	9.2%
1990 - 1994	30	7.7%
1995 - 1999	56	14.3%
2000 - 2004	57	14.6%
Subtotal	**391**	
No Response	6	
Total	**397**	

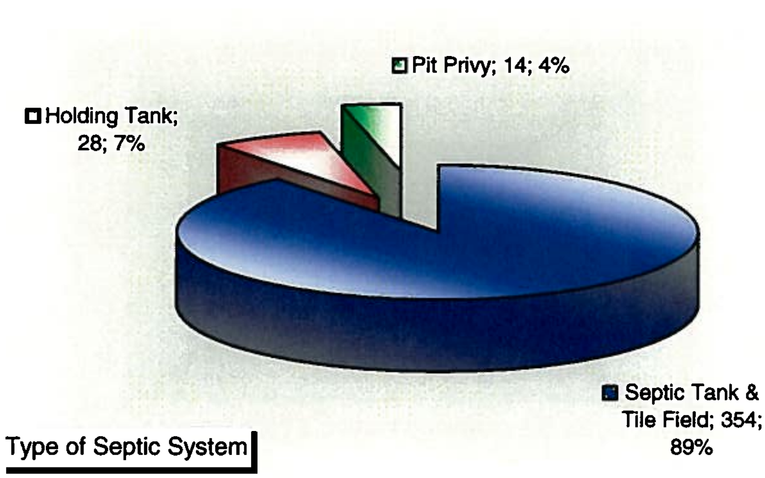


	1920 - 1929	1930 - 1939	1940 - 1949	1950 - 1954	1955 - 1959	1960 - 1964	1965 - 1969	1970 - 1974	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994	1995 - 1999	2000 - 2004
Frequency	4	10	7	12	16	27	36	36	23	41	36	30	56	57

Question 8 What kind of a sewage treatment system do you have?

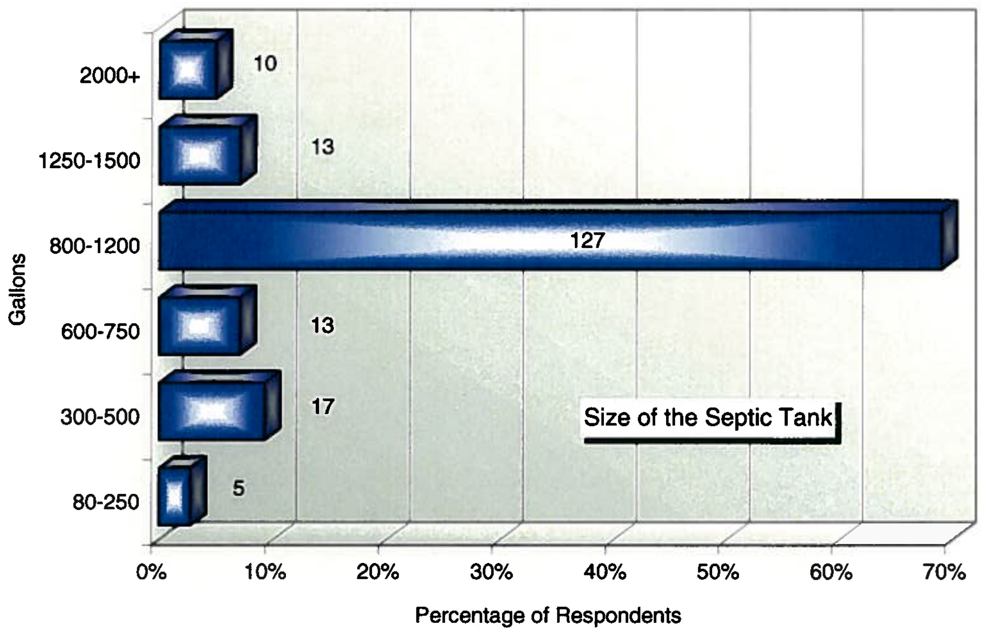
(a) Septic tank and tile field?

Type	Frequency	Percentage
Septic Tank & Tile Field	354	89.2%
Holding Tank	28	7.1%
Pit Privy	14	3.5%
Subtotal	**396**	
No Response	1	
Total	**397**	



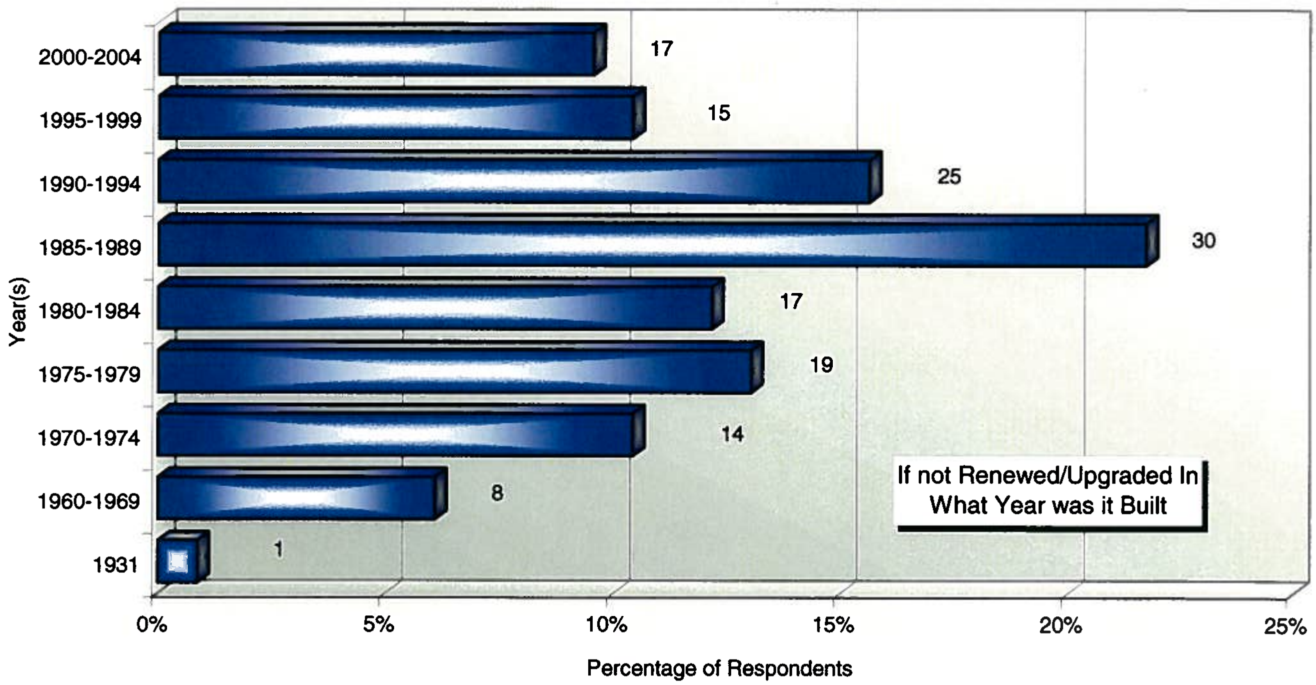
Question 8(b): What is the size of the tank?

Gallons	***Frequency***	***Percentage***
80-250	5	2.7%
300-500	17	9.2%
600-750	13	7.1%
800-1200	127	69.0%
1250-1500	13	7.1%
2000+	9	4.9%
Subtotal	**184**	
No Response	198	
Total	**382**	



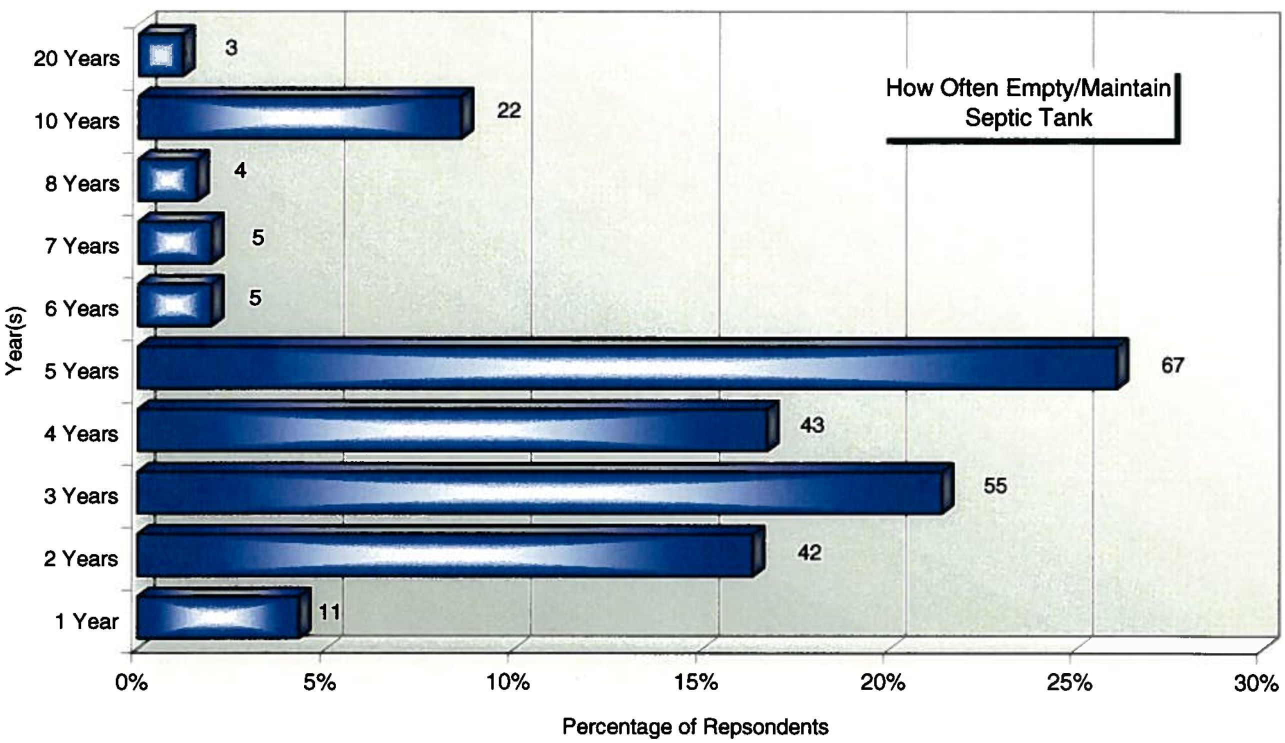
Question 8(c): If it hasn't been renewed/upgraded, in what year was it

Year	Frequency	Percentage
1931	1	0.9%
1960-1969	7	6.1%
1970-1974	12	10.4%
1975-1979	15	13.0%
1980-1984	14	12.2%
1985-1989	25	21.7%
1990-1994	18	15.7%
1995-1999	12	10.4%
2000-2004	11	9.6%
Subtotal	**115**	
No Response	58	
Total	**173**	



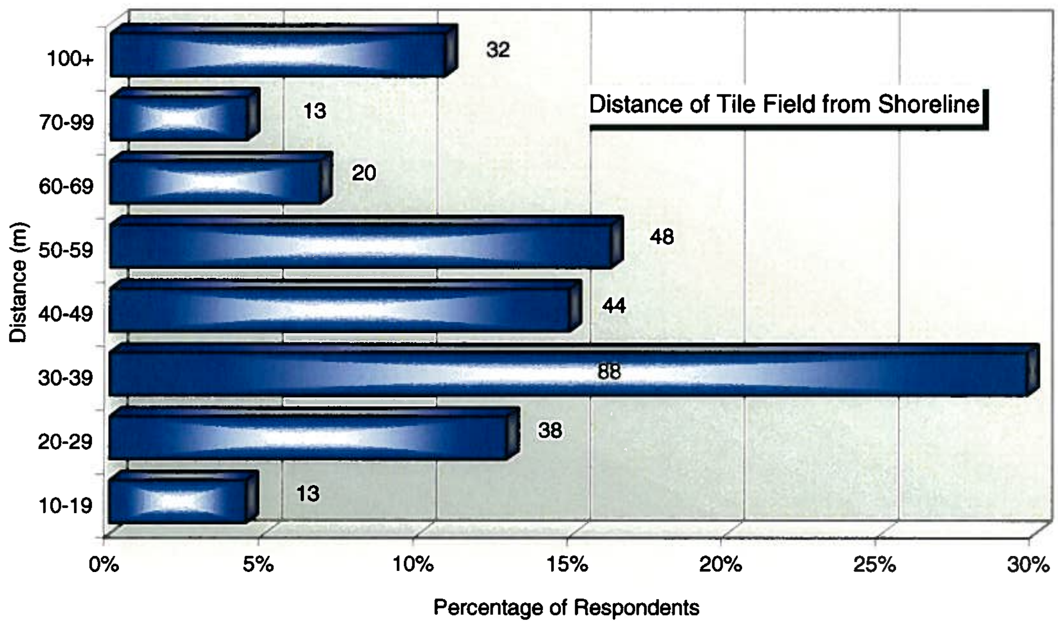
Question 8(d): How often do you empty or maintain the septic tank (in years - approx.)?

Year	***Frequency***	***Percentage***
1 Year	11	4.3%
2 Years	42	16.3%
3 Years	55	21.4%
4 Years	43	16.7%
5 Years	67	26.1%
6 Years	5	1.9%
7 Years	5	1.9%
8 Years	4	1.6%
10 Years	22	8.6%
20 Years	3	1.2%
Subtotal	**257**	
No Response	97	
Total	**354**	



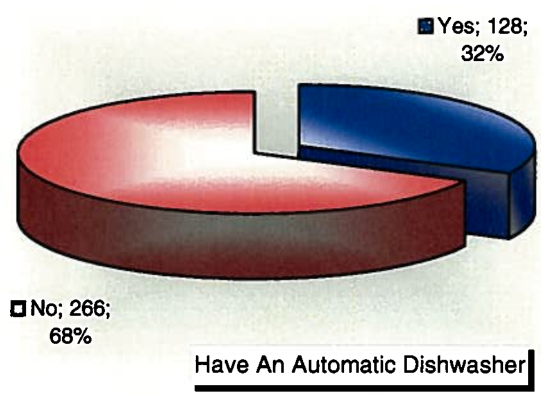
Question 8(e): How far from the shoreline of the lake is the tile field?

Distance (m)	Frequency	Percentage
10-19	13	4.4%
20-29	38	12.8%
30-39	88	29.7%
40-49	44	14.9%
50-59	48	16.2%
60-69	20	6.8%
70-99	13	4.4%
100+	32	10.8%
Subtotal	**296**	
No Response	58	
Total	**354**	



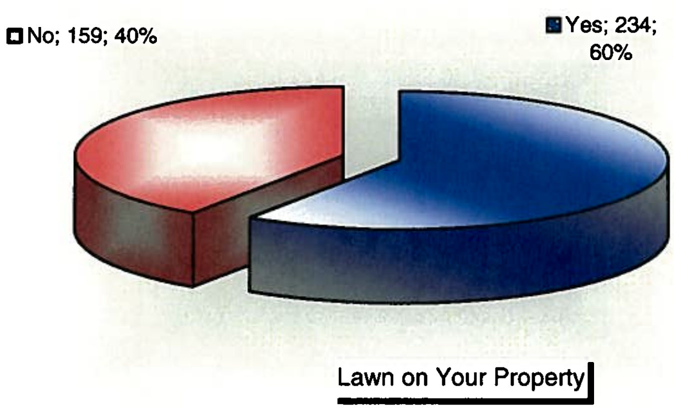
Question 9: Do you have an automatic dishwasher?

Response	***Frequency***	***Percentage***
Yes	128	32.5%
No	266	67.5%
Subtotal	**394**	
No Response	3	
Total	**397**	



Question 10: Do you have a lawn on your property?

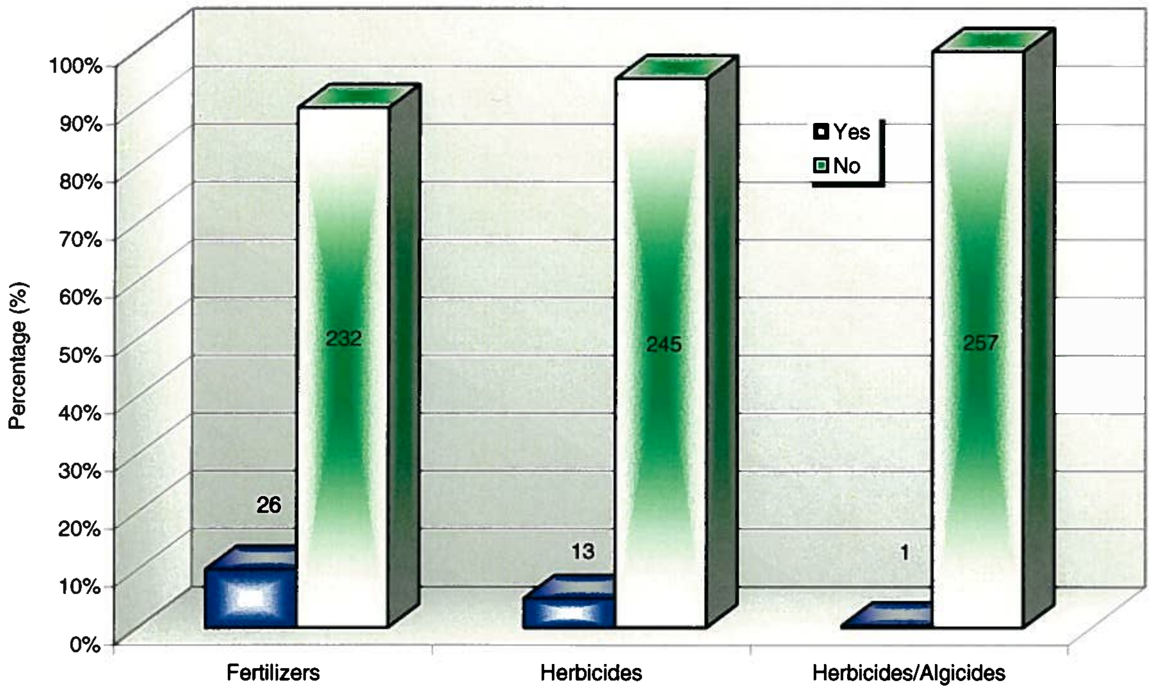
Response	*Frequency*	*Percentage*
Yes	234	58.9%
No	159	40.1%
Subtotal	**393**	
No Response	4	
Total	**397**	



Question 11(a): Do you apply fertilizers to your lawn? Do you apply herbicides to your lawn? Do you apply herbicides/agicides to your lawn/lake?

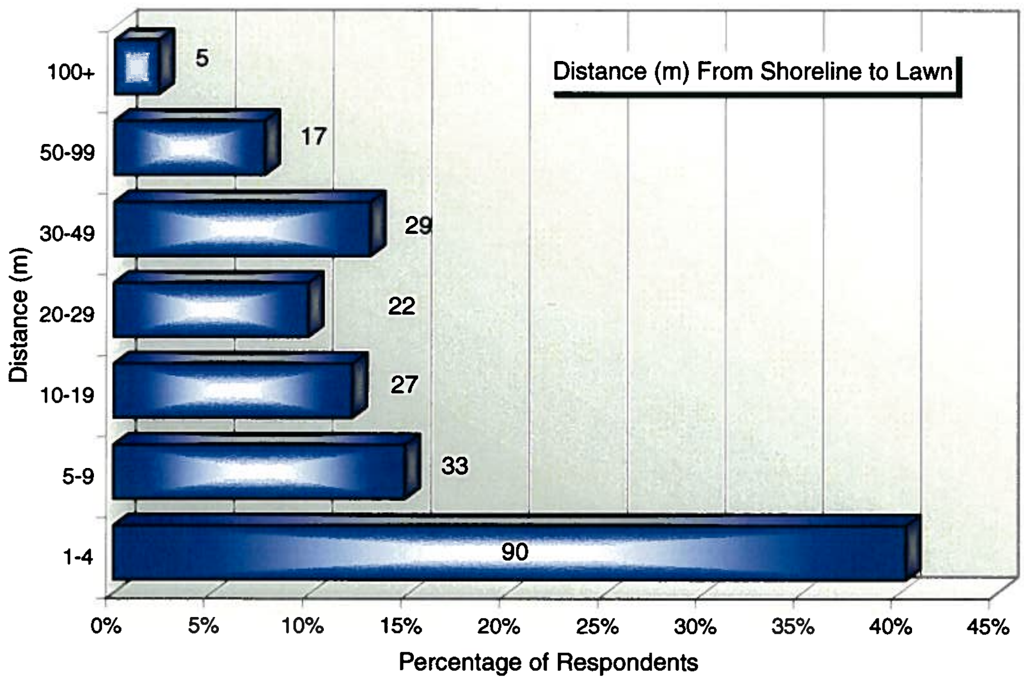
Response	Frequency			Percentage		
	Fertilizers	Herbicides	Herbicides/ Algicides	Fertilizers	Herbicides	Herbicides/ Algicides
Yes	26	13	1	10.1%	5.0%	0.4%
No	232	245	257	89.9%	95.0%	99.6%
Total	**258**	**258**	**258**	**100.0%**	**100.0%**	**100.0%**

Application of Fertilizers, Herbicides, Herbicides/Algicides to Lawn/Lake



Question 11(b): How far from the shoreline is the closest part of the lawn? (in metres

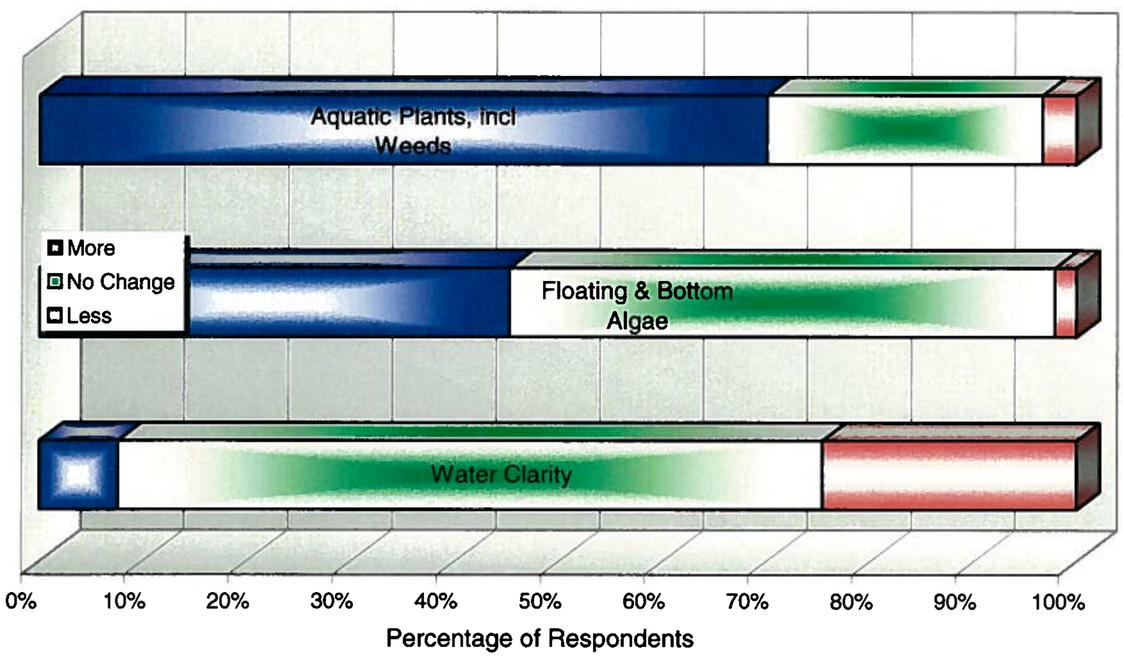
Distance (m)	Frequency	Percentage
1-4	90	40.4%
5-9	33	14.8%
10-19	27	12.1%
20-29	22	9.9%
30-49	29	13.0%
50-99	17	7.6%
100+	5	2.2%
Subtotal	**223**	
No Responses	174	
Total	**397**	



Question 12: Over the last 10 years, have you noticed any changes in the nearshore environment of Chandos Lake?

Response	Frequency			Percentage		
	Water Clarity	Floating & Bottom Algae	Aquatic Plants, incl Weeds	Water Clarity	Floating & Bottom Algae	Aquatic Plants, incl Weeds
More	22	129	211	7.6%	45.3%	70.1%
No Change	196	150	80	67.8%	52.6%	26.6%
Less	71	6	10	24.6%	2.1%	3.3%
Subtotal	**289**	**285**	**301**			
No Response	108	112	96			
Total	**397**	**397**	**397**			

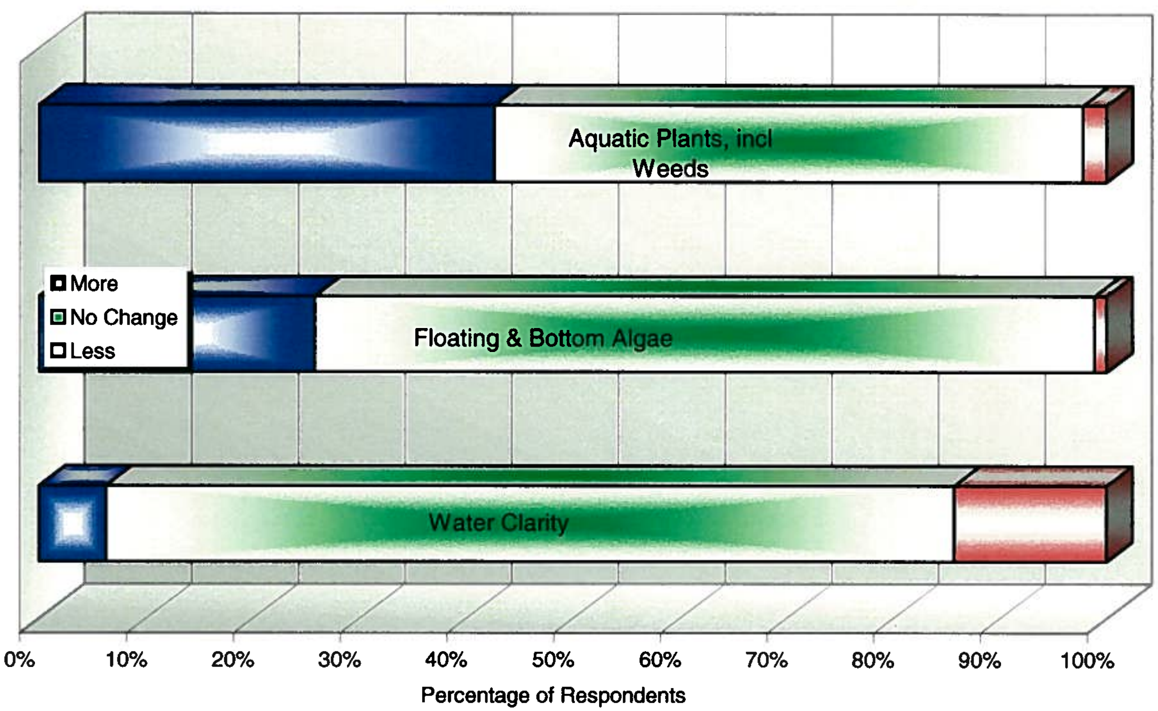
Changes in the Nearshore Environment of Chandos Lake



Question 13: Over the last 10 years, have you noticed any changes in the deep water environment of Chandos Lake?

Response	Frequency			Percentage		
	Water Clarity	Floating & Bottom Algae	Aquatic Plants, incl Weeds	Water Clarity	Floating & Bottom Algae	Aquatic Plants, incl Weeds
More	17	67	115	6.2%	25.8%	42.6%
No Change	217	190	149	79.5%	73.1%	55.2%
Less	39	3	6	14.3%	1.2%	2.2%
Subtotal	**273**	**260**	**270**			
No Response	124	137	127			
Total	**397**	**397**	**397**			

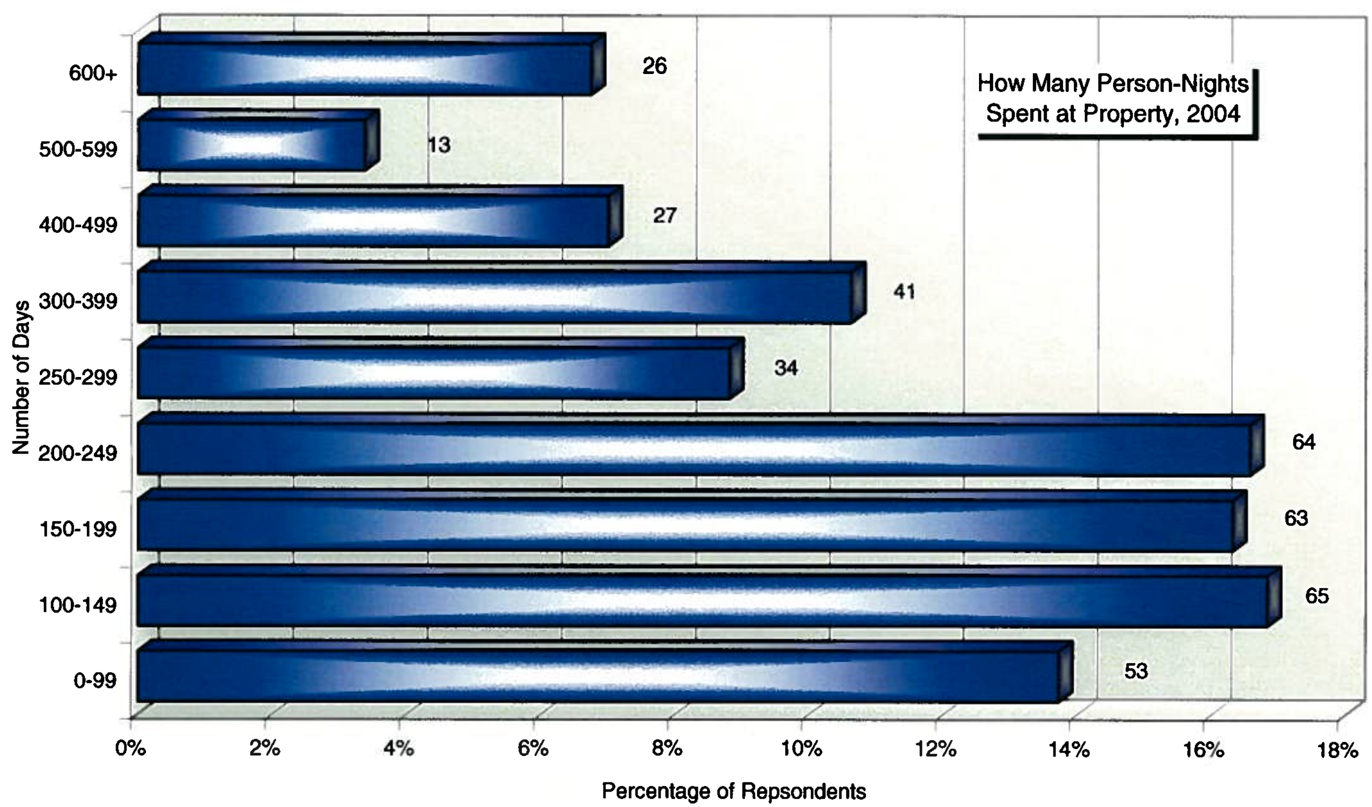
Changes in the Deep Water Environment of Chandos Lake



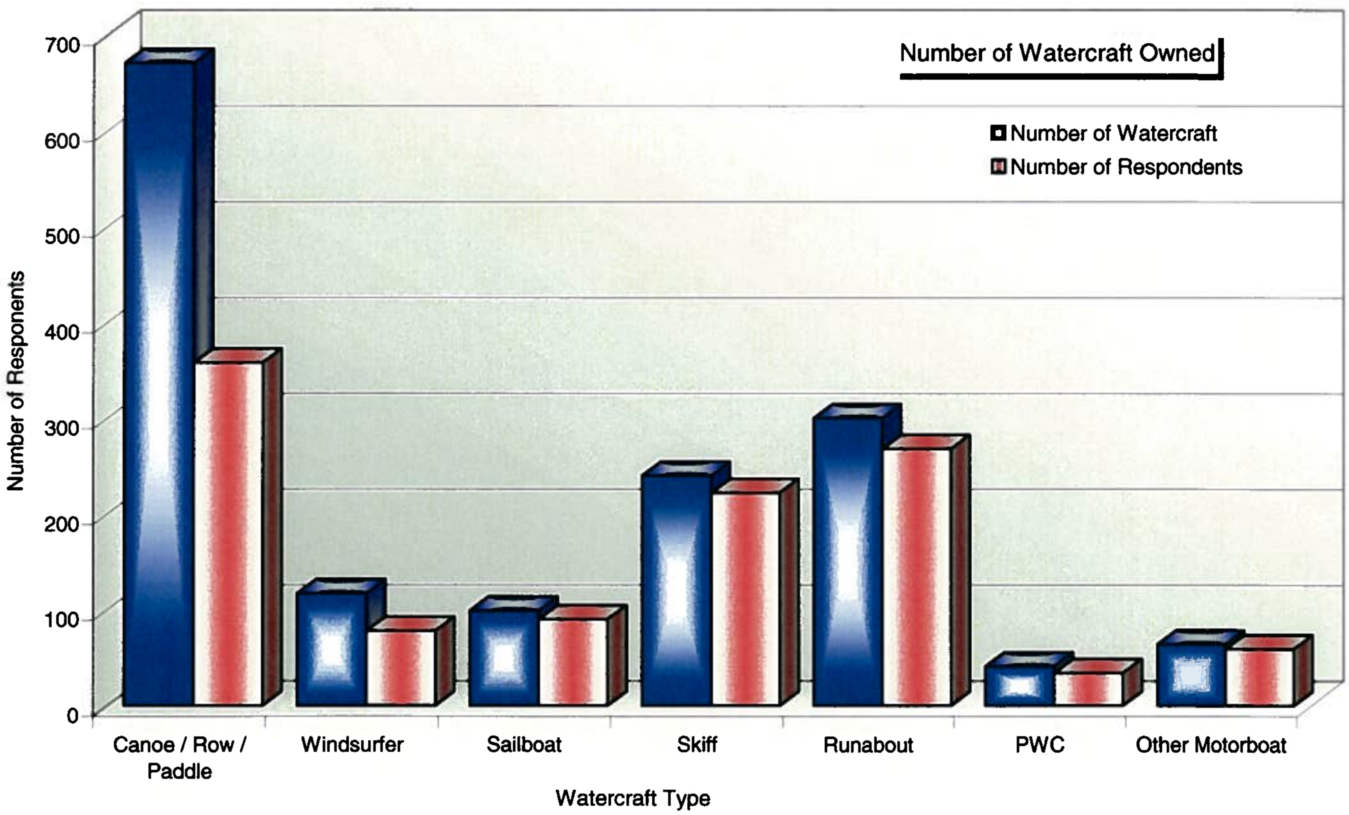
Question 14: Could you estimate about how many person-nights you, your family, your guest, and any tenants will spend at the property in 2004 (January to December)?

Number of Days	Frequency	Percentage
0-99	53	13.7%
100-149	65	16.8%
150-199	63	16.3%
200-249	64	16.6%
250-299	34	8.8%
300-399	41	10.6%
400-499	27	7.0%
500-599	13	3.4%
600+	26	6.7%
Subtotal	**386**	
No Response	11	
Total	**397**	

# of Person Nights	Principle Residence		Seasonal Residence		Total	Mean User Days
	Total	# of Responses	Total	# of Responses		
23,155	42	39				593.72
72,237			360	345		209.38
95,392					395	241.50
2 Surveys - No Response						



Watercraft Type	Total Number of Watercraft	Percentage of Total Watercraft	Number of Respondents (397)	Mean of # of Boats
Canoe / Row / Paddle	671	43.8%	358	1.9
Windsurfer	117	7.6%	78	1.5
Sailboat	99	6.5%	90	1.1
Skiff	240	15.7%	222	1.1
Runabout	300	19.6%	268	1.1
PWC	41	2.7%	34	1.2
Other Motorboat	64	4.2%	59	1.1
Total	**1532**	**100.0%**		3.9



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