Results of the 1997-2006 Kings County Volunteer Water Quality Monitoring Program*

Prepared for

Kings County Water Quality Monitoring Volunteers
and
Kings County Department of Community Development Services

By

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1. Introduction

The Kings County Volunteer Water Quality Monitoring Program (KCWMP) has now completed ten years of data collection. Ten lakes were monitored during 2006. Eight of these are located within the Gaspereau River watershed, one (Tupper Lake) is located within the Cornwallis River watershed and has been monitored for the last three years, and one (Hardwood Lake), which serves as a control lake, is located in the LaHave River watershed and has been monitored since the beginning of the program. This report provides a summary of the monitoring results to date.

2. Water Quality Criteria

The criteria typically used to assess water quality in terms of lake trophic status are listed in Table 2.1. The causal factor responsible for determining the trophic state of a lake is total phosphorus, the nutrient that most often limits the level of lake productivity. The two response variables are phytoplankton chlorophyll *a*, a measure of algal biomass, and Secchi Depth, a measure of water clarity. An increase in phosphorus levels leads to an increase in the growth of algae and a corresponding decrease in water clarity. The criteria listed in Table 2.1 have been developed using a broad compilation of temperate zone lakes. Recent studies*, however, suggest that these criteria may not be entirely applicable to the types of lakes being monitored by the KCWMP which are mainly ‘dystrophic’ brown water lakes. In this type of lake, phosphorus concentrations are naturally high, and Secchi depth is influenced more by color that by algal concentration. However, chlorophyll *a* concentration is still likely to be a valid indicator of trophic state.

Table 2.1. Water quality criteria (based on OECD 1985).

Parameter	Oligotrophic (Good)	Mesotrophic (Moderate)	Eutrophic (Poor)
Total Phosphorus (µg/l)	<10	≥10 – <20	≥20
Chlorophyll *a* (µg/l)	<3.5	≥3.5 - <5.0	≥5.0
Secchi Depth (meters)	>5	≥3 – ≤5	<3

*See for example, Havens, K.E. and G.K. Nurnberg. 2004. The phosphorus-chlorophyll relationship in lakes: Potential influences of color and mixing regime. Lake and Reservoir Management. 20(3):188-196.

3. Results of the 2006 Monitoring Program

3.1 Trophic State Parameters

Figure 3.1 is a bar graph of the mean values of the trophic state parameters for each lake over the entire course of the monitoring program. During 2005, phosphorus levels were the highest that had been recorded for seven of the ten lakes (Figures 3.2 and 3.4). In contrast, during 2006 phosphorous levels were generally the lowest that have ever been recorded for most of the lakes being monitored.[*]

The values for chlorophyll *a* during 2006, however, do not exhibit the same trend as total phosphorus. They in fact exhibit the opposite trend and were the highest values recorded for any year (Figures 3.3 and 3.4). These two contrasting trends are difficult to explain. If correct, the chlorophyll *a* levels indicate most of the lakes to be at the mesotrophic and eutrophic levels. Only Tupper Lake remained near the oligotrophic level.

Secchi Disk depths during 2006 were generally lower than those recorded during previous years in most lakes, but it is not clear if this was due to chlorophyll *a* or water colour since the latter were also reported to be the highest levels recorded since the beginning of the monitoring program (Figure 3.4).

In an attempt to better understand the yearly trends in water quality parameters, bar graphs of the annual mean values of total phosphorus, Secchi depth, chlorophyll *a* and water colour for all lakes were generated (Figure 3.4). Data from years prior to 2005 suggest that the factor controlling both total phosphorus concentration and Secchi Disk depth is related to water color. The annual trend in color shows a positive relationship to total phosphorus and a negative relationship to Secchi Disk depth. These trends are typical of coloured lakes. In contrast, there is no obvious trend in chlorophyll *a* concentrations. However, the data for 2006 shows an increase in color, but significant decreases in phosphorus and chlorophyll *a*. It is difficult to reconcile this trend and it may be related to the changes in laboratory procedures used between 2004 and 2006.

[*] The phosphorus levels reported for 2004 are probably incorrect due to difficulties experienced by the QEII laboratory during that year. In 2005, phosphorus was analyzed by a New Brunswick laboratory. In 2006 phosphorus samples were once again analyzed by QEII, but using a technique different from that previously employed. These changes in laboratory and procedures may be at least partly responsible for the differences observed in phosphorus levels between 2004 and 2006.

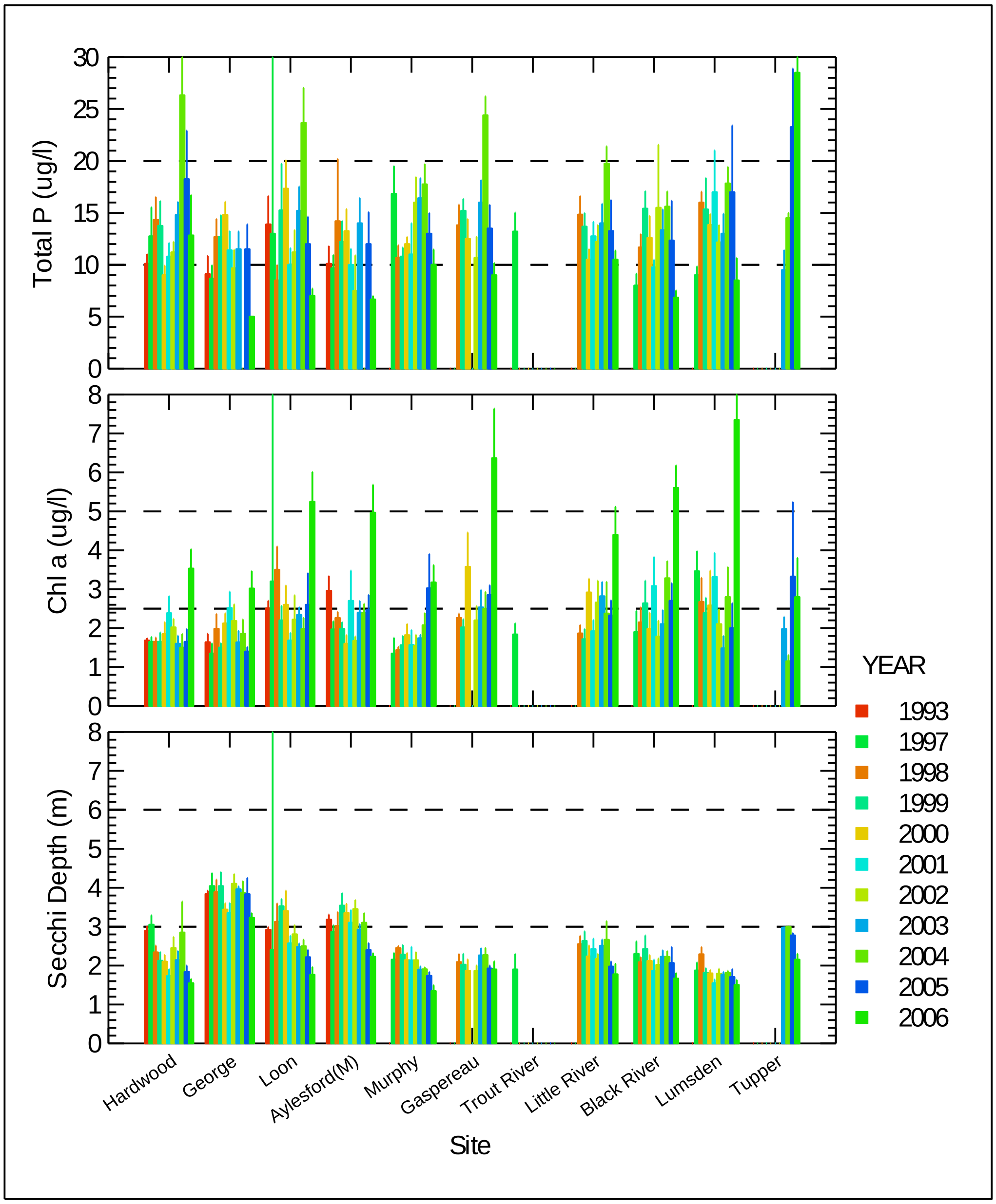

Figure 3.1. Mean values of total phosphorus, chlorophyll *a* and Secchi Disk depth at each site for each year (error bars are one standard error of the mean).

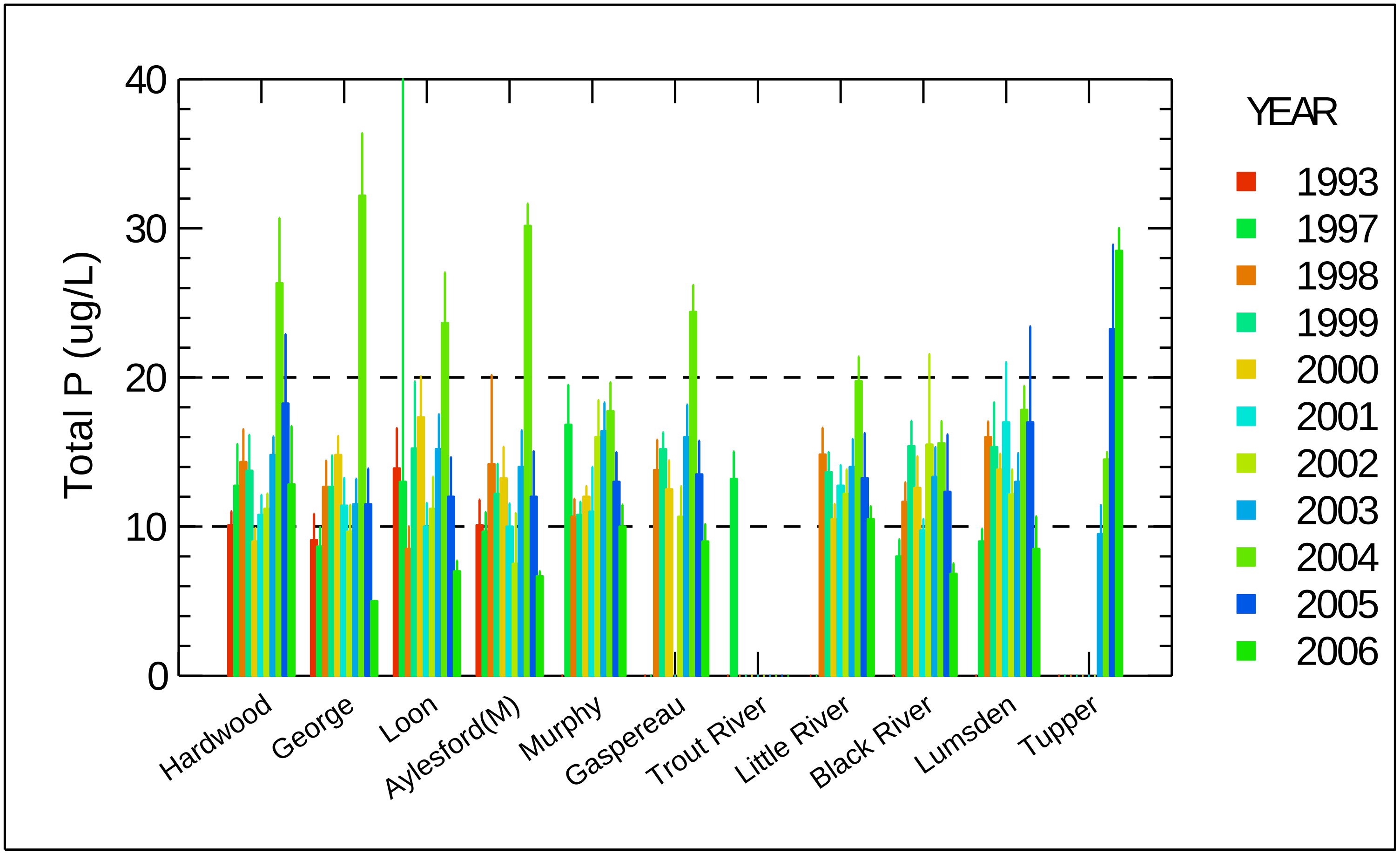

Figure 3.2 Mean values of total phosphorus concentration at each site for each year (error bars are one standard error of the mean)

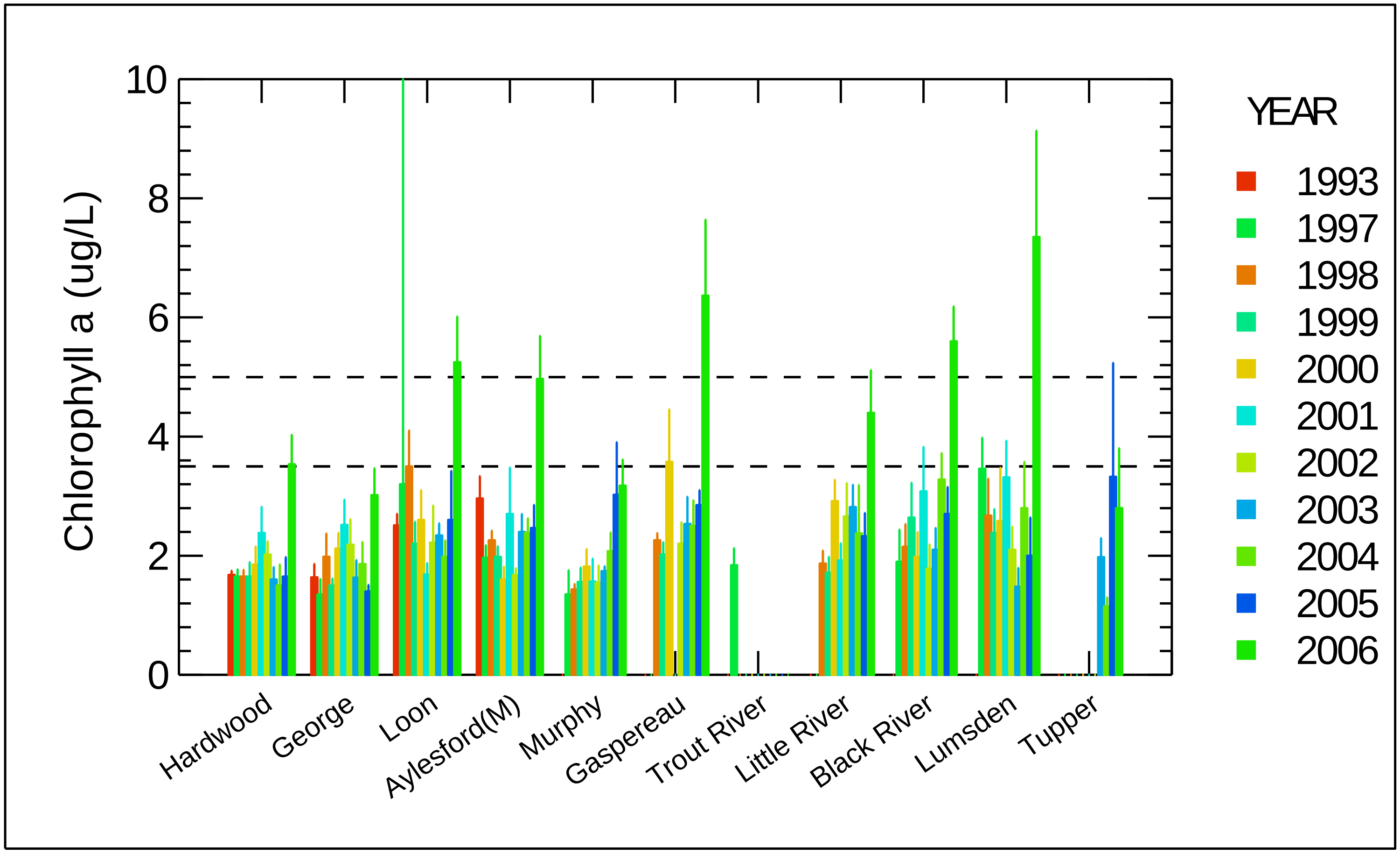

Figure 3.3 Mean values of chlorophyll *a* concentration at each site for each year (error bars are one standard error of the mean)

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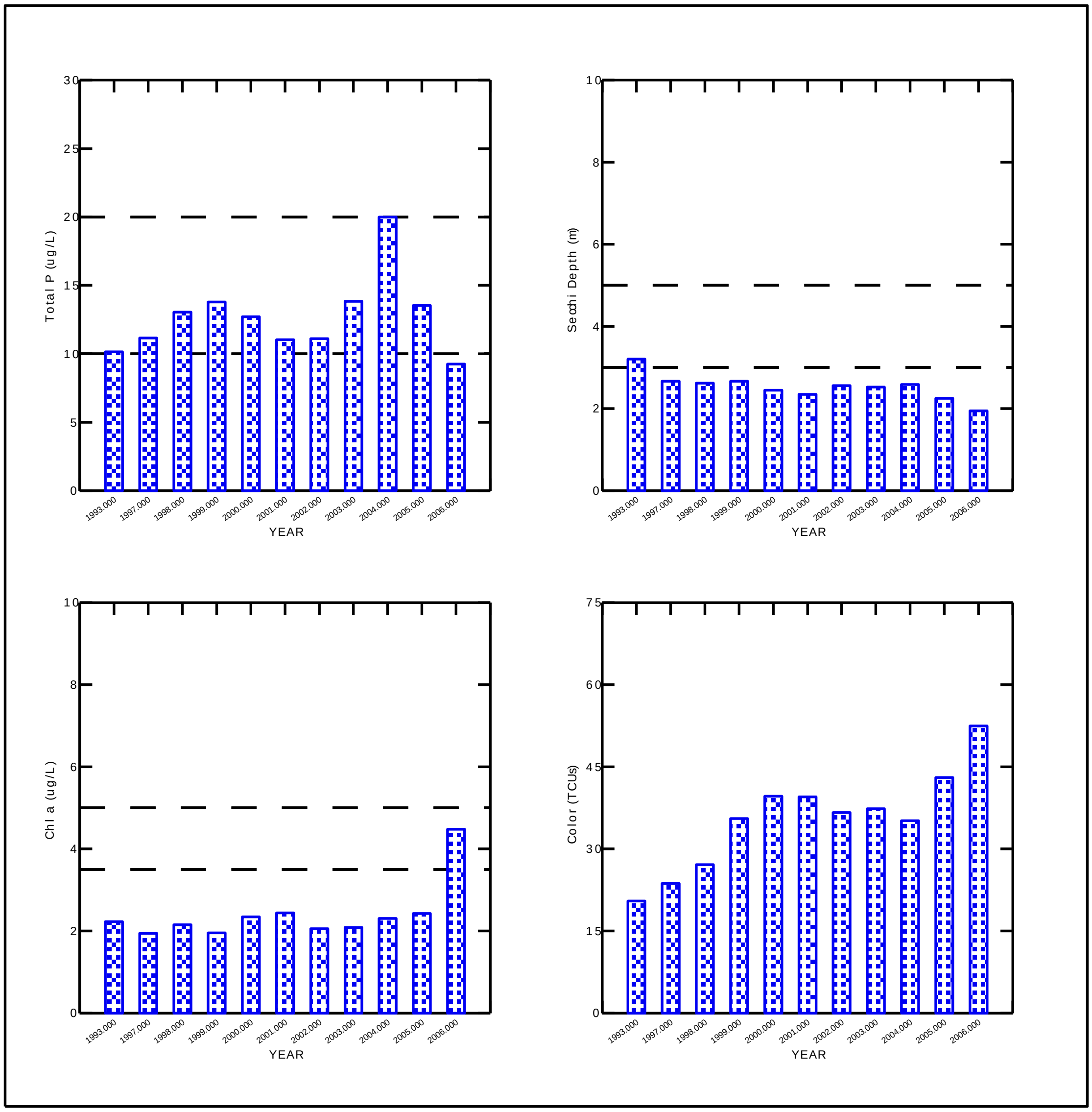


Figure 3.4. Annual means of selected water quality variables for all lakes combined

3.2 Alkalinity and pH

During 2000 there appeared to be a significant decrease in the alkalinity of most lakes. Since then, all of the lakes have exhibited an increase in alkalinity and, although alkalinity is relatively low, the highest alkalinities since monitoring began were observed during 2006 (Figure 3.5). pH has remained relatively constant at about 6.5 since monitoring began,

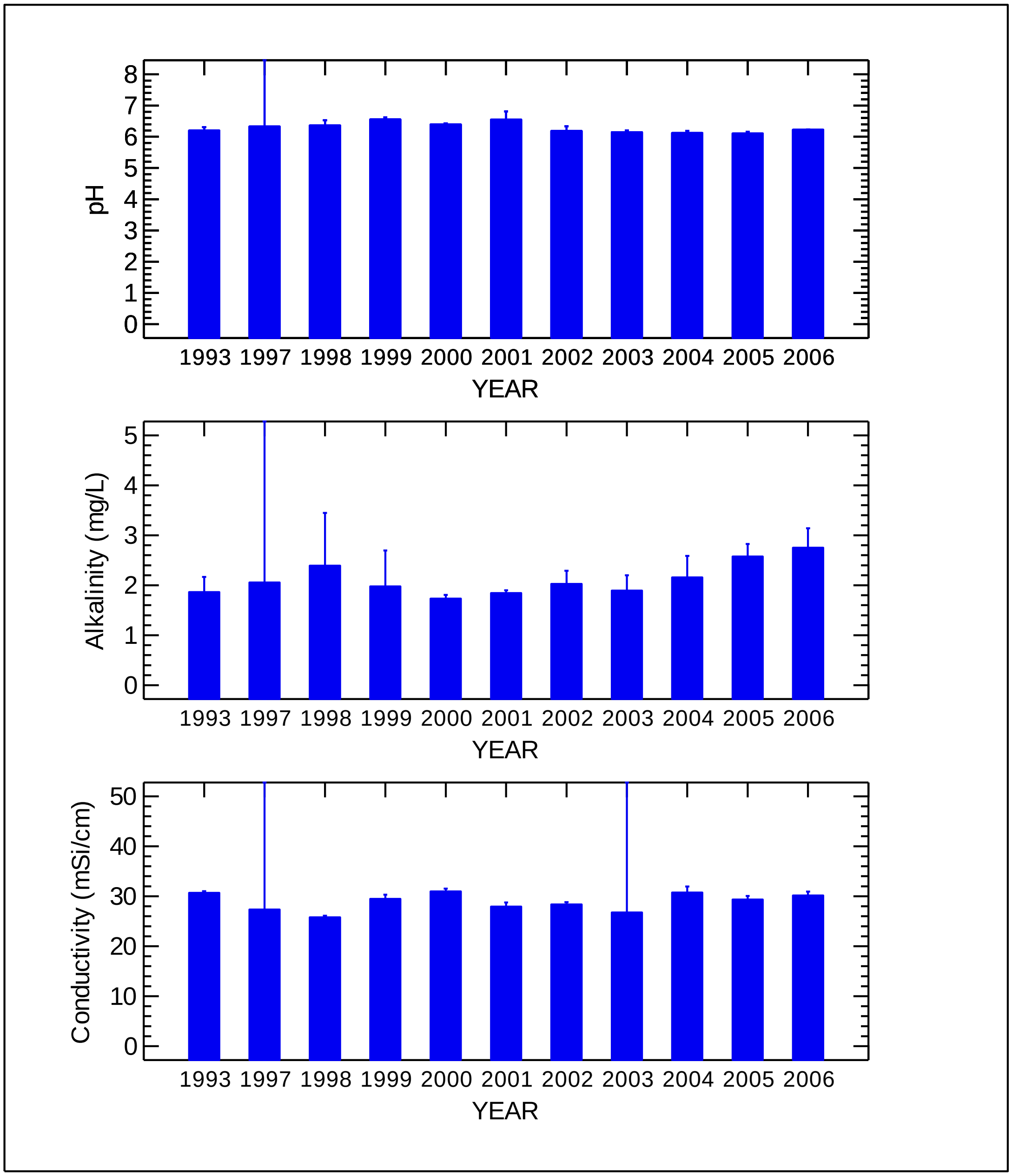


Figure 3.5. Mean values of pH, alkalinity and conductivity at each site for each year (error bars are one standard error of the mean).

4. Lake Temperature Stratification

Water column temperature stratification at a number of lakes has been monitored since 1999. Temperature stratification can influence lake water quality in a number of ways. Most importantly, if a lake becomes stratified, the warm surface layer becomes isolated from the cold bottom layer. As a result, oxygen that enters the lake from the atmosphere is less likely to be mixed into the deeper bottom waters. If the level of production in the surface water of the lake is high, organic matter that sinks to the bottom and undergoes decomposition can deplete the bottom waters of dissolved oxygen which can then lead to hypoxic and/or anoxic conditions.

Figure 4.1 shows the water temperature data that has been collected since 1999. Of the five lakes being monitored for temperature, three (Aylesford, Lumsden, and Hardwood) seldom exhibit any evidence of significant water column stratification. In contrast, Black River Lake and Lake George are usually stratified.[*] Of the two, Black River Lake stratifies most strongly.

5 References

OECD (Organization for Economic Co-Operation and Development). 1982. Eutrophication of Waters. Monitoring, Assessment and Control. OECD, Paris. 156p.

[*]During 1999 and 2000 Black River Lake did not exhibit any stratification. This, however, was most likely due to the shallowness of the sampling station during that period. In 2001 and subsequent years, the sampling site was moved to a deeper portion of the lake.

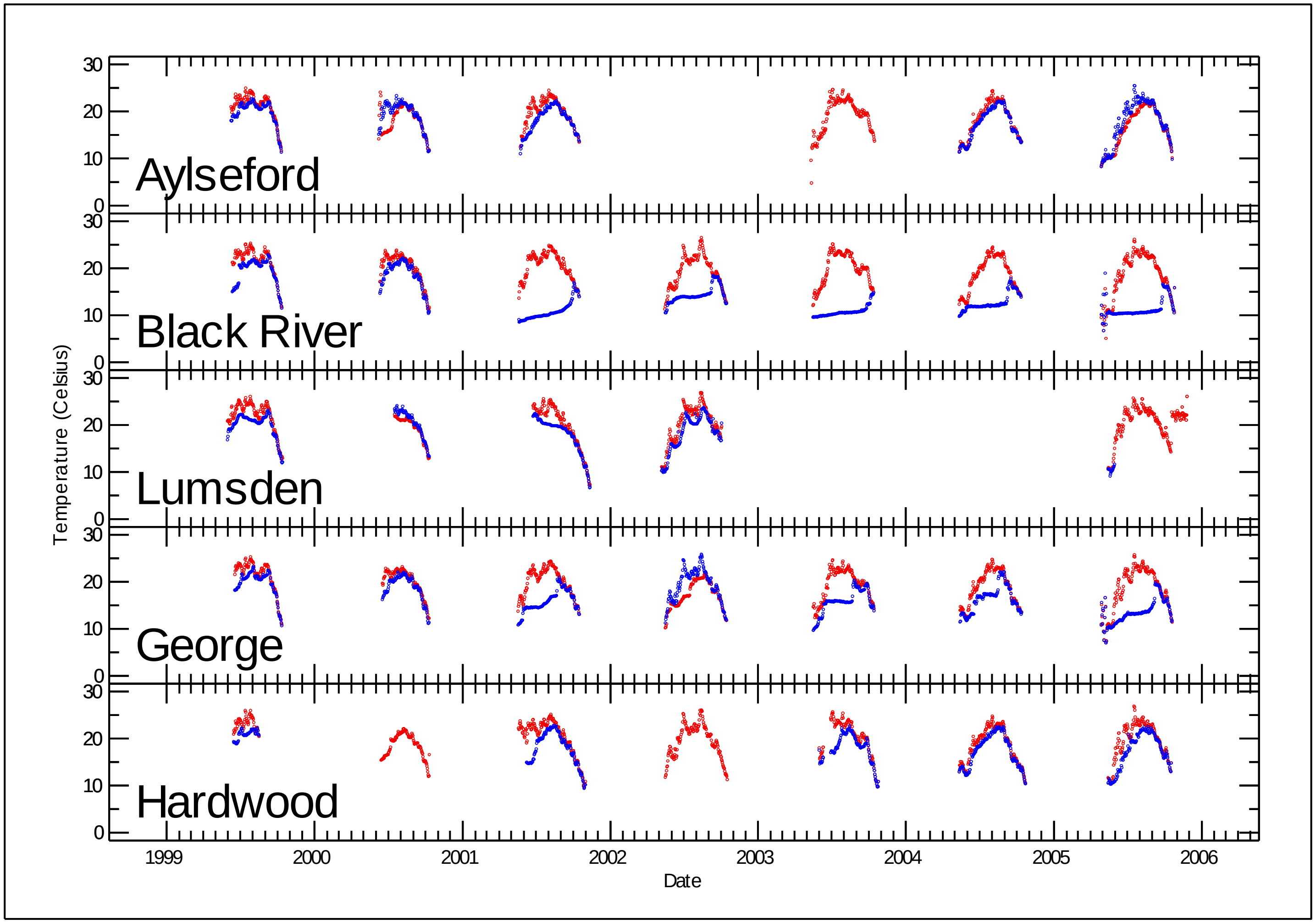
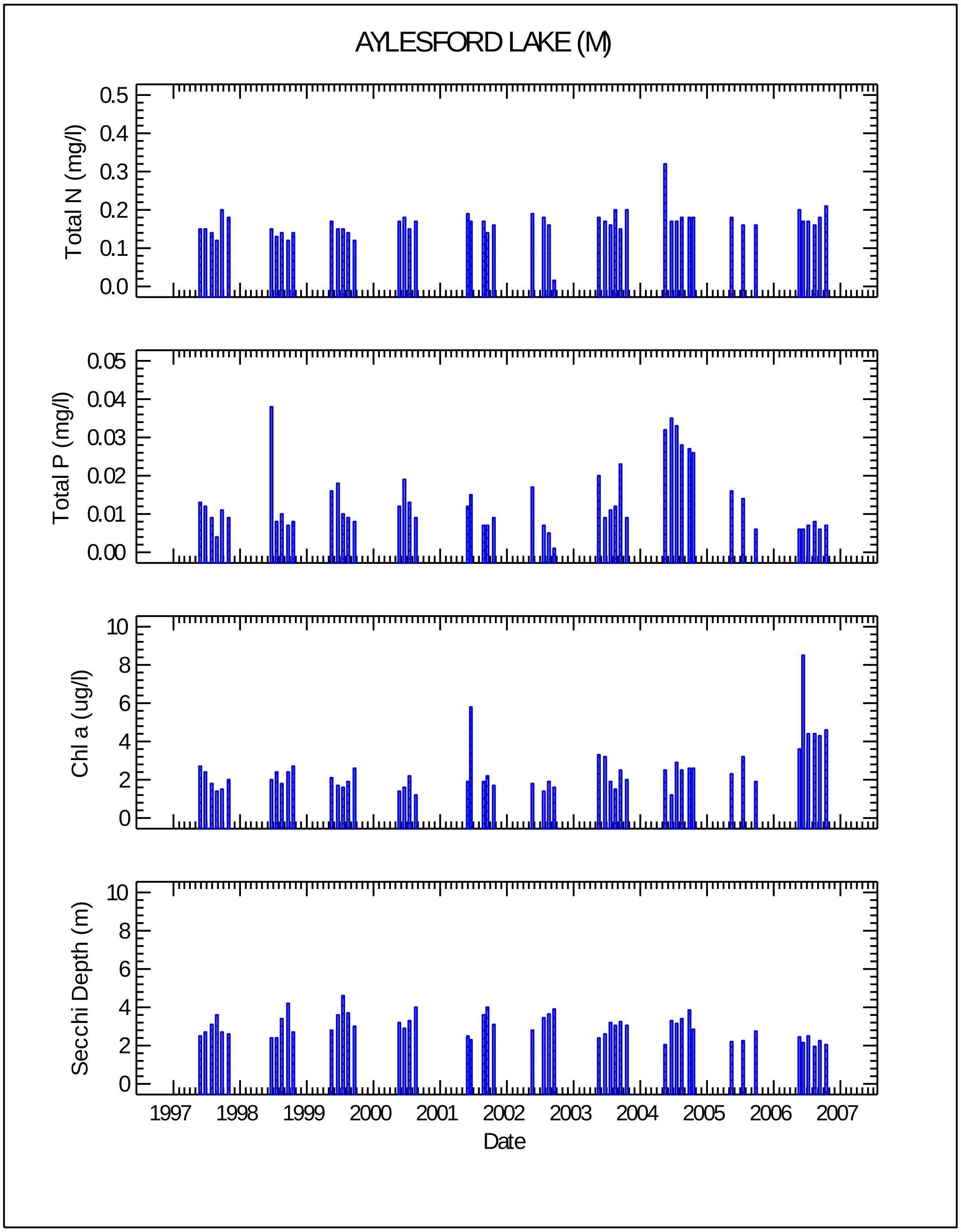
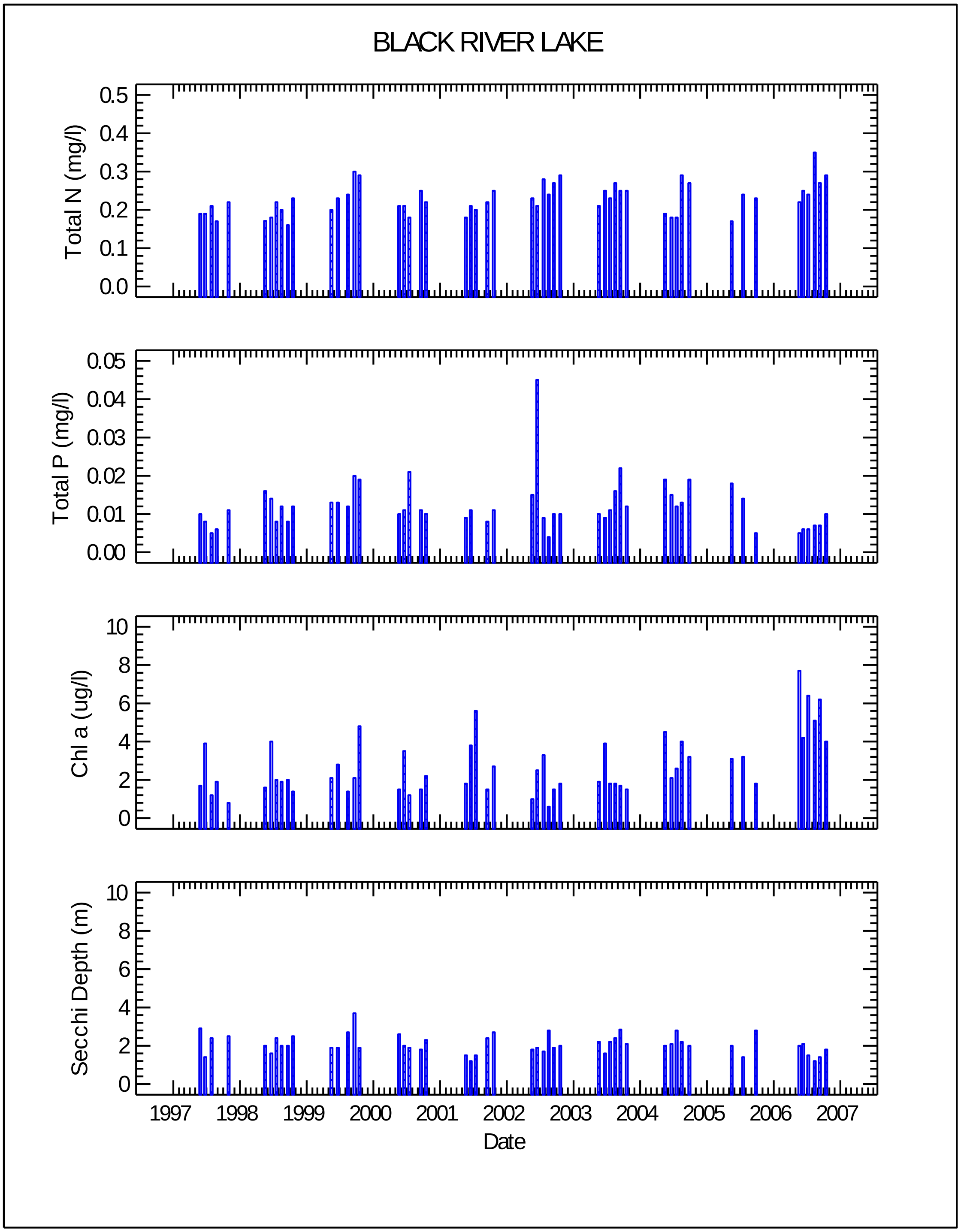


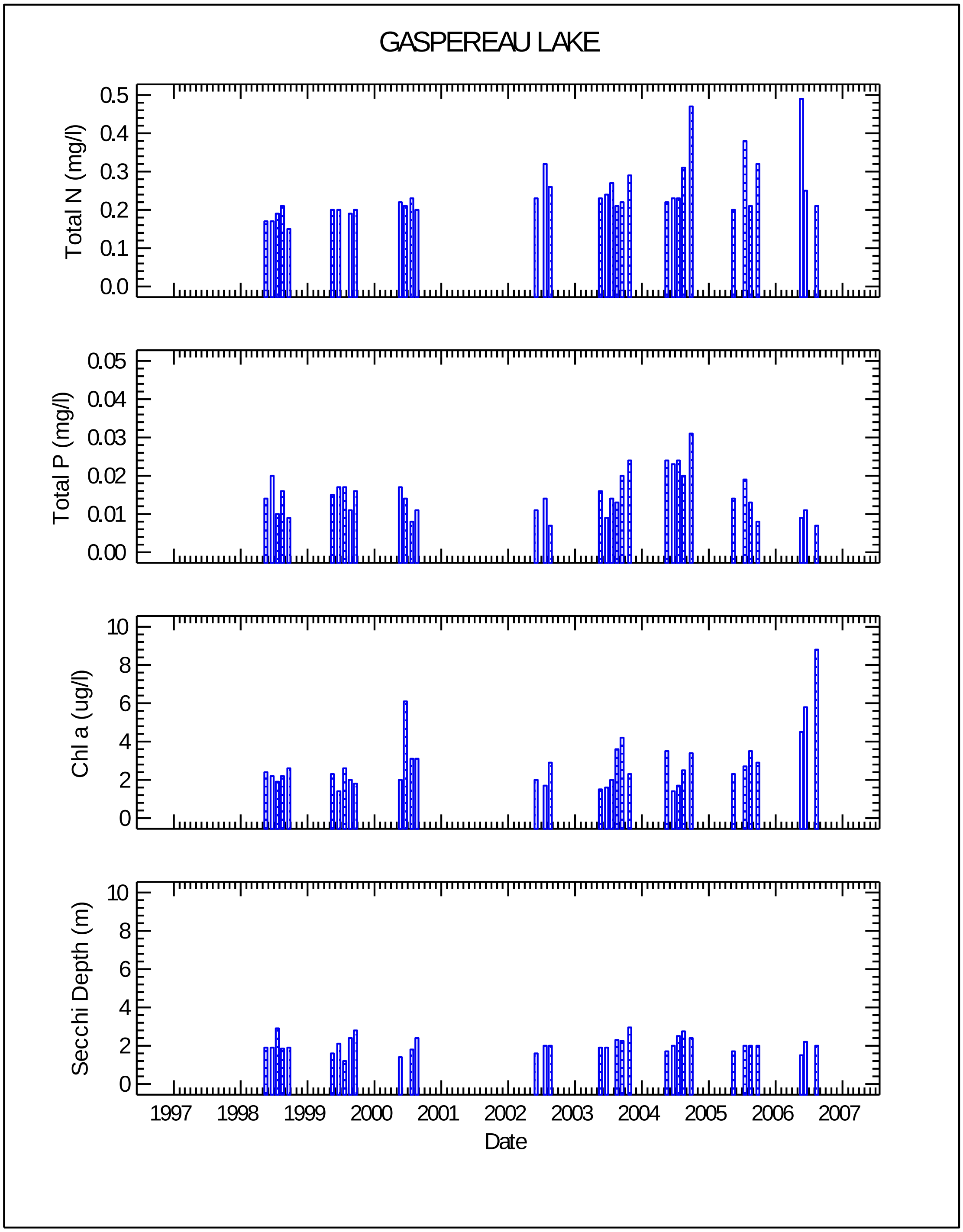
Figure 4.1 Surface (red) and bottom (blue) water temperatures recorded by data loggers (surface data loggers were located one meter below the surface; bottom data loggers were located one meter above the bottom).

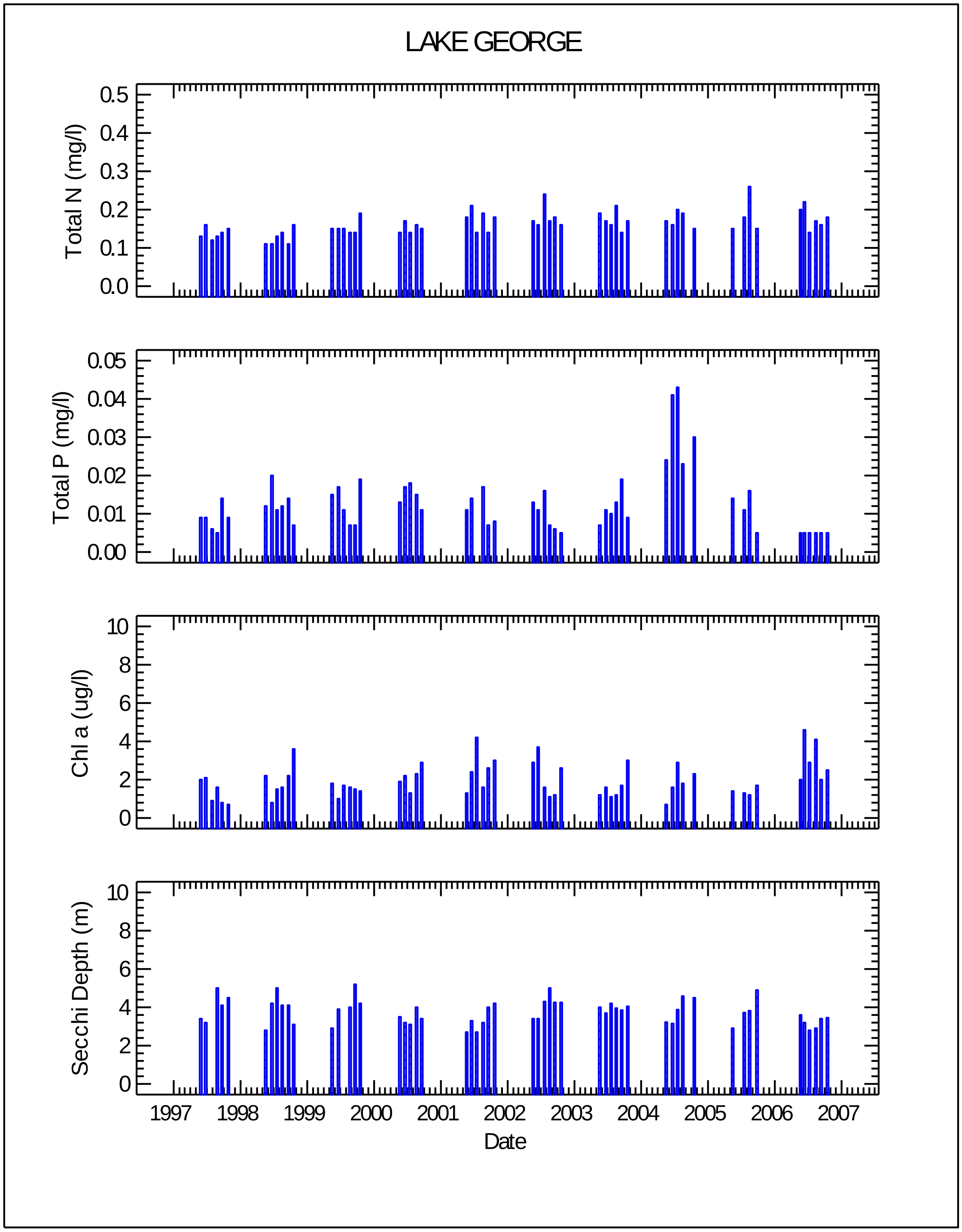
APPENDIX I

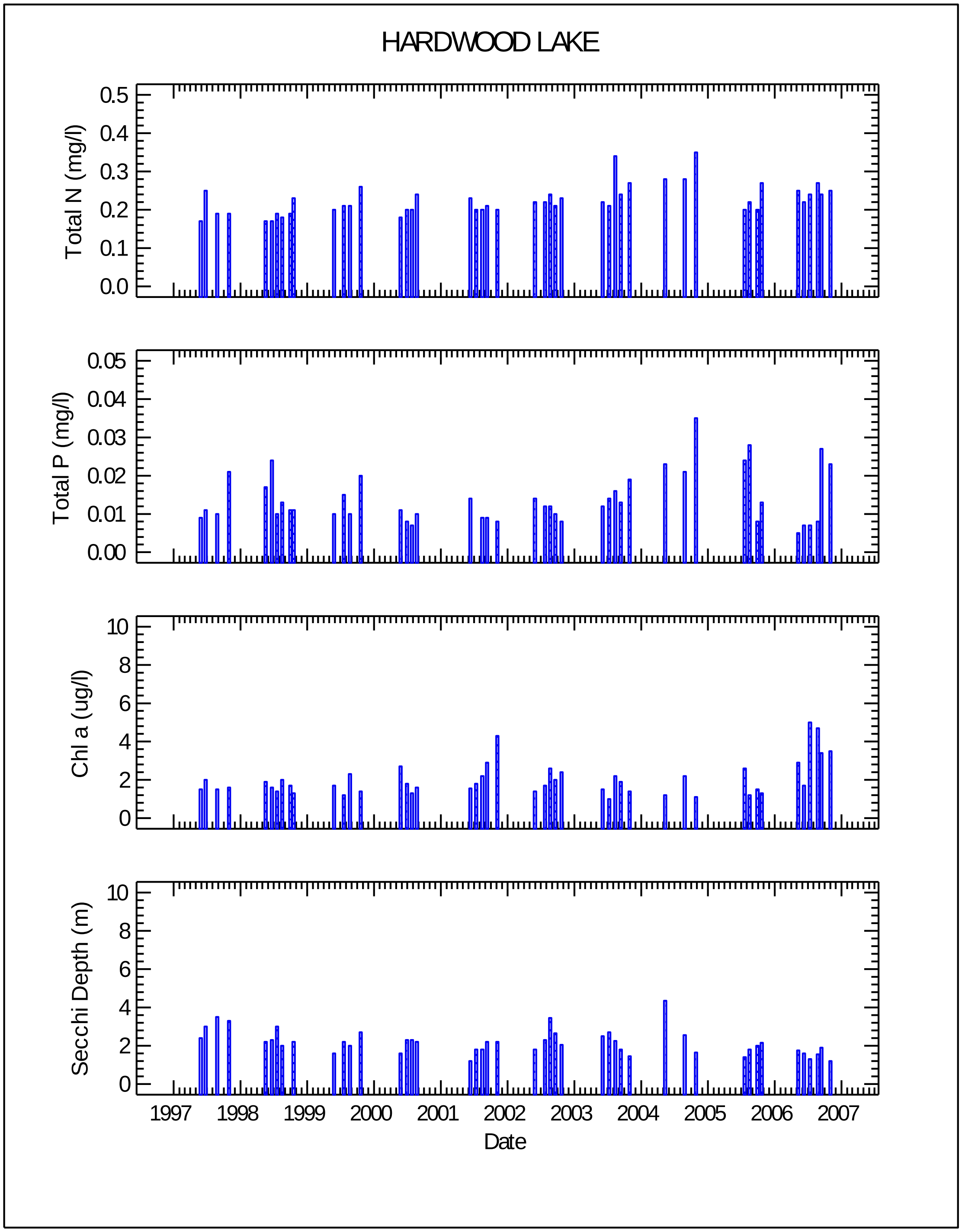
Time Series Data for All Lakes

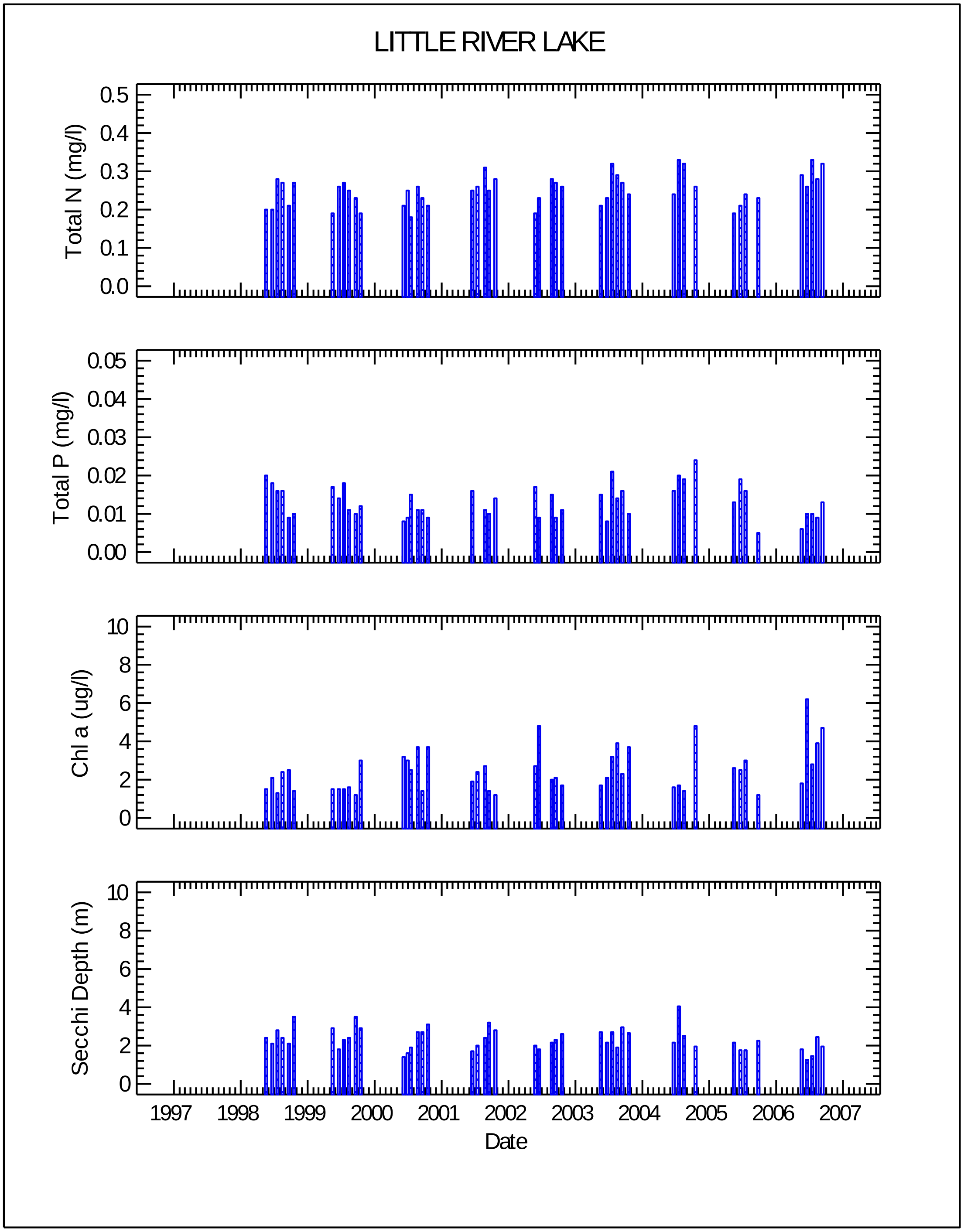

AYLESFORD LAKE (M)
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Date


BLACK RIVER LAKE
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Date


GASPEREAU LAKE
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Date


LAKE GEORGE
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Date


HARDWOOD LAKE
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Date


LITTLE RIVER LAKE
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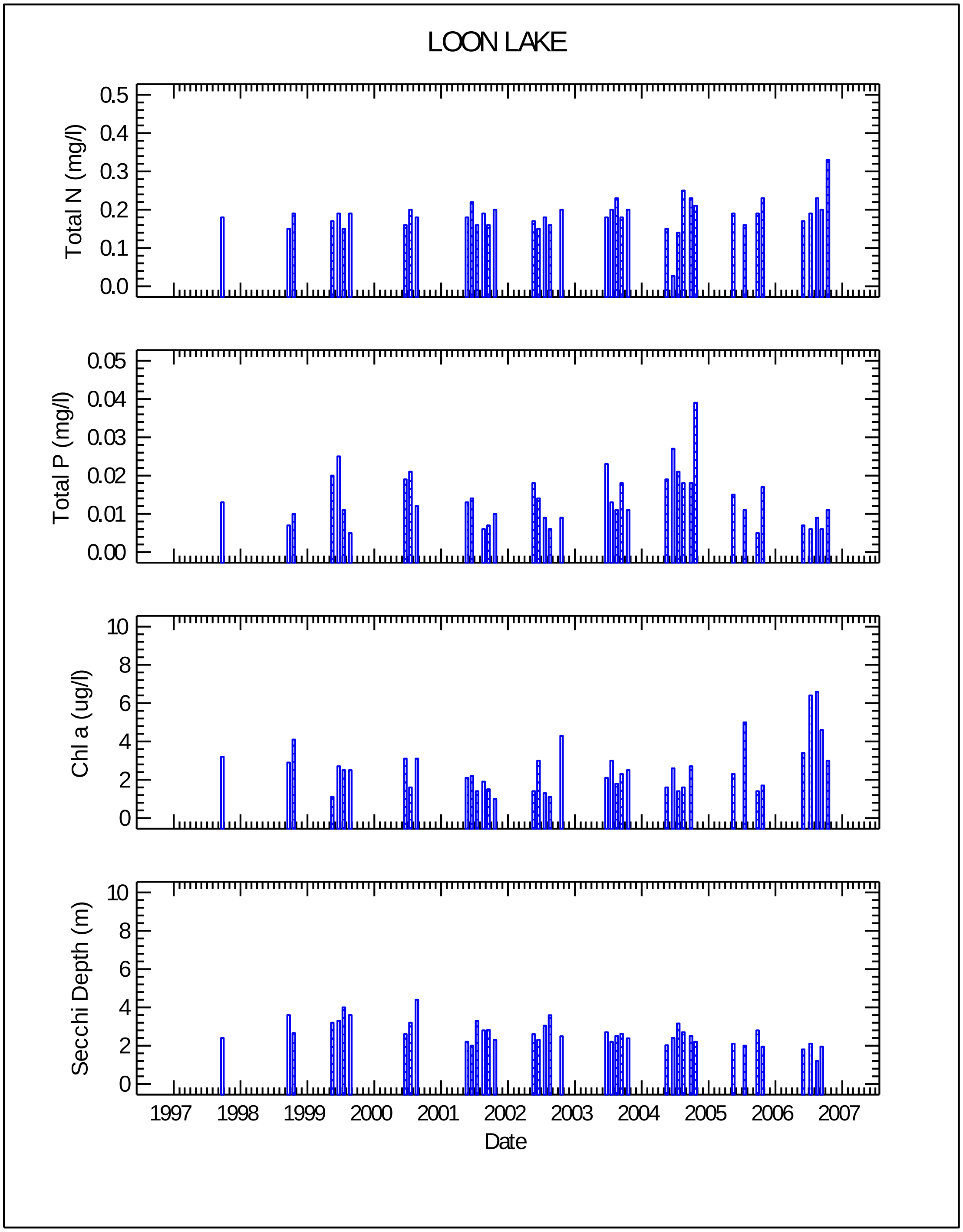
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
Date


LOON LAKE
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0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
10
1997
1998
1999
2000
2001
2002
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2004
2005
2006
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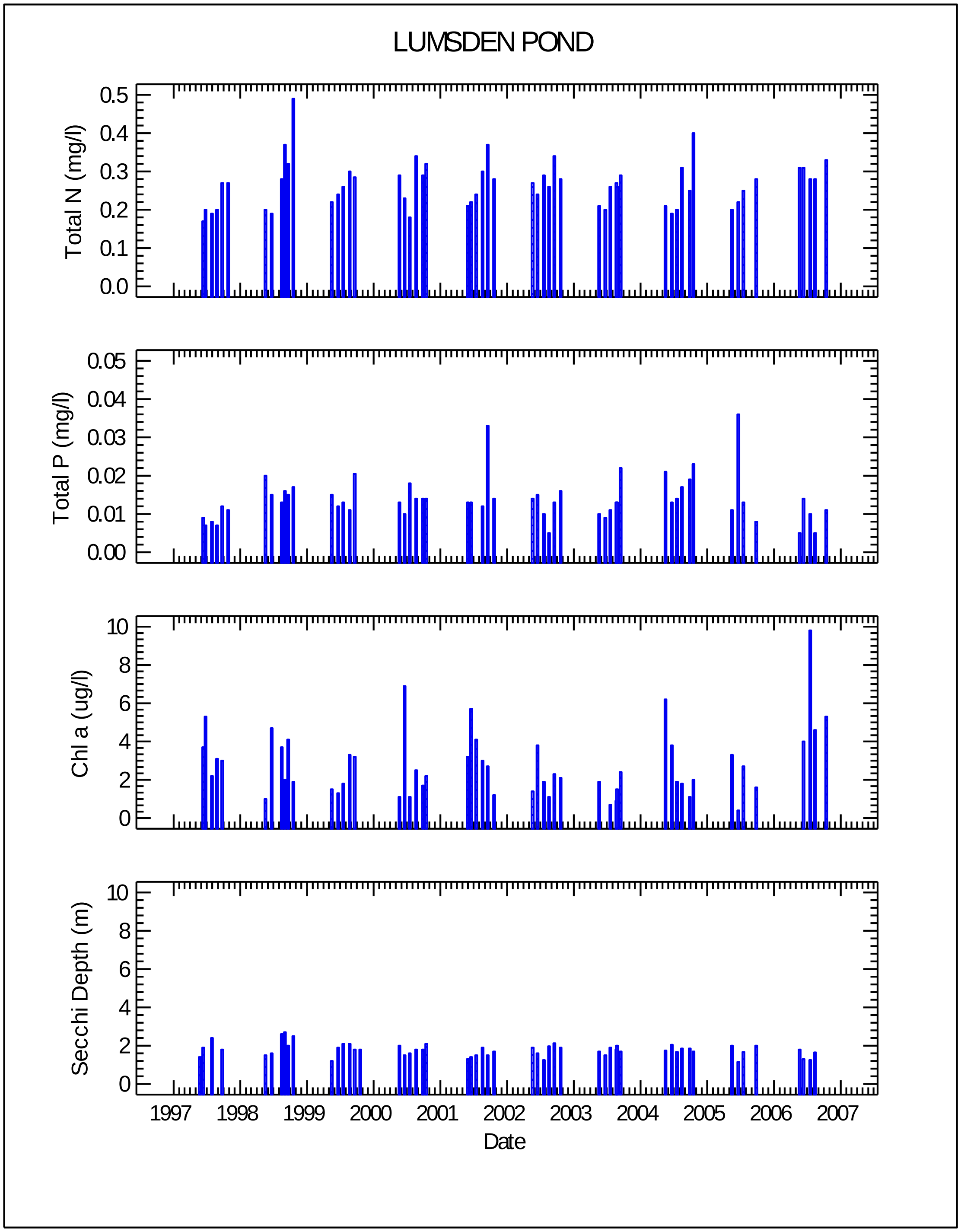
Date



LUMSDEN POND
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
8
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1997
1998
1999
2000
2001
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2003
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2005
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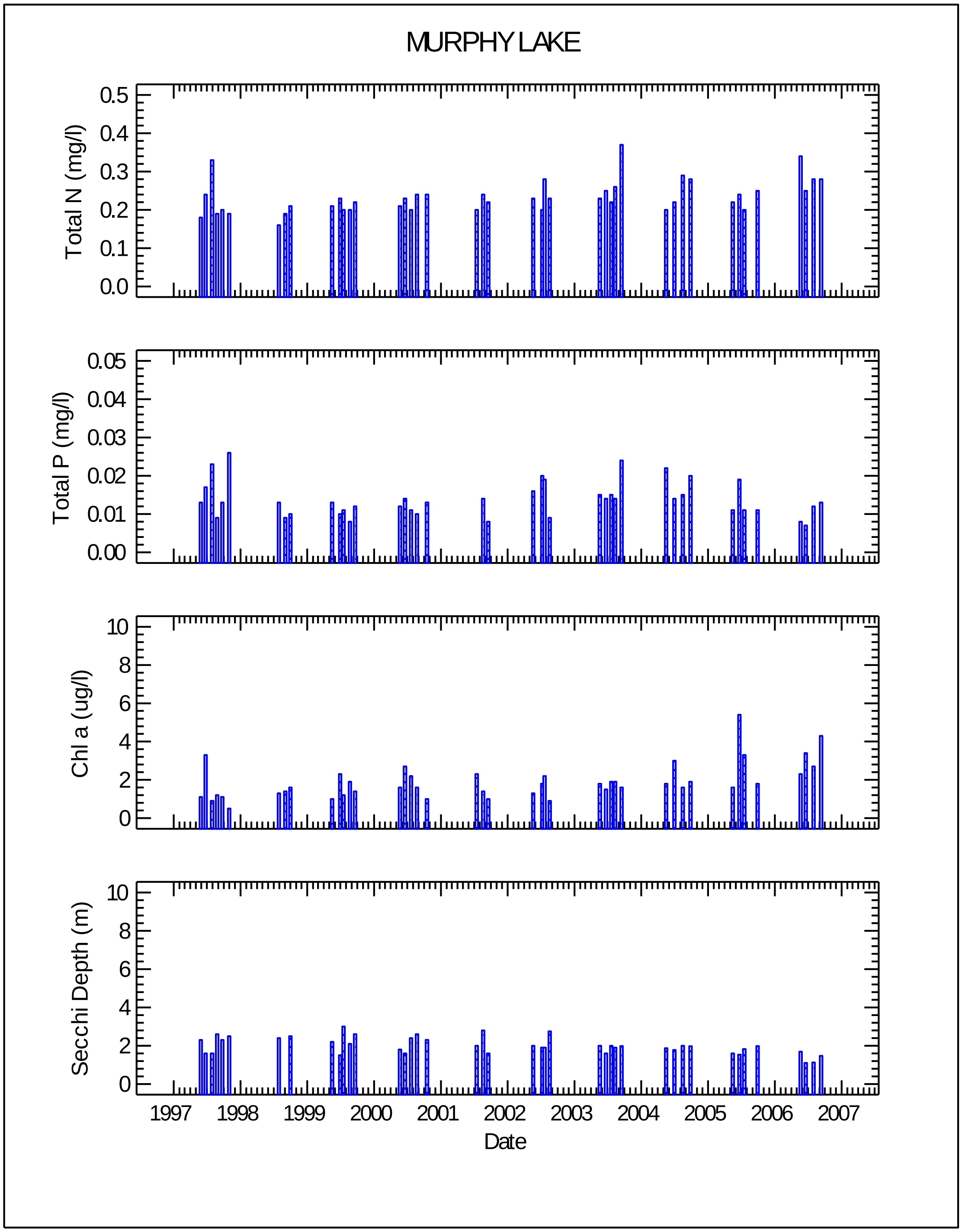
Date


MURPHY LAKE
Total N (mg/l)
0.5
0.4
0.3
0.2
0.1
0.0
Total P (mg/l)
0.05
0.04
0.03
0.02
0.01
0.00
Chl a (ug/l)
10
8
6
4
2
0
Secchi Depth (m)
10
8
6
4
2
0
1997
1998
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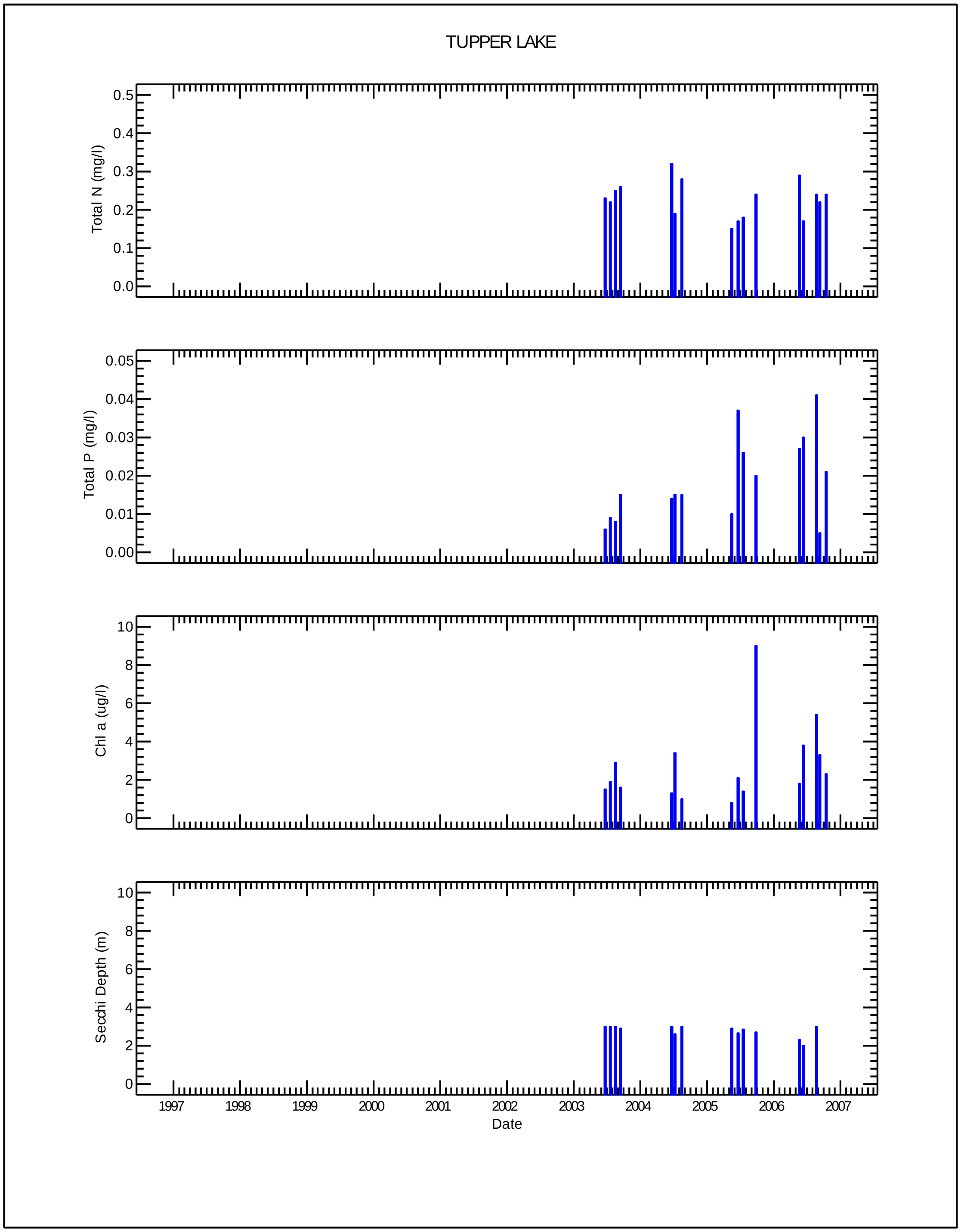
2005
2006
2007
Date


TUPPER LAKE
Total N (mg/l)
0.0
0.1
0.2
0.3
0.4
0.5
Total P (mg/l)
0.00
0.01
0.02
0.03
0.04
0.05
Chl a (ug/l)
0
2
4
6
8
10
Secchi Depth (m)
0
2
4
6
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1997
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Date