Alberta Lake Management Society
Lakewatch 2000
Report.

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4. Introduction

Alberta's volunteer lake monitoring program known as Lakewatch has been an important source of water quality data for Alberta Environment and lake associations. In 2000, volunteers from several lake associations, the Alberta Lake Management Society (ALMS) and Alberta Environment employees collected water samples bi-monthly from Chestermere Lake, Calling Lake, Gull Lake, Lac LaNonne, Sandy Lake, Shorncliffe Lake, Sylvan Lake, Vincent Lake. This report outlines the Lakewatch program and results from the 2000 water quality survey of these eight lakes.

Why have a volunteer lake monitoring program?

Volunteer lake monitoring programs are intended to accomplish four primary objectives for lake management: (i) They act as a platform for educating lake users about the aquatic environment; (ii) they foster and enhance public involvement in lake management; (iii) they facilitate a link between aquatic scientists and lake users; and (iv) they can provide reliable water quality data that, in the present era of funding constraints, can result in cost-savings to government programs.

Volunteer monitoring programs have been implemented in several provinces in Canada and states in the U.S., where one or two of these objectives have been emphasized, but usually all four are achieved in part. In Alberta, the volunteer program known as Lakewatch has operated for nine years and collected data from 30 lakes. Volunteer programs elsewhere have become so successful that they have expanded into a principle source for lake water quality data. For example, in the United States, the Missouri Volunteer Monitoring Program involves 33 volunteers monitoring 15 lakes annually. The resulting volunteer dataset was independently tested using professionally collected data and was considered highly accurate for its representation of summer conditions for individual lakes. The utility of volunteer programs in collecting reliable and inexpensive water quality data has been recognized by the EPA to the point that they maintain a web site with access to manuals, data reporting, and data at http://www.epa.gov/OWOW/monitoring/

How does Lakewatch help Albertans?

Much concern has been raised over the 'pollution' of Alberta lakes. It is a common belief that human activities, including industry, urbanization, forestry, agriculture, and residential dwellings contribute pollutants to lakes causing excessive algal growth, weeds and murky water. Lakewatch allows people to be involved in determining lake water quality so that they can make informed decisions at council meetings regarding developments that may impact their lakes.

5. Indicators of water quality: Sampling for what?

Water samples are collected in Lakewatch to determine chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in Lakewatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of a lake's potential productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

Phosphorus and Nitrogen

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass concentrations, the trophic states are; oligotrophic, mesotrophic, eutrophic and hypereutrophic. A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these catagories as well as a sample of Alberta lakes are shown in Appendix 1.

Chlorophyll *a*

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

Secchi Disk Transparency

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is the Secchi depth. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

General Water Chemistry

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components. Chemicals that become electrically charged in water are called ions. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. Hydrophobic (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer application.

6. Methods

Lakewatch determines which lakes will be included in the sampling program based on the following three priorities:

Priority 1. The highest priority are lakes where little or no baseline data are available.

Priority 2. The second priority are lakes where data exist but are more than five years old.

Priority 3. The lowest priority are lakes where data exist within the last five years.

Once a lake is included, it may be sampled for several years depending on management pressures at the lake and on the enthusiasm of the volunteers that own property at the lake.

A pool of eligible lakes is formed each year from interest expressed by lake associations at the annual ALMS general meeting. Representation at ALMS general meetings is a basic requirement for inclusion in Lakewatch. Time and locations for ALMS meetings are posted at :
http://www.biology.ualberta.ca/alms/home.htm
or can be obtained by calling Preston McEachern at (780) 427-1197. The program was limited to eight lakes for 2000 by funding constraints. The selected lakes (Chestermere Lake, Calling Lake, Gull Lake, Lac LaNonne, Sandy Lake, Shorncliff Lake, Sylvan Lake, Vincent Lake) were routinely sampled every two weeks over the open water months for selected trophic, mineral and physical data.

The sampling protocol was taught to the volunteers at the initial training session held at each of the lakes in May. The volunteers were organized ahead of time by the lake association coordinator who made the arrangements for the training session at the lake. At this meeting the coordinator was provided with a recent morphometric map of the lake, a copy of the “Lake sampling Procedures Manual” (Alberta Environmental Protection, 1995) and the equipment necessary to collect and prepare water samples for analysis. The equipment included a Secchi disk, integrating water sampling tube, filtering pump and apparatus, water collection carbouy, pre-labeled and coded sample bottles, standard record sheets, cold pack and cooler chest.

The number of volunteers at these training sessions ranged from 2 to 12 individuals. Training included an informal lecture style presentation of the theory and practical aspects of water quality and monitoring, boating and water safety issues, and an “on-the-lake” demonstration of equipment and sampling procedures. Training sessions concluded on land with a demonstration of sample preparation. The volunteers all had an opportunity to master the procedures at each stage of the sampling process before the session ended.

The main sampling site and 9 additional locations were selected. These sites were identified on the basis of morphometric data and information on land use and water quality provided by the volunteers. The deepest location in the lake was chosen as the main sampling site because current theory suggests that such locations best represent the dominant open-water environment of the lake. The ten sites were marked on the morphometric map for future reference and a laminated copy was later provided to the lake coordinator.

On the training day and on each sampling day the volunteers - using their own boat(s) - anchored at the main sampling site of the lake. All pertinent meteorological, lake activity, and Secchi depth data were measured according to methods outlined in the procedures manual (Alberta Environmental Protection, 1995). The euphotic depth was estimated by multiplying the Secchi depth by a factor of 2.0.

Integrated water samples from the surface to the bottom of the euphotic zone were collected at each site with the sampling tube and deposited into a clean, rinsed carbouy. When multiple samples were collected, the same number of samples were taken at each site to maintain an equal and consistent representation from all ten sites.

The integrated water sample(s) of the euphotic zone were collected at each of the remaining nine sites and combined with the sample from the main site. Determination of the sampling depth was based on the estimate of the euphotic depth from the main site. Where water column depth was less than the euphotic depth the water sample was collected from approximately 0.5m above the bottom, without disturbing the bottom sediment. Effort and care were required to eliminate contamination of the water samples.

The samples were returned to a suitable location on land and the samples were prepared for analysis. The sample carbouy was shaken vigorously and whole water samples were poured off into several water chemistry bottles used to estimate, among other variables, phosphorus and selected chemical ions. The samples were placed in a thermally insulated cooler with freezer packs to keep the temperature of the samples as close to 4^oC as possible. Arrangements were made to transport the samples for analysis within 24 hours of being collected.

Samples for total phosphorus, chlorophyll *a*, major anions and cations, alkalinity, hardness and ionic balance, were sent to the University of Alberta, Water Quality lab in Edmonton for analysis.

The Water Quality Section of AEP archived and administered the data collected in 2000. A copy of the was sent to the Alberta Lake Management Society for inclusion in the annual Alberta Lakewatch Report.

Water column profiles were measured monthly when an ALMS representative was at each lake. On these occasions depth profiles of specific conductance, pH, % O_2 saturation, dissolved oxygen, and redox potential provided additional information on water quality conditions at the main lake sites.

7. Results

General characteristics for each lake.

Chestermere Lake

Chestermere Lake was initially included in Lakewatch in 1999. Continued sampling was considered necessary as this lake is under intense ecosystem stress due to the growth of Calgary, its receipt of Calgary's storm water and high sediment and nutrient loads from Bow River and Nose Creek via the Western Irrigation District canal. Chestermere Lake is an excellent candidate to remain in Lakewatch because the local cottage association and town of Chestermere are willing to continue sampling and contribute funds to cover sampling and analytical costs. Continued monitoring of Chestermere Lake will reveal the impacts of development pressure and the effectiveness of proposed management programs.

Chestermere Lake is shallow over most of its depth. During the original survey conducted by the Alberta government, Chestermere Lake was more than 7 m deep. The deepest areas have accumulated little sediment as maximum depth is still between 5 and 7 m depending on lake water levels (White 2000). Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as 2 m has accumulated (White 2000).

Aquatic weeds are a problem in Chestermere Lake. Weed growth in Chestermere is extensive because of its shallow depth with about 50% of the lakes area having depths under 2 m. The prevailing theory on weed growth is that weeds dominate in shallow lakes that contain relatively clear water. Some shallow lakes have poor water clarity either because of excessive algal growth or because of suspended sediments. These lakes tend to have few weed problems no matter how shallow they are. Among shallow lakes these two states, turbid but weed free versus clear but weed dominated exist as two stable possibilities for the same lake. The current evidence suggests that a lake can be pushed from weed dominated to weed free by a single event causing high suspended sediments. Turbid and algae dominated conditions then persist because the stability of both the water column and bottom sediments provided by the rooted plants disappears. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in 11 days. Inflow of this magnitude may actually contribute to maintaining water clarity in Chestermere Lake and thus the success of weeds compared to lakes of similar depth in Alberta.

It is important to note that water bodies less than 2 m deep are considered wetlands by Canadian and U.S. classification criteria. This is not to detract from the beauty of Chestermere but simply to acknowledge the reality that a large portion of Chestermere should be dominated by aquatic plants. Chestermere is vital to local recreational use and requires a strong educational drive to increase awareness that a fringe of reeds followed by floating leafed and submerged vegetation may be unavoidable. At the same time depth must be maintained in the lake to provide weed-free areas. Aggressive weed removal by mechanical methods will provide respite from the weeds but will probably be required on a continuous basis.

Unlike 1999, stratification was not observed in Chestermere Lake during 2000. As a result, dissolved oxygen concentrations remained above 8 mg·L^{-1} throughout the lake.

Total phosphorus concentrations averaged 25 µg•L^{-1} (Fig. 1) similar to values reported for 1984 and lower than the concentration from 1999 (Table 1). Total nitrogen concentrations averaged 229 µg•L^{-1} (Fig 2). The average nitrogen : phosphorus ratio was 9 compared to 11 in 1999 indicating an even stronger possibility for algal blooms as outlined in the 1999 report. Except for a growth spurt in late June, algal chlorophyll concentrations remained relatively stable through the summer at mesotrophic levels (Fig. 3). Enhanced algal growth was observed in late June and corresponded to a 2.5-fold increase in TP and increase in chlorophyll from 6 µg•L^{-1} to 24 µg•L^{-1}. However, maximum sampled chlorophyll *a* concentrations remained within the mesotrophic range and never reached official bloom (nuisance) conditions. A similar event occurred in late August 1999 when chlorophyll concentrations increased from 5 to 27 µg•L^{-1}. The algal peak observed on June 26 was no longer apparent on the next sampling date (July 13).

Ion concentrations were similar to previous years. Calcium (37 mg·L^{-1}), magnesium (14 mg·L^{-1}) and potassium (1 mg·L^{-1}) were identical to 1999 values and similar to values reported for 1983 in the Atlas of Alberta Lakes (Mitchell & Prepas 1990). Mean sodium (8 mg·L^{-1}) was half that reported in 1999 and similar to vaules reported prior to 1999. Chloride was indicated as a possible concern in 1999, concentrations were still high compared to historic values but declined to 5 mg·L^{-1} from the 1999 value of 7 mg·L^{-1}. Sodium and chloride are often contributed by de-icing salt from roads or other human sources. While the observed concentrations of sodium and chloride are not high, levels of chloride should be monitored until it is determined if concentrations are rising. In 2000, the Na:Cl ratio did increase compared to 1999 indicating urban runoff may have comprised a higher proportion of the Chestermere water balance.

Calling Lake

Calling Lake is considered *dimictic*, a term describing lakes that stratify and mix twice per year. During early spring, surface waters warm from 0° C and eventually reached the same temperature as deeper waters (around 4° C). This period of uniform temperature induces a spring mixing event often referred to as spring turnover. Stratification was apparent at 5 m by June and slowly moved downward through the summer to 8 m. Isothermic conditions were restored by September. Dissolved oxygen concentrations declined below the thermocline, particularly below 8 m. At the end of July, surface waters also became saturated in dissolved oxygen, likely as a result of algal growth.

Calling Lake is eutrophic according to mean summer phosphorus, chlorophyll *a* and transparency criteria. Eutrophic lakes are common in Alberta and are distinguished by high algal growth and low water clarity. Occasionally, algal growth may reach nuisance levels and detract from recreational aesthetics of this lake. Total phosphorus concentrations averaged 55 $\mu g \bullet L^{-1}$, similar to values recorded in 1988. Total phosphorus was at its highest during the late summer corresponding to peak algal growth (Fig. 1). Total nitrogen averaged 656 $\mu g \bullet L^{-1}$ and increased gradually from a July low through the summer (Fig. 2). TN:TP ratios averaged 14 and only dropped below 10 in September.

Chlorophyll *a* concentrations were low during the spring and through to mid-July (Fig. 3), given the amount of phosphorus available during the same period. Algal growth accelerated by mid-July likely corresponding to warming of the lake, the development of a thermocline, and reduced vertical mixing of water. By mid-August algal growth produced a large quantity of chlorophyll and likely a doubling algal biomass in the lake. To residents, this would have appeared as a large decline in water quality as Calling Lake switched from mesotrophic to hypereutrophic over a two to three week period. While this change from clear to green water would have been dramatic it was well within expected natural nutrient and chlorophyll parameters for the lake and does not necessarily represent recent pollution.

Major ion concentrations did not fluctuate appreciably through the summer but were low for a eutrophic lake. Mean values for calcium (22 $mg \bullet L^{-1}$), magnesium (6 $mg \bullet L^{-1}$), sodium (5 $mg \bullet L^{-1}$), and potassium (2 $mg \bullet L^{-1}$) were identical to those reported for 1988 in the Atlas of Alberta Lakes. Sulfate concentrations were low (3.6 $mg \bullet L^{-1}$) and consistent with concentrations of other ions. Total alkalinity, a measure of the ability for a lake to neutralize acidity, was 84 $mg \bullet L^{-1}$. The low ion concentrations are likely a result of the extensive wetlands in the drainage basin.

Gull Lake

Gull lake is intermediate in depth (8 m). However, the lake is polymictic during open water, and mixes at least once possibly many times through the spring and summer. This type of mixing occurs in Gull Lake because it has a relatively large surface area compared to its depth. Like a dimictic lake (see Calling Lake above) surface waters warm during the summer; however, mixing by wind action at the surface forces warm water to deeper depths. As a result, no true thermocline existed in Gull Lake. Weak stratification may occur occasionally in Gull Lake during hot calm weather. Such conditions were not observed during our monthly sampling.

The importance of temporary stratification events is that if they last several days they allow the reduction of dissolved oxygen concentrations in deeper water and the release of phosphorus into the water column when the temporary stratification breaks down. Cottage owners at Gull Lake should make an effort to document the occurrence of hot calm weather and the response in water colour and algae growth following hot spells. Presently these temporary events are not represented in our data. The Lakewatch data suggests bloom conditions were rare in 1999 and 2000.

Low oxygen concentrations [DO] during winter are possible. However, Gull Lake remained well oxygenated through the summer except in August when reduced DO was observed below 4 m depth. DO depletion occurred despite the lack of an apparent thermocline. A thermocline may have existed prior to sampling, however, the rapid decline in DO following this temporary stratification suggests the lake is more sensitive to oxygen depletion than originally thought in 1999. Dissolved oxygen in the top 4 m of water was always above 8 $mg^{.}L^{-1}$. In August, Do below 4 m declined to 5 $mg^{.}L^{-1}$ at the sediment surface. A severe winter with long ice-cover could significantly lower winter oxygen concentrations as seen by the rapid decline during August due to a short period of stratification. Dissolved oxygen concentrations would quickly return to acceptable levels after ice melt.

Gull Lake is eutrophic based on nutrient, chlorophyll and transparency criteria. This means the lake water, like many lakes in Alberta, is generally green with limited visibility, may undergo occasional blooms of noxious algae and could have low winter oxygen concentrations with a potential for winter fish-kill. Total phosphorus concentrations (TP) doubled through the summer (Fig. 1). Increasing TP is indicative of internal phosphorus loading derived from temporary stratification or continuous enrichment from warm sediments. Chlorophyll *a* concentrations likewise increased from oligotrophic conditions in early spring to mesotrophic and eutrophic conditions by mid July. Total nitrogen concentrations in Gull Lake appear high (>1300 $\mu g \bullet L^{-1}$). However, both nitrate and ammonium concentrations were relatively low indicating that the observed total nitrogen concentrations are likely not a problem. Total nitrogen averaged 46 times that of phosphorus similar to the ratio observed in oligotrophic lakes. Inputs from animal and human sewage (such as feed lots) contain N:P ratios less than 5. The high lake TN:TP ratios in combination with indications that Gull Lake nutrient concentrations have not changed over the past 17 years (Table 1) suggest human impacts have not become more pronounced in the last decade.

Concentrations of base cations were similar to 1999 values. Again the mean concentration of calcium was low (11 mg•L^{-1}), but concentrations were relatively high in magnesium (63 mg•L^{-1}), sodium (192 mg•L^{-1}) and potassium (21 mg•L^{-1}). Chloride concentrations were low for a eutrophic lake (4.8 mg•L^{-1}) and on an ion equivalent basis were less than 2% of sodium concentrations. The low chloride to sodium ratio indicated human and animal sewage were not as likely a source as local geology for the ion concentrations observed. Like many large shallow lakes in agricultural watersheds, Gull Lake cations were dominated by sodium and potassium (> 60% of ion equivalents). This is indicative of high evaporative loss both in the watershed and from the lake. Stream data are currently being collected from Gull Lake and will be instrumental in determining the water budget for this lake. A reduction in the amount of water derived from a watershed is an unavoidable consequence of our recent (decade) dry climate.

Lac La Nonne

Lac La Nonne is deep (20 m) with a water residence time of 6.5 years. Like Calling Lake, La Nonne is dimictic with a uniform mixing event occurring at 4º C in May. Stratification of the water column was already well underway by June 1 with the primary thermocline at 3.5 m and thermal stability between the surface and layers deeper than 1 m. Despite its depth Lac La Nonne is warm with typical summer surface temperatures of > 22º C and bottom temperatures of 12º C. Dissolved oxygen concentrations [DO] were typical for a dimictic lake being highly oxygenated at the surface (> 10 mg/L) and declining with depth below the thermocline (4 m). Sampling was limited to 11 m, where oxygen concentrations remained above 4 mg/L through the summer. Previous AENV data suggests this is typical, with much of the bottom remaining oxygenated until mid-July when anoxic conditions prevail below 15 m.

Lac La Nonne contains hypereutrophic phosphorus concentrations and eutrophic mean chlorophyll *a* concentrations. The high nutrient concentrations in La Nonne are a concern and were examined during initial development plans for La Nonne (1980). At that time, AENV determined that a majority of the high phosphorus loading to La Nonne came from the Majeau watershed, and was particularly related to the number of cattle. The total phosphorus load was estimated to be 3.6 times higher than natural levels primarily due to cattle operations which exported 5.5 times more phosphorus than was received from cottage sewage. In 2000, lake total phosphorus concentrations averaged 187 µg•L^{-1}, similar but slightly lower than values recorded in 1978-9. Total phosphorus was at its highest during the mid summer and remained high through the summer (Fig. 1). Total nitrogen averaged 1526 µg•L^{-1} and increased from July to August (Fig. 2). TN:TP ratios averaged 10 but were particularly low (6) by late August. A shift to noxious and potentially toxic algae would be expected during these late summer months. Available data from 1979 support the occurrence of a shift in algal species with Cyanophyta comprising 100% of the algal population after July.

Chlorophyll *a* concentrations were surprisingly low during the spring and through to mid-July (Fig. 3). A bloom in algal growth occurred at the end of July which appeared to collapse in August followed by another smaller bloom in late August. These types of cyclical growth spurts are not uncommon for algae in hypereutrophic lakes. Unfortunately, the collapse periods can cause significant water quality concerns noted predominately by their odor. Undoubtedly, the rapid change from clear to green water in mid July would have been dramatic to local residents. Improvements in water quality at Lac La Nonne should be possible if phosphorus loading from cattle operations are controlled. The process will be slow because of the long water retention time and because phosphorus has already accumulated in bottom sediments and causes elevated concentrations in deeper waters.

Major ion concentrations did not fluctuate through the summer. Mean values for calcium (32 $mg{\bullet}L^{-1}$), magnesium (10 $mg{\bullet}L^{-1}$), sodium (19 $mg{\bullet}L^{-1}$), and potassium (12 $mg{\bullet}L^{-1}$) were within an expected range for this lake. Chloride concentrations were low (4 mg/L). Sulfate concentrations were 13 $mg{\bullet}L^{-1}$ and consistent with concentrations of other ions. Total alkalinity was 153 $mg{\bullet}L^{-1}$ indicating that the lake was highly protected from acidification.

Sandy Lake

Sandy Lake is a shallow lake for its size with a maximum depth of 4.5 m. The 2000 data suggest Sandy Lake is monomictic or polymictic becoming stratified in the winter but remaining completely mixed through the summer. Water temperatures in Sandy Lake quickly rose to 13° C in the south basin and 15º C in the north basin. Our hydrolab data do not include July 2000, however, it appears the lake remained cooler than usual as surface temperatures historically exceed 20º C into August.

Sandy Lake was consistently hypereutrophic throughout the sampling period. The two basins of Sandy Lake behaved similarly in respect to nutrient and chlorophyll *a* concentrations. Mean total phosphorus concentrations were 132 and 140 $\mu g{\bullet}L^{-1}$ for the north and south basins, respectively. In May, TP concentrations were 150 $\mu g{\bullet}L^{-1}$ and declined with some fluctuation through the summer (Fig. 1). Compared to the other lakes, Sandy Lake contained high concentrations of nitrogen with TN ranging from 4.6 to 5.4 $mg{\cdot}L^{-1}$, with a mean of 5.0 $mg{\cdot}L^{-1}$ (Fig. 2). Despite these high TN concentrations nitrate-nitrite concentrations remained below 10 $\mu g{\bullet}L^{-1}$. TN:TP ratios were high in Sandy lake averaging 40 and 37 for the north and south basins, respectively.

Chlorophyll *a* concentrations in Sandy Lake north and south were high. Though the maximum concentration observed (200 $\mu g{\bullet}L^{-1}$) is exceeded in other lakes, the mean chlorophyll concentrations (123 and 113 µg•L^{-1}) are among the highest in Alberta (Fig. 4). The algal community was in constant bloom conditions from early August through to the end of September with CHL : TP ratios > 1. These conditions are highly undesirable for recreation and represent low water quality. Historic data suggest water quality in Sandy Lake has declined (Table 1) with increased phosphorus and 2 to 4-fold increases in chlorophyll concentrations. Although Sandy Lake has always been fertile, loss of inflow, reduced lake depth and increased pressure from cottage development have enhanced the fertility of the lake. Significant management controls will have to be implemented on Sandy Lake to restore conditions that were described by locals as once being excellent.

Cation and anion concentrations were low for a hypereutrophic lake known to receive groundwater. Calcium concentration (7 mg·L^{-1}) and magnesium (9 mg·L^{-1}) were similar to historic values. Sodium (128 mg·L^{-1}) and potassium (16 mg·L^{-1}) were almost double 1978-9 values and 20% higher than 1988-9 values. Chloride concentrations were 3-fold higher than 1978-9 values and double 1988-9 values. The continuous rise in both sodium and chloride likely reflects a loss of surface and shallow groundwater inflows. Both sodium and chloride can be contributed by deeper groundwater, however, the Na:Cl ratio has declined by > 30% indicating human and animal inputs may be a serious problem for Sandy Lake.

Shorncliffe Lake

Shorncliffe Lake is shallow (4 m) with most of its depth less than 2 m. Alberta Environment has little data on Shorncliffe lake, most coming from earlier involvement in Lakewatch during 1992. Like other shallow lakes in Alberta it is polymictic with potential stratification over the winter and a generally mixed water column through the summer. Water temperatures were >20º C from surface to the bottom by August. The water column remained well oxygenated throughout the summer.

Shorncliffe Lake is eutrophic by phosphorus criteria but hypereutrophic by chlorophyll *a* criteria. The mean total phosphorus concentration (67 µg•L^{-1}) was similar to reported values from 1992 (Table 1). Mean total nitrogen concentration (2731 µg•L^{-1}) was high for a eutrophic lake resulting in a TN:TP ratio of 40.

Chlorophyll *a* concentrations in Shorncliffe Lake started at expected eutrophic levels (10 µg•L-1) but rose to hypereutrophy (>25 µg•L^{-1}) by early July. Algal production per unit phosphorus rose slowly through the summer reaching "bloom" conditions at the end of July when maximum chlorophyll concentrations were recorded (72 µg•L-1). Algal growth may have been enhanced by ammonium concentrations that were above 20 µg•L^{-1} for most of the summer.

While phosphorus and chlorophyll *a* concentrations were within expected ranges for a shallow eutrophic lake, ion concentrations were more remarkable. Calcium concentration (16 mg/L) was low, while concentrations of magnesium (187 mg/L), sodium (732 mg/L), and potassium (34 mg/L) were high. Sulfate (537 mg/L) and chloride (944 mg/L) were exceptionally high. Mean specific conductivity was 4620 µs•cm^{-1} indicating the lake is moderately saline. The Na:Cl ratio was 1.2, indicating very high chloride concentrations even when compared to saline lakes in southern Alberta. Sodium concentrations increased slightly between 1992 and 2000, however, chloride concentrations doubled. Without inflow data it is difficult to determine the source of such high chloride concentrations. Sodium chloride deposits do exist in eastern Alberta but are deep. It is unlikely that the Na:Cl ratio is natural. The few cottages that exist around the lake likewise would explain the observed Na:Cl ratio. Animal waste may be one source but even this is unlikely to provide such a large chloride load. Oil rig operations and other potential polluters should be examined in the area. (N.B. Further investigation by AENV suggests the source may be a surface disposal site for saline groundwater. Discussion with the municipality and monitoring by AENV is ongoing).

Sylvan Lake

Sylvan Lake is relatively deep (18 m). Like Calling Lake (above) it is dimictic. Rapid heating resulted in warm surface waters by the end of June and a thermocline at approximately 4 m. The depth of the thermocline appeared to fluctuate through the summer between 4 and 8 m. Dissolved oxygen concentrations began to decline at depths below 8 m but typically remained above 7 mg/L to a depth of 12 m.

Sylvan Lake is mesotrophic by phosphorus and chlorophyll *a* criteria. Water quality is generally exceptional with the potential for occasional declines due to minor algal blooms. The mean total phosphorus concentration was 19 µg•L^{-1} which has not changed from reported values in 1984 (Table 1). Mean total nitrogen was 618 µg•L^{-1}, historic values of total nitrogen were not available. Mean TN:TP ratio was 36, typical for a deep lake with low algal productivity. Chlorophyll *a* concentrations were < 3 µg•L^{-1} bordering on oligotrophic standards through the summer until mid-August (Fig. 3). Chlorophyll *a* concentrations rose during the late summer corresponding to increased water temperature below 4 m. Chlorophyll production per unit TP remained below 0.5 indicating algal production remained low for the amount of nutrients in the system. Water quality in Sylvan Lake is considered one of the best in central Alberta for recreational use.

Cation and anion concentrations did not fluctuate through the summer. Calcium concentration (17 mg·L^{-1}), magnesium (37 mg·L^{-1}), sodium (63 mg·L^{-1}), potassium (8 mg·L^{-1}) and sulfate (13 mg/L) were not different from values reported in 1986. Chloride concentrations were low (2.8 mg/L) but were at least double the trace concentrations reported in 1986. The source for the elevated chloride could be agricultural but may also be related to increased human pressure and recreational activities. Further monitoring of sources will be required.

Vincent Lake

Vincent Lake has an intermediate depth (9.5 m) but maintains this over a large portion of its area such that its mean depth is 5.7 m. Vincent Lake boarders on being dimictic. Stratification was apparent in early July at approximately 3 m depth. Stratification remained below 4 m through July but the lake was mixed mid August. The lake remained well oxygenated over most of its depth for the summer. Oxygen was depleted below 5 m from late July through August but the August breakdown in stratification restored oxygen concentrations in September.

Vincent Lake is eutrophic by phosphorus and chlorophyll *a* criteria. The mean total phosphorus concentration was 49 µg•L^{-1} which is substantially lower than values reported for 1983 and 1992 (Table 1). Mean total nitrogen was 1726 µg•L^{-1}, slightly higher than values reported in 1983. Mean TN:TP ratio was 47 which is typical for lakes what are not polluted. Chlorophyll a concentrations were < 4 µg•L^{-1} bordering on oligotrophic standards through the summer until early August. Chlorophyll *a* concentrations rose above 25 µg•L^{-1} by mid-August and remained eutrophic until mid-September when they declined again (Fig. 3). Chlorophyll *a* production per unit TP remained below 0.5 indicating algal biomass remained low for the amount of nutrients in the system.

Cation and anion concentrations did not fluctuate through the summer. Calcium (30 mg·L^{-1}), magnesium (35 mg·L^{-1}), sodium (16 mg·L^{-1}), potassium (30 mg·L^{-1}), sulfate (49 mg/L) and chloride (5 mg/L) concentrations were typical for eutrophic lakes. Total alkalinity (222 mg/L $CaCO_3$) indicated a well buffered system.

8. Summary

Data from the eight Lakewatch lakes sampled in 2000 do not indicate a reduction in water quality from historical data except perhaps in Sandy and Shorncliffe Lakes. Calling, Chestermere, Gull and Sylvan lakes demonstrated little to no change in the common quality variables of total chlorophyll *a*, Secchi depth, nitrogen and phosphorus while Lac La Nonne and Vincent Lakes may have demonstrated improvement. Sandy and Shorncliffe lakes appear to have demonstrated declines in water quality; however, these latter four lakes are highly productive and may demonstrate considerable variation in quality from year to year.

Cottage owners from each of the sampled lakes have concerns about perceived problems on their lake. For example, Sandy Lake is experiencing continuous algal blooms. Chestermere has a problem with excessive weed growth and occasional blooms. We have attempted to characterize these problems with current data. In the case of Sandy Lake for example, cottagers can expect continuing poor water quality unless nutrient concentrations are reduced and water levels are stabilized. The Lakewatch program is not designed to provide solutions to aquatic weed problems, however, we have attempted to discuss some of the issues surrounding weed growth and the balance in shallow lakes between high water quality and weeds versus poor water quality and weed-free conditions.

Except in Sandy and Shorncliffe Lakes, ion concentrations were largely unchanged from previous records, indicating that the water balance had not shifted greatly to evaporative loss compared to the previous decade. If reduced inflow volumes and heightened evaporation had occurred we would have expected higher ion concentrations in 2000 than in previous years. In both Sandy and Shorncliffe Lakes an increase in chloride concentrations and ratio with sodium was alarming. Potential polluters should be monitored in these lake basins.

Smaller points have been raised such as noting trends in N:P ratios. Most importantly, cottage owners should note the occurrence of water quality declines in the form of algal blooms or high turbidity along with notation for recent climate conditions and their feeling on why the problem occurred. These concerns can be submitted to the Lakewatch page (PrestonM@telusplanet.net) and will be posted to maintain a directory of problem events. Simply measuring lake surface temperature and Secchi depth on a daily or weekly basis could vastly improve our understanding of lakes in Alberta.

It is important to note the costs of the Lakewatch program. The eight lakes sampled in 2000 cost Alberta Environment $5000 for sample analysis and shipping and an additional $1000 for equipment some of which can be reused. ALMS spent an additional $5000 to cover travel costs. The time contributed by the volunteers and Alberta Environment staff probably exceeds these totals.

Finally, 2000 was a successful year for Lakewatch. Training, sample collection, processing and the quality of final data were remarkable. This was the second year of a new program structure and it proceeded without difficulty largely due to the expertise and dedication of Alberta Environment staff and the volunteers. Due to the success of 2000, Lakewatch expanded to include twenty lakes during the summer of 2001. The work is currently underway and has met with similar success. On behalf of ALMS and Alberta Environment, I look forward to the continued cooperation of all the parties that support Lakewatch and hope it continues to expand for the benefit of all lake communities in Alberta.

9. References

Most **historic data** were obtained from:

The Atlas of Alberta Lakes, Mitchell P. and E. E. Prepas (eds) © 1990 University of Alberta Press, Edmonton.

White, J. (2000). Water quality of Chestermere Lake: A state of the knowledge report. Aquality Environmental Consulting Ltd.

Additional Reading

Most scientific information can be found in journals For example the following reference summarizes the why **macrophytes** dominate in some lakes and not in others:

Scheffer, M., S. H. Hasper, M-L Meijer, B. Moss, & E. Jeppesen. (1993). Alternative equilibria in shallow lakes. TREE 8(8) 275-279.

An alternate and excellent source for additional reading on **macrophyte growth and importance in lakes** is:

The Structuring Role of Submerged Macrophytes in Lakes. E. Jeppesen, M. Sondergaard, M. Sondergaard and K. Christoffersen (eds.) © 1998 Springer, N.Y.

Eutrophication of lakes

Eutrophication: Causes, consequences, Correctives. Edmondson, W. T. (Ed.) © 1969 Washington D.C., National Academy of Sciences.

Schindler, D. W. (1975). Whole lake eutrophication experiments with phosphorus, nitrogen, and carbon. Verh. Internat. Verin. Limnol. Stuttgart **9:** 3221-3231.

Trophic state

Canfield, D. E. Langeland, K. A., Maceina, M. J., Haller, W. & J. R. Jones (1983). Trophic state classification of lakes with aquatic macrophytes. Can. J. Fish. Aquat. Sci. **40:** 1713-1717.

Nurnberg, G. 1996. Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake Reserv. Man. **12(4):** 432-447.

Toxic algae

Kotak, B. G., S. L. Kenefick, D. L. Fritz, C. G. Rousseaux, E. E. Prepas & S. E. Hrudey (1993). Occurrence and toxicological evaluation of cyanobacterial toxins in Alberta lakes and farm dougouts. Wat. Res. **27(3):** 495-506.

Table1: Mean values from summer 2000. Historic values indicated with * are reported in the Atlas of Alberta lakes. Total Kjeldahl Nitrogen (TKN) is reported along with total nitrogen (TN) in brackets where available or (s) indicating the TKN and TN values were within 3 µg•L^{-1} of each other.

Lake	Year	TP (µg/L)	Chl (µg/L)	Secchi (m)	TKN (µg/L) (TN)
Calling Lake	1988* 2000	50 55	19.1 20.6	2.7	770 656 (s)
Chestermere Lake	1984* 1999 2000	28 32 25	6.5 7.6	2.7	482 335 200 (229)
Gull Lake	1983* 1999 2000	36 44 39	7.3 8.0 8.0	2.9 1.9	1540 1528 1546 (s)
Lac La Nonne	1988* 2000	168 187	55.5 20.6	1.9	2224 1526 (s)
Sandy Lake N.	1978 1988* 2000	90 211 132	59 67.8 123.1	0.5 0.6	4750 3736 4998 (s)
Sandy Lake S.	1978 1988* 2000	81 88 140	35 29.9 113.4	1.3 1.5	3330 2876 4962 (s)
Shorncliffe Lake	1992 2000	71 67	9.1 30.5		 2731 (s)
Sylvan Lake	1984-6* 2000	20 19	3.8 4.5	5.0	NA 618 (s)
Vincent Lake	1983 2000	235 50	16.6 13.0	3.3	(1354) 1726 (s)

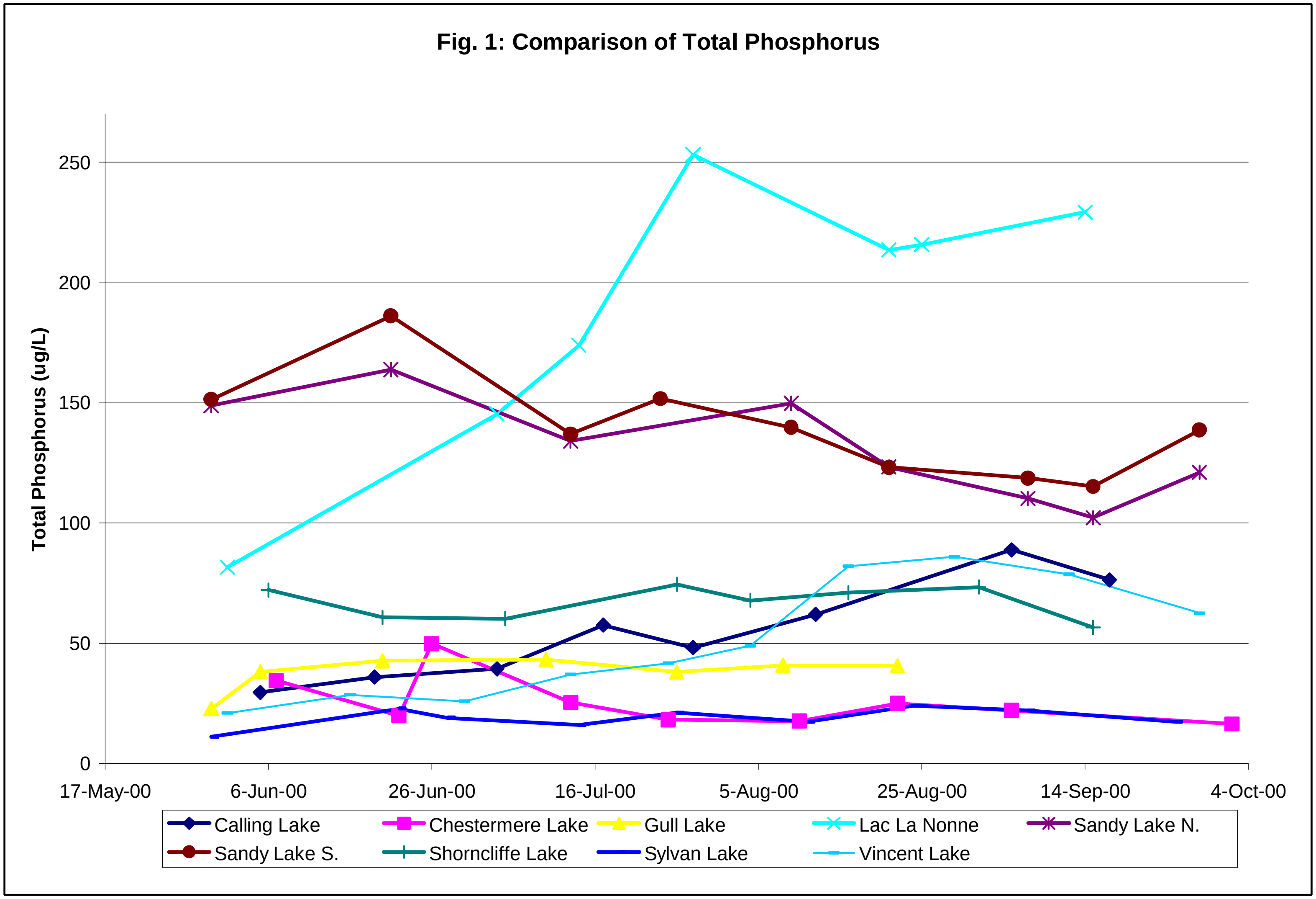


Fig. 1: Comparison of Total Phosphorus
Total Phosphorus (ug/L)
0
50
100
150
200
250
17-May-00
6-Jun-00
26-Jun-00
16-Jul-00
5-Aug-00
25-Aug-00
14-Sep-00
4-Oct-00
Calling Lake
Chestermere Lake
Gull Lake
Lac La Nonne
Sandy Lake N.
Sandy Lake S.
Shorncliffe Lake
Sylvan Lake
Vincent Lake

Fig. 2: Comparison of Total Nitrogen

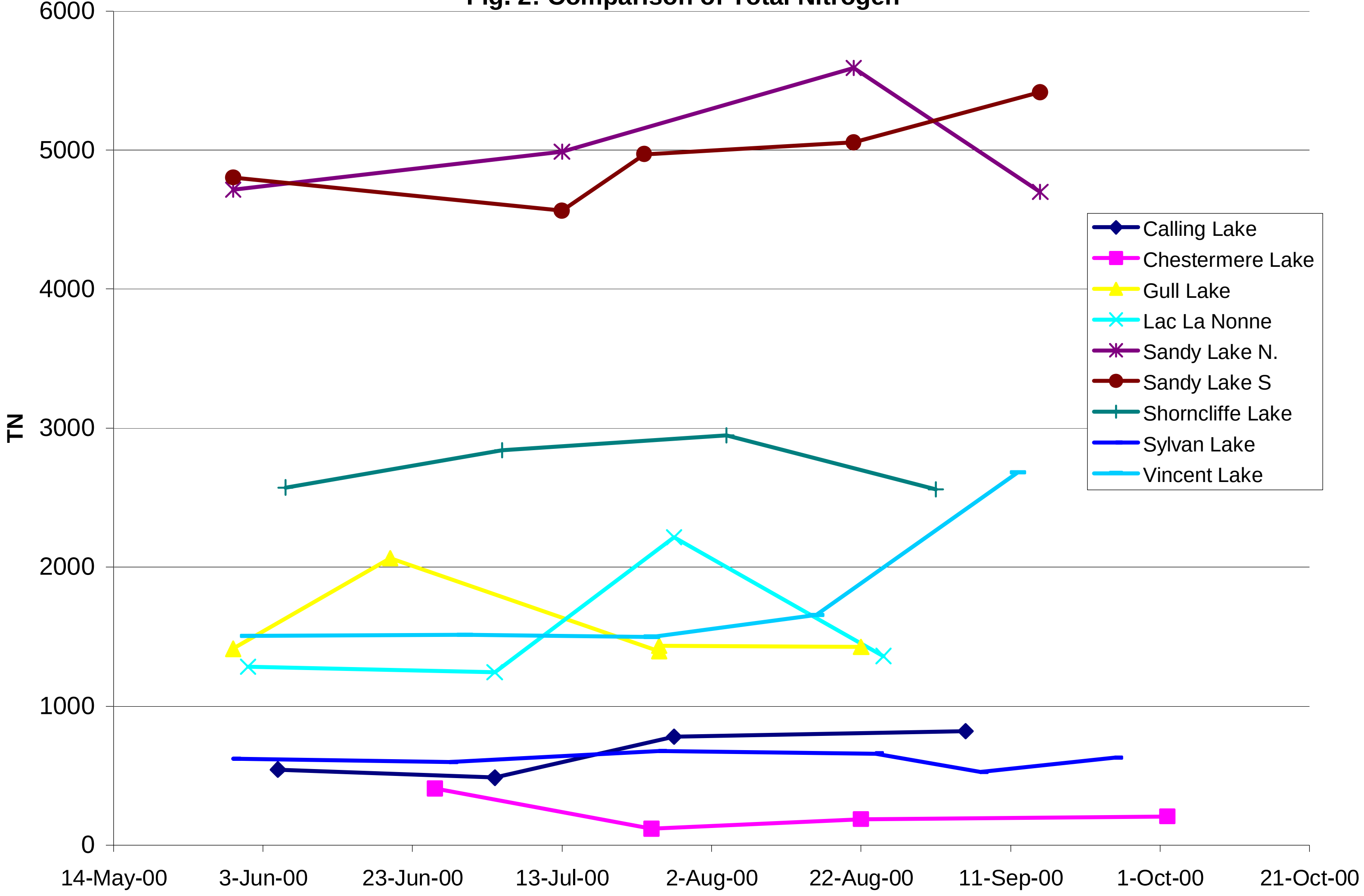


Fig. 3: Chlorophyll a

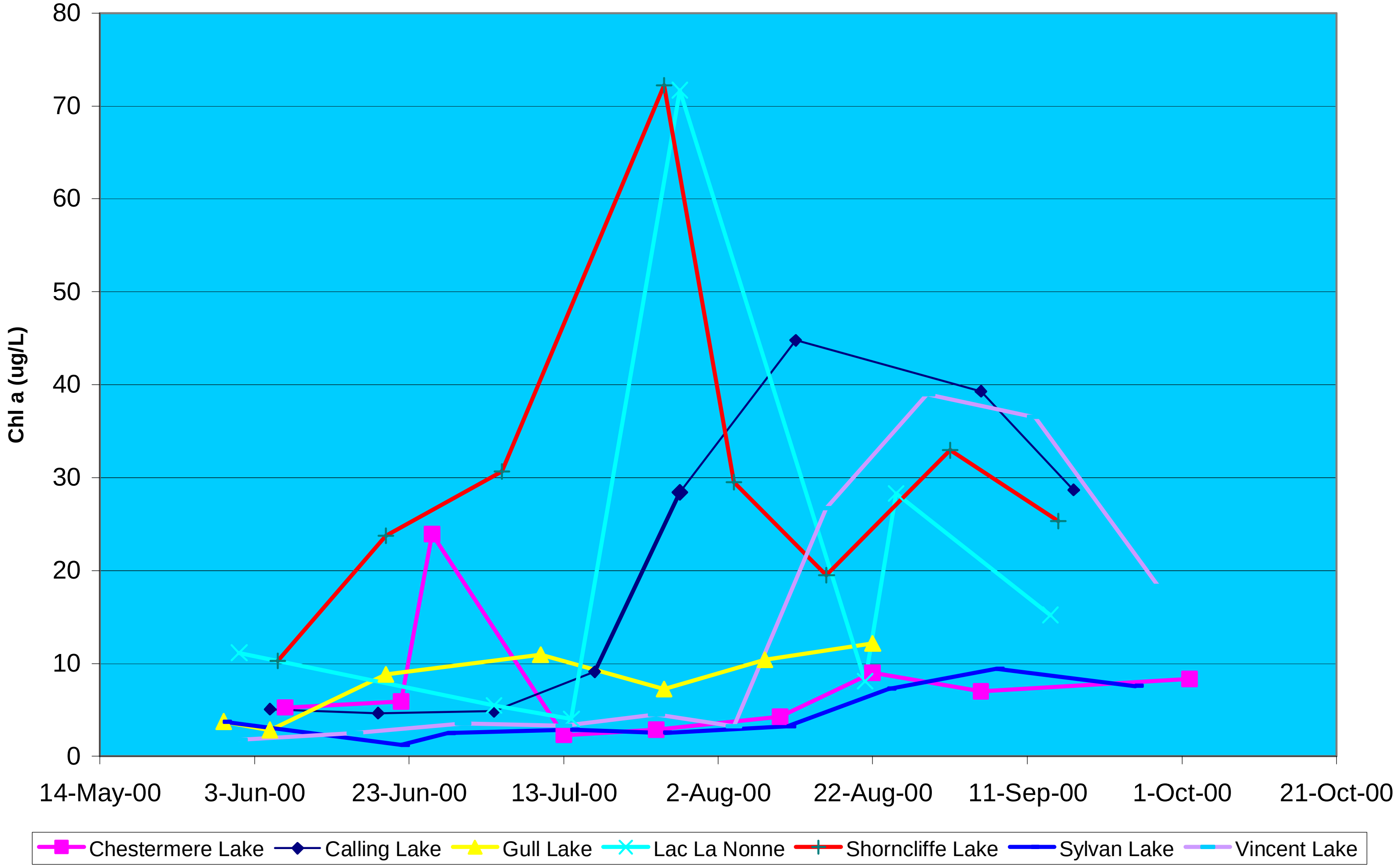
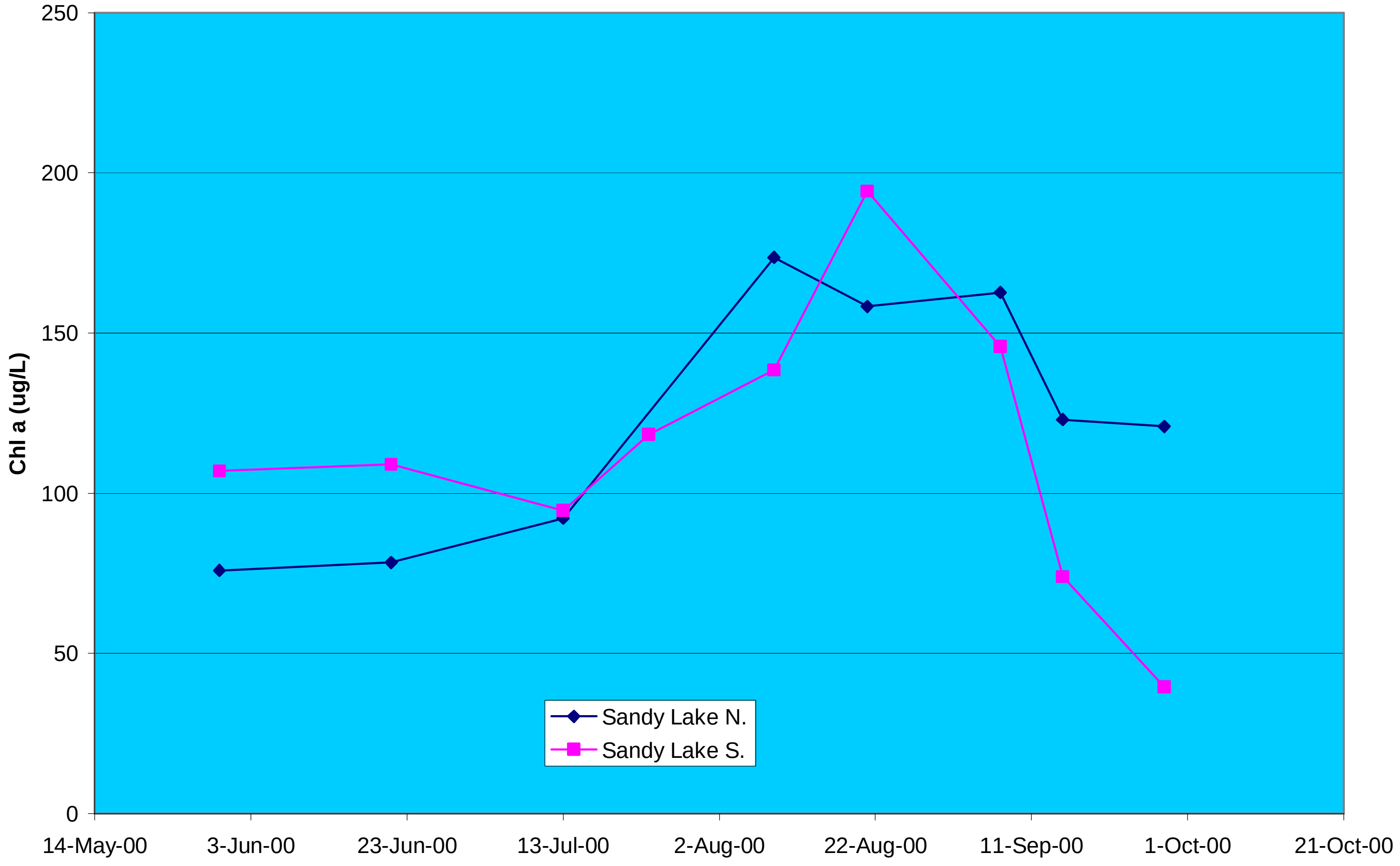
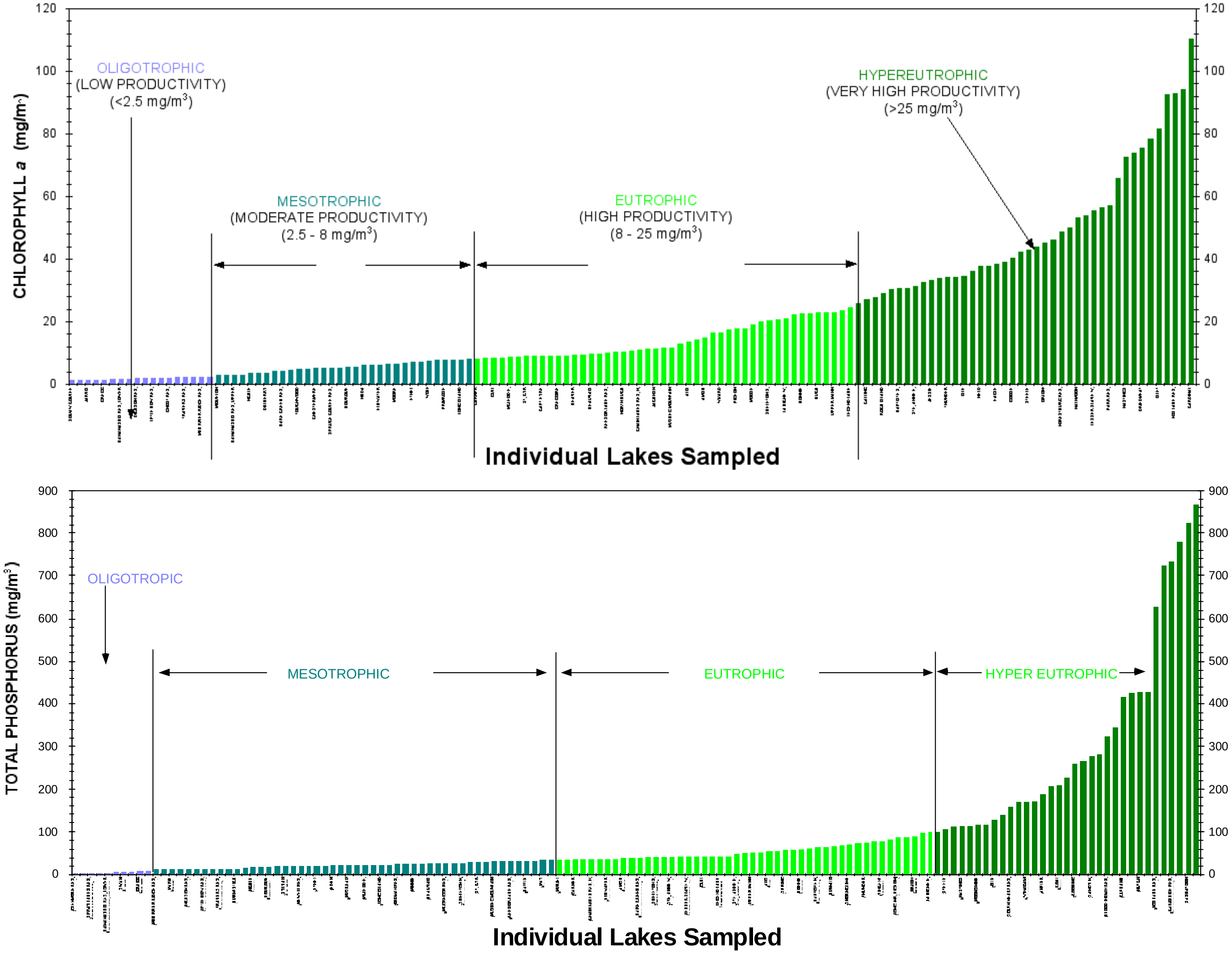


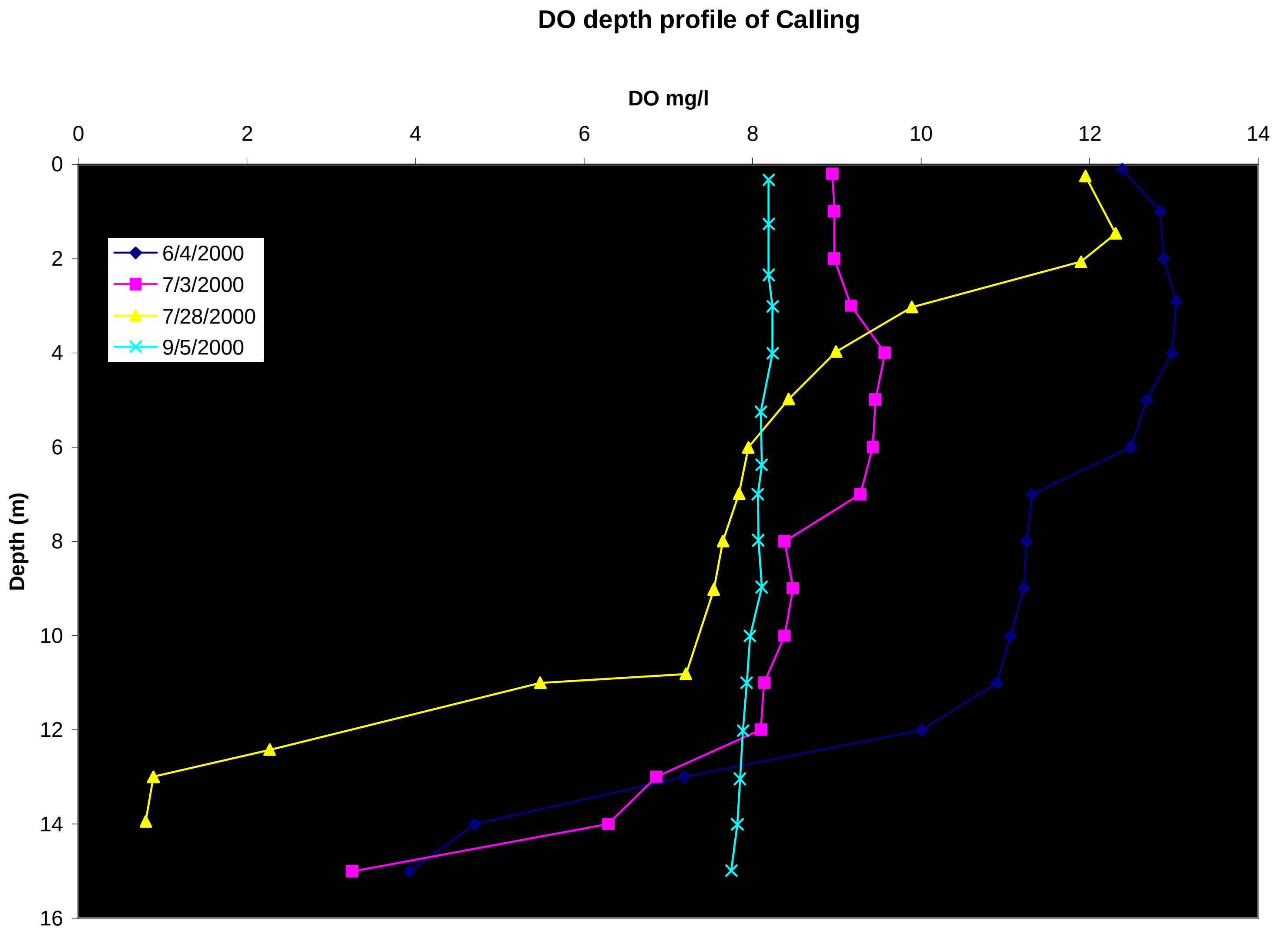
Fig. 4: Chlorophyll a for Sandy



Appendix 1: Total Chlorophyll *a* and phosphorus concentrations for selected lakes in Alberta. Data collected by Alberta Environment May-September 1980-1993



Appendix 2: Dissolved oxygen and temperature profiles



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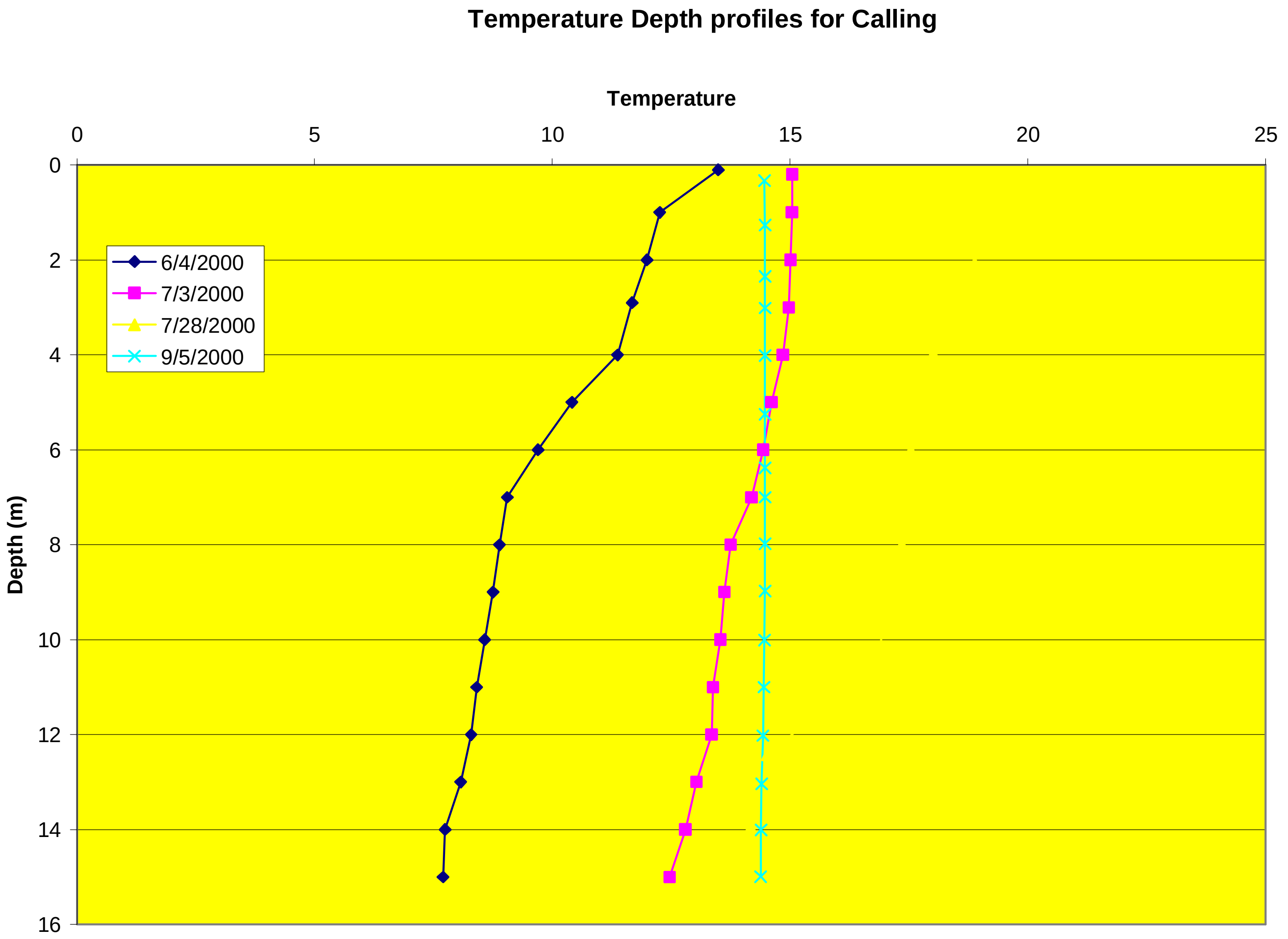

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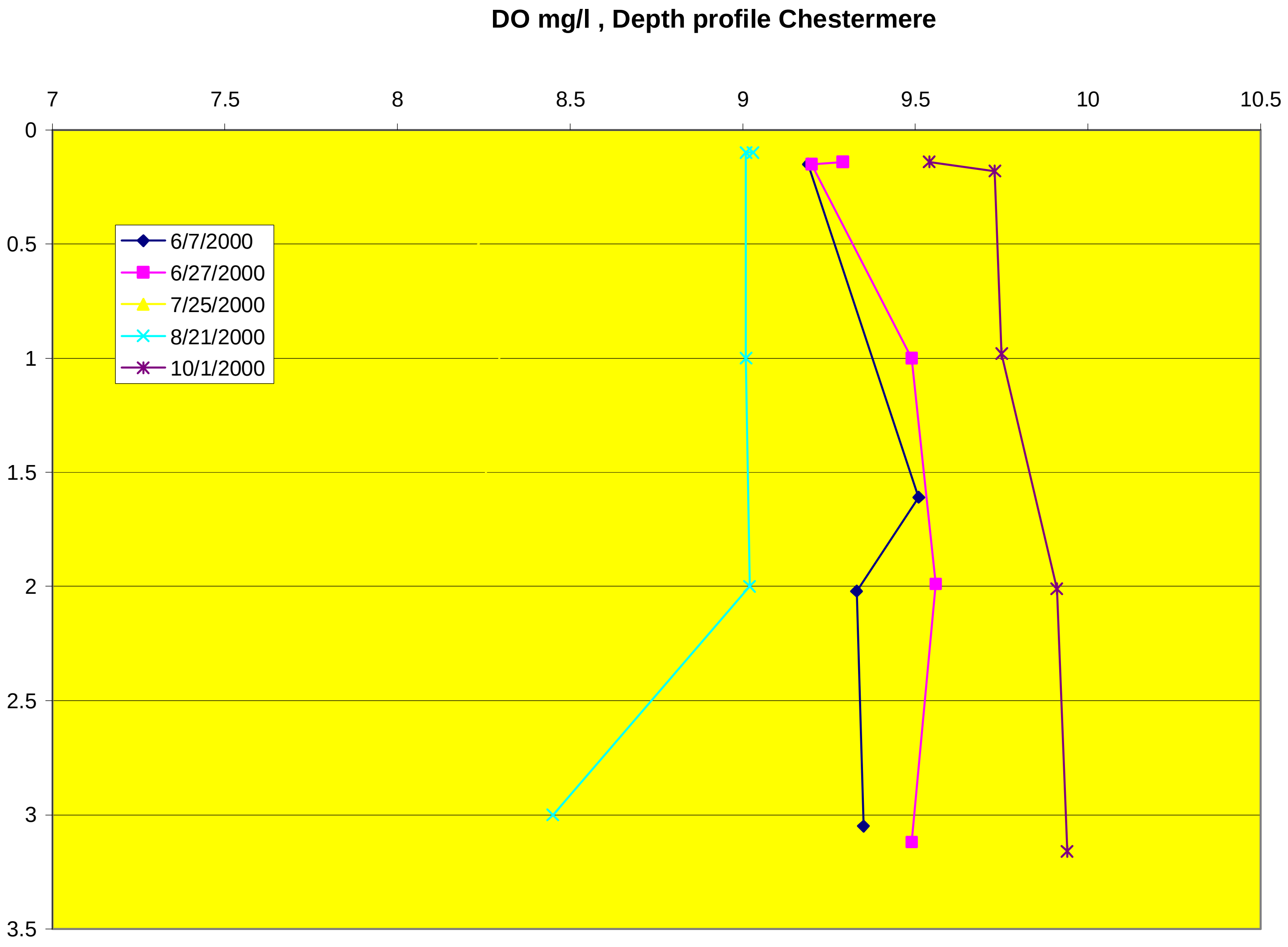

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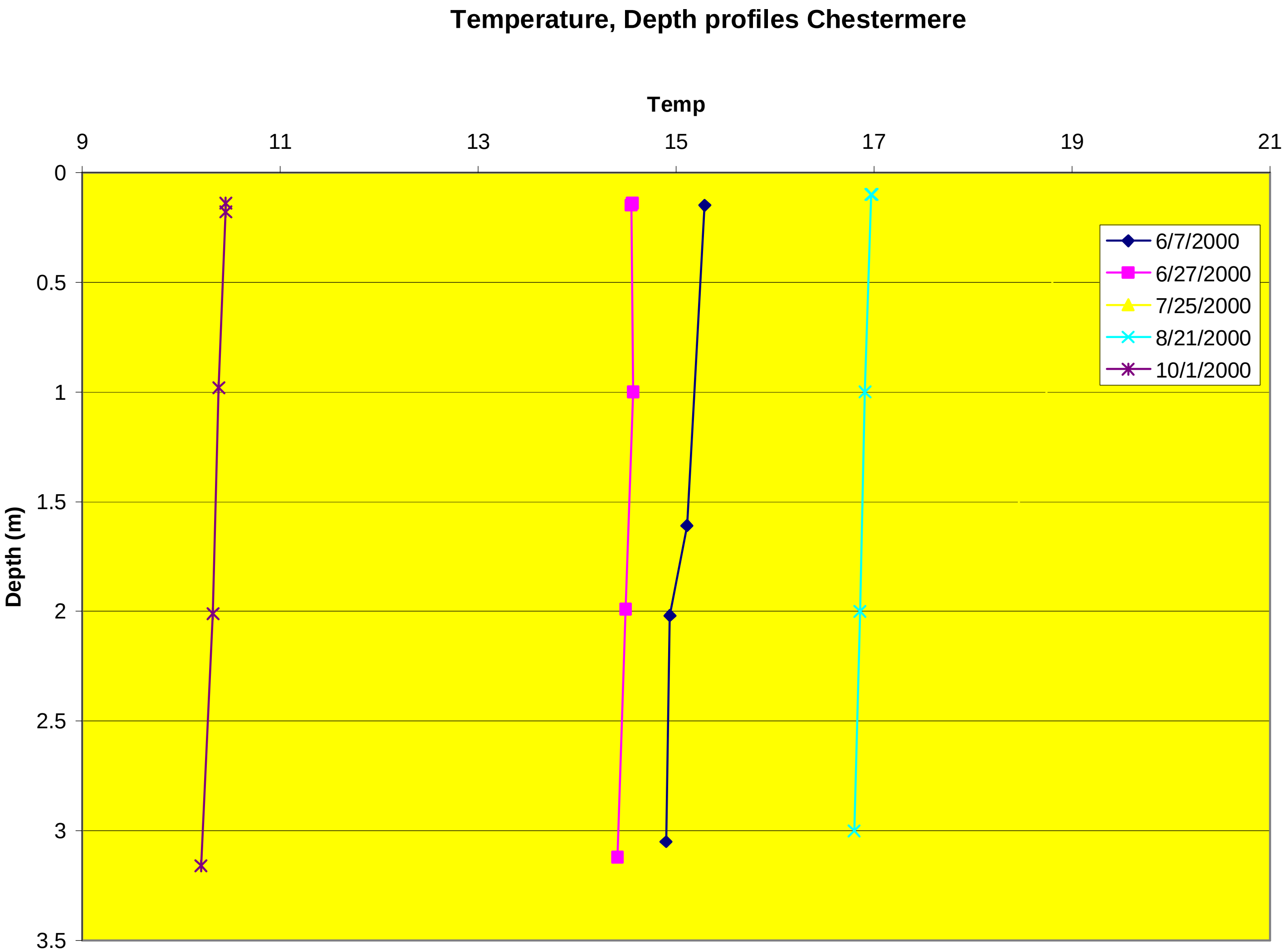

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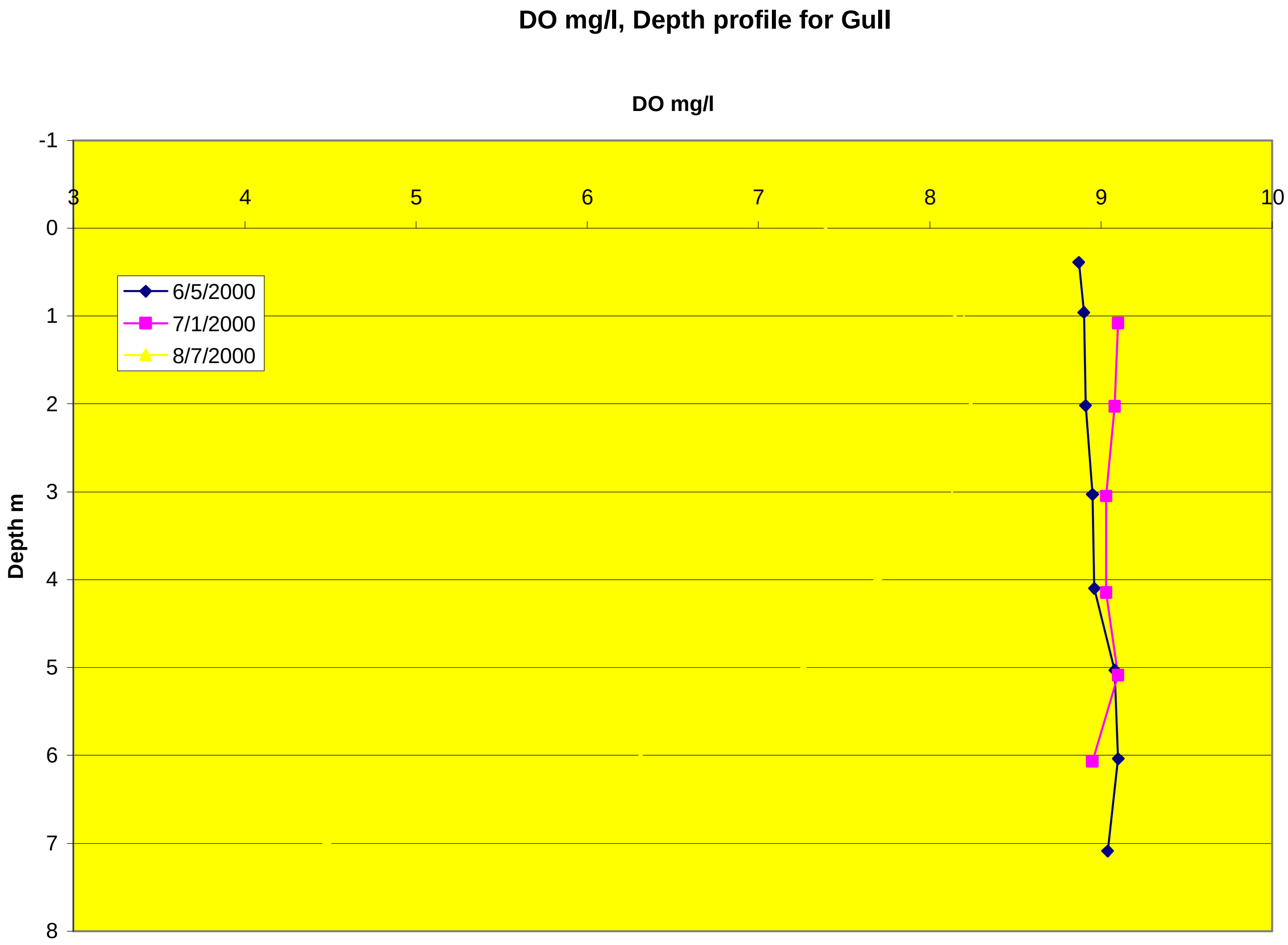

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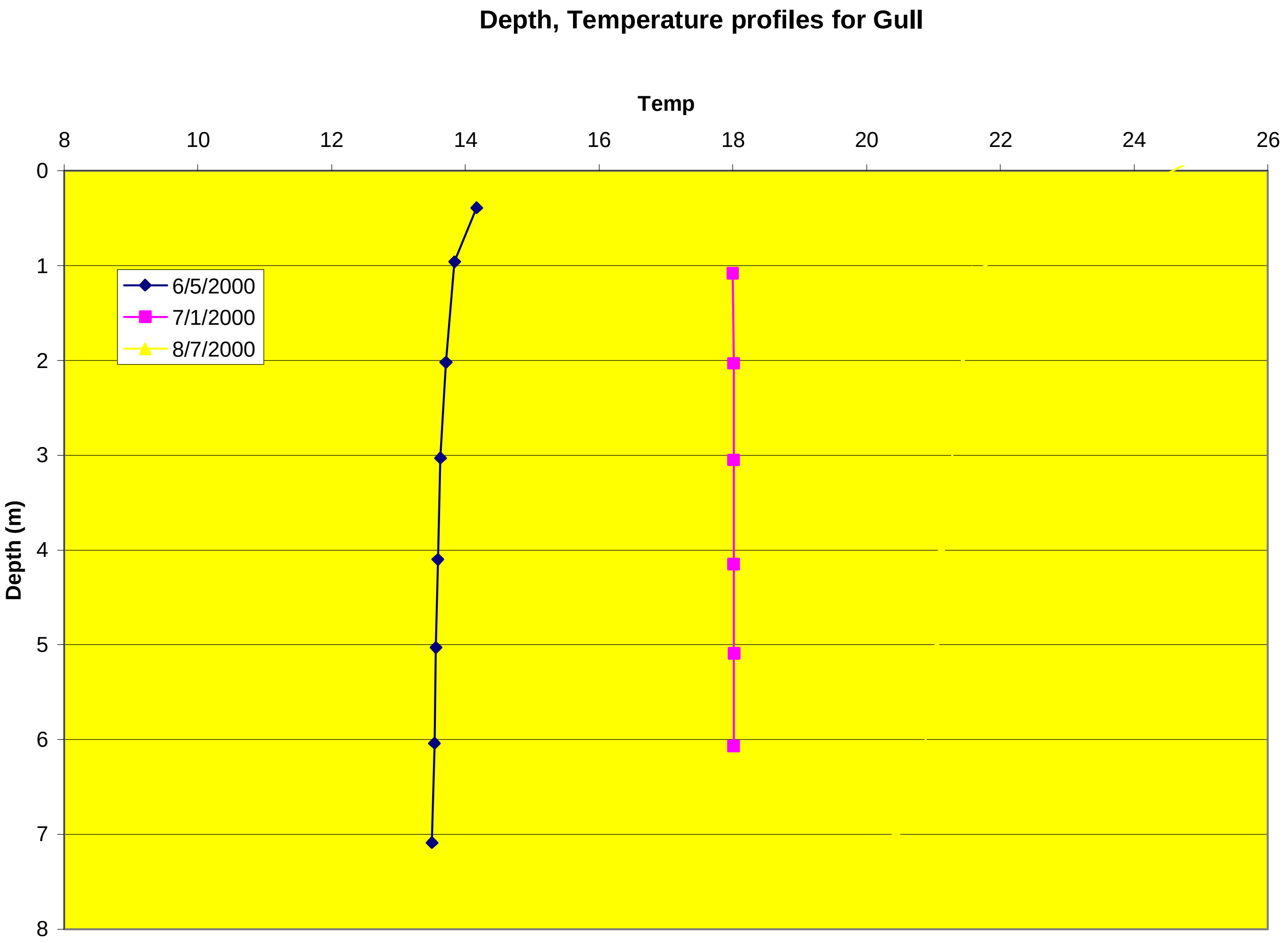

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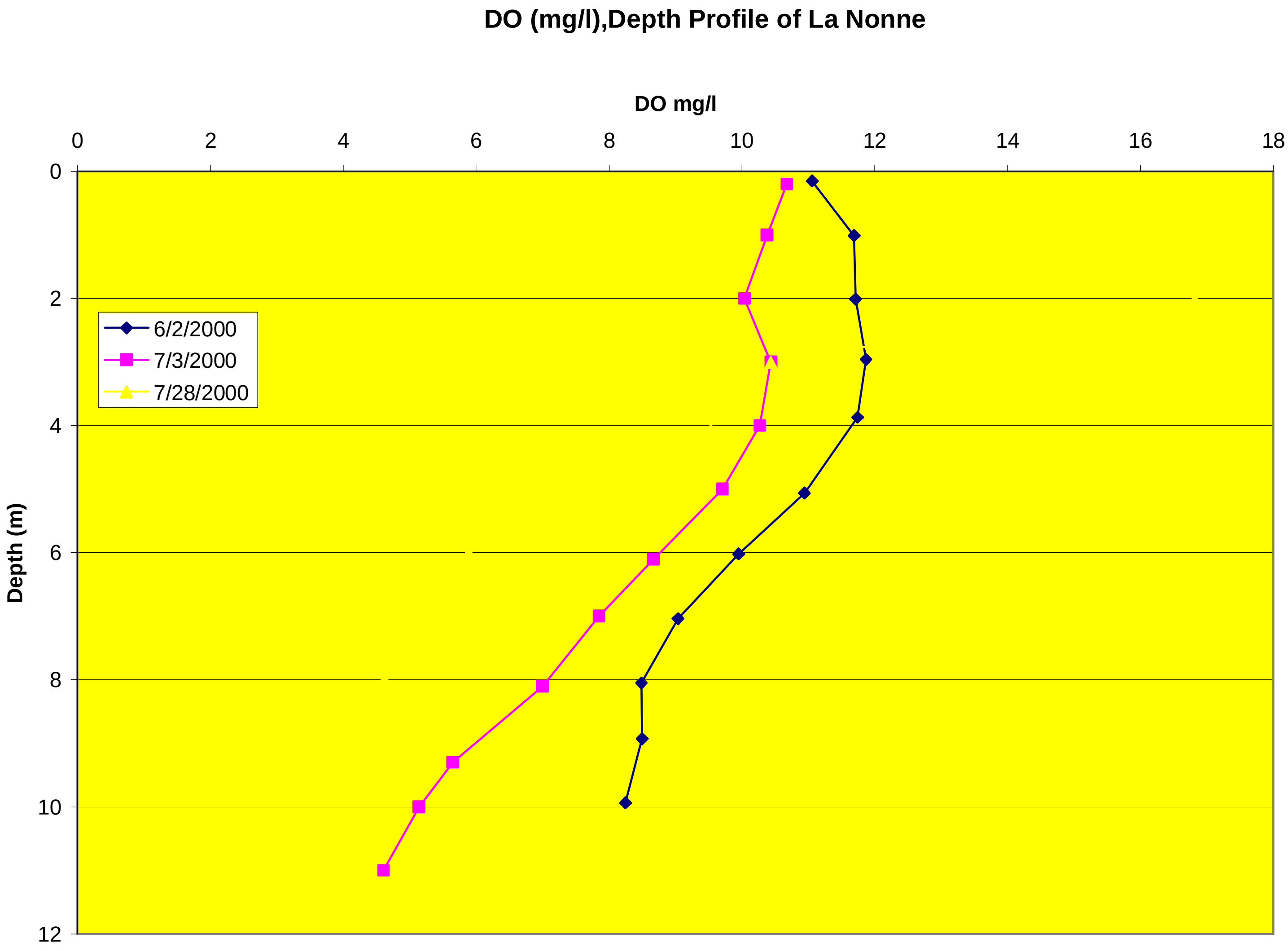

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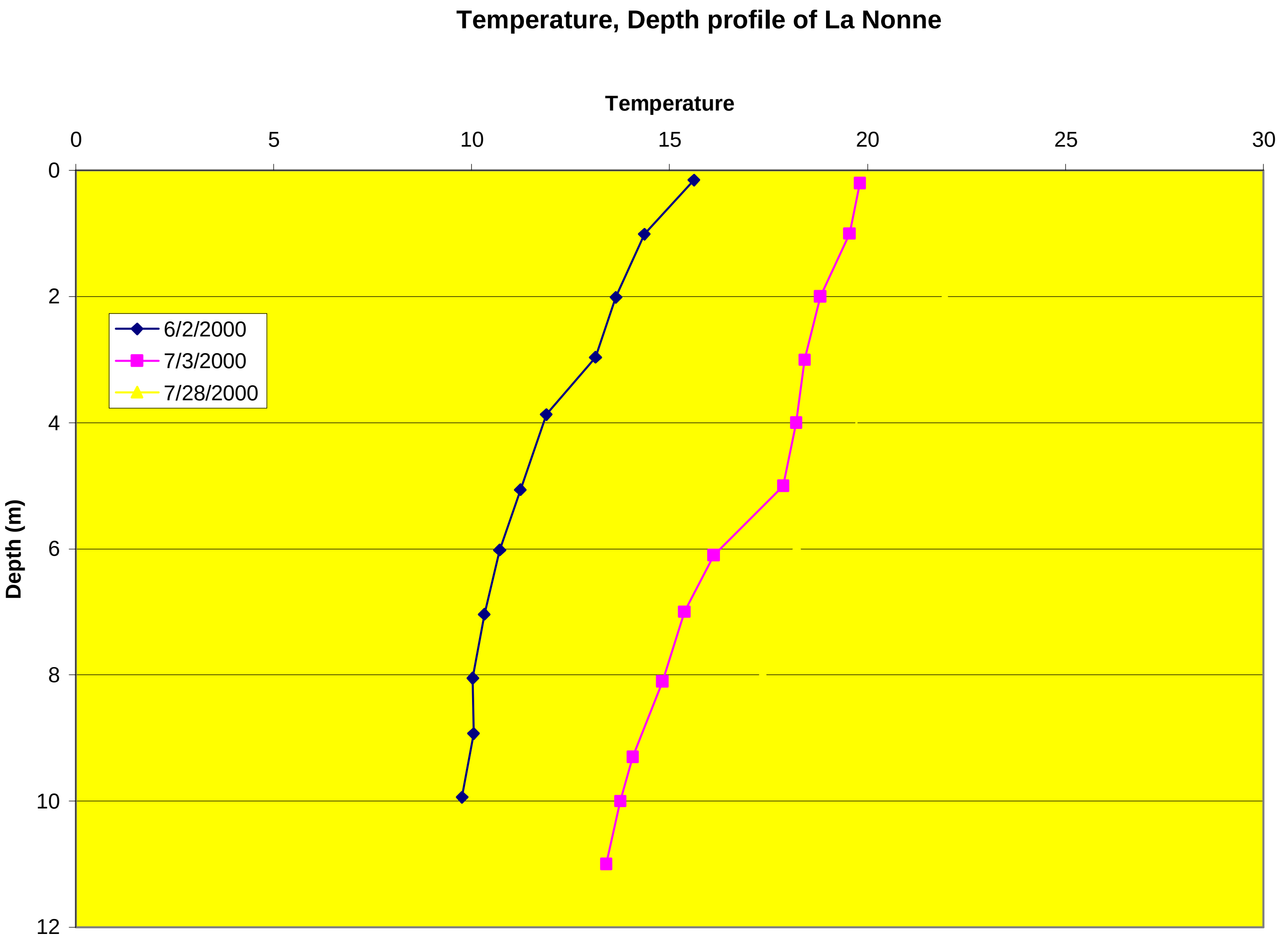

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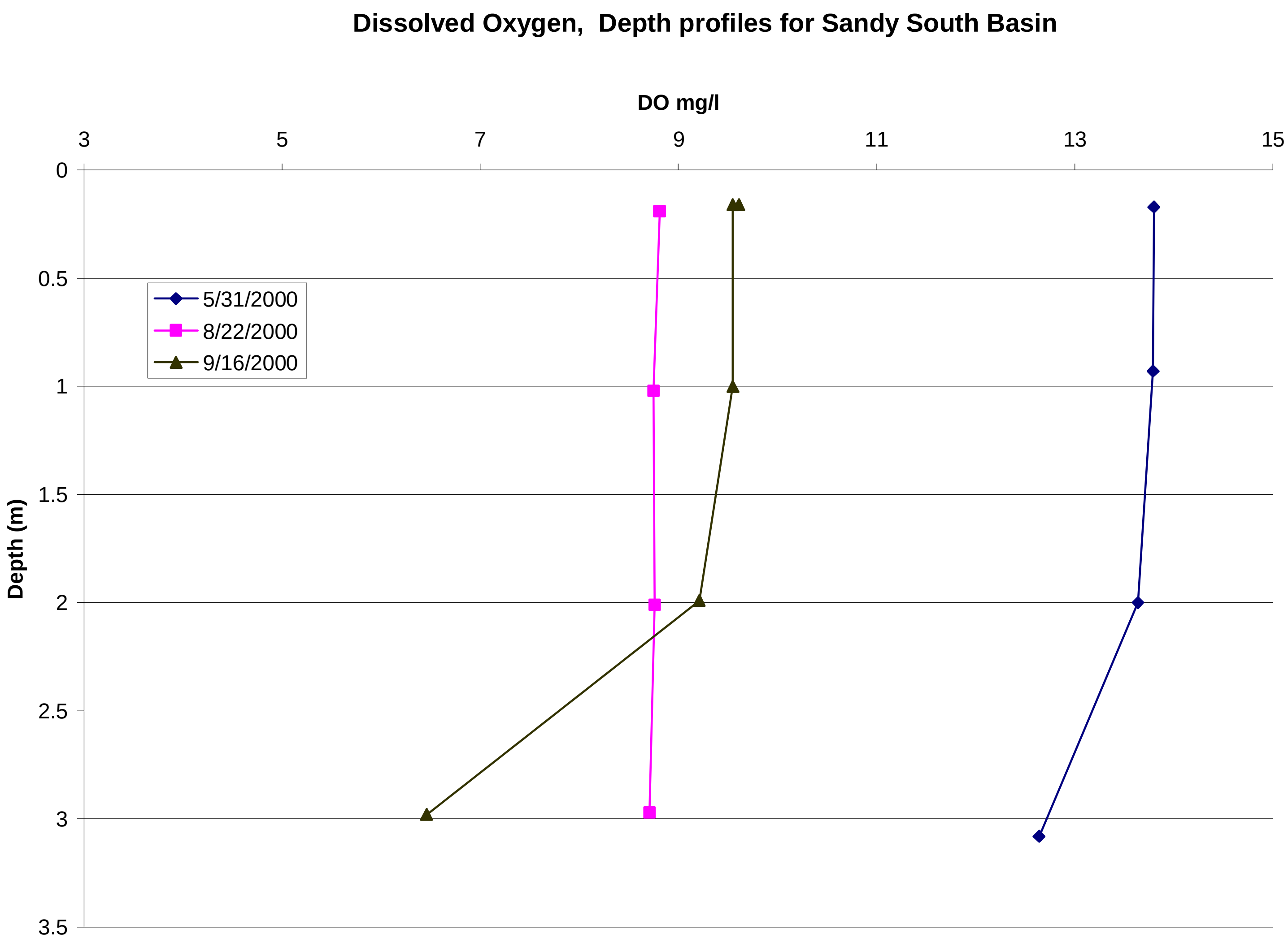
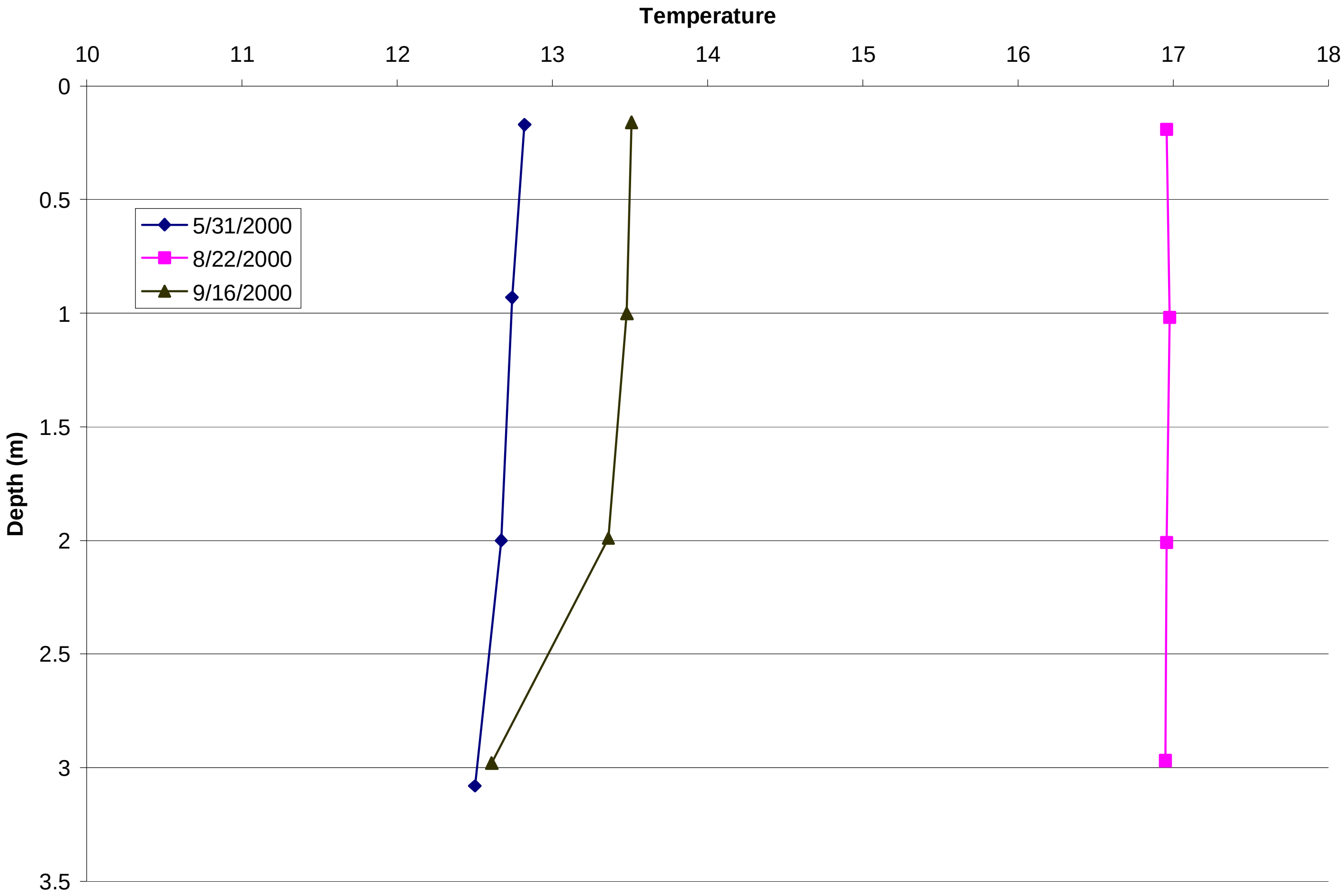


Appendix 2: Dissolved oxygen and temperature profiles

Temperature Depth Profile for Sandy South Basin



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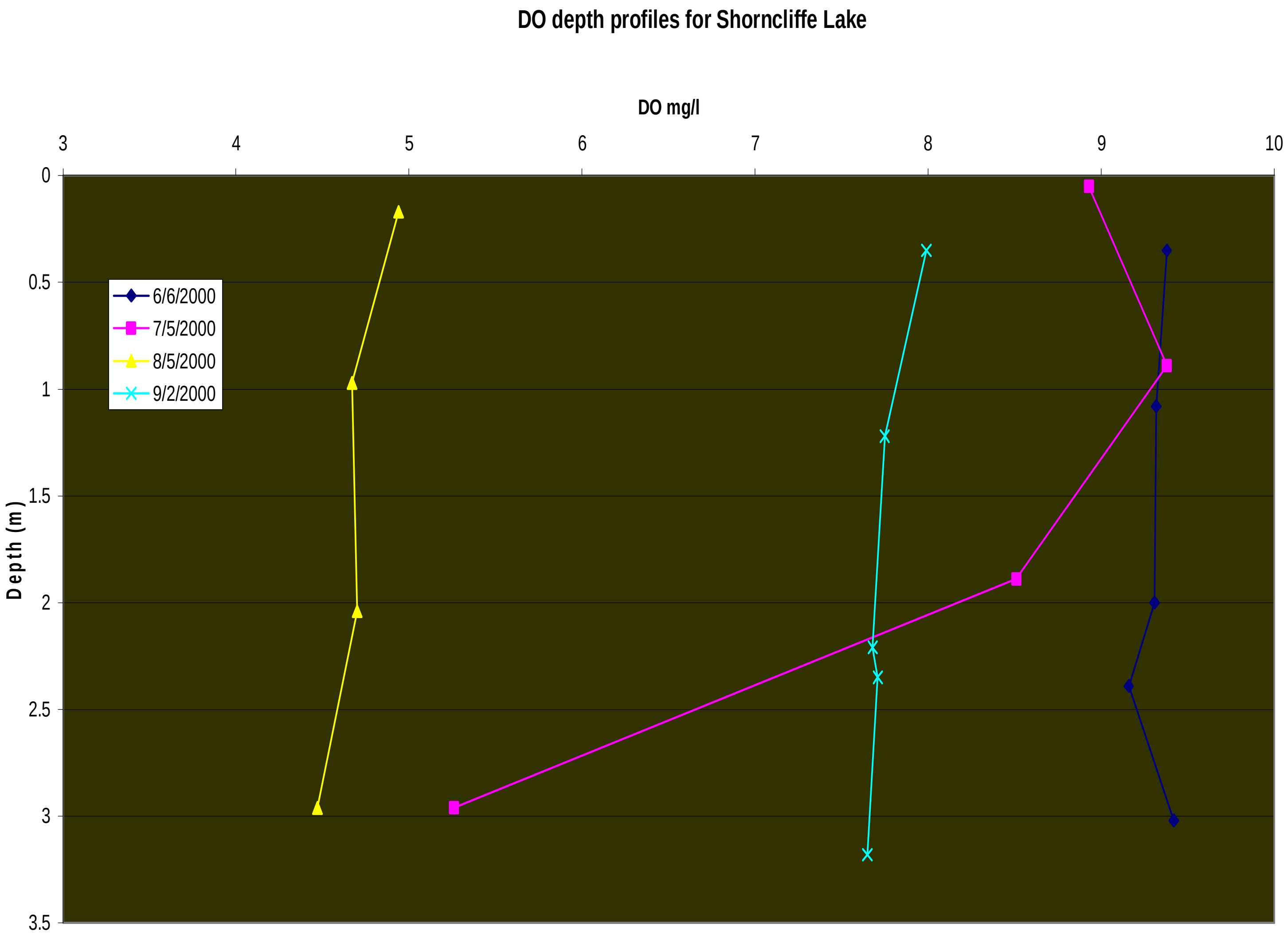

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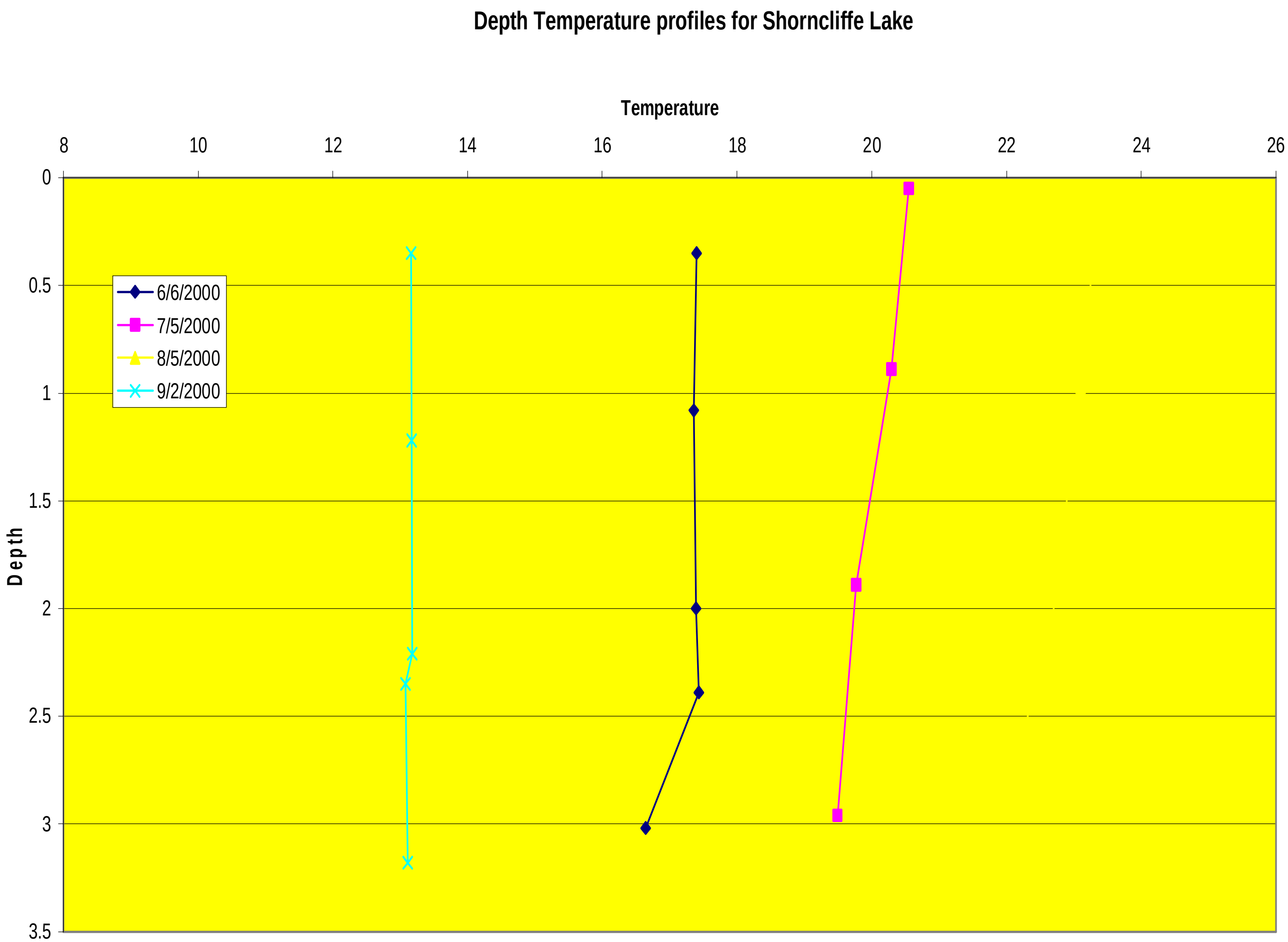

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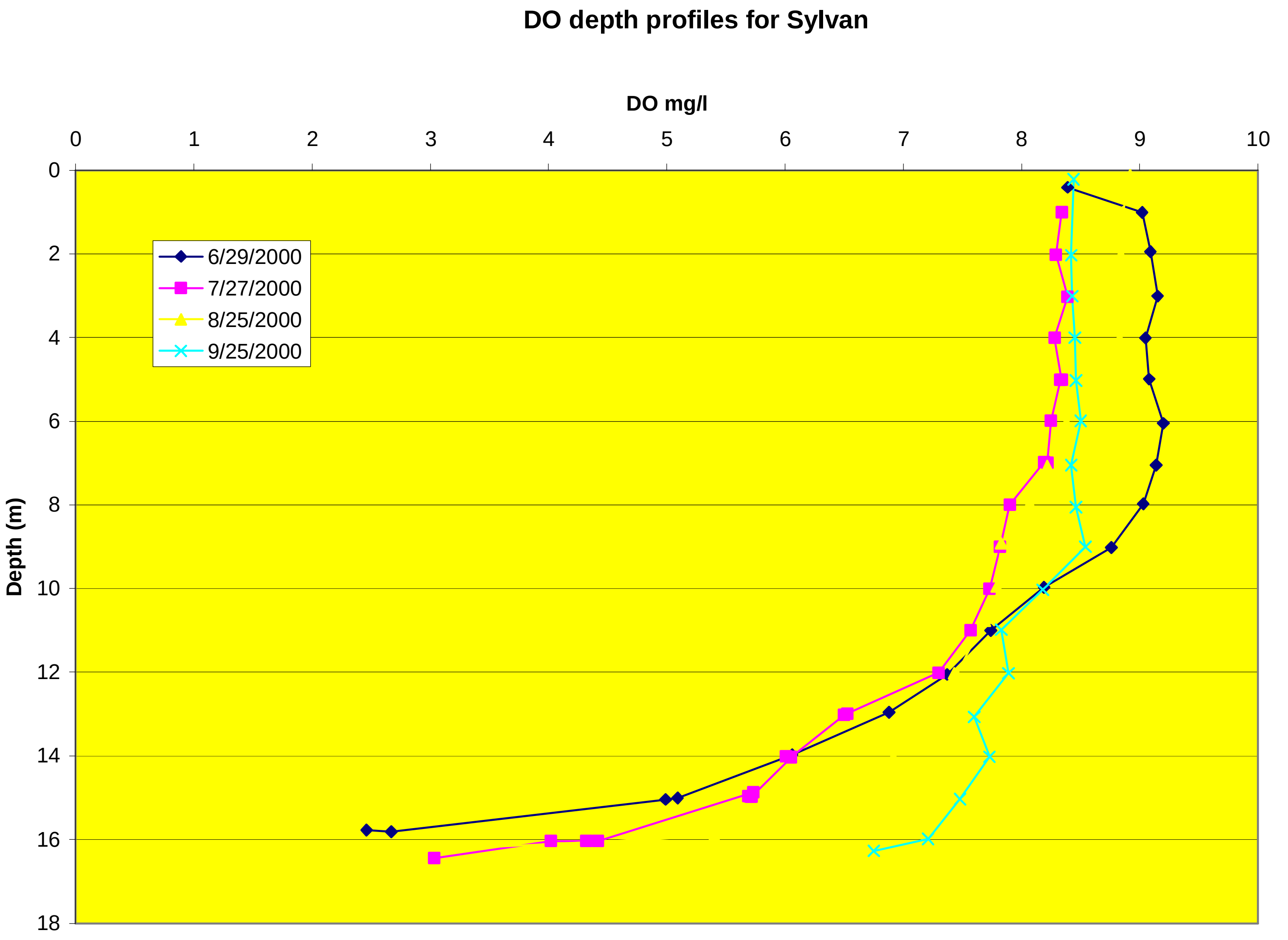

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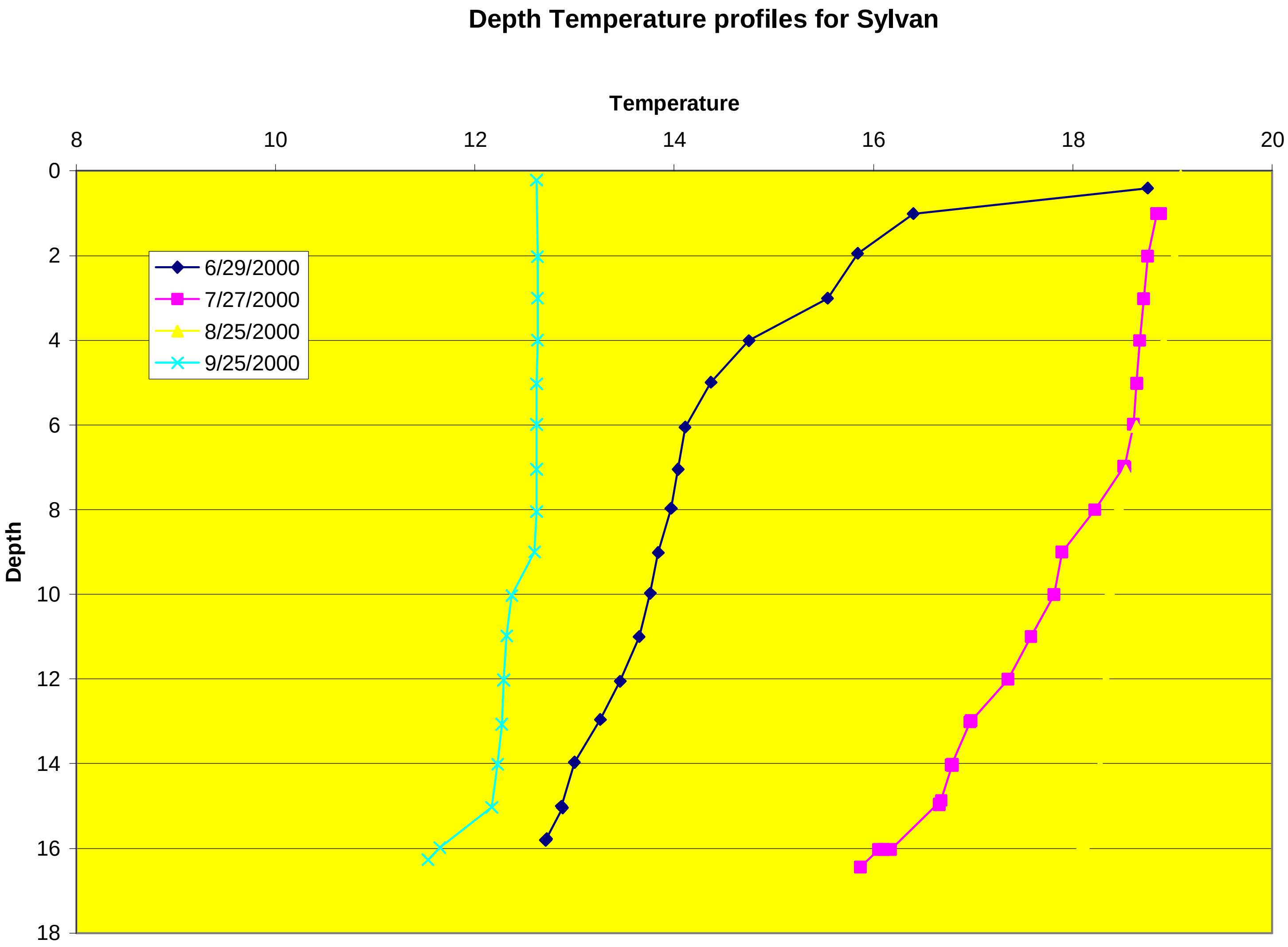

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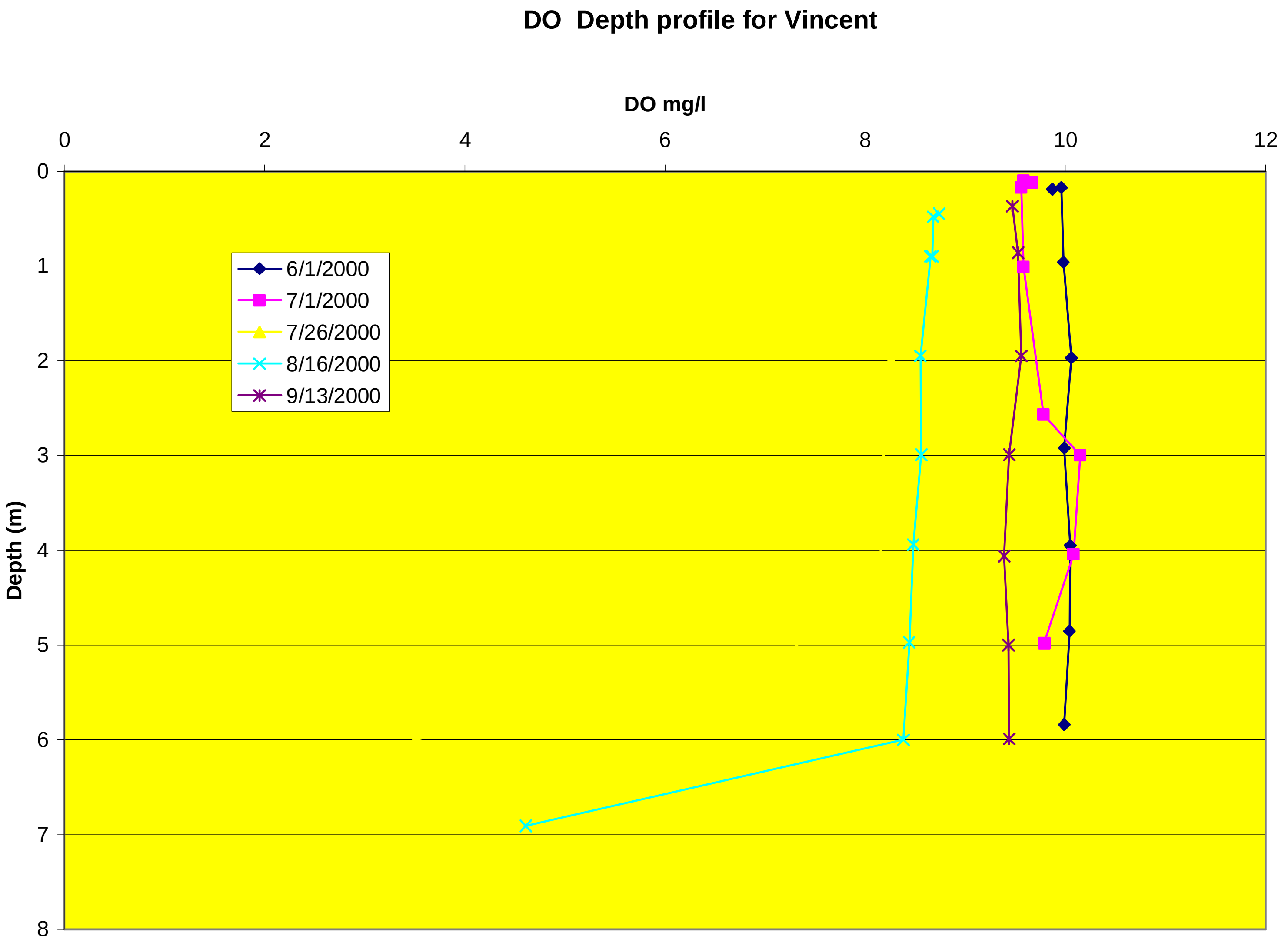

Appendix 2: Dissolved oxygen and temperature profiles