Water Quality

State of Water Quality of Langford Lake 1973-1995

Canada - British Columbia Water Quality Monitoring Agreement

Water Quality Section
Water Management Branch
Ministry of Environment, Lands and Parks

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Executive Summary

Langford lake is located on southern Vancouver Island near Victoria, B.C. The watershed for this small lake is 3.3 km².

This report assesses 16 years of water quality data and made the following conclusions:

- Spring overturn sampling indicates that there are less nutrients (e.g., total phosphorus, total dissolved phosphorus, Kjeldahl nitrogen, and dissolved ammonia) in the water column in recent years. These changes in nutrient values may be attributed to a change in the amount of nutrients entering the lake, to a change in hydrological and limnological processes of the lake, or to the cumulative effect of operating the aerator in the lake.
- Phosphorus is the limiting nutrient for algal growth in Langford Lake.
- The public bathing beach on the north side of Langford Lake was suitable for recreational bathing between 1980 and 1995.
- Total manganese values exceeded the lower criterion (0.10 mg/L) for the protection aquatic life in 1984 and 1985. These values have declined and met this criterion since 1985.
- Specific conductivity values increased over time but were below all criteria.

We recommend monitoring:

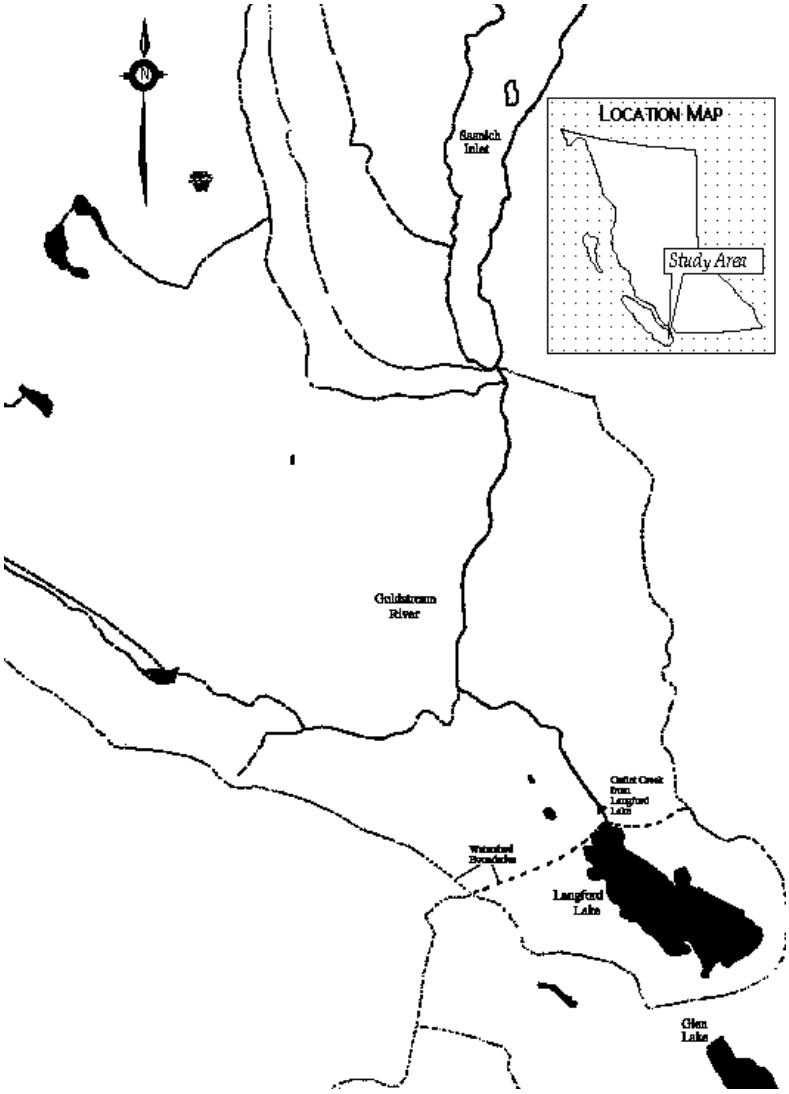
- to identify changes in water quality attributed to activities within the watershed such as urbanization, changes in nonpoint discharge, biological activity, and lake aeration.

This monitoring program could be implemented by a Langford Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

- to determine whether the public beach is suitable for bathing.

The monitoring program is being implemented by the Capital Regional District's Health Protection and Environmental Program Division. In future, local interest groups (e.g., Langford Lake stewardship group, Municipality of Langford) could assist with this ongoing monitoring.

Figure 1 Langford Lake Watershed
Approximate Scale 1:50,000



Author

Holms, G. Bruce B.Sc. Research Officer. Water Quality Branch, Environmental Protection Department, Victoria, B.C.

Acknowledgements

Drafts of this report were sent to Lloyd Erickson and John Deniseger, Environmental Protection in Nanaimo, Gary Gibson, Capital Regional District, Barry Boettger, Public Health Protection, Rick Nordin and Larry Pommen, Water Quality. Valuable comments were provided and incorporated into this report.

Introduction

Langford Lake is located on southern Vancouver Island near Victoria, B.C. The watershed for this small lake is 3.3 km². The surface area of the lake is 60 ha and has an average flushing rate of once in 3.3 years (Nordin and McKean, 1988). The lake has a maximum depth of 15 m and a mean depth of 6.4 m (Figure 2). There is one inflow stream and one outlet stream from Langford lake. The outlet stream discharges into Saanich Inlet via Goldstream River.

The Ministry of Environment, Lands and Parks monitored the water quality at the deepest point (15 m) of the basin between 1973 and 1995. The data are stored on the provincial data base, SEAM, under station numbers 1100944 and 1100953. The two purposes for monitoring the water quality of Langford lake are to identify:

- long-term changes in water quality as a consequence of development within the watershed; and
- how these changes may impinge on certain uses of water from the lake.

The Capital Regional District's Health Protection and Environmental Division collected fecal coliform samples from one bathing beach on the north side of the lake off Goldstream Road (Figure 2). Weekly sampling begins in April each year and continues through the bathing season, ending in September. Fecal coliform results from five samples collected within a 30-day period are used to establish a geometric mean at the beginning of the season. A beach advisory notice, warning of the potential for increased risk to bathers' health, is considered for posting if the geometric mean exceeds 200 fecal coliforms/100 mL over a 30-day period. More intense sampling may occur if the results of a single sample exceeds 400 fecal coliforms/100 mL.

This report assesses 22 years of water quality data. These data consist of:

- three years (1973, 1980, 1981) of water quality sampling,
- two years (1976-1978) of intensive water quality sampling,
- 15 years (1979-1995) of spring overturn water quality sampling, and
- 14 years (1980-1995) of fecal coliform sampling.

The water quality data are plotted in Figures 3 to 15 and summarized in Tables 1 and 2.

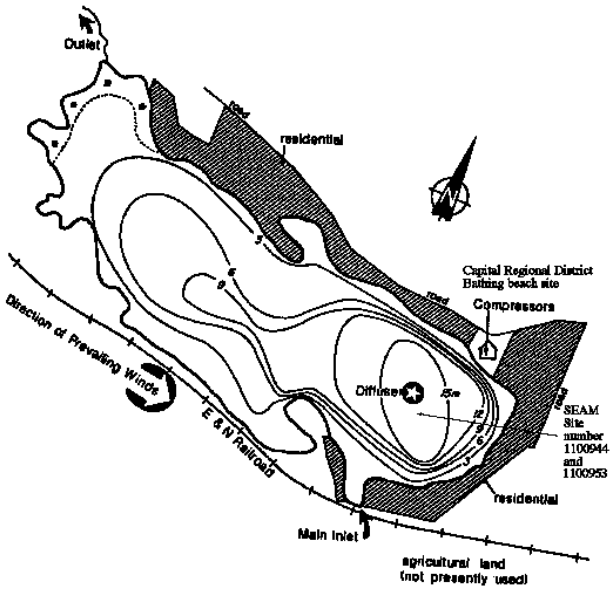
The box plots, in Figures 3 to 15, represent the variability of water quality indicators collected at the surface, mid depth, and near the bottom of the lake. Each plot is comprised of a rectangle with the top portraying the upper quartile (75th percentile of the data series, Q(0.75)), the bottom portraying the lower portion (25th percentile of the data series, Q(0.25)), and a horizontal line within the rectangle portraying the median. Vertical lines extend from the ends of the rectangle to the adjacent values, also known as "whiskers", and are defined by:

- computing the interquartile range, IQR=Q(0.75)- Q(0.25);
- defining the upper adjacent value as the largest observed value between the upper quartile and the upper quartile plus 1.5 X IQR.
- defining the lower adjacent value as the smallest observed value between the lower quartile and the lower quartile minus 1.5 X IQR.

Values that fall outside the range of the adjacent values are defined as "outside values" and are plotted as asterisks (*). Values are defined as "far outside values" if they are located outside the outer range which is defined as the upper quartile plus 3 X IQR or the lower quartile minus 3 X IQR. These values are plotted as empty circles (O).

Trends in water quality data collected at different depths and at different frequencies over time are assessed by comparing yearly changes in median values in conjunction with the size of sample variability. The size of sample variability is represented in the box plots by the rectangle, whiskers, and the two types of outliers. A change is observed when the median values and sample variability do not overlap.

Figure 2 Bathymetric map of Langford Lake
Adapted from Nordin and McKean (1988)
Scale 1:13,000



Quality Assurance

The water quality plots were reviewed. Total residue (i.e. dissolved and suspended solids) from Langford Lake increased in 1994 (Figure 11). Dissolved residues did not increase in 1994 which indicates that the increase in total residues values during this period may be outliers or questionable values. The effect of suspended solids (non-filterable residues) values on total residues values in 1994 could not be determined because suspended solids values were not collected.

State of the Water Quality

The state of the water quality is assessed by comparing the values to any site-specific water quality objectives or to Ministry of Environment, Lands and Parks' Approved and Working Criteria for Water Quality (Nagpal *et al.*, 1995) if objectives have not been set. Any levels or trends in water quality that are deleterious to sensitive water uses are noted.

Nordin and McKean (1988) identified two water uses (water-based recreation and fisheries) for Langford lake. These uses were threatened by excessive phosphorus loading from agricultural runoff and phosphorus being generated from the sediments in the lake. An aerator was installed in 1984 to provide oxygen to the deep waters of the lake and to reduce the amount of phosphorus released by the lake sediments.

Spring Overturn

The water in Langford Lake is vertically mixed (no thermal stratification) between November and the end of April. A key time for sampling is late during this period of mixing. The objective of this monitoring is to assess water quality from year to year and to estimate the potential algal growth during the summer months in Langford Lake.

Total phosphorus (Figure 3) values before thermal stratification, average of samples taken at different depths within the water column, were outside limits (0.005-0.015 mg/L) for protecting aquatic life between 1973 and 1988. These values were within these limits between 1989 and 1995. The criterion (0.01 mg/L) for recreational use was exceeded between 1973 and 1992. Total phosphorus values, before thermal stratification, met this criterion between 1993 and 1995.

Ortho-phosphorus values, with the exception of an increase in 1985, approximated the minimum detectable limit (0.003 mg/L). **Total phosphorus** (Figure 4) and **Total dissolved phosphorus** (Figure 5) values decreased over time. This decrease of phosphorus in the water column may be attributed to several factors including:

- an increase in Ultra Violet light (UVb) penetration in the water column,
- an increase in phosphorus uptake by aquatic plants,
- an increase in phosphorus fixing by lake sediments,
- a result of the free-floating full-lift hypolimnetic aerator,

- a reduction in phosphorus loadings to the lake, and
- an increase in the flushing rate of Langford Lake.

Nitrogen, dissolved ammonia (Figure 6) and **nitrate/nitrite** (Figure 7) were below all criteria. **Kjeldahl nitrogen** (Figure 8) and dissolved ammonia values were less variable after 1984 and decreased over time. Kjeldahl nitrogen and nitrite/nitrate concentrations are added together to represent total nitrogen in the lake. These concentrations are used to calculate the N:P ratio.

Nordin and McKean (1988) reported an average N:P ratio of 26:1 in 1983/1984. This ratio has approximately doubled between 1985 and 1995 (Figure 9). Phosphorus is the limiting nutrient for algal in Langford Lake (N:P > 15:1). The dissolved ammonia:nitrate ratio (Figure 10) decreased over time. The trends in the ratios indicate that there are changes occurring in the lake systems (e.g. land use, biological activity) which affect water quality.

Fecal coliform samples were collected by the Capital Regional District's Health Protection and Environmental Division at a bathing beach on the north side of the lake off Goldstream Road. Samples were collected between 1980 and 1995 (Table 2). These values ranged between 1 MPN/100 mL and 1100 MPN/100 mL. Fecal coliform values from this beach may not be similar to values collected elsewhere in the lake. Resident waterfowl populations make these areas unique and may cause fecal coliform values to be higher than at other sites in the lake. The bathing beach on the north side of Langford Lake was suitable for bathing between 1980 and 1995 (Table 2).

Total residue (i.e. dissolved and suspended solids) increased in 1994 (Figure 11). Dissolved residues did not increase in 1994 which indicates that the increase in total residues values during this period may be outliers or questionable values. There are no criteria for total residues. **Dissolved solids** (filterable residues) and **suspended solids** (non-filterable residues) values were collected in 1984, and 1993. There was insufficient suspended solids data to apply the criterion for the protection of aquatic life. **Specific conductivity (µS/cm)** (Figure 12) can be used to indicate dissolved solid concentrations. These values ranged between 164 µS/cm and 188 µS/cm. Specific conductivity values increased over time but were below all criteria.

Total calcium shows that Langford lake has a low sensitivity to acid inputs (the lake is highly buffered to acidic inputs). These concentrations ranged from 18 mg/L to 23.5 mg/L between 1984 and 1995.

Total manganese: (Figure 13) 13% of the values exceeded the lower criterion (0.10 mg/L) for protecting aquatic life. These 3 values occurred in 1984 and 1985. Total manganese values were at or near the minimum detection limit (0.01 mg/L) between 1985 and 1995. The upper criterion (1.0 mg/L) was not exceeded.

Iron values were below all criteria.

Chloride values were below all criteria.

Dissolved silica (Figure 14) values increased and decreased between 1983 and 1995. These changes in dissolved silica values may be attributed to the activity of the diatom population in the lake. Dissolved silica is not the limiting nutrient (< 0.5 mg/L) for diatom growth in Langford Lake (Wetzel, 1975).

pH (Figure 15) values met all criteria. These values ranged between 7.1 and 8.3.

Dissolved oxygen, extinction depth, and water temperature were measured in 1994. Dissolved oxygen and water temperature values met all criteria and were similar to those reported by Nordin and McKean (1988). The extinction depth value was similar to those reported by Nordin and McKean (1988). There are not criteria for extinction depth.

Conclusions - State of Water Quality

- Spring overturn sampling indicates that there are less nutrients (e.g., total phosphorus, total dissolved phosphorus, Kjeldahl nitrogen, and dissolved ammonia) in the water column in recent years. These changes in nutrient values may be attributed to a change in the amount of nutrients entering the lake, to a change in hydrological and limnological processes of the lake, or to the cumulative effect of operating the aerator in the lake.
- Phosphorus is the limiting nutrient for algal growth in Langford Lake.
- The public bathing beach on the north side of Langford Lake was suitable for bathing between 1980 and 1995.
- Total manganese values exceeded the lower criterion (0.10 mg/L) for the protection aquatic life in 1984 and 1985. These values have declined and met this criterion since 1985.
- Specific conductivity values increased over time but were below all criteria.

Recommendations for Water Quality Management

Remediation

A destratification aeration system was installed in 1984. The aerator operates between April and October. There are no other apparent water quality remediation measures needed at this time.

Monitoring

We recommend that sampling at the surface and at depth during spring overturn and between June and September at SEAM site 1100994. The focus of this monitoring will be to identify changes in water quality attributed to activities within the watershed such as urbanization, changes in nonpoint discharge, biological activity, and lake aeration. This monitoring program would include the following water quality indicators:

- water temperature and dissolved oxygen profiles,
- total phosphorus, dissolved ammonia, nitrate/nitrite, kjeldahl nitrogen, total and dissolved organic carbon, true colour, turbidity, dissolved silica from 3 samples taken 1 m below the surface, at mid depth and 1 m above the bottom;
- chlorophyll a, sampled, between June and September, near the surface between; and
- extinction depth (i.e., Secchi depth) and UVb absorption.

This monitoring program could be implemented by a Langford Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

We recommend that fecal coliform sampling continue at the bathing beach on the north side of Langford Lake. The monitoring program is being implemented by the Capital Regional District's Health Protection and Environmental Division. In future, local interest groups (e.g., Langford Lake stewardship group, Municipality of Langford) could assist with this ongoing monitoring.

Figure 3 Total phosphorus (average in the water column before stratification) from Langford Lake

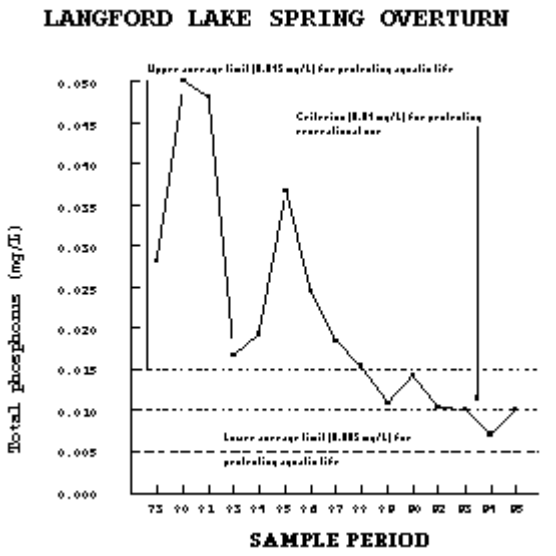


Figure 4 Total phosphorus from Langford Lake

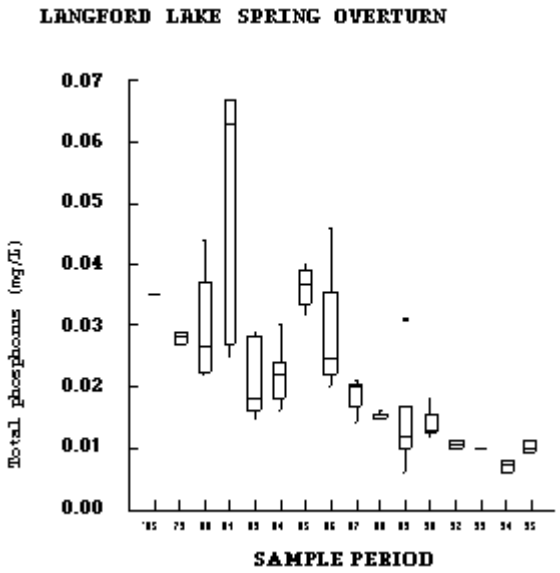


Figure 5 Total dissolved phosphorus from Langford Lake

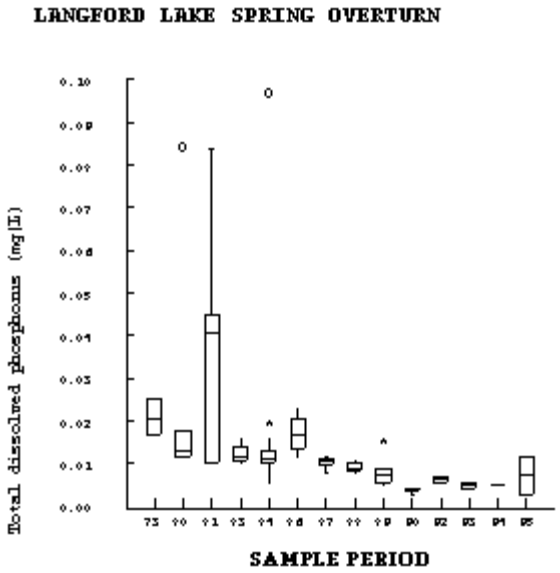


Figure 6 Dissolved ammonia from Langford Lake

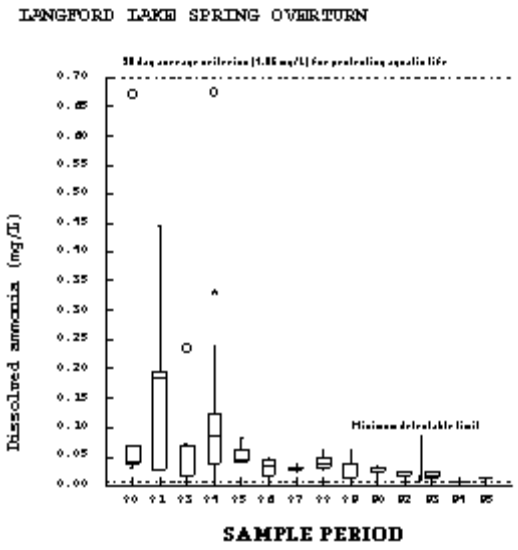


Figure 7 Nitrate/Nitrite from Langford Lake

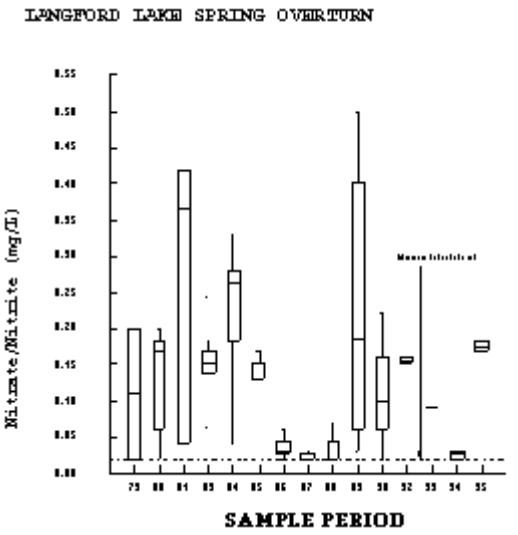


Figure 8 Kjeldahl nitrogen from Langford Lake

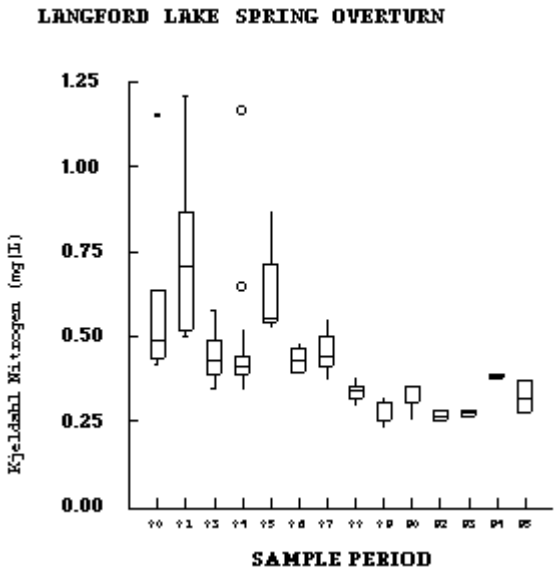


Figure 9 N:P ratio from Langford Lake

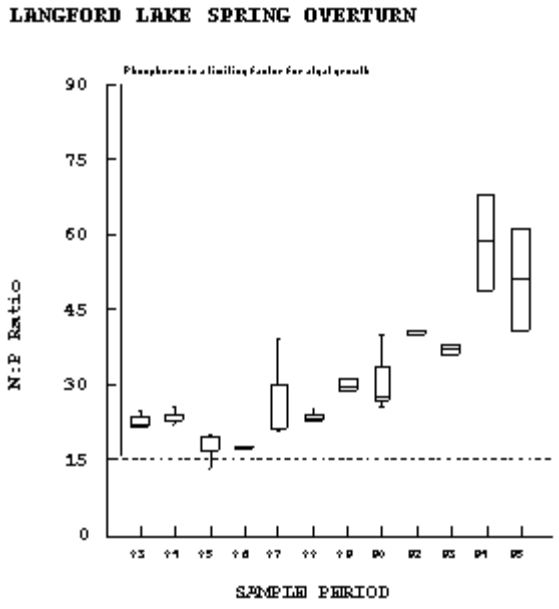


Figure 10 Dissolved ammonia:nitrate ratio from Langford Lake

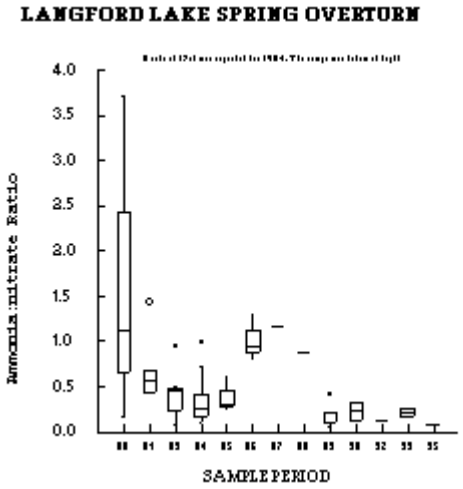


Figure 11 Total residues from Langford Lake

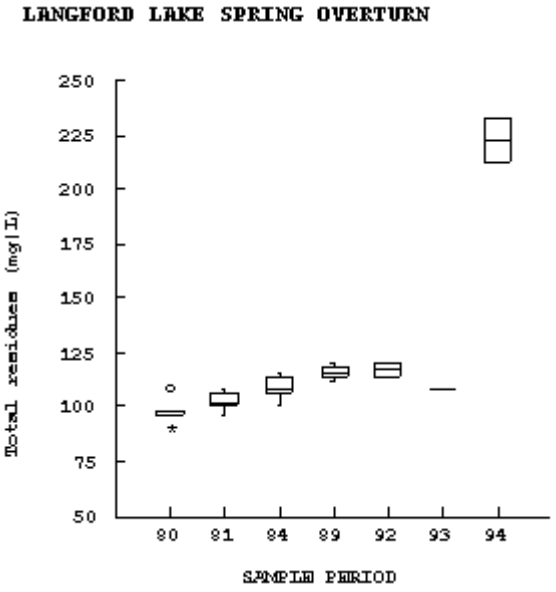


Figure 12 Specific conductivity from Langford Lake

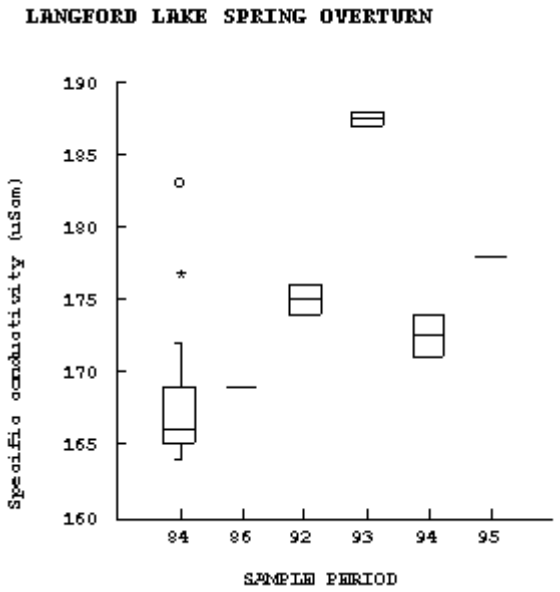


Figure 13 Total manganese from Langford Lake

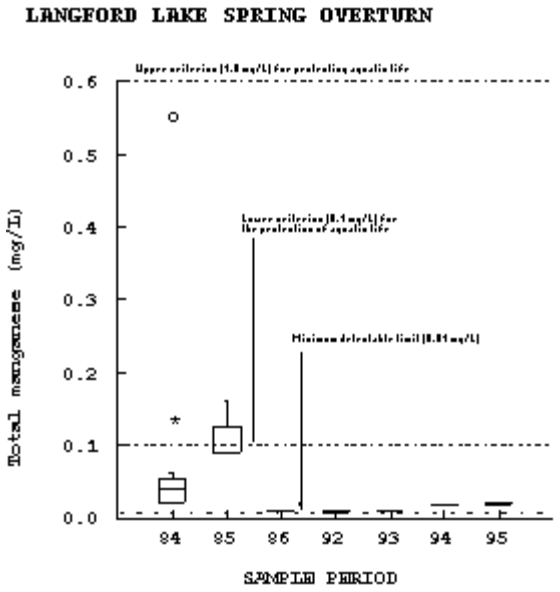


Figure 14 Dissolved silica from Langford Lake

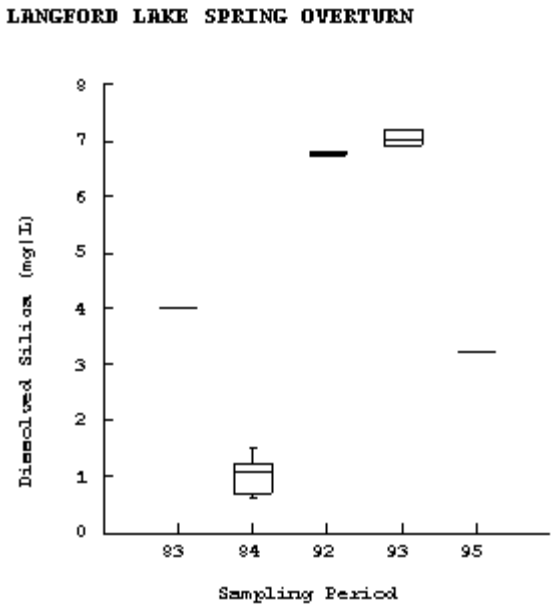


Figure 15 pH from Langford Lake

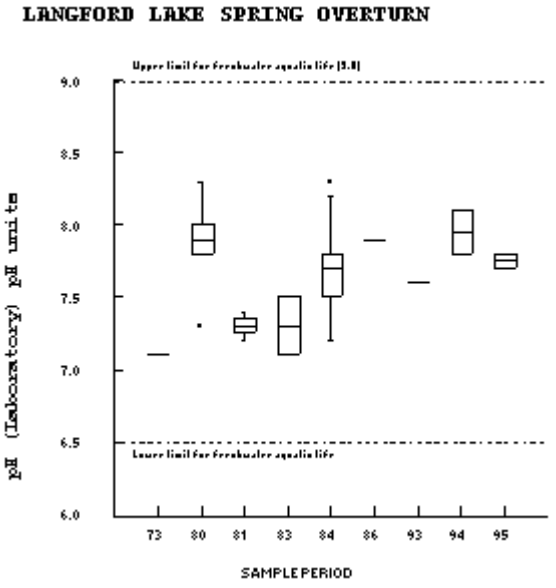


Table 1 Summary of water quality data from Langford Lake (SEAM sites 1100944 and 1100953)

Water Quality Indicator	Average	Std Dev	Number of samples	Maximum	Minimum
SPRING OVERTURN MONITORING	.	.	.	.	.
Water Clarity and Colour	.	.	.	.	.
Turbidity (NTU)	0.76	0.218	13	1.1	0.4
Colour, true (TCU)	6.8	2.52	11	10	5
Residues, nonfilterable (mg/L)	2.4	1.12	11	L 4	1
Extinction depth (m)	3.95	0.532	4	4.5	3.4
General Ions	.	.	.	.	.
pH (pH units)	7.68	0.298	26	8.3	7.1
Residues, filterable (mg/L)	106.7	3.06	3	110	104
Residues, total (mg/L)	123.2	36.52	18	232	100
Specific conductivity (µS/cm)	171.7	7.13	24	188	164
Calcium, total (mg/L)	20.63	1.535	21	23.5	18.1
Chloride, dissolved (mg/L)	10.93	0.427	12	11.4	10.1
Magnesium, total (mg/L)	4.264	0.4282	21	5.05	3.55
Silica, dissolved (mg/L)	3.48	2.455	15	7.2	0.6
Sulphate, dissolved (mg/L)	16.18	8.523	4	24.9	7.9
Temperature, water (° C)	9.53	2.275	57	19.5	5.9
Nutrients	.	.	.	.	.
Carbon, total organic (mg/L)	2.5	1.65	14	6	L1
Carbon, total inorganic (mg/L)	16.3	2.23	14	20	11
Nitrogen, total (mg/L)	0.655	0.1751	27	1.21	0.35
Nitrogen, ammonia (mg/L)	0.066	0.1115	57	0.675	L 0.005
Nitrogen, Kjeldahl (mg/L)	0.421	0.1541	57	1.17	0.24
Nitrogen, organic (mg/L)	0.358	0.0535	29	0.5	0.28
Nitrogen, nitrate+nitrite (mg/L)	0.146	0.111	59	0.5	L 0.02
Phosphorus, total (mg/L)	0.024	0.0200	62	0.151	0.006
Phosphorus, ortho (mg/L)	0.007	0.0137	45	0.089	L 0.003
Phosphorus, total dissolved (mg/L)	0.013	0.0125	56	0.097	L 0.003
Oxygen, dissolved (mg/L)	11.20	1.250	54	13.7	7.5
Chlorophyll a (mg/L)	0.006	0.0009	6	0.0063	0.004
Metals	.	.	.	.	.
Aluminum, total (mg/L)	.	.	8	L 0.02	L 0.015
Antimony, total (mg/L)	.	.	9	L 0.02	L 0.015
Arsenic, total (mg/L)	.	.	21	L 0.25	L 0.04
Boron, total (mg/L)	.	.	8	L 0.04	0.008
Barium, total (mg/L)	.	.	8	L 0.007	L 0.004
Beryllium, total (mg/L)	.	.	8	L 0.001	L 0.001
Bismuth, total (mg/L)	.	.	8	L 0.02	L 0.02
Cadmium, total (mg/L)	.	.	21	L 0.01	L 0.002
Cobalt, total (mg/L)	.	.	21	L 0.1	L 0.003
Chromium, total (mg/L)	.	.	21	L 0.05	L 0.002
Copper, total (mg/L)	.	.	21	0.012	L 0.001

Iron, total (mg/L)	0.05	0.057	21	0.26	0.01
Lead, total (mg/L)	.	.	21	L 0.1	L 0.02
Manganese, total (mg/L)	0.06	0.118	21	0.55	0.009
Molybdenum, total (mg/L)	.	.	21	L 0.01	L 0.004
Nickel, total (mg/L)	.	.	21	L 0.05	L 0.008
Selenium, total (mg/L)	.	.	8	L 0.03	L 0.03
Sodium, dissolved (mg/L)	7.5	0.34	8	8	6.9
Silicon, total (mg/L)	2.02	0.772	8	2.84	0.8
Silver, total (mg/L)	.	.	8	L 0.03	L 0.01
Strontium, total (mg/L)	0.056	0.007	8	0.064	0.047
Tin, total (mg/L)	.	.	8	L 0.02	L 0.02
Zinc, total (mg/L)	.	.	8	L 0.003	L 0.003

Note: L = less than

Table 2 Summary of Capital Regional District's Health Protection and Environmental Division's Bacteriological data from Langford Lake (on the north side of the lake off of Goldstream Road)

Year	Maximum	Minimum	Geometric Mean	Number of samples
1980	35	5	13.48	8
1981	38	24	26.92	4
1982	700	L 3	20.98	8
1983	8	5	5.44	10
1984	24	7	8.35	11
1985	43	28	33.93	14
1986	240	3	10.47	8
1988	1100	3	14.9	18
1990	17	11	14.03	5
1991	29	5	10.16	12
1992	15	4	6.87	13
1993	4	1	1.97	12
1994	6	2	2.80	13
1995	3	1	1.9	10

Note: L = less than

References

Nagpal, N.K., L.W. Pommen, and L.G. Swain (1995). Approved and Working Criteria for Water Quality. Ministry of Environment, Lands and Parks. Environmental Protection Department, Water Quality Branch, Victoria, BC.

Nordin, Richard N. and C.J.P. McKean (1988) Destratification-Aeration of Langford Lake: Physical, Chemical and Biological Responses. Water Quality Unit, Resource Quality Section, Water Management Branch Ministry of Environment, Victoria B.C.

McKean, C.J.P. and N. Munteanu (1982) An Assessment of the water quality of Langford Lake with proposals for the possible solutions to its eutrophication problem. Report submitted to the Langford Lake Improvement District and the Capital Regional District Planning Department. Victoria B.C.