State of Water Quality of Cusheon Lake

1974-1999

Canada - British Columbia
Water Quality Monitoring Agreement

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

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Executive Summary

Cusheon Lake is located on Salt Spring Island (Figure 1). The watershed for this small lake is 7.24 km^2. Domestic consumption, primary (e.g., swimming) and secondary (e.g., canoeing and angling) recreation, irrigation, aquatic life and wildlife are the water uses for Cusheon Lake.

This report assesses water quality data for 1974-95 (1974-99 for total phosphorus). We concluded:
· There was weak evidence of an increasing trend in spring overturn total phosphorus during 1975 to 1999. Total phosphorus values were above the upper guideline for aquatic life for 6 of 14 years, and above the guideline for drinking water and recreation for 10 of 14 years between 1975 and 1999.
· Chlorophyll a values were collected in 1980 and exceeded the guidelines for aquatic life, drinking water, and recreation.

· Phosphorus was the limiting nutrient for algal growth in Cusheon Lake.
· Increases in sodium, chloride, and specific conductivity indicated possible disturbances within the watershed.
· Total organic carbon values exceeded the guideline for raw drinking water. Chlorinating the water may produce trihalomethanes that may exceed the drinking water guideline.
· The Capital Health Region determined that the public beach on Cusheon Lake was suitable for bathing between 1981 and 1995.
· True colour values exceeded the guideline for drinking water aesthetics in 33% of the samples from Cusheon Lake.
· Dissolved oxygen did not meet the guideline for protecting adult and juvenile salmonids from production impairment in 29% of the samples during 1974-94. The guideline for protecting adult and juvenile salmonids from moderate production impairment was not met in 2% of the samples during this period.
· Water temperature exceeded the drinking water aesthetics guideline at the deep station in Cusheon Lake in October 1980. The guideline may also have been exceeded during the summer months.
· Total calcium values show that the lake had a low sensitivity to acid inputs (the lake was well buffered).
· Total iron values exceeded the guideline for drinking water aesthetics and aquatic life in two samples collected in 1974. Total manganese exceeded the guideline for drinking water aesthetics in samples collected in 1993 and 1994.
· One extinction depth value collected in October 1980 did not meet the guideline for swimming and may indicate that the guideline was not met in the summer months when swimming would most likely have occurred.
· Turbidity exceeded the aesthetics objective for drinking water (with disinfection only) in 20% of the samples collected between 1974 in 1995. The drinking water health guideline was exceeded in 80% of the lake samples. The turbidity levels in the Cusheon Lake were such that treatment processes to remove it are required prior to drinking.

We recommend that a remediation plan be developed and implemented to improve water quality in Cusheon Lake. The focus of the remediation plan would be:
· to determine the suitability of Cusheon Lake for recreation, drinking water, and sustaining aquatic life;
· to identify the sources of nutrients and contaminants in the watershed and lake;
· to identify what is required to improve the water quality in Cusheon Lake to make it suitable for recreation, drinking, and sustaining aquatic life; and
· to evaluate remediation options and recommend the most efficient approach to improving water quality in the lake.

The plan should be developed and implemented by a Cusheon Lake stewardship group in conjunction with the Islands Trust.

We recommend monitoring:
· to establish site-specific water quality objectives to protect water uses;
· to identify the sources of nutrients and contaminants in the watershed and lake; and
· to identify changes in water quality due to biological activity in the lakes, activities within the watershed such as urbanization, and changes in non-point discharge.

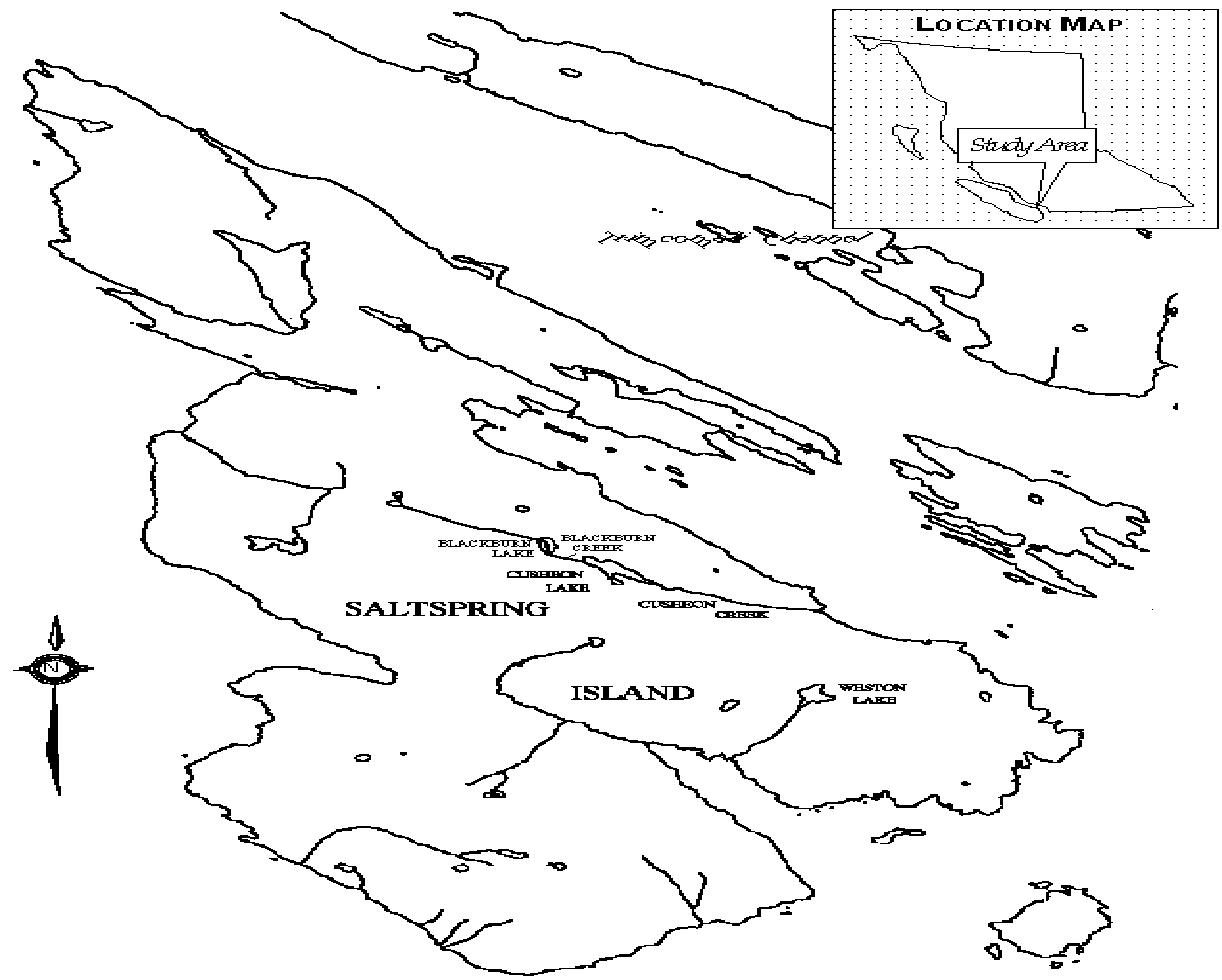
A Cusheon Lake stewardship group could implement this monitoring program with assistance from the Ministry of Environment, Lands and Parks.

Other monitoring is also recommended:

· to determine whether the public beach is suitable for bathing. The Capital Health Region will continue to continue monitor and assess the suitability of the public beach for bathing.

· to determine trihalomethane levels in chlorinated water from the water works. The water works licensee (Beddis Water Works District) and Capital Health Region are implementing this monitoring.

· to determine the quality of drinking water at the 35 domestic water licenses on Cusheon Lake. A Cusheon Lake stewardship group could implement this monitoring program with assistance from the Capital Health Region, and/or the Ministry of Environment, Lands and Parks.



Scale 1: 120,000

Figure 1 Cusheon Lake Watershed

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Introduction

Cusheon Lake is located on Salt Spring Island. The watershed for this small lake is 7.24 km^2 (Figure 1). The surface area of the lake is 26.9 ha and it has an average flushing rate of once in 0.8 years. The lake has a maximum depth of 9.14 m and a mean depth of 4.5 m (Figure 2).

Blackburn Creek flows southeast from Blackburn Lake and is the major inflow into Cusheon Lake. Also, there are several intermittent ditches and creeks that drain the north and south sides of the drainage basin. Cusheon Lake drains into Cusheon Creek that empties into the Pacific Ocean at Trimcomali Channel.

The Ministry of Environment, Lands and Parks monitored the water quality at various depths over the deepest point (9.14 m) of Cusheon Lake between 1974 and 1995. The data are stored on the provincial database, EMS (formerly SEAM), under station number 1100123 (Figure 2). The two purposes for monitoring the water quality of Cusheon Lake were 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 Health Region collected water samples for bacteriological analyses from Beaver Beach on Cusheon Lake (Figure 2). Weekly sampling began in April each year and continued through the bathing season, ending in September. Fecal coliform results from five samples collected within a 30-day period were 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, was considered for posting if the geometric mean exceeded 200 fecal coliforms/100 mL over a 30-day period. More intense sampling may have occurred if the results of a single sample exceeded 400 fecal coliforms/100 mL.

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

- four years (1974 -1976, 1980) of intensive water quality sampling,
- 22 years (1974-1995) of spring overturn water quality sampling (1974-99 for total phosphorus), and
- 13 years (1980-1995; no samples were collected in 1987 and 1989) of fecal coliform sampling.

The water quality data are plotted in Figures 3 to 28 and summarized in Tables 1 and 2.

The box plots in Figures 3 to 28 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 (75^{th}percentile of the data series, Q(0.75)), the bottom portraying the lower portion (25^{th} 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 were 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 were 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 were 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.

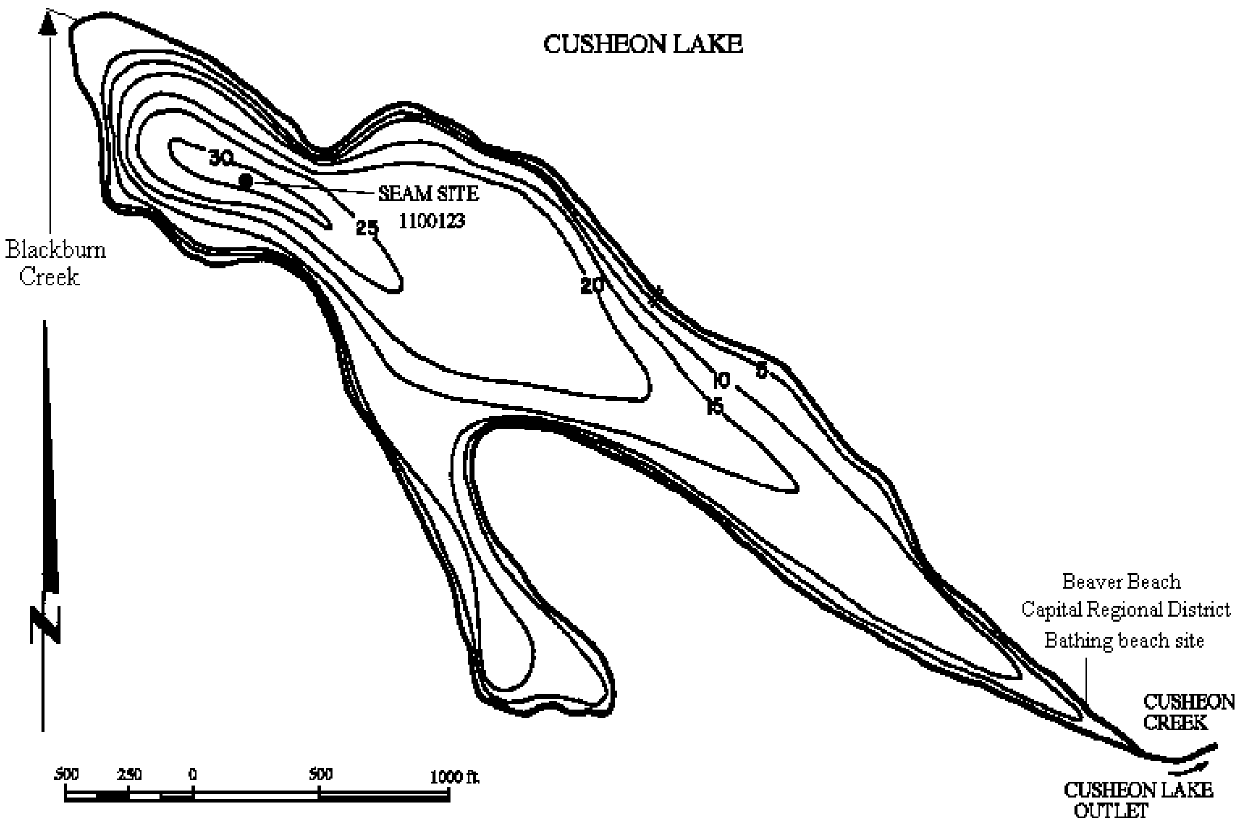

Figure 2 Bathymetric map of Cusheon Lake

Quality Assurance

The water quality plots were reviewed. No questionable values or values that were known to be in error were found.

State of the Water Quality

The state of the water quality was assessed by comparing the values to Ministry of Environment, Lands and Parks' approved and working guidelines for Water Quality (Nagpal *et al.*, 1998a,b). (Guidelines were formerly called criteria, and this older term has been used in many of the figures in this report.) Site-specific water quality objectives have not been set for Cusheon Lake. Any levels or trends in water quality that were deleterious to sensitive water uses, including drinking water, aquatic life and wildlife, recreation, irrigation, and livestock watering are noted below.

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

Goddard (1976) identified five water uses for Cusheon Lake: domestic consumption, primary (e.g., swimming) and secondary (e.g., canoeing and angling) recreation, irrigation, aquatic life, and wildlife.

There were 35 domestic water licenses that may have been used as drinking water sources, and two local authority water works licenses on Cusheon Lake. The Beddis Water Works District holds the water works licenses.

Total phosphorus average values at spring overturn before thermal stratification (average of samples taken at different depths within the water column) are shown in Figure 3. They were above the upper guideline (0.015 mg/L) for protecting aquatic life in 6 of 14 years, and exceeded the guideline for protecting recreation and drinking water (0.010 mg/L) in 10 of 14 years during 1975-99. The spring overturn total phosphorus data were examined using non-parametric statistics, and weak evidence (i.e., 90% confidence level) of an increasing trend over 1975-99 was found (Regnier, 1999).

Ortho-phosphorus values (Figure 5) ranged from the minimum detectable limit (0.003 mg/L) to 0.238 mg/L. This high value was not included in this assessment as the sample may have contained bottom sediment. Seventy percent of the values were below the minimum detectable limit. Future monitoring should include total phosphorus and total dissolved phosphorus as a measure of bio-available phosphorus.

Ammonia-N values (Figure 6) were below the guideline (30-day average 1.85 mg/L) to protect aquatic life from toxicity. Generally, these values decreased between 1980 and 1995 with the exception of an increase in 1990.

Nitrate/nitrite-N values (Figure 8) were below the drinking water guideline (10 mg/L) and increased over time. The values ranged from the minimum detectable limit (0.02 mg/L) to 0.65 mg/L.
The **ammonia:nitrate ratio** (Figure 10) decreased over time, with the exception of 1990, due to decreasing ammonia levels and increasing nitrate/nitrite levels.

Kjeldahl nitrogen (Figure 7) and nitrite/nitrate concentrations were added together to calculate **total nitrogen** (Figure 9), which was fairly constant over time. Total nitrogen and total phosphorus were used to calculate the **Nitrogen:Phosphorus** (N:P) **ratio** (Figure 11). This ratio indicates that phosphorus was the limiting factor for algae growth (N:P > 15). All ratios that were less than 15 occurred in October and November of 1974, 1976, 1980, and 1981. Future monitoring should include Kjeldahl nitrogen, nitrate/nitrite, and dissolved ammonia.

Total calcium values (Figure 12) show that the lake had a low sensitivity to acid inputs (the lake was well buffered to acid inputs).

Total organic carbon values (Figure 13) exceeded the raw drinking water guideline (4 mg/L) in 88% of the samples collected between 1974 and 1980. The water has the potential to form trihalomethanes in excess of the 0.1 mg/L drinking water guideline if disinfected with chlorine. Trihalomethane measurements should be included in future monitoring of chlorinated drinking water from the lake.

Inorganic carbon (Figure 14) and **organic carbon** (Figure 13) were highly variable in 1980. Fluctuations in carbon values may be due to:
_ the demand for carbon dioxide for photosynthesis in relation to amount released through respiration occurring in the lake and sediments;
_ changes in the rate of decomposition of organic matter;
_ changes in the rate of microbial methane fermentation;
_ changes in the rate of nitrification of ammonia; and
_ changes in the rate of sulfide oxidation.

Dissolved chloride (Figure 15) values met all guidelines. Chloride values increased over time, which may indicate a disturbance within the watershed. Future monitoring should include dissolved chloride as a measure of changes in the rate that ions are released within the watershed, and as an indicator of possible disturbances within the watershed.

Chlorophyll a: Monthly samples were collected at several depths in 1980. The values ranged from 2.5 to 34 _g/L, with a mean of 13.7 _g/L. The guidelines for aquatic life (1-3.5 _g/L; Nordin 1985) and drinking water and recreation (2-2.5 _g/L; Nagpal *et al.* 1998a) were exceeded in most of the samples. Future monitoring should include chlorophyll a.

Fecal coliform values were collected between 1981 and 1995, and ranged from 2 to 240 /100 mL at the public beach near the boat ramp on Cusheon Lake (Table 2). The values from the beach site may not be representative of values elsewhere in the lake. The Capital Health Region determined that the public beach was suitable for bathing between 1981 and 1995. The Capital Health Region will continue to measure fecal coliforms at the beach.

There were 35 domestic water licenses that may have been used as drinking water sources, and two local authority water works licenses held by the Beddis Water Works District. The Ministry of Health recommends that all surface waters in the province receive disinfection, as a minimum, before being used for drinking. Raw water fecal coliform values must not exceed the 90th percentile guideline of 100 /100 mL for partially treated and disinfected drinking water, and 10 /100 mL for drinking water receiving only disinfection. Fecal coliforms monitoring was not done near water intakes, nor at a sufficient frequency to permit comparison to drinking water guidelines. Future monitoring should include fecal coliform measurements near drinking water intakes to evaluate the suitability of Cusheon Lake water as a raw drinking water source.

True colour values (Figure 16) exceeded the guideline (15 units) for drinking water aesthetics in 33% of the samples collected from Cusheon Lake. Future monitoring should include true colour.

Extinction depth values (Figure 17) ranged from 1 to 5.4 m during 1974-94. One value measured in October 1980 did not meet the guideline (>1.2 m) for swimming, and may indicate that the guideline was not met in the summer months when swimming would most likely have occurred. Future monitoring should include extinction depth as an indicator of water clarity and changes in the amount of particulate and dissolved matter in the water column.

Total iron values (Figure 18) exceeded the guideline (0.3 mg/L) for aquatic life and drinking water (aesthetics) in two samples collected in 1974. Since then, the guideline has been met.

Total manganese values (Figure 20) exceeded the guideline (0.05 mg/L) for drinking water (aesthetics) in two samples in 1993 and one sample in 1994.

Dissolved oxygen values (Figure 21) did not meet the guideline (8 mg/L) for protecting adult and juvenile salmonids from production impairment in 29% of the samples collected during 1974-94. Dissolved oxygen values that did not meet this guideline were collected between October and December, in samples collected at depth, and in one value collected in April 1994. The guideline (5 mg/L) for protecting adult and juvenile salmonids from moderate production impairment was not met in 2% of the samples during 1974-94. This guideline was not met in samples collected in October and December 1980 at depth. Future monitoring should include dissolved oxygen.

pH values (Figure 22) met all guidelines, ranging between 6.7 and 7.7. Future monitoring should include pH.

Total residue (i.e., dissolved plus suspended solids) values, collected between 1980 and 1994, ranged from 72 mg/L to 106 mg/L (Figure 23). There are no guidelines for total residue. The guideline for suspended solids could not be used because there were insufficient suspended solids (non-filterable residue) data.

Dissolved silica values (Figure 24) ranged from 5 to 11.6 mg/L in samples collected between 1980 and 1995. The decrease in dissolved silica values in 1994 may be due to an increase in the diatom population. Dissolved silica was not a limiting nutrient (i.e., values were greater than 0.5 mg/L) for diatom growth in Cusheon Lake (Wetzel, 1975).

Dissolved sodium values (Figure 25) increased between 1975 and 1993 in Cusheon Lake in the same manner as chloride, but met all guidelines. Future monitoring should include dissolved sodium as a measure of changes in the rate that ions are released within the watershed and as an indicator of possible disturbances within the watershed.

Specific conductivity (Figure 28) can be used to indicate dissolved solids concentrations. The values ranged from 58 to 134 _S/cm, and were below all guidelines. Specific conductivity values increased over time. Future monitoring should include specific conductivity as a measure of changes in the rate that ions are released within the watershed, and as an indicator of possible disturbances within the watershed.

Water temperature (Figure 27) exceeded the drinking water (aesthetics) guideline (15 ^{o}C) at the deep station in Cusheon Lake in October 1980. The values were collected from the surface and to a depth of 6 m, and imply that the guideline may also have been exceeded during the summer. Future monitoring should include water temperature.

Turbidity (Figure 28) was measured for five years during 1974-95. The 5 NTU aesthetics objective for drinking water (with disinfection only) was met except for a few values in 1980. The drinking water health guideline (1 NTU) was exceeded in 80% of the samples. All values collected in 1994-95 met the turbidity guideline and objective. Increased turbidity may be caused by:
_ natural erosion within the Cusheon Lake basin,
_ changes in land-based activities adjacent to the lake (e.g., forestry, agriculture, urbanization), or
_ an increase in the amount of biological material (e.g., plankton) in the water column.
The turbidity levels in the Cusheon Lake were such that treatment to remove it would have been needed

prior to drinking. Future monitoring should include turbidity to evaluate the suitability of the lake water as a drinking water supply.

Conclusions - State of Water Quality

· There was weak evidence of an increasing trend in spring overturn total phosphorus during 1975-99. Total phosphorus values were above the upper guideline for aquatic life for 6 of 14 years, and above the guideline for drinking water and recreation for 10 of 14 years between 1975 and 1999.
· Chlorophyll a values were collected in 1980 and exceeded the guidelines for aquatic life, drinking water, and recreation.
· Phosphorus was the limiting nutrient for algal growth in Cusheon Lake.
· Increases in sodium, chloride, and specific conductivity indicated possible disturbances within the watershed.
· Total organic carbon values exceeded the guideline for raw drinking water. Chlorinating the water may produce trihalomethanes that exceed the drinking water guideline.
· The Capital Health Region determined that the public beach on Cusheon Lake was suitable for bathing between 1981 and 1995.
· True colour values exceeded the guideline for drinking water aesthetics in 33% of the samples from Cusheon Lake.
· Dissolved oxygen did not meet the guideline for protecting adult and juvenile salmonids from production impairment in 29% of the samples during 1974-94. The guideline for protecting adult and juvenile salmonids from moderate production impairment was not met in 2% of the samples during this period.
· Water temperature exceeded the drinking water aesthetics guideline at the deep station in Cusheon Lake in October 1980. The guideline may also have been exceeded during the summer months.
· Total calcium values show that the lake had a low sensitivity to acid inputs (the lake was well buffered).
· Total iron values exceeded the guideline for drinking water aesthetics and aquatic life in two samples collected in 1974.
· Total manganese exceeded the guideline for drinking water aesthetics in samples collected in 1993 and 1994.
· One extinction depth value measured in October 1980 did not meet the guideline for swimming and may indicate that the guideline was not met in the summer months when swimming would most likely have occurred.
· Turbidity exceeded the aesthetics objective for drinking water (with disinfection only) in 20% of the samples collected between 1974 in 1995. The drinking water health guideline was exceeded in 80% of the lake samples. The turbidity levels in the Cusheon Lake were such that treatment processes to remove it are required prior to drinking.

Recommendations for Water Quality Management

Remediation

Chlorophyll a, total phosphorus, total organic carbon, true colour, total iron, total manganese, water temperature and turbidity did not meet the guidelines for drinking water at times. Total phosphorus and extinction depth did not meet the guidelines for primary and secondary recreation at times, and total phosphorus and dissolved oxygen did not meet the guidelines to protect aquatic life at times.

Given the above, we recommend that a remediation plan be developed and implemented to improve water quality in Cusheon Lake. The plan should be developed and implemented by a Cusheon Lake watershed group in conjunction with Islands Trust. The focus of the remediation plan would be:
· to determine the suitability of Cusheon Lake for recreation, drinking water and sustaining aquatic life;
· to identify the sources of nutrients and contaminants in the watershed and lake;
· to identify what is required to improve the water quality in Cusheon Lake to make it suitable for recreation, drinking and sustaining aquatic life; and
· to evaluate remediation options and recommend the most efficient approach to improving water quality in the lake.

Monitoring
We recommend monitoring be continued at the deep station on Cusheon Lake (EMS site 1100123). Water quality samples should be collected during spring overturn and monthly between June and October. The results from these samples will be used to determine the water quality in Cusheon Lake and to set water quality objectives to protect water uses. Also, these results may be used to recommend and evaluate possible remediation activities. This monitoring program, at the deep station on Cusheon Lake, would require sampling of the following water quality indicators:
_ water temperature and dissolved oxygen collected at
one-metre intervals from the surface to the bottom;
_ duplicate chlorophyll <u>a</u> samples collected at zero, two,
four, six metre water depths. These samples should be collected every four weeks between May to August;
_ total phosphorus, dissolved ammonia, nitrate/nitrite, Kjeldahl nitrogen, total and dissolved organic carbon,
true colour, turbidity, pH, dissolved silica from three samples taken one metre below the surface, at mid-depth and one metre above the bottom;
_ total metals; and
_ extinction depth (i.e., Secchi depth) and UVb absorption.

The Cusheon Lake watershed should be inspected and monitoring conducted to identify and quantify the sources of nutrients and contaminants entering the lake. This monitoring should be done year-round for one year, at a frequency ranging from weekly during wet, high flow conditions to monthly during dry conditions, and include flow, total phosphorus, dissolved ammonia, nitrate/nitrite, Kjeldahl nitrogen, total and dissolved organic carbon, true colour, turbidity, total metals, and fecal coliforms.

A Cusheon Lake stewardship group could implement this monitoring program with assistance from the Ministry of Environment, Lands and Parks.

We recommend that bacteriological sampling continue at the public access on Cusheon Lake. The Capital Health Region is currently conducting the monitoring program. In future, a Cusheon Lake stewardship group could assist with this ongoing monitoring.

We recommend that the water works licensee (Beddis Water Works District) monitor the chlorinated water for trihalomethanes. The results of this monitoring should be reported, on a quarterly basis, to the Capital Health Region.

We recommend that bacteriological and water quality sampling be conducted at the 35 domestic water licenses on Cusheon Lake that may be used as a drinking water sources. Ten fecal coliform samples, taken in any consecutive 30-day period, within 10 m of domestic intakes should be collected to determine the suitability of the water for drinking and the level of treatment needed. Also, water quality samples should be collected with the fecal coliform samples and should be analyzed for total phosphorus, organic carbon, true colour, total iron, total manganese, water temperature, and turbidity. A Cusheon Lake stewardship group could implement this monitoring program with assistance from Capital Health Region and/or the Ministry of Environment, Lands and Parks.

Figure 3 Total Phosphorus (average in the water column before stratification)

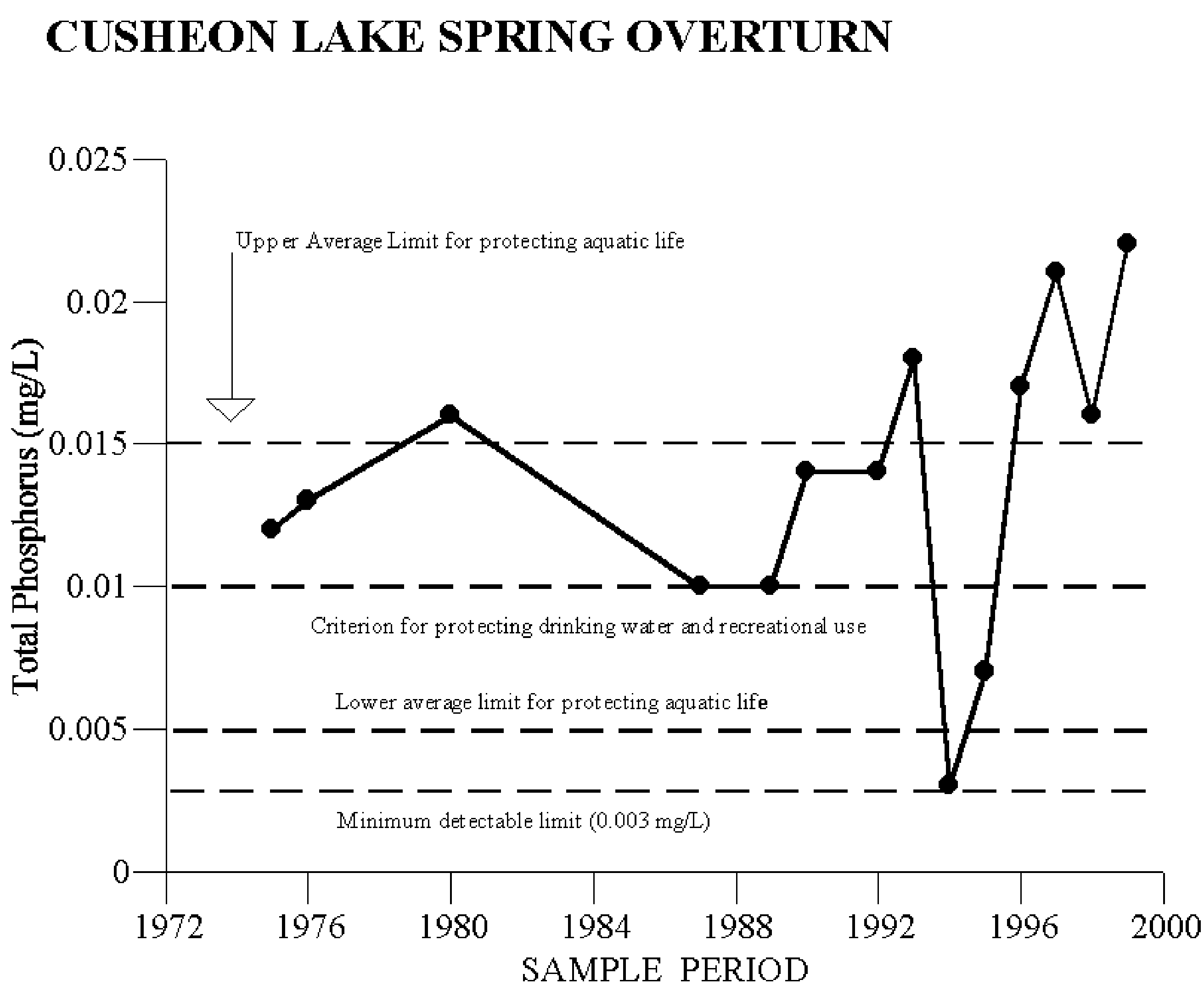

Figure 4 Total dissolved phosphorus from Cusheon Lake

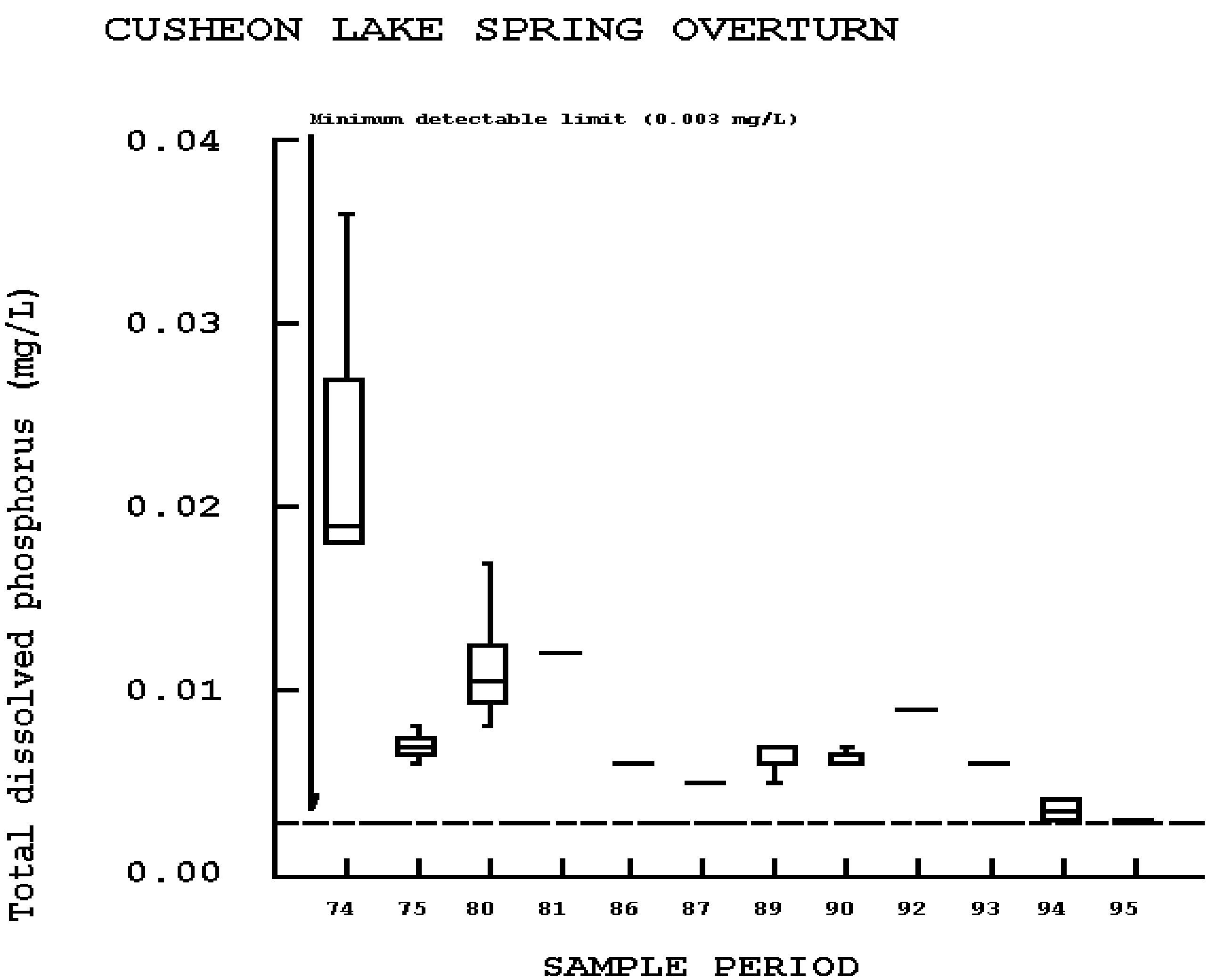

Figure 5 Dissolved Ortho-phosphorus from Cusheon Lake

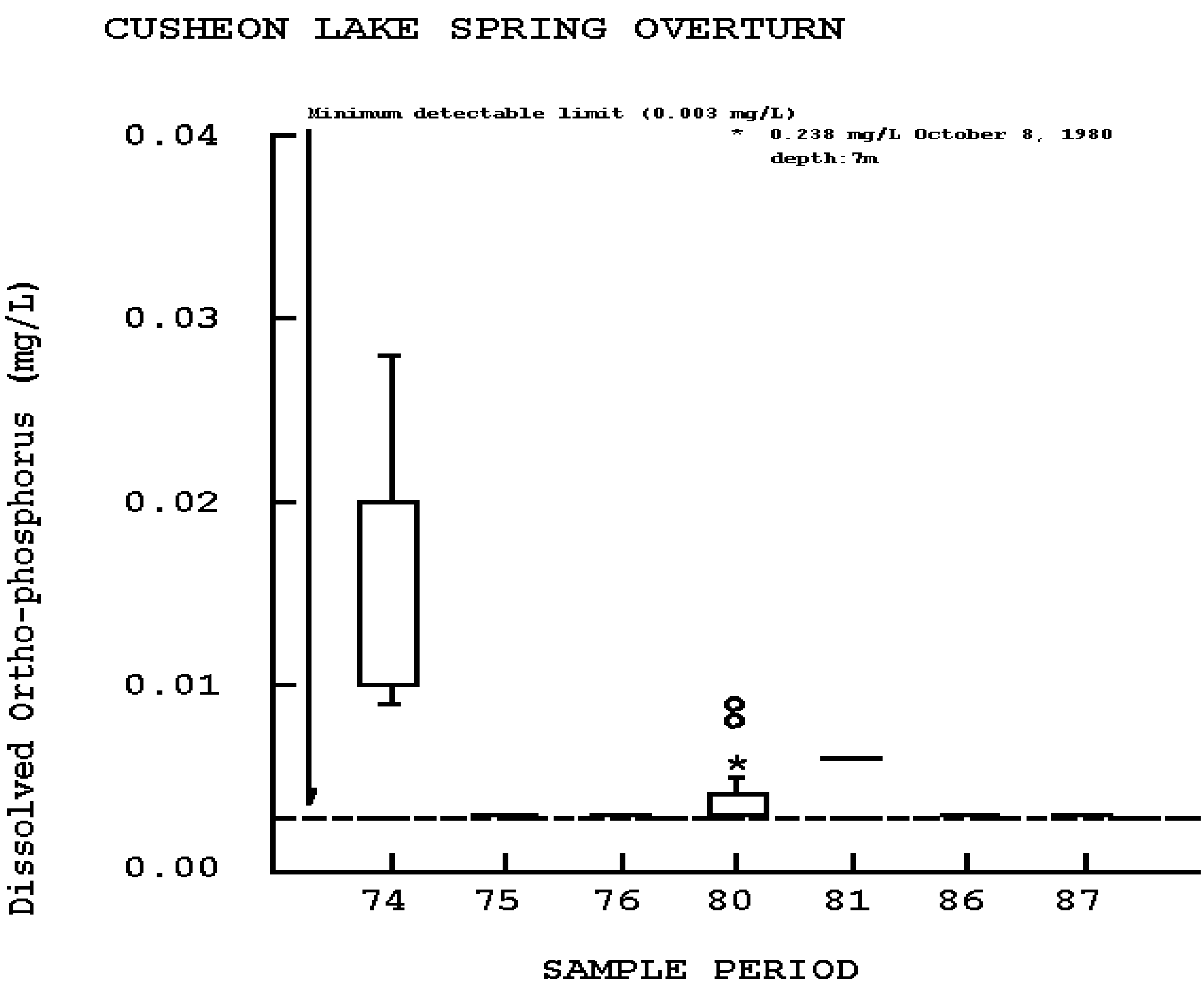

Figure 6 Dissolved ammonia from Cusheon Lake

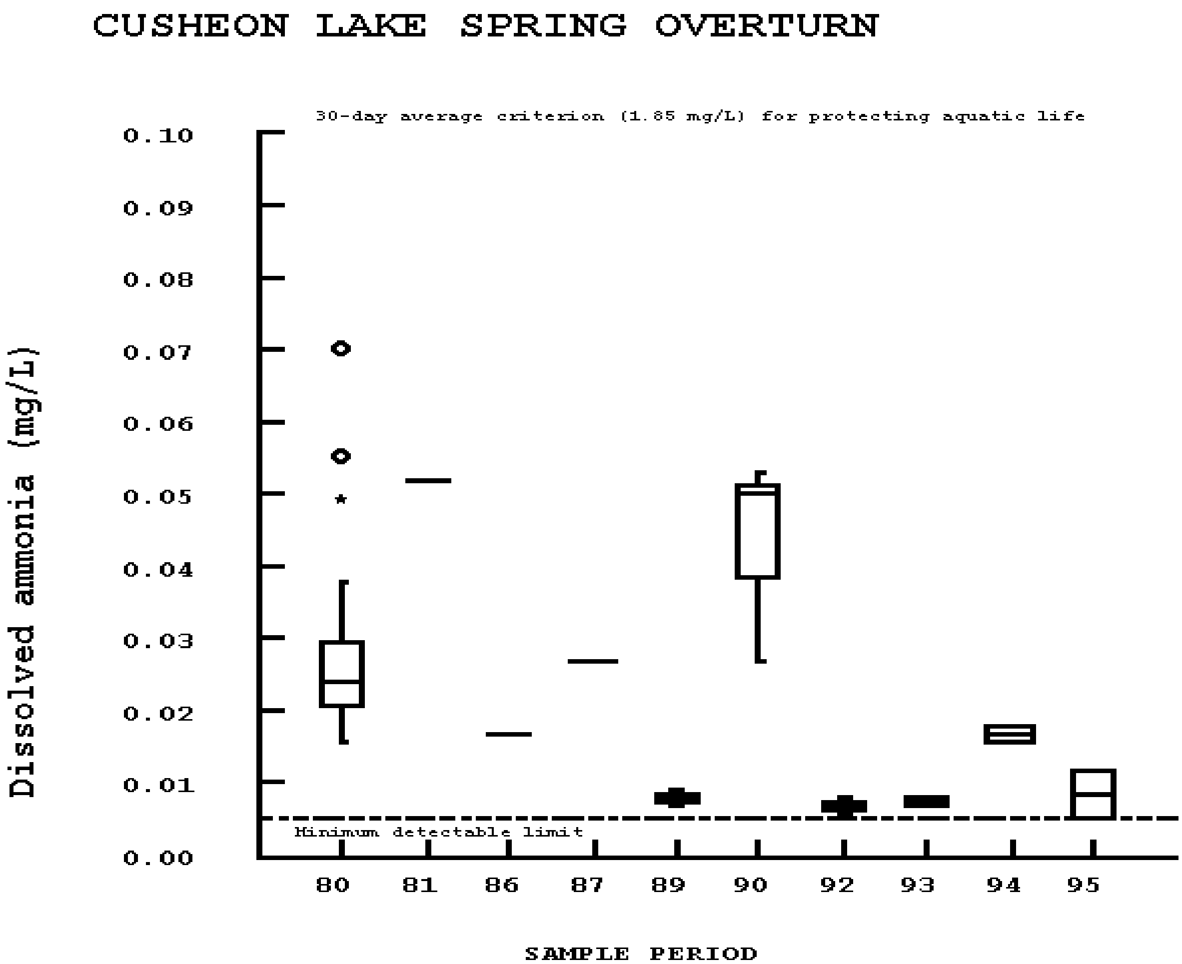

Figure 7 Kjeldahl nitrogen from Cusheon Lake

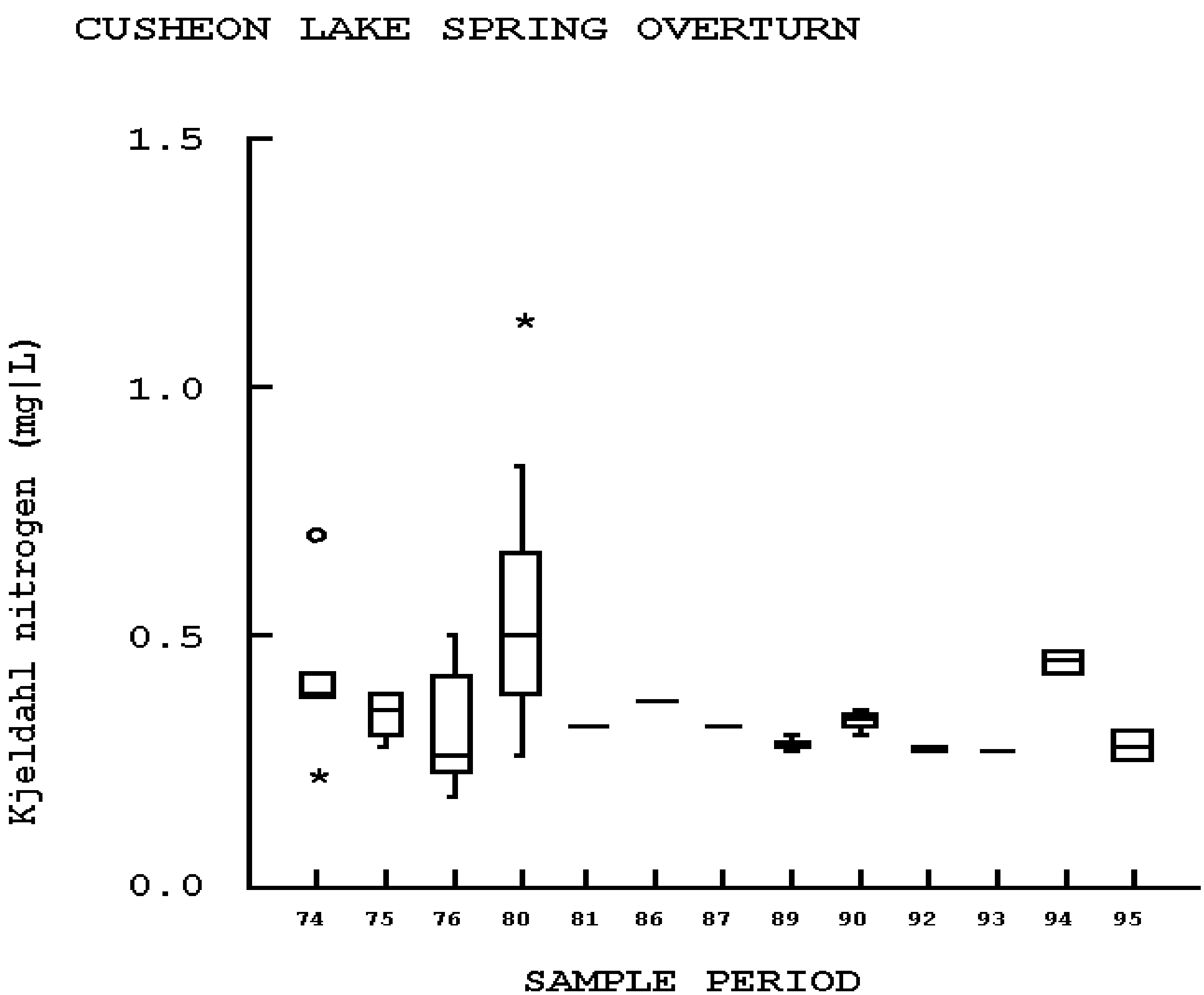

Figure 8 Nitrate/Nitrite from Cusheon Lake

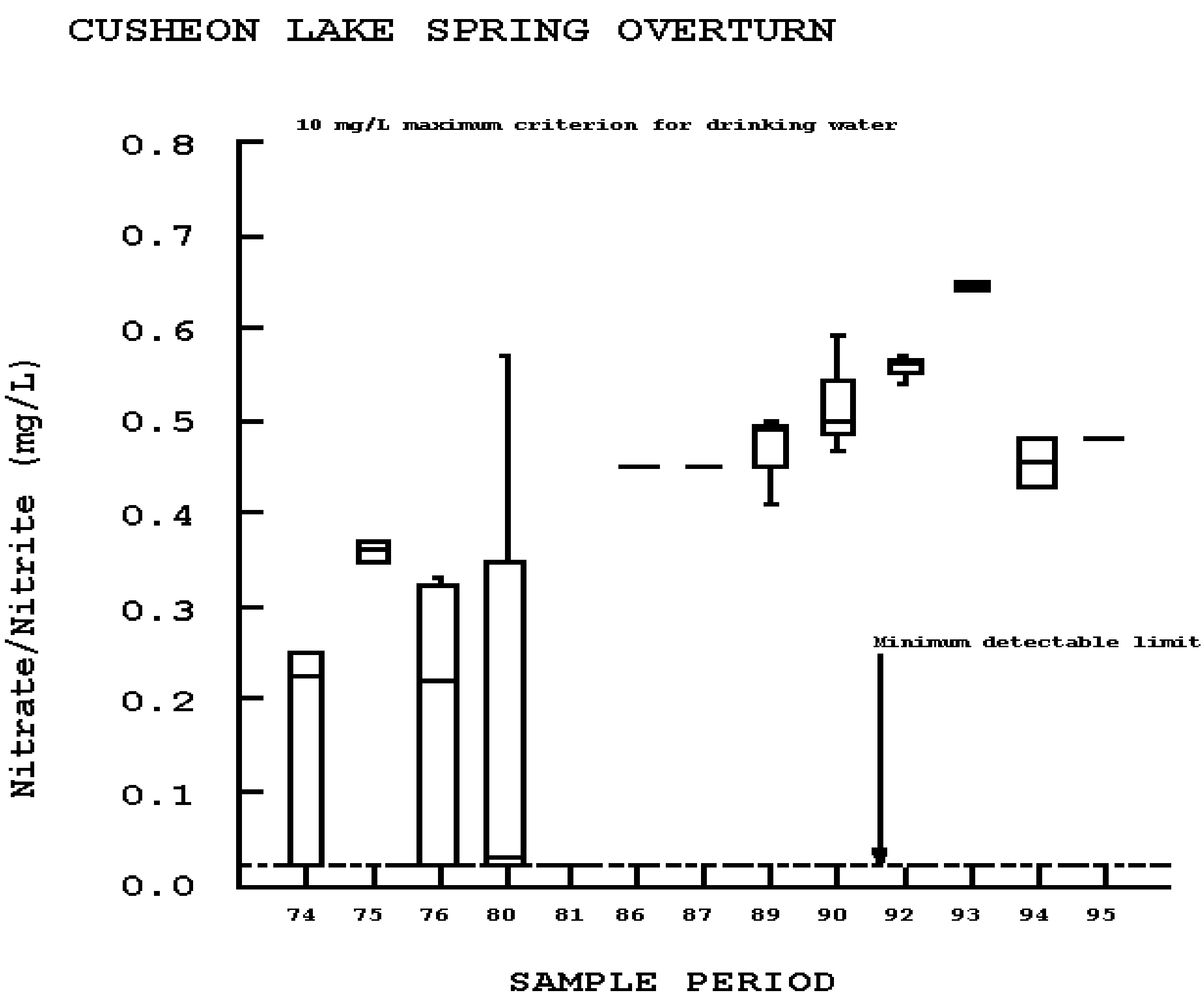

Figure 9 Total nitrogen from Cusheon Lake

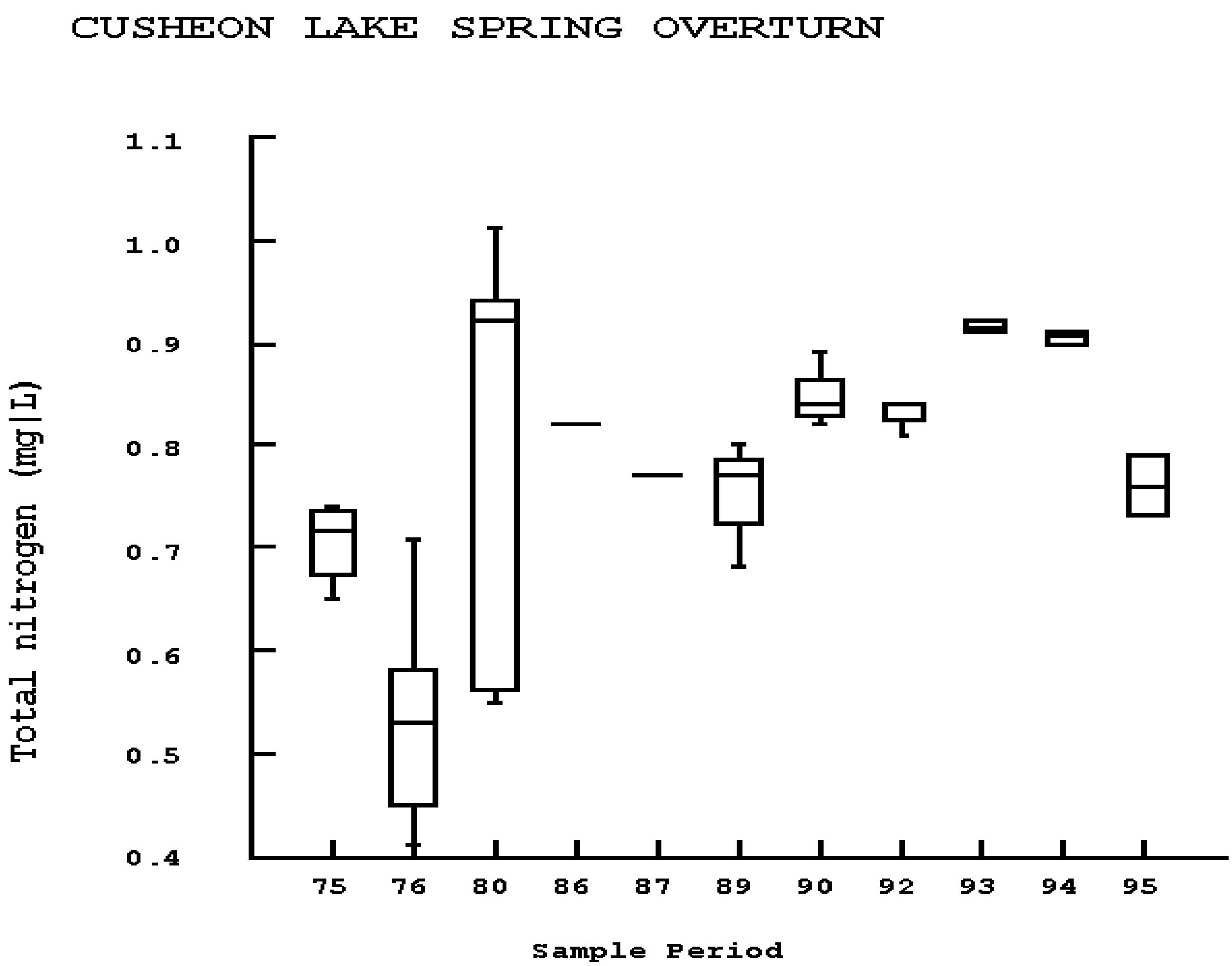

Figure 10 Ammonia:nitrate ratio from Cusheon Lake

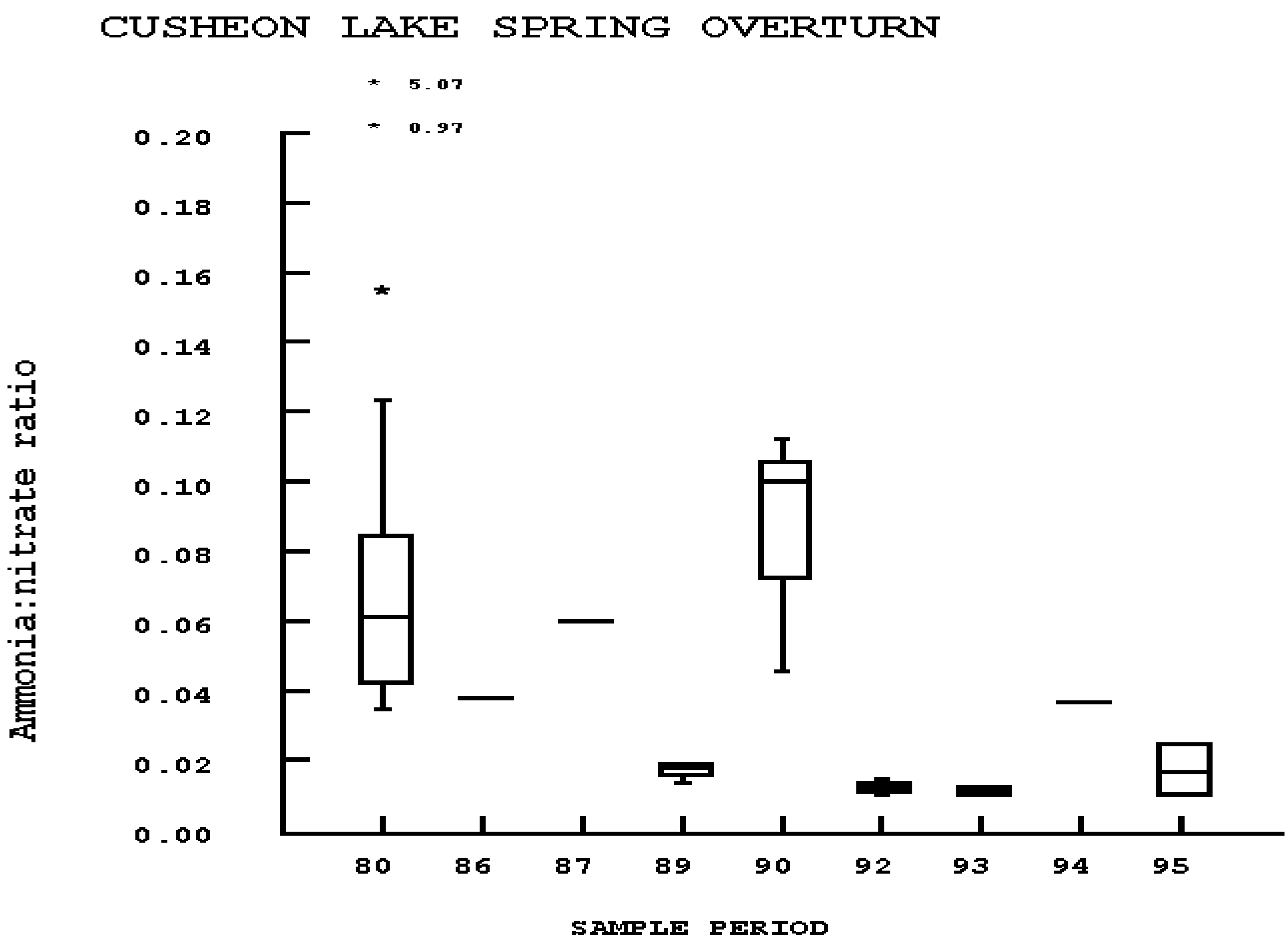

Figure 11 N:P ratio from Cusheon Lake

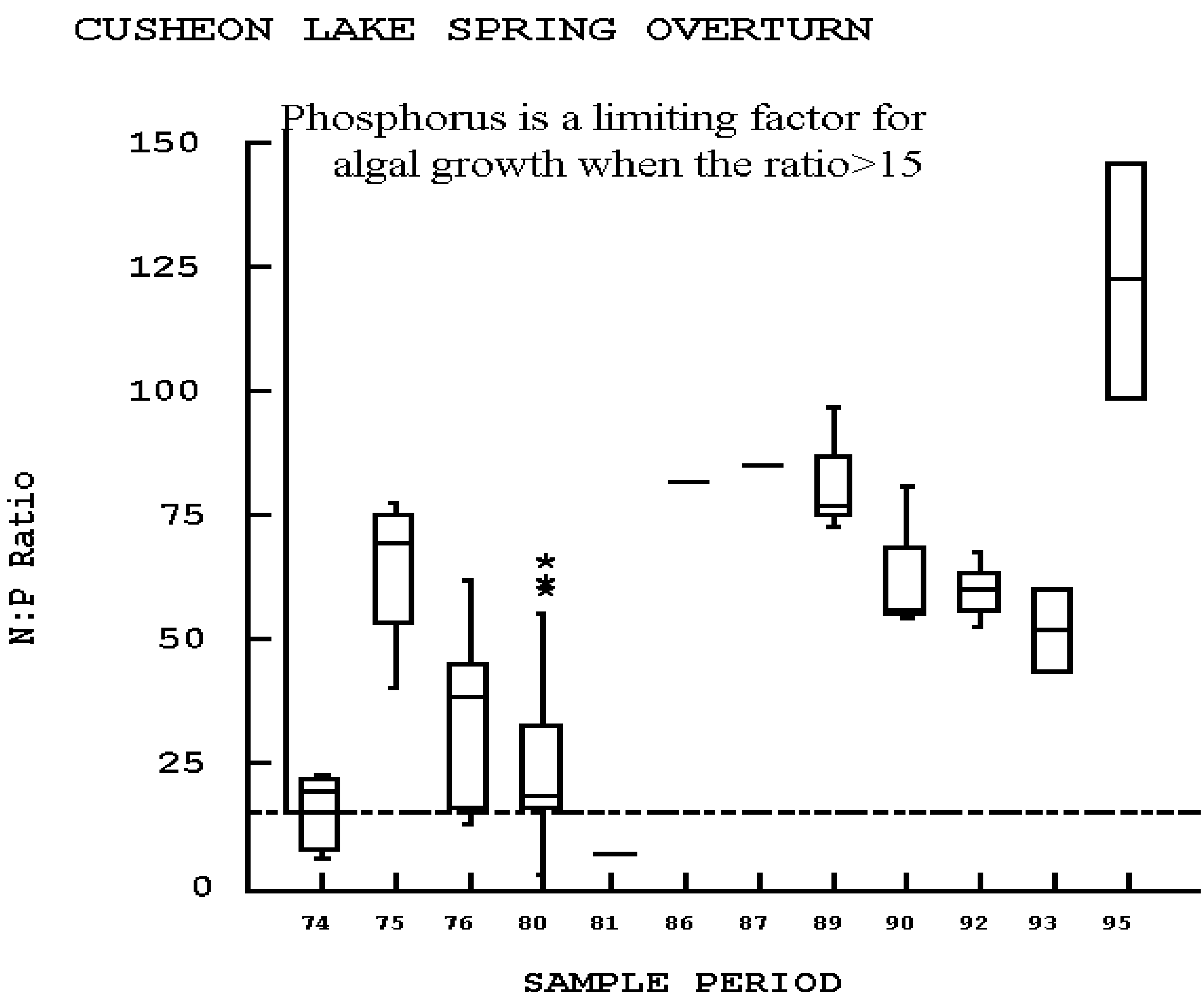

Figure 12 Total calcium from Cusheon Lake

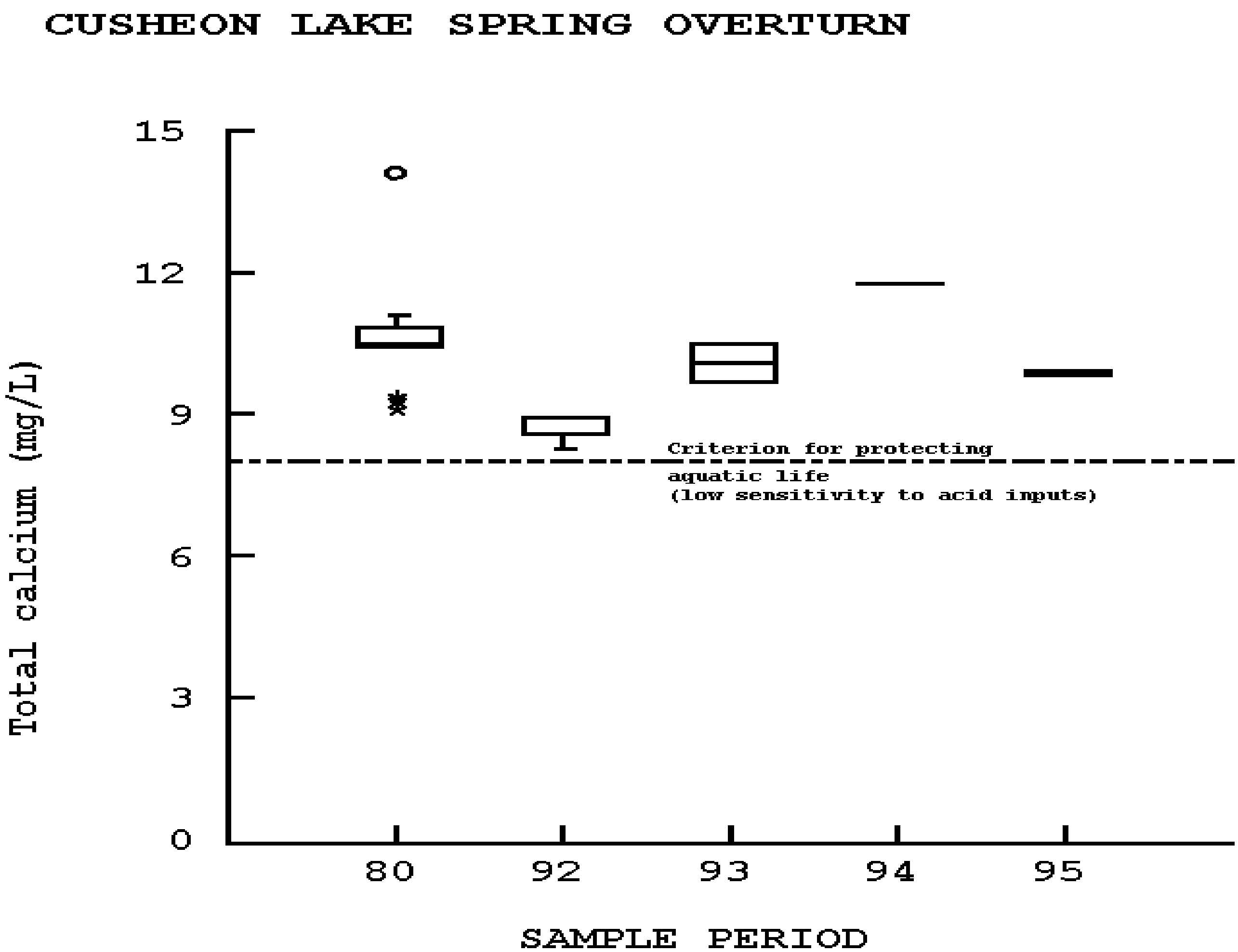

Figure 13 Total organic carbon from Cusheon Lake

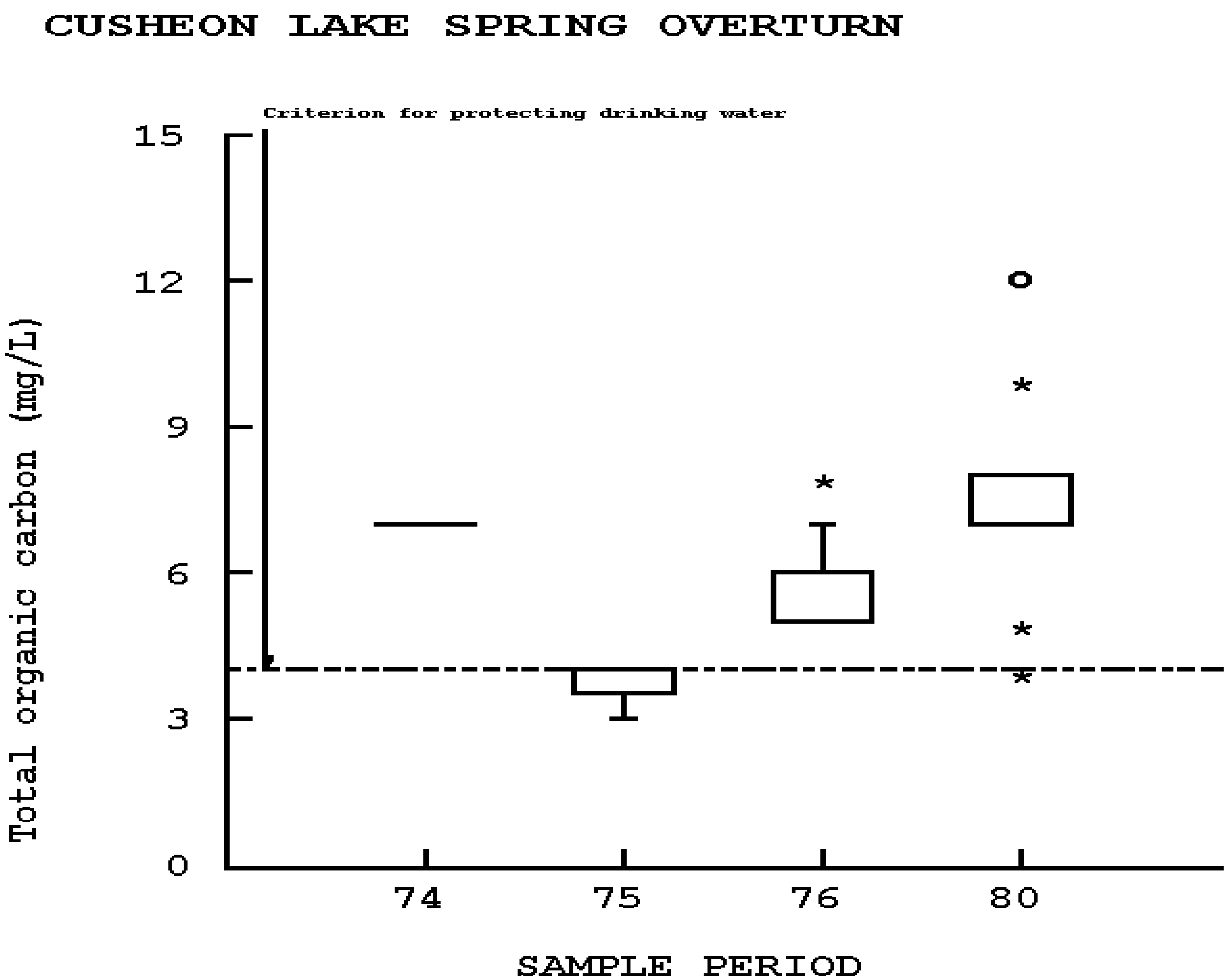

Figure 14 Total inorganic carbon from Cusheon Lake

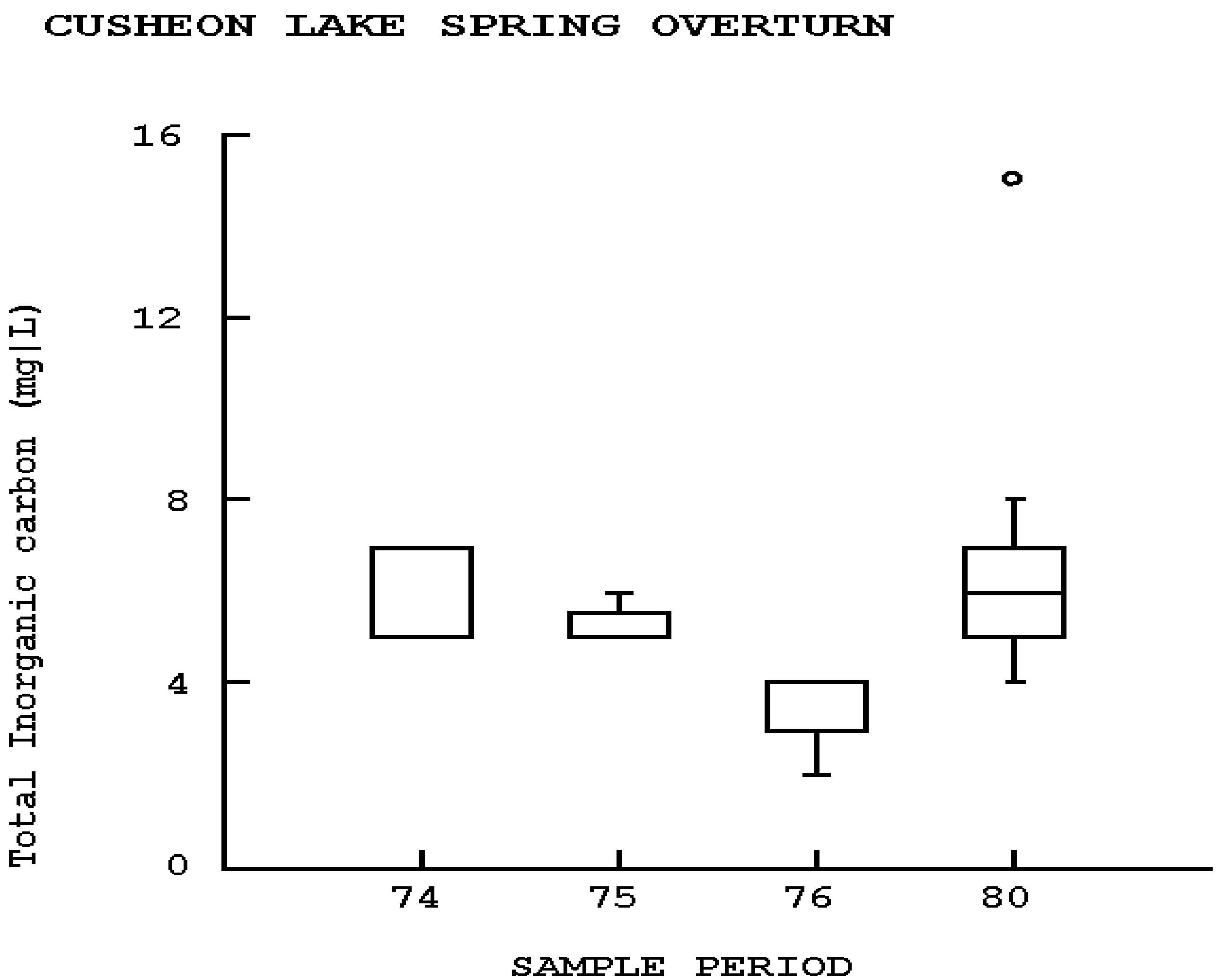

Figure 15 Dissolved chloride from Cusheon Lake

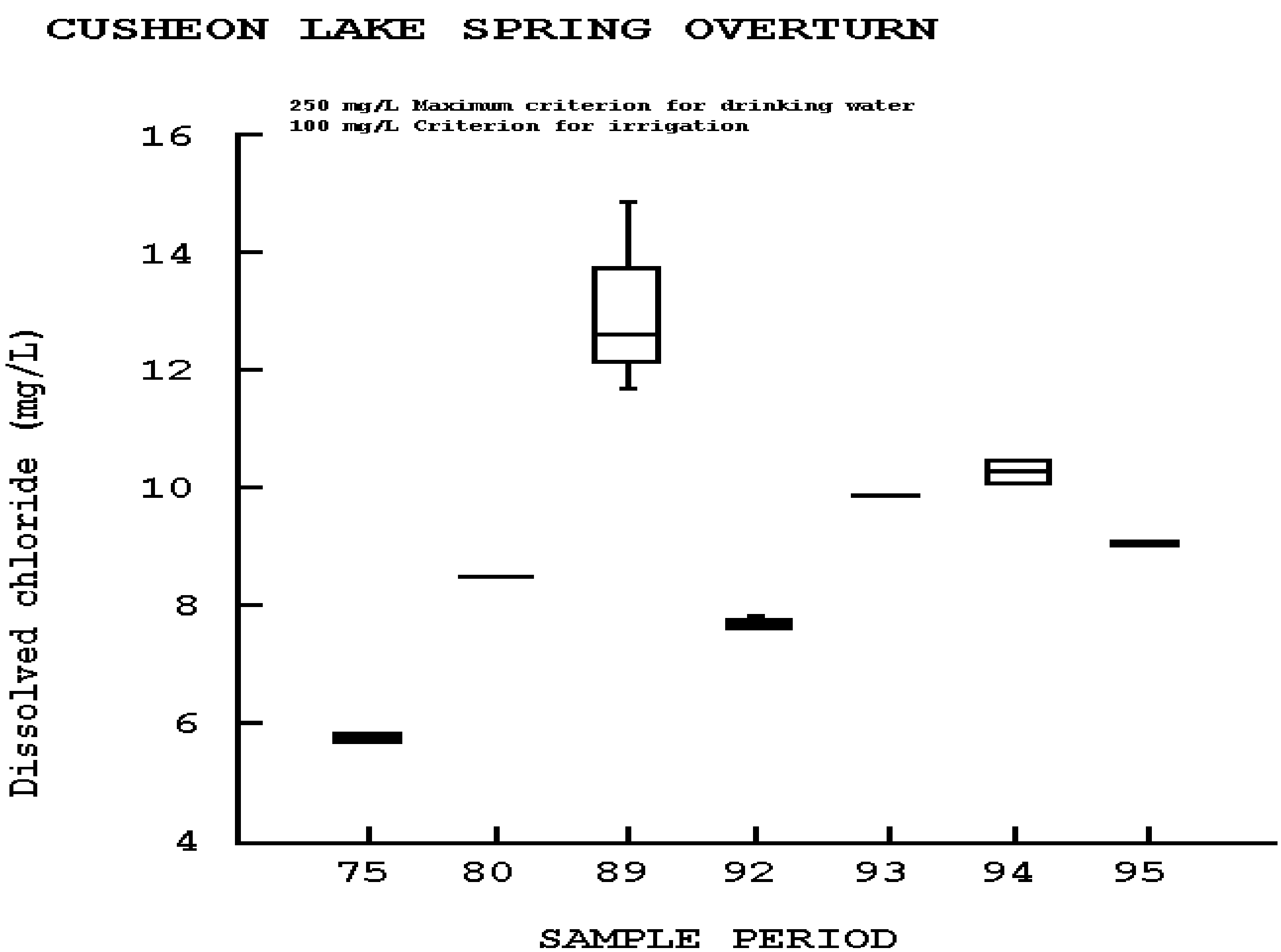

Figure 16 True colour from Cusheon Lake

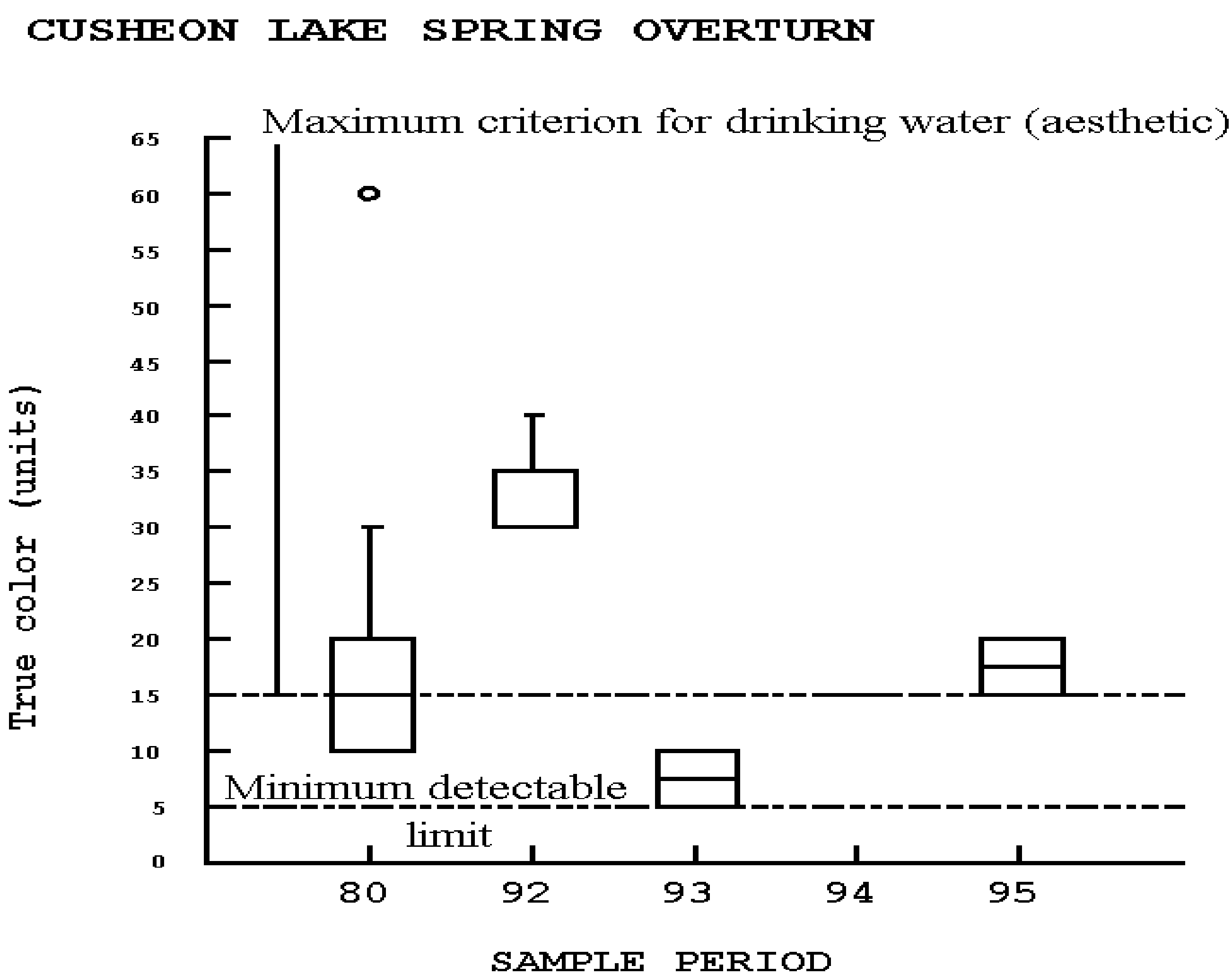

Figure 17 Extinction depth from Cusheon Lake

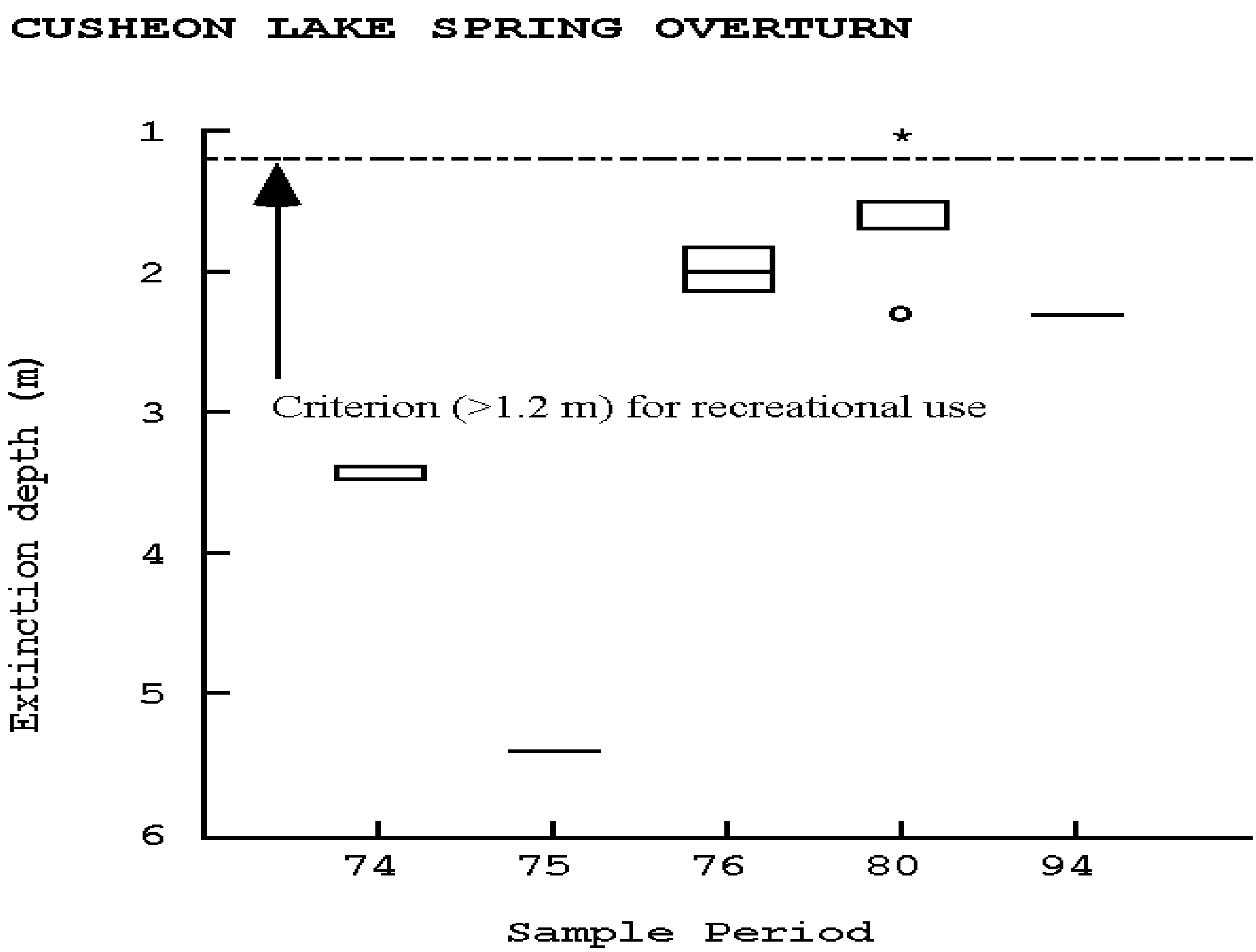

Figure 18 Total iron from Cusheon Lake

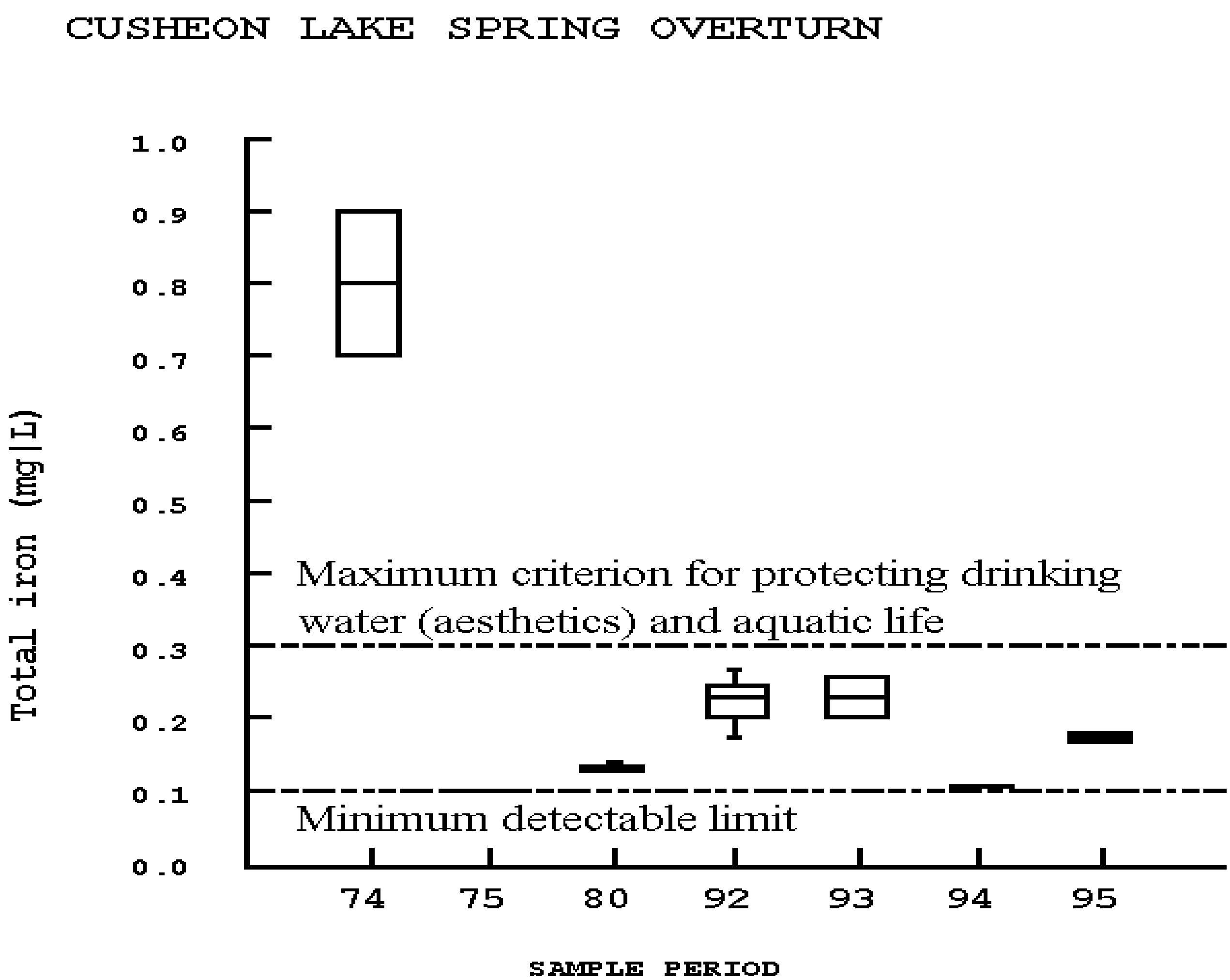

Figure 19 Total magnesium from Cusheon Lake

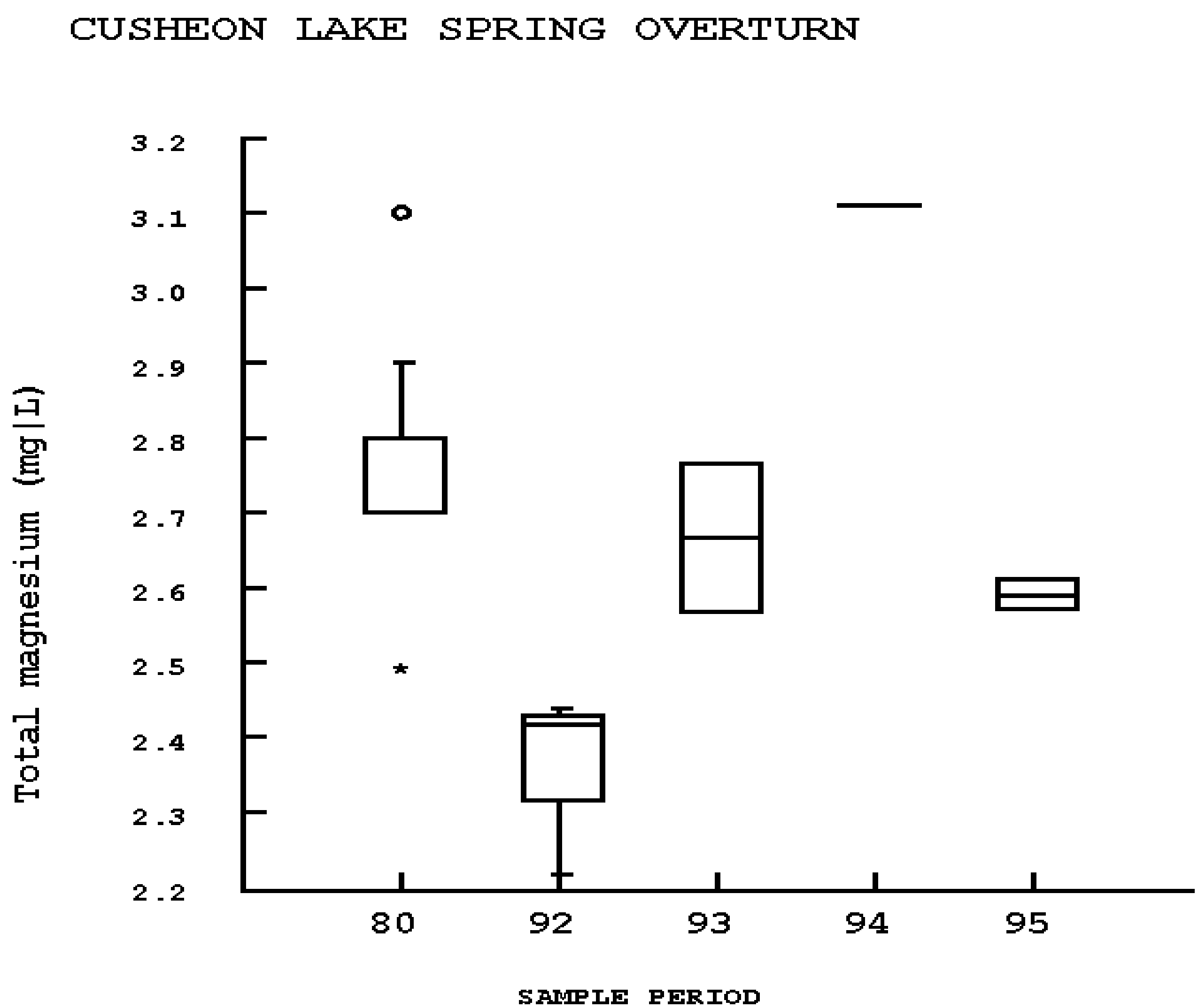

Figure 20 Total manganese from Cusheon Lake

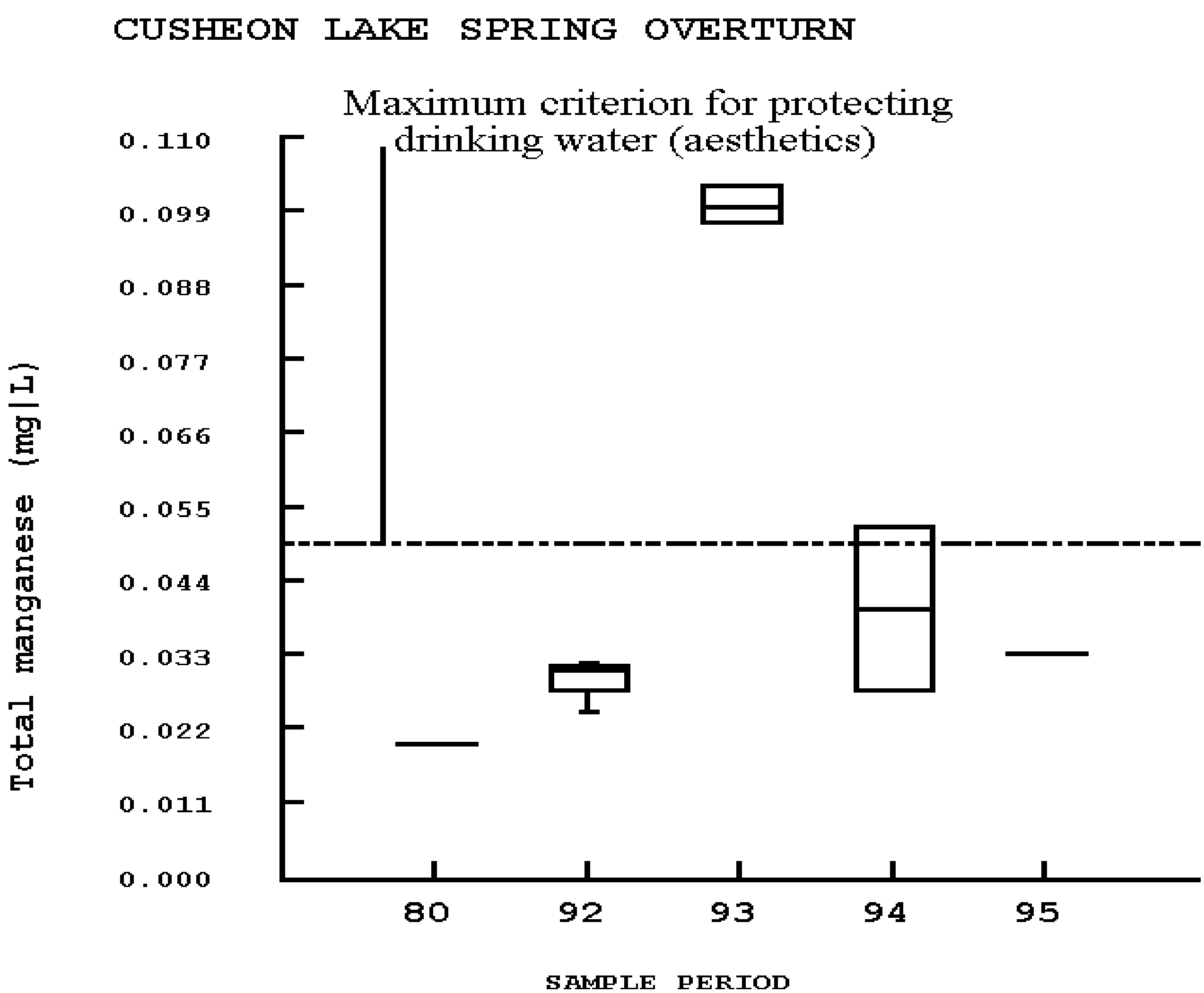

Figure 21 Dissolved oxygen from Cusheon Lake

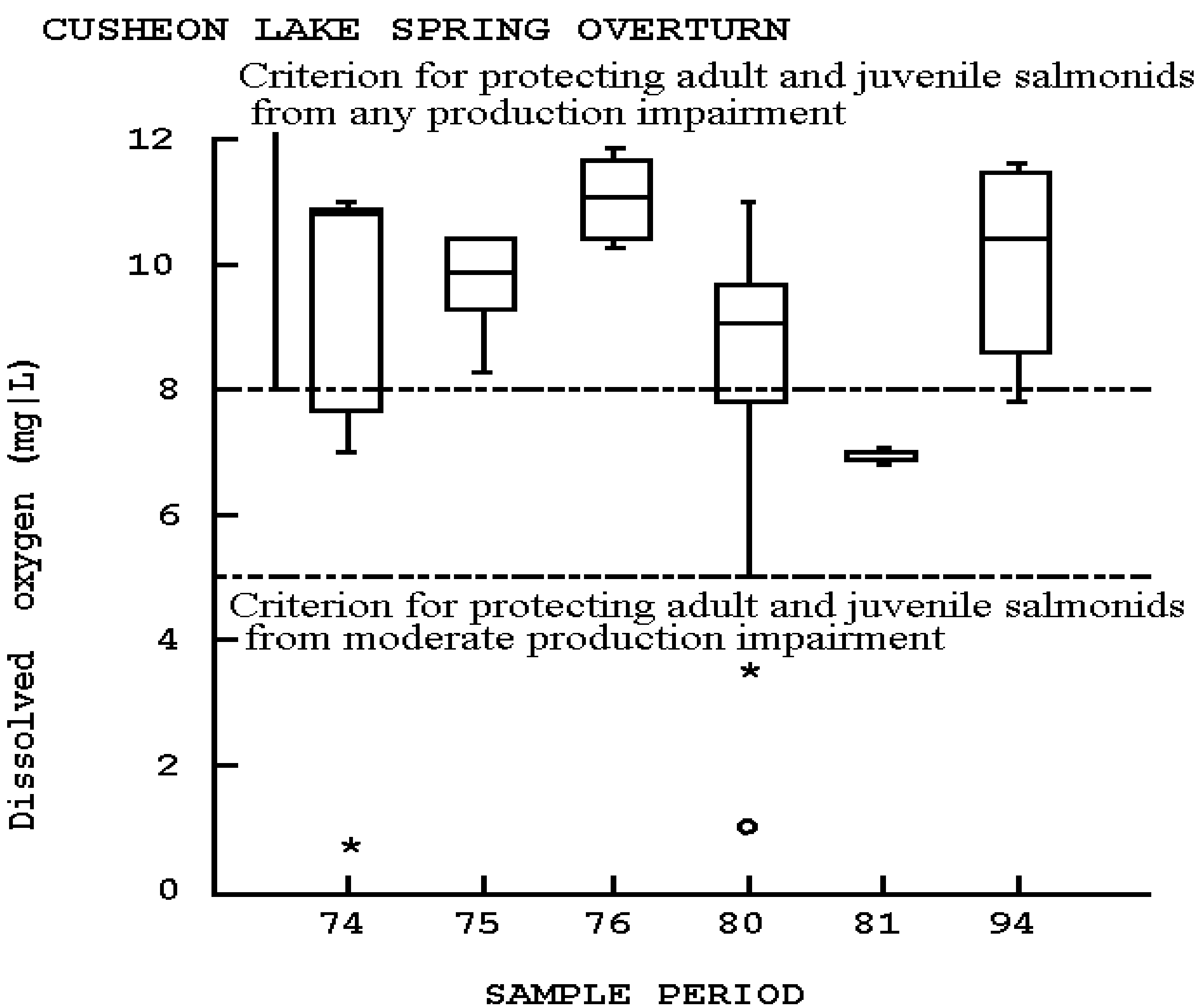

Figure 22 pH from Cusheon Lake

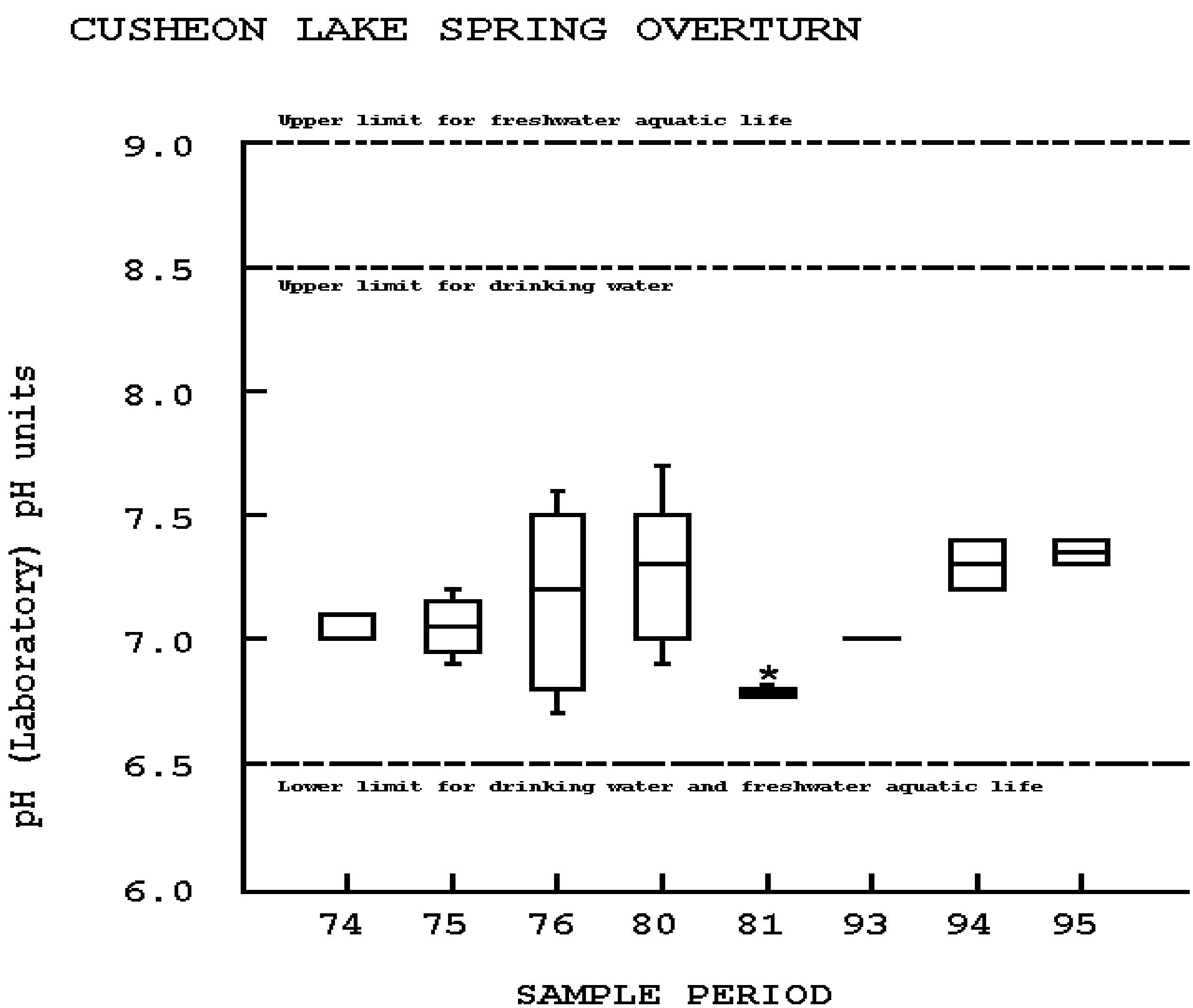

Figure 23 Total residues from Cusheon Lake

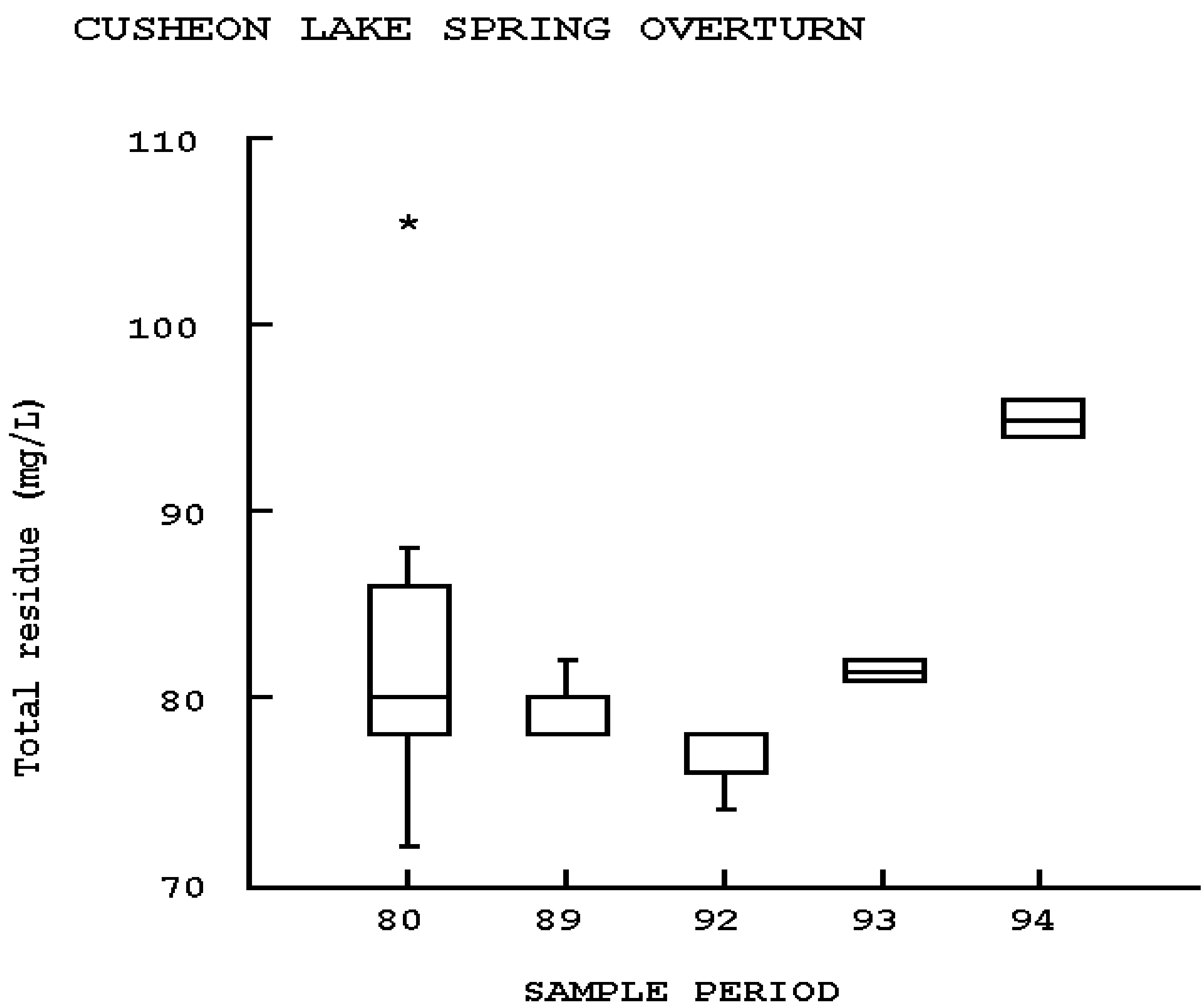

Figure 24 Dissolved silica from Cusheon Lake

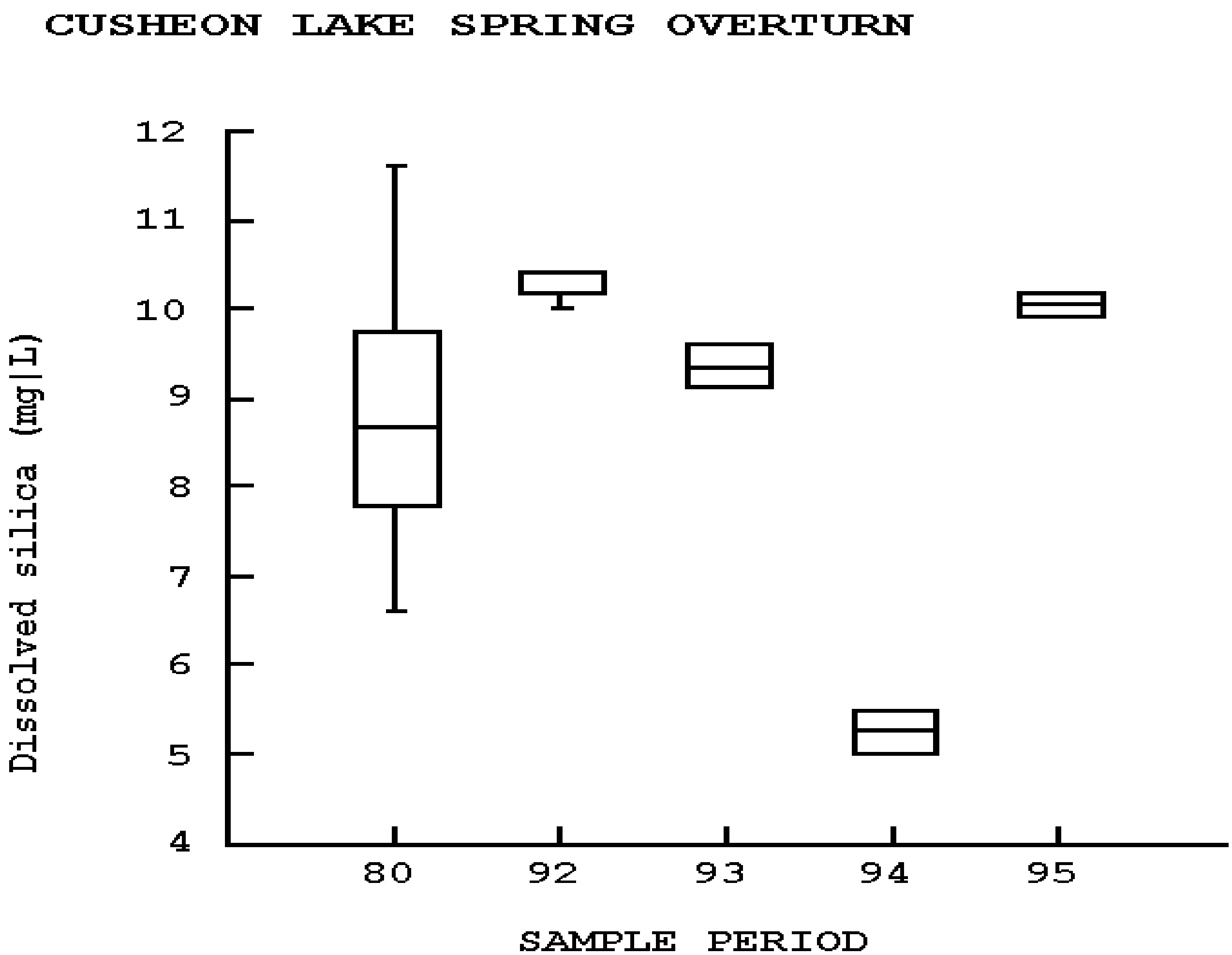

Figure 25 Dissolved sodium from Cusheon Lake

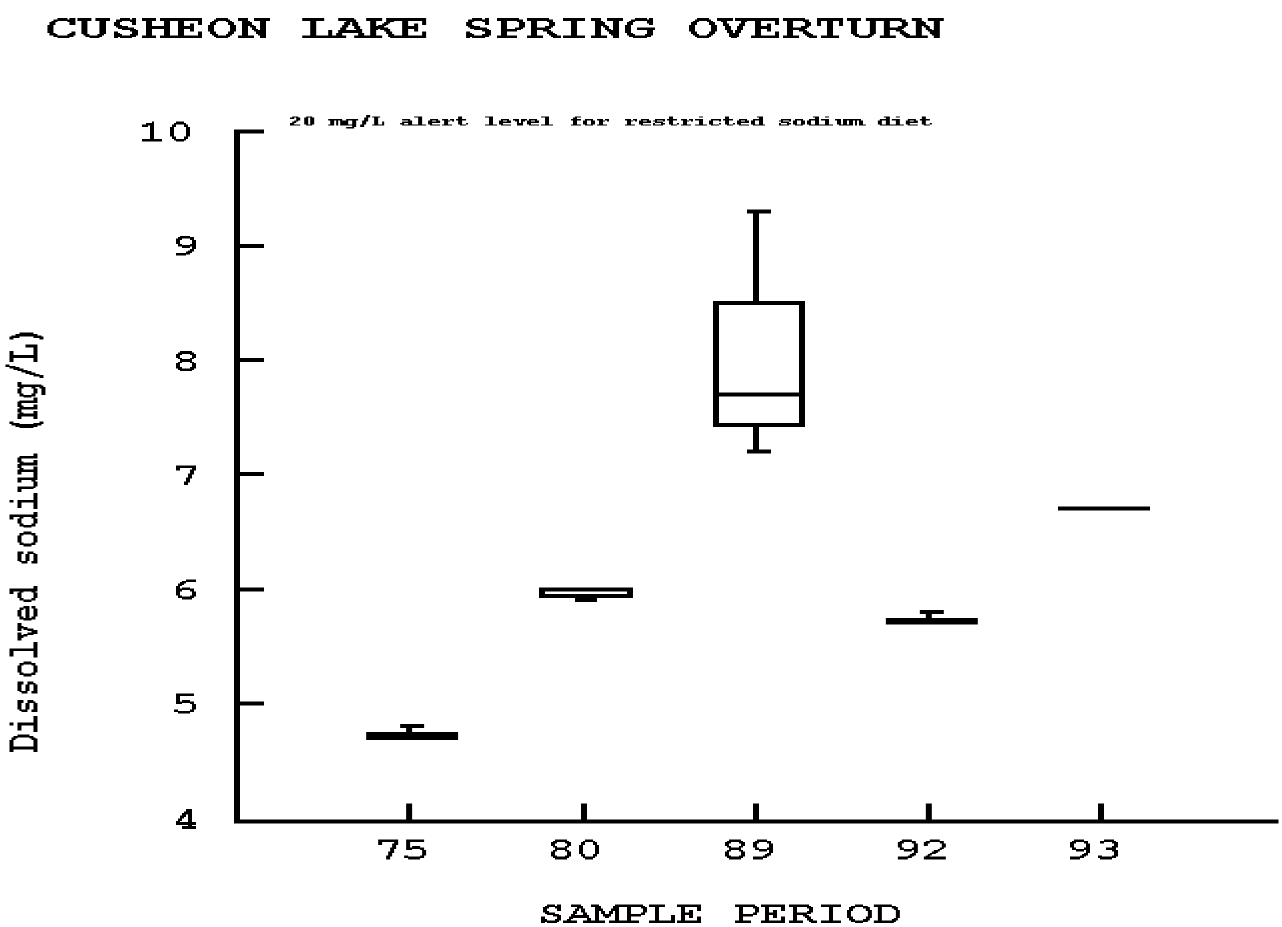

Figure 26 Specific conductivity from Cusheon Lake

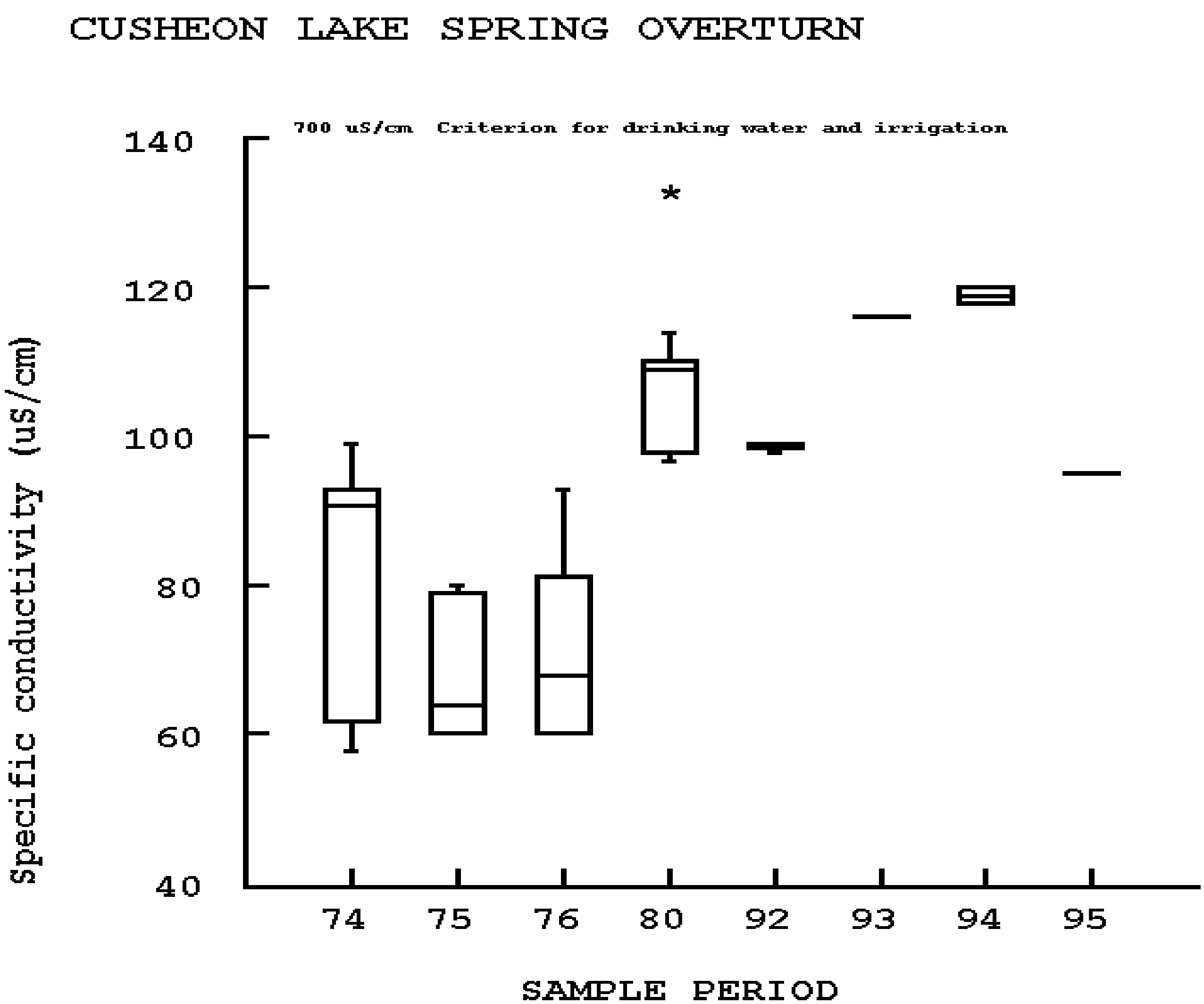

Figure 27 Water temperature from Cusheon Lake

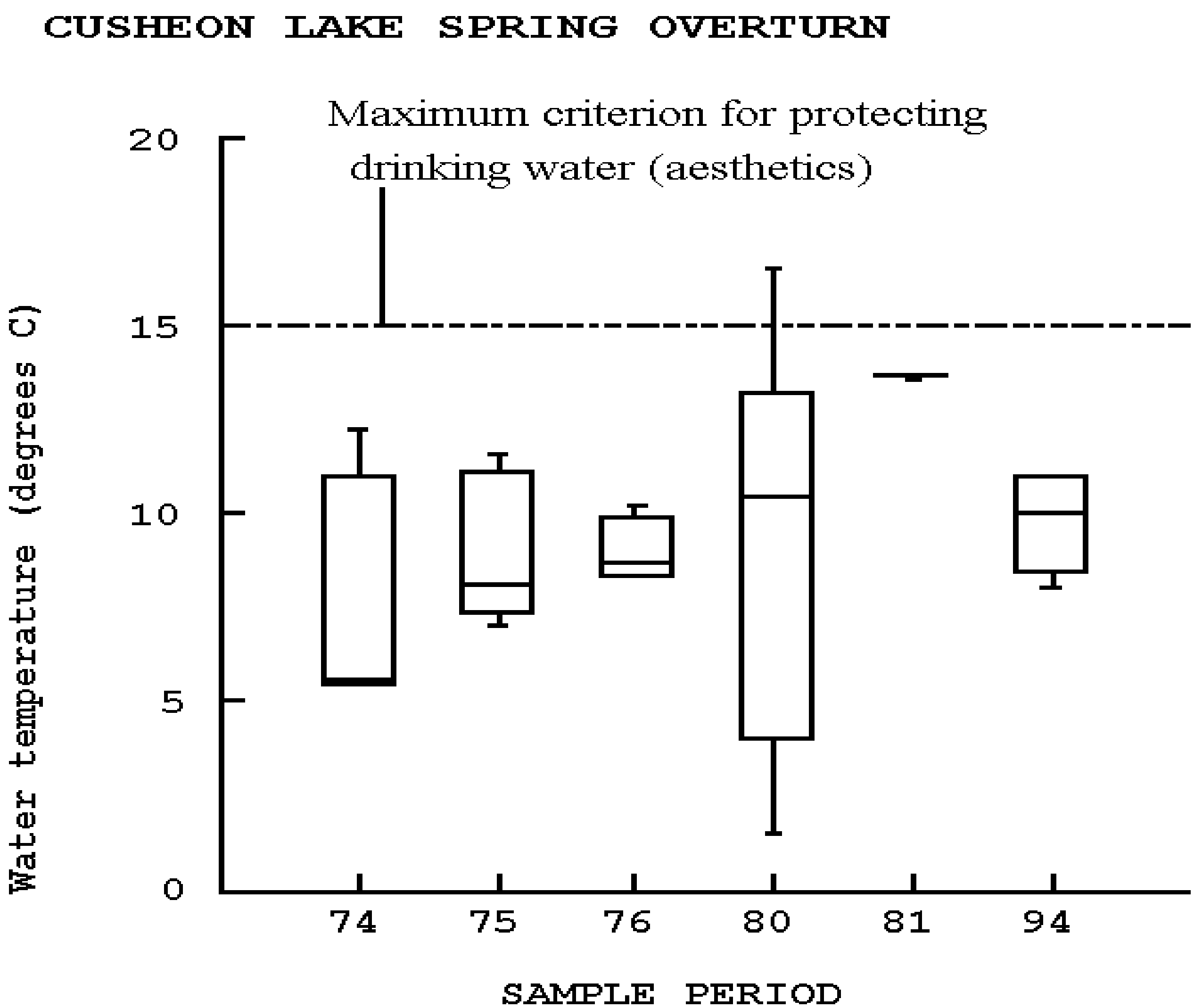

Figure 28 Turbidity from Cusheon Lake

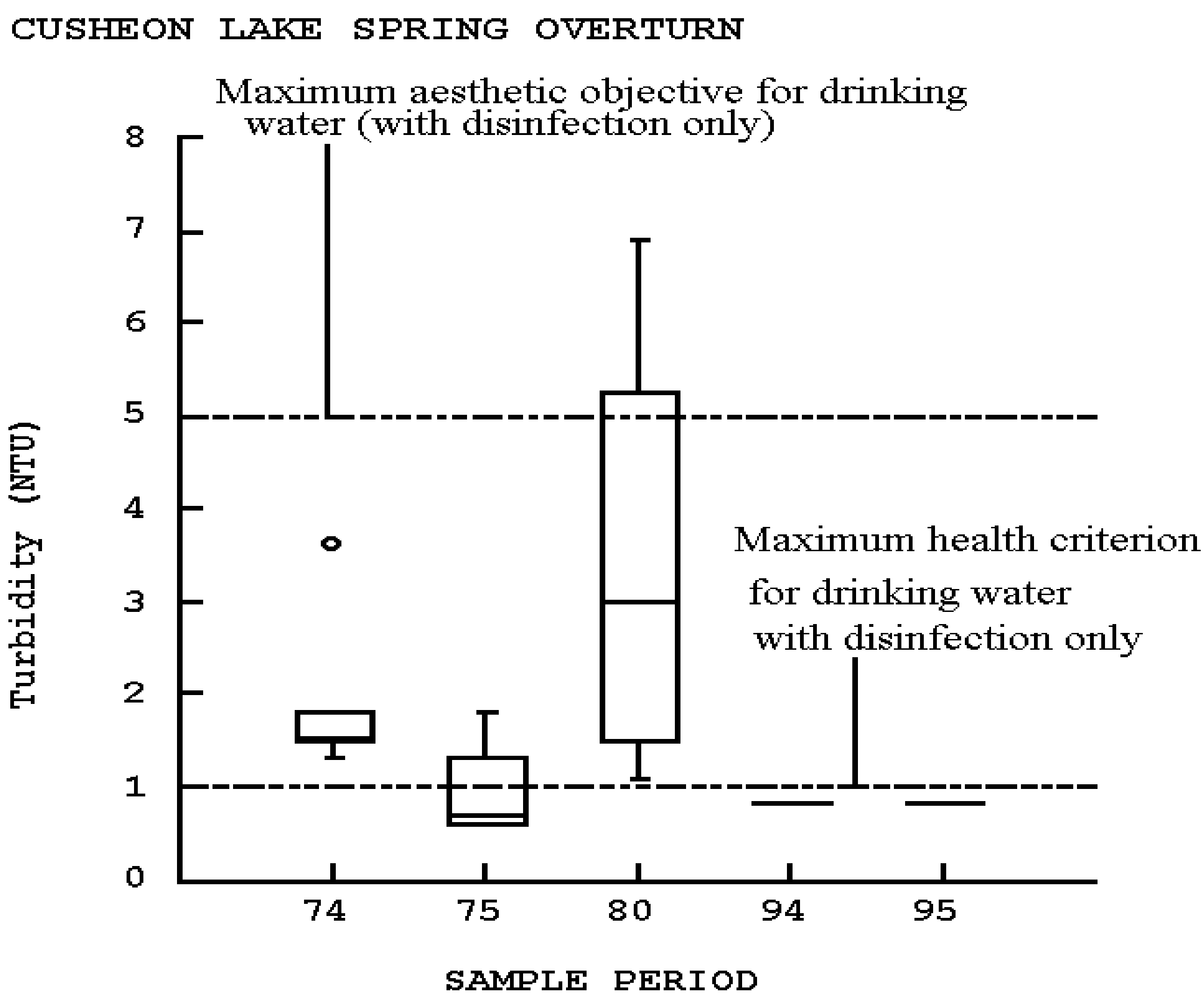

Table 1 Summary of water quality data for Cusheon Lake (EMS site 1100123)

Water Quality Indicator	Average	Std Dev.	Number of samples	Maximum	Minimum
SPRING OVERTURN MONITORING					
Water Clarity and Colour					
Turbidity (NTU)	2.9	2.48	35	12	0.6
Colour, true (TCU)	18.2	11.26	30	60	5
Extinction depth (m)	3.13	1.48	18	5.40	1
General Ions					
pH (pH units)	7.14	0.26	53	7.7	6.7
Residues, total (mg/L)	82	6.8	31	106	72
Specific conductivity (_S/cm)	85.9	19.4	87	134	58
Calcium, total (mg/L)	10.38	1.18	24	14.1	8.29
Chloride, dissolved (mg/L)	8.91	2.45	19	14.9	5.7
Magnesium, total (mg/L)	2.69	0.21	24	3.11	2.22
Potassium, dissolved (mg/L)	0.46	0.078	7	0.6	0.4
Silica, dissolved (mg/L)	8.86	1.66	24	11.6	5
Sulphate, Dissolved (mg/L)	10.72	1.01	14	12.8	9.5
Tannin & Lignin (mg/L)	0.68	0.282	18	1.3	L 0.2
Temperature, water (^{O}C)	9.04	3.8	116	16.6	1.5
Alkalinity (mg/L)	24.4	5.6	33	48.4	18.9
Hardness as $CaCO_3$ (mg/L)	38.1	3.3	9	46.7	36.1
Nutrients					
Carbon, total organic (mg/L)	6.55	1.72	40	12	3
Carbon, total inorganic (mg/L)	5.85	2.08	34	15	2
Nitrogen, ammonia (mg/L)	0.045	0.12	43	0.8	L 0.005
Nitrogen, Kjeldahl (mg/L)	0.41	0.175	62	1.15	0.18
Nitrogen, organic (mg/L)	0.46	0.161	26	0.82	0.22
Nitrogen, Nitrate (mg/L)	0.69	0.205	36	1.15	0.24
Nitrogen, Nitrate+Nitrite (mg/L)	0.291	0.021	62	0.65	L 0.02
Total Phosphorus (mg/L)	0.028	0.046	62	0.368	L 0.003
Phosphorus, ortho (mg/L)	0.01	0.034	47	0.239	L 0.003
Phosphorus, total dissolved (mg/L)	0.015	0.034	53	0.256	L 0.003
Oxygen, dissolved (mg/L)	8.96	2.25	109	11.9	0.8
Chlorophyll a (_g/L)*	13.7	10.7	34	34	2.5

Phaeophyton a (_g/L)	0.5	0	25	0.5	0.5

* Chlorophyll a samples were collected in 1980.

Table 1 Summary of water quality data for Cusheon Lake (EMS site 1100123) Continued

Water Quality Indicator	Average	Std Dev.	Number of samples	Maximum	Minimum
Metals					
Aluminum, total (mg/L)	0.103	0.05	12	0.2	0.06
Boron, total (mg/L)	0.06	0.027	9	0.1	0.031
Barium, total (mg/L)	0.0068	0.0007	9	0.008	0.006
Cadmium, total (mg/L)	0.0015	0.0007	15	0.002	0.0005
Cobalt, total (mg/L)			9	L 0.004	L 0.003
Chromium, total (mg/L)			9	L 0.002	L 0.002
Copper, total (mg/L)	0.0016	0.0007	18	0.004	L 0.001
Iron, total (mg/L)	0.23	0.217	18	0.9	0.1
Lead, total (mg/L)	0.014	0.0135	18	0.03	L 0.001
Manganese, total (mg/L)	0.041	0.029	12	0.103	0.02
Molybdenum, total (mg/L)			9	L 0.004	L 0.004
Sodium, dissolved (mg/L)	6.11	1.27	15	9.3	4.7
Silicon, total (mg/L)	3.9	0.711	9	4.66	2.7
Sulphur, total (mg/L)	2.90	0.15	3	2.99	2.73
Strontium, total (mg/L)	0.69	0.008	9	0.082	0.056
Thallium, total (mg/L)	0.003	0.001	9	0.007	0.003
Zinc, total (mg/L)	0.007	0.002	18	0.012	0.005

Table 2 Summary of Capital Health Region fecal coliform data (number/100 mL) for Cusheon Lake

Year	Maximum	Minimum	Geometric Mean	Number of samples
1981	4	3	3	4
1982	15	L 3	3.5	12
1983	14	6	7	10
1984	10	4	6	11

1985	46	3	7.5	14
1986	240	3	5.5	8
1988	93	3	4	12
1990	6	4	4	5
1991	5	3	5	12
1992	5	3	3	13
1993	3	2	2	12
1994	2	2	2	13
1995	2	2	2	10

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