



Water Quality

Water Quality Criteria for Lead

Overview Report

Prepared pursuant to Section 2(e) of the
Environment Management Act, 1981

Original signed by T. R. Johnson
Deputy Minister
Ministry of Environment and Parks
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Summary

This report is one in a series which establishes water quality criteria for the province. The report sets criteria for lead to protect a number of water uses. These include drinking water, freshwater and marine aquatic life, wildlife, livestock, irrigation, and recreation.

The criteria are set as either maximum concentrations of total lead which should not be exceeded at any time, or average concentrations which should not be exceeded over a 30-day period. Actual values are summarized in Table 2.

Except for aquatic life, the criteria are consistent with Canadian Water Quality Guidelines drafted by the CCREM Task Force on Water Quality Guidelines (1987). For aquatic life, the criteria are slightly less restrictive than the CCREM guidelines which are considered to be over-protective with regard to no-effect levels reported in the literature. A major use of the criteria is as a guideline for assessments of water quality conditions. They are thus one of the factors considered when water quality objectives for a specific body of water are being set.

Tables

Table 1: Summary of Water Quality Criteria for Lead

Water Use	30-Day Average (µg/L Total Lead)	Maximum (µg/L Total Lead)
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Drinking Water Supply	None proposed	50 µg/L total lead
Fresh Water Aquatic Life (water hardness as Ca CO ₃ less than or equal to 8 mg/L)	None proposed	3 µg/L total lead
Fresh Water Aquatic Life (water hardness as Ca CO ₃ greater than 8 mg/L)	Less than or equal to 3.31 + e(1.273 ln (mean hardness) - 4.704)	e(1.273 ln (hardness) - 1.460)
Wildlife Water Supply	None proposed	100 µg/L total lead
Livestock Water Supply	None proposed	100 µg/L total lead
Marine and Estuarine Aquatic Life	Less than or equal to 2 µg/L total lead —— (80% of the values less than or equal to 2 µg/L total lead)	140 µg/L total lead
Irrigation Water Supply (neutral and alkaline fine-textured soils)	None proposed	400 µg/L total lead
Irrigation Water Supply (all other soils)	None proposed	200 µg/L total lead
Industrial Water Supply (food processing industry)	None proposed	50 µg/L total lead
Recreation and Aesthetics	None proposed	50 µg/L total lead

The average is calculated from at least 5 weekly samples taken in a period of 30 days.

If natural levels exceed the criteria for aquatic life, the increase in total lead above natural levels to be allowed, if any, should be based on site-specific data.

Table 2: Evaluation of 30-Day Average Levels Based on Five Observations Collected Over a 30-Day Period

CASE A	Water Hardness	Lead Concentration in the Water
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Observation #1	20 mg/L as CaCO ₃	1.0 µg/L total lead
Observation #2	30 mg/L as CaCO ₃	2.0 µg/L total lead
Observation #3	40 mg/L as CaCO ₃	2.5 µg/L total lead
Observation #4	25 mg/L as CaCO ₃	7.0 µg/L total lead
Observation #5	35 mg/L as CaCO ₃	3.0 µg/L total lead
30-Day Mean Level	30 mg/L as CaCO ₃	3.1 µg/L total lead
30-Day Mean Criterion	30 mg/L as CaCO ₃	4.0 µg/L total lead
Maximum Criterion	20 mg/L as CaCO ₃	10 µg/L total lead

CASE A: Meets the criterion; only one of five observations exceeds 1.5 times the 30-day average criterion at the given hardness and the average does not exceed the 30-day average criterion.

CASE B	Water Hardness	Lead Concentration in the Water
Observation #1	20 mg/L as CaCO ₃	1.0 µg/L total lead
Observation #2	30 mg/L as CaCO ₃	2.0 µg/L total lead
Observation #3	25 mg/L as CaCO ₃	6.5 µg/L total lead
Observation #4	35 mg/L as CaCO ₃	3.0 µg/L total lead
Observation #5	40 mg/L as CaCO ₃	7.5 µg/L total lead
30-Day Mean Level	30 mg/L as CaCO ₃	4.0 µg/L total lead
30-Day Mean Criterion	30 mg/L as CaCO ₃	4.0 µg/L total lead
Maximum Criterion	20 mg/L as CaCO ₃	10 µg/L total lead

CASE B: Does not meet the criterion; two of five observations exceed 1.5 times the 30-day average criterion at the given hardness.

CASE C	Water Hardness	Lead Concentration in the Water
Observation #1	7 mg/L as CaCO ₃	1.0 µg/L total lead
Observation #2	10 mg/L as CaCO ₃	1.5 µg/L total lead
Observation #3	15 mg/L as CaCO ₃	2.0 µg/L total lead
Observation #4	5 mg/L as CaCO ₃	3.0 µg/L total lead
Observation #5	8 mg/L as CaCO ₃	4.5 µg/L total lead
30-Day Mean Level	9 mg/L as CaCO ₃	2.4 µg/L total lead
30-Day Mean Criterion	9 mg/L as CaCO ₃	3.0 µg/L total lead
Maximum Criterion	8 mg/L as CaCO ₃	3.0 µg/L total lead

CASE C: Does not meet the criterion; no observation exceeds 1.5 times the 30-day average criterion but one exceeds the maximum criterion.

CASE D	Water Hardness	Lead Concentration in the Water
Observation #1	150 mg/L as CaCO ₃	8.0 µg/L total lead
Observation #2	80 mg/L as CaCO ₃	5.0 µg/L total lead
Observation #3	50 mg/L as CaCO ₃	4.0 µg/L total lead
Observation #4	120 mg/L as CaCO ₃	7.0 µg/L total lead

Observation #5	100 mg/L as CaCO ₃	11.0 µg/L total lead
30-Day Mean Level	100 mg/L as CaCO ₃	7.0 µg/L total lead
30-Day Mean Criterion	100 mg/L as CaCO ₃	6.0 µg/L total lead
Maximum Criterion	50 mg/L as CaCO ₃	34 µg/L total lead

CASE D: Does not meet the criterion; only one of five observations exceeds 1.5 times the 30-day average criterion at the given hardness but the average exceeds the 30-day average criterion.

CASE E	Water Hardness	Lead Concentration in the Water
Observation #1	80 mg/L as CaCO ₃	7.0 µg/L total lead
Observation #2	75 mg/L as CaCO ₃	6.0 µg/L total lead
Observation #3	85 mg/L as CaCO ₃	8.0 µg/L total lead
Observation #4	100 mg/L as CaCO ₃	8.5 µg/L total lead
Observation #5	90 mg/L as CaCO ₃	7.5 µg/L total lead
30-Day Mean Level	86 mg/L as CaCO ₃	7.4 µg/L total lead
30-Day Mean Criterion	86 mg/L as CaCO ₃	6.0 µg/L total lead
Maximum Criterion	75 mg/L as CaCO ₃	57 µg/L total lead

CASE E: Does not meet the criterion; no observation exceeds 1.5 times the 30-day average criterion at the given hardness but the average exceeds the 30-day average criterion.

THE MINISTRY OF ENVIRONMENT, LANDS AND PARKS (now called Ministry of Water, Land and Air Protection) develops province-wide ambient water quality guidelines for variables that are important in the surface waters of British Columbia. This work has the following goals:

1. to provide guidelines for the evaluation of data on water, sediment, and biota
2. to provide guidelines for the establishment of site-specific ambient water quality objectives

Ambient water quality objectives for specific waterbodies will be based on the guidelines and also consider present and future uses, waste discharges, hydrology/limnology/oceanography, and existing background water quality. The process for establishing water quality objectives is more fully outlined in *Principles for Preparing Water Quality Objectives in British Columbia*, copies of which are available from Water Quality Section of the Water Management Branch.

Neither guidelines nor objectives which are derived from them, have any legal standing. The objectives, however, can be used to calculate allowable limits or levels for contaminants in waste discharges. These limits are set out in waste management permits and thus have legal standing. The objectives are not usually incorporated as conditions of the permit.

The definition adopted for a guideline is:

A maximum and/or a minimum value for a physical, chemical or biological characteristic of water, sediment or biota, which should not be exceeded to prevent specified detrimental effects from occurring to a water use, including aquatic life, under specified environmental conditions.

The guidelines are province-wide in application, are use-specific, and are developed for some or all of the following specific water uses:

- Raw drinking, public water supply and food processing
- Aquatic life and wildlife
- Agriculture (livestock watering and irrigation)
- Recreation and aesthetics
- Industrial (water supplies)

The guidelines are set after considering the scientific literature, guidelines from other jurisdictions, and general conditions in British Columbia. The scientific literature gives information on the effects of toxicants on various life forms. This information is not always conclusive because it is usually based on laboratory work which, at best, only approximates actual field conditions. To compensate for this uncertainty, guidelines have built-in safety factors which are conservative but reflect natural background conditions in the province.

The site-specific water quality objectives are, in most cases, the same as guidelines. However, in some cases, such as when natural background levels exceed the guidelines, the objectives could be less stringent than the guidelines. In relatively rare instances, for example if the resource is unusually valuable or of special provincial significance, the safety factor could be increased by using objectives

which are more stringent than the guidelines. Another approach in such special cases is to develop site-specific guidelines by carrying out toxicity experiments in the field. This approach is costly and time-consuming and therefore seldom used.

Guidelines are subject to review and revision as new information becomes available, or as other circumstances dictate.

The guidelines apply to the ambient raw water source before it is diverted or treated for domestic use.

The Ministry of Health regulates the quality of water for domestic use after it is treated and delivered by a water purveyor.

Guidelines relating to public health at bathing beaches are the same as those used by the Ministry of Health which regulates the recreation and aesthetic use.

Recommended Guidelines

These criteria are based on information presented in a technical document and are summarized in Table 1. The criteria are consistent with the Canadian Water Quality Guidelines (CCREM guidelines) issued by the Canadian Council of Resource and Environment Ministers (1987), except as noted.

1. DRINKING WATER SUPPLY

In raw drinking water, with and without treatment, the total lead concentration should not exceed 50 µ/L at any time.

Certain water treatment processes (e.g., coagulation with alum or ferrous sulphate, lime softening, etc.) do remove lead, but these are not normally practiced in British Columbia. It is recommended that any allowance for lead removal by water treatment be determined on a case-specific basis, depending on the water treatment processes involved.

2. AQUATIC LIFE

For aquatic life, the criteria are expressed in terms of total lead. This provides the highest safety factor in the absence of detailed site-specific information. However, as more knowledge on bioavailable forms of lead in water becomes available, the form of lead in the criteria can be modified, as justified by the data (see Application of Criteria for Aquatic Life).

2.1 Freshwater Aquatic Life

(a) The average concentration of total lead in water over a 30-day period (based on a minimum of 5 weekly samples) at an average hardness of water greater than 8 mg/L as CaCO₃ should not exceed the average criteria given by:

$$30\text{-day Average Criteria } (\mu\text{g/L}) = 3.31 + e^{(1.273 \ln(\text{average hardness}) - 4.705)}$$

Examples based on this relationship are as follows:

Average Water Hardness in mg/L CaCO ₃	30-Day Average Lead Criteria in µg/L
20	4.0
30	4.0
40	4.0
50	5.0
80	6.0
100	6.0
200	11.0
300	16.0

Criteria for intermediate values of hardness may be obtained from the above relationship.

In addition, not more than 20% (e.g., 1 in 5) of the values in a 30-day period should exceed 1.5 times the 30-day average criterion.

The 30-day average criterion does not apply to waters of average (30-day) hardness less than or equal to 8 mg/L CaCO₃.

(b) The maximum concentration of total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO₃ is set at 3.0 µg/L.

When water hardness exceeds 8.0 mg/L CaCO₃ the maximum concentration of lead at any time is given by:

$$\text{Maximum Criteria } (\mu\text{g/L}) = e^{(1.273 \ln(\text{hardness}) - 1.460)}$$

Examples based on this relationship are as follows:

Water Hardness in mg/L CaCO ₃	Maximum Lead Criteria in µg/L
less than or equal to 8	3
20	10
30	18
40	25
50	34
80	61
100	82
200	197
300	330

(c) If natural (i.e., non-anthropogenic) lead levels in water exceed (a) or (b) above, then the increase in total lead to be allowed, if any, should be based on site-specific conditions.

The 30-day average criteria are slightly less restrictive than the CCREM guidelines for maximum lead which are considered to be over-protective with regard to no-effect levels reported in the literature.

2.2 Marine and Estuarine Aquatic Life

(a) The average concentration of total lead in water over a 30-day period (based on a minimum of 5 weekly samples) should not exceed 2 µg/L. Not more than 20% (e.g., 1 in 5) of the values in a 30-day period should exceed 3 µg/L.
(b) The maximum concentration of total lead in water at any time should not exceed 140 µg/L.
(c) If natural levels exceed (a) or (b) above, then the increase in total lead to be allowed, if any, should be based on site-specific conditions.

2.3 Fish / Shellfish for Consumption

A total lead concentration of 0.8 µg/g (wet weight) in the edible portions of fish/shellfish should be considered as an alert level; i.e., site specific investigations would be required if the total lead concentration in the edible portions of fish/shellfish approaches or exceeds 0.8 µg/g (wet weight).

3. WILDLIFE

The concentration of total lead in water for wildlife use should not exceed 100 µg/L at any time.

4. LIVESTOCK WATER SUPPLY

The concentration of total lead in livestock drinking water supply should not exceed 100 µg/L at any time.

5. IRRIGATION

(a) For neutral and alkaline fine-textured soils the total lead concentration in irrigation water should not exceed 400 µg/L at any time

(b) The concentration of total lead in irrigation water for use on all other soils should not exceed 200 µg/L at any time.

6. RECREATION AND AESTHETICS

In water used for recreational activities, total lead should not exceed 50 µg/L at any time.

7. INDUSTRIAL WATER SUPPLIES

The concentration of total lead in water used in the food processing industry should not exceed, at any time, the drinking water criterion of 50 µg/L recommended in section 1.

No criteria are recommended for other industries at this time due to lack of information.

Application of the Guidelines

Application of Criteria for Aquatic Life

1. FORM OF LEAD

Toxicity of lead has been expressed in terms of total as well as soluble (e.g., dissolved lead, free lead, acid soluble lead, etc.) forms of lead. However, only total lead is recommended to be analysed for assessing water quality or setting water quality objectives for a given waterbody. The advantages of total lead are several fold:

1. all the lead that may potentially be toxic is included in the measurement. If the total lead concentration in water is within the criteria limits, then it is safe to conclude that no lead pollution exists;
2. for comparison purposes, there is sometimes a considerable amount of historical background data available for total lead; and
3. total lead measurement is routine and relatively inexpensive.

Dissolved lead (field filtered and acidified) should also be measured when investigating lead concentration problems. The main disadvantage of using total lead to assess water quality is that a large fraction of total lead may be in a form that is biologically unavailable (e.g., organically and inorganically complexed lead, lead sorbed by suspended matter, etc.). Therefore total lead may over-estimate toxicity, especially in waters with high complexing capacity.

2. MEETING THE 30-DAY AVERAGE CRITERION

Conceivably, the lead concentration in water may vary widely but still meet the 30-day average criterion. The converse may also be true. To illustrate this, the 30-day average lead levels in water based on five assumed measurements collected over a 30-day period are shown in Table 2. In one hypothetical situation that could be common, Case E, lead levels in water fluctuated up and down in the vicinity of the recommended average criterion, but did not exceed 1.5 times the recommended average levels at a given hardness of water. Yet the 30-day average lead level based on all five observations did not meet the criterion in this instance.

In Case A, lead concentrations in water again fluctuated around the recommended average criterion levels; in only one observation (at hardness of water = 25 mg/L CaCO₃) out of the five the lead concentration exceeded 1.5 times the 30-day average criterion level. The 30-day average lead level, however, met the recommended 30-day average criterion.

Case D is similar to Case A, and only one observation (at hardness of water = 100 mg/L CaCO₃) out of the five exceeded 1.5 times the recommended average level. However, although the other four observations were closer to the recommended average criterion levels, the 30-day average level did not meet the criterion.

The 30-day average lead levels in Case B and Case C did not meet the recommended 30-day average criterion. The reasons being that, in Case B, two observations (at hardness of water = 25 and 40 mg/L CaCO₃) out of the five exceeded 1.5 times the recommended 30-day average criterion level, and in Case C, one observation (at hardness of water = 8 mg/L CaCO₃) exceeded the maximum criterion level. Note that in both cases (Case B and Case C) the 30-day average lead levels (based on all five observations) appear to meet the criterion.

3. ASSESSMENT OF EXISTING WATER QUALITY

The criteria recommended in this document are primarily based on laboratory bioassays, which usually have been performed using soluble lead and dilution waters of low complexing capacities. The criteria are therefore likely to be over-protective for many waterbodies, especially those in which lead complexes may form. Based on total lead measurements, it cannot be concluded with certainty that lead pollution exists in a waterbody if the measurements exceed the criteria levels. However, if the measurements exceed the criteria levels, and if lead is anthropogenically generated, then a more intensive investigation of the site in question using other methods may be warranted. Other methods may include one or more assessment techniques such as measurement of complexing capacity, long-term bioassays on sensitive resident species using local water, and population studies on biota. Because of the complexity and cost of these alternative methods, they should be reserved for waterbodies with high fisheries values, which are threatened by a controllable lead source.

4. SETTING WATER QUALITY OBJECTIVES

Natural (i.e., non-anthropogenic) concentrations in a waterbody occasionally will not meet the criteria. In a case where natural lead concentrations in water equal or exceed the criteria, the objectives should be based on the natural levels and any increase in total lead to be allowed should be based on site-specific investigations. Atmospheric deposition is a major source of anthropogenic lead, and thus determining whether lead levels are natural or anthropogenic may be difficult. When natural concentrations of total lead are less than the criteria levels, then the criteria, or more stringent values if justified, should apply. In some cases, socioeconomic factors may justify objectives which are less stringent than the criteria. Site-specific impact studies would be required in such cases.