



WATER QUALITY CRITERIA FOR
NUTRIENTS AND ALGAE

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**Province of
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Ministry of
Environment and Parks

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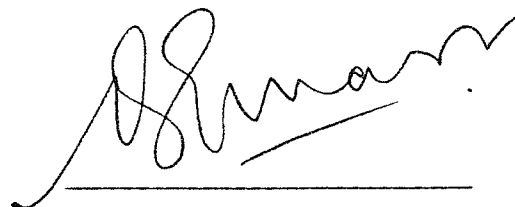
MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

WATER QUALITY CRITERIA FOR
NUTRIENTS AND ALGAE

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Richard N. Nordin
Water Quality Unit
Resource Quality Section
Water Management Branch
Victoria, B.C.

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Date



Signature
Deputy Minister

PREFACE

The Ministry of Environment is developing province-wide water quality criteria for variables that are important in the surface waters of British Columbia. This work has the following goals:

- (i) to provide criteria for the evaluation of data on water, sediment and biota for water quality assessments.
- (ii) to provide criteria for the establishment of site-specific water quality objectives.

The water quality objectives for specific waterbodies will be based on the criteria as well as on present and future water uses, waste discharges, hydrology/oceanography and 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 the Water Management Branch.

The definition adopted for criterion is:

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

The criteria are province-wide in application, but use-specific, and are being developed for the following water uses:

- Drinking, public water supply and food processing*
- Aquatic life and wildlife
- Agriculture (livestock watering and irrigation)

*For raw water sources prior to treatment (the responsibility for regulating the quality of domestic water as supplied by a water purveyor lies with the Ministry of Health).

- Recreation and aesthetics**
- Industrial (other than food processing)

Criteria from the literature and other jurisdictions are evaluated, and criteria are adopted or developed from this evaluation. Recognizing that criteria from the literature do not necessarily reflect adequately the effects of contaminants in all waterbodies, the criteria in this document should be interpreted as guidelines. Site-specific criteria may be developed in special cases where the province-wide criteria are judged to be inadequate.

If a waterbody has several water uses, then the criteria for the most sensitive water use will be considered for developing water quality objectives. For specific waterbodies, particular circumstances could lead to objectives which are either more or less stringent than the criteria.

The criteria will be subject to review and revision as new knowledge becomes available, or as other circumstances dictate.

**The Ministry of Health has the responsibility for regulating the use of public bathing beaches with respect to the public health aspects.

RECOMMENDED CRITERIA

These criteria are based on a detailed analysis given in a technical appendix. Criteria are specified separately for streams (including brooks, rivers and creeks) and lakes (including ponds and reservoirs). The criteria for streams are specified as biomass of periphytic algae. The criteria for lakes are specified as phosphorus concentration. In rare cases where a lake is shown to be nitrogen limited, nitrogen criteria can be derived. Refer to the technical appendix for details.

DRINKING WATER (Includes Food Processing Water)

(i) streams

No criterion recommended.

(ii) lakes

For lakes used as a source of drinking water, the total phosphorus concentration should not exceed 10 µg/L. The criterion will ensure that algae will not exceed acceptable limits in surface waters being used as a supply source. This will minimize treatment costs and reduce risk of taste and odour from algae. The criterion will also ensure that deeper waters, which are cooler and may be used preferentially as a source of water, are protected from low oxygen concentrations caused by excess algal growth. Low oxygen levels could result in undesirable concentrations of hydrogen sulphide, soluble iron and manganese compounds, and organic carbon. For details of phosphorus sampling see the section on application of criteria which follows.

RECREATION AND AESTHETICS

(i) streams

The criterion recommended is less than 50 mg/m² chlorophyll a. The criterion is specified as this index of algal biomass

rather than nutrients since there are several other conditions of water velocity, light, temperature and invertebrate grazing pressure which must be satisfied before nutrients become the most important factor limiting stream algal growth. The level of biomass was determined on the basis of information from the literature and experiences reported from British Columbia.

(ii) lakes

The criterion recommended is less than 10 $\mu\text{g/L}$ total phosphorus. The major consideration in the recreational use or aesthetic attractiveness in lakes is water clarity. Since the concentration of phosphorus can be directly related to water clarity, the criterion value was chosen to insure high water clarity in lakes.

AQUATIC LIFE

(i) streams

For protection of aquatic life in streams, a maximum biomass of 100 mg/m^2 chlorophyll a is suggested. This criterion is designed primarily to protect fish habitat and changes in communities of organisms such as invertebrates which are important themselves or which may be important fish-food organisms.

(ii) lakes

It is not possible to specify a single phosphorus concentration to achieve protection of aquatic life in lakes. A range of total phosphorus concentrations (5-15 $\mu\text{g/L}$) is suggested as the criterion which can be used as the basis for site specific water quality objectives. The criterion is limited in application to include only lakes where salmonid species are the fish of major importance.

APPLICATION OF CRITERIA

Criteria are proposed to protect water resources in British Columbia from degradation caused by excessive amounts of algae which may impair man's use of lakes and streams. Where problem concentrations of algae occur, over-supply of nutrients (generally phosphorus) is the cause. A general goal in dealing with the eutrophication problem is to quantify the amounts of algae which cause problems, and the concentrations of phosphorus which may be associated with algal problems, in order to set limits which would protect specific uses.

Because of fundamental differences between lakes and streams, the criteria are specified in terms of different parameters and different measurement units. For lakes, a clear relationship has been established between phosphorus and algal biomass whereas no such relationship exists in streams. Thus for lakes, phosphorus concentration provides the best indicator of actual or potential problems. For streams there are many factors which determine the amount of algae which will be present and phosphorus is much less important. Thus for streams, the algal biomass itself must be measured to determine actual or potential problems.

For lakes, phosphorus concentrations are measured at spring overturn (if the epilimnetic water residence time is greater than six months) or measured through the growing season (if the epilimnetic water residence time is less than six months). The timing of spring overturn in lakes can vary considerably in different parts of the province and even from year to year in an individual lake. Spring overturn can be considered to occur when the water column is isothermal prior to the presence of significant algal growth ($<0.5 \mu\text{g/L}$ chlorophyll a). Samples should be taken from near the surface (one metre), near the bottom, and at one or two intermediate depths. Mean growing season phosphorus concentration should be calculated by sampling at three-week intervals over the summer growing period (generally May to September) from near the surface, at the middle of the epilimnion and near the bottom of the epilimnion. The mean concentration over the summer growing period is then compared to the criterion.

For lakes, a general correspondence between phosphorus concentration and mean growing season chlorophyll a, as well as water clarity or hypolimnetic oxygen deficit, exists. For example, a phosphorus concentration of 10 µg/L results in a chlorophyll a concentration of 2.0 - 2.5 µg/L. The potential thus exists for setting chlorophyll a criteria or water clarity criteria, however this is advantageous only in special cases. In general it is best to use phosphorus concentration as the criterion.

For streams the criteria levels apply to naturally growing periphytic algae as opposed to algae growing on artificial substrates. Sub-samples are to be taken randomly from the stream section and the mean biomass of the sample is to be compared to the criterion. The criterion should not be exceeded by the mean sample value obtained at any one time.

No criteria for protection of estuarine or marine waters from eutrophication are proposed due to the lack of information available on levels of nutrients or algal biomass which would be desirable in B.C. coastal waters.

SUMMARY OF WATER QUALITY CRITERIA FOR NUTRIENTS AND ALGAE

Characteristics Water Use	Total Phosphorus* µg/L	Chlorophyll <u>a</u> ** mg/m ²
Drinking Water Lakes only	10 maximum	none proposed
Aquatic Life Streams only	none proposed	100 maximum
Aquatic Life Lakes only (with salmonids as predominant fish species)	5 - 15 inclusive	none proposed
Recreation Streams only	none proposed	50 maximum
Recreation Lakes only	10 maximum	none proposed

* Total phosphorus in lakes is either the spring overturn concentration, if the residence time of the epilimnetic water is greater than 6 months, or the mean epilimnetic growing-season concentration, if the residence time of the epilimnetic water is less than 6 months.

**Chlorophyll a criteria in streams apply to naturally-growing periphytic algae.