Water, Air and Climate Change Branch

WATER QUALITY

Developing Water Quality Objectives in British Columbia: A User's Guide

February 1996

Table of Contents

Summary

We summarize in this report, for BC Ministry of Environment (now called Water, Land and Air Protection) staff, project proponents and contractors, the key requirements for preparing water quality assessment and objectives documents. We outline the key information which should be included on hydrology (limnology and/or oceanography), water uses, permitted waste discharges, non-point sources, and ambient water quality.

We present examples of different types of tables and figures to use. We also present the rationale for proposing Water Quality Objectives based directly on Water Quality Criteria. We include the reasoning as to the types of situations where more detailed justification may be required to propose a Water Quality Objective. Finally, we outline the administrative procedure to formalize the proposed Water Quality Objective as Ministry policy.

Return to the Table of Contents

Acknowledgements

This User's Guide represents the culmination of a ten-year evolutionary process for the development of Water Quality Objectives and Criteria in British Columbia begun in the early 1980's. During most of that decade, this process was spearheaded in the Ministry of Environment, Lands, and Parks (Water, Land and Air Protection) by three individuals; the late Dr. Ron Buchanan, and Messrs. Roland Rocchini and Larry Pommen. These individuals did not act alone, but were supported by numerous technical staff who themselves developed many of the concepts put forth in this User's Guide.

As well, during that time period, the draft documents were reviewed by countless individuals from

Environment Canada and Department of Fisheries and Oceans, as well as Ministry staff in regions and Victoria.

The User's Guide itself has been reviewed by many individuals from the Water Quality Branch, including Drs. Rick Nordin and Narender Nagpal, and Messrs. Prad Khare, Larry Pommen, Roland Rocchini, Bob Nijman, and Ron Hall. Ms. Jennifer Nener from the Department of Fisheries and Oceans provided valuable review comments from a non-Ministry perspective.

To these people we express our gratitude.

To those individuals who follow, we pass the torch, and wish them well.

Return to the Table of Contents

Introduction

The Ministry of Environment, Lands, and Parks (Water, Land and Air Protection) is responsible for protection and management of the water quality of all fresh, estuarine, and marine waters in the Province of British Columbia. In an aquatic environment, water quality refers to the quality of the entire aquatic ecosystem: the water, the bottom and suspended sediments, and the biological organisms inhabiting the water and sediment. We manage water quality through a process that begins with a detailed assessment of a water body, and culminates in the development of site-specific Water Quality Objectives. If attained, these Objectives will protect the most sensitive water use designated for the water body. Water uses which can be designated for protection are drinking water, recreation, irrigation, protection for wildlife, livestock watering, and aquatic life.

This manual is meant to provide the Ministry Regions with a simplified outline of the requirements for developing Water Quality Objectives in British Columbia. Specifically, it is intended for use by Ministry staff, consultants, and others who will be performing water quality assessments with the goal of proposing objectives for a water basin. More detailed documents available to the interested reader, and used to derive this manual, are the Principles For Preparing Water Quality Objectives in British Columbia (Ministry of Environment and Parks, 1986), and the Guide to the Environmental Assessment of Mine Development Proposals In British Columbia (Ministry of Environment, Lands, and Parks, 1994). As well, the Ministry has prepared about 40 reports since about 1985 which can be examined.

We have organized this guide by task as would be found in the subject documents to be produced. We include information on the recommended report style such as font or page format (see Appendix 1). We also include an Administrative Procedure for formalizing the establishment of the proposed Water Quality Objectives as Ministry policy.

Return to the Table of Contents

The Water Quality Assessment

A Water Quality Assessment and Objectives report consists of two parts:

1. an *Overview* (previously known as the short report) which summarizes the findings of the Technical Report and is mainly written for the Ministry Executive and the public
2. the *Technical Report* (previously known as the Technical Appendix)

The *Overview* is published both as a *stand-alone* document as well as jointly with the Technical Report. Both the Overview and the Technical Report include sections/chapters on proposed Water Quality Objectives and a monitoring program.

Outline of Assessment Document

A general outline for an assessment document is given below. More details on each major report division follow in the latter sections of this chapter. The document will usually consist of the following in the order listed:

1. Overview Report (included at front of Technical Report and stand-alone), including cover page with formal sign-off by Ministry Executive
2. Technical Report

- Title Page: Water Quality Assessment and Objectives for ... , followed by the author's name and affiliation, and date of endorsement of the Water Quality Objectives as Ministry policy
- Table of Contents
- List of Tables
- List of Figures
- Acknowledgments
- Chapter 1-Introduction
- Chapter 2-Hydrology, Limnology and/or Oceanography, as appropriate
- Chapter 3-Water Uses
- Chapter 4-Permitted Discharges
- Chapter 5-Non-Point Sources
- Chapter 6-Ambient Water Quality Assessment and Proposed Water Quality Objectives
- Chapter 7-Proposed Water Quality Monitoring Program
- References
- Figures
- Tables
- Appendices

Return to Water Quality Assessment

The Overview

The Overview is published both as a separate document and with the Technical Report. It has a one page summary of the entire assessment, as well as individual summaries for each chapter. Include a simple glossary of terms. The Assistant Deputy Minister of Regions and the Executive Director of the Environmental Protection Department sign the cover page, indicating that the water quality objectives have been formally approved. Arrange the Overview in the manner shown below:

- Title Page (see Appendix 2)
- Glossary
- Summary (of the entire assessment)
- Preface
  - Purpose of Water Quality Objectives
  - How Water Quality Objectives are determined
  - How Water Quality Objectives are used
  - Objectives and Monitoring
- Introduction
- Water Body Profile
  - Hydrology
  - Water Uses
  - Point and Non-point Sources
- Water Quality Assessment and Objectives
  - Water Quality Assessment
  - Water Quality Objectives
  - Monitoring Recommendations

Note that certain sections contained within the *Preface* and *Introduction* are generic in nature (e.g., How Water Quality Objectives are determined and How Water Quality Objectives are used, etc.). These are boiler-plate statements which can be transferred from one Water Quality Objectives document to another

without changes. We have prepared a comprehensive Glossary which can also be transferred to (and subsequently amended by) writers of Water Quality Objectives in Region.

Return to Water Quality Assessment

The Introduction

This chapter is usually fairly short, about two to three pages, and provides an introduction to:

- the need for development of Water Quality Objectives for a given water body
- the process of establishing water quality objectives in BC
- the general area to be described in the assessment report. Include a general description of the watershed and ecosystem, with such information as the length of a river and its slope, drainage area, pattern, water body size, predominant weather patterns, biogeoclimactic classification, etc.

Return to Water Quality Assessment

Hydrology, Limnology and/or Oceanography

Include, as appropriate, a description of the water body with major tributaries and other important features of the area, such as stream and river flows (including Water Survey of Canada gauging stations), lake characteristics and water retention times, and/or marine currents and tidal action. Especially important are seven-day low flows (mean annual and 1-in-10 year) and their timing so that you can make worst-case calculations in chapters that follow. For lakes, include bathymetric maps (can be obtained from Ministry of Environment Fisheries Branch, or for some cases, Water Management) and present any profile information in time/depth diagrams. Other pertinent information may include factors such as precipitation quantities (available from Environment Canada).

Return to Water Quality Assessment

Water Uses

It is desirable to obtain public input into the perceived water uses which should be protected for a water body. Sub-divide water uses into categories such as contact recreation (contact local Ministry of Health office), licensed water withdrawals (available from Water Management of the Ministry of Environment) and use by aquatic life. Include information on contact recreation such as areas of the water body used by humans, the timing of this use, and the purpose of the recreational use. With information provided on

aquatic life use, include:

- species (local Fisheries Branch staff of Ministry of Environment) and their numbers (return numbers over different decades is beneficial in terms of salmon escapements, obtained from Department of Fisheries and Oceans)
- areas of the water body used by fish or shellfish, the timing of this use, and the purpose of the use (e.g., spawning, rearing, migration)
- physical constraints to the use of the water body by fish or shellfish, and the monetary value of the fishery, if available
- presence of rare or endangered species

The information on use by fish such as salmon should be obtained from staff of the Department of Fisheries and Oceans, or data reports published by that Department. For resident fish species, Fisheries Branch staff of the Ministry of Environment are appropriate contacts.

Note the locations of licensed water withdrawals on a map, and tabulate information related to the type of withdrawal, licence number and associated volumes for each type of withdrawal (see table below).

Type of withdrawal	Total number of licences	Licensed volume	Licence numbers
Domestic	—	—	—
Irrigation	—	—	—
Industrial	—	—	—

Note constraints which may exist to some use (such as climate, no soil available on which to grow crops, a domestic licence not used for drinking water but for livestock watering, etc.).

Return to Water Quality Assessment

Permitted Discharges

These are usually associated with discharges to soil or water and will have the potential to have some sort of impact on water quality. The presence of such discharges can be obtained from files of Environmental Protection of the Ministry of Environment. Describe each permit in terms of the operation/ process, and list permit requirements. Summarize all monitoring data for the discharge as shown below in a table. Review and discuss these data for their environmental impact in terms of loadings, dilution

available in the initial dilution zone and with complete mixing, and in the case of discharges to ground, the distance to surface waters. Include a discussion of substances which may have an environmental impact due to the nature of the discharge, but for which no data are available.

Table XXXXX
Summary of Effluent Discharged from Operation XXXXX (PE XXXXX)

Variable	No. of Values	Maximum	Minimum	Median	Mean	Standard deviation
Suspended solids	—	—	—	—	—	—
BOD5	—	—	—	—	—	—
Fluoride	—	—	—	—	—	—

Impacts from Discharges

Include in the discussion any critical single or periodic receiving water measurements showing the possible impact on water quality of a particular discharge. Place these types of tables within the text (see example below) since they are short, do not disturb the flow of the text when reading the assessment, and allow the data to be easily examined simultaneously with the explanation.

Coliform Concentrations in the River Near PE 146

Sample Site	200 m u/s Hwy. 97	100 m u/s PE 146	400 m d/s PE 146	1.6 km d/s PE 146	8 km d/s PE 146	16 km d/s PE 146	20 km d/s PE 146
Date	east...west	east...west	east...west	east...west	east... west	east...west	east... west
April 22 1987	10...2	20...2	100...2400	8...2400	14...1500	20...60	—
Sep. 16 1987	130...5	13...5	540...49	540...11	540...130	920...79	350...540
Nov. 13 1991 (diffuser)	6...12	17...18	7...250	16...390	12...45	120...49	250...120

When a large number of discharges occur to a large area, summarize the information based on tributaries and/or river reach as shown in the following table (which would be located in the section of tables at the rear of the document).

REACH: Tete Jaune Cache to Nechako River

Name of discharger	Permit number	Report section	Discharge type	Permitted volume m^3/day
Village of McBride	PE 402	4.2.1	Municipal	750
Northwood Upper Fraser	PE 2655	4.2.2	Municipal	273

REACH: Nechako River confluence to Hope

Name of discharger	Permit number	Report section	Discharge type	Permitted volume m^3/day
Quesnel River Pulp Co.	PE 5803	4.3.12	Industrial	28,000
Cariboo Pulp and Paper	PE 1152	4.3.13	Industrial	118,200
City of Williams Lake	PE 255	4.3.14	Municipal	6820

Return to Water Quality Assessment

Non-point Sources

Non-point or *diffuse* sources refer to activities which can contribute contaminants to a water body in a diffuse manner, but which do not result in a discharge through a pipe which is under permit. Examples of these types of discharges are storm water from a city, or agricultural runoff. Precipitation chemistry information (obtained from Environment Canada) might appropriately be placed in this chapter. For non-point source discharges, provide information for factors such as the areas of forestry activities, agricultural land use, numbers of homes using septic tanks and tile fields, soil sensitivity (to generate surface runoff or leaching to ground water), and numbers and locations of livestock grazing.

Impacts from Agricultural Operations

We present below an example table estimating increases in concentrations in a water body due to livestock grazing. We base these estimates upon literature values such as from Bangay (1976) for the amount of nitrogen and phosphorus generated by types and sizes of different livestock, and on:

- the number of livestock units in an area
- the length of time in that area
- the number of weeks over which the accumulated wastes might be released

Assumptions which we might make and which should be stated as such in the Technical Report include:

- all the wastes generated over the period reach the water body
- all the wastes accumulated over a certain time period are transported to the water body
- flows in the water body are consistent throughout the release period

Release period	One week		Two weeks		Four weeks	
River reach	P	N	P	N	P	N
Upper Fraser River	0.58	4.95	0.29	2.48	0.15	1.24
Middle Fraser River	1.11	9.5	0.55	4.8	0.28	2.4

P: Phosphorus (mg/L); N: Nitrogen (mg/L)

Impacts from Storm Water Discharges

You may often be able to estimate loadings from storm water discharges using existing studies undertaken in BC, extrapolating actual loadings to the area of interest. Below is an example presenting the final results for this type of information for an assessment report.

Variable	Estimated Loadings (kg/d)		Estimated Increases (mg/L)	
	Prince George	Quesnel	Prince George	Quesnel
aluminum	15.7	2.4	0.0017	0.0003
cadmium	2.13	0.32	0.0002	0.0001
zinc	3.38	0.52	0.0004	0.0001
suspended solids	578.1	88.9	0.6	0.009

total nitrogen	40.9	6.30	0.004	0.0007
total phosphorus	5.15	0.79	0.0005	0.0001

Often, calculations should be based on worst-case loadings which reflect maximum quantities of contaminants after a period of dry weather when these have accumulated.

Return to Water Quality Assessment

Ambient Water Quality and Proposed Water Quality Objectives

Some individuals may prefer to develop these two topics separately in two chapters. That is acceptable.

Ambient Water Quality

Summarize ambient water quality data in tables at the end of the text. The sources for data will vary from Region to Region, but in general would include Ministry data files, the Ministry SEAM computer data base, federal government Departments such as Environment Canada (and their ENVIRODAT data system) or Department of Fisheries and Oceans, and universities. Below is an example of a common data summary.

Summary of Ambient Water Quality Data
for Site E XXXXX on the XXXXX River at XXXXX (dates)

Variable mg/L or as noted	No. of values	Maximum	Minimum	Median	Mean	Standard deviation
Alkalinity	—	—	—	—	—	—
Metals (total)	—	—	—	—	—	—
Oxygen (dissolved)	—	—	—	—	—	—
pH (units)	—	—	—	—	—	—
suspended solids	—	—	—	—	—	—
temperature (degrees C)	—	—	—	—	—	—
turbidity (NTU)	—	—	—	—	—	—

In assessing water quality you should:

- detail data/information gaps
- examine the range of values obtained at each station relative to applicable water quality criteria
- document the number and extent that each variable exceeds the criteria
- allow for the effect (within expected conditions for the water body itself) of ancillary variables such as pH, temperature, conductivity, and hardness which can affect the toxicity of some substances
- consider the dilution capacity of downstream tributaries which may have more sensitive designated water uses than upstream water bodies
- examine loadings and potential increases or decreases in the water quality variables in the water body from natural sources, such as tributary streams
- examine loadings and potential increases or decreases in the water quality variables in the water body from anthropogenic sources
- discuss ameliorating factors which may necessitate that criteria considered should be relaxed or made more stringent (e.g., complexing, hardness)
- ultimately propose Water Quality Objectives for a reach of the water body where anthropogenic sources are (or may be) responsible for changes in a variable that threatens water uses. You should seek public input at this point

Proposing Water Quality Objectives

We recommend that key variables (e.g., ones that exceed Water Quality Criteria or need Water Quality Objectives) be displayed in graphs or tables within the text. This will allow important spatial and temporal aspects of their distribution to be displayed.

Include a statement in the text, preferably after the first Water Quality Objective is defined for a water body, which defines the initial dilution zone where the Objective does not apply. The layout for the first objective proposed and the definition of the initial dilution zone would be similar to:

> The Ministry criteria for induced suspended solids concentrations to protect aquatic life are that **for background concentrations of less than 100 mg/L, suspended solids could increase by as much as 10 mg/L, while for background concentrations greater than 100 mg/L, suspended solids concentrations could increase by up to 10%. These are the proposed water quality objectives for suspended solids.** These Water Quality Objectives apply along the Given River, from Point 1 to Point 2, except in initial dilution zones of effluents.

These initial dilution zones of effluents are to extend no further than 25% (in some cases 50%) across the river width, from the bed to the surface, and extending no further than 100 m downstream (in any direction for discharges to lakes or marine areas, and upstream when tidally influenced) from a discharge or a series of discharges. In the case of non-point sources such as forestry operations, the dilution zone would be along the length of the forestry operation area, and up to 100 m downstream from the furthest downstream edge of that area, unless such a definition should cause the dilution zone to infringe on fish/ shellfish habitat, recreation areas, or water intakes. In such a case, the dilution zone would terminate at the upstream edge of the area, and the proposed water quality objectives would be expected to be achieved within the area.

Common Water Quality Objectives

In most instances, the proposed Water Quality Objectives are the same as the Provincial Water Quality Criteria for a variable of concern in relation to the water uses designated for protection (i.e., designated water uses). A table showing some examples of Water Quality Objectives for different combinations of designated water uses is shown below, while a more comprehensive table is included as Appendix 3. The tables are based upon British Columbia Water Quality Guidelines (Criteria): 1998 Edition which is updated periodically. Develop Water Quality Objectives for other variables, or where there is a different combination of designated water uses, using appropriate criteria from the current edition of British Columbia Water Quality Guidelines (Criteria): 1998 Edition, available from the Water Quality Branch (Victoria).

Common Water Quality Objectives for Different Water Uses

Variable	Applicable Water Uses for the Water Body				
	Column 1 Wildlife and Freshwater Aquatic Life	Column 2 Column 1 plus Drinking Water	Column 3 Column 2 plus Irrigation	Column 4 Column 3 plus Livestock Watering	Column 5 Column 4 plus Recreation
residual chlorine	100 µg/L max; 2 µg/L mean continuous exposure; 1074 (minutes exposure) $^{-0.74}$ mean controlled intermittent exposure				
chlorophenols	See Tables 26 and 27 in: British Columbia Water Quality Guidelines (Criteria): 1998 Edition				
fecal coliforms *Escherichia coli*	none	0 with no treatment; 10 (90th percentile) - disinfection only; 100 (90th percentile) - partial treatment			

Proposing Water Quality Objectives for Atypical Situations

There are times when the water quality criteria, as specified in the current edition of the British Columbia Water Quality Guidelines (Criteria): 1998 Edition, cannot be used directly as Water Quality Objectives for various reasons.

Naturally Higher Levels

An example would be a certain metal in a water body that occur at levels at a naturally higher level than the criterion. In such situations, we usually decide that, as long as there is no change from background concentrations, no harmful effects should take place. We define the term no change as a difference of not greater than 20% going from upstream to downstream from a discharge or series of discharges. We rationalize the 20% increase (this percentage can be reduced in situations where replicate sampling has been carried out with the monitoring program) as not being an increase since:

- the precision for measurement of low concentration metals in replicate samples is not usually better than 20% in ideal situations in a laboratory
- natural variability is often greater than 20%

We have used this approach in many published water quality assessments. Another approach which we have used when there were enough data, has been to base the Water Quality Objective on the historical background levels, allowing little or no change from one or more of the historical statistics.

Characteristics with no Published Criteria

In other situations, we may need to develop Objectives for variables for which there are no published criteria. In one approach we compared data from uncontaminated areas (background) to those from more populated or contaminated areas. We then used literature values to determine what concentrations may cause an adverse effect and developed a number which protected the given water body. We developed sediment quality objectives for Burrard Inlet on this basis.

Challenging Existing Criteria

In very rare situations, you may find that criteria from other jurisdictions are overly restrictive at first examination. You may need a detailed investigation to examine the literature, and justify preparing a new criteria document. In some very sensitive environments, we have found that we have had to develop an Objective which was more restrictive than the Criterion. We did this for a number of areas where we were using the Canadian Council of Ministers of the Environment criteria for dissolved oxygen.

Another approach, which has been rarely used because of cost, is to do site-specific studies such as modeling (e.g., metals speciation), bioassays, or population studies, etc., to derive an Objective which better reflects local water quality conditions. This approach would likely only be undertaken where other approaches are unsatisfactory. Methods for Deriving Site-Specific Water Quality Objectives in British

Columbia and Yukon.

For all situations, situations, apply sound logic, and convey this logic to the reader of the Technical Report. This gives the Water Quality Objective proposed strong support. This may mean, for example, putting a short one page justification into the Technical Report. If more detail is required, place it into an Appendix to the Technical Report.

Return to Water Quality Assessment

Proposed Water Quality Monitoring Program

Propose a water quality monitoring program that will allow you to check the attainment of the Water Quality Objectives in the future. Indicate in the water quality monitoring program:

- site locations
- frequency of monitoring
- variables to be monitored
- sampling period

Locate sites close to the edge of the initial dilution zone(s) of discharges where you suspect that the Objectives would likely be exceeded. Determine the frequency of sampling, to a large degree, from the quality/quantity of data required to satisfy the Objectives themselves. Also, make allowance for the type of statistic required (e.g., maximum, mean, median, 90th percentile) which in itself defines a minimum frequency (e.g., mean of a minimum of five times in a 30-day period separated in time by a weekly interval). Determine the period of sampling during the year should be determined from:

- the time during the year when the objective applies (e.g., recreation season)
- the time(s) during the year when the objective is likely to be exceeded

An example table outlining monitoring which should be included in the Technical Report and in the Overview report, is shown in Appendix 4.

A quality assurance component should be noted as being required for the monitoring program. The details of the program will vary; however, it should include submission of blanks, replicates, and standard reference materials.

Return to Water Quality Assessment

References

Traditionally, we referenced information in the Technical Report using the number notation system (123). Equally acceptable is the use of the author/date notation method (Swain, 1994). Regardless of the notation used, apply it consistently throughout the Technical Report and document these references fully in a section of the report immediately following the text. We do not normally cite references in the Overview report.

Figures

Use Figures with appropriate scales (1:50 000 is common) within the Technical Report to document the location of the watershed within British Columbia and site locations within watersheds of anything significant to aquatic quality. These site locations can be:

- Flow monitoring sites
- Permitted waste discharge locations
- Water intakes
- Recreation areas
- Fish / shellfish habitat
- Forestry operations
- Agricultural operations
- Residential areas
- Dams
- Marinas or harbours
- Ambient water quality monitoring sites
- Storm water and combined sewer overflows

Locate the Figures after the text and reference them in the Technical Report. Follow the text of the Overview Report with a Figure showing the sites to be monitored for the proposed Water Quality Objectives.

Return to Water Quality Assessment

Tables

We have documented examples of tables to be included in previous sections of this Chapter. Locate large tables after the text, references, and Figures in the Technical Report. In the Overview report, a Table summarizing the water quality objectives is included, as illustrated in Appendix 5.

Appendices

Use Appendices as appropriate to include, more bulky supporting information in the report which cannot be readily referenced to other documents. We consider information included in Appendices as normally essential to data interpretation, or to avoid loss of the information were it to be summarized.

Return to the Table of Contents

Administrative Procedure

To be formally approved by the Ministry, ensure a review and critique of the Technical and Overview Reports as follows:

- carry out a review of the first draft of the Technical Report and the Overview report within Region to ensure quality and accuracy of all material
- carry out a review of the second draft of the Technical Report and the Overview report by Water Quality Branch, Federal Agencies (e.g., Environment Canada, Fisheries and Oceans) and other government and non-government stakeholders
- carry out a review of the penultimate draft of the Overview report by Program Directors for Water Management, Environmental Protection, and Fisheries Management
- obtain sign-off of the title page of the Overview report by the Assistant Deputy Minister for Regions and the Executive Director of the Environmental Protection Department
- obtain a library catalogue number (CIP) from the legislative library (Catalogue Section) by sending copies of title page and table of contents

We suggest that every effort be made to limit review time to about one month for reviews of each of the first and second drafts.

There may be occasions when you need to incorporate proposed Water Quality Objectives into a Waste

Management permit or Operational Certificate prior to formal approval through the above process. We stress that even in these types of situations, the Water Quality Objectives should be put through the formal review process so that these can be treated equally with other Water Quality Objectives for the purpose of obtaining funding for monitoring. You should understand that without sign-off, the Objectives will not be formal Ministry policy.

Return to the Table of Contents

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Return to the Table of Contents >> Appendices

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