Water Quality

Ambient Water Quality Assessment And Objectives For The Lower Columbia River Birchbank To The Us Border

Overview Report

Water Management Branch
Environment And Resource Division
Ministry Of Environment, Lands And Parks

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SUMMARY

This document is one in a series that describes ambient water quality objectives for British Columbia. It has two parts: the following overview and a technical appendix that was prepared by a consultant as a separate document and published by Environment Canada in 1997. The overview provides general information about water quality in the lower Columbia River between Birchbank and the international boundary, and provides explanations as to differences in water quality objectives in this document compared to the technical appendix. The technical appendix presents the details of the water quality assessment for this area, and forms the basis of the recommendations and most of the objectives that are presented in the overview.

The overview is intended for both technical readers and for readers who may not be familiar with the process of setting water quality objectives. Tables listing water quality objectives and monitoring recommendations are included for those readers requiring data about these water bodies. A separate report has been published which describes the water quality assessment and objectives for the lower Columbia River from the Hugh Keenleyside Dam to Birchbank.

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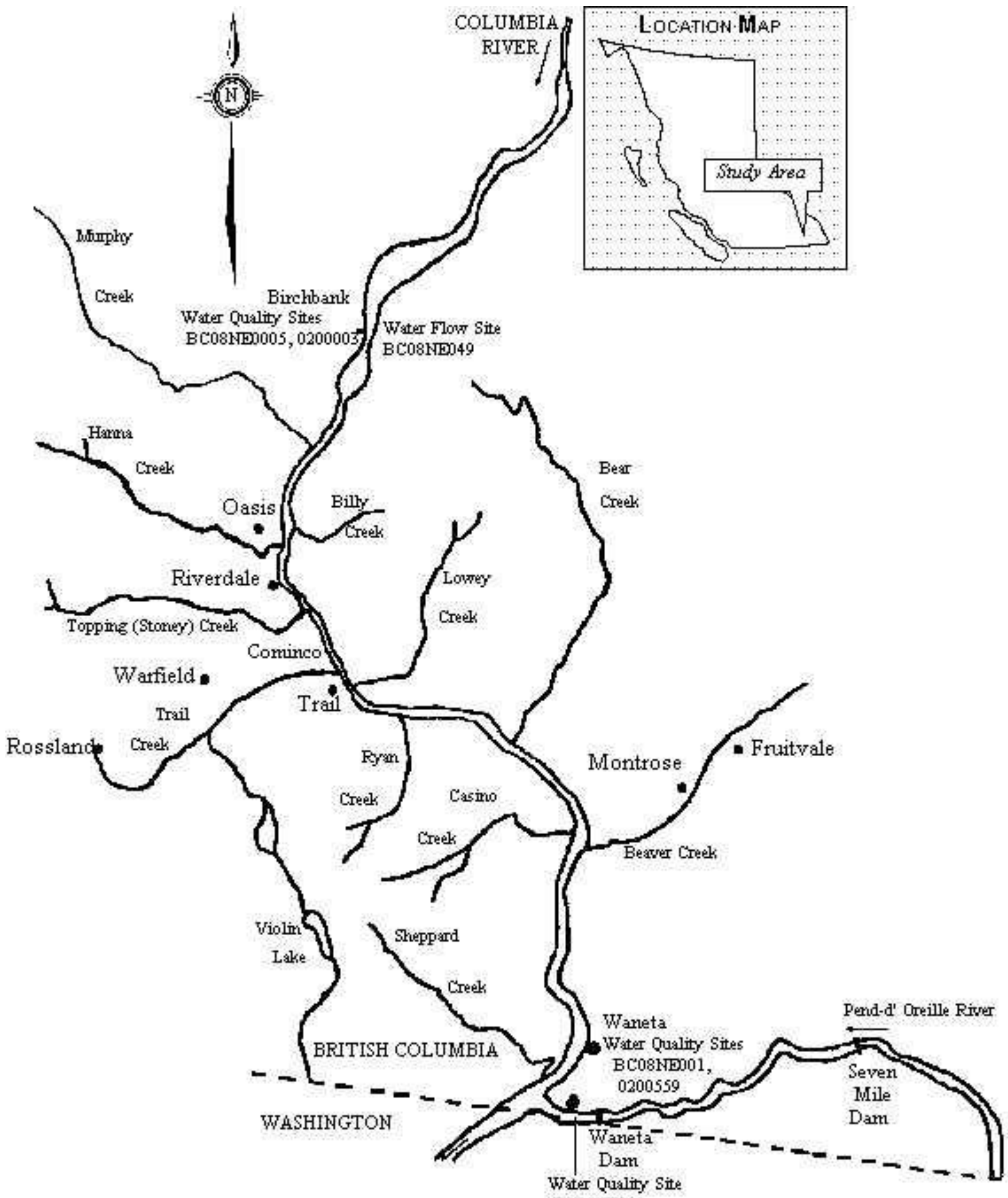
The Columbia River is an important trans-boundary river system that generates a host of benefits to people in Canada and the United States. In addition to in-stream water uses (*i.e.*, fish and aquatic life), the Columbia River provides an important source of raw water for municipal water supplies, irrigation, livestock watering, and industrial water uses. The Columbia River and its tributaries have also been impounded extensively to support hydroelectric power production, water storage, and flood control. Recreation and aesthetics represent important uses of the aquatic environment that generate both social and economic benefits to area residents.

Concerns related to water quality conditions in the Columbia River are primarily related to discharges of industrial and municipal wastes. Discharges of heavy metals from the Cominco lead-zinc smelter in Trail and chlorinated substances from the Celgar Pulp Company pulpmill in Castlegar have represented the main sources of contaminants. However, discharges of treated municipal sewage from the City of Trail (primary) and the City of Castelgar (secondary) and various non-point sources also contribute to contaminant loading to the lower Columbia River. Elevated levels of dissolved gases and fluctuating water levels are also significant concerns in this system, being generated at dams on the system.

This report describes water quality objectives for the lower Columbia River from Birchbank to the international boundary. These water quality objectives specify the characteristics of water, sediment, and fish muscle tissues necessary to protect aquatic life, wildlife, livestock watering, irrigation, recreation and drinking water supplies in this portion of the river.

Figure 1. Lower Columbia River Location Map



PREFACE
Purpose of Water Quality Objectives

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

Water quality objectives are based the BC approved and working criteria as well as national water quality guidelines. Water quality criteria and guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical or biological characteristics affecting that waterbody.

How Objectives Are Used

Water quality objectives routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated.

Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly enforced, these objectives become legally enforceable when included as a requirement of a permit, licence, order, or regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water.

For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value).

INTRODUCTION

The Columbia River drains an area of 669 500 km^2 of British Columbia, Washington, Oregon, Idaho and Montana, making it the dominant river system in the Pacific Northwest. The Columbia River is characterized by a proliferation of impoundments, both in Canada and the United States. From its headwaters at Columbia Lake on the west slope of the Rocky Mountains near Canal Flats, the Columbia River flows some 760 km to its confluence with the Pend d'Oreille River at the international border. Three major dams have been constructed on the Canadian portion of the Columbia River main stem, Mica Dam that created Kinbasket Lake, Revelstoke Dam that formed Revelstoke Lake and Hugh Keenleyside Dam which increased the size of the Arrow Lakes. Major tributaries to the Columbia River include the Kootenay and Pend d'Oreille rivers; several dams regulate the flows in both of these. These two tributaries account for 60% of the mean annual flow of the Columbia River at the international boundary.

The Ministry of Environment, Lands and Parks established water quality objectives in 1992 for the reach of the Columbia River from the Hugh Keenleyside Dam to the Birchbank. This report deals with the Columbia River from Birchbank to the international border. The purpose of this report is to develop water quality objectives for the downstream portion of the lower Columbia River, which encompasses a distance of some 32.5 km.

HYDROLOGY

Streamflow in the lower Columbia River has been regulated through the construction of a series of dams on the Columbia, Kootenay, and Pend d'Oreille rivers. The operation of these facilities, to a large extent, is dictated by the terms of the Columbia River Treaty (1962) and the Non-Treaty Storage Agreement. As these facilities are operated to control flooding and/or to generate electricity, contemporary hydrological conditions do not reflect a natural streamflow regime. Under the regulated streamflow regime, high flows usually occur between December and mid-February. Low flows occur during two periods of the year: March and April; and, September through November. At Birchbank, minimum mean monthly flows are predicted to drop below 630 m^3/s only 0.2% of the time (*i.e.*, one-month in 40).

WATER USE

Consumptive water uses in this reach of the Columbia River include withdrawals of cooling and process water for the Cominco Ltd. lead-zinc smelter at Trail, raw water for municipal water supplies at Trail and Warfield, and limited withdrawals for irrigation. Non-consumptive water uses include hydroelectric power generation (*i.e.* in upstream areas and on major tributaries), in-stream uses for fish and aquatic life, recreation and aesthetics. Fisheries values in the lower Columbia River are considered to be high, with 24 species using the river during portions of their life histories. Included in this total are several important sportfish species, including rainbow trout, walleye, mountain whitefish, and bull trout. White sturgeon and burbot are two endangered species in this portion of the Columbia River.

The free-flowing portion of the Columbia River is becoming increasingly important for recreational water uses, including kayaking, canoeing, rafting, and powerboat cruising. The navigational locks at the Hugh Keenleyside Dam provide boaters with an opportunity to travel some 500 km between Revelstoke and the Grand Coulee Dam. Recreational water uses are also expanding in the United States portion of the basin, especially within the Coulee Dam National Recreation Area. Sportfishing is a primary recreational pursuit in this area.

WASTE WATER DISCHARGES

There are a number of wastewater discharges that contribute contaminants to the lower Columbia River. The most significant discharges are from the Cominco Ltd. lead-zinc smelter at Trail and the Celgar Pulp Company pulpmill at Castlegar. Historically, Cominco has discharged significant quantities of heavy metals (including arsenic, cadmium, copper, chromium, lead, mercury, and zinc), while Celgar has discharged organic substances (including dioxins and furans, chlorophenols, resin acids, and fatty acids) into the river, both through wastewater discharges and uncontrolled spills. However, major upgrades have been completed at both of these facilities, resulting in significant improvements in effluent quality. Sewage treatment plants located near Castlegar and Trail release secondary and primary treated sewage, respectively, into the river.

Non-point sources of contaminants have not been fully evaluated in the lower Columbia River basin. However, limited data indicate significant loading of arsenic, cadmium and zinc is originating from old landfills in Stoney Creek basin (which is located near the Cominco Ltd. property). There is also some evidence to suggest that stormwater discharges from the Trail area are contributing contaminants to the river. Agricultural and forestry land uses are considered to be minor sources of contaminants to the lower Columbia River.

WATER QUALITY ASSESSMENT

To prepare water quality objectives, information on water quality, sediment quality, and tissue contaminant levels from several locations was examined to assess water quality conditions in the lower Columbia River. The results of this assessment indicate that conditions are fairly good near Birchbank. Monitoring between 1996 and 1999 has shown the concentrations of trace metals, suspended solids, microbial indicators, and nutrients typically fell at or below the water quality guidelines for the protection of aquatic life. However, total gas pressure usually exceeded the levels needed to protect fish and other aquatic organisms.

Water quality was not as good downstream from Trail, with elevated levels of cadmium, copper, lead and zinc observed downstream from the lead-zinc smelter. Elevated levels of certain microbial indicators were also observed at this site. Water quality appears to improve somewhat between Trail and Waneta. However, the levels of cadmium, copper, chromium and zinc still represent potential hazards to aquatic organisms at Waneta.

Historic wastewater discharges have resulted in contamination of bed sediments in several locations within the study area. Elevated levels of various trace metals, including cadmium, copper, lead, mercury and zinc have been observed in Columbia River sediments downstream of the Cominco Ltd. lead-zinc smelter. Both slag from this facility and bed sediments from a downstream location (Beaver Creek) have also been shown to be acutely toxic to aquatic organisms. Detectable levels of resin acids, fatty acids, dioxins, and furans have also been observed at various locations; however, these substances are not considered to represent significant hazards to aquatic organisms at the concentrations measured.

Fish from the lower Columbia River have historically contained relatively high levels of certain trace metals and organic substances. Specifically, the concentrations of lead, mercury, and dioxins and furans in muscle and liver tissues from several fish species exceeded the levels that are recommended for the protection of human health and/or fish-eating wildlife. Elevated levels of trace metals and organic substances have also been observed in aquatic plants and/or benthic invertebrates. However, the most recently collected data indicate that the levels of these contaminants have declined markedly over the past few years, and all consumption advisories have subsequently been lifted.

WATER QUALITY OBJECTIVES

The designated water uses that need to be protected in the lower Columbia River from Birchbank to the international boundary include raw water for drinking water supplies that receive partial treatment and disinfection, freshwater aquatic life, wildlife, recreation and aesthetics, irrigation, livestock watering and industrial water supplies. In water, the priority substances with respect to the protection of these uses include pH, suspended solids, total gas pressure, microbial indicators, ammonia and trace metals. In sediments and fish, the priority substances include trace metals, as well as dioxins and furans. Resin and fatty acids may be a concern in sediments; however, there are no guidelines available against which to judge.

An objective has been added for each of dissolved oxygen and ammonia concentrations in the water column. The values listed for the water column for microbiological indicators, zinc and cadmium and in tissues and sediments for dioxins and furans have been modified from those recommended in the technical appendix. There are several reasons for these decisions.

- Microbiological Indicators: the proposed levels of 10/100mL, 10/100 mL and 3/100 mL for fecal coliforms, Escherichia coli and Enterococcus, respectively, have been raised to 100, 100 and 25, respectively. This is necessary since the water requires at least partial treatment prior to human consumption because of turbidity levels, while also needing to provide consistent objectives with those both upstream, and downstream in Washington State.
- Dissolved Oxygen: primary and secondary-treated sewage is discharged to the river. Since there are important fish species in the river, the BC Environment dissolved oxygen guidelines are applied on a site-specific basis, taking general periods when fish eggs will be buried (November to April) into account. The oxygen percent saturation level of 80% is meant to reflect the influence that temperature can have on available oxygen concentrations.
- Ammonia: the consultant had recommended the 30-day mean ammonia concentrations. The BC guidelines also have instantaneous maximum allowed concentrations, which we have added as site-specific objectives.
- Dioxins and furans: the level proposed by the consultant for sediments is based on a draft BC guideline which has been used in the Fraser River, and for consistency will be used in the lower Columbia River. The level has been met. CCME have recently released draft numbers for dioxins and furans in sediments and fish, but these will not be used for the Columbia. Interestingly, the sediment objective we propose for the Columbia River is more restrictive than the draft CCME number. For fish, the draft BC guideline value which is to protect the organism health of 50 pg/g (normalized for lipid content) is slightly more restrictive than that proposed by the consultant to protect wildlife, but is slightly more lenient than the draft CCME number. None of the levels are presently met and the objective is long-term. We expect that the objective will be met in the near future since the Celgar mill has reduced loading in the early 1990's.
- Cadmium: the proposed level by the consultant was that the 30-day mean concentration should not exceed 0.03 µg/L. This will remain as the long-term objective for the lower Columbia, while the short-term objective will be a 30-day mean concentration of 0.05 µg/L. The rationale for this decision is as follows. The data collected under the Federal/Provincial monitoring program at Waneta and Birchbank indicate that the sampling and analytical methods are very reliable when measuring concentrations of extractable cadmium at 0.06 to 0.09 µg/L, but less reliable at 0.01 to 0.03 µg/L. The short-term objective will allow the application of these site-specific precision data in the development of the objective. The cadmium data collected in recent years indicate that mean cadmium concentrations are decreasing, due to effluent treatment improvements and the capture of runoff and seepage entering Stoney Creek, and that the short-term objective

should likely be met. Turbidity levels are low throughout the river, with turbidity values generally all less than 5 NTU, and about 85% to 90% of all values less than 1 NTU. These low values mean that metal concentrations measured as total, extractable or dissolved will probably give similar results.

- Zinc: the proposed level of 7 µg/L was based upon a draft CCME guideline prepared by BC Environment. In developing the approved BC guideline, we proposed two concentrations (not normal for CCME), a maximum concentration and a 30-day mean concentration. A problem with using only the maximum 7 µg/L value is that zinc is an essential element and the 7 µg/L level could result in possible zinc deficiency to aquatic organisms. By using the approved BC maximum and 30-day mean guidelines, the full set of toxicological data could be used and the issue of zinc deficiency can be addressed. The objective for the lower Columbia is that the 30-day mean concentration should not exceed 7.5 µg/L and the maximum concentration should not exceed 33 µg/L.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions that can be met in the future. To limit the scope of the work, Objectives are currently being prepared only for water bodies and for water quality characteristics that may be affected by human activity now and in the foreseeable future.

The water quality objectives for the lower Columbia River from Birchbank to the international boundary are presented in Table 1 and Tables 2 and 3. These objectives are based on the approved and working water quality guidelines for British Columbia, on additional toxicological information and available data on ambient water quality, wastewater discharges, water uses, and streamflow.

The water quality objectives for many of the priority substances identified are currently being met most or all of the time within portions of the lower Columbia River. Where these objectives are not being met presently, they represent targets that should be used to identify priorities for future investigations, management actions and remedial measures.

In the past, streamflow in the lower Columbia River has been managed in accordance with the provisions of the Columbia River Treaty and the Non-Treaty Storage Agreement. As such, water management objectives were primarily focussed on flood control and hydroelectric power generation. In recent years, however, it has been recognized that alterations of the natural hydrological regime now have the largest potential to adversely affect aquatic organisms and their uses (such as recreation and aesthetics). For this reason, it is recommended that the flow regime be managed to protect the structure, productivity, and health of aquatic communities, while respecting the obligations in the Columbia River Treaty (and associated agreements) and societal needs for power generation and flood control.

WATER QUALITY MONITORING

Monitoring programs should be designed and carried out to determine the degree to which the water quality objectives are being met during critical ecological periods. When objectives are exceeded, one or more designated water uses may be threatened. Monitoring ecosystem responses to environmental disturbances provides a direct means of identifying situations where more restrictive effluent standards may be required or where the water quality objectives need to be adjusted to meet water management goals. A recommended monitoring program design for the lower Columbia River is presented in Table 4. The actual monitoring undertaken will depend upon available regional resources and will be co-ordinated with other monitoring programs such as the Columbia River Integrated Environmental Monitoring Program (CRIEMP).

TABLES

A summary of the water quality objectives is provided in Table 1. The recommended monitoring program for the lower Columbia River is presented in Table 4. The objectives typically specify ranges of water quality conditions that are likely to protect the designated water uses in a waterbody. As such, the objectives often specify maximum, 90th percentile or mean or average values that are not to be exceeded. In some cases minimum values are also specified.

Some readers may be unfamiliar with terms such as: maximum concentrations, 30-day average concentration, 90th percentile, and not applicable (NA). A maximum concentration refers to the value for a specific variable that should never be exceeded. A 30-day average or mean concentration defines the level that should not be exceeded by the average value calculated for five or more samples that are collected at approximately equal intervals during a period of 30 days. The term 90th percentile indicates that 9 out of 10 values should be less than a particular value. Not applicable means that water uses are not threatened for that particular variable.

TABLES

TABLE 1. WATER QUALITY OBJECTIVES FOR THE COLUMBIA RIVER FROM BIRCHBANK TO THE INTERNATIONAL BOUNDARY.

Designated water uses
Drinking water (partial treatment plus disinfection)
aquatic life, wildlife, livestock, irrigation and primary-contact recreation.

Characteristics	Objectives
Fecal coliforms	**less than or equal to 100/100 mL (90 th percentile)**
Enterococci	**less than or equal to 25/100 mL (90 th percentile)**

Escherichia coli	less than or equal to 100/100 mL (90 th percentile)
ammonia	AMMONIA TABLE
pH	6.5 to 8.5
dissolved oxygen	May to October greater than or equal to 5 mg/L instantaneous minimum 30-day average greater than or equal to 8.0 mg/L or 80% saturation, whichever is higher ..... November to April greater than or equal to 9 mg/L instantaneous minimum 30-day average greater than or equal to 11 mg/L
total gas pressure	less than or equal to 110%
arsenic	5 µg/L mean less than or equal to 5.7 µg/g (dry-weight) in sediments less than or equal to 471 µg/kg wet-weight in fish muscle tissue
cadmium	0.03 µg/L long-term mean 0.05 µg/L short-term mean less than or equal to 0.6 µg/g (dry-weight) in sediments less than or equal to 900 µg/kg wet-weight in fish muscle tissue
chromium	1 µg/L mean less than or equal to 36.4 µg/g (dry-weight) in sediments less than or equal to 940 µg/kg wet-weight in fish muscle tissue
copper	2 µg/L mean less than or equal to 7.2 µg/L maximum less than or equal to 35.1 µg/g (dry-weight) in sediments
lead	4.8 µg/L mean less than or equal to 37.9 µg/L maximum less than or equal to 33.4 µg/g (dry-weight) in sediments less than or equal to 160 µg/kg wet-weight in fish muscle tissue
mercury	less than or equal to 0.16 µg/g (dry-weight) in sediments less than or equal to 100 µg/kg wet-weight in fish muscle tissue

thallium	less than or equal to 0.8 µg/L mean
zinc	less than or equal to 7.5 µg/L mean less than or equal to 33 µg/L maximum less than or equal to 120 µg/g (dry-weight) in sediments
dioxins and furans 2,3,7,8-T_4CDD -TEQ's-	in sediments less than or equal to 0.25 pg. TEQ/g (normalized to 1% organic carbon) ..... in fish muscle or fish eggs (long term) less than or equal to 50 pg/g (wet-weight) normalized to lipid content

Water quality objectives do not apply in initial dilution zones where acutely toxic conditions are not permitted. Water quality objectives do apply to discrete samples of water and sediment from all other parts of the Columbia River from Birchbank to the International Boundary. In practice, the extent of initial dilution zones is defined on a site-specific basis, with due regard to water uses, aquatic life, including migratory fish and other waste discharges. However, where sufficient site-specific data are not available for defining initial dilution zones, the initial dilution zones will be defined as extending up to 100 metres downstream from a discharge and occupying no more than 25% of the stream width around the discharge point, from the bed of the stream to the surface. It is also important to note that objectives for fish tissues apply to all parts of the river, including fish in the initial dilution zone.
The average or mean, and the 90th percentiles are calculated from at least five weekly samples in a period of thirty days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the statistic. The 75th or 90th percentiles can be extrapolated by graphical methods when fewer than ten samples are collected.

Table 4. RECOMMENDED WATER QUALITY MONITORING FOR THE COLUMBIA RIVER FROM BIRCHBANK TO THE INTERNATIONAL BOUNDARY

Site Number	Location	Frequency	Dates	Variables

0200003	Columbia River at Birchbank on the westbank	5 times at weekly intervals in 30 days	January April September	temperature, fecal coliforms, *Enterococci*, *Escherichia coli*, turbidity, dissolved oxygen, total gas pressure, NH_3 nitrogen, pH, hardness, suspended solids, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River Birchbank to Stony Creek	once 12 fish	July	species, age, sex, condition, gross abnormalities, lipid content, moisture content, As, Cd, Cr, Cu, Pb, Hg, Tl, Zn, PCDDs and PCDFs
New Site	Columbia River Birchbank to Stony Cree	once 5 replicates	September	TOC, AVS, particle size, total and SEM metals for As, Cd, Cr, Cu, Pb, Hg, Tl and Zn, dehydroabietic and total resin acids, PCDDs and PCDFs, fatty acids, acute and short-term chronic toxicity for *Chironomus riparius* and *Hyalella azteca*
New Site	Columbia River 100 m D/S from Stoney Creek on west bank	5 times at weekly intervals in 30 days	January April September	temperature, turbidity, pH, dissolved oxygen, hardness, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River at old Trail bridge on west bank	5 times at weekly intervals in 30 days	January April September	temperature, turbidity, dissolved oxygen, NH3 nitrogen, pH, hardness, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River 100 m downstream from Kootenay Boundary Regional District STP Outfall	5 times at weekly intervals in 30 days	January April September	fecal coliforms, *Enterococci*, *Escherichia coli*, NH_3 nitrogen, turbidity

New Site	**Columbia River between West Trail Bridge and Waneta**	**once 12 fish**	**July**	**species, age, sex, condition, gross abnormalities, lipid content, moisture content, As, Cd, Cr, Cu, Pb, Hg, Tl, Zn, PCDDs and PCDFs**
New Site	**Columbia River between West Trail Bridge and Waneta**	**once 5 replicates**	**September**	**TOC, AVS, particle size, total and SEM metals for As, Cd, Cr, Cu, Pb, Hg, Tl, Zn, dehydroabietic and total resin acids, PCDDs and PCDFs, fatty acids, acute and short-term chronic toxicity of *Chironomus riparius* and *Hyalella azteca***
0200559	**Columbia River at Waneta on East Bank**	**5 times at weekly intervals in 30 days**	**January April September**	**temperature, fecal coliforms, *Enterococci*, *Escherichia col*, , turbidity, dissolved oxygen, total gas pressure, NH_3 nitrogen, pH, hardness, turbidity, suspended solids, As, Cd, Cr, Cu, Pb, Tl, Zn**

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