Water Quality

Ambient Water Quality Objectives For The Lower Columbia River Hugh Keenleyside Dam To Birchbank

Overview Report

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

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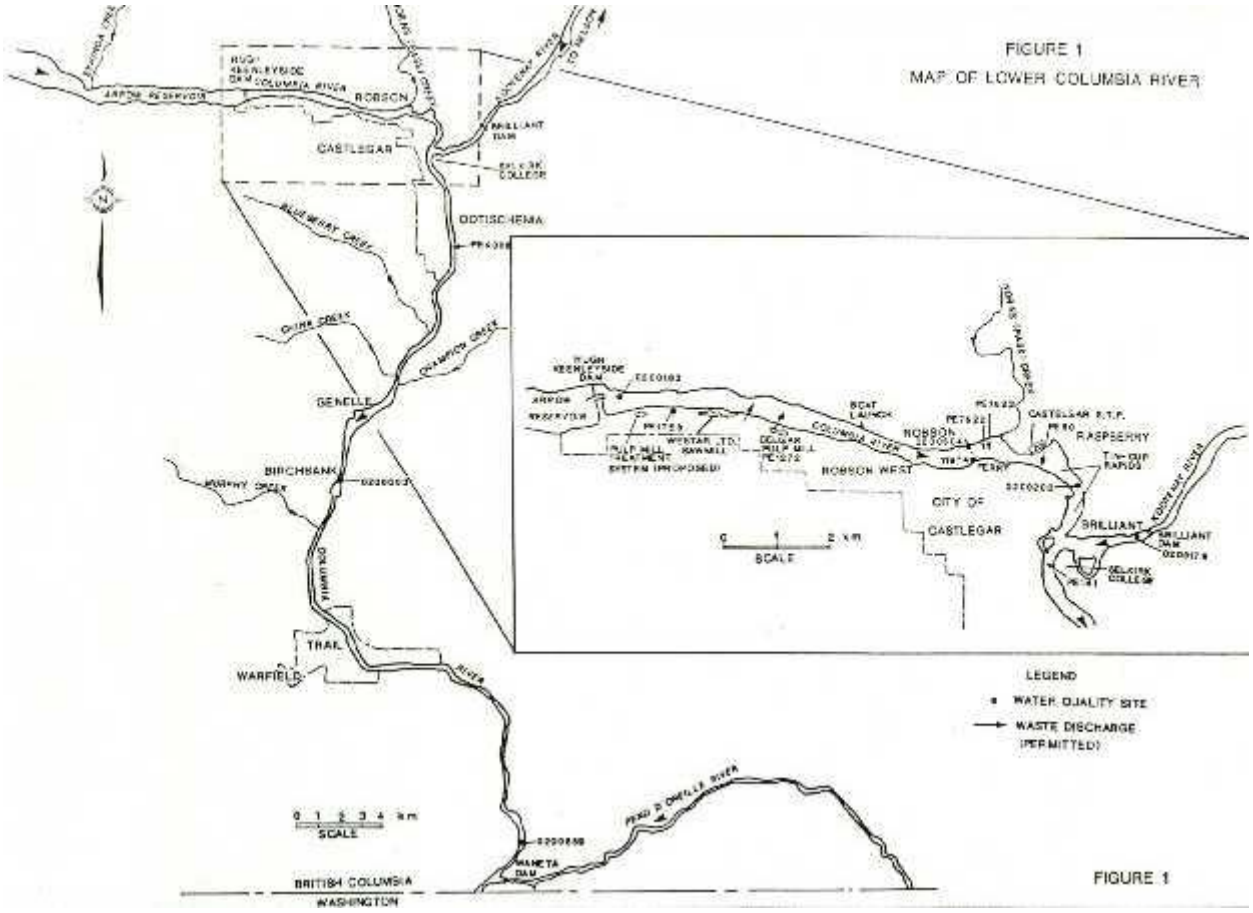
Figure 1. Lower Columbia River Location Map



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 socioeconomic 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

This is the first of two reports assessing water quality and setting water quality objectives for the lower Columbia River from the Hugh Keenleyside Dam to the US border. In this report the 28 km reach from the dam to Birchbank is considered.

The status of existing and future water quality is examined with respect to the existing and future water uses. Provisional water quality objectives are set to protect designated water uses. A monitoring program to check the attainment of these objectives is recommended. The goal of this report is to guide the water quality management of this reach of the Columbia River. A detailed technical appendix was prepared and forms the basis for the conclusions presented in this summary.

HYDROLOGY

This reach begins approximately 700 km downstream from the headwater source of the Columbia River and ends approximately 60 km upstream from the BC-Washington border. Streamflow regulation of this reach began in 1968 with the construction of the Hugh Keenleyside Dam. Since regulation, winter flows have increased as water is released, and spring/summer flows have decreased as the floods are stored. The period of low flow varies between early March and late June. As specified by the Columbia River Treaty, the average weekly outflow from the Keenleyside Dam is to be greater than 142 m^3/s, except if agreed otherwise by the Treaty signatories. On average, flows of approximately 142 m^3/s occur approximately 3.5 percent of the time.

The mean annual flow of the Columbia River at the Keenleyside Dam increases from 1110 m^3/s at the Keenleyside dam to 2020 m^3/s at Birchbank. The Kootenay River is the largest tributary within this reach contributing to 42% of the mean annual flow at Birchbank. The Kootenay River thus provides significant dilution for anthropogenic discharges within this reach.

WATER USE

Present licensed withdrawals represent 1.8% of the minimum outflow from the Keenleyside Dam. The largest water use (69.2%) is for industrial purposes at the Westar Timber Ltd. sawmill and the Celgar pulp mill. Irrigation of gardens and hay crops accounts for 30.5%. Only 0.01% of the withdrawal is for domestic consumption. The City of Castlegar takes its water supply directly from the Arrow Reservoir via pipeline as do Celgar and Westar.

A total of 22 fish species are known to inhabit the Columbia River between the Keenleyside Dam and the US border. Of these, there are six important sport fish species: rainbow trout, yellow walleye, mountain whitefish, kokanee, Dolly Varden char, and burdot Their presence provides for a popular sport fishery which is the dominant water-based recreational activity in this reach. Other recreational attributes of the river are boating, swimming, aesthetics (tourism, viewing). Water quality has been identified as the principle factor detracting from the enjoyment of the river recreation in this reach.

WASTE WATER DISCHARGES

The most important waste discharges affecting water quality in this reach of the Columbia River are the industrial effluent from the Celgar pulp mill (PE 1272) and the treated sewage effluent from the City of Castlegar (PE 80, PE 4008). There are several smaller discharges of treated sewage which are not considered to be problems, including that from the sawmill and pulp mill (PE 1273), from a neighborhood pub (PE 7622), and from Selkirk College (PE 141).

Non-Point Sources

Diffuse-source contamination from land activities does not appear to have any significant effect on river water quality. Agriculture is largely part-time and limited to small-scale livestock production and irrigated hay crops. There are some unpermitted domestic effluent discharges within the potential for local fecal contamination, but not discerned by available river water quality monitoring data. There are two landfills operated by the sawmill and pulp mill located approximately 150 m from the river's edge; however, leachate is routed to an exfiltration pond and effects in the river have not been measured. Water-based log storage and handling at the sawmill and pulp mill have altered the benthos with sunken logs, branches, and bark debris, and has the potential (though undocumented) to degrade the quality of the overlying water column.

Celgar Pulp Mill

The Celgar pulp mill is the oldest interior kraft pulp mill and, since start-up in 1961, it has discharged u treated effluent to the Columbia River via a submerged diffuser located 3.3 km downstream from the Keenleyside Dam. Although some progress in effluent improvement has been made in recent years, by present industry standards the pulp mill is functionally obsolescent. Beginning in 1991, Celgar is rebuilding and expanding the mill, increasing production from 560 to 1200 ADt/d. Approval for the expansion was given after review by a panel convened jointly by the Federal and Provincial Governments. Details of the mill process changes are provided in the Technical Appendix.

Important future changes relative to receiving water quality include: installation of secondary treatment; a reduction in mean effluent flow from 116 000 m^3/d to 93 000 m^3/d (summer) and 76 900 m^3/d (winter); a 40% reduction in chlorine usage; and reduction in chlorinated dioxins and furans to levels below current detection limits. Reduction in the effluent levels of BOD, suspended solids, colour, and toxic organics (Absorbable Organic Halogens (AOX), resin acids, phenolics) are also expected after 1994 with the completion of mill modernization. Effluent phosphorus levels are expected to remain high (102 kg/d compared to present loading of 112 kg/d), while nitrogen levels are expected to increase from the present level of 350 kg/d to 511 kg/d.

The effluent from the Celgar pulp mill in its pre-modernized condition has consistently exceeded permit target levels for BOD, suspended solids, pH, and toxicity. Rainbow trout bioassay data indicate that the 96-h LC_{50} of the effluent ranged from 2.6 to 30% and averaged 13%. Extrapolation from the bioassay data indicates that receiving water concentrations at low flow were 7 to 70 times higher than the safe levels recommended for persistent and cumulative toxicants, after complete mixing. With the exception of levopimaric acid and the chlorinated resin acids, all of the resin acids have been measured at levels exceeding their reported 96-h LC_{50} values, indicating their presence in the effluent at acutely lethal levels. Total organochlorines, as measured by AOX, averaged 4.8 kg/ADt in the pre-modernized mill, which is close to twice the Ministry mandated level of 2.5 kg/ADt (for 1991). The organochlorines identified from the effluent included 2,3,7,8-TCDF, H_6CDD, all five chlorophenol congeners (mono- to penta-), the chloroguaiacols, and chlorocatechols. With mill modernization proceeding, Celgar is expected to meet the 1.5 kg/ADt objective by July 1, 1994.

The City of Castlegar

The City of Castlegar has two separate secondary sewage treatment systems: one on the north bank of the river authorized to discharge 45% of the City's effluent and one on the east side of the river authorized to discharge the remainder. All available for the total effluent in the Columbia River is in excess of 5000:1.

WATER QUALITY ASSESSMENT

Assessment of the available data indicates that effluent from the Celgar pulp mill has been negatively altering the water quality of the Columbia River, although the larger river dilution, periodic flushing, and dissolved gas supersaturation from the Keenleyside Dam ameliorate much of the toxicity impact.

The colour of the Columbia River between the mill and the Kootenay River was degraded by the effluent to dark brown and could reach levels which impaired the water for downstream recreational use and for drinking water. Surface foaming, taste, and odour problems due to the pulp mill effluent are also recurring aesthetic problems with the mill in its present state. Mill modernization is projected to reduce (although not eliminate) the discolouration and eliminate the foaming, taste, and odour problems.

Acute toxicity was not a problem in the Columbia River downstream from Celgar's discharge outside the initial dilution zone; however, sublethal stress on aquatic organisms was expected to occur between Celgar and the Kootenay River confluence under present pre-modernized conditions. With mill modernization and secondary treatment, there should be few sublethal effects beyond the initial dilution zone. Receiving water resin acid levels were within the BC working criteria for the protection of aquatic life and by themselves were not responsible for sublethality outside the initial dilution zone. Organochlorines (as measured by AOX) have contaminated the water column of the river downstream from the mill to at least the US border. All receiving water chlorophenol measurements, however, have been less than the interim BC criteria for the protection of aquatic life. The only dioxin/furan congener detected in the receiving waters has been H_7CDD at 0.12 pg TCDD TEQ/L, which is considerably lower than the interim guideline for dioxins in drinking water (15 pg/L). The sediments downstream from Celgar have also been found to be contaminated with organocholorines, including EOX, dioxins (H_6CDD, H_7CDD, OCDD), furans (TCDF, PCDF), and chlorinated phenolics (guaiacols, catechols, anisoles, and veratroles).

Fibre discharge from the mill has resulted in fibre-matting on the bottom of the Columbia River for up to 2 km downstream from Celgar. The fibre mat is comprised of decomposed pulp fibres, fine sediments, and a slime covering or biofilm. Chemical analysis of this material indicates that organocholorines are present, but not at levels which could classify the material as "special waste" under the proposed MOE Special Waste Regulations.

High levels of dissolved gases were present downstream from the Keenelyside Dam as far as the Roosevelt Reservoir. Approximately 80% of dissolved gas measurements have exceeded 110%, which is the approximate threshold for acute effects. It is not presently known to what extend gas supersaturation affects the health of aquatic life in the Columbia River. Severe gas bubble disease observations have not been made to date, nor have there been significant fish kills reported. Installation of turbines in the Keenleyside Dam, as proposed by BC Hydro, would ameliorate gas supersaturation for most of the year when the sluiceway is not used.

Celgar's effluent has had minimal effect on the suspended solids, pH, or dissolved oxygen of the receiving waters. Water column pH has continued to remain in the pH 6.5 - 8.5 range, thereby meeting the approved BC criteria for pH. There is also no evidence from monitoring data that effluent induced suspended solids have exceeded 10 mg/L over background, BC's approved criteria for the protection of aquatic life. All surface dissolved oxygen data for this reach have been high, exceeding 10 mg/L. The supersaturated conditions created by the Keenleyside Dam allow for ready assimilation of the high BOD loading from the pulp mill. Even with a future scenario of reduced dissolved gas supersaturation (due to turbine installation at Keenleyside Dam), dissolved oxygen levels are not projected to fall below a minimum of 9.5 mg/L (largely because of mill modernization and BOD reductions).

The Celgar mill accounted for approximately 90% of the total phosphorus and 92% of the total nitrogen entering this reach of the Columbia River; however, these loadings have not contributed to eutrophication or excess algal growth. Predicted receiving water nutrient concentrations for post-expansions have been calculated and indicate no change over present total phosphorus increases, but a three-fold increase in the Kjeldahl nitrogen concentration. This indicates that mill expansion could further increase the phorphorus limitation on downstream algal growth.

Benthic Macroinvertebrates

The available information shows that some toxicity effects have occurred among the more sensitive benthic macroinvertebrate populations of the Columbia River within this reach. Sensitive organisms are no longer a significant component of the benthic community. There has been an accommodation of community structure with invertebrates classed as tolerant and facultative (considered less desirable from a fish-food perspective) dominating from Celgar to the Kootenay River.

Analysis of freshwater mussel tissue has indicated the presence of chlorophenol, chloroguaiacol, and dioxin/furan contamination in animals sampled downstream from Celgar. Low levels of TCDD and TCDF were present in mussels taken upstream from Celgar. The implications of these mussle tissue organochlorine levels for the health of the mussle community is presently unknown. These levels, however, may be sufficiency high to be unsafe for wildlife and human consumers.

Fish Tissue Dioxin and Furan Residues

The furan 2,3,7,8-TCDF has been the predominant congener contaminating the fish of the Columbia River, with the highest levels found in whitefish and sturgeon. In a North American context, the TCDF levels downstream from Celgar were high and would rank among the most contaminated samples measured to date. Dioxins also contaminate the lake whitefish (2,4,7,8-TCDD) and rainbow trout (OCDD, H_6CDD, H_7CDD) in this reach. All of the fish species tested downstream from Celgar had tissue TCDD TEQ levels exceeding the threshold for EROD (an hepatic mixed function oxidase enzyme) induction, an early warning stress threshold. TCDD concentrations in whitefish eggs from Roosevelt Reservoir had also exceeded the TCDD concentration in lake trout eggs reported to cause 50% mortality (LD 50) in swim-up fry. This suggests the possibility of reproduction impairment in the fish community downstream from Celgar. The majority of samples also exceeded a reported tissue criterion for the protection of wildlife feeding primarily on fish.

WATER QUALITY OBJECTIVES

Provisional water quality objectives are set to protect a variety of designated water uses between the Keenleyside Dam and Birchbank including: aquatic life (and their habitats), wildlife consumption of aquatic life, recreational use, aesthetic values, and drinking water. As future receiving water monitoring programs improve the data base and as changes in effluent quality occur (*e.g.*, pulp mill modernization), these objectives will be reviewed and revised if necessary. The provisional objectives are shown in Table 1 and Table 2.

These objectives apply to all parts of this reach of the Columbia River, except for the initial dilution zones of effluents. This is the initial part of the mixing zone where the Province accepts some degree of adverse biological effect, *i.e.*, sublethal stress, but not conditions that are acutely toxic or that would cause harmful bioaccumulation, or adverse sludge deposits. For this reach of the Columbia River these excluded dilution zones are defined arbitrarily as extending up to 100 m downstream from the discharge point from the surface to the bottom and no more than 50% across the width of the river for the pulp mill discharge and no more than 25% for all other discharges. Initial dilution zones are not to impinge on bathing beaches or fish spawning habitat.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource mangers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits, licenses, and orders, and the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular water body can be checked, and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by man's activity, now and in the foreseeable future.

The provisional objectives for dissolved oxygen, pH, temperature, resin acids, and suspended solids and turbidity are presently being met all of the time and can also be met in the future. The provisional objectives for colour, substrate sedimentation, and dissolved gases are not being met at present and are not projected to be met in the near future right at the edge of the initial dilution zone for the Celgar mill (although the dissolved gases objective can be met with future changes to the Keenelyside Dam). Those characteristics which are exceeding the recommended objectives at present, but which could meeting them in the near future with pulp mill modernization and secondary treatment, include toxicity and chlorinated resin acids. The objectives for dioxins and furans in fish tissue and sediment, presently exceeding the objectives, may take a longer time for attainment as levels in the sediments and food-chain are dissipated. At this time there are insufficient data to determine whether the objectives for microbiological indicators, periphyton standing crop, chlorophenols, or chlorinated dioxins and furans (in water) are being met at or could be met in the future.

WATER QUALITY MONITORING

The recommended receiving water quality monitoring program is outlined in Table 3. This is a minimum monitoring program and was designed to check attainment of the objectives set for the Keenelyside to Birchbank reach of the Columbia River. It is part of the larger Lower Columbia River Integrated Environmental Monitoring Program (CRIEMP) which started in 1991 with the cooperation of the BC Ministry of Environment, Environment Canada, Department of Fisheries and Oceans, the City of Castlegar, the City of Trail, and the industrial users (Cominco, BC Hydro, and Celgar). CRIEMP has begun monthly monitoring for most characteristics and these additional data will be used in any assessment of whether or not the water quality objectives are being met. The results will be published by the Water Quality Branch in its annual report on the attainment of all provincial water quality objectives.

TABLES

Table 1. Provisional Water Quality Objectives for the Lower Columbia River (Keenleyside Dam to Birchbank)

Characteristics	Objectives
designated water uses	aquatic life, wildlife, recreation, drinking water
dissolved oxygen	10 mg/L minimum
pH	unrestricted change in pH 6.5-8.5 CO_2 less than 60 mg/L

colour	**15 TCU maximum**
suspended solids	**10 mg/L maximum increase**
turbidity	**5 NTU maximum increase**
substrate sedimentations	**sediment TOC not to increase d/s relative to u/s at 95% confidence level**
temperature	**less than 1 degree Celcius maximum increase**
dissolved gases	**less than 110% maximum saturation**
fecal coliforms	**less than 100/100 mL 90th percentile**
Escherichia coli	**less than 100/100 mL 90th percentile**
toxicity	**[%] of mill effluent in river water less than 0.05 of the 96h LC_{50} after complete mixing**
chlorinated phenols	**TCP less than 0.05 micrograms/L TTCP less than 0.1 micrograms/L PCP less than 0.05 micrograms/L**
dioxins/furans in fish	**1 pg TCDD TEQ/g maximum**
dioxins/furans in water	**0.2 pg TCDD TEQ/L maximum**
dioxins/furans in sediment	**0.7 pg TCDD TEQ/g sediment TOC maximum**
resdin acids in water	**see Table 2.**
chlorinated resin acids in water	**6.0 micrograms/L maximum of monochloro- and dichloro-DHA**
periphyton standing crop	**less than 50 mg/m^2 chlorophyll *a* average**

Note: The objectives apply to discrete samples from all parts of the waterbody, except from initial dilution zones of effluents. This exclusion does not apply to objectives for fish as noted below.
1. For suspended solids and turbidity the increase in mg/L or NTU is over levels measured at a control site away from, generally upstream, a discharge or series of discharges and as close to them as possible and applies to areas affected by the discharge.
2. For fecal coliforms and Escherichia coli the 90th percentile is calculated from at least 5 weekly samples taken in a period of 30 days.
3. For dioxins/furans in fish the objective applies only to muscle tissue (not to the whole fish or organs) of a fish of any species caught in any part of the waterbody, including initial dilution zones of effluents. It is expressed on a wet weight basis.
4. For dioxins/furans in sediment and substrate sedimentation the sediment level is the average of the results from at least 3 replicate samples of bottom surface sediments at each site on any one sampling date.
5. For the periphyton standing crop the average is calculated from at least six randomly located samples from natural substrates at each site on any one sampling date.
6. For substrate sedimentation the increase applies to the total organic carbon content of surface bottom sediments. No increase means that there should be no significant difference in sediment TOC, at the 95% confidence level, between an upstream control site and an affected site outside the initial dilution zones of effluents.

Table 2. Resin Acids Objectives

pH of river water	DHA in micrograms/L	total resin acids in micrograms/L
6.5	4	9
7.0	8	25
7.5	12	45
8.0	13	52
8.5	14	60

The total concentrations of DHA, dehydroabietic acid, and total resin acids in water should not exceed the table values for the specified pH levels. Total resin acids are defined as the sum of the individual concentrations of abietic, dehydroabietic, isopimaric, levopimeric, neoabietic, pimaric and sandaracopimaric acids.

Table 3. Recommended Receiving Water Monitoring Keenleyside Dam to Birchbank

Sites and Numbers	Frequency and Dates	Characteristics to be Measured
Upstream from Celgar: 0200183	5 weekly samples in 30-days	temperature, DO, pH, suspended solids, turbidity, colour, sodium, total dissolved gases, fecal coliforms, *Escherichia coli*, enterococci, foam/floatables/odour observations
100 m downstream from Celgar: new site		
at Castlegar: 0200200		
Upstream from Celgar: 0200183	Once in April	resin acids, chlorinated resin acids, chloroguaiacols and chlorophenols, AOX, dioxins/furans in sediment and water
100 m downstream from Celgar: new site		
at Castlegar: 0200200		
Birchbank: 0200003	5 weekly samples in 30 days, April	DO, total disslved gases, *Escherichia coli*, enterococci, foam/floatables/odour observations
	twice between Federal/Provincial biweekly sampling, March/April	temperature, pH, suspended solids, turbidity, colour, sodium, fecal coliforms
	once, April	resin acids, chlorinated resin acids, chloroguaiacols and

		chlorophenols, dioxins/furans in water and sediment
upstream from Celgar: 0200183	**Once in summer**	**periphyton standing crop**
at Castlegar: 0200200		
at Birchbank: 0200003		
u/s and d/s from Celgar: new sites	**once, anytime, 3 reps at each site**	**substrate sedimentation (TOC)**
between Celgar and the Kootenay River	**once, annually, anytime, 4 reps of each**	**fish tissue and sediment dioxin/furan levels**

This is a minimum monitoring program designed to measure the attainment of the recommended water quality objectives. This program is augmented by the data being generated under the auspices of the Columbia River Integrated Monitoring Program (CRIEMP).
The fish tissue dioxin/furan levels is from a sport fish fillet (species to be determined by regional samplers) at a minimum of one reference site.
The sediment dioxin/furan levels are taken at a minimum of one reference site.

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