Water Quality

Ambient Water Quality Assessment And Objectives For The Fraser River Sub-Basin From Kanaka Creek To The Mouth

Overview Report

Resource Quality Section
Water Management Branch
Ministry Of Environment

Prepared Pursuant To Section 2(E) Of The Environment Management Act, 1981

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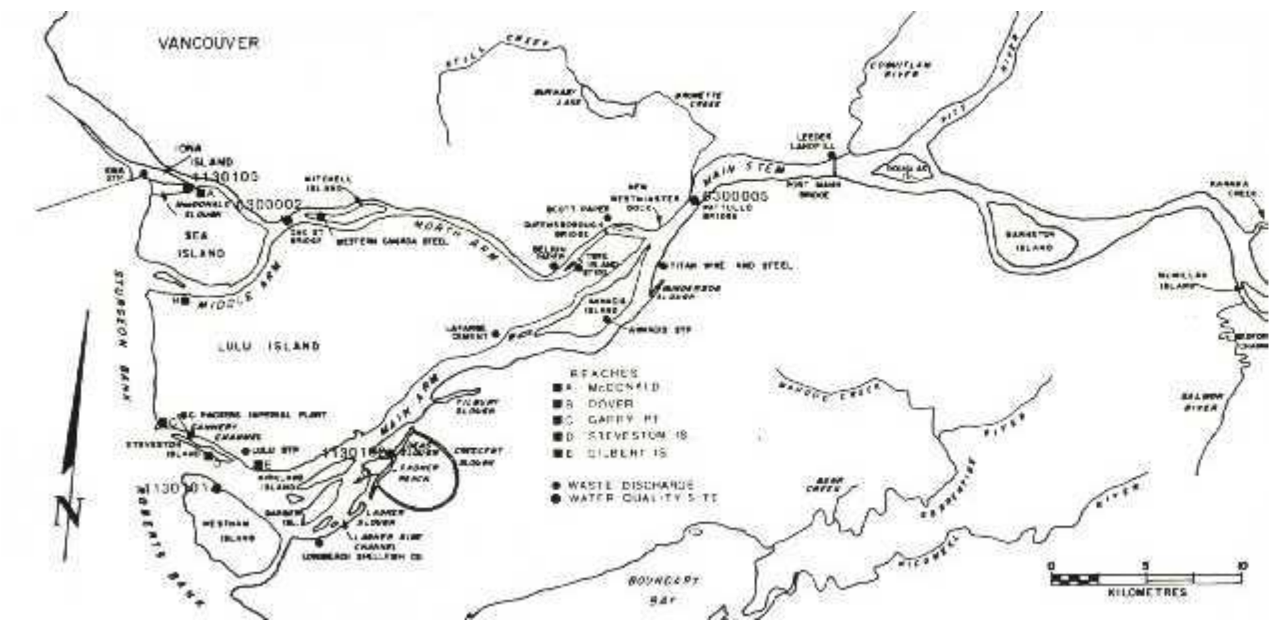
November 25, 1985.

Figure 1. Fraser River sub-basin from Kanaka Creek to the mouth



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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

This report examines the water quality in the Fraser-Delta area downstream from Kanaka Creek to and including, Sturgeon and Roberts Banks (see attached Figure 1). The review covers water quality data and effluent quality data from about 1979 to December 1982. This period of record was selected since data up to the end of 1978 already had been examined by the Water Quality Work for Phase I of the Fraser River Estuary Study. The main purpose of the review is to develop water quality objectives in reaches where designated water uses are threatened, either now or in the future. Two additional reports form part of this assessment: one dealing with the water quality in the Fraser River from Hope to Kanaka Creek and the other dealing with water quality in the Serpentine, Nicomekl and Campbell Rivers and Boundary Bay.

The water quality of some tributaries entering the Fraser River was considered in order to estimate their impact on the river. A detailed technical appendix was prepared and forms the basis for the conclusions presented in this report.

HYDROLOGY and OCEANOGRAPHY

The flow in the Fraser River is large relative to other provincial rivers. The yearly average flow is about 3475 m^3/s. The minimum flow ranges from 575 to 1040 m^3/s from January through March, while the maximum flow is up to 139,000 m^3/s in June.

The Main Stem of the Fraser River divides into two channels near New Westminster, with 15% of the flow entering the North Arm and 85% entering the Main Arm.

The water movement in the lower Fraser River, below Chilliwack at low river flows and below Mission at high flows, is a function of tides in the Strait of Georgia and river discharge. The speed and the direction of the river flow depend on the stage of the tide outside the estuary. Tidal influence is particularly pronounced in river reaches below New Westminster. As in all tidal rivers, the outgoing ebb lasts longer than the incoming flood.

An important feature affecting flow distribution in the river is the intrusion of dense saline water from the Strait of Georgia upstream to New Westminster. The saline water is forced upstream in the form of a wedge by the rising tide, reducing the cross-sectional area for the outflowing river water at a given level, causing the water level to rise.

The relative shallowness of the North Arm prevents the salt wedge from moving upstream to New Westminster. Flow reversals in the river, which can occur in the lower reaches at low river flow and high tide, complicate the understanding of the impact of point source discharges on the river. Effluents are influenced by varying dilutions while contaminants can remain in the river for varying periods of time. The effects of tides on effluent dispersion have been studied. Four peaks in the concentration of an effluent in the river from a point discharge were predicted over a 24 hour period, each corresponding to slack water. Occasional flow reversals can cause the same particle of water to pass a discharge point several times, thereby creating multiple doses of effluent at that point.

WATER USES

The North Arm, Main Arm and Main Stem of the Fraser River are extremely important migration routes for juvenile and returning adult salmon. To leave or reach the river, the fish must cross Sturgeon and/or Roberts Banks. The estuary is also a rearing for various salmon and trout. There are 14 fish species using the lower Fraser River that are migratory, six species having periodic migration and 18 species that are not know to migrate regularly.

The three channels of the Fraser River also are for irrigation, secondary-contact recreation (fishing, boating) and by industry for transportation. Irrigation water is obtained from several ditches along the North and Main Arms, which are allowed to flood for irrigation use by local drainage authorities.

Both Roberts and Sturgeon Banks are used for transportation while being very important habitat for fish and waterfowl. In addition, extensive recreational use is made of the area. These activities include small boat use, sports fishing and beach activities at Iona Island (between the jetties), McDonald Beach, Dover Beach, Garry Point, including the beach area adjacent to the Tsawwassen jetty. The area is closed to molluscan shellfish harvesting.

WASTE DISCHARGES

The Fraser River downstream from Kanaka Creek is the most heavily urbanized and industrialized water body in British Columbia. Approximately 230,000 m^3/d of municipal effluent and 360,000 m^3/d of industrial effluent is discharged to the river. About 450,000 m^3/discharged to Sturgeon Bank from the Iona STP. Of the total discharged to the river, 25% is discharged to the Main Stem, 15% to the North Arm and 60% to the Main Arm. In addition, large quantities of contaminated surface runoff enter each of these channels, especially the North Arm. The following operations, which are illustrated on the location map, are projected to have the largest impact on ambient water quality.

The Iona STP, which discharges primary-treated sewage, has degraded an area of Sturgeon Bank within a 3 km radius around its discharge point. A long sea outfall now is being considered as a permanent solution to rehabilitate the degraded area of Sturgeon Bank and prevent oxygen depletion in the shallow water of the Bank. As well, the Greater Vancouver Sewerage and Drainage District has installed additional, primary treatment facilities to eliminate raw sewage bypasses at the plant.

The Annacis STP discharges about 200,000 m^3/d of primary-treated sewage to a portion of the Main Arm of the Fraser River where tidal influences exist. The tidal effects, in combination with projected effluent loadings, could result in impacts on river quality in the future at extremely low river flows. These impacts could be caused by copper, lead, zinc and un-ionized ammonia. Fecal coliform values are presently high outside the initial dilution zone. High metal and ammonia levels potentially could stress aquatic life, while high fecal coliforms could impair the use of the water for irrigation or recreation.

The Lulu STP is also located on the Main Arm of the Fraser further downstream from the Annacis STP. It discharges about 25,000 m^3/d of primary-treated effluent. Its lower flow in relation to the Annacis STP causes its impact on river quality to be far less than the latter, even considering tidal influences and future projected effluent loadings. The only impact would be from un-ionized ammonia at the edge of the initial dilution zone, at extremely low river flow conditions. Ammonia could cause stress or acute toxicity to aquatic life.

Three metal fabricating companies, Titan Wire and Steel on the Main Arm and Tree Island Steel and Western Canada Steel on the North Arm, discharge wastewater to exfiltration ponds adjacent to the river. Seepage from these ponds potentially can affect levels of certain metals in the river, especially copper, lead and zinc.

The discharge from Lafarge Cement (about 1200 m^3/d, maximum) which has a high pH, can potentially cause localized increases in pH in the Main Arm of the river. This is turn can increase the levels of un-ionized ammonia and increase the toxicity to fish in an area adjacent to the initial dilution zone.

Calculations have indicated that the discharge from Scott Paper, a paper mill discharging about 10,000 m^3/d to the North Arm, should not affect most water quality characteristics after complete mixing. However, actual measurements just outside the initial zone (before mixing is complete) have indicated that this discharge can raise temperature and suspended solid levels, while lowering the river's dissolved oxygen concentration. These effects can stress aquatic life.

Belkin Packaging is a paper board mill which recycles paper and discharges about 15,000 m^3/d. In the past it has increased polychlorinated biphenyls (PCBs) in the water column and sediments of the North Arm. Improvements made to the operation have resulted in improved effluent quality.

Another location where impacts on river quality were noticed in the past, is near the Leeder landfill on the north bank of the Main Stem. The closing of the landfill and its subsequent capping with an impervious material, has helped to diminish its impact, formerly noted by increased ion concentrations and decreased dissolved oxygen levels. The BC Packers Imperial plant and the Long Beach Shellfish Company operate intermittently, but discharge to side channels in the Main Arm of the river. These discharges, which are relatively low flows containing material exerting a high oxygen demand, can cause localized dissolved oxygen depressions due to inadequate effluent dispersion. The low dissolved oxygen levels can have a deleterious effect on aquatic life in these localized areas.

Stormwater runoff is a major source of contaminants entering the river. For example, runoff from forest industry operations such as sawmills, where chlorophenols are used as fungicides, can cause these substances to enter the river. These substances can be long lasting and extremely toxic.

Stormwater runoff from urban areas can increase levels of fecal coliforms, suspended solids, COD, nitrogen, aluminum, iron, copper, lead and zinc in the river. Calculations show that stormwater could cause noticeable impacts, in particular in the North Arm of the river. Here, there are large numbers of stormwater outfalls and relatively smaller river flows compared to either the Main Arm or the Main Stem. Grit and sediment associated with stormwater discharged into the river has higher concentrations of lead, zinc and PCB's than natural Fraser River sediments. Metals can cause stress, or at high concentrations, acute toxicity to aquatic life. PCB's have an extremely long life and are toxic. Fecal coliforms can affect water use for irrigation or recreation.

A special case of stormwater runoff is combined sewer overflows. Overflows of raw sewage and stormwater occur only intermittently during very heavy rainfall when the sewers cannot handle the combined flow of sewage and stormwater. Several of these overflows exist near New Westminster. Their impact on the North Arm is estimated to be intermediate between the impact of raw sewage discharges and that of stormwater runoff. For this reason, it is expected that combined sewer overflows would tend to lower dissolved oxygen and may increase levels of suspended solids, fecal coliforms and several metals in the river, for short intermittent periods. Such effects so far have not been definitely identified.

Numerous other operations which discharge effluents in the study area are projected to have a minimal impact on the water quality of the river. Since there are so many effluents discharged to the lower Fraser River, there is some concern about the additive effect of initial dilution zones associated with the effluents. In practice, effluents with low loadings will require very small areas for dilution. Generally, permitted contaminant concentrations in effluents are controlled such that levels in the initial dilution zone are not acutely toxic to aquatic life. These initial dilution zones are also areas where chemical changes, precipitation, absorption and microbiological action affect the effluent composition, thus reducing any additive effects.

AMBIENT WATER QUALITY

The water quality of four tributaries to the Main Stem of the Fraser River was examined by evaluating data which were collected at monitoring sites close to their confluence with the Fraser. In this way, the impact of each on the Fraser could be estimated. The four tributaries in total contribute less than 1% of the flow in the Fraser. Therefore, only extreme variations in their quality from that in the Fraser would have significant impact within the Fraser itself. Any influence would be evident only near their confluence with the Fraser.

Three of the tributaries, Kanaka Creek, the Coquitlam River and the Pitt River, had similar water quality to that in the Fraser. This was evident in the pH values, buffering capacity, dissolved oxygen and fecal coliforms which were lower than in the Fraser and metal values which were low, generally below detection limits and within water working quality criteria for the protection of aquatic life.

The fourth tributary, the Brunette River, drains a populated area and had water quality very different from that of the other three tributaries. Although the Brunette River had soft water with a high pH and acid buffering capacity similar to the Fraser River, some high level metal values were recorded. These include values for copper, lead, chromium and zinc and were probably due to stormwater runoff since the high metal values were associated with high suspended solids. Nitrogen compounds were as much as three times higher and orthophosphorus two times higher, than values recorded in the Fraser River. These higher nutrient values may have been the result of leaching of commercial fertilizers from the land. Fecal coliforms in the Brunette River were about the same as those found in the Fraser River. Dissolved oxygen levels generally were acceptable for maintenance of aquatic life. However, once the Brunette River flows have mixed with the Fraser River, no effect should be noticeable in the Fraser River.

The water quality of all three channels, the Main Stem, Main Arm and North Arm, was fairly consistent and was as good or better than reported in 1979. The river had a pH from 7.0 to 8.0, with a moderate buffering capacity to acidic discharges, but a poor buffering capacity against alkaline discharges. The river was moderately soft and metal values were generally below working water quality criteria for the protection of aquatic life. However, total copper and total iron values in the three channels did not always meet certain water quality for aquatic life. This is believed to be a natural situation. Dissolved oxygen values in the main river channels were high, while nutrients did not cause nuisance algal growths. Fecal coliform values did not meet criteria for primary-contact recreation such as swimming, but strong currents, low water temperatures and high natural turbidity usually preclude swimming in the river; these activities usually occur on Roberts and Sturgeon Banks, at the site mentioned earlier.

Metal values in fish in the Fraser River remained the same in 1980 as in 1973, or declined from values reported in 1973. Copper values in fish did not appear to be related to anthropogenic activity. Bio-accumulation of certain organic contaminants was related to effluent discharges, but values in fish tissue were generally low.

PROVISIONAL WATER QUALITY OBJECTIVES

A summary of designated water uses and proposed provisional water quality objectives is given in Table 1. Provisional water quality objectives are proposed for the Main Stem, Main Arm and North and Middles Arms of the Fraser River, downstream from Kanaka Creek and for Sturgeon and Roberts Banks. The objectives are based on working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and river flows. The objectives will remain provisional until receiving water monitoring programs provide adequate date and The Ministry has established approved water quality criteria for the characteristics of concern.

The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. For example, they can be used to draw up waste management permits and plans, regulate water use or plan fisheries management. They can also provide a reference against which the state of water quality in a particular water body can be checked.

Water quality objectives have no legal standing and their direct enforcement would not be practical. This would be due to the difficulty of accurately measuring contaminants in receiving water and attributing the contamination exceeding the objective to particular sources for legal purposes and thus of proving violations and their causes. Hence, although water quality objectives should be used when determining effluent permit limits, they should not be incorporated as part of the conditions in a waste management permit.

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 water bodies and for water quality characteristics which may be affected by man's activity, now and in the foreseeable future.

Designated water uses in the Fraser include the protection of aquatic life and wildlife, livestock watering, irrigation and secondary-contact recreation. On Sturgeon Banks, designated uses are aquatic life and wildlife and recreation.

Un-ionized ammonia can be toxic to aquatic life. An objective therefore is proposed for the North, Middle and Main Arms and for Sturgeon Banks, areas receiving treated sewage or overflows which can contain high total ammonia concentrations. As a further aid, an objective for pH is also proposed. The amount of un-ionized ammonia in aqueos solution which can form at a certain temperature and salinity is greatly reduced if the pH is reduced. The working criteria for un-ionized ammonia were based on toxicity to marine organisms, therefore the degree of protection that the proposed objectives will provide to marine species is not known.

Fecal coliform objectives are proposed for the main river channels to permit the water to be used for irrigation from April through October. A much more restrictive objective for bathing beaches on Sturgeon and Roberts Banks is proposed to permit recreation from June through August. Since the sewage treatment plants chlorinate their effluents in the summer to reduce fecal coliforms, an objective is proposed for total chlorine residual to protect aquatic life.

Metals are not of concern in the Main Stem, but some anthropogenic activities can increase copper, lead and zinc levels in the Main and North Arms. Objectives therefore are proposed for these metals, taking into account the hardness of the water and background metal values.

Minimum dissolved oxygen values are proposed as objectives in the main river channels and on the Banks, to protect the migration of salmon. Presently, at certain times of the year, the objective may not be met in the bottom waters in parts of certain sloughs and backwaters.

Objectives are proposed for chlorophenols in the water column, bottom sediments and fish muscle. Chlorophenols enter the river through diffuse sources, often associated with the forest industry. The proposed chlorophenol objective for the sum of tri-, tetra-, and pentachlorophenol in the water column if 0.0002 mg/L, twice the present analytical detection limit, but only one-half the working water quality criterion for pentachlorophenol alone. The proposed objective is deliberately conservative because of the limited information on the toxicity of chlorophenols.

The proposed objective for chlorophenols in fish muscle (0.1 ppm wet weight) is an objective which appears to be met in the North Arm and Main Stem, but may not always be met in the Main Arm in the future. This fact and the general relationship of concentrations in the water column to concentrations in fish muscle, were used to determine the objective, since there are no working criteria for chlorophenols in fish.

Existing levels in certain bottom sediments were used in setting a provisional objective at 10 ppb (dry weight). Levels of this magnitude occur in relatively uncontaminated parts of the Fraser River and other rivers in Canada. At 10 ppb or less in sediments, there should be little tendency for chlorophenols to accumulate in aquatic life.

Polychlorinated biphenyls (PCB's) can enter the river channels through urban stormwater runoff, sewage discharges or from the Belkin paperboard plant on the North Arm. Objectives are therefore proposed to limit a buildup of these substances. The objective of 0.05 ppm (wet weight) in muscle from fish is based upon a recognized working criterion to protect aquatic life. The objective of 30 ppb (dry weight) in sediments has been set to minimize the passage of PCB's along the food web. It is met generally in parts of the river which are relatively uncontaminated by PCB's.

MONITORING RECOMMENDATIONS

Monitoring programs have been proposed in Table 2 to check attainment of the provisional objectives and to develop new objectives. Monitoring to check attainment of the objectives will take place at a practical sampling frequency and at points in the environment where objectives are most likely to be exceeded. Monitoring may need to be increased if it is believed that the objectives are not being attained. New data would be used in the future to finalize provisional objectives, revise objectives or develop new objectives.

The recommended monitoring program is based upon technical considerations. Regional priorities and available funding are factors which could either limit or expand the program.

TABLES

Table 1 Provisional Water Quality Objectives for the Fraser River sub-basin from Kanaka Creek to the mouth

Water Bodies	Fraser River	Sturgeon and

	Main Stem	North and Middle Arms	Main Arm	Roberts Banks
designated water uses	aquatic life, wildlife, recreation, livestock, irrigation	aquatic life, wildlife, recreation, livestock, irrigation	aquatic life, wildlife, recreation, livestock, irrigation	aquatic life, wildlife, recreation
fecal coliforms	less than or equal to 1000 MPN/100 mL geometic mean, April to October; 4000 MPN/100 mL maximum, April to October	less than or equal to 1000 MPN/100 mL geometic mean, April to October; 4000 MPN/100 mL maximum, April to October	less than or equal to 1000 MPN/100 mL geometic mean, April to October; 4000 MPN/100 mL maximum, April to October	less than or equal to 200 MPN/100 mL geometic mean and 400 MPN/100 mL 90th percentile, at bathing beaches, June through August
pH	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	not applicable
dissolved oxygen	7.75 mg/L minimum	7.75 mg/L minimum	7.75 mg/L minimum	9 mg/L minimum
un-ionized ammonia-nitrogen	not applicable	0.03 mg/L maximum; less than 0.007 mg/L mean	0.03 mg/L maximum; less than 0.007 mg/L mean	0.03 mg/L maximum; less than 0.007 mg/L mean
chlorophenols	10 ng/g dry weight maximum in bottom surface sediments 100 ng/g wet weight maximum in fish muscle 0.2 micrograms/L maximum in water	10 ng/g dry weight maximum in bottom surface sediments 100 ng/g wet weight maximum in fish muscle 0.2 micrograms/L maximum in water	10 ng/g dry weight maximum in bottom surface sediments 100 ng/g wet weight maximum in fish muscle 0.2 micrograms/L maximum in water	10 micrograms/g dry weight maximum in bottom surface sediments
PCBs	30 ng/g dry weight maximum in bottom surface sediments 500 ng/g wet weight maximum in fish muscle	30 ng/g dry weight maximum in bottom surface sediments 500 ng/g wet weight maximum in fish muscle	30 ng/g dry weight maximum in bottom surface sediments 500 ng/g wet weight maximum in fish muscle	not applicable
suspended solids	not applicable	10 mg/L maximum increase when u/s is greater than or equal to	not applicable	not applicable

		100 mg/L 10 % maximum increase when u/s is less than or equal to 100 mg/L	
total chlorine residual	not applicable		0.002 mg/L maximum
total lead	not applicable	0.010 mg/L maximum less than or equal to 0.003 mg/L mean	not applicable
total zinc	not applicable	0.10 mg/L maximum less than or equal to 0.05 mg/L mean	not applicable
total copper	not applicable	when hardness is greater than or equal to 35 mg/L 0.006 mg/L maximum less than or equal to 0.004 mg/L mean when hardness is less than 35 mg/L 0.004 mg/L maximum less than or equal to 0.003 mg/L mean or 20% maximum increase whichever is greater	not applicable

Note: The objectives apply to discrete samples from all parts of the water body except from initial dilution zones of effluents. These excluded dilution zones are defined as extending up to 100 m downstream (or upstream at times of tide reversal) from a discharge and occupying no more than 25% percent of the stream width around the discharge point, from the bed of the stream to the surface. These excluded initial dilution zones in marine waters are defined as extending up to 100 m horizontally in all directions, but not to exceed 25% of the width of the waterbody. This exclusion does not apply to objectives for fish as noted below.

1. The fecal coliform geometric mean and 90th percentile are calculated from at least 5

weekly samples taken in a period of 30 days. The recreation objective (200-400/100 mL) applies during the recreation season and the irrigation objective (1000-4000/100 mL) applies during the irrigation season.
2. Since the total chlorine residual objective is less than the minimum detectable concentration, it will be necessary to estimate the receiving water concentration using effluent loading and streamflow. The objective applies only if sewage effluent is chlorinated.
3. The average un-ionized ammonia is calculated from at least 5 weekly samples taken in a period of 30 days.
4. The suspended solids increase in mg/L or % is over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible and applies to downstream levels.
5. pH measurements can be made in-situ but must be confirmed in the laboratory if the objective is exceeded.
6. The term chlorophenol means the sum of tri-, tetra- and pentachlorophenol which may be present in water, sediment or fish.
7. For PCB's and chlorophenols in sediments the maximum value should not be exceeded in bottom sediments taken in any part of the sub-basin, except in initial dilution zones of effluents. The average of at least three replicate samples taken from the same site should be used to check the objective.
8. The PCB's and chlorophenols objectives apply only to fish muscle tissue, not the whole fish or organs of a fish, of any species, caught in any part of the sub-basin, including the initial dilution zones of effluents.
9. The term PCBs applies to the sum of Aroclor 1242, 1254 and 1260 which may be present in water, sediment or fish.

Table 2 Recommended Effluent and Water Quality Monitoring for the Fraser River sub-basin from Kanaka Creek to the mouth

Sites	Frequency and Timing	Characteristics to be Measured
Fraser River at Mission (site 0300006)	**6 times/year every year every ten days in April through June every five years**	**pH; suspended solids; specific conductivity; temperature; dissolved oxygen; nitrate, nitrite, Kjeldahl, total and ammonia-nitrogen; total and total dissolved phosphorus; silica; total copper, mercury and zinc**
Fraser River at Pattullo Bridge (site 0300005), Oak Street	**6 times in December**	**pH; suspended solids; dissolved oxygen; ammonia-nitrogen;**

Bridge (site 0300002) and Deas Island (site 1130102)	through March for one year 2 times in December through March in subsequent years	chlorophenols; fecal coliforms; total copper, lead and zinc
Annacis STP effluent(PE 387), Lulu STP effluent (PE 233)	4 times/year every five years	PAHs; phthalate esters; chlorophenols
Fraser River u/s and d/s from Annacis STP (PE 387), Lulu STP (PE 233) and Langley STP	once/year at low flow	chlorophenols in water, sediments and fish; temperature; pH; fecal coliforms; dissolved oxygen; ammonia nitrogen; total copper, lead and zinc; PCBs in fish and sediments
BC Forest Products effluent (PE2756), Crown Zellerbach effluent (PE 412), Scott Paper effluent (PE 335), MacMillan Bloedel effluent (PE 1664), Belkin Packaging effluent (PE 17)	four times/year every five years	chlorophenols; ammonia and organic nitrogen; total dissolved phosphorus; PCBs (for Belkin Packaging only)
Fraser River u/s and d/s from Belkin Packaging and Scott Paper	once/year at low flow	chlorophenols in water, sediments and fish; temperature; suspended solids; dissolved oxygen; total mercury, copper, lead and zinc; PCBs in fish and sediments
Western Canada Steel effluent (PE 2087), Tree Island Steel effluent (PE 3190), Titan Steel effluent (PE 161)	four times/year every five years	cyanide, phenols
Fraser River u/s and d/s from Western Canada Steel, Titan Steel and Tree Island Steel	once/year at low flow	pH; dissolved copper, lead and zinc
Fraser River at Pattullo Bridge (site 0300005), Ewan Slough	three times/year every year	PCBs and chlorophenols in bottom sediments and fish muscle

(site 1130101), MacDonald Slough (site 1130105), Roberts and Sturgeon Banks		
Fraser River at Pattullo Bridge (site 0300005), Ewan Slough (site 1130101), MacDonald Slough (site 1130105), Roberts and Sturgeon Banks	**once/year every five years**	**chromium, PAHs (fluoranthene), butyl benzyl phthalate and mercury in fish; cadmium, copper, lead, mercury and zinc in invertebrates and sediments; % carbon and particle size distribution in sediments**
Globe West effluent (PE 2071), Canada LaFarge effluent (PE 42), Genstar effluent (PE 4513)	**four times/year every five years**	**total chromium, zinc, phosphorus and dissolved phosphorus**
Borden effluent (PE 1549)	**four times/year every five years**	**total iron, lead, phosphorus and dissolved phosphorus; ammonia, nitrate, nitrite and organic nitrogen**

Note: Sampling may need to be increased to check objectives, depending on circumstances.

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