Water Quality

Ambient Water Quality Objectives For Boundary Bay And Its Tributaries Fraser-Delta Area

Overview Report

Resource Quality Section
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Ministry Of Environment And Parks

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SUMMARY
This report assesses the water quality of Boundary Bay and its major tributaries: the Little Campbell River, the Serpentine River and the Nicomekl River. Provisional water quality objectives are set to protect aquatic life and recreation in Boundary Bay, and aquatic life, wildlife, irrigation and livestock watering in the tributaries.

Boundary bay sustains a crab and herring fishery and the tributaries provide important habitat for steelhead and cutthroat trout and coho and chum salmon.

Ministry of Environment & Climate Change Strategy
Water Protection and Sustainability Branch
Environmental Sustainability and Strategic Policy Division
Mailing Address:
PO Box 9362
Stn Prov Govt
Victoria BC V8W 9M2
Telephone: 250 387-9481
Facsimile: 250 356-1202
Website: www.gov.bc.ca/water

Most of the water contamination comes from diffuse agricultural sources. It has raised levels of nutrients, biochemical oxygen demand and fecal coliforms in the major tributary streams. As a result, oxygen deficiencies have occurred in the streams causing problems for fish, and the water must be completely treated before domestic use. The effect in Boundary Bay is that fecal coliform levels are too high for shellfish harvesting, although the levels are suitable for swimming.

Provisional water quality objectives have been set for nutrients, dissolved oxygen and fecal coliforms. Attainment of these objectives will protect aquatic life and will be one factor enabling shellfish harvesting to return to Boundary Bay. A strategy to identify and to control agricultural sources of contamination will need to be developed to achieve these objectives consistently

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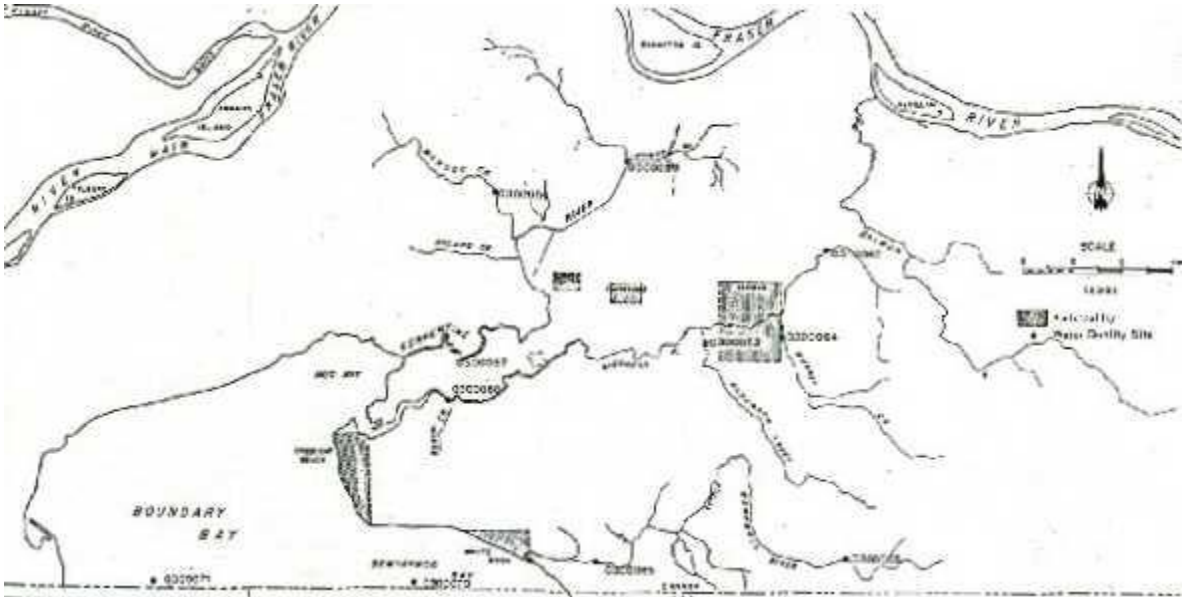
Figure 1. Fraser River Sub-Basin: Boundary Bay and its Tributaries



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 Little Campbell River, Serpentine River, the Nicomekl River and their tributaries and Boundary Bay (Figure attached). For convenience, Boundary Bay is taken here to include Mud Bay and the Canadian portion of Semiahmoo Bay. The review covers water quality and effluent quality data for the period 1972 to 1986. The main purpose of the review was to develop water quality objectives in areas where designated water uses are threatened, either now or in the future, so that these objectives could be used by the Greater Vancouver Regional District in the preparation of their liquid waste management plan. The conclusions in this report are based on a more detailed technical appendix.

The Little Campbell River is approximately 30 km in length and has a drainage area of about 65 km^2. The Nicomekl River is approximately 34 km in length and together with Anderson and Murray Creeks, its major two tributaries, has a drainage area of 149 km^2. The 116 km^2 Serpentine River drainage basin contains the 35 km Serpentine River as well as Latimer, Mahood (Bear) and Hyland Creeks, it main tributaries.

Boundary Bay is located on the south side of the Fraser-Delta area approximately 19 km south from the City of Vancouver. It is 15 km long and 4 km wide and covers an area of about 6085 ha. The Bay is rectangular in shape and faces southeast onto the Straight of Georgia.

HYDROLOGY AND OCEANOGRAPHY

Sufficient flow data were not collected on the Little Campbell River to calculate 7-day average low flows; however the mean daily flow between 1961 and 1964 was 0.94 m^3/s. On the Serpentine River upstream from Mahood Creek, the estimated two-year, 7-day average low flow was 0.057 m^3/s, based upon data from only two partial years. On Mahood (Bear) Creek, the two-year, 7-day low flow was 0.073 m^3/s, while the ten-year, 7-day low flow was 0.0175 m^3/s. Two- and ten-year, 7-day average low flows in the Nicomekl River drainage were 0.24 m^3/s and 0.13 m^3/s on the Nicomekl River; 0.149 m^3/s and 0.13 m^3/s on Anderson Creek and 0.006 m^3/s and 0.001 m^3/s on Murray Creek, respectively.

Water movement within Mud and Boundary Bays is tidally influenced with respect to flushing and velocity. Seasonally, flushing occurs on a daily basis in October and from January to June and twice per day for the remainder of the year. Ebb tides are more concentrated on the eastern side. Water entering Boundary Bay comes from Puget Sound, Drayton Harbour and the Serpentine River, as well as the Strait of Georgia.

WATER USES

The Little Campbell, Serpentine and Nicomekl Rivers and their tributaries provide important spawning and rearing habitat for steelhead and cutthroat trout and coho and chum salmon. The Little Campbell River system ranks fifth or sixth in steelhead angling importance in the Lower Mainland Region. Boundary Bay sustains crab and herring fisheries, is used as a migratory corridor by salmonids to reach spawning areas and in the past has sustained an oyster fishery which had to be closed because of unacceptable bacteriological quality.

Primary-contact (swimming) recreation takes place in the Little Campbell River at one location and at several beaches in Boundary Bay.

Water from the Little Campbell, Serpentine and Nicomekl Rivers and their tributaries is used for irrigation, livestock watering and drinking. For irrigation on a yearly basis, 686 dam^3 is licenced from the Little Campbell River, 2085 dam^3 is licenced from the Serpentine River and 2272 dam^3 is licenced from the Nicomekl River. For drinking water supplies 12.8 m^3/d is licenced from the Little Campbell River, 4.6 m^3/d is licenced from the Serpentine River and 11.4 m^3/d from the Nicomekl River. These waters are not approved by the Ministry of Health as drinking water sources for public water supplies. An alternative source of water exists through the Greater Vancouver Water District should this area approach urban population densities. Livestock watering is a licenced use on the Little Campbell (242 dam^3/year), the Nicomekl (9.8 dam^3/year) and the Serpentine (0.4 dam^3/year) Rivers.

WASTE DISCHARGES

Most of the operations discharging effluents within the Little Campbell drainage basin use soil disposal. This, combined with the small quantities of wastewater involved, makes these discharges of little concern to the water quality within the drainage basin. Exceptions are two feedlot operations which intermittently discharge to tributaries within the drainage basin. An impact on the water quality of one tributary adjacent to one feedlot operation has caused nuisance algal growths in the tributary creek.

No permitted effluent is discharged directly to the Serpentine River; however, untreated cooling water, stormwater and effluent from an iron foundry are discharged to Mahood (Bear) Creek, its major tributary. Treated stormwater runoff from a concrete ready-mix operation is discharged to a second tributary, Hyland Creek. The remaining operations discharge effluent to soil disposal systems. No impact on water quality has been observed; however, it appears from loading calculations that iompacts are possible from PCBs and oil and grease.

In 1984 a fish kill occurred in Highland Creek as the result of a chlorophenol spill. Chlorophenols are not discharged normally into the Serpentine River or its tributaries. The 1984 spill was an isolated incident and there was no lasting impact on the Serpentine River system.

Discharges of most effluents within the Nicomekl drainage basin have not been observed to impact the river. These discharges include several soil disposal systems. Leachate from one landfill operation has severely impacted a tributary used for spawning and caused fungal growths in the Nicomekl River itself.

Sewage pump stations in White Rock were connected to the Greater Vancouver Sewage and Drainage District (GVS and DD) in 1977. Pump stations near Cresent Beach can overflow during power or pump failures. The Semiahmoo Indian Band reserve was unsewered in 1977 with possible septic tank seepage occurring at three residences. This area remains unsewered. There are no permits to discharge wastes into Boundary Bay.

Diffuse agricultural sources can influence ammonia, phosphorus, BOD_5 and fecal coliform concentrations in the Little Campbell, Serpentine and Nicomekl Rivers and their tributaries. This is probably the most notable influence on water quality, other than urban stormwater runoff, within these water sheds. Other factors related to water quality are floodgates to prevent outward flow of the rivers at high tides.

There are no houseboat communities in Mud Bay or Boundary Bay. Sewage from Cresent Beach Marina in Surrey is sent via a sanitary sewer to the Annacis Island Sewage Treatment Facility. Sewage from the marina at the mouth of the Nicomekl River also goes to this facility.

WATER QUALITY

Water quality for the period of record throughout the Little Campbell River was characteriuzed by low metal and ammonia-nitrogen values and moderate to low buffering to acidic discharges. The water is usually moderately soft. Nitrate-nitrogen and phosphorus concentrations were elevated during periods of low flow and high temperature. These can lead to excessive algal growths. Dissolved oxygen values were low and percent saturation varied widely in certain reaches, providing a low level of protection to mature salmonids and still less protection for egg-to-juvenile stages. Bacteriological quality, in terms of fecal coliform concentrations, was generally poor throughout the system.

The pH in the Serpentine river can vary by as much as 3.0 pH units from minimum to maximum. Alkalinity values can be from moderate to low and the water would be classed as soft. Some high metal values for total aluminum, copper, lead, iron, manganese and zinc have been measured but are thought to be either naturally occurring or possibly due to stormwater. If phosphorus is the limiting factor values were high enough to cause algal blooms. Ammonia and nitrite toxicity are thought not to be a concern. Large variations occurred in dissolved oxygen and percent saturation values, likely due to algal respiration. These variations are sufficient to put aquatic life under severe stress with low dissolved oxygen concentrations providing a low level of protection to mature salmonids. Oxygen-consuming materials also exert a demand for oxygen. Fecal coliform values were high. Dissolved solids reflected the influence of saltwater intrusion near the mouth but were not so high in the upper reaches as to restrict and water uses.

The Nicomekl River basin has naturally high pH and is well buffered to acidic inputs. Some higher metal values were recorded but these were likely naturally occurring. High lead values may originate from stormwater discharges. Ammonia and nitrite values met criteria to protect aquatic life. High levels of phosphorus and oxygen-consuming materials are believed to be responsible for low dissolved oxygen

levels and wide fluctuations in percent saturation values. This situation occurs because phosphorus promotes algal growth which, in turn, due to photosynthesis, respiration and decay, can cause either a depletion or excess in dissolved oxygen concentrations. These effects were not as pronounced in two tributary creeks, Murray and Anderson, or the headwaters of the Nicomekl River, as they were in the majority of the Nicomekl River. Fecal coliform levels were hiogh. High dissolved solids near the mouth of the Nicomekl River reflect saltwater intrusion.

Water quality in Boundary Bay was generally consistent for the period of record. Data for pH, nutrients and most metals were within the range to protect marine aquatic life. Values for copper, lead, mercury and zinc occasionally exceeded working criteria; these may be either natural background levels in Boundary Bay or may originate from surface runoff from the City of White Rock or sewage discharges and surface runoff from Blaine or Drayton Harbour. Dissolved oxygen levels were sufficient to support marine life. Fecal coliforms were too high to permit the harvesting of shellfish but were within current standards to permit use of the Bay for swimming.

PROVISIONAL WATER QUALITY OBJECTIVES

A summary of designated water uses and proposed provisional water quality objectives in given in Table 1. Provisional water quality objectives are proposed for the Little Campbell River, the Serpentine River, the Nicomekle River and their tributaries, and Boundary Bay. The objectives are based on approved Ministry criteria as well as preliminary working criteria foer water quality and on available data on ambient water quality, waste discharges, water uses and river flows. The objectives will renmain provisional until receiving water monitoring programs provide adequate data, and the Ministry has established approved water quality criteria for all the characteristics of concern.

Water quality objectives have no legal standing and would not be directly enforced. The objectives ares policy guidelines for resource managers to protect water uses in the specified water bodies.They will guide the evaluation of water quality, the issuing of permits, licences and orders and the management of the fisheries and of the Province's land base.They 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.

Designated water uses, including protection of aquatic life and wildlife, drinking water (complete treatment), irrigation and livestock watering are proposed for the Little Campbell, Serpentine and Nicomekl River basins. The drinking water use is not designated fo tributaries of the Serpentine River. Primary-contact recreation is proposed in addition for the Little Cambell River as well as for Boundary Bay where the protection of aquatic life and wildlife is also a designated use.

Ammonia can be toxic to aquatic life. Objectives therefore are proposed for the Little Campbell, Serpentine and Nicomekl River drainage basins since ammonia nitrogen can enter all three systems from agricultural operations (Table 2 and Table 3). The proposed objectives were met. Corresponding

objectives for nitrite are proposed, since the incomplete oxidation of ammonia can produce toxic concentrations of nitrite (Table 4).

The proportion of ammonia that is toxic in aqueous solution is a function of the corresponding specific conductivity, temperature and pH. Therefore a pH objective is also proposed for these water bodies. A lower maximum pH is proposed for the Little Campbell River, as well as for the Serpentine and Nicomekl Rivers and Murray and Anderson Creeks, since the background pH is lower in these streams, and the amount of ammonia toxicity is greatly reduced at lower pH values.

Fecal coliform objectives are proposed to protect bathing beaches in Boundary Bay and the Little Campbell River from April through October and to maintain existing conditions in Mahood, Hyland and Latimer Creeks. These proposed objectives were usually met. A less stringent objective is proposed for the Serpentine and Nicomekl Rivers and Anderson and Murray Creeks to maintain existing conditions and to protect irrigation water supplies. A more stringent long-term objective is proposed for all the freshwater bodies to upgrade their quality to meet higher irrigation standards for crops eaten raw. Such improvements would also help to achieve the long-term objective for fecal coliforms in Boundary Bay which, if met, would permit shellfish harvesting to take place once again. This assumes the habitat is still suitable for shellfish growth. Consideration could be given to controlled commercial harvesting which would be subject to controlled purification requirements and/or eventual "conditional openings" of the area at certain times of the year as bacteriological quality improves.

Objectives have been proposed in all the water bodies for suspended solids to prevent possible physical damage to aquatic life. As well an objective for substrate sedimentation is also proposed to protect spawning beds. Objectives for turbidity are meant to address the effect of light attenuation on aquatic life.

Peripyton chlorophyll-*a* objecxtives have been proposed to control algal growth so that excessive growth will not occur which would impair use. Although measurements have not been made, it is suspected that the proposed objective will not be met since large fluctuations in dissolved oxygen levels would appear to indicate problems with algal growths. Therefore, the objective for chlorophyll-*a* may have to be a long-term objective which will require action to eliminate nutrient sources.

Two different objectives are proposed for dissolved oxygen in the freshwater tributaries to Boundary Bay to protect spawning and rearing habitats for trout and salmon. Each objective is dependent upon the life stage (*e.g.*, egg, alevin or fry) of the affected fish. In addition, in order to upgrade dissolved oxygen levels, a long-term minimum value is proposed which is higher than can be presently achieved; however, a second long-term objective is proposed to improve levels in the Bay.

An objective for total lead is proposed for the Nicomekl River, due to the concern for inputs of stormwater from Langley.

Objectives for PCBs are proposed in the water column, bottom surface sediments and fish in Mahood Creek and the Serpentine River since PCBs can potentially be discharged from a BC Hydro Facility. An objective for PCBs is proposed for sediments in Boundary Bay since these contaminants may settle in the Bay.

Should a development be proposed in the future for any of these watersheds where provisional objectives do not exist for characteristics of concern, the designated water uses should be protected while objectives are developed for these characterictics.

MONITORING RECOMMENDATIONS

Several monitoring programs have been proposed (Table 5), some dealing with verifying achievement of the proposed water quality objectives and others to aid in the development of further objectives. Appropriate monitoring of waste discharges should be conducted at the same time as receiving water monitoring. The recommended monitoring is based upoin technical considerations, and actual programs will depend on budget allocations and project priorities.

TABLES

Table 1 Provisional Water Quality Objectives for the Little Campbell River, Nicomekl River, Serpentine River, their tributaries and Boundary Bay

Water Bodies	Little Campbell River (and tributaries)	Mahood, Hyland and Latimer Creeks	Serpentine River	Nicomekl River	Anderson and Murray Creeks	Boundary Bay
Designated Water Uses	aquatic life, wildlife, irrigation, livestock watering, primary-contact recreation	aquatic life, wildlife, irrigation, livestock watering	aquatic life, wildlife, irrigation, livestock watering	aquatic life, wildlife, irrigation, livestock watering	aquatic life, wildlife, irrigation, livestock watering	aquatic life, wildlife, primary-contact recreation
fecal coliforms	less than or equal to 200 MPN/100 mL as a geometric mean from April to October less than or equal to 400 MPN/100 mL as a 90th	less than or equal to 1000 MPN/100 mL as a geometric mean from April to October less than or equal to 4000 MPN/100 mL as a maximum from April to October				less than or equal to 200 MPN/100 mL as a geometric mean from April to October less than or equal to 400 MPN/100 mL as a

	percentile from April to October			**90th percentile from April to October**
fecal coliforms	**not applicable**	**less than or equal to 200 MPN/100 mL as a geometric mean year round (long-term objective)**		**less than or equal to 14 MPN/100 mL as a median year round (long-term objective) less than or equal to 43 MPN/100 mL as a 90th percentile year round (long-term objective)**
Suspended solids	**10 mg/L maximum increase when upstream values are less than or equal to 100 mg/L 10% maximum increase when upstream values exceed 100 mg/L**			
Substrate sedimentation	**no significant increase (95% confidence level) by weight in particulate matter for particles up to 3 mm in diameter**			
Turbidity	**5 NTU maximum increase when upstream values are less than or equal to 50 NTU 10% maximum increase when upstream values exceed 50 NTU**			
Ammonia-nitrogen, total	**Maximum Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life. Average 30-day Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life.**			**not applicable**
Nitrite-nitrogen	**Maximum and 30-day average Allowable Nitrite (N) Concentration**			**not applicable**
periphyton	**50**	**100 mg/m^2 maximum**	**100 mg/m^2 maximum**	**not**

chlorophyll-a	mg/m^{2}maximum average	average (long-term objective)		average	applicable
Oxygen, dissolved	6.0 mg/L minimum June to October	8.0 mg/L minimum	6.0 mg/L minimum June to October	8.0 mg/L minimum	6.5 mg/L minimum 9.0 mg/L minimum as a long-term objective
	8.0 mg/L minimum June to October long-term objective	not applicable	8.0 mg/L minimum June to October long-term objective	not applicable	
	11.0 mg/L minimum when salmonid eggs, larvae or alevin are present				
pH	6.5 to 8.5	6.5 to 8.5 or 0.2 maximum increase when u/s is less than 8.5			not applicable
Lead, total	not applicable		0.005 mg/L average 0.010 mg/L maximum	not applicable	
PCBs	not applicable	0.001 micrograms/L maximum in water 0.03 micrograms/g dry weight maximum in bottom surface sediments 0.1 micrograms/g wet weight in whole small fish subject to predation 0.5 micrograms/g wet weight in muscle of larger fish eaten by man	not applicable		0.03 micrograms/g dry weight maximum in bottom surface sediments

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 from the discharge point and no more than 50 percent across the width of the stream, from the surface to the bottom. These excluded dilution zones in the Bay are defined as extending up to 100 m horizontally in all directions and not to exceed more than 25 percent of the width of the waterbody.
1. The fecal coliform geometric mean, median and 90th percentile are calculated from at least 5 samples taken weekly in a period of 30 days. The recreation objective (200-400/100 mL) applies during the recreation season and the irrigation objectives (1000-4000/100 mL) applies during the irrigation season.
2. The increase (in NTU, mg/L or %) for turbidity and suspended solids, is over levels measured at a site u/s from a discharge or series of discharges and as close to them as possible, and applies to d/s levels. In Boundary Bay control samples should be obtained from areas of similar physical characteristics to those areas where measurements near a discharge are to be made.
3. The periphyton chlorophyl-a average is calculated from at least 5 randomly located samples taken from natural substrates at each site on any one sampling date.
4. pH measurements may be made in-situ but must be confirmed in the laboratory if the objective is exceeded.
5. The total lead is calculated from at least 5 weekly samples taken in a period of 30 days.
6. PCB objectives do not apply to Hyland or Latimer Creeks. The term PCBs applies to the sum of Aroclor 1242, 1254 and 1260 which may be present in water, sediment or fish. The maximum value should not be exceeded in bottom surface sediments taken in any part of the sub-basin, except in the initial dilution zones of effluents. The average of at least three replicate sediment samples taken from the same site should be used to check the objectives. Also, the objective applies to fish of any species caught in any part of the creeks or river, including the initial dilution zones of effluents.

Table 5 Recommended Effluent and Water Quality Monitoring for Boundary Bay and its Tributaries

Sites	Frequency and Timing	Characteristics to be Measured
Little Campbell River (sites 0300065 and 0300066)	**five samples in a 30-day period June to September and November to January**	**dissolved oxygen, pH, temperature, specific conductivity, ammonia-N, nitrite-N, nitrate-N, dissolved**
Nicomekl River (sites 0300060 and 0300062)		

Anderson Creek (site 0300063)		**orthophosphorus, total ophosphorus, fecal coliforms, turbidity, suspended sediments, substrate sedimentation, dissolved solids, periphyton chlorophyll-*a*, dissolved and total copper, iron, manganese and lead.**
Murray Creek (site 0300064)		
Latimer and Hyland Creeks near the mouth		
Serpentine River (sites 0300057 and 0300059)		**dissolved oxygen, pH, temperature, specific conductivity, ammonia-N, nitrite-N, nitrate-N, dissolved orthophosphorus, total ophosphorus, fecal coliforms, turbidity, suspended sediments, substrate sedimentation, dissolved solids, periphyton chlorophyll-*a*, dissolved and total copper, iron, manganese and lead, PCBs.**
Mahood Creek (site 0300056)		
Little Campbell, Nicomekl and Serpentine Rivers (sites to be determined)	**once per year timing to be determined**	**determine impact of land use on water quality in the river basins characteristics to be determined**
Mahood Creek (sites to be determined)	**once, timing to be determined**	**determine if the discharges from two foundaries are significantly affecting water quality**
Boundary Bay (sites 0300070 and 0300071d)	**5 samples in a 30-day period**	**dissolved oxygen, fecal coliforms and PCBs in sediments**

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

L. G. Swain, P.Eng.
G. B. Holms
Resource Quality Section
Water Management Branch
Ministry of Environment and Parks