MINISTRY OF ENVIRONMENT

PROVINCE OF BRITISH COLUMBIA

SHUSWAP-MABEL AREA

BESSETTE CREEK

WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

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1. INTRODUCTION

1.1 BACKGROUND

The Ministry of Environment is preparing water quality assessments and objectives for priority water bodies. This report describes the water quality of Bessette Creek, a tributary to the Shuswap River (Figures 1 and 2). The main purpose of this review was to develop provisional water quality objectives for use by resource managers. Presented within this report are data collected to the end of 1989.

1.2 PROVISIONAL WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are established in British Columbia for water bodies on a site-specific basis [(1)]. The objective can be a physical, chemical, or biological characteristic of water, biota, or sediment, which will protect the most sensitive designated water use at a specific location with an adequate degree of safety [(1)]. The objectives are aimed at protecting the most sensitive designated water use with due regard to ambient water quality, aquatic life, waste discharges, and socio-economic factors [(1)].

Water quality objectives are based upon approved or working water quality criteria which are characteristics of water, biota, or sediment[1] that should not be exceeded to prevent specified detrimental effects from occurring to a water use [(1)]. The working criteria upon which many of the proposed provisional objectives are based come from the literature, and are referenced in the following chapters. The B.C. Ministry of Environment is in the process of developing approved criteria for water quality characteristics, applicable province-wide, to form part of the basis for permanent objectives.

As a general rule, objectives are only set in water bodies where man-made influences threaten a designated water use, either now or in the future. Provisional objectives are proposed in this report, and are to be reviewed as more monitoring information becomes available and as the Ministry of Environment establishes approved water quality criteria.

The provisional objectives take into account the existing and potential use of the water to be protected and the existing water quality. They allow for changes from background which can be tolerated, or for upgrading which may be required. Any change from background which is allowed indicates that some waste assimilative capacity can be used while still maintaining a good margin of safety to protect designated water uses. In cases of water quality degradation, objectives will set a goal for corrective measures.

The objectives do not apply to initial dilution zones of effluents. These zones in rivers are defined as extending up to 100 m downstream from a discharge, and occupying no more than 50 percent of the width of the river, from its bed to the surface. In lakes, initial dilution zones are defined as extending up to 100 m horizontally in all directions from the discharge, but not to exceed 25% of the width of the water body.

In cases where there are many effluents discharged, there could be some concern about the additive effect of dilution zones in which water quality objectives may be exceeded. Permits issued pursuant to the Waste Management Act control effluent quality which in turn determines the extent of the initial dilution zones and the severity of conditions within them. In practice, small volume discharges or discharges with low levels of contaminants will require mixing zones much smaller than the maximum dilution zone allowed. The concentrations of contaminants permitted in effluents are to be such that levels in the dilution zones will not be acutely toxic to aquatic life or create objectionable or nuisance conditions. Processes such as chemical changes, adsorption and microbiological action, as well as dilution, take place in these zones to aid in the achievement of water quality objectives at their border.

Some of the data summarized are given as mean values, but often with median values. The reason for this apparent inconsistency is that many data were collected over long time periods during which many detection limits may have existed. The author has used whichever statistic has more meaning. Median values are always reported for coliforms and pH.

1.3 DESCRIPTION OF WATER COURSES

Bessette Creek is formed by the joining of Harris and Duteau creeks near the town of Lumby (Figure 2). Harris Creek flows in a northerly direction, and is joined just south from Lumby by Duteau Creek from the west. Once north from Lumby, Bessette Creek flows easterly until it meets the Shuswap River, to which it is a major tributary.

Upstream from Lumby, Harris and Duteau creeks and their tributaries, Spider and Creighton creeks, but not Lawson Creek, generally flow through forested mountain areas. Some reaches remain in fairly natural condition although several headwater tributaries have been dammed, and many sections have undergone channelization, bank stabilization, and shade tree removal. Lawson Creek flows through agricultural and industrialized areas.

Just south from Lumby, Harris Creek descends to a valley through which it flows to its confluence with Duteau Creek, the combined flow being Bessette Creek. Creighton Creek is a tributary which enters Harris Creek from the east.

Bessette Creek flows in a northerly direction prior to flowing easterly to its confluence with the Shuswap River. Approximately four kilometres north from Lumby, Vance Creek, a tributary from the west meets Bessette Creek. Vance Creek has a drainage area of about 75 km^2. The valley through which Bessette Creek flows is used mainly for agriculture. Bessette Creek has a drainage area of about 600 km^2 at its confluence with the Shuswap River.

Bessette Creek has rock or gravel substrata from the headwaters to the mouth, and provides good habitat for salmonid fish as well as for "clean water" benthic invertebrates such as mayflies, stoneflies, and caddisflies.

2. HYDROLOGY

Flows for most of the creeks described in this technical appendix are regulated, so that frequency analysis cannot be performed. It is also difficult to discuss flow regimes. However, seasonal cycles still occur. Natural flows would likely have seen freshet occur during spring snowmelt and with flows typically diminishing during the hot summer months.

Flows in Harris Creek have been measured at station 08LC005 located upstream from Lumby and the confluence of Duteau Creek. (There is some confusion about where Bessette Creek begins and Harris Creek terminates. For the purpose of this assessment, Bessette Creek has been established as the water body formed in Lumby downstream from the Duteau Creek confluence. Flow station 08LC005 is cited in the literature as being on Bessette Creek.) The drainage area to station 08LC005 is 253 km^2.

Station 08LC042 is located on Bessette Creek just downstream from Lumby, with a drainage area of 469 km^2. Station 08LC039 is located near the mouth of Bessette Creek, with a drainage area of 603 km^2.

Seven-day low flows for 25 years of records have ranged from 0.010 to 0.772 $m^3\ s^{-1}$ at station 08LC005 on Harris Creek (mean: 0.111 $m^3\ s^{-1}$); for 15 years of records, seven-day low flows were from 0.195 to 0.747 $m^3\ s^{-1}$ at station 08LC042 on Bessette Creek (mean: 0.350 $m^3\ s^{-1}$); while for 11 years of complete records, seven-day low flows at station 08LC039 were from 0.275 to 1.07 $m^3\ s^{-1}$ (mean: 0.490 $m^3\ s^{-1}$).

Flows (natural) have been measured in Vance Creek, at a station (08LC040) (75 km^2) located about four kilometres north from Lumby. Seven-day low flows at this station have been from 0.020 to 0.111 $m^3\ s^{-1}$, with a mean flow of 0.068 $m^3\ s^{-1}$. Flows (natural) have been measured in Creighton Creek, at a station (08LC033) (38 km^2) located about eight kilometres upstream from its confluence with Harris Creek. Flow records at this station are not available for a complete calender year for the period 1959 to 1965 when records were kept. Mean monthly flows were from 0.098 to 1.09 $m^3\ s^{-1}$.

Flows have also been measured in Duteau Creek at station 08LC006, above its confluence with Spider Creek. (The drainage area for this station has not been recorded). Seven-day low flows at this station for 48 years of records have ranged from 0.000 to 2.02 $m^3\ s^{-1}$ with a mean of 0.079 $m^3\ s^{-1}$.

3. WATER USES

The following will detail water uses in Bessette Creek and its major tributaries: Duteau, Spider, Lawson, Vance, and Harris creeks.

3.1 BESSETTE CREEK

Consumptive water uses are two licensed water withdrawals for 6.8 $m^3\ d^{-1}$ for domestic consumption (including stockwatering) and 15 withdrawals for 1 162 $dam^3\ a^{-1}$ for irrigation.

Bessette Creek provides the necessary habitat for four fish species of economic importance: rainbow trout, kokanee, chinook salmon, and coho salmon. The annual value of the salmon produced from Bessette Creek stocks is approximately $200 000, and the value of rainbow trout exceeds $1 000 000 per year.

Kokanee from Mabel Lake migrate up the Shuswap River to Bessette Creek in October and spawn in a six kilometre reach just upstream from its confluence with the Shuswap River. The young fry emerge in April and May and migrate to Mabel Lake. Rainbow trout spawn in Bessette Creek in April and May, with many of the young trout remaining in the creek for several years, or for life. Bessette Creek provides most of the rainbow trout stock for Mabel Lake.

Bessette Creek also has important runs of chinook and coho salmon. The following was the average yearly escapement for the corresponding time periods :

	Chinook	Coho
1962-1969	13	1 225
1970-1978	18	733

The adult salmon deposit their eggs from August to November and the young emerge from the gravel in April and May. Many of the young spend at least one year growing in Bessette Creek.

3.2 DUTEAU CREEK

Consumptive water uses in Duteau Creek are two licensed water withdrawals for domestic consumption for 6.8 m^3 d^{-1}, six licensed water withdrawals for 22 480 dam^3 a^{-1} for irrigation, and six withdrawals for 10.4 dam^3 d^{-1} for waterworks which could include irrigation.

Coho salmon utilize Duteau Creek from its confluence with Harris Creek to a distance upstream of about 10 km . In 1978, there were erratic flow fluctuations due to a dam operated by the Vernon Irrigation District (VID). Therefore, an agreement was reached between the VID and the Department of Fisheries and Oceans to establish minimum flows to satisfy fisheries requirements. Brown *et al*.(2) noted that heavy agricultural use of the land around the creek had resulted in the breakdown and erosion of banks along the creek.

Prior to 1976, fish escapements were included with those for Bessette Creek. In 1976, 1977, and 1978, 325, 94, and 400 coho salmon were recorded, respectively.

3.3 SPIDER CREEK

Spider Creek enters Lawson Creek just above its confluence with Duteau Creek. Consumptive water uses for Spider Creek are four licensed water withdrawals for 18.2 $m^3\ d^{-1}$ for domestic water use, including stockwatering, one withdrawal for 1.3 $dam^3\ a^{-1}$ for irrigation, and one withdrawal for 2.28 $m^3\ d^{-1}$ for industrial use by Riverside Forest Products.

There are no records of salmon escapements to Spider Creek; however, it does provide spawning habitat.

3.4 LAWSON CREEK

Lawson Creek is a tributary to Duteau Creek. There are only three licensed water withdrawals on Lawson Creek. Two are for 9.1 $m^3\ d^{-1}$ for domestic use and one for 4.5 $m^3\ d^{-1}$ for industrial use by Riverside Forest Products.

There are no records of salmon escapements to Lawson Creek; however, Lawson Creek has high fisheries values for spawning habitat.

3.5 HARRIS CREEK

Consumptive water uses are six withdrawals for domestic consumption for 10.3 $m^3\ d^{-1}$ and 23 withdrawals for irrigation for 1031 $dam^3\ a^{-1}$. The Village of Lumby maintains a series of infiltration wells adjacent to Harris Creek, which were flooded in the Spring of 1990. These wells are the main water supply for the Village of Lumby.

Harris Creek is considered to have high fisheries resource values, particularly for spawning habitat. Salmon escapements to Harris Creek were included with those for Bessette Creek until 1976. In 1976, 1977, and 1978, there were 105, none observed, and 150 coho salmon, respectively. Coho salmon utilize the reach from its confluence with Duteau Creek upstream for four kilometres, arriving between mid-October and the end of December [(2)]. Brown et al. noted that the creek was suffering from the input of mill debris and agricultural encroachment[(2)].

3.6 Creighton Creek

On Creighton Creek, there are 15 withdrawals for domestic consumption for 55 m^3 d^{-1} and 22 withdrawals for irrigation for 169 dam^3 a^{-1}.

Two irrigation weirs are located on Creighton Creek, 0.8 and 4 km upstream from the mouth. These weirs made it impossible for fish to migrate upstream until the lower weir was removed in 1984. Coho salmon now spawn in the lower 4 km reach. The mean annual escapements of coho were 27 for the period 1971 to 1980 (maximum 50) and 34 for the period 1980 to 1984. Spawning occurs from October through December.

3.7 VANCE CREEK

Consumptive water uses are eight water withdrawals for domestic consumption for 29.5 m^3 d^{-1} and ten withdrawals for irrigation for 562.5 dam^3 a^{-1}.

Salmon do not utilize Vance Creek.

4. PERMITTED WASTE DISCHARGES

Permitted waste discharges can be located on Figure 2 by their permit numbers.

4.1 Corporation of the Village of Lumby (PE 173)

The Village of Lumby operates an aerated lagoon system for treatment of municipal waste water. Sewage is treated in an aerated cell with a capacity of 12 300 m^3 from where it flows to a second cell with a capacity of 42 300 m^3. Effluent from this cell is chlorinated, and is discharged to a third cell with a capacity of 74 100 m^3. This last cell serves as a storage/dechlorination chamber.

Waste Management permit PE 173 allows for the discharge of treated effluent from the third cell to Bessette Creek as follows:

June 15-October 2	Zero discharge
October 3-April 14	455 m^3 d^{-1} maximum
April 15-June 14	1 640 m^3 d^{-1} maximum

Other requirements of the permit are that the maximum BOD_5 should be 45 mg L^{-1} and the maximum suspended solids concentration 60 mg L^{-1}.

There are no data on effluent quality since there has been no overflow from the lagoon system due to wastewater exfiltrating from the ponds. Since the treated sewage is filtered in this exfiltration process, suspended solids should not be elevated, and much of the nutrients and biochemical oxygen demand should be eliminated. This should result in very little impact being seen in the creek.

Data have been collected in Bessette Creek both upstream and downstream from the sewage lagoons at Sites 0500293 (U/S) and 0500697 (D/S), respectively. Coincident measurements (mg L^{-1}) made at the two sites were as follows:

	Diss. Oxygen		Nitrate		Organic N.		Ammonia	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
80.07.03	9.6	10.1	-	-	-	-	-	-
80.10.01	12.2	11.8	-	-	-	-	-	-
81.06.11	11.2	11.7	0.02	0.04	0.29	0.33	<0.005	0.008
81.11.03	11.2	11.2	0.05	0.06	0.15	0.19	0.005	0.016
89.10.18	-	-	-	-	-	-	<0.005	0.008

	Diss. Phos.		Total Phos.	
	U/S	D/S	U/S	D/S
80.03.20	-	-	0.075	0.115
80.07.03	-	-	0.028	0.030
80.10.01	-	-	0.043	0.032
81.06.11	0.026	0.034	0.107	0.150
81.11.03	0.021	0.025	0.027	0.029
89.10.18	0.013	0.021	0.019	0.026
89.11.23	0.018	0.036	0.023	0.042

These data indicate that the exfiltration from the lagoon is increasing concentrations of nitrogen and phosphorus in a downstream direction from the lagoon on most occasions. However, many of the data are quite old and the downstream site is about four kilometres downstream from the lagoons, so that a definitive conclusion as to the exact cause of these increases cannot be made. Dissolved oxygen concentrations did not appear to be impacted by the exfiltrate from the lagoons in 1980-1981.

4.2 <u>Riverside Forest Products</u> (PR 4542, PR 7046)

This company operates a sawmill/veneer plant with an associated landfill operation which is located approximately 4 km west from Lumby. The sawmill landfill site (PR 4542) is bordered on the west by Spider Creek (which has been diverted around the sawmill property).

Waste products which are sent to the landfill include logs, limbs, and bark. Waste Management permit PR 4542 allows the discharge of 7.6 m^3 of material per day to the landfill.

The company also operates a second landfill (also just for wood products) adjacent to the first and bordered on the north by Lawson Creek. Waste Management permit PR 7046 allows the disposal of an average of 12 m^3 d^{-1} and a total annual discharge of 3 060 m^3.

Sites 0500643 (U/S) and 0500644 (D/S) are located upstream and downstream, respectively, from the landfill (PR 4052) adjacent to Spider Creek. Samples have only been collected twice, in April 1986 and December, 1987. Increases in concentrations were as follows:

	Spec.Cond. uS cm^{-1}		Chloride mg L^{-1}		Ammonia mg L^{-1}		NO2/NO3 mg L^{-1}		Potassium mg L^{-1}	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
86.04.17	456	490	1.3	2.1	<0.005	<0.005	<0.02	<0.02	4.6	5.0
87.12.09	722	890	2.2	9.5	0.011	0.022	0.14	0.23	8.0	8.6

Leachate from the landfill would appear to be increasing dissolved solids and nitrogen constituents in Spider Creek. Acidity was also measured at both sites in December 1987, and increased from 0.002 mg L^{-1} to 30.3 mg L^{-1}.

Changes, mostly decreases were also noted as follows:

	pH		Diss. Phosphorus		Total Phosphorus	
			mg L^{-1}			
	U/S	D/S	U/S	D/S	U/S	D/S
86.04.17	8.3	8.0	0.043	0.047	0.068	0.071
87.12.09	8.2	7.5	0.078	0.044	0.115	0.085

The increased acidity associated with the December 1987 sample would explain why the pH has declined; however, the reason for the decrease in phosphorus concentration is unknown.

Samples have been collected on Lawson Creek at two sites, 0500645 upstream (U/S) from the landfill (PR 7046), and Site 0500646 (D/S) downstream from the landfill and just upstream from the confluence with Duteau Creek. In between these two sites, Spider Creek enters Lawson Creek which then flows through a marsh area receiving groundwater releases at a number of points. A number of data have been collected at these sites throughout the years; however, for the purposes of this assessment, only data collected since about 1985 will be used in order that recent impacts from the refuse sites can be assessed. The use of older data may indicate a problem which existed in the past but has since been corrected.

	pH		Susp.Solids		Sp.Cond.		Acidity		Chloride	
			mg L^{-1}		uS cm^{-1}		mg L^{-1}			
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
86.04.17	7.7	7.7	-	-	893	712	-	-	4.1	4.5
87.12.09	7.3	7.6	-	-	660	710	21.1	14.3	4.6	6.0
89.10.18	8.1	8.2	1	4	580	640	-	-	5.4	8.6
90.01.30	7.8	7.9	11	13	760	770	-	-	41.5	39.9

These data indicate that, between these two sites, there is an apparent decrease in acidity on a day when the pH increased by 0.3 units, contrary to what would be expected if Site 0500646 is a representative site to note impacts from the landfill. Three of four specific conductivity values increased, as would be expected.

4.3 <u>Leo and Gabrielle Headington</u> (PR 5513)

This couple own the property to which the Weyerhauser Canada Ltd. sawmill discharged typical log yard refuse from 1979 to 1985. Waste Management permit PR 5513 (cancelled in 1988) allowed the discharge of 23 m^3 d^{-1} of material to the site. The site is located about 30 m west from Harris Creek. A ditch to the south of the landfill collects leachate and discharges to Harris Creek.

Data have been collected in the period 1980 to 1983 in Harris Creek at locations upstream (Site 0500731) and downstream (0500732) from this landfill. The data for both sites are summarized in Tables 10 and 11. Values going from upstream to downstream did not show a significant change.

4.4 <u>Corporation of the Village of Lumby</u> (PE 7042)

The Village of Lumby has a Waste Management permit (PE 7042) for a stormwater drain into which Weyerhauser Canada Ltd. discharges runoff from its sawmill operation. The storm drain discharges to Harris Creek and is located south of the railway tracks and west from Harris Creek.

Weyerhauser operates a pre-discharge grit chamber and oil separator to treat runoff from its property since approximately 95 % of the discharge originates from its sawmill operation.

Sediment samples collected in February 1990 by the Department of Fisheries and Oceans from the stormwater ditch just prior to it entering Harris Creek contained 0.0173 ug g^{-1} tetrachlorophenol and 0.0645 ug g^{-1} pentachlorophenol. The impact from this discharge is discussed in Section 4.5, since the discharge occurs immediately upstream from the Bell Pole property.

4.5 Bell Pole

Bell Pole has operated a pole plant (telephone type) /chlorophenate thermal wood preserving plant in Lumby at its east yard, just north and west from Harris Creek, since 1968. Bell Pole operated a pole treatment plant in its west yard using creosote from 1931 to 1971.

Pentachlorophenol treatment of poles in the east yard involves successive hot and cold treatment of the poles. Treatment occurs in open metal tanks in the ground which have concrete secondary containment. The metal treatment tank is separated from the concrete wall by a sand layer.

The operation does not have a Waste Management permit for wastewater discharges since there is no direct discharge of waste water to the environment, per se. However, the company does hold a permit for air emissions (PA 1990). There is evidence of groundwater and soil contamination with chlorophenols. The high groundwater levels in the area allow water to seep into the secondary containment pits through cracks in the concrete. Vapourization of water in the treatment oil allows occasional foaming of treatment solutions and the escape from the treatment tanks. Groundwater migrates south and east and discharges to Harris Creek to the southeast from the treating area[3]. Stormwater runoff from the process area and treated pole storage yard is not contained or collected.

Contaminated water from the tank area is pumped to a holding tank to separate entrained oil, then to two-1.0 m^3 filtration units consisting of layers of bark, sawdust, and fiberglass, and finally through a 0.2 m^3 drum with activated carbon and fiberglass. Effluent from the filtration unit is discharged to the ground, under a Waste Management Approval. Contaminated sawdust and bark are burned on-site weekly.

Soil samples taken in the treating area had concentrations of pentachlorophenol ranging from 0.7 to 156 ug g^{-1}, whereas samples from adjacent to Harris Creek had concentrations of < 1.0 ug g^{-1} [3]. Soil near the dip tanks has concentrations of pentachlorophenol up to about 1 780 ug g^{-1} at a depth of about 5 metres[22], with average concentrations of about 300 ug g^{-1}. One reviewer[22] of this document indicated that soil samples in the treating area had concentrations as high as 143 000 ug g^{-1}. Groundwater samples from within the treating area contained concentrations of pentachlorophenol from 1 mg L^{-1} to 50.3 mg L^{-1} [3]. Groundwater samples from sites east from the treating area were generally less than 0.2 mg L^{-1}, while water samples from Harris Creek had values as high as 23 ug L^{-1} [3].

The Ministry of Environment has collected samples upstream

(E206608) and downstream (E208042) from Bell Pole in November 1989 and February 1990. Chlorophenol concentrations in the water column were as follows:

	Penta		Tetra		Tri	
	ug L^{-1}					
	Nov.89	Feb.90	Nov.89	Feb.90	Nov.89	Feb.90
Harris Cr. U/S	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Harris Cr. D/S	0.2	0.5	<0.1	0.2	<0.1	<0.1

These data indicate that concentrations of pentachlorophenol and tetrachlorophenol are increasing in a downstream direction from the Bell Pole operation. These samples were all collected when there was no runoff from the property taking place, thus suggesting that the quantity of contaminated groundwater entering the creek may be significant.

The Ministry of Environment also placed leeches in cages located upstream and downstream from the operation in July 1989 for a period of seven days[4]. Chlorophenol concentrations (wet weight) in the leeches were as follows:

	Penta	Tetra	Tri
	ug g^{-1}		
Harris Cr. U/S	0.1	0.05	<0.05
Harris Cr. D/S	1.2	0.48	<0.05

These data confirm that there is an increase in chlorophenol concentrations downstream from the Bell Pole property.

In February 1990, the Department of Fisheries and Oceans collected water, insect, and fish samples at three sites and sediment samples from six sites along the length of Harris Creek adjacent to the Bell Pole property. The results for the water samples were as follows:

	Penta	Tetra
	ug L^{-1}	
Harris Cr. U/S at Shuswap Ave.	N.D.	N.D.
Harris Cr. D/S S. from Bell Pole	0.105	0.035
Harris Cr. D/S N.E. from Bell Pole	0.010	0.0045

At the same time, insects and fish were collected from these same three sites. The results for fish (species unknown- whole fish analysis assumed) were as follows:

	Penta	Tetra
	(ug g^{-1} wet)	
Harris Cr. U/S at Shuswap Ave.	0.0016	0.0003
Harris Cr. D/S S. from Bell Pole	0.1080	0.0610
Harris Cr. D/S N.E. from Bell Pole	0.0632	0.0471

The results for insects (composite of at least 25 grams of all insects collected from gravel) were as follows:

	Penta	Tetra
	(ug g^{-1} wet)	
Harris Cr. U/S at Shuswap Ave.	0.0012	0.0008
Harris Cr. D/S S. from Bell Pole	0.0075	0.0089
Harris Cr. D/S N.E. from Bell Pole	0.0061	0.0048

The highest concentration of penta and tetrachlorophenols were found in sediments of Harris Creek at a site located almost immediately east from the treatment tanks, approximately half-way between the two downstream sites identified previously. Concentrations were 0.0111 ug g^{-1} tetrachlorophenol and 0.0116 ug

g^{-1} pentachlorophenol (dry-weight). This compares to concentrations at the upstream site of 0.0016 ug g^{-1} pentachlorophenol and non-detectable (<0.0001 ug g^{-1}) concentrations of tetrachlorophenol (dry-weight).

All of these data indicate that the Bell Pole operation is increasing chlorophenol concentrations considerably in the water, fish, sediments, and benthic community of Harris Creek. A remedial action plan is not in-place at this time, although a temporary plan has been developed for implementation in late 1990.

Dioxins, furans, and other phenolics can be present in chlorophenate mixtures as impurities. No testing has been done for the presence of these substances. It is recommended that some data be collected for these substances to determine if there is a related concern.

Elevated PAH levels indicate residual creosote contamination to be present in the subsurface soils of the west yard. Groundwater from the part of the operation is believed to flow towards Duteau Creek. This was monitored by the Ministry of Environment during 1990.

4.6 <u>Corporation of the Village of Lumby</u> (PE 1662)

Waste Management permit PE 1662 was issued in 1972 in relation to the discharge of cooling water from a compressor at the Lumby arena. The discharge to Duteau Creek occurs from October 1 to March 30 on a yearly basis. The cooling water originates from the domestic water supply. There is no treatment of the water prior to discharge.

The permit allows the discharge of a yearly average of 182 m^3 d^{-1} of cooling water at a maximum temperature of 13° C. There are no data on the quality of this discharge or its impact on Duteau Creek. It is recommended that monitoring in Duteau Creek occur near this discharge.

4.7 Silver Star Sports Limited (PE 6738)

Silver Star Sports Limited operates a ski hill on Silver Star Mountain, 22 kilometres northeast from Vernon. The operation is located in the headwaters of Vance Creek. Sewage from the operation is treated in an extended aeration system, followed by dual media filtration and chlorination. The treated effluent is discharged to a storage/exfiltration reservoir. The accumulated effluent was to be used for snow-making; however, this has never occurred.

Waste management permit PE 6738 allows the discharge of an average 272.4 m^3/d and a maximum of 408.6 m^3/d from the sewage treatment facility to the reservoir. The total volume of effluent converted to snow was not to exceed 62 107 m^3 during the operating period November 15 to April 15. The effluent from the sewage treatment facility was to have a maximum 20 mg L^{-1} BOD_5 and 10 mg L^{-1} suspended solids. Limited monitoring data between 1985 and 1990 for the effluent have indicated a BOD_5 (n=8) from < 10 mg L^{-1} to 40 mg L^{-1} (average of 24 mg L^{-1}) and suspended solids (n=10) from 15 to 54 mg L^{-1} (average of 29 mg L^{-1}).

Since it is likely that exfiltration of the treated sewage from the storage reservoir is taking place, it is recommended that ambient monitoring occur in Vance Creek near the reservoir to determine if an impact is occurring.

4.8 Quinto Mine (AE 6158)

An un-utilized mine/ mill operation exists just north from Lumby on the east side of Bessette Creek. This mining property has been the subject of test drilling for gold and silver in the late 1980's, but no firm development proposals exist at this time. When further details are known about whether this operation will be reactivated, additional water quality objectives can be developed for Bessette Creek at that time.

5. DIFFUSE SOURCES

The effects of forestry and residential developments have not been examined in this assessment. However, each would have some impact on water quality of some of the tributaries. For example, forestry impacts would be expected in the headwater areas of Harris and Duteau creeks. The town of Lumby with paved areas and stormwater runoff would have some impact on Bessette Creek, as well as the lower reach of Harris and Duteau creeks.

Creighton Creek is surrounded by agriculture, as are the lower reaches of Bessette Creek. Crops are: corn for silage, grain, and hay. It is expected that pesticides and fertilizers applied to these crops could make their way to these creeks in small quantities.

In an attempt to determine if cattle could affect any of these watersheds, a visual assessment was made in August 1989. This assessment identified where cattle were located. To quantify the numbers of cattle involved, statistics on the number of cattle registered with the Beef Assurance Program of the Ministry of Agriculture and Fisheries were examined. Cattle appear to be concentrated just south and just west from Lumby. Therefore, the only three creeks potentially affected by cattle wastes are Bessette, Harris, and Duteau creeks.

The estimates for nutrient coefficients proposed by Bangay[24] were used to determine potential loadings. These were 7.92 kg P and 68 kg N per animal for cows and 3.2 kg P and 39.9 kg N per animal per year for yearlings.

5.1 Harris Creek

Ministry of Agriculture and Fisheries data indicate a minimum of 40 cows and 15 yearlings in the Harris Creek watershed. These would result in a potential yearly loading of 365 kg P and 3 300 kg N.

For the purpose of this assessment, the following will be assumed:

1. All of the generated N and P will reach Harris Creek.
2. The nutrients will be transported at an even rate throughout the year.

Using a mean seven-day low flow of 0.111 m^3 s^{-1}, the following maximum increases from cattle are predicted:

Potential Increase in Nutrient Concentrations (mg L^{-1}) Due to Cattle

Phosphorus	0.10
Nitrogen	0.94

These potential increases would be reduced at greater creek flows, but increased at lower flows. A comparison to values measured in the creek will be made in Chapter 6. Although the loadings are likely an over-estimate of the loading to the creek for this number of cattle, it must be remembered that all cattle in the watershed are not necessarily registered with the Beef Assurance Program, since it is a voluntary program. As well, operations with less than 20 head are not eligible for the program.

The Village of Lumby uses a series of infiltration wells to obtain its drinking water. The infiltration wells were flooded during the Spring of 1990. These were shut down until the flood waters receded and the wells were disinfected. Repeated attempts to disinfect the wells were unsuccessful due to high fecal coliform concentrations, likely originating from diffuse sources upstream.

5.2 Duteau Creek

Ministry of Agriculture and Fisheries data indicate a minimum of 577 cows and 284 yearlings in the Duteau Creek watershed. These would result in a potential yearly loading of 5500 kg P and 50 600 kg N.

For the purpose of this assessment, the following will be assumed:

1. All of the generated N and P will reach Duteau Creek.
2. The nutrients will be transported at an even rate throughout the year.

Using a mean seven-day low flow of 0.079 $m^3 s^{-1}$, the following maximum increases from cattle are predicted:

Potential Increase in Nutrient Concentrations ($mg L^{-1}$) Due to Cattle

Phosphorus	2.2
Nitrogen	20.3

These potential increases would be reduced at greater creek flows, but increased at lower flows. A comparison to values measured in the creek will be made in Chapter 6. Although the loadings are likely an over-estimate of the loading to the creek for this number of cattle, it must be remembered that all cattle in the watershed are not necessarily registered with the Beef Assurance Program, since it is a voluntary program. As well, operations with less than 20 head are not eligible for the program.

5.3 Bessette Creek

Ministry of Agriculture and Fisheries data indicate a minimum of 11 cows and 37 yearlings in the lower Bessette Creek watershed. These would result in a potential yearly loading of 232 kg P and 2 224 kg N.

For the purpose of this assessment, the following will be assumed:

1. All of the generated N and P will reach Bessette Creek.
2. The nutrients will be transported at an even rate throughout the year.

Using a mean seven-day low flow of 0.35 m^3 s^{-1}, the following maximum increases from cattle are predicted:

Potential Increase in Nutrient Concentrations (mg L^{-1}) Due to Cattle

Phosphorus	0.21
Nitrogen	2.01

These potential increases would be reduced at greater creek flows, but increased at lower flows. A comparison to values measured in the creek will be made in Chapter 6. Although the loadings are likely an over-estimate of the loading to the creek for this number of cattle, it must be remembered that all cattle in the watershed are not necessarily registered with the Beef Assurance Program, since it is a voluntary program. As well, operations with less than 20 head are not eligible for the program.

6. AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

Water quality will be assessed in this report for the separate creeks prior to their eventual joining to form Bessette Creek at Lumby.

6.1 Lawson and Spider creeks

Lawson Creek flows from west to east and joins Duteau Creek east from Lumby. Prior to its confluence it is joined by Spider Creek, which enters from the north just upstream from Duteau Creek.

Lawson Creek has been sampled at Site 0500645 upstream from Riverside Forest Products and Spider Creek, at Site 0500648 just downstream from Spider Creek, and at Site 0500646 just upstream from Duteau Creek. The data are summarized in Tables 1 to 3. Spider Creek has been sampled once in each of 1986 and 1987 at Site 0500643 upstream from Riverside Forest Products and Site 0500644 near the mouth. The data are in Tables 4 and 5.

Designated water uses for Spider and Lawson creeks are use as a drinking water supply, for aquatic life, irrigation, wildlife, and livestock watering.

6.1.1 pH and ALKALINITY

The pH in Spider Creek decreased from 8.3 and 8.2 at Site 0500643 to 8.0 and 7.5 at Site 0500644. Alkalinity measurements were not made, but it is speculated that there would still be residual buffering available to acidic inputs (Tables 4 and 5).

The working criteria for pH are that the pH should be in the range from 6.5 to 8.5 to protect aesthetics of drinking water supplies[10] and from 6.5 to 9.0 to protect aquatic life[6].

The median pH in Lawson Creek decreased ever so slightly from 7.9 at Site 0500645 to 7.85 at Site 0500646 and to 7.8 at Site 0500648. Total alkalinity was seldom measured, with an average value of 208 mg L^{-1} at Site 0500645 (n=2), 239 mg L^{-1} at Site 0500646 (n=2), and 191 mg L^{-1} at Site 0500648 (n=1). These data indicate that Lawson Creek is well buffered to acidic inputs.

In Section 4.1, it was illustrated that the acidity of Spider Creek increased going from upstream to downstream from Riverside Forest Products. It is assumed that a similar situation could exist on Lawson Creek, although the monitoring sites have not been situated close enough to each other to confirm this. <u>A provisional water quality objective is proposed for both Spider and Lawson creeks to protect aquatic life from both acidic and alkaline inputs</u>. <u>The objective is that the pH in any sample collected in either creek should be in the range from 6.5 to 8.5</u>, except for samples collected in the initial dilution zones described in Section 6.1.3. The more restrictive upper level for the range of 8.5 to protect drinking water supplies has been applied in this case since the upstream pH in Lawson Creek has exceeded this value on only one of 63 occasions.

6.1.2 HARDNESS and METALS

Data on the hardness of Spider Creek have not been collected. In Lawson Creek, hardness values at Site 0500645 were from 288 to 394 mg L^{-1} (n=2). High hardness concentrations often are beneficial in alleviating the toxic effects of metals.

There were no metals measured in Spider Creek. In Lawson Creek, the only metals detected were aluminum, iron, manganese, molybdenum, vanadium, and zinc. The minimum detectable concentrations for chromium, copper, and nickel were above environmentally significant levels for most of the analyses. The B.C. criteria for aluminum are expressed as dissolved aluminum, and the maximum total value of 0.13 mg L^{-1} exceeded the maximum criterion of 0.1 mg L^{-1} dissolved to protect aquatic life[5].

The maximum iron and manganese concentrations of 0.5 mg L^{-1} and 0.16 mg L^{-1}, respectively, at Site 0500648 exceeded the working criteria of 0.3 mg L^{-1} and 0.1 mg L^{-1} maximum, respectively, to protect aquatic life[6] and for aesthetics related to drinking water supplies[10]. The maximum vanadium concentration (0.04 mg L^{-1}) met the working criterion of 0.1 mg L^{-1} to protect drinking water, irrigation, and livestock[6], while the maximum zinc value of 0.01 mg L^{-1} met the working criterion[6] of 0.03 mg L^{-1} to protect aquatic life. The criterion of 0.01 mg L^{-1} molybdenum to protect irrigation water supplies[7] was not exceeded.

Since there are no known sources of metals to these creeks at this time, water quality objectives are not proposed. It is recommended that data for dissolved and total metals and hardness continue to be collected in these creeks for baseline information.

6.1.3 DISSOLVED OXYGEN and OXYGEN-CONSUMING MATERIALS

There are no data available for dissolved oxygen concentrations in either Spider or Lawson creeks. In addition, there are no data on oxygen-consumption rates. It is recommended that dissolved oxygen concentrations be measured any time that samples are collected in these creeks.

In the interim period and in the absence of data, it is proposed that provisional water quality objectives be established in both Spider and Lawson creeks to protect aquatic life. In Section 6.4.3, working criteria are developed for dissolved oxygen. It is proposed that these criteria be adopted as the water quality objectives for Spider and Lawson creeks, i.e., that the minimum dissolved oxygen concentration should be 8.0 mg L^{-1} at all times of the year except when salmonid embryos and larvae are present, when the minimum concentration should be 11.0 mg L^{-1}. The objectives apply along the length of both Spider and Lawson creeks, except in the initial dilution zones of effluents.

The initial dilution zones in these creeks will be defined as existing along the length of the refuse site and extending up to 25% of the width of the creeks. The 25% width restriction has been applied in this case, as opposed to 50% which is more often applied for small creeks, since the dilution zone is longer than traditionally defined, and the input of contaminants from this source would be considered diffuse rather than point source discharge.

6.1.4 NUTRIENTS

Ammonia-N concentrations have been low both times they were measured on Spider Creek at both sites. The highest concentration was 0.022 mg L^{-1} at Site 0500644, well below the criteria in Tables 6 and 7 to protect aquatic life [8]. In Lawson Creek, most of the ammonia-N data have been collected at Sites 0500645 and 0500648. The maximum ammonia-N concentration of 0.328 mg L^{-1} was well below criteria to protect aquatic life. In Section 4.2, it was illustrated that the refuse site apparently increases ammonia-N concentrations in Spider Creek. For this reason, a provisional water quality objective is proposed for ammonia. The objective is that the maximum and average ammonia-N concentrations should not exceed the values listed in Tables 6 and 7[8]. The objectives apply along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3.

All nitrate and nitrate/nitrite-N concentrations in both creeks were well below the most stringent criterion of 10 mg L^{-1} maximum to protect drinking water supplies[8]. Nitrite-N concentrations in Spider Creek were either at or below the detection limit of 0.005 mg L^{-1} (Tables 4 and 5). In Lawson Creek, nitrite-N values as high as 0.027 mg L^{-1} and 0.034 mg L^{-1} were measured at Sites 0500645 and 0500648, respectively. These are all below the B.C. criterion of a maximum of 0.06 mg L^{-1} (Table 8) to protect aquatic life, but may have exceeded the 30-day average criterion, depending on the chloride concentration at the time[8]. Both these maxima were measured in March 1979.

In Section 4.2, it was noted that there were increases in nitrate/nitrite-N concentrations in Spider Creek going from upstream to downstream from the refuse site. For this reason, provisional water quality objectives are proposed for nitrate and nitrite concentrations in Spider and Lawson creeks. The objectives are that the maximum nitrate-N concentration should not exceed 10.0 mg L^{-1}, while the nitrite-N concentrations should not exceed the concentrations listed in Table 8[8]. The objectives apply along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3.

Phosphorus concentrations were usually higher than the most stringent criterion for lakes of 0.01 mg L^{-1} for drinking water and recreation, and often higher than 0.015 mg L^{-1} for the protection of aquatic life[9]. In creeks such as these, phosphorus is not the best indicator of potential algae problems since other factors such as light, creek flows, and substrate availability are important.

Since phosphorus can potentially be increased by livestock wastes, fertilizers, logging, and other land disturbances which can result in additional phosphorus entering the creeks, a provisional water quality objective is proposed for periphyton chlorophyll-a. The objective, which is the same as the B.C. criterion to protect aquatic life[9], is a maximum of 100 mg m^{-2} of chlorophyll-a. This is to be based upon the average of at least five periphyton chlorophyll-a samples collected from natural substrate on the same day, outside the initial dilution zones of effluents described in Section 6.1.3. Since measurements have not been made, it is not known if this objective can be achieved.

6.1.5 SOLIDS and TURBIDITY

Dissolved solids have not been measured directly in Spider Creek and only on infrequent occasions in Lawson Creek. One of two values for Lawson Creek at Site 0500646 was 540 mg L^{-1}, in excess of the working criteria of a maximum 500 mg L^{-1} to protect drinking water supplies[10]. Specific conductivity measurements are an indirect measure of dissolved solids. Although an exact correlation does not exist, some correlation should exist for a water body. For the three coincident specific conductivity and dissolved solids values in Lawson Creek, ratios were 1.41:1, 1.48:1, and 1.65:1. Thus, the 500 mg L^{-1} dissolved solids criterion corresponds to a specific conductivity from 700 to 825 uS cm^{-1}, based upon these ratios.

Specific conductivity values in excess of 825 uS cm^{-1} at each site were as follows: for 4 of 55 values at Site 0500645; for no values at Site 0500646; and for 2 of 49 values at Site 0500648. Exceeding the 700 uS cm^{-1} limit (which also corresponds to the lower limit to protect irrigation water supplies, depending on the crop and soil[6]) were 5 of 55 values at Site 0500645, 3 of 27 values at Site 0500646, and 4 of 49 values at Site 0500648. Although likely of concern at times for the aesthetics of drinking water, these conductivity values are below the criterion of a maximum of 1 400 uS cm^{-1} to protect livestock[6].

In Spider Creek, specific conductivity values were as high as 720 uS cm^{-1} at Site 0500643 (Table 4) and 890 uS cm^{-1} at Site 0500644 (Table 5). These data show that there can also be times when dissolved solids are too high for the water to be desirable for irrigation and drinking water supplies, but not so high as to be a concern for livestock watering.

In Section 4.2, it was noted that increases in specific conductivity occurred going from upstream to downstream from the refuse site on Spider Creek. For this reason, a provisional water quality objective is proposed for dissolved solids in Lawson and Spider creeks. The objective is that the maximum dissolved solids concentration should not exceed 500 mg L^{-1}. The objective applies along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3. At times when the upstream concentrations exceed the 500 mg L^{-1} proposed objective, values downstream from the landfills should increase by no more than 20 % of the upstream value. The rationale for the use of this 20 % increase is outlined in Reference 23.

Suspended solids were not measured in Spider Creek, and infrequently in Lawson Creek. Coincident values upstream and downstream from the Riverside Forest Products operation noted in Section 4.2 showed increases of less than 10 mg L^{-1}, the B.C. criterion to protect aquatic life[11]. Since there can be increases in suspended solids concentrations, a provisional water quality objective is proposed for suspended solids in Spider and Lawson creeks. The objective is that the maximum induced suspended solids concentration should be 10 mg L^{-1} when upstream concentrations are $\leq$ 100 mg L^{-1} and no greater than 10% of upstream when upstream concentrations exceed 100 mg L^{-1}. The objective applies along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3.

Lawson Creek is considered to have high fisheries resource values, particularly for spawning habitat. Every effort should be made to preserve this. The B.C. criterion to protect spawning areas applies to limiting the induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm[11]. A water quality objective is therefore proposed for induced substrate sedimentation. The proposed objective is that there should be no significant increase in the percentage of particles < 3 mm on the basis of accumulation by weight.

Although the criterion is to apply at a 95% confidence level, this is not a practical alternative since an inordinate number of samples would need to be collected to measure this significance level. Therefore, no significant increase will mean no increase greater than 20% going from upstream to downstream from a site, assuming three measurements of sediments at each site. Should it be determined that the increase is > 20%, subsequent sampling efforts should be increased to a level where a 95% confidence level can be achieved.

B. C. criteria for turbidity are a maximum induced turbidity of 5 NTU for background levels < 50 NTU[11]. Turbidity was measured once at both sites in Spider Creek. Both values were less than 5 NTU (Tables 4 and 5).

Considerably more turbidity data were collected at the three sites on Lawson Creek. Eleven coincident turbidity measurements in 1978 at Sites 0500645 and 0500646 showed increases in turbidity of less than 1 NTU on all dates. For Sites 0500645 and 0500648 where 22 coincident measurements were made between 1978 and 1982, increases greater than 5 NTU were noted on only two occasions, in May 1978 (22 NTU increase) and February 1979 (20 NTU increase). It is not possible to determine if these increases were due to runoff or leachate from the Riverside Forest Products operation or flows from Spider Creek. Since turbidity may be increased due to runoff from the refuse site, a <u>provisional water quality objective is proposed for induced turbidity in Spider and Lawson creeks</u>. The objective is that the <u>maximum induced turbidity concentration should be 5 NTU when upstream concentrations are < 50 NTU and no greater than 10% of upstream when upstream concentrations exceed 50 NTU</u>. The objective applies along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3.

6.1.6 COLOUR and BACTERIOLOGICAL QUALITY

Fecal coliforms were not measured in Spider Creek, so it is not possible to determine bacteriological quality. On Lawson Creek, only two measurements have been made at each of Sites 0500645 and 0500646. The highest value of 205 CFU cL^{-1} (colony forming units per centilitre) was recorded at Site 0500645, which exceeds the 200 cL^{-1} criterion for a maximum for general livestock use[12], but not the 1 000 cL^{-1} criterion for general irrigation[12]. It is likely that the 90th percentile value exceeded the 100 cL^{-1} criterion requiring partial treatment of the water for a drinking water supply[12].

A water quality objective is proposed to protect the bacteriological quality of these two creeks. The objective is that the maximum fecal coliform and E. coli concentrations should be 200 cL^{-1} while the 90th percentiles should not exceed 100 cL^{-1}, and the maximum enterococci concentration should not exceed 50 cL^{-1} while the 90th percentile should not exceed 25 cL^{-1}.

Colour measurements have not been made in Spider Creek. In Lawson Creek, measurements have been made at Sites 0500645 (Table 1) and 0500648 (Table 3). Three of 23 values at Site 0500645 and 4 of 24 values at Site 0500648 exceeded the working water quality criterion (for aesthetics) of a maximum 15 true colour units in untreated drinking waters[11]. Since colour can be imparted from the refuse site to the creeks, a provisional water quality objective is proposed for colour in Spider and Lawson creeks. The objective is that the maximum colour content of the water should not exceed 15 true colour units. The objective applies along the lengths of both Spider and Lawson creeks, except in the initial dilution zones of effluents, described in Section 6.1.3. At times when upstream levels exceed the proposed objective, the maximum increase going from upstream to downstream should not exceed 20 % of the upstream value.

6.1.7 RESIN ACIDS and TANNIN and LIGNIN

Resin acids have not been measured in Spider Creek. In Lawson Creek, these have been measured in November 1989 and January 1990 at Sites 0500645 and 0500646 at the same times, as well as in October 1989 at Site 0500646. All seven resin acids measured (abietic, dehydroabietic, isopmaric, levo pimaric, neoabietic, pimaric, and sandaracopimaric) were less than the detection limit of 0.001 mg L^{-1} for all samples. Working criteria for resin acids are in Table 9. On the days the samples were collected, the pH was always above 7.5. Therefore, the criteria of a maximum 12 ug L^{-1} dehydroabietic acid and a maximum of 45 ug L^{-1} for total resin acids[13] were not exceeded. Since the lowest pH allowed by proposed provisional water quality objectives in Section 6.1.1 is pH 6.5, and although values have been below detection on those infrequent sampling occasions, provisional water quality objectives are proposed for dehydroabietic acid and total resin acids. The objectives are that the maximum concentrations should not exceed the values listed in Table 9. The objectives apply along the length of both Spider and Lawson creeks, except in the initial dilution zones of effluents described in Section 6.1.3.

Tannin and lignins have not been measured in Spider Creek. In Lawson Creek, measurements have been made at all three sites. The tannin and lignin values measure only tannin and lignin-like compounds derived from plant materials, and therefore have only some limited use for indicating the presence of woodwaste leachates. The only working criterion for total tannin and lignin is a maximum of 0.4 mg L^{-1}, which is cited as a threshold for taste, odour, and colour in drinking water supplies[(14)]. Values in excess of this criterion were measured on 6 of 29 sampling dates at Site 0500645, 1 of 12 dates at Site 0500646, and 11 of 28 dates at Site

0500648. It would appear that tannin and lignin levels in the creek are naturally elevated and not due to the landfill. The objectives already proposed for colour and for resin acids should cover concerns meant to be addressed by tannin and lignin.

6.1.8 PHENOLS

Total phenols have not been measured in Spider Creek. In Lawson Creek, measurements have been made at all three sites. The working water quality criterion to prevent tainting of fish flesh is a maximum of 0.001 mg L^{-1} [6]. Although the detection limit cited of 0.002 mg L^{-1} is in excess of the criterion, values above detection and therefore exceeding the criterion have been recorded as follows: for 8 of 30 values at Site 0500645; for 7 of 15 values at Site 0500646; and for 11 of 28 values at Site 0500648.

On days when coincident measurements were made in Lawson Creek at Sites 0500645 and 0500646(N = 14), increases were noted on four occasions to 0.003 or 0.004 mg L^{-1}. The highest value at Site 0500646 was 0.054 mg L^{-1} when a value was not measured at Site 0500645. On that day, a value of 0.008 mg L^{-1} was measured at Site 0500648.

No objective is proposed for phenols since "phenols" appear to be elevated naturally in Lawson Creek, and it is recognized that chlorophenols are the phenolic compounds that cause fish tainting.

6.2 DUTEAU CREEK

Duteau Creek has only been sampled on two occasions in November 1989 and February 1990 at Site E208041, just prior to its confluence with Harris Creek, to form Bessette Creek. The samples were analyzed for only ammonia, fecal coliforms, and specific conductivity.

Designated water uses in Duteau Creek are protection of aquatic life and wildlife, and use of the water for a drinking water supply, for irrigation, and livestock use.

The ammonia values were 0.03 and 0.029 mg L^{-1}, respectively. These are well below the B.C. criteria in Tables 6 and 7 for aquatic life.

The fecal coliform values were 15 and 50 CFU cL^{-1}, indicating that if these two data are representative, the water could be used as a drinking water supply with partial treatment[12].

The specific conductivity values were 199 and 320 uS cm^{-1}, respectively. Given the ratios discussed in Section 6.1.5 for dissolved solids and conductivity, and assuming that these two values are representative, the water is satisfactory for drinking water and livestock watering[6].

In Section 4.5, it was noted that creosote from the Bell Pole operation may have entered the groundwater and be flowing towards Duteau Creek. There are no data for the creek to confirm this suspicion. As well, there are no ambient data related to the discharge of cooling water from the Lumby arena. It is recommended that an ambient monitoring program be undertaken to define the water quality of Duteau Creek.

No water quality objectives are proposed for Duteau Creek at this time, except for temperature. The working water quality criterion to protect aquatic life is that the maximum change in natural levels is ± 1° C[21]. The proposed water quality objective for Duteau Creek is a maximum increase of 1°C, which applies to all reaches of Duteau Creek, except in initial dilution zones of effluents described in Section 6.1.3.

6.3 HARRIS CREEK

Data for Harris Creek from two locations well upstream from its confluence with Duteau Creek, were collected between 1980 and 1983. The data for Sites 0500731 and 0500732 are summarized in Tables 10 and 11, respectively. It is assumed that the data for these two sites are fairly representative of conditions along the length of Harris Creek. Other more recent data collected near the Bell Pole operation have been discussed in Section 4.5. These will be referred to for setting water quality objectives.

Designated water uses in Harris Creek are protection of aquatic life and wildlife, and use of the water for a drinking water supply, for irrigation, and livestock use.

6.3.1 pH and ALKALINITY

The pH in Harris Creek ranged from 6.7 at Site 0500732 to 8.2 at both sites. The working water quality criteria for drinking water aesthetics are that the pH be in the range from 6.5 to 8.5[10].

Since the storm sewer from the Weyerhauser property can carry woodwaste leachate which can be acidic, a provisional water quality objective is proposed for the pH in Harris Creek. The objective is that the pH should be in the range from 6.5 to 8.5.

The proposed objective applies along the length of Harris

Creek, except in the initial dilution zones of effluents. In Harris Creek, these excluded initial dilution zones will be defined as extending up to 100 metres downstream from a discharge and extending no further than 50% of the width of the creek, from the bed to the surface.

Alkalinity was not measured at either site.

6.3.2 NUTRIENTS

The maximum ammonia-N concentration of 0.029 mg L^{-1} was recorded at Site 0500731. This value is well below both the aquatic life criteria for maximum and average concentrations (Tables 6 and 7). All nitrite-N values were less than detection (0.005 mg L^{-1}) and well below the aquatic life criteria in Table 8. Nitrate-N and nitrate/nitrite-N concentrations were well below the criterion of 10 mg L^{-1} to protect drinking water supplies[8].

Since there are diffuse sources of nutrients to Harris Creek, <u>water quality objectives are proposed for ammonia, nitrate, and nitrite</u>. The objectives are that the <u>maximum nitrate-N (or nitrate plus nitrite) concentration should not exceed 10 mg L^{-1}, and the maximum and average nitrite-N and ammonia-N concentrations should not exceed the values in Tables 6, 7, and 8</u>. The proposed objectives apply along the length of Harris Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

Total phosphorus concentrations were as high as 0.447 mg L^{-1}. This is higher than the most stringent criterion for lakes of 0.01 mg L^{-1} for drinking water and recreation, and often higher than 0.015 mg L^{-1} for the protection of aquatic life[9]. In creeks such as this, phosphorus is not the best indicator of potential alga problems since other factors such as light, creek flows, and substrate availability are important.

Since phosphorus can potentially be increased by livestock wastes, fertilizers, and from land disturbances such as logging, a provisional water quality objective is proposed for periphyton chlorophyll-a. The objective, which is the same as the B.C. criterion to protect aquatic life in streams[9], is a maximum of 100 mg m^{-2} chlorophyll-a. This is to be based upon the average of at least five periphyton chlorophyll-a samples collected from natural substrate on the same day, outside the initial dilution zones of effluents described in Section 6.3.1. Since measurements have not been made, it is not known if this objective can be achieved.

6.3.3 SOLIDS and TURBIDITY

B. C. criteria for turbidity are a maximum induced turbidity of 5 NTU for background levels < 50 NTU[11]. Turbidity was measured only once at each site, with a maximum of 1.8 NTU at Site 0500731. Since the value downstream measured on the same date was 1.1 NTU, the criterion was achieved. Since the storm sewer from the Weyerhauser property can carry solids to the creek, a provisional water quality objective is proposed for induced turbidity. The objective is that the maximum induced turbidity concentration should be 5 NTU when upstream concentrations are < 50 NTU and no greater than 10% of upstream when upstream concentrations exceed 50 NTU. The proposed objective applies along the length of Harris Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

Suspended solids also decreased in a downstream direction on the one sample date, from 14 to 12 mg L^{-1}. The B.C. criterion is a maximum induced suspended solids concentration of 10 mg L^{-1} for background levels < 100 mg L^{-1} [11]. Since suspended solids can be increased along Harris Creek, a provisional water quality objective is proposed for induced suspended solids concentrations. The objective is that the maximum induced suspended solids concentration should be 10 mg L^{-1} when upstream concentrations are < 100 mg L^{-1} and no greater than 10% of upstream when upstream concentrations exceed 100 mg L^{-1}.

Harris Creek is considered to have high fisheries resource values, particularly for spawning habitat. Every effort should be made to preserve this. The B.C. criterion to protect spawning areas limits the induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm[11]. A water quality objective is therefore proposed for induced substrate sedimentation. The proposed objective is that there should be no significant increase on the basis of accumulation by weight.

Although the criterion is to apply at a 95% confidence level, this is not a practical alternative since an inordinate number of samples would need to be collected to measure this significance level. Therefore, no significant increase will mean no increase greater than 20% going from upstream to downstream from a site, assuming three measurements of sediments at each site. Should it be determined that the increase is > 20%, subsequent sampling efforts should be increased to a level where a 95% confidence level can be achieved.

The working criterion to protect drinking water supplies is a maximum of 500 mg L^{-1} dissolved solids[10]. Both values at each site were well below the working criterion, with a maximum concentration of 136 mg L^{-1}. No objective is proposed for dissolved solids.

6.3.4 RESIN ACIDS and TANNIN and LIGNIN

The only working criterion for total tannin and lignin is a maximum of 0.4 mg L^{-1}, which is cited as a threshold for taste, odour, and colour in drinking water supplies[14]. All values at both sites were above this working criterion. The tannin and lignin values measure only tannin and lignin-like compounds derived from plant materials, and therefore have only limited use for indicating the presence of woodwaste leachates.

Resin acids have not been measured in Harris Creek. It is possible that these could be introduced from a number of sources: from the woodwaste refuse site (PR 5513), the Weyerhauser storm sewer, the Bell Pole property, or other abandoned woodwaste areas. Working criteria for resin acids in ambient waters are in Table 9. The criteria are a maximum 12 ug L^{-1} dehydroabietic acid and a maximum of 45 ug L^{-1} for total resin acids at pH 7.5[13]. Provisional water quality objectives are proposed for dehydroabietic acid and total resin acids. The objectives are that the maximum concentrations should not exceed those values listed in Table 9. The objectives apply along the length of Harris Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

6.3.5 PHENOLS

The working water quality criterion to prevent tainting of fish flesh is a maximum of 0.001 mg L^{-1} [6]. Values as high as 0.009 mg L^{-1} were recorded at Site 0500732. Only 1 of 6 values at Site 0500731 and 2 of 7 values at Site 0500732 were below the detection limit of 0.002 mg L^{-1}, which itself exceeds the criterion.

In Section 4.5, a number of data were presented to show that the Bell Pole operation is increasing chlorophenol concentrations considerably in the water, sediments, fish, and benthic community of Harris Creek. Draft B.C. water quality criteria for the protection of aquatic life[20] are summarized in Table 15. Since the toxicity of chlorophenols is temperature and pH dependent, the lowest 96-h LC_{50} with an application factor of 0.03 has been used in this assessment. Provisional water quality objectives are proposed for the water column outside the initial dilution zones of effluents. The proposed objectives are that the maximum concentrations should not exceed: monochlorophenol, 0.5 ug L^{-1}; dichlorophenol, 0.1 ug L^{-1}; trichlorophenol, 0.05 ug L^{-1}; tetrachlorophenol, 0.10 ug L^{-1}; and pentachlorophenol, 0.05 ug L^{-1}. These objectives apply to discrete samples collected outside the initial dilution zones of effluents described in Section 6.3.1.

A provisional water quality objective has been established for chlorophenols (sum of tri-, tetra-, and penta-) in sediments in the Fraser River of a maximum of 0.01 ug g^{-1} (dry-weight)[18]. In Section 4.5, data for sediments collected upstream from Bell Pole were well below (<0.002 ug g^{-1}) this value, while those adjacent to the property were in excess of this value. This value had been selected as reflecting concentrations at relatively uncontaminated areas of the Fraser River[18]. Since this value may not be realistic for Harris Creek because of its sediments possibly being coarser and non-contaminated sites having lower concentrations, a different provisional water quality objective for chlorophenols in sediments is proposed for Harris Creek. The objective is that the maximum chlorophenol concentration in sediments collected from outside initial dilution zones should not exceed 0.005 ug g^{-1} (dry-weight). The level in surface sediments (top 5 cm) allows for some increase from upstream values. It should be considered to be the average of three replicate samples from the same site.

Singleton reported that for a number of species of fish collected along the entire length of the Fraser River, chlorophenol (sum of tri-, tetra-, and penta-) concentrations in muscle were all less than 0.06 ug g^{-1} (wet-weight) near Quesnel and McBride and all less than 0.1 ug g^{-1} (wet-weight) downstream from Chilliwack[19]. In Section 4.5, it was noted that the sums of penta- and tetra- concentrations were about 0.0019 ug g^{-1} (wet-weight) upstream from Bell Pole, but 0.169 ug g^{-1} (wet-weight) downstream. Since fish in Harris Creek are apparently accumulating chlorophenols, <u>a provisional water quality objective is proposed for chlorophenols in fish muscle tissue</u>. The objective is that <u>the maximum concentration should not exceed 0.1 ug g^{-1} (wet-weight)</u>. The objective for fish muscle is based on concentrations in Fraser River fish, for which an extensive data base (large number of species and individuals) existed. The objective applies to fish of any species caught in any part of Harris Creek, including the initial dilution zones of effluents.

6.3.6 DISSOLVED OXYGEN

Dissolved oxygen concentrations have not been measured in Harris Creek. This should be done when any water quality data are being collected, since Harris Creek is an important fish habitat. In the interim period and in the absence of data, it is proposed that a <u>provisional water quality objective</u> be established to protect aquatic life. In Section 6.4.3, working criteria are developed for dissolved oxygen. It is proposed that these criteria be adopted as the water quality objectives for Harris Creek, i.e., <u>that the minimum dissolved oxygen concentration should be 8.0 mg</u>

L^{-1} at all times of the year except when salmonid embryos and larvae are present, when the minimum concentration should be 11.0 mg L^{-1}. The objectives apply along the length of Harris Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

6.4 BESSETTE CREEK

For the purpose of this assessment, Bessette Creek proper is considered to be that water body downstream from the confluence of Harris and Duteau creeks. Bessette Creek has been sampled at three sites: Site 0500293 upstream from the Lumby STP, Site 0500697 about four kilometres downstream from the Lumby STP, and Site 0500006, near the mouth of Bessette Creek. The data are summarized in Tables 12, 13, and 14, respectively.

Designated water uses in Bessette Creek are protection of aquatic life and wildlife, and use of the water for a drinking water supply, for irrigation, and for livestock.

6.4.1 pH and ALKALINITY

The pH of Bessette Creek does not appear to change among the three sites. The range of values at the three sites was from 6.7 at Site 0500006 (Table 14) to 9.2 at Site 0500293 (Table 12), with a median value of about 8.0. These values indicate that Bessette Creek is generally alkaline in nature. The working water quality criteria for drinking water aesthetics are that the pH be in the range from 6.5 to 8.5[10], while the range to protect aquatic life is from 6.5 to 9.0[6]. Since a water quality objective is proposed in later sections of this report for ammonia, and the toxicity of ammonia is reduced at lower pH values, a water quality objective is proposed for pH in Bessette Creek. The objective is that the pH should be in the range from 6.5 to 8.5. When upstream values are higher than 8.5, the maximum increase should be 0.2 units.

The alkalinity has ranged from 23.6 mg L^{-1} at Site 0500293 to 190 mg L^{-1} at Site 0500006, with an average concentration at the three sites of 112.5 mg L^{-1}. These data indicate that Bessette Creek has a low sensitivity to acidic inputs.

6.4.2 HARDNESS and METALS

The hardness of Bessette Creek water ranged from 24 mg L^{-1} at Site 0500293 to 225 mg L^{-1} at Site 0500006, with an average value of about 130 mg L^{-1} for the three sites. Increasing water hardness often can ameliorate the toxic effects of metals to aquatic life.

Many of the metals measured at the three sites were below varying detection limits and approved British Columbia or working water quality criteria for the protection of aquatic life. Exceptions are discussed below.

One of eleven total and dissolved chromium values (0.007 mg L^{-1}) exceeded the working criterion of a maximum 0.002 mg L^{-1} to protect aquatic life[6].

The approved British Columbia criterion for maximum total copper is defined by the equation (0.094(hardness) +2) ug L^{-1} [15]. For the average hardness of Bessette Creek, this is a maximum of 14.2 ug L^{-1}. The 30-day average concentration is to be less than 0.04(hardness), or 5.2 ug L^{-1}. The maximum copper concentration was 11 ug L^{-1} dissolved copper at Site 0500697, which meets the criterion for maximum total copper, but is greater than the 30-

day average value.

The working water quality criterion for total iron is 0.3 mg L^{-1} to protect aquatic life[6] and aesthetics of raw drinking water[10]. This concentration was exceeded by all six values at Site 0500293, by 2 of 4 values at Site 0500697, and by 7 of 10 values at Site 0500006. Since all but one dissolved iron concentrations were less than 0.3 mg L^{-1}, the water would be satisfactory for drinking with suspended solids removal, while the iron may also not be biologically available.

The working criterion for total zinc to protect aquatic life is a maximum of 0.03 mg L^{-1} [6]. This criterion for total zinc was exceeded by 1 of 6 dissolved zinc values (0.05 mg L^{-1}) at Site 0500697 and 1 of 11 dissolved values (0.05 mg L^{-1}) at Site 0500006.

Water quality objectives are not proposed for metals in Bessette Creek since there are no current anthropogenic sources of metals, and sufficient detail is not available about the Quinto Mine to determine metals which might be released if this operation were to start up.

6.4.3 NUTRIENTS

All ammonia-N concentrations at the three sites were below the approved British Columbia criteria for aquatic life in Tables 6 and 7. This was also the case for nitrite-N levels which were below the aquatic life criteria in Table 8, and nitrate-N and nitrate/nitrite-N concentrations which were below the British Columbia criterion of a maximum 10 mg L^{-1} to protect drinking water supplies[8].

Since there are diffuse sources of nutrients to Bessette Creek, as well as the possibility of a discharge to the creek from the Village of Lumby STP, water quality objectives are proposed for ammonia, nitrate, and nitrite. The objectives are that the maximum nitrate-N (or nitrate-N plus nitrite-N) concentration should not exceed 10 mg L^{-1}, and the maximum and average nitrite-N and ammonia-N concentrations should not exceed the values in Tables 6, 7, and 8. The proposed objectives apply along the length of Bessette Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

Phosphorus concentrations were as high as 0.268 mg L^{-1} at Site 0500006. This and the maximum total phosphorus concentrations at the other two sites are higher than the most stringent criterion for lakes of 0.01 mg L^{-1} for drinking water and recreation, and often higher than 0.015 mg L^{-1} for the protection of aquatic life[9]. In creeks such as this, phosphorus is not the best indicator of potential algal problems since other factors such as light, creek flows, and substrate availability are important.

Since nutrients can potentially be increased by livestock wastes entering the creek, as well as from the Village of Lumby STP, a provisional water objective is proposed for periphyton chlorophyll-a. The objective, which is the same as the B.C. criterion to protect aquatic life in streams[9], is a maximum of 100 mg m^{-2} chlorophyll-a. This is to be based upon the average of at least five periphyton chlorophyll-*a* samples collected from natural substrate on the same day, outside the initial dilution zones of effluents described in Section 6.3.1. Since measurements have not been made, it is not known if this objective can be achieved.

6.4.4 DISSOLVED OXYGEN and OXYGEN-CONSUMING MATERIALS

The CCREM[6] has developed criteria for dissolved oxygen, based on EPA criteria[16]. The criteria are based on warm-water and cold-water biota being present in a system. Cold-water systems were defined as any with at least one salmonid present. In British Columbia, this definition covers virtually the entire province.

The EPA[16] had based its criteria and discussed its findings on the basis of salmonids and non-salmonids. Table 3-7 in CCREM (page 3-14) is from EPA[16]. The EPA indicated that there was no impairment at 11.0 mg L^{-1} when salmonid embryos and larvae were present or 8.0 mg L^{-1} for other life stages, and slight impairment at 9.0 mg L^{-1} and 6.0 mg L^{-1}, respectively. The EPA[16] based its criteria (accepted by CCREM) on the slight impairment levels, and then added 0.5 mg L^{-1} to arrive at the criteria. In British Columbia, we are fortunate enough to generally have high quality waters, and there is no need to accept the slight impairment level. Therefore, the criteria which will be used for dissolved oxygen in this document will be based on salmonids and should provide for no impairment (i.e., 8.0 mg L^{-1} and 11.0 mg L^{-1} minima).

Embryos and larvae would not be present during the summer and 11.0 mg L^{-1} is greater than 100% saturation above about 8° C. All the dissolved oxygen values achieved the criterion of a minimum of 8.0 mg L^{-1}. The criterion of 11.0 mg L^{-1} was not achieved for 1 of 10 values at Site 0500293 (July 1980), for 1 of 4 values at Site 0500697 (July 1980), and for 3 of 16 values at Site 0500006 (May 1972, August 1975, and July 1980). However, the 11.0 mg L^{-1} criterion would only likely be applicable to the May 1972 sample; the appropriate criterion for the other noted excursions would be 8.0 mg L^{-1}.

It is proposed that a provisional water quality objective be established to protect aquatic life and that the aforementioned criteria be adopted as the water quality objectives for Bessette Creek, i.e., that the minimum dissolved oxygen concentration should be 8.0 mg L^{-1} at all times of the year except when salmonid embryo and larvae are present, when the minimum concentration should be 11.0 mg L^{-1}. The objectives apply along the length of Bessette Creek, except in the initial dilution zones of effluents.

All percent saturation values were in the range from 80% to 120%, a range considered by this author to be indicative of a water body not experiencing dissolved oxygen excursions resulting from the presence of algae.

6.4.5 SOLIDS and TURBIDITY

The B.C. criteria for turbidity are a maximum induced turbidity of 5 NTU for background levels < 50 NTU[11]. The criteria were exceeded on 1 of 5 occasions between Sites 0500293 and 0500697, and 2 of 7 occasions between Sites 0500293 and 0500697, when coincident measurements were made. The maximum turbidity concentration was 65 NTU at Site 0500006. Turbidity removal would be needed prior to use for drinking water during much of the year.

Since the Village of Lumby STP can discharge suspended solids to the creek, a provisional water quality objective is proposed for induced turbidity. The objective is that the maximum induced turbidity concentration should be 5 NTU when upstream concentrations are < 50 NTU and no greater than 10% of upstream when upstream concentrations exceed 50 NTU. The proposed objective applies along the length of Bessette Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

The B.C. criterion for suspended solids is a maximum induced suspended solids concentration of 10 mg L^{-1} for background levels < 100 mg L^{-1} [11]. This criterion was exceeded for 2 of 7 coincident measurements between Sites 0500293 and 0500006. Coincident measurements between Sites 0500293 and 0500697 were made only once, and there was no difference in the concentration.

Since suspended solids can be discharged to Bessette Creek, a provisional water quality objective is proposed for induced suspended solids concentrations. The objective is that the maximum induced suspended solids concentration should be 10 mg L^{-1} when upstream concentrations are < 100 mg L^{-1} and no greater than 10% of upstream when upstream concentrations exceed 100 mg L^{-1}. The proposed objective applies along the length of Bessette Creek, except in the initial dilution zones of effluents described in Section 6.3.1.

Bessette Creek has high fisheries resource values, particularly for spawning habitat. Every effort should be made to preserve this. The B.C. criterion to protect spawning areas limits the induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm[11]. A water quality objective is therefore proposed for induced substrate sedimentation. The proposed objective is that there should be no significant increase on the basis of accumulation by weight. Although the criterion is to apply at a 95% confidence level, this is not a practical alternative since an inordinate number of samples would need to be collected to measure this significance level. Therefore, no significant increase will mean no increase greater than 20% going from upstream to downstream from a site, assuming three measurements of sediments at each site. Should it be determined that the increase is > 20%, subsequent sampling efforts should be increased to a level where a 95% confidence level can be achieved. The objective applies outside the initial dilution zones of effluents described in Section 6.3.1.

The working criterion to protect drinking water supplies is a maximum of 500 mg L^{-1} dissolved solids[10]. The maximum dissolved solids concentration measured was 309 mg L^{-1} at Site 0500293, a value well below the criterion. Therefore, no objective is proposed for dissolved solids in Bessette Creek.

6.4.6 BACTERIOLOGICAL QUALITY AND COLOUR

Very few data are available for fecal coliform concentrations. The maximum recorded was 400 CFU cL^{-1} at Site 0500293, upstream from the Lumby STP. Median values were less than 100 cL^{-1}. It is likely that the 90th percentile value exceeded the 100 cL^{-1} criterion requiring partial treatment of the water for a drinking water supply[12].

Since coliforms can be discharged from the Village of Lumby STP should positive discharges occur, <u>a water quality objective is proposed for microbiological indicators</u> in Bessette Creek. <u>The objective is that the 90th percentile values should be < 100 cL^{-1} for each of fecal coliforms and Escherichia coli and < 25 cL^{-1} for enterococci, and the maximum concentrations for each should be 200, 200, and 50 cL^{-1}, respectively</u>. The objective applies outside the initial dilution zones of effluents described in Section 6.3.1, and is intended to protect raw drinking water that will receive partial treatment prior to use.

For colour, the working water quality criterion is a maximum of 15 true colour units in untreated drinking waters[10]. Colour measurements were made at only Sites 0500293 and 0500006. This criterion was exceeded for 5 of 7 values at Site 0500293 and 7 of 14 values at Site 0500006. No water quality objective is proposed for colour since colour is naturally high and there are no sources of colour discharging to Bessette Creek.

6.4.7 PHENOLS

The working water quality criterion[6] to prevent tainting of fish flesh by phenols is a maximum of 0.001 mg L^{-1}. Although the detection limit cited of 0.002 mg L^{-1} is in excess of the criterion, values above detection and therefore exceeding the criterion have been recorded as follows: for 2 of 5 values at Site 0500293 and for 4 of 7 values at Site 0500006.

6.4.8 TANNIN and LIGNIN

The only working criterion for total tannin and lignin is a maximum of 0.4 mg L^{-1}, which is cited as a threshold for taste, odour, and colour in drinking water supplies[14]. This criterion was exceeded by 9 of 10 values at Site 0500293 and 7 of 10 values at Site 0500006, but by neither of the two values at Site 0500697.

7. RECOMMENDED MONITORING

Water quality objectives have been proposed for a number of water quality characteristics. Generally, these should be checked in the summer when low flows would normally occur, and after a period of time when leachate from the numerous refuse sites has been generated and possibly reached the water bodies.

To check attainment of average or percentile values, a minimum of five samples should be collected in a thirty-day period. When percentiles such as the 90th percentile are to be calculated, for the purpose of checking attainment of the objective, it will be deemed acceptable to interpolate the 90th percentile from a graphical presentation of the data.

8. CONCLUSIONS

The water bodies considered in this water quality assessment were Bessette, Harris, Duteau, Lawson, and Spider creeks. With the exception of Spider Creek, all of these creeks have been identified as having extremely high fisheries values as habitat for returning Shuswap River salmon. Water is withdrawn from all these creeks for irrigation, and from some of the creeks for drinking water and stock watering. Flows in these water bodies are regulated by dams.

The major sources of contaminants to these water bodies are woodwaste from numerous operations. The Bell Pole property has the most significant contaminant problem and is a major problem area. Further work should be undertaken at that facility to identify all contaminants generated and to institute management practices to reduce the impact of these contaminants on the environment.

The major impact from the contaminant sources would appear to be the release of chlorophenols from the Bell Pole property to Harris Creek, which raises concentrations in the water, sediment, and biota. In comparison, woodwaste refuse sites are a less significant problem, although still of concern. The Village of Lumby STP which does not have a positive discharge, would seem to be the source of least concern.

Diffuse agricultural sources can also add nutrients and bacteriological contaminants to the different creeks. Water quality objectives have been proposed to address these concerns.

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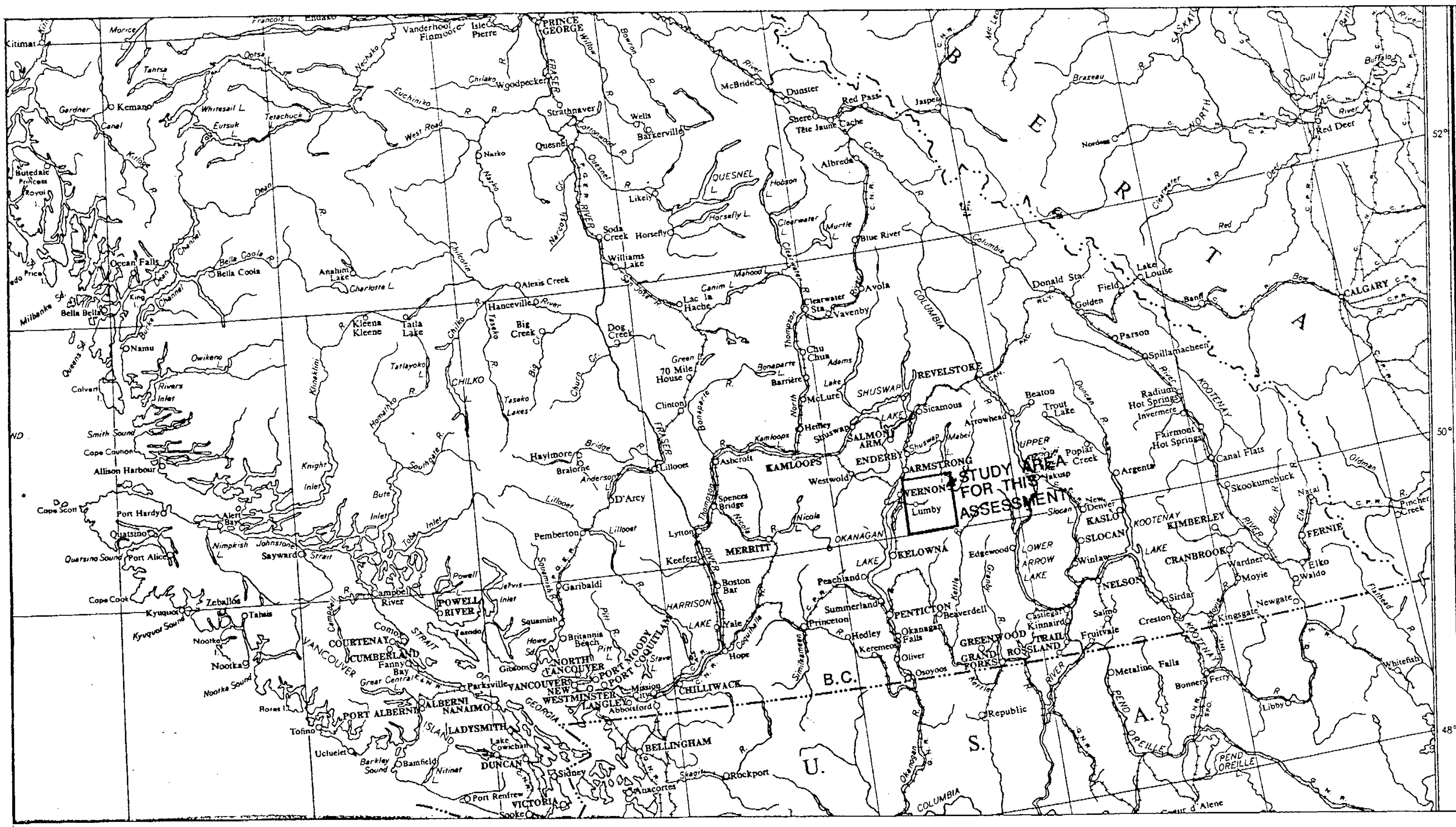

FIGURE 1 : LOCATION MAP

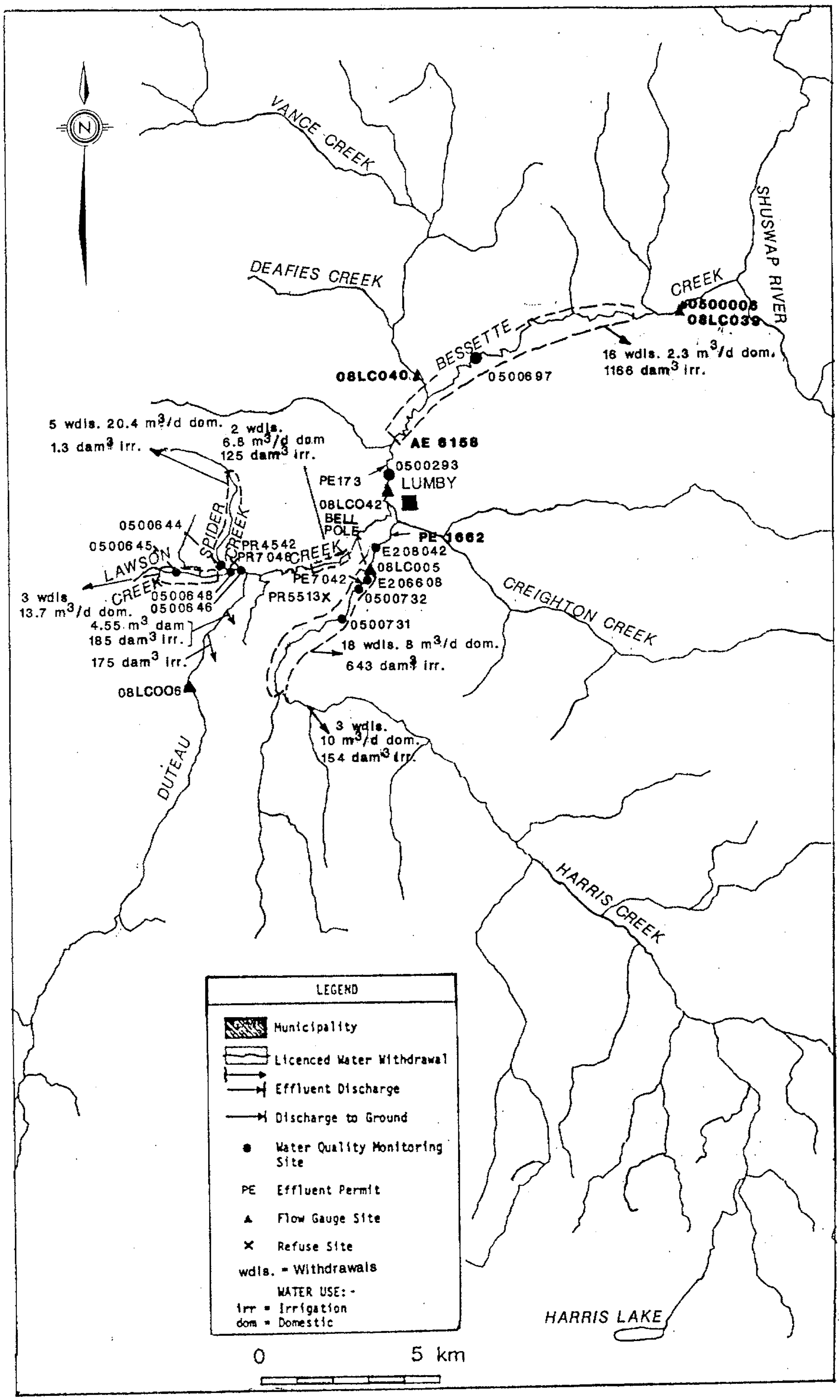

FIGURE 2 : LOCATIONS OF WASTE DISCHARGES, LICENSED WATER WITHDRAWALS, AND AMBIENT WATER QUALITY MONITORING SITES.

TABLE 1
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500645: LAWSON CREEK U/S RIVERSIDE FOREST PRODUCTS

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Resin Acids-Abietic	2	<0.001	<0.001	-	-
-Dehyroabietic	2	<0.001	<0.001	-	-
-Isopimaric	2	<0.001	<0.001	-	-
-Levo Pimaric	2	<0.001	<0.001	-	-
-Neoabietic	2	<0.001	<0.001	-	-
-Pimaric	2	<0.001	<0.001	-	-
-Sandaracopimaric	2	<0.001	<0.001	-	-
Acidity	2	21.1	5.2	13.2	-
Alkalinity	2	212	204	208	-
Carbon-Organic	18	20	<1	3.56	5.43
Chloride	6	41.5	1.9	10.1	15.4
Coliforms-Fecal	2	205	3	104+	-
Colour(True)	2	40	15	27.5	-
(TAC)	24	19	2	7.75	3.98
Hardness-Total	2	394	288	-	-
-Calcium	2	121	87.5	104.3	-
-Magnesium	2	22.2	16.9	19.6	-
Metals (Total)					
-Aluminum	2	0.13	<0.1	0.115	-
-Chromium	2	<0.01	<0.01	-	-
-Copper	2	<0.01	<0.01	-	-
-Iron	2	0.07	0.03	0.05	-
-Manganese	2	0.1	0.04	0.07	-
-Molybdenum	2	0.01	<0.01	-	-
-Nickel	2	<0.05	<0.05	-	-
-Zinc	1	0.006	-	-	-
Microtox(5EC50)	1	>100	-	-	-
(15EC50)	1	>100	-	-	-
Nitrogen					
-Ammonia	36	0.324	<0.005	0.061	0.081
-Kjeldahl	34	2	0.1	0.4	0.46
-Nitrate	32	4.38	0.43	0.81	0.79
-Nitrite	34	0.027	<0.005	0.007	0.005
-Nitrate/ Nitrite	34	4.4	0.43	0.82	0.77
-Organic	32	2	0.09	0.35	0.44
-Total	30	3.86	0.62	1.08	0.74
pH	63	10.0	6.2	7.9+	-
Phenols	30	0.012	<0.002	0.0025	0.0019

TABLE 1 (CONTINUED)

CHARACTERISTIC	NUMBER OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Phosphorus					
-Total Diss	32	0.02	0.004	0.010	0.005
-Total	33	0.268	0.007	0.035	0.052
Potassium	4	5.7	5.2	5.4	0.22
Solids-Dissolved	1	342	-	-	
-Suspended	3	262	1	91	147.9
-Total	1	604	-	-	-
Specific Conductivity	55	895	425	550	116.1
Sulphate	8	331	71.5	148.4	101.8
Tannin & Lignin	29	2.8	0.1	0.44	0.53
Temperature	27	16	1	10	3.5
Turbidity	27	18	0.4	2.0	3.4

PERIOD OF RECORD : 1977-1990

+ Median Value

*All values are as mg L^{-1} except:

1) Coliforms as CFU cL^{-1}
2) Colour as Colour units
3) Microtox as % effluent
4) pH
5) Specific Conductivity as uS cm^{-1}
6) Temperature as °C
7) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT
DATA RETRIEVAL SYSTEM

TABLE 2
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500646: LAWSON CREEK D/S RIVERSIDE FOREST PRODUCTS

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Resin Acids-Abietic	3	<0.001	<0.001	<0.001	-
-Dehydroabietic	3	<0.001	<0.001	<0.001	-
-Isopimaric	3	<0.001	<0.001	<0.001	-
-Levo Pimaric	3	<0.001	<0.001	<0.001	-
-Neoabietic	3	<0.001	<0.001	<0.001	-
-Pimaric	3	<0.001	<0.001	<0.001	-
-Sandaracopimaric	3	<0.001	<0.001	<0.001	-
Acidity	2	14.3	5.1	9.7	-
Alkalinity	2	246	232	239	-
Carbon-Organic -Total	11	3	<1	1.2	0.6
Chloride	4	39.9	4.5	14.8	16.9
Coliforms-Fecal	2	47	4	-	-
Hardness-Total	1	400	-	-	-
-Calcium	1	123	-	-	-
-Magnesium	1	22.6	-	-	-
Metals (Total)					
-Aluminum	1	0.1	-	-	-
-Chromium	1	<0.01	-	-	-
-Copper	1	<0.01	-	-	-
-Iron	1	0.25	-	-	-
-Manganese	1	0.15	-	-	-
-Molybdenum	1	0.01	-	-	-
-Vanadium	1	0.04	-	-	-
-Zinc	1	0.01	-	-	-
Microtox (5EC50)	2	>100	>100	-	-
(15EC50)	2	>10	>100	-	-
Nitrogen					
-Ammonia	16	0.121	0.007	0.032	0.034
-Kjeldahl	14	0.66	0.14	0.24	0.13
-Nitrate	12	0.65	0.45	0.54	0.05
-Nitrite	14	0.009	<0.005	0.006	0.002
-Nitrate/ Nitrite	14	0.69	0.45	0.56	0.06
-Organic	12	0.34	0.13	0.19	0.06
-Total	12	1	0.63	0.75	0.10
pH	28	8.3	6.9	7.85+	-
Phenols	15	0.054	<0.002	0.006	0.013

TABLE 2 (CONTINUED)

CHARACTERISTIC	NUMBER OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Phosphorus					
-Total Diss	14	0.023	0.006	0.011	0.006
-Total	14	0.104	0.008	0.023	0.026
Potassium	4	6.2	2.7	5.15	1.64
Solids-Dissolved	2	540	388	464	-
-Suspended	2	13	4	8.5	-
Specific Conductivity	27	770	440	521	89.1
Tannin & Lignin	12	0.6	0.2	0.27	0.12
Temperature	12	14	8	11.5	1.8
Turbidity	13	1.8	0.6	1.0	0.43

PERIOD OF RECORD : 1978-1990

+ Median Value

*All values are as mg L^{-1} except:
1) Coliforms as CFU cL^{-1}
2) Microtox as %
3) pH
4) Specific Conductivity as uS cm^{-1}
5) Temperature as °C
6) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT
DATA RETRIEVAL SYSTEM

TABLE 3
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500648: LAWSON CREEK U/S DUTEAU CREEK

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Acidity	3	5.6	3.3	4.1	-
Alkalinity	1	191	-	-	-
Carbon-Organic -Total	18	13	<1	4	4.4
Chloride	1	3.8	-	-	-
Colour TAC	23	23	4	10.5	4.7
Colour true	1	40	-	-	-
Metals (Total)					
-Cadmium	1	<0.0005	-	-	-
-Copper	1	<0.001	-	-	-
-Iron	1	0.5	-	-	-
-Lead	1	<0.001	-	-	-
-Manganese	1	0.16	-	-	-
-Mercury	1	<0.00005	-	-	-
-Molybdenum	1	0.0091	-	-	-
-Zinc	2	0.01	0.007	0.0085	-
Nitrogen					
-Ammonia	30	0.328	0.009	0.056	0.079
-Kjeldahl	30	4	0.064	0.60	0.76
-Nitrate	30	4.07	0.11	0.67	0.78
-Nitrite	30	0.034	<0.005	0.009	0.007
-Nitrate/ Nitrite	30	4.1	0.12	0.68	0.79
-Organic	29	3.88	0.04	0.58	0.76
-Total	28	5	0.46	1.10	0.89
pH	58	9.9	6.0	7.8+	-
Phenols	28	0.008	<0.002	0.003	0.001
Phosphorus					
-Total Diss	29	0.025	0.007	0.015	0.005
-Total	29	0.137	0.011	0.041	0.033
Specific Conductivity	49	863	390	563	99
Sulphate	7	305	73.9	151.5	94.6
Tannin & Lignin	28	1	0.2	0.47	0.23
Temperature	28	16	1	10.7	3.7
Turbidity	25	28	0.5	4.2	6.9

PERIOD OF RECORD : 1978-1984   + Median Value

*All values are as mg L^{-1} except:

1) Colour as Colour units
2) pH
3) Specific Conductivity as uS cm^{-1}
4) Temperature as °C
5) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500643: SPIDER CREEK U/S RIVERSIDE FOREST PRODUCTS

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM
Acidity	1	2.7	-
Chloride	2	2.2	1.3
Microtox (5EC50)	1	>100	-
(15EC50)	1	>100	-
Nitrogen			
-Ammonia	2	0.011	<0.005
-Kjeldahl	2	2.32	0.22
-Nitrite	2	<0.005	<0.005
-Nitrate/ Nitrite	2	0.14	<0.02
pH	2	8.3	8.2
Phenols	1	0.002	-
Phosphorus			
-Total Diss	2	0.078	0.043
-Total	2	0.115	0.068
Potassium	2	8	4.6
Specific Conductivity	2	722	456
Turbidity	1	4.7	-

PERIOD OF RECORD : 1986-1987

+ Median Value

*All values are as mg L^{-1} except:
1) pH
2) Microtox as %
3) Specific Conductivity as uS cm^{-1}
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 5
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500644: SPIDER CREEK D/S RIVERSIDE FOREST PRODUCTS

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM
Acidity	1	30.3	-
Chloride	2	9.5	2.1
Micrtox (5EC50)	1	>100	-
(15EC50)	1	>100	-
Nitrogen			
-Ammonia	2	0.022	<0.005
-Kjeldahl	2	0.4	0.22
-Nitrite	2	0.005	<0.005
-Nitrate/ Nitrite	2	0.23	<0.02
pH	2	8.0	7.5
Phosphorus			
-Total Diss	3	0.047	0.044
-Total	2	0.085	0.071
Potassium	2	8.6	5.0
Specific Conductivity	2	890	490
Turbidity	1	3.7	-

PERIOD OF RECORD : 1986-1987

+ Median Value

*All values are as mg L^{-1} except:
1) pH
2) Microtox as %
3) Specific Conductivity as uS cm^{-1}
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 6

AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.6	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.7	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.8	2.08	2.05	2.02	1.99	1.96	1.94	1.92	1.90	1.88	1.86	1.84
6.9	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.2	2.08	2.05	2.02	1.99	1.96	1.95	1.92	1.90	1.88	1.86	1.85
7.3	2.08	2.05	2.02	1.99	1.97	1.95	1.92	1.90	1.88	1.86	1.85
7.4	2.08	2.05	2.02	2.00	1.97	1.95	1.92	1.90	1.88	1.87	1.85
7.5	2.08	2.05	2.02	2.00	1.97	1.95	1.93	1.91	1.88	1.87	1.85
7.6	2.09	2.05	2.03	2.00	1.97	1.95	1.93	1.91	1.89	1.87	1.85
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93	1.91	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.59
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161	0.160	0.160	0.160	0.160
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.6	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.7	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.8	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.42	1.32	1.22
6.9	1.82	1.81	1.80	1.78	1.77	1.64	1.53	1.42	1.32	1.22
7.0	1.83	1.81	1.80	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	1.83	1.81	1.80	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	1.83	1.81	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	1.83	1.82	1.81	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	1.84	1.82	1.81	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 6.
- each measured value is compared to the corresponding individual values in Table 6. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding objective values in Table 6.

TABLE 7

MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26.0	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25.0	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7	22.5	22.2	22.0	21.8
7.0	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19.0	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16.0
7.4	16.2	16.0	15.7	15.5	15.3	15.2	15.0	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14.0	13.8	13.6	13.4	13.3	13.1	13.0	12.9	12.7
7.6	12.6	12.4	12.2	12.0	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10.0	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.40	8.32	8.25
7.9	7.82	7.71	7.60	7.51	7.42	7.33	7.25	7.17	7.10	7.04	6.98
8.0	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.90	4.84	4.80	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.90	3.86	3.83	3.80	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.40
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.60	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.831
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681	0.681	0.680	0.681	0.682

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	25.2	25.0	24.8	24.6	24.5	24.3	24.2	24.0	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23.0	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22.0	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21.0	20.8	20.7	20.6	20.5	20.4
7.0	20.3	20.2	20.0	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18.0	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14.0	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12.0
7.6	11.1	11.0	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.50	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.90	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8.0	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.60
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.50	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.90	1.90	1.90	1.90	1.90	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.684	0.688	0.692	0.698	0.704	0.711	0.720	0.729	0.740	0.752

TABLE 8

CRITERIA FOR NITRITE-N FOR PROTECTION OF FRESHWATER AQUATIC LIFE

	Concentration (mg $L^{-1}N$)	
Chloride	Maximum Nitrite-N	30-day Average Nitrite-N
<2	0.06	0.02
2-4	0.12	0.04
4-6	0.18	0.06
6-8	0.24	0.08
8-10	0.30	0.10
>10	0.60	0.20

NOTE: The 30-d average chloride concentration should be used to determine the appropriate 30-d average nitrite concentration .

SOURCE: REFERENCE 8

TABLE 9

CRITERIA FOR RESIN ACIDS FOR PROTECTION OF FRESHWATER AQUATIC LIFE

Maximum Concentration (ug L^{-1})		
pH	Dehydroabietic Acid	Total Resin Acids
5.0	1	1
5.5	2	3
6.0	2	4
6.5	4	9
7.0	8	25
7.5	12	45
8.0	13	52
8.5	14	60
9.0	14	62

SOURCE: REFERENCE 13

TABLE 10
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500731: HARRIS CREEK U/S PR 5513

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Acidity	2	1.6	1.4	-	-
Carbon-Organic	1	9	-	-	-
Nitrogen					
-Ammonia	8	0.029	<0.005	0.014	0.009
-Kjeldahl	8	0.49	0.11	0.23	0.12
-Nitrate	4	0.02	<0.02	<0.02	-
-Nitrite	4	<0.005	<0.005	-	-
-Nitrate/ Nitrite	8	0.02	<0.02	-	-
-Organic	8	0.46	0.1	0.22	0.11
-Total	8	0.49	0.13	0.24	0.12
Oxygen-BOD	1	<10	-	-	-
pH	11	8.2	6.8	7.8⁺	-
Phenols	6	0.006	<0.002	0.003	0.0015
Phosphorus					
-Total Diss	4	0.041	0.014	0.024	0.011
-Total	4	0.447	0.017	0.139	0.206
Solids-Dissolved	2	128	64	-	-
-Suspended	1	14	-	-	-
-Total	1	142	-	-	-
Specific Conductivity	10	167	25	92	39.6
Tannin & Lignin	6	1.8	0.5	1.0	0.5
Temperature	3	20	7	12	4
Turbidity	1	1.8	-	-	-

PERIOD OF RECORD : 1980-1983

⁺ Median Value

*All values are as mg L^{-1} except:
1) pH
2) Specific Conductivity as uS cm^{-1}
3) Temperature as °C
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 13
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500732: HARRIS CREEK D/S PR 5513

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Acidity	3	2.3	1.3	1.7	0.55
Carbon-Organic	1	11	-	-	-
Nitrogen					
-Ammonia	9	0.028	<0.005	0.013	0.008
-Kjeldahl	9	0.55	0.09	0.25	0.14
-Nitrate	4	0.03	<0.02	<0.02	-
-Nitrite	4	<0.005	<0.005	-	-
-Nitrate/ Nitrite	9	0.03	<0.02	-	-
-Organic	9	0.52	0.09	0.24	0.13
-Total	9	0.55	0.09	0.26	0.13
Oxygen-BOD	1	<10	-	-	-
pH	12	8.2	6.7	7.8+	-
Phenols	7	0.009	<0.002	0.004	0.0025
Phosphorus					
-Total Diss	5	0.037	0.018	0.024	0.008
-Total	5	0.427	0.022	0.137	0.194
Solids-Dissolved	2	136	62	-	-
-Suspended	1	12	-	-	-
-Total	1	148	-	-	-
Specific Conductivity	11	172	26	92	38.9
Tannin & Lignin	7	1.8	0.5	0.9	0.5
Temperature	3	20	7	12	7
Turbidity	1	1.1	-	-	-

PERIOD OF RECORD : 1980-1983

+ Median Value

*All values are as mg L^{-1} except:
1) pH
2) Specific Conductivity as uS cm^{-1}
3) Temperature as °C
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 12
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500293: BESSETTE CREEK U/S LUMBY STP

CHARACTERISTIC	NUMBER OF VALUES	VALUES* MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Acidity	2	2	1.6	-	-
Alkalinity	14	187	23.6	104.2	53.3
Carbon-Organic	4	12	4	8.3	3.3
Chloride	32	6.2	0.8	2.3	1.2
Coliforms-Fecal	5	400	7	64+	-
Colour (True)	4	50	10	32.5	17.1
(TAC)	3	53	9	34.7	22.9
Hardness-Total	6	219	24	111	79.9
-Calcium	9	66.5	7.3	31.9	20.2
-Magnesium	9	12.9	1.4	6.5	3.6
Metals-Arsenic(T)	2	0.005	<0.005	-	-
-Cadmium(D)	1	<0.0005	-	-	-
-Cadmium(T)	2	<0.0005	<0.0005	-	-
-Chromium(D)	1	<0.01	-	-	-
-Chromium(T)	1	<0.01	-	-	-
-Copper(D)	1	0.002	-	-	-
-Copper(T)	4	0.005	<0.001	0.003	0.002
-Iron(D)	2	0.25	0.22	-	-
-Iron(T)	6	0.9	0.32	0.57	0.24
-Lead(D)	2	0.001	<0.001	-	-
-Lead(T)	3	0.001	<0.001	<0.001+	-
-Manganese(D)	2	0.05	0.04	-	-
-Manganese(T)	4	0.05	0.02	0.035	0.013
-Mercury(T)	1	<0.00005	-	-	-
-Molybdenum(D)	2	<0.01	<0.01	-	-
-Molybdenum(T)	2	<0.01	<0.01	-	-
-Nickel(T)	2	0.05	<0.05	-	-
-Zinc(D)	1	<0.005	-	-	-
-Zinc(T)	4	<0.005	<0.005	<0.005	-
Nitrogen					
-Ammonia	46	0.088	<0.005	0.016	0.016
-Kjeldahl	47	0.52	0.12	0.25	0.09
-Nitrate	17	0.3	<0.02	0.13	0.10
-Nitrite	44	0.007	<0.005	<0.005+	-
-Nitrate/ Nitrite	43	0.35	<0.02	0.13	0.11
-Organic	24	0.44	0.1	0.23	0.09
-Total	27	0.76	0.12	0.34	0.14

TABLE 12 (CONTINUED)

CHARACTERISTIC	NUMBER OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Oxygen-BOD	5	<10	<10	<10	-
-Dissolved	10	15.2	9.6	11.7	1.5
-% Saturation	10	119.7	86.8	100.5	9.8
pH	61	9.2	6.9	7.9+	-
Phenols	5	0.005	<0.002	0.003	0.002
Phosphorus					
-Ortho Diss	7	0.036	0.012	0.018	0.008
-Total Diss	39	0.04	0.007	0.022	0.006
-Total	49	0.133	0.019	0.042	0.025
Potassium	8	4.3	0.8	2.5	1.2
Sodium	29	10.5	2.1	5.7	2.0
Solids-Dissolved	17	309	62	170	68
-Suspended	19	28	1	8	8.9
-Total	17	318	91	179	63.5
Specific Conductivity	63	455	60	232	100
Tannin & Lignin	10	1.9	0.3	1.02	0.5
Temperature	16	20.5	1	7.5	5.2
Turbidity	33	18	0.7	3.3	3.9

PERIOD OF RECORD : 1973-1989

+ Median Value

*All values are as mg L^{-1} except:
1) Coliforms as CFU cL^{-1}
2) Colour as Colour units
3) % Sat as percent
4) pH
5) Specific Conductivity as uS cm^{-1}
6) Temperature as °C
7) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 13
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500697: BESSETTE CREEK D/S LUMBY

CHARACTERISTIC	NUMBER OF VALUES	MAXIMUM	VALUES[*] MINIMUM	MEAN	STANDARD DEVIATION
Acidity	2	1.7	1.5	-	-
Alkalinity	1	130	-	-	-
Chloride	1	3	-	-	-
Coliforms-Fecal	1	30	-	-	-
Hardness-Total	2	137	83.5	-	-
-Calcium	2	42	22	-	-
-Magnesium	2	7.82	6.95	-	-
Metals-Arsenic(D)	1	<0.005	-	-	-
-Arsenic(T)	6	0.008	<0.005	<0.005[+]	-
-Cadmium(D)	5	<0.0005	<0.0005	<0.0005	-
-Cadmium(T)	1	<0.0005	-	-	-
-Copper(D)	7	0.011	<0.001	0.004	0.004
-Copper(T)	4	0.005	<0.001	0.002	0.002
-Iron(D)	7	0.3	0.1	0.17	0.09
-Iron(T)	4	0.4	0.25	0.33	0.07
-Lead(D)	7	0.002	<0.001	<0.001[+]	-
-Lead(T)	4	0.001	<0.001	<0.001[+]	-
-Manganese(D)	2	0.04	0.03	-	-
-Manganese(T)	2	0.05	0.03	-	-
-Molybdenum(D)	2	<0.01	<0.01	-	-
-Molybdenum(T)	2	<0.01	<0.01	-	-
-Zinc(D)	6	0.05	<0.005	<0.005[+]	-
-Zinc(T)	4	<0.005	<0.005	-	-
Nitrogen					
-Ammonia	3	0.016	0.008	0.011	0.005
-Kjeldahl	2	0.34	0.21	-	-
-Nitrate	2	0.06	0.04	-	-
-Nitrite	3	0.005	<0.005	<0.005[+]	-
-Nitrate/ Nitrite	3	0.12	0.04	0.07	0.04
-Organic	2	0.33	0.19	-	-
-Total	2	0.38	0.27	-	-
Oxygen-Dissolved	4	11.8	10.1	11.2	0.8
-% Saturation	4	113.1	95.2	104.7	7.5
pH	15	8.9	7.4	8.1[+]	-

TABLE 13 (CONTINUED)

CHARACTERISTIC	NUMBER OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Phosphorus					
-Ortho Diss	1	0.02	-	-	-
-Total Diss	4	0.036	0.021	0.029	0.007
-Total	7	0.15	0.026	0.061	0.05
Solids-Dissolved	1	198	-	-	-
-Suspended	1	1	-	-	-
Specific Conductivity	14	440	96	252	116.5
Tannin & Lignin	2	1.8	0.9	-	-
Temperature	7	16	2.5	9.6	5.1
Turbidity	5	21	0.8	6.2	8.6

PERIOD OF RECORD : 1979-1989

+ Median Value

*All values are as mg L^{-1} except:
1) Coliforms as CFU cL^{-1}
2) % Saturation as percent
3) pH
4) Specific Conductivity as uS cm^{-1}
5) Temperature as °C
6) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 14
AMBIENT WATER QUALITY DATA SUMMARY
SITE 0500006: BESSETTE CREEK AT MOUTH

CHARACTERISTIC	NUMBER OF VALUES	VALUES*			
		MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Alkalinity	18	190	37.9	118.1	46.6
Carbon-Organic	13	26	2	9.2	6.33
Chloride	21	3.9	0.8	1.7	0.76
Coliforms-Fecal	6	350	20	80+	-
Colour	14	60	5	24.3	18.8
Hardness-Total	19	225	40.2	140.3	54.3
-Calcium	21	69	12.8	42.9	15.7
-Magnesium	20	12.8	2	7.39	3.25
Metals					
-Aluminum(D)	1	0.02	-	-	-
-Cadmium(D)	11	<0.01	<0.0001	<0.0005+	-
-Cadmium(T)	3	<0.0005	<0.0005	<0.0005	-
-Chromium(D)	7	<0.01	<0.005	<0.005+	-
-Chromium(T)	2	0.007	<0.005	-	-
-Copper(D)	14	<0.01	<0.001	0.0035	0.0027
-Copper(T)	6	0.006	0.001	0.0033	0.0021
-Iron(D)	16	0.36	<0.04	0.15	0.09
-Iron(T)	10	3.7	0.3	1.43	1.41
-Lead(T)	5	0.002	<0.001	<0.001+	-
-Manganese(D)	13	0.06	0.01	0.029	0.013
-Manganese(T)	6	0.13	<0.02	0.06	0.043
-Mercury(D)	1	<0.00005	-	-	-
-Mercury(T)	10	<0.00005	<0.00005	<0.00005	-
-Molybdenum(D)	1	<0.01	-	-	-
-Molybdenum(T)	1	0.0005	-	-	-
-Nickel(D)	7	<0.05	<0.01	<0.01+	-
-Nickel(T)	3	0.01	<0.01	<0.01+	-
-Zinc(D)	11	0.05	<0.005	0.012	0.014
-Zinc(T)	8	0.011	<0.005	0.006	0.002
Nitrogen					
-Ammonia	17	0.115	0.005	0.029	0.029
-Kjeldahl	24	0.68	0.08	0.26	0.15
-Nitrate	11	0.47	0.03	0.13	0.14
-Nitrite	21	0.01	<0.005	<0.005+	-
-Nitrate/ Nitrite	20	0.48	<0.02	0.136	0.138
-Organic	21	0.42	0.04	0.25	0.10
-Total	26	0.936	0.09	0.38	0.19

TABLE 14 (CONTINUED)

CHARACTERISTIC	NUMBER OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Oxygen-Dissolved	16	13.6	8.9	11.6	1.22
-% Saturation	16	116.3	88.9	100.3	6.85
pH	42	8.7	6.7	8.1+	-
Phenols	7	0.006	<0.002	0.003	0.002
Phosphorus					
-Ortho Diss	11	0.058	0.009	0.026	0.017
-Total Diss	12	0.059	0.017	0.027	0.011
-Total	29	0.268	0.016	0.073	0.060
Solids-Dissolved	4	256	80	155.5	86.8
-Suspended	18	195	2	31.6	49.9
-Total	19	434	134	235	67.3
Specific Conductivity	43	465	90	275	112.2
Sulphate	21	57.8	8.8	30.8	14.9
Tannin and Lignin	10	1.8	0.2	0.83	0.54
Temperature	24	21.5	0.0	7.7	5.76
Turbidity	18	65	0.9	14.4	20.4

PERIOD OF RECORD : 1972-1982

+ Median Value

*All values are as mg L^{-1} except:

1) Coliforms as MPN/100mL
2) Colour as Colour units
3) % Saturation as percent
4) pH
5) Specific Conductivity as uS cm^{-1}
6) Temperature as °C
7) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

TABLE 15

DRAFT
CRITERIA FOR CHLOROPHENOLS FOR PROTECTION OF FRESHWATER AQUATIC LIFE

Concentration (ug L^{-1})		
COMPOUND Chlorophenol	0.03 x 96-h LC50	Lowest Value (Assumed Maximum Criterion)
2-mono	1.06	
3-mono	0.94	0.5
4-mono	0.48	
2,3-di	0.31	
2,4-di	0.16	
2,5-di	0.14	0.1
2,6-di	0.56	
3,4-di	0.16	
3,5-di	0.12	
2,3,4-tri	0.13	
2,3,5-tri	0.14	
2,3,6-tri	0.44	0.05
2,4,5-tri	0.12	
2,4,6-tri	0.32	
3,4,5-tri	0.05	
2,3,4,5-tetra	0.10	
2,3,4,6-tetra	0.30	0.10
2,3,5,6-tetra	0.13	
2,3,4,5,6-penta	0.05	0.05

SOURCE: REFERENCE 20