Brief presented to the British Columbia Pollution Control Board Inquiry Pertaining to the Annacis Island Sewage Treatment Plant and Municipal Waste Discharges into the Lower Fraser River

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Canadian Industry Report of Fisheries

and Aquatic Sciences No. 126

June 1981

BRIEF PRESENTED TO THE BRITISH COLUMBIA POLLUTION CONTROL BOARD INQUIRY PERTAINING TO THE ANNACIS ISLAND SEWAGE TREATMENT PLANT AND MUNICIPAL WASTE DISCHARGES INTO THE LOWER FRASER RIVER

by

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PREFACE

In September 1979 Dr. C. J. G. Mackenzie, chairman of the Pollution Control Board, province of British Columbia, invited the Department of Fisheries and Oceans (D.F.O.) to present testimony at a public hearing to be held in Vancouver, British Columbia, during February 1980. The hearing was to consider the adequacy of the provincial government's Municipal Type Waste Objectives to protect the lower Fraser River from a "polluted condition" and, in particular to address the level of treatment provided at the Annacis Island sewage treatment plant.

The invitation to participate in the hearings was accepted by the Director General on behalf of the Pacific and Yukon Region of D.F.O.

A brief was prepared in conjunction with the International Pacific Salmon Fisheries Commission (IPSFC) and presented by Dr. I.K. Birtwell (Resource Services Branch, D.F.O.) to the Pollution Control Board and its advisory panel comprising the following representatives:

E. H. Vernon, (Co-ordinator) Special Advisor, Fisheries, Ministry of Environment; Member, Pollution Control Board

A. L. H. Gameson, Head, Coasts & Estuaries Division, Water Research Centre, Stevenage Laboratory, Stevenage, Herts, England.

J. E. Dew-Jones, Chief, Resource Recovery Division, Waste Management Branch, Ministry of Environment

H. D. C. Hunter, Barrister & Solicitor: Member, Pollution Control Board

Randolph Martin, retired City Engineer, City of Vancouver

R. Rocchini, Environmental Studies Division, Ministry of Environment; Chairman, Water Quality Work Group - Fraser River Estuary Study.

During crossexamination of the D.F.O./I.P.S.F.C. brief technical advice was provided by the following staff: Drs. I. K. Birtwell, J. C. Davis, I. H. Rogers, J. A. Servizi (IPSFC), M. Waldichuk; M. D. Nassichuk and M. Hobbs.

This document presents the brief together with a summary given at the conclusion of the hearing and provides supplementary information which was requested by the chairman of the Pollution Control Board.

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ABSTRACT

Birtwell, I. K., J. C. Davis, M. Hobbs, M. D. Nassichuk, M. Waldichuk and J. A. Servizi. 1981. Brief presented to the British Columbia pollution control board inquiry pertaining to the Annacis Island sewage treatment plant and municipal waste discharges into the lower Fraser River. Can. Ind. Rep. Fish. Aquat. Sci. 126: xi + 40 p.

Information on the biological resources of the lower Fraser River, associated economic considerations and the effects of municipal waste disposal comprise this joint Department of Fisheries and Oceans and International Pacific Salmon Fisheries Commission brief. The brief was prepared for, and presented at, a public hearing held by the government of British Columbia, February 1980, Vancouver, B.C. The hearing was related to the Annacis Island sewage treatment plant which discharges primary treated effluent into the Fraser River, and the adequacy of the provincial government's Municipal Type Waste Objectives to protect these waters from a polluted condition.

Key words: municipal wastes, Fraser River, salmonids, fishery values, toxicity,sublethal effects, effluent regulation.

RÉSUMÉ

Birtwell, I. K., J. C. Davis, M. Hobbs, M. D. Nassichuk, M. Waldichuk and J. A. Servizi. 1981. Brief presented to the British Columbia pollution control board inquiry pertaining to the Annacis Island sewage treatment plant and municipal waste discharges into the lower Fraser River. Can. Ind. Rep. Fish. Aquat. Sci. 126: xi + 40 p.

Ce mémoire conjoint du ministère des Pêches et des Océans et de la Commission internationale de la pêche du saumon dans le Pacifique traite des ressources biologiques de la partie inférieure du fleuve Fraser, des questions économiques qui y sont rattachées ainsi que des effets de l'évacuation des eaux d'égoût par les municipalités. Le mémoire, qui avait été préparé pour l'occasion, a été présenté à une audience publique qu'a tenue le gouvernement de la Colombie-Britannique à Vancouver (C.-B.) en février 1980. L'audience portait sur l'usine de traitement des eaux usées de l'île Annacis, qui déverse dans le fleuve Fraser les eaux d'égoût après leur avoir fait subir un traitement primaire, ainsi que sur le bien-fondé des objectifs du gouvernement provincial concernant les eaux d'égoût municipales en vue d'empêcher la pollution de l'eau.

Mots-cles: eaux d'égoût municipales, fleuve Fraser, salmonidés, valeurs halieutiques, toxicité, effets sous-léthals, réglementation sur les effluents.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are abstracted from the main text of the brief. Attention has been deliberately given to the Annacis Island sewage treatment plant and protection of the salmon resources of the Fraser River. Implicit in this approach is the recognition that measures taken to protect salmon and their aquatic habitat will undoubtedly benefit other aquatic organisms and their habitats.

CONCLUSIONS

Effluent Dilution and Dispersal

Elevated levels of certain constituents of sewage effluent have been found in waters receiving effluent from the Annacis Island sewage treatment plant, even though all measured constituents of the effluent were reported to be within Pollution Control Branch level BB objectives, for this type of discharge.

Effluent dispersion and dilution was reduced at times of slack tide, resulting in pooling and layering of the effluent in surface receiving waters. At about half the projected maximum effluent flow from the Annacis Island sewage treatment plant, predicted effluent dispersal under conditions of minimum dilution will be in contradiction with the description for the "initial dilution zone" given by the Pollution Control Branch (PCB 1975). It is anticipated that dilution will be less at times of maximum effluent discharge and low river flows.

The "initial dilution zone" concept, wherein Pollution Control Branch objectives for the receiving environment do not apply, does not afford maximum protection to aquatic organisms.

Effluent Contact with Juvenile Salmon

Migrating and rearing juvenile salmon are frequently present close to the water surface in the lower sections of rivers and in estuaries. Effluent from the Annacis Island sewage treatment plant is discharged into the South Arm of the Fraser River which is used by large numbers of salmon. The possibility of juvenile salmon encountering surface water concentrations of this effluent will be greater at times of reduced effluent dispersion and dilution (as may occur under low freshwater flow conditions, e.g. March and early April, when very high numbers of juvenile salmon are migrating seaward) than under conditions of maximum effluent dilution and dispersal (periods of high freshwater flow).

Dissolved Oxygen

Dissolved oxygen levels in sewage effluent from the Annacis Island sewage treatment plant are below air saturation, and reductions in the levels of dissolved oxygen proximal to the outfall have been recorded. It is anticipated that greater reductions in the levels of dissolved oxygen in the receiving waters will occur at times of maximum effluent discharge rates and low river flow (conditions of minimum dilution and dispersion). Such water quality conditions are of concern due to the presence of juvenile salmon in these surface waters, particularly in relation to the increased sensitivity of aquatic organisms which generally occurs when they are exposed to toxic and sublethal levels of pollutants at relatively low levels of dissolved oxygen. Such effects could be particularly significant in slow-flowing and poorly-flushed side channels and sloughs.

Effluent Toxicity and Sublethal Effects

The acute toxicity of effluent from the Annacis Island sewage treatment plant did not decrease between 1976 and 1979, and the 96h LC50 value remained substantially less than 75% $^{v}/v$. Accordingly, the effluent toxicity level does not meet the criteria given in PCB Permit PE-387 (level BB criteria, PCB Municipal Type Waste Objectives).

Effluent from the Annacis Island sewage treatment plant contains organic compounds, some of which are known to accumulate in aquatic organisms and to produce sublethal effects. These effluent constituents are not routinely monitored nor specified under the conditions of PCB Permit PE-387. There is a paucity of information on the quantities, fate, distribution and effects of these compounds in the aquatic environment.

Heavy metals are discharged in effluent from the Annacis Island sewage treatment plant. It is of major concern that there is evidence of accumulation of heavy metals, to levels approaching or exceeding recommended values in aquatic animal products in some commercially harvested organisms within the lower Fraser River and estuary. Heavy metals levels in the effluent from the Annacis Island sewage treatment plant may contribute to acute toxicity, and exert sublethal effects on a variety of aquatic organisms.

Monitoring

In January, 1979, the Pollution Control Branch eliminated the requirement of the Greater Vancouver Sewerage and Drainage District to monitor the receiving environment at three sewage treatment plants on the lower Fraser River. Evidence of sewage contamination was found in the receiving waters adjacent to two of these plants (Annacis Island, Iona Island) prior to elimination of the monitoring requirements.

Municipal Type Waste Objectives

Recent information suggests that the Municipal Waste Type Objectives are not adequate to protect the aquatic environment (e.g. lower

Fraser River) from a condition of pollution that imposes an unacceptable risk upon the fishery resource and its supporting habitat.

RECOMMENDATIONS

Effluent from the Annacis Island Sewage Treatment Plant

A routine (at least quarterly) comprehensive analysis of effluent from the sewage treatment plant is required. Particular emphasis should be placed upon the determination of concentrations of organic compounds in the effluent.

The toxicity of effluent from the sewage treatment plant should be routinely determined, at least monthly, using the most sensitive testing method, and samples of the effluent which is to be discharged. Continuous flow bioassays are recommended using juvenile salmonids as the test organisms.

Effluent toxicity should be reduced to produce an effluent with a 96 h LC50 equal to 100% $^{v}/v$ (Municipal Type Waste Objectives, level AA criteria).

Effluent quality should be improved to minimize any effects on receiving waters and aquatic organisms. Of particular concern is the reduction of effluent constituents (e.g. heavy metals, organic compounds) which can be a) acutely toxic to aquatic organisms or produce sublethal effects, and b) persistent and accumulated by aquatic organisms in the lower Fraser River and estuary. Implicit in this recommendation is the requirement to instigate and enforce a "source control" program to elevate the quality of effluents entering the sewerage system to the Annacis Island sewage treatment plant. In addition, secondary treatment should be provided at the Annacis Island sewage treatment plant to ensure the attainment of the above-mentioned effluent quality requirements.

Implementation of a comprehensive "source control" program in the lower B.C. mainland and provision of additional treatment at the Annacis Island sewage treatment plant should occur, ideally, in 1980.

Receiving Waters

It is essential that dissolved oxygen levels in the receiving environment are, at all times, maintained above 70% of air saturation for the protection of important fishery stocks using the lower Fraser River and estuary.

The use of an "initial dilution zone" in which Municipal Type Waste objectives do not apply should be discontinued. Such an approach is inconsistent with maintaining the integrity of receiving waters for the protection of aquatic organisms.

The dilution capacity of receiving waters should not be used as the primary means to eliminate or reduce the effects of pollutants. Effluents discharged to the Fraser River cannot be considered in isolation from other discharges in relation to the impact upon aquatic organisms. It is recommended that effluent quality is improved, and detoxification occurs prior to discharge so that the dilution capacity of the receiving waters will act as a safety factor; thus reducing the risk of adverse effects to aquatic ortanisms from effluent constituents.

Environmental monitoring programs (chemical, physical and biological) must be undertaken in the lower Fraser River to document the changes (beneficial or detrimental) of municipal waste discharges. In view of proposed additional sewerage connections and increased effluent discharges, a high priority should be given to reinstituting a monitoring program to assess the impact of effluent from the Annacis Island sewage treatment plant upon the lower Fraser River.

General

Clarification of the responsibility for implementing a contaminant "source control" program is required, together with the appropriate delegation (to the Greater Vancouver Sewerage and Drainage District) or acceptance (by the Pollution Control Branch) to undertake such a program.

It is essential that a detailed review of the Municipal Type Waste Objectives is undertaken. However, it is equally important to determine if "permittees" comply with PCB permit stipulations, and that surveillance capabilities are adequate to enforce such stipulations.

1. INTRODUCTION

This brief is submitted on behalf of the Department of Fisheries and Oceans (DFO) in accordance with the Department's mandate in British Columbia, pursuant to the Fisheries Act, to manage, protect, enhance and regulate Canada's salmon, saltwater fishes, shellfish, and marine mammals and plants. The International Pacific Salmon Fisheries Commission (IPSFC) assisted DFO staff in the preparation of this document.

We appreciate the opportunity to express our opinions regarding the Annacis Island sewage treatment plant and the adequacy of the provincial government's Municipal Type Waste Objectives for the protection of the lower Fraser River from a polluted condition. At this time, we consider it appropriate to confine most of our comments to the Annacis Island sewage treatment plant and protection of fishery resources. A joint federal-provincial project to document the environmental condition of the Fraser estuary is currently imcomplete and information from this project should be relevant to any assessment of the protection of the estuary from pollutants. Furthermore, the DFO and IPSFC are currently undertaking and proposing research designed to assess the impact of discharges of municipal wastes on fish, freshwater and estuarine receiving environments (Table 1, Appendix 1). It is envisaged that the information obtained through the research projects and that provided by the joint federal-provincial project will form the basis of a submission by the Department of Fisheries and Oceans at the future hearings concerning Municipal Type Waste Objectives.

2. BIOLOGICAL RESOURCES

a) Background Information

Investigations on the ecology of the lower Fraser River have increased in recent years providing information on a variety of organisms (e.g., Northcote et al. 1976, 1978; Levy et al. 1979; Beak Consultants Limited; DFO; Dobrocky Seatech Limited; unpublished information) processes (e.g., Kistritz 1978; Northcote et al. 1979) and environmental conditions (e.g., Dobrocky Seatech Limited, unpublished information; Northcote et al. 1975; Johnston et al. 1975; Koch et all 1977; Slaymaker and Lavkulich 1978). While there is not an abundance of ecological information on the lower Fraser River it is pertinent to detail the results of some investigations which were unavailable during earlier deliberations on the quality of effluent to be discharged from the Annacis Island sewage treatment plant. Hopefully, the provision of this information may assist decisions regarding the release and dispersal of effluents from this treatment plant. We consider that such biological information is essential to the process of determining environmentally safe effluent and receiving water criteria: the integrity of the receiving environment will be protected by taking into account not only the lethal effects of effluents but also their persistence, bioaccumulation and sublethal effects.

A number of studies have been undertaken on the ecology of fish in the lower Fraser River e.g., Northcote 1974; Dunford 1975; Goodman 1975; Envirocon 1978; Northcote et al. 1978; Northcote et al. 1979; Levy et al. 1979; Beak Consultants Ltd.; DFO, unpublished information) and a list of species captured in particular sections of the lower Fraser River is shown in Table 2 (Appendix 1). It is apparent from this information that both resident and non-resident fish are likely to encounter dilutions of sewage effluent from the Annacis Island sewage treatment plant.

b) The Salmon Resource

Of particular concern to the DFO is the protection of migrating and rearing salmon in the lower Fraser River and estuary. We recognize that not only salmon and their aquatic habitat and food organisms but also other biological resources and their aquatic habitats require protection. However, actions taken to protect salmon and their aquatic habitats will undoubtedly benefit other organism. We consider that maintenance of the ecological integrity of the lower Fraser River and estuary is fundamental to the preservation of resident and migratory aquatic organisms.

Pacific Salmon (Oncorhynchus sp.) comprise the most economically important group of fish in the Fraser River system. Five species of salmon: chinook, O. tshawytscha, coho, O. kisutch, chum. O. keta, pink, O. gorbuscha and sockeye, O. nerka spend various parts of their life cycle, as eggs rearing and migrating as juveniles, and migrating and spawning as adults, in the Fraser River system. All of these salmon must, at some stage in their life cycle, utilize the lower Fraser River and estuary for variable periods of time and therefore significant numbers of salmon will come into contact with waters receiving effluent from the Annacis Island sewage treatment plant.

i) Adult salmon

The total annual estimated adult Fraser River salmon run (escapement plus catch) averaged over the 10 year period between 1969 and 1978 ranged from 5.8 million fish (non-dominant sockeye, no pink salmon) to 9.9 million fish (dominant run sockeye, no pink salmon) to 14.3 million fish (non-dominant sockeye, pink salmon). These data are presented in Table 3 (Appendix 1) in association with the relative catch information (DFO, unpublished information).

The year to year variation in the number of fish comprising adult salmon runs is related to the return of pink salmon in odd numbered years and the return of sockeye salmon, which although having dominant runs of some races returning every year, have a particularly dominant run occurring one year of every four years.

Although the upstream migration of adult salmon occurs throughout the year in the Fraser River system, peak migration periods have been identified:

chinook - end of January to early November; chum - end of August to end of December; coho - August to the end of December; pink - mid-August to mid-October; sockeye - mid-June to the end of October.

ii) Juvenile salmon

Based upon a 5 year period between 1973 and 1977 the juvenile salmon downstream migration, resulting from the spawning of those salmon which escape the fishery, has been estimated to range between 231 million (no pink salmon) to 524 million fish (dominant sockeye run and pink salmon)(DFO, unpublished information). These data were obtained by the DFO and the IPSFC through a sampling programme carried out at Mission between February and June. Whereas the majority of juvenile salmon migrating downstream are less than one year of age (0+) some juvenile sockeye, coho and chinook salmon are older (1+, 2+), having reared in the freshwater environment of lakes or streams.

iii) Juvenile salmon migration and utilization of the lower Fraser River and estuary

Juvenile salmon are generally considered relatively "sensitive" fish in regard to their environmental tolerances and in comparison to other fish and invertebrates. Furthermore, their general behaviour and ecology may increase their susceptibility to environmental disturbances and pollutants. Resident species of fish may be more susceptible to adverse water quality (especially in relation to the bioaccumulation of contaminants) and physical disturbances than anadromous fish. However, it is evident from the information presented in Table 4 (Appendix 1) that juvenile salmon, particularly juvenile chinook, chum and sockeye salmon (age 0+) may also be susceptible to environmental disturbances due to their migrating and rearing requirements in the lower Fraser River and estuary.

In addition to the general habitat requirements of juvenile salmonids, their behaviour during the downstream migration and estuarine phase of their life cycle may conflict with the requirement to dispose of wastes into surface waters of the river and estuary. Recent investigations under experimental (Birtwell 1977, 1978; Birtwell and Harbo, 1979; DFO - unpublished information; EVS Consultants Limited, 1978, 1979) and natural conditions (Birtwell and Harbo 1979; Beak Consultants Limited; DFO; unpublished information) have revealed that migrating juvenile salmonids in the lower sections of rivers and in estuarine areas, occur in the upper water layers (60% occur particularly from the surface to about 1 m depth) and furthermore the fish tend to be concentrated close to shorelines, and in estuarine surface waters receiving toxic effluents (e.g. from pulp mills) water quality conditions may develop which are harmful to salmon (Birtwell and Harbo 1979; EVS Consultants Limited 1978, 1979).

iv) Salmonid Enhancement

The federal salmonid enhancement objectives for the Fraser River will further increase the number of salmon utilizing this system. The objective is to increase the annual adult runs of chinook salmon by 750,000, chum salmon by

700,000 and coho salmon by 1 million fish. Furthermore, according to the objectives, the annual pink salmon runs should increase by 2 million fish (that is 4 million every two years) and the annual sockeye runs by 5.6 million fish (that is 22.4 million every 4 years). Accordingly, the numbers of junenile downstream migrating salmon should be significantly increased.

3. ECONOMIC CONSIDERATIONS

The Fraser River salmon stocks contribute to the commercial fishery, sport (tidal and freshwater) fisheries, and the native Indian food fisheries.

In 1978 the commercial fisheries of B.C. provided employment for approximately 17,000 persons; a significant income earning component, particularly in smaller costal communities (Sinclair 1971; Burns 1977). The fishing efforts of commercial fishermen range widely according to the time and coastal area in which resources are available for capture.

a) Commercial Salmon Fishery

The contribution of the Fraser River and estuary to the livelihood of commercial fishermen cannot be precisely calculated from present statistical information. It is known, however, that Fraser River salmon represent approximately 25% of the total catch in British Columbia. Currently, the net wholesale value of the Fraser River salmon catch approximates $37 million annually, (Table 5, Appendix 1). Salmon returning to the Fraser River pass through Queen Charlotte and Johnstone Straits to the north, and the Strait of Juan de Fuca to the south, and as fishermen range coastally with the runs, it is clear that these resources are shared by the majority of B.C. salmon fisheries. British Columbians are fortunate to have salmonids and other fish species in many of their coastal waters and rivers, and the Fraser River system has played a critical role in the past, and will continue to do so, in the economic future of the British Columbia fishing industry.

b) Salmon Sport Fishery

The Fraser River salmon stocks also contribute a value of $7 million annually to the Georgia Strait sport fishery (Table 6, Appendix 1). In addition, a large "bar" fishery exists in the lower Fraser River from which it is estimated that about 7,800 salmon are caught in 14,300 angler days. These stocks are also susceptible to upstream interception, however, no estimates are available on catch or effort.

c) Native Food Fishery

Approximately 91 native Indian Bands with a total population of 18.000 are located on the Fraser River. This represents 48% of the total Bands and 37% of the total population of native people, in Britsh Columbia.

There are no accurate estimates available to indicate the numbers of salmon taken annually for the native food fishery. It is known that salmon play a key role in the native lifestyle (Bennett 1973).

d) Non-Salmonid Fishery

The Fraser River estuary is also important for other fisheries such as those for crab and herring. No data exist which permit a statement of the dollar value directly associated with estuary dependent populations of these species. The Fraser River estuary supports significant stocks of herring, some of which are taken in the commercial herring fishery. In addition, the 1978 commercial crab fishery produced 357 metric tons (approximately 30% of the total B.C. catch) with a gross wholesale value of $862,000.

Eulachon spawn in the lower Fraser River between mid-March and mid-May. This run of fish supports recreational, commercial and Indian fisheries (Samis 1977). The average annual commercial catch is 61,000 kg (1975 to 1979). The value of the catch fluctuates according to the quantity landed and local demand, and has ranged from $0.77 per kg to $1.65 per kg.

e) Public Use

Direct public use of the estuary and near estuarine areas extends through sport fishing on streams or sandbars (Eddie 1973), crabbing, hunting, nature study and nature appreciation, strolling, picnicking and swimming to saltwater sport fishing and boating (Harrison 1979).

4. RECEIVING WATER CONSIDERATIONS

a) Effluent Dilution and Dispersal

B.C. Research (1978a) summarized the available information on the effects of the discharge from the Annacis Island sewage treatment plant on the Fraser River. They carried out dye studies to predict effluent dispersal prior to operation of the plant and found that at slack tide the effluent would pool around the outfall. While effluent is continuously discharged from the outfall, the tidal upstream and downstream movement of water past the outfall will raise the concentration of effluent constituents above estimates based upon simple dilution using total river flow. Subsequent to the operation of the sewage treatment plant, elevated levels of several constituents of the effluent were determined in the receiving waters of B.C. Research (1978a), even though maximum concentrations of all constituents measured in the effluent were within PCB level BB objectives for the discharge, (PCB 1975). Based upon the elevated levels of effluent constituents, a minimum effluent dilution of 3:1 occurred over the outfall at slack tide, whereas during ebb and flood tides effluent dilution ranged between 107 to 173:1 (600 m downstream) to 300 to 700:1 (1.6 km upstream). Furthermore, effluent constituents were not uniformly distributed in the river and were more concentrated at the river surface than at depth proximal to the outfall. This information was obtained when effluent discharge rates were 1.36 to 1.84 m^3s^{-1} (B.C. Research 1978a).

Additional information on effluent dispersal under extreme slack water conditions and low river flow has been predicted by Western Canada Hydraulics Laboratories Ltd., (1973). Assuming an effluent flow of 3.2 m^3s^{-1}, (predicted rate of discharge in 1977) and 2 hours of slack tidal conditions, effluent pooling would occur and extend almost to both banks of the river before subsequent water movement. Subsequent tidal dispersion would result in a minimum dilution of 4:1, 60 m from the outfall, 11:1 at 1,200 m and 15:1 at 2,400 m. It is almost certain that dilution of the sewage effluent would be less under the same predicted receiving water conditions but with approximately double the effluent discharge (6.8 m^3s^{-1}) that is, the projected future maximum dry weather flow.

Receiving water criteria specified in the Pollution Control Objectives for Municipal Type Waste Discharges in British Columbia (PCB 1975) are generally considered to be inapplicable within an initial dilution zone. We consider, as reported by Harvey (1976) that such an approach does not afford maximum protection to the receiving environment and its aquatic resources and it is in contradiction with the concept of maintaining the integrity of receiving waters. Furthermore, based on the information supplied by Western Canada Hydraulics Laboratories Ltd., (1973), the initial dilution zone description (PCB 1975) would not be applicable in the lower Fraser River under extreme slack water conditions and low river flow.

<u>Conclusions:</u> <u>Elevated levels of certain constituents of sewage effluent have been found in waters receiving effluent from the Annacis Island sewage treatment plant, even though all measured effluent constituents were reported to be within PCB Level BB objectives for this type of discharge.</u>

<u>Effluent dispersion and dilution was reduced at times of slack tide, resulting in pooling and layering of the effluent in surface receiving waters. At about half the projected maximum effluent flow from the Annacis Island sewage treatment plant, predicted effluent dispersal under conditions of minimum dilution will be in contradiction with the description for the "initial dilution zone" given by the Pollution Control Branch. It is anticipated dilution will be less at times of maximum effluent discharge and low river flows.</u>

<u>The initial dilution zone concept, wherein PCB objectives for</u>

the receiving environment do not apply, does not afford maximum protection to aquatic organisms.

b) Effluent Contact with Juvenile Salmon

The determination and predictions of effluent dilution and dispersal are of significance in relation to the potential effects of the effluent upon resident and transient aquatic organisms. The minimum dilution afforded the sewage effluent under certain conditions could result in receiving water conditions which may be harmful to migrating juvenile salmon, particularly at maximum effluent flow from the Annacis Island sewage treatment plant. At slack tide, low river temperatures and low freshwater flow conditions which would occur in March and early April when maximum numbers of juvenile of some salmon species are migrating seaward, (Table 4, Appendix 1), minimum dilution, pooling and layering of the effluent in surface waters can create receiving water conditions which could be harmful to those fish.

Avoidance reactions to sewage effluent have not been investigated in the field with juvenile salmon. However, avoidance reactions by juvenile chinook, chum and coho salmon have been documented in response to the discharge of pulp mill effluent into estuarine surface waters (Birtwell 1977; Birtwell and Harbo 1979). Perhaps it is of some importance that Alexander et al.(1977) found no significant avoidance by whitefish (Coregonus clupeaformis) exposed to dilutions of sewage effluent. These fish exhibited a slight preference or neutral response to sublethal concentrations and actually preferred lethal sewage effluent concentrations. Exposure of the whitefish to individual effluent components revealed that both avoidance and preference responses occurred. This suggested that the response of the fish to sewage effluent was the result of an integration of preference and avoidance responses to effluent constituents. The same authors also found that reduced survival of rainbow trout occurred when these fish were forced to swim during exposure to sewage effluent. Other evidence for the avoidance and preference to sewage effluents by fish is presented by Tsai (1975). Such findings could be of major concern to fishery resources in relation to the discharge of effluent from the Annacis Island sewage treatment plant. Irrespective of the potential effects of the sewage effluent, the behaviour and presence of juvenile migrating salmon in surface waters will increase the possibility of them encountering relatively high concentrations of effluent especially in the vicinity of the outfall. Furthermore, it is unlikely that many juvenile fish will be able to swim effectively against the strong currents that occur in certain reaches of the Fraser River at particular tidal states and freshwater flow conditions. Accordingly, the ability of fish to avoid areas of degraded water quality could be impaired at these times resulting in exposure to pollutants they would otherwise avoid.

Conclusions: Migrating and rearing juvenile salmon are frequently present close to the water surface in the lower sections of rivers and and in estuaries. Effluent from the Annacis Island sewage treatment plant is discharged into the South Arm of the Fraser

River which is used by large numbers of salmon. The possibility of juvenile salmon encountering surface water concentrations of this effluent will be greater at times of reduced effluent dispersion and dilution (as may occur under low freshwater flow conditions, e.g. March and early April when high numbers of juvenile salmon are migrating seaward) than under conditions of maximum effluent dilution and dispersal (periods of high freshwater flow).

c) Dissolved Oxygen

A reduction in the level of dissolved oxygen, below air saturation values, could occur in the Fraser River due to natural causes and to the discharge of effluents with a high oxygen demand. Accordingly, fish in the lower Fraser River would be subjected to stressful conditions and the problem compounded by the presence of pollutants. Reduced levels of dissolved oxygen have been found to increase the sensitivity of juvenile salmonids to pollutants (e.g. Hicks and Dewitt 1971; Davis 1975; Kruzynski 1979). Such effects would be of concern especially during the upstream and downstream salmon migration. Due to the forecasted increased flows of sewage effluent from the Annacis Island sewage treatment plant, the immediate "oxygen demand" will be three to four times the present level (B.C. Research 1978a). Therefore, dissolved oxygen depletion in the receiving waters will increase and be of more concern at times of minimum effluent dilution (slack tide). Davis (1975) recommends that in order to assure a high degree of safety for very important fish stocks (mixed freshwater fish populations including salmonids - such as occur in the Fraser River adjacent to Annacis Island) dissolved oxygen levels should be maintained above 70% of air saturation. The importance of this level is emphasized due to the probable additional stresses that could be imposed upon fish due to the discharge of toxic or sublethal levels of sewage effluent constituents, into the Fraser River.

In 1977 B.C. Research determined that dissolved exygen levels in the Fraser River were usually close to air saturation, except, on occasions, in the immediate vicinity of the outfall for the Annacis Island sewage treatment plant (B.C. Research 1978a). On March 1, 1977, a time when juvenile salmon would have been migrating downstream in the lower Fraser River, a dissolved oxygen level of 75% of air saturation was recorded by B.C. Research in the receiving waters at the outfall. At times of minimum effluent dilution, dissolved oxygen depressions could occur due to the biological and chemical demand of the effluent. Between November 1975 and October 1977, the dissolved oxygen content of effluent from the Annacis Island sewage treatment plant averaged 3.8 mgL^{-1} and ranged from 1.9 to 7.9 mgL^{-1} (B.C. Research 1978a). Such relatively low dissolved oxygen levels in the sewage effluent and its residual biochemical oxygen demand (B.O.D.) will cause a reduction in dissolved oxygen levels in the receiving waters following discharge, at times of minimum dilution. The extent of reductions in dissolved oxygen was limited, according to information supplied by B.C. Research, but more severe dissolved oxygen depletion could occur at times of minimum effluent dilution. The temperature differential between effluent and receiving waters will probably compound this concern by promoting effluent layering in surface waters. This may lead to reductions in dissolved oxygen levels in the surface waters which are used by migrating juvenile salmon.

Conclusions: Sewage effluent from the Annacis Island sewage treatment plant has dissolved oxygen levels which are generally below air saturation values. It also has a significant B.O.D. Reductions in the levels of dissolved oxygen in the receiving waters have been recorded proximal to the sewage outfall, and it is anticipated that greater dissolved oxygen depletion will occur at maximum effluent discharge rates. A reduction in the dissolved oxygen content of surface waters could occur due to layering and pooling of the sewage effluent at times of low dilution. It could be particularly significant in slow-flowing and poorly flushed side channels and sloughs. These conditions would be of concern due to the presence of juvenile salmon in surface waters, and the additional stress which could be imposed upon them due to the presence of lethal or sublethal levels of pollutants.

d) Effluent Toxicity and Sublethal Effects

i) Acute toxicity

In 1976, Servizi et al. (1978) found that effluent from the Annacis Island sewage treatment plant was toxic to juvenile sockeye salmon, the 96 h LC50 value being in the range 17 to 45% $^{v}/v$. The Pollution Control Branch (PCB) permit, April 4, 1977 (PE-387) for the discharge of effluent from the Annacis Island sewage treatment plant stipulates that the toxicity of the effluent must meet the level BB criterion of a 96 h LC50 equal to 75% $^{v}/v$. Current work by the IPSFC (J.A. Servizi) and the DFO has determined that acute toxicity of the effluent has not decreased from that found in the earlier investigations. That is, the toxicity of the effluent is in violation of the PCB permit.

Higgs (1977) and B.C. Research (1978) have also determined the toxicity of effluent from the Annacis Island sewage treatment plant. The results obtained varied between studies perhaps reflecting upon the method of sample collection, testing procedure employed, and/or variation in toxicity of the effluent.

Chlorine, ammonia, chloramines, heavy metals, phenols, detergent and cyanide are constituents of sewage effluents that are believed to contribute to the acute toxicity of sewage effluents. According to B.C. Research (1978a) none of the potential toxicants analyzed, during B.C. Research or Greater Vancouver Sewerage and Drainage District surveys of Annacis Island sewage effluent characteristics were present at concentrations individually acutely toxic to fish; but, it was suggested that aggregate effects of sublethal concentrations of ammonia, surfactants and copper may contribute to acute toxicity of the effluent.

No research has been undertaken to determine if the waters receiving the discharge from the Annacis Island sewage treatment plant are toxic to or otherwise affect aquatic organisms. Limited effluent dilution and dispersion, and surface water layering proximal to the outfall under certain tidal states and environmental conditions may contribute to the formation of water quality conditions which may be detrimental to fish and other aquatic organisms. Projected increases in the volume of effluent discharged from the outfall may well increase the severity of any present effects.

Conclusions: The acute toxicity of effluent from the Annacis Island sewage treatment plant did not decrease between 1976 and 1979. The 96 h LC50 value is substantially less than 75% $^{v}/v$ and accordingly does not meet the terms of PCB permit PE-387 (level BB criteria, PCB Municipal Type Waste Objectives).

ii) Organic constituents

Under the terms of the PCB permit PE-387 particular maximum concentrations of effluent constituents are listed. In addition to the listed constituents other compounds occur in the effluent which are of concern. Disinfection of sewage effluent by chlorination accurs during the summer months at the Annacis Island sewage treatment plant. Although the chlorination and dechlorination of sewage effluent does not generally increase the acute toxicity of the effluent, chlorinated organic compounds may be produced which can be acutely toxic and cause sublethal stress to aquatic organisms under conditions of long term exposure.

Reference to one organic compound in the Annacis Island sewage discharge will illustrate our concern. Rogers et al. (1979) determined a maximum concentration of resin acids in effluent from a hardboard plant located by the Fraser River, to be 27.15 mgL^{-1} of which the relatively stable dehydroabietic acid (DHA) was a major constituent. Effluent from the hardboard plant is collected by the Annacis Island sewage treatment plant. Recent analyses carried out by Rogers (unpublished) shows that DHA passes through, and is discharged unchanged from, the Annacis Island sewage treatment plant.

Information on the effects of specific resin acids on fish is not abundant however, work by Kruzynski (1979) has shown that DHA can be accumulated in fish tissue (juvenile sockeye salmon) and has the potential to produce histophathological changes. Furthermore, at low exposure levels this compound can affect the schooling behaviour of juvenile sockeye salmon causing them to disperse, and also disrupts their osmo-regulation and their ability to tolerate full strength seawater. The toxicity of the compound is increased at a dissolved oxygen level of 75% of air saturation, a level which has been recorded at the outfall of the Annacis Island sewage treatment plant (B.C. Research 1978a). Sockeye salmon migrate quickly from fresh to saltwater and any compound which affects the physiological adaptation process and behaviour at this time may effectively reduce the survival of the fish (possibly by rendering them more susceptible to predators, etc.). Resin acids, such as DHA and other organic compounds toxic to fish can be effectively degraded by biological treatment systems, (Leach at al. 1977; B.C. Research 1978b). However, degradability of chlorinated resin acids was not as efficient (B.C. Research 1978b).

The accumulation of chlorinated hydrocarbon residues in Fraser River fish was investigated by Johnston et al. (1975). They concluded that residue concentrations were relatively low in comparison to values noted for other regions of North America. However, high levels of polychlorinated biphenyls (PCB's) were found in fish from the lower reaches of the Fraser River suggesting that localized loadings of organochlorine compounds may be significant. PCB's were found in effluent from the Annacis Island sewage treatment plant (Garrett, in prep.). More recently, Keith and Lewis, (1979) concluded that there was not a high level of organhalogens in crabs, salmon and clams in the vicinity of the Iona Island sewage treatment plant discharge. However, flounders were found to have some elevated levels of organic compounds (PCB's). It is conceivable that th PCB's accumulated in the sediments and that these bottom fish became contaminated from this source.

Conclusions: Effluent from the Annacis Island sewage treatment plant contains organic compounds some of which are known to accumulate in aquatic organisms and produce sublethal effects. These effluent constituents are not routinely monitored, nor specified under the conditions of PCB permit PE-387. There is a paucity of information on the quantities, fate, distributon and effects of these compounds in the aquatic environment.

iii) Heavy metals

Heavy metals in the Annacis Island sewage effluent may contribute to the documented acute toxicity of the effluent and could have sublethal effects on aquatic organisms in the Fraser River. Samples of Annacis Island sewage effluent examined by Higgs (1977) and Servizi, et al. (1978) contained heavy metal concentrations which exceed levels known to be acutely toxic to or have sublethal effects on fish and other aquatic organisms (Windom et al. 1979). For example, Higgs reported a mean total copper level of 0.15 mg L^{-1} (average of four 24 h composite samples); B.C. Research (1978a) suggested that the effects of copper acting synergistically with other effluent constituents might account for part of the acute toxicity of the Annacis effluent. However, the action of metal toxicity in sewage effluents is complex as indicated by the findings of Servizi et al. (1978). They concluded that metals did not directly contribute significantly to the acute toxicity of sewage effluent from the Annacis Island sewage treatment plant.

Lorz and McPherson (1977) found that exposure of yearling coho salmon to sublethal concentrations of total copper (0.005 to 0.030 mg L^{-1}) had deleterious effects on downstream migration in a natural stream, lowered gill ATPase acitivity and reduced subsequent survival in seawater, in experiments in Oregon. Similar results were found by Davis and Shand (1978) who exposed juvenile sockeye salmon for 24 to 48 h to 30 µg $Cu^{++}l^{-1}$ (total copper) in freshwater. This exposure interfered with the osmo-regulation and the salinity tolerance of the fish when they were transferred to salt water. Some mortality occurred. While caution must be exercised in comparing results from controlled experiments such as those of Lorz and McPherson and Davis and Shand to possible impacts of metals in sewage effluents on organisms in the Fraser River, the experimental data serve to illustrate the potential serious effects of very low levels of metals on fish exposed to effluent from the Annacis Island sewage treatment plant.

In addition to contributing to the toxicity of effluent, accumulation of various metals in fish and invertebrates has been observed in a number of studies. A review of such information is presented by Leland et al. (1979). Such accumulation of metals can be toxic to the organisms themselves and to humans or other consumers. Metal concentrations in fish in the lower Fraser River are generally quite low in comparison to many other river systems (Northcote et al. 1975) although localized areas of sediment metal accumulation and elevated levels of specific metals in some aquatic organisms are of concern. Northcote et al., reported that mercury levels in squawfish and prickly sculpins were "within the range of values reported for areas of moderate to heavy pollution in Canada". McGreer and Vigers (1979) documented significantly higher levels of mercury in clams and flounders from Sturgeon Bank compared with samples from Roberts Bank suggesting that the effluent from the Iona Island sewage treatment plant was the source of metal contamination. High levels of mercury were also found by McGreer and Vigers in sediments and organisms near the Iona sewage discharge. Arsenic levels in some samples of crabs and flounders exceeded the recommended level of 5.0 μgg^{-1} wet weight, for aquatic animal products. Accumulation of elevated metal levels in those organisms may be a function of direct uptake or accumulation through the ingestion of metal contaminated food. Heavy metal contamination of sediment and organisms was also apparent on Roberts Bank thus indicating the complex problem of metal contamination in the vicinity of urban and industrial complexes. It was concluded that sources other than the Iona Island sewage treatment plant contributed metals to the Fraser estuary. Estuarine processes in the Fraser River estuary probably contribute to extraction of metals, carried in dissolved and particulate form by the river water and deposition in the sediments. Metals discharged from the Annacis Island sewage treatment plant will probably contribute to an elevation of metal levels in sediments and aquatic organisms in the lower Fraser River. The reduction in heavy metals which would result from the upgrading of the Annacis treatment plant or institution of a "source control" program would reduce the risk of heavy metal contamination and sublethal effects on fish and other aquatic organisms, in the lower Fraser River.

Conclusions: Heavy metals are discharged in effluent from the Annacis Island sewage treatment plant. It is of major concern that there is evidence of bioaccumulation of heavy metals to levels approaching or exceeding recommended values in aquatic animal products in some commercially harvested organisms within the lower Fraser River and estuary. Heavy metal levels in the effluent from the Annacis Island sewage treatment plant may contribute to acute toxicity, exert sublethal effects and accumulate in aquatic organisms.

e) Microorganisms

A major concern with sewage disposal into natural waters is the presence of pathological microorganisms. Disease organisms, e.g., viral hepatitis can be transmitted through the consumption of raw and partially cooked shellfish. Chlorination is applied at the Annacis Island sewage treatment plant to disinfect the effluent. However, it is known that this method of disinfection is not fully effective against viruses. It is suggested that a higher degree of treatment be afforded the sewage effluent from the Annacis Island plant to further assist in the destruction of pathogenic organisms that may be present.

f) Commercial Fishery

The majority of fishing in the lower Fraser River occurs under relatively high freshwater flows when effluent dilution would be promoted. However, depending upon salmon management decisions the commercial fishery may operate on the following schedule: for chinook salmon, from the third week in April up to October; for sockeye salmon, the third week of June until October; for pink salmon (odd numbered years), August and September; for chum salmon, September to early December. Catches of coho salmon are incidental to those for other fisheries. The Fraser River adjacent to Annacis Island is an important 'drift' region for the commercial fishery. At the present time there does not appear to be any effect of the discharge of effluent from the Annacis Island sewage treatment plant on the harvesting of salmon in the lower Fraser River.

5. MONITORING

Concern has been expressed in the DOE brief to these hearings over the method used to collect and test effluent samples for measurement of acute toxicity. Not only should samples used for bioassays be representative of the effluent to be discharged but they should also be tested using sensitive techniques.

In January 1979, the Pollution Control Branch advised the GVSDD that certain aspects of environmental monitoring would not be required. Environmental monitoring was not required in the receiving water adjacent to the Annacis Island sewage treatment plant, Lulu Island sewage treatment plant and Iona Island sewage treatment plant. The reasons for such cancellations were not given. We consider that such monitoring is important to assess any impacts which these discharges would have on the receiving environment. Prior to the cancellation of the above environmental monitoring programs, evidence of effluent constituents from the Annacis Island sewage treatment plant was found in the receiving waters, (B.C. Research 1978a) and the area of Sturgeon

Banks affected by wastes from the Iona Island sewage treatment plant was considered to be expanding (B.C. Research 1977). Additional effluent flows to sewage treatment plants, especially that at Annacis Island will only compound any present effects. It is most difficult to assess the impact of effluents on receiving waters based upon a knowledge of toxicity, some effluent constituents, biological resources, and flow characteristics. The problem is further compounded in estuaries with their inherent dynamic interaction of physical, chemical and biological factors. In order to assess the affects of effluent flows and additional pollutants, and improvements of effluent quality, a comprehensive analysis of the effluent is required in conjunction with chemical, physical and biological receiving water studies. We appreciate the problems associated with this approach. However, in order to maintain a high level of environmental quality through the control of pollutants, identification of, and determination of the effects of these effluents is an integral component of the associated regulatory, enforcement and management responsibilities.

Conclusions: In January 1979, the Pollution Control Branch eliminated the requirement of the Greater Vancouver Sewerage and Drainage District to monitor receiving environments at three sewage treatment plants on the lower Fraser River. Evidence of sewage contamination was found in the receiving waters adjacent to two of these plants (Annacis Island, Iona Island) prior to elimination of the monitoring requirements.

6. MUNICIPAL TYPE WASTE OBJECTIVES

The above comments have been concerned with the Annacis Island sewage treatment plant and its discharge to the Fraser River. However, some of those comments are applicable to the broader topic of the adequacy of the Municipal Type Waste Objectives to protect the lower Fraser River from a polluted condition. We recognize that there are many pollutants other than municipal wastes which enter the lower Fraser River thus compounding the problem of pollution control. However, we consider that there is sufficient information to suggest that the Municipal Type Waste Objectives (PCB 1975) are currently inadequate to protect the lower Fraser River from a polluted condition. For example, the presence of potentially harmful organic compounds found in sewage effluents is not addressed by the Objectives, and there needs to be recognition of the sublethal effects of effluent constituents on the organisms in the receiving environment. The bioaccumulation of certain compounds appears to be a potential problem in the lower Fraser River, and the bacteriological quality of shellfish growing waters is affected by the transport of Fraser River water to harvesting areas (DOE, unpublished information).

Each effluent discharged to the Fraser River cannot be considered in isolation from other discharges in relation to the impact upon aquatic organisms. There is insufficient evidence and knowledge to predict their combined impact. Therefore to use dilution to disperse toxic constituents of wastewaters until detrimental effects on the receiving waters are imminent or manifest imposes a high level of environmental risk. Significant environmental damage may occur before tests meeting scientific criteria can demonstrate adverse effects. The effect of the Iona Island sewage treatment plant discharge on Sturgeon Bank is such an example.

As an alternative to using dilution to disperse toxic effluents, improvement in effluent quality and detoxification prior to discharge is a preferred procedure. This procedure has been accomplished on some effluent discharges to the upper Fraser River with apparent success. Using this approach, dilution capacity acts as a safety factor to lower the risk of adverse effects to aquatic organisms from effluent constituents. Currently, through the PCB permit system, the acute toxicities of industrial effluents discharged to the lower Fraser River are being reduced to meet level A criteria. Accordingly, we recommend that such an approach be undertaken for the discharges of municipal wastes into the lower Fraser River.

We recommend the upgrading of the quality of effluents discharged to aquatic systems in order to protect biological resources. The application of "source control" to eliminate or reduce potentially harmful substances, prior to discharge to municipal sewers is highly recommended and we endorse the stand taken by the Pollution Control Branch in regard to the Greater Vancouver Regional District. Implicit in this recommendation is the delegation (to the Greater Vancouver Sewerage and Drainage District) or acceptance (by the Pollution Control Branch) of legislative responsibility and authority to undertake such actions. If effluent standards are to be improved, enforcement of these standards is essential.

Conclusion: Recent information suggests that the Municipal Type Waste Objectives are inadequate to protect the aquatic environment (e.g. lower Fraser River) from a condition of pollution that imposes an unacceptable risk upon the fishery resource and its supporting habitat.

7. RECOMMENDATIONS

a) Effluent from the Annacis Island Sewage Treatment Plant

A routine (at least quarterly) comprehensive analysis of effluent from the sewage treatment plant is required. Particular emphasis should be placed upon the determination of concentrations of organic compounds in the effluent.

The toxicity of effluent from the sewage treatment plant should be routinely determined, at least monthly, using the most sensitive testing method and samples of the effluent which is to be discharged. Continuous-flow bioassays are recommended using juvenile salmonids as the test organisms.

Effluent toxicity should be reduced to produce an effluent with a 96 h LC50 equal to 100% $^{v}/v$ (Municipal Type Waste Objectives, level AA criteria).

Effluent quality should be improved to minimize any effects on receiving waters and aquatic organisms. Of particular urgency is the reduction of effluent constituents (e.g., heavy metals, organic compounds) which can be a) acutely toxic to aquatic organisms or produce sublethal effects, b) persistent and bioaccumulated by aquatic organisms in the lower Fraser River and estuary. Implicit in this recommendation is the requirement to instigate and enforce a "source control" program to elevate the quality of effluents entering the sewerage system to the Annacis Island sewage treatment plant. In addition, secondary treatment should be provided at the Annacis Island sewage treatment plant to ensure the attainment of the above mentioned effluent quality requirements.

Implementation of a comprehensive "source control" program on the lower B.C. mainland and provision of additional treatment at the Annacis Island sewage treatment plant should occur, ideally in 1980.

b) Receiving Waters

It is essential that dissolved oxygen levels in the receiving environment are at all times maintained above 70% of air saturation, for the protection of important fishery stocks using the lower Fraser River and estuary.

The use of an initial dilution zone in which Municipal Type Waste Objectives do not apply should be discontinued. Such an approach is inconsistent with maintaining the integrity of receiving waters for the protection of aquatic organisms.

The dilution capacity of receiving waters should not be used as the primary means to eliminate or reduce the effects of pollutants. Effluents discharged to the Fraser River cannot be considered in isolation from other discharges in relation to the impact upon aquatic organisms. It is recommended that effluent quality be improved and detoxification by provided prior to discharge so that the dilution capacity of the receiving waters acts as a safety factor; thus reducing the risk of adverse effects to aquatic organisms from effluent constituents.

Environmental monitoring programs (chemical, physical and biological) must be undertaken in the lower Fraser River to document the changes (beneficial or detrimental) of municipal waste discharges. In view of proposed additional sewerage connections and increased effluent discharges, a high priority should be given to reinstituting a monitoring program to assess the impact of effluent from the Annacis Island sewage treatment plant upon the lower Fraser River.

c) General

Clarification of the responsibility for implementing a contaminant "source control" program is required together with the appropriate delegation (to the Greater Vancouver Sewerage and Drainage District) or acceptance by the (Pollution Control Branch) to undertake such a program.

It is essential that a detailed review of the Municipal Type Waste Objectives be undertaken. However, it is equally important to determine if "permittees" comply with PCB permit stipulations, and whether surveillance capabilities are adequate to enforce such stipulations.

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APPENDIX I

Table 1. Department of Fisheries and Oceans, International Pacific Salmon Fisheries Commission: Current and proposed investigations in relation to the discharge of municipal wastes.

Primary researcher	Address	
I. H. Rogers	Department of Fisheries & Oceans Salmon Habitat Research Division Resource Services Branch West Vancouver Laboratory 4160 Marine Drive, West Vancouver, B.C.	Continuing research into the presence and fate of halogenated organic compounds in municipal and industrial wastewater. Attention is being focussed upon the Annacis Island sewage treatment plant.
J.A. Servizi	Environment Conservation Division, International Pacific Salmon Fisheries Commission, P.O. Box 30 New Westminster, B.C.	Further studies to examine temporal variability of acute toxicity. Continuing research into the formation of halogenated organics (a cooperative project with I.H. Rogers) attention is being forcussed upon the Annacis Island sewage treatment plant.
M.D. Nassichuk	Department of Fisheries & Oceans Water Quality Unit Habitat Management Division Field Services Branch 1090 West Pender Street Vancouver, B.C. V6E 2P1	Current research on the impact of municipal wastes in the Cowishan River, Vancouver Island. A joint project with the provincial government's Waste Management Branch, and the federal government's Environmental Protection Service.
S.C. Samis	Department of Fisheries & Oceans Water Quality Unit Habitat Management Division Field Services Branch 1090 West Pender Street Vancouver, B.C. V6E 2P1	Related research (nutrients organic particulates, etc.): on the impact of hatchery wastes upon the Capilano, Puntledge, Qualicum and Quinsam Rivers.
I.K. Birtwell	Department of Fisheries & Oceans Salmon Habitat Research Division Resource Services Branch West Vancouver Laboratory 4160 Marine Drive West Vancouver, B.C.	Proposed research on the impact of the Iona Island sewage treatment plant on fishery resources of Sturgeon Bank.
R.M. Harbo	Department of Fisheries & Oceans Water Quality Unit Habitat Management Division Field Services Branch 1090 West Pender Street Vancouver, B.C. V6E 2P1	Continuing research on the uptake of heavy metals by oyster adjacent to the Iona Island sewage treatment plant.

Table 2. Fish species occurring in the Fraser River between Mission and Steveston.

Family name	Species	Mission to New Westminster 1, 2	Annacis Island (City Reach, Annacis Channel) 3, 4	Tilbury Isl. (Tilbury Slough, Gravesend Reach) 5	Deas Island (Deas Slough, Ladner & Woodward Reach) 6	Duck, Barber, Woodward Island (Ladner & Sea Reach) 7, 8
Acipensaridae	White sturgeon	+	+		+	
Ammodytidae	Pacific sand lance					+
Catostomidae	Largescale sucker	+	+	+	+	+
	Longnose sucker	+				
Centrarchidae	Black crappie	+			+	
Clupeidae	Pacific herring					+
	American shad	+				
Coregonidae	Mountain whitefish	+	+	+	+	+
Cottidae	Prickly sculpin	+	+	+	+	+
	Aleutian sculpin	+				
	Staghorn sculpin		+	+	+	+
Cyprinidae	Carp	+	+	+	+	+
	Brassy minnow	+		+	+	+
	Peamouth chub	+	+	+	+	+
	Northern squawfish	+	+	+	+	+
	Longnose dace	+			+	+
	Leopard dace		+			
	Redside shiner	+	+	+	+	+
Embiotocidae	Shiner perch					+
Gadidae	Burbot	+				
	Pacific tomcod				+	+
Gasterosteidae	Threespine stickleback	+	+	+	+	+
Ictaluridae	Brown bullhead	+	+		+	+
Osmeridae	Eulachon	+	+	+	+	+
	Longfin smelt	+	+	+	+	+
	Surf smelt					+
Petromizontidae	Pacific lamprey	+	+	+	+	+
	Western Brook lamprey	+	+			+
	River lamprey	+	+		+	+
Pholidae	Crescent gunnel					+
Pleuronectidae	Starry flounder	+	+	+	+	+
Salmonidae	Pink salmon	+	+	+	+	+
	Chum salmon	+	+	+	+	+
	Coho salmon	+	+	+	+	+
	Sockeye salmon	+	+	+	+	+
	Chinook salmon	+	+	+	+	+

Table 2. (continued)

Family name	Species	Mission to New Westminster 1, 2	Annacis Island (City Reach, Annacis Channel) 3, 4	Tilbury Isl. (Tilbury Slough, Gravesend Reach)5	Deas Island (Deas Slough, Ladner & Woodward Reach)6	Duck, Barber, Woodward Island (Ladner & Sea Reach)7, 8.
Cutthroat trout	Cutthroat trout	+	+	+	+	+
Rainbor (steelhead	Rainbow (steelhead) trout	+	+	+	+	+
Dolly Varden char	Dolly Varden char	+	+	+	+	+
	Brook trout	+				

1.Northcote (1974); 2. Northcote et al. (1978); 3. Beak Consultants Limited, unpublished information; 4. Envirocon Limited (1978); 5. Department of Fisheries and Oceans unpublished information; 6. Department of Fisheries and Oceans unpublished information; 7. Dunford (1975); 8. Levy et al. (1979).

Table 3. Total Fraser River Salmon Runs

	Escapement $\bar{x}$	Escapement %of Run	Catch(Commercial Sports, Indian) $\bar{x}$	Catch(Commercial Sports, Indian) %of Run	Total Runs: $\bar{x}$	Total Runs: Range	Catch to Escapement Ratio
Sockeye (*Oncorhynchus nerka*)[1]: 1969, 1973, 1977	1,104,697	19	4,786,754	81	5,891,000	4,978,000-6,914,000	4:1
1970, 1974, 1978	2,077,285	26	6,015,564	74	8,093,267	6,131,000-9,480,800	3:1
1971, 1975	876,173	16	4,757,585	84	5,641,000	3,678,000-7,604,000	5:1
1972, 1976	835,580	21	3,190,003	79	4,026,000	3,715,000-4,337,000	4:1
Pink (*O. gorbuscha*)[1]: 1969, 1971, 1973, 1975, 1977	1,768,387	27	4,900,014	73	6,668,401	3,830,000-9,707,007	3:1
Chinook (*O. tshawytscha*)[2]: 1969-1978	65,938	10	594,275[3]	90	660,213	468,427-847,689	9:1
Coho (*O. kisutch*)[2]: 1969-1978	64,316	25	193,117[3]	75	257,433	164,049 385,872	3:1
Chum (*O. keta*): 1969-1978	442,570	49	462,190	51	904,760	421,000-1,655,800	1:1

1. International Pacific Salmon Fisheries Commission;Annual Reports, 1969-1978.
2. Department of Fisheries and Oceans - unpublished information.
3. Does not include U.S. interception.

Table 4. Data on the presence of juvenile salmon (Oncorhynchus sp.) in the lower Fraser River and estuary.

PINK SALMON (O. gorbuscha) (Age 0+): Limited rearing occurs in backwaters of the lower Fraser River (hours to days - Levy et al. (1979). Prior to the saltwater phase of their life cycle juvenile pink salmon are abundant near foreshore marshes for a few months. (Feller 1974; Parker and LeBrasseur 1974).

Lower river utilization period: February to June inclusive with peak abundance late April.

CHUM SALMON (O. keta) (Age 0+): These juvenile salmon reside temporarily in riverine backwaters and estuarine areas before moving to higher salinity waters (DFO - unpublished information; Dunford 1975). The residence of an individual in the lower Fraser River may be for days or weeks (Levy et al. 1979).

Lower river utilization period: Late January to the middle of June; peak abundance occurs from later March to the end of April.

COHO SALMON (O. kisutch) (Age 1+): Rearing generally takes place in freshwater areas after which the fish (1+) commence downstream migration. These fish tend to be more abundant away from the river banks, and although they may move directly into salt water, many remain in the vicinity of Sturgeon and Roberts Bank throughout the summer (DFO - unpublished information; Goodman 1975; Barraclough and Phillips 1978).

Lower river utilization period: Late April to late June with peak abundance occurring in early June.

SOCKEYE SALMON (O. nerka) (0+, 1+): Fry generally rear in lakes and commence downstream migration as yearlings (1+). They migrate mainly in mid river and are uncommon in backwater areas (Dunford 1975; DFO - unpublished information; Goodman 1975). These migrating juvenile salmon undergo a rapid transition from the Fraser River plume to the open ocean (Barraclough and Phillips 1978).

Lower river utilization period: 0+, late April to early October, peak abundance occurs in June and early July. 1+, late April to late June, peak abundance occurs in late April to early May.

CHINOOK SALMON (O. tshawytscha) (0+, 1+): Coastal populations of chinook salmon produce 0+ downstream migrants which may rear in riverine and estuarine back waters for variable periods before entering salt water. Their use of specific areas may be for weeks or months (Dunford 1975; DFO - unpublished information; Levy et al 1979).

Yearling (1+) juvenile downstream migrants are commonly produced by chinook which spawn in the headwaters of the Fraser River. These 1+ fish migrate primarily in mid river and move rapidly through the inner estuary (Dunford 1975; DFO - unpublished information). These fish utilize areas of Sturgeon and Roberts Bank for several months before moving offshore (Goodman 1975).

Lower river utilization period: 0+, late February until early July, and late August to early December. Peak abundance occurs from late March to early May. 1+, early April until late July, with peak abundance occurring in late April.

Table 5. Annual net wholesale value associated wtih Fraser River salmon stocks (1978 value).

Species	Escapement	Total catch[3]	Total Canadian commercial catch[4]	Annual net wholesale value: Canadian catch[4]
Chinook	65938[1]	645951	284219	3350490
Chum	442570[1]	462910	369752	3905230
Coho	64316[1]	193117[5]	106461	730075
Pink	884193[2]	2450007	1592504	6135552
Sockeye	1296945[2]	4739829	2749100	22915170
Total				$ 37036517

[1] Department of Fisheries and Oceans - unpublished information.

[2] International Pacific Salmon Fisheries Commission: annual reports 1969 to 1978 (pink salmon estimates have been averaged over all years to provide an annual estimate).

[3] Includes Canadian Commercial, sport and native Indian catch and American interceptions.

[4] Barclay, J.C. 1977. Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account. In Appendix 2 of the "Economic Rationale for the Salmon Enhancement Program." Department of Fisheries and Oceans, unpublished information.

[5] Does not include U.S. interceptions.

Table 6. Contribution of Fraser River salmon to the Georgia Strait tidal sport fishery (1978 values).

Species	Catch[1]	Value generated per sport fish captured ($)[2]	Annual value associated with sport tidal catch ($)
Chinook	258380	21.08	5446650
Coho	76260	21.08	1607560
Total			7054210

1 Masse, W. D., and K. Peterson. Evaluation of Incremental Recreational Benefits from Salmon Enhancement. In Appendix 6 of the "Economic Rationale for the Salmonid Enhancement Program." Department of Fisheries and Oceans, unpublished information.

2 Based upon a value of $17.35 per 'angler-day', 2.7 people per boat.

APPENDIX 2

DEPARTMENT OF FISHERIES AND OCEANS SUMMARY PRESENTED AT THE CONCLUSION OF THE HEARINGS

This hearing has heard information from the Department of Fisheries and Oceans with regard to the need for source control and the installation of secondary treatment at the Annacis Island sewage treatment plant. In our brief, we expressed concern over the need to upgrade the quality of sewage discharged to a non-acutely toxic level by removal of hazardous contaminants. Our concerns arise from the mandate of the Department of Fisheries and Oceans; namely, to protect, conserve and restore Fraser River fisheries stocks to historic levels. We have heard of the vital importance of the Fraser River salmon runs to the economy of British Columbia, of the highly significant dollar value and the fact that they directly and indirectly employ many people perform a highly valued recreational and tourist function and constitute a basic element of the lifestyle and livelihood of Native peoples. We should like to emphasize the value of such an important sustainable resource that may be harvested in perpetuity, and the fact that decisions made now regarding the Fraser River will affect the future of this resource and the success of rehabilitation programs such as the Salmonid Enhancement Program.

We have heard considerable technical testimony with regard to acute and sub-lethal toxicity, dilution and assimilative capacity of the river to receive wastes. Arguments have been presented that the dilution potential of the river will eliminate harmful effects and that little evidence of problems associated with the Annacis waste discharge now exists in the river. Our position is that hazardous materials do indeed exist in the effluent, that the effluent does not currently meet provincial level BB standards and that discharge of toxic wastes to a tidal system is not acceptable from the standpoint of potential risk to aquatic resources. We feel that dilution is an unacceptable solution to the discharge of toxic wastes.

Dilution will not solve the problem of loading of the lower Fraser River with toxic, persistent or otherwise, hazardous materials in terms of volumes discharged. On the other hand, removal of toxicants at source or prior to discharge will substantially reduce toxic loadings.

We feel we are at a turning point with regard to the Fraser River water quality. Failure to act now may constitute further loss of aquatic resources and a situation may result from which it will be very costly or perhaps impossible to recover from. It is vitally important to remember that municipal and industrial growth will continue, and that the type and complexity of domestic and industrial chemicals in common use will increase. Thus, toxic loading and potential impacts on the river and its biological resources will increase with time unless action is taken.

We have a great responsibility to protect the resources of the Fraser River system. It is essential for us to make sure we follow the proper course to protect those resources in perpetuity.

In conclusion, we again express our appreciation to the Pollution Control Board for permiting us to state our concerns.

APPENDIX 3

Table 1. Spawning escapement and area 29 commercial catches of Fraser River salmon from 1979 to 1979.

	Sockeye		Pink		Chum		Coho		Chinook	
Year	Escapement	Area 29 catches	Escapement	Area 29 catches	Escapement	Area 29 catches	Escapement	Area 29 catches	Escapement	Area 29 catches
1970	1,943,000	575,000	-	1,000	303,000	179,000	66,000	100,000	63,000	133,000
1971	748,000	1,317,000	1,805,000	626,000	357,000	22,000	109,000	70,000	60,000	140.000
1972	830,000	527,000	-	-	580,000	256,000	40,000	81,000	48,000	123,000
1973	1,181,000	1,064,000	1,751,000	284,000	452,000	191,000	57,000	54,000	81,000	100,000
1974	1,757,000	714,000	-	-	565,000	93,000	72,000	27,000	76,000	87,000
1975	991,000	427,000	1,367,000	355,000	235,000	73,000	62,000	44,000	80,000	93,000
1976	823,000	558,000	-	1,000	589,000	174,000	38,000	14,000	44,000	83,000
1977	1,113,000	1,176,000	2,388,000	294,000	539,000	14,000	72,000	45,000	80,000	98,000
1978	2,514,000	581,000	-	1,000	415,000	125,000	78,000	56,000	73,000	60,000
1979	1,408,000	1,074,000	3,561,000	103,000	*	7,000	55,000	9,000	56,000	55,000

* Information currently unavailable.

Table 2. Fraser River salmon enhancement objectives and current adult run [1]Information.

Species	Present annual run	Objective: Annual increase in run Catch	Escapement	Total	Objective: total run
Chinook	660,000	670,000	80,000	750,000	1,410,000
Coho	260,000	750,000	255,000	1,000,000	1,260,000
Chum	900,000	668,000	32,000	700,000	1,600,000
Sockeye[2]	5,900,000	5,400,000	200,000	5,600,000	11,500,000
Pink[3]	6,700,000	1,850,000	150,000	2,000,000	8,700,000

[1]Run = catch plus escapement to the Fraser River.

[2]Dominant runs will occur every 4 years; data averaged to annual basis.

[3]Dominant runs will occur every 2 years; data averaged to annual basis.

Table 3. Current annual escapement, catch and economic values associated with Fraser River salmon ($ 1978).

Species	Current escapement	Current total catch(3)	Current Canadian commercial catch(4)	Current net whole-sale value: Cdn catch(4)	Current gross whole-sale value: Cdn catch(4)
Chinook	65,938(1)	645,951	284,219	3,350,490	5,814,270
Coho	64,316(1)	193,117(5)	106,461	730,075	1,170,582
Chum	442,570(1)	462,190	369,752	3,905,230	6,344,574
Sockeye	1,296,945(2)	4,739,829	2,749,100	22,915,170	34,268,015
Pink	884,193(2)	2,450,007	1,592,504	6,135,552	9,816,442
Total	2,753,962	8,491,094	5,102,036	37,036,517	57,413,883

(1) Department of Fisheries and Oceans - unpublished information.

(2) International Pacific Salmon Fisheries Commission: Annual Reports 1969 to 1978. (Pink salmon estimates have been averaged over all years to provide an annual estimate).

(3) Includes Canadian commercial, sport and native food catch and American interceptions.

(4) Barclay, J.C. 1977. Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account. Unpublished, Department of Fisheries and Oceans.

(5) Does not include U.S. Interceptions.

Table 4. Potential annual escapement, catch and economic values associated with Fraser River salmon ($ 1978).

Species	Potential escapement (1)	Potential total catch (1) & (3)	Potential Canadian commercial catch (3)	Potential net wholesale value cdn catch (3)	Potential net wholesale value Cdn catch (3)
Chinook	145,938	1,315,951	579,018	7,365,706	11,845,004
Coho	314,316	997,585	428,962	2,941,679	4,716,582
Chum	474,570	1,130,190	904,152	9,549,427	15,514,344
Sockeye	1,496,945	10,139,829	5,881,101	49,022,014	73,308,936
Pink	1,034,193	4,300,007	2,795,004	13,016,979	17,228,838
Total	3,465,962	17,883,562	10,588,237	81,895,805	122,613,704

(1) Department of Fisheries and Oceans unpublished information based on catch/ escapement ratios of enhanced salmon production.

(2) Includes Canadian commercial, sport and native food catch and American interceptions.

(3) Barclay, J.C. 1977. Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account. Unpublished, Dept. of Fisheries and Oceans.

Table 5. Native Indian food fish catches on the Fraser River (5 year average 1972 to 1976) (1)

Total	Sockeye	Coho	Pinks	Chum	Chinook	Steelhead
278,000	204,300	23,800	19,200	11,100	17,400	2,200

(1) Friedlander, Michael J. and Gregory Reif. 1979. Working paper on Indian food fisheries and salmonid enhancement. Government of Canada, Dept. of Fisheries and Oceans.

Table 6. Prosecutions - Pacific Region (Sec. 31, 33(2), 33(3) Fisheries Act - 1971-1979.[1]

Name Address	Offence	Date of Offence	Judgement	Place of Offence
1971				
B.C. Forest Products, Vancouver	33(3) Log debris	16-07-71 to 02-12-71	dismissed	Wakeman River
Stearns-Roger Engineering, Highland Valley	33(2) Del. subst.	07-11-71 to 23-11-71	appealed	Thompson River
1972				
Barker, Richard, N. Vancouver	33(2) Del. subst.	14-07-72	$25	Westview Harbour
Canadian Cellulose, Port Edward	33(2) Del. subst.	13-10-72	$1500	Wainright Basin
Canadian Pacific, Vancouver	33(2) Del. subst.	15-09-72	withdrawn	Bell's Creek
Crown Zellerbach, Lake Cowichan	33(3) Log debris	01-01-72 to 31-12-72	withdrawn	Lake Cowichan
Jack Cewe Ltd., (Johnson Truck Ltd.)	33(2) Del. subst.	21-12-72	$3500	*Coquitlam River
MacMillan Bloedel, Uculet	33(2) Del. subst.	24-11-72 to 28-11-72	$2500	trib. of Palmerston Cree'
Onion Lake Logging Co., Terrace	33(3) Log debris	15 and 30-09-72	$100	Cecil Creek
Twinriver Timber Ltd., Terrace	33(2) Del.subst.	07, 09-01-72	withdrawn	Terrace
1973				
B.C. Forest Products, Prince George (F&W)	33(3) Log debris	11-05-73	dismissed	Prince George
Canada Packers Ltd., Sardis	33(2) Del. subst.	03-05-73	$1500	*Atchelitz Creek
Caron, Lawrence A., Prince George	33(3) Log debris	06-02-73 to 31-03-73	$300	Salmon River
Empire Mills, Vancouver	33(2) Del. subst.	26-10-73	$1000	Mamquam Channel
Eurocan Pulp and Paper, Kitimat	33(2) Del. subst.	25-10-73	$2500	Kitimat River
Eurocan Pulp and Paper, Kitimat	33(3) Log debris	12-02-73 to 07-03-73	dismissed	trib. Kitimat River
Gibralter Mines Ltd. (F&W)	33(2) Del. subst.	30-10-73	$2000	McLease Lake
Hatzic Booming Ltd.	33(2) Del. subst.	10-04-73	$100	*Hatzic
Home Oil Distributors	33(2) Del. subst.	11-03-73	$250	North Bentrick Arm
Imperial Oil & B.C. Hydro	33(2) Del. subst.	05-11-73	$1000 each	Vancouver
Jordan River Mines Ltd., Jordan River	33(2) Del. subst.	31-01-73	$1000, $1	Jordon River
Lang, George, Mission	33(2) Del. subst.	01-03-73	dismissed	*Mission
Martin, Michael J., Campbell River	33(2) Del. subst.	21-02-73	not guilty	Osborne Bay
Newton Ready-Mix, Surrey	33(2) Del. subst.	19-02-73 to 22-02-73	dismissed	*Surrey
Norgaard Ready-Mix, Merritt	33(2) Del. subst.	29-11-73	$1000	Merritt
North-west Falling Contractors Ltd., Nanaimo	33(3) Log debris	01-02-73 to 26-04-73	dismissed	Kanim Lake
Pacific Logging Co., Duncan (F&W)	33(3) Log debris	02-05-73	$1500	Duncan
Pacific Terex Ltd., Campbell River	33(2) Del. subst.	14-05-73	stay	Nunns Creek
Pas Lumber Co. Ltd., Prince George (F&W)	33(3) Log debris	07-06-73	$500	Prince George
Rayner & Bracht, Alberni (F&W)	33(2) Del. subst.	06-06-73	$100	Port Alberni
Rayonier Canada, Port Hardy	33(2) Del. subst.	10-08-73	$1500, $1500	Port Hardy

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1973 (continued)					
Shell Canada Ltd.,	Abbotsford	33(2) Del. subst.	30-08-73	$100, stay	* Abbotsford
Skytte, Marvin		33(2) Del. subst.	05-06-73	$100	Westview
Slegg Forest Products,	Duncan	33(2) Del. subst.	27-02-73	not paid	Cowichan Bay
Smith Cedar Products,	Victoria	33(2) Del. subst.	30-05-73	$750	Victoria
Smith, Charles		33(3) Log debris	-07-73	$100	Cacoohtin Creek
Tammen Pole Services,	Surrey	33(2) Del. subst.	22-01-73 to 07-05-73	$500	* Surrey
1974					
B.C. Forest Products,	Crofton	33(2) Del. subst.	09-08-74	app.&dismissed	Crofton
Bulkey Valley For. Ind.,	(F&W)	33(3) Log debris	03-03-74	dismissed	Collier Lake
D.J. Manning Const. Co.,	Vancouver	33(2) Del. subst.	24-09-74	$500	Kinman Creek
Finlay Forest Products	(F&W)	33(2) Del. subst.	22-05-74	$1500	Mesilinka River
Fix Log Co.,	Sandspit, QCI	33(2) Del. subst.	01-06-74	$300	Haan's Creek
Friell Lake Log Co.,	Vancouver	33(2) Del. subst.	11-10-74	$100	Kyuguot
Friell Lake Log Co.,	Vancouver	33(2) Del. subst.	14-11-74	$500	Kyuguot
Geddes Construction Ltd.,	Kelowna	33(2) Del. subst.	16-05-74	$3000	Whonock Creek
Gold River pulpmill		33(2) Del. subst.	04-01-74	$1000	Gold River
Gulf Oil of Canada		33(2) Del. subst.	01-02-74	$400	Vancouver
May's Lumber Company,	Nanaimo	33(3) Log debris	-07-74	$500	Kalone Creek
MacMillan Bloedel		33(2) Del. subst.	21-03-74	dismissed	Vancouver
MacMillan Bloedel		33(3) Log debris	01-06-74	withdrawn	Haan's Creek
Mercury Marine,	W. Vancouver	33(2) Del. subst.	06-03-74	$300	Strait of Georgia
Pallan Timber Products,	Campbell River (F&W)	33(2) Del. subst.	31-05-74	$600	Campbell River
Rayonier-Woodfibre Mill,	Howe Sound	33(2) Del. subst.	18-08-74	$500	Woodfibre
Slegg Forest Products,	Duncan	33(3) Log debris	04-01-74	$3000	Cowichan Bay
Standard Oil,	Vancouver	33(2) Del. subst.	11-0-7-74	$1000	Westview Harbour
Staub, Harold	(F&W)	33(3) Log debris	03-05-74	$500	Trabor Creek
Tahsis Company (Nootka Logging Div.)	Tahsis	33(2) Del. subst.	20-12-74	$500	Tahsis Inlet
Capt. J. Tindale,	Vancouver	33(2) Del. subst.	19-12-74	$50, $500	North Vancouver
Triangle Pacific Forest Products	(F&W)	33(3) Log debris	16-08-74	$100 + 6mos. probation	Trail
Truman, James & Robert Simpson		33(3) Debris	04-09-74	stay	Nazko River
Valley Drum Ltd.,	Surrey	33(2) Del. subst.	02-10-74	$500	* Surrey
Weldwood of Canada,	Vancouver	33(3) Log debris(x4)	20-11-74	$1000	Powell and Toba River
Weldwood of Canada,	Vancouver	33(2) Del. subst.	14-08-74 and 29-07-74	$2000	Kakweiken River
Weldwood of Canada,	Vancouver	33(3) Debris (x5)	20, 12-11-74	$1000	Toba River

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1975					
B.C. Cement Company (EPS)		33(2) Del. subst.	15-12-75	$1000	Bamberton
Canadian Pacific Ltd., (EPS)		33(2) Del. subst.	30-10-75	$4000	False Creek
Coupal, Giles,	Port Alberni	33(3) Debris	06-05-75	$75	Cherry Creek
Coupal, Jerome,	Port Alberni	33(3) Debris	06-05-75	$75	Cherry Creek
Fowler, Dan		33(3) Log debris	12-05-75		Forbes Bay, Forbes Creek
Hoefer Drill & Blast,	Hope	33(3) Log debris	03-04-75	not guilty	Tahsis Inlet
Johnson Truck Western Ltd.,	Vancouver	33(2) Del. subst.	1975	$100 dismissed*	Coquitlam River
Kolida, Steve,	McBride (F&W)	33(2) Del. subst.	19-12-75	$250	Kitimat
MacMillan Bloedel,	Powell River (EPS)	33(2) Del. subst.	07-04-75	$2500	Powell River
MacMillan Bloedel,	Queen Charlotte Islands	33(3) Log debris	15-04-75	$1500 (appeal)	Yakoun River
Miller, Thomas B.,	Duncan	33(3) Log debris	04-10-75	$50	Cowichan River
Mulder, Karen A.,	Kitimat	33(2) Del. subst.	19-12-75	$250	Kitimat
N & N Contracting,	Squamish	33(3) Log debris	03-04-75	$500	Tahsis Inlet
North Arm Transport		33(3) Del. subst.	01-03-75		Kendrick Inlet
P & R II Holdings,	Prince Rupert	33(3) Debris	01 to 23-06-75	$250	Lakelse Lake
Parkinson, G.D.,	Prince Rupert	33(2) Del. subst.	10-05-75	withdrawn	Prince Rupert
Reid, Wayne -	Port Alberni	33(3) Debris	06-05-75	$75	Cherry Creek
Seaspan International (EPS)		33(2) Del. subst.	30-04-75	$500	Skidegate Inlet
1976					
Alberni Rentals,	Victoria (F&W)	33(2) Del. subst.	01-11-76	$3500	Duncan
Aluminum of Canada	(Kitimat) (EPS, DFO)	33(2) Del. subst.	16-01-76	$400	Moose Creek
A & R Logging Ltd.,	Pemberton	33(3) Log debris	30-09-76	$100	Pemberton
Coulson, P.L.,	Port Alberni	33(3) Log debris	04-08-76	$500	Barkley Sound
Cresbrook Forest Ind.,	Cranbrook (F&W)	33(3) Log debris	01-07-76 and 07-10-76	voided	Kimberley
Douglas Stewart Border Feedlot,	Surrey (EPS)	33(2) Del. subst.	12-10-76		Campbell River
Ganzeyeld Lumber,	Enderby	33(3) Log debris	05-05-76	$500	Shuswap River
Gretchon Creek Log Co.,	Duncan	33(3) Log debris	16-06-76	$500	Toquart Bay
Haack, Lothar,	Port Alberni	33(2) Del. subst.	30-08-76	$300	Spaht Creek
Island Salvage,	Campbell River	33(2) Del. subst.	18-03-76	$200	Campbell River
Kinden Holdings,	Merritt	33(3) Debris	18-05-76	$750	Nicola River
MacMillan Bloedel (F&W)	Port Alberni	33(2) Del. subst.	14-09-76	quashed	Cook Creek
Mawly, H.,	Port Alberni	33(3) Log debris	22-07-76	dismissed	Deer Creek
New, L.,	Chase, B.C.	33(2) Del. subst.	12, 22, 23-04-76	$800	Shuswap Lake
OK Paving Co.,	Victoria, B.C.	33(2) Del. subst.	20-05-76	$750	Tahsis
Ram Supplies,	Campbell River	33(2) Del. subst.	15 to 20-03-76	$1500	Unnamed Creek

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1976 (continued)					
Riverside Forest,	Enderby, B.C.	33(3) Debris	26, 31-03-76	$1000	Shuswap River
Schrul, R.,	Chilliwack	33(2) Del. subst.	09-10-76	$50	* Veddar Crossing
Seaward Construction,	Surrey (F&W)	33(2) Del. subst.	13-08-76	$15	Nanaimo
Seaway Towing,	Campbell River	33(2) Del. subst.	02-06-76	$1500	Campbell River
Tahsis Company Ltd.,	Tahsis	33(2) Del. subst.	15-06-76	$500	Gold River
Tappen Valley Ltd.,	Tappen	33(3) Log debris	06-05-76	$500	Shuswap Lake
Weldwood of Canada,	Duncan	33(3) log debris	01-08-76	$2500	Shoal Harbour Creek
1977					
Bosch, Dan.,	Edgmont	33(3) Log debris	04-02-77	$100	Edgmont
Bradford Collison,	Fort Nelson (F&W)	33(3) Debris	25-07-77 to 04-08-77	$400	Mary Creek
Canadian Cellulose Co. Ltd.,	Prince Rupert (EPS)	33(2) Del. subst.	22 to 27-01-77	appeal	Prince Rupert
Canadian Forest Products,	Port Mellon (EPS)	33(2) Del. subst.	15-09-77	$10,000	Port Mellon
Canadian Fishing Co. Ltd.,	Steveston (EPS)	33(2) Del. subst.	29-08-77	$1,000	* Steveston
Cailson, Thomas,	Vanderhoof (F&W)	33(3) log debris	26-01-77	$100	Nechako River
Drillwell Enterprises,	Cowichan Stn., (F&W)	33(2) Del. subst.	07-10-77	$2000	Shawnigan Creek
George Ware Logging,	Merritt (F&W)	33(3) Log debris	03 to 31-01-77	aquittal	Voght Creek
Gulf of Georgia Towing,	Vancouver	33(2) Del. subst.	03-11-77	stay	Sandpoint
Henderson, Samuel,	Vancouver (F&W)	33(2) Del. subst.	02-10-77	$250	Squamish
Hoisington, Robert,	Salmon Arm	33(2) Del. subst.	24-11-77	$200	Salmon River
Keith Mon's & Sons Ltd.,	Nanaimo (F&W)	33(2) Del. subst.	22-04-77	dismiss	Nanaimo
Kwan, Kenneth,	Smithers	33(2) Del. subst.	13-04-77	$75	Smithers
Logan, William,	Vancouver	33(2) Del. subst.	21-12-77	$150	Tutahun Cres.
Marsh, Fred James,	Kitimat	33(2) Del. subst.	01, 02-06-77	not guilty	Kitimat
Michaels, Lorne,	Nanaimo (F&W)	33(2) Del. subst.	-12-77	$750	Nanaimo
Phillips, Albert	(F&W)	33(3) Log debris	05-01-77	$25	* Fraser River (Crescent S
Pineault, Gilles	QC City	33(3) Log debris	-09-77	$50	Hecate Straight
Raven Lumber Ltd.,	Campbell River (F&W)	33(2) Del. subst.	24-10-77	stay	Campbell River
Rayonier Canada,	Port McNeil (F&W)	33(2) Del. subst.	22-04-77	$3000	Klogh River
Roberts, Benjamin,	Vancouver	33(2) Del. subst.	18-12-77	not guilty	* Musqueam Creek
Zeider Forest Industries,	McBride (F&W)	33(3) Log debris	21-06-77	$500	Castle Creek

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1978					
Abaccus City, Kamloops (F&W)		33(2) Del. subst.	27-04-78	$100	Paull Lake
Bennett, Robert I.		33(3) Log debris	02-03-78	$1200	Benson Lake
Blackham's Construction		31-Alter habitat	21-11-78	dismissed	* Chilliwack
Bosch, Dorhn		33(3) Log debris	04-08-78	$200	Anderson Creek
B.C. Forest Products, Crofton		33(3) Log debris	09-10-78		Osborne Bay
B.C. Hydro		33(2) Del. subst.	15-09-78		Quatse River
B.C. Packers Ltd., Steveston		33(2) Del. subst.	24-04-78	$1000	Porpoise Harbour
Butler Lafarge, Nanaimo (F&W)		33(2) Del. subst.	31-05-78	$100	Craig Creek
Canadian Pacific Ltd. (EPS)		33(2) Del. subst.	17-05-78	$12,000	False Creek
C.P. Railway, Salmon Arm (R&W)		31(1) Alter habitat	06-05-78	stay	Broderick Creek
Charles Self Logging, Prince George (F&W)		33(3) Log debris	-05-78	$500	Davie Lake
Courtney, Corp of (F&W)		31(1), 33(2), Alter habitat, del. subst.	21-10-78	$2000 stay	Courtenay
Dag's Logging, Clinton, B.C. (F&W)		33(3) log debris	01 to 05-05-78	$1000	Crystal Creek
Dawson Construction, Vancouver (F&W)		31(1) Alter habitat	28-07-78	$3000	Bear Creek
Downie St. Sawmills, Three Valley Gap		31(1) Alter habitat	25-04-78	$2000, stay	Eagle River
Fort Nelson Forest Industry (F&W)		33(3) log debris	01-02-78 to 31-03-78	$500	Tsimeh Creek
Gogo, Michael, T.		33(3) log debris	24-01-78		McNaughton Creek
Guerin, Robert		33(2) Del. subst.	01-02-78	stay	* Musqueam Res.
Jackson Bros. Logging Company		33(3) log debris	13-03-78, 03-04-78		Angus Creek, Burnet Creek
Jesse Homes Ltd., Campbell River (F&W)		31(1) Alter habitat	23-01-78	$700	Nunns Creek
Kany Construction		33(2) Del. subst.	29-11-78, 14-09-78		Trustee Creek
Lunn, Nic, Nanaimo (F&W)		33(2) Del. subst.	-10-78		Nanaimo
MacDonald Cedar Products		33(2) Del. subst.	14-09-78		Kwatna River
MacDonald Cedar Products		33(3) Log debris	14-09-78		Kwatna River
MacMillan Bloedel Limited, Vancouver		31, 33(3)	07-03-78		Survery Creek
MacMillan Bloedel (F&W)		33(3) Log debris	29-01 to 21-02-78	$1500	Queen Charlotte Islands
Mills, William		31 Alter habitat	23-11-78	stay	Chilliwack
Morhart, James		33(3) Log debris	01-02-78	s.s	New Remo
Naden Harbour Timber, Masset, B.C. (F&W)		31(1), 33(3)Alter and debris	15-05 to 03-06-78	dismissed	Queen Charlotte Islands
Port McNeil, Mun., of		33(2) Del. subst.	29-05-78		Unnamed Creek
Sjostrom, Harold		33(2) Del. subst.	19-12-78		Cherry Creek
Smith, Arthur, J.		33(3) Log debris	20-03-78	$100	Chindemash Creek
Southwest Contracting		33(2) Del. subst. 31(1)	27-02-78	dismissed	* MacDonald Slough

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1978 (continued)					
Sproat Transport		33(2) Del. subst.	19-10-78		Taylor River
Standard General		33(2) Del. subst.	24-08-78	withdrawn	Nanaimo
Standeven, Richard		31 Alter	21-11-78	stay	Chilliwack
Thackray, Donald, Vanderhoof (F&W)		31(1) Alter	15-03-78 to 25-04-78	$100	Nechako River (nr. Vander
Tri-pae Studs, Quesnel (F&W)		33(3) Log debris	-04-78	stay	Ramsey Creek
Upland Excavating (Campbell River) (F&W)		33(2) Del. subst.	20-03-78	$100	Chase River
Vorady, Paul		31(1) Alter	02-08-78		Fundale
Warder, Ken Qualicum (F&W)		33(2) Del. subst.	-05-78	$200	Nanaimo
Wold, Lyn		31(1) Alter	02-08-78		Fundale
1979					
Arbour, Edward		31(1) Alter habitat	17-10-79		Campbell River
Alberni Auto Trans. Ltd.		33(2) Del. subst.	11-06-79		Nanaimo
Betkowski, Jerzy		33(3) Dumping river	17-05-79		* Fraser River
Buchanan, Bruce		31(1) 33(2) alter and Del. subst.	01-02-79		West Vancouver
Candy, Nicholas		31(1)dis. habitat	21-06-79		Brackendale
Construction Aggregates Limited		33(2) Del. subst.	26-10-79		Dakota Creek
Dowad, Wilfred		31(1) Destruct hab.	21-05-79		Brackendale
Dowad, Wilfred		33.1 fail submit plans	21-05-79		Brackendale
Ernst Forest Products Limited		31(1) Alter habitat	25-07-79		Quesnel
Ernst Forest Products Limited		33(2) Del. subst.	25-07-79		Quesnel
Fulford Inn Holdings Limited		31(1) Alter habitat	17-08-79		Fulford Harbour
Fulford Inn Holdings Limited		33(2) Del. subst.	17-08-79		Fulford Harbour
Furmanek, George		33(3) dumping river	16-06-79	dismissed	Terrace
Geise, Alvin		33(1) Alter habitat	22-11-79		Campbell River
Grapevine Construction		33(2) Del. subst.	23-01-79		Trustee Creek
Graham, Norman		33(2) Del. subst.	07-03-79		Tribune Creek
Henrick, Delton		33(2) Del. subst.	14-02-79		Port Hardy
Kany Construction and Engin. Limited		33(2) Del. subst.	14-02-79, 23-01-79		Trustee Creek
Land, Victor		31(1) Alter habitat	01-02-79	stay	West Vancouver
Land, Victor		33(2) Del. subst.	01-02-79	stay	West Vancouver
Lim, Ron		31(1)destruct hab.	22-05-79	$1500	Swarsky Creek
Lim, Ron		33(2) Del. subst.	22-05-79	withdrawn	Swarsky Creek

Table 6. Continued

Name	Address	Offence	Date of Offence	Judgement	Place of Offence
1979 (continued)					
Markland Road Builders Limited		33(1) Alter habitat	20-04-79	$1000	Takla Lake
Markland Road Builders Limited		33(2) Del. subst.	20-04-79	stay	Takla Lake
McLellan Logging Limited (F&W)		33(3) log debris	16 to 25-04-79	$300	Kelowna
Norm's Backhoe and Exc. Limited		31(1) Alter habitat	22-05-79	$1500	Swansky Creek
Norm's Backhoe and Exc. Limited		33(2) Del. subst.	22-05-79	dismissed	Swansky Creek
Shoal Bay Lodge Limited		33(2) Del. subst.	04-03-79		Shoal Bay
Simaid, Raymond		31(1) Alter habitat	17-08-79		Fulford Harbour
Simaid, Raymond		33(2) Del. subst.	17-08-79		Fulford Harbour
Traer and Mahood Contractors		33(3) Log debris	23-04-79	dismissed	Milton River
Thomson Industries		33(3) Log debris	10-10-79		Rivers Bight
Upland Excavating Limited		31(1) Alter habitat	13-12-79		Campbell River
Upland Excavating Limited		33(2) Del. subst.	13-12-79		Campbell River
Verge, Ralph		31(1) Alter habitat	08-10-79		Campbell River

[1] The table comprises available listed information: a few omissions could occur in the list.

* Fraser River system

* = Fraser River System.