Fraser River Estuary Study
Water Quality

Trace Organic Constituents In Discharges

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SUMMARY

Effluent samples from Annacis, Iona and Lulu sewage treatment plants were analysed by GC-MS and found to contain measurable amounts of pentachlorophenol, tetrachlorophenol, polychlorinated biphenyls, hexachlorobenzene and phthalate esters.

Samples taken from industrial outfalls, three sewage treatment plants and drainage ditches were analysed for chlorinated phenolic compounds. Seventeen phenolic compounds were identified; of these pentachlorophenol and tetrachlorophenol were present in over 85% of the samples. The median concentrations of pentachlorophenol and tetrachlorophenol were 1.8 and 1.0 ppb respectively.

A few industrial discharges were found to have very high levels of phenolic compounds. For example 3 mg/L 2,4,6-trichlorophenol was observed in the drainage ditch paralleling the former location of Later Chemicals and 6 mg/L pentachlorophenol in the ditch fronting Coast Laminated Timber.

Note: R. J. Cain is currently employed by McMillan Bloedel Ltd., and N. R. Zorkin is undertaking graduate studies at the University of British Columbia.

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PREFACE

The Fraser River Estuary Study was set up by the Federal and Provincial Governments to develop a management plan for the area.

The area under study is the Fraser River downstream from Kanaka Creek to Roberts Bank and Sturgeon Bank. The Banks are included between Point Grey and the U.S. Border. Boundary Bay and Semiahmoo Bay are also included but Burrard Inlet is not in the study area.

The study examined land use, recreation, habitat and water quality, and reports were issued on each of these subjects.

Since the water quality report was preliminary, a more detailed analysis of the information was undertaken by members of the water quality work group. As a result, eleven background technical reports, of which this report is one, are being published. The background reports are entitled as follows:

- Municipal effluents
- Industrial effluents
- Storm water discharges
- Impact of landfills
- Acute toxicity of effluents
- Trace organic constituents in discharges
- Toxic organic contaminants
- Water chemistry; 1970 - 1978
- Microbial water quality; 1970 - 77
- Aquatic biota and sediments
- Boundary Bay

Each of the background reports contains conclusions and recommendations based on the technical findings in the report. The recommendations do not necessarily reflect the policy of government agencies funding the work. Copies of these reports will be available at all main branches of the public libraries in the lower mainland.

Five auxiliary reports are also being published in further support of the study. These cover the following subjects:

- Site registry of storm water outfalls
- Dry weather storm sewer discharges
- Data report on water quality
- Survey of fecal coliforms in 1978
- Survey of dissolved oxygen in 1978

Copies of these reports will be available from the Ministry of Environment, Parliament Buildings, Victoria, British Columbia.

To bring this work together the water quality work group has published a summary report. This document summarizes the background reports, analyzes their main findings and presents final recommendations. Some of the recommendations from the background reports may be omitted or modified in the summary report, due to the effect of integrating conclusions on related topics. Copies of the summary report are in public libraries, and extra copies will be available to interested parties from the Ministry of Environment in Victoria.

INTRODUCTION

Each year increasing amounts of domestic and industrial wastewater are being discharged into the Fraser River, some of these wastes containing toxic organic chemicals. Routine effluent and water quality monitoring programs usually have included the traditional water quality parameters such as BOD_5, suspended solids, or pH, but often have overlooked trace organic compounds. Therefore little is known about the presence, toxicity or accumulation of these compounds in wastewaters discharged to the Fraser River. The purpose of this study was to obtain some preliminary information on the occurrence of trace organic compounds in the many types of effluent that discharge either directly or indirectly into the Fraser River. This preparatory work is necessary for the design of future studies of this complex problem.

Two sets of samples were collected for this study. Effluents from three municipal sewage treatment plants were investigated by combined gas chromatography/mass spectrometry for the presence of trace organic compounds. Additionally, a variety of wastewater samples were taken in the Greater Vancouver area and investigated by gas chromatography for chlorinated phenolic compounds. All analyses were performed by CAN TEST Laboratories under contract to the British Columbia Ministry of Environment.

PART I

TRACE ORGANIC CONSTITUENTS OF THREE MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENTS

1.0 DESCRIPTION OF SEWAGE TREATMENT PLANTS SAMPLED

There are seven sewage treatment plants (STP's) in the lower Fraser River/Estuary. Of these the Iona, Annacis and Lulu Island plants account for about 97% of the total volume of municipal effluent discharged to the Fraser River (Cain and Swain, 1980).

1.1 Iona Island STP

The Iona Island primary STP treats sewage from the City of Vancouver, a portion of the Municipality of Burnaby and the University Endowment Lands. The sewerage system is a combined sanitary, industrial and storm water collection system encompassing an estimated area of 14 400 hectares with a contributing population of 464,000. During 1977 the daily flows, averaged monthly, ranged between 312 000 m^3/day and 570 000 m^3/day [68.6 million gallons per day (MGD) and 125.4 MGD (GVRD* Annual Report 1977)].

1.2 Annacis Island STP

The Annacis Island primary STP treats sewage from eleven municipalities and serves an area of approximately 46 600 hectares with a contributing population of 370,000. Domestic, industrial and storm wastewater is collected in a combined sanitary and stormwater sewerage system. During 1977 the daily flows, averaged monthly, ranged between 148 000 m^3/day and 186 000 m^3/day [32.6 MGD and 41.0 MGD (GVRD Annual Report 1977)].

The major industries on line to the Annacis Island STP include pulp, paper and lumber industries (B.C. Research 1978). A few plating and chemical plants are also connected to the Annacis sewerage system.

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*Greater Vancouver Regional District

1.3 Lulu Island STP

The Lulu Island primary STP treats sewage from an area which encompasses the Township of Richmond. The Lulu Island plant is the smallest of the three* Greater Vancouver Regional District's STPs with a contributing population of 55,000. During 1977 the daily flows, averaged monthly, ranged between 17 700 m^3/day and 25 500 m^3/day [3.9 MGD and 5.6 MGD (GVRD Annual Report 1977)].

The location of the three municipal STPs and an outline of the area they serve is given in Figure 1.

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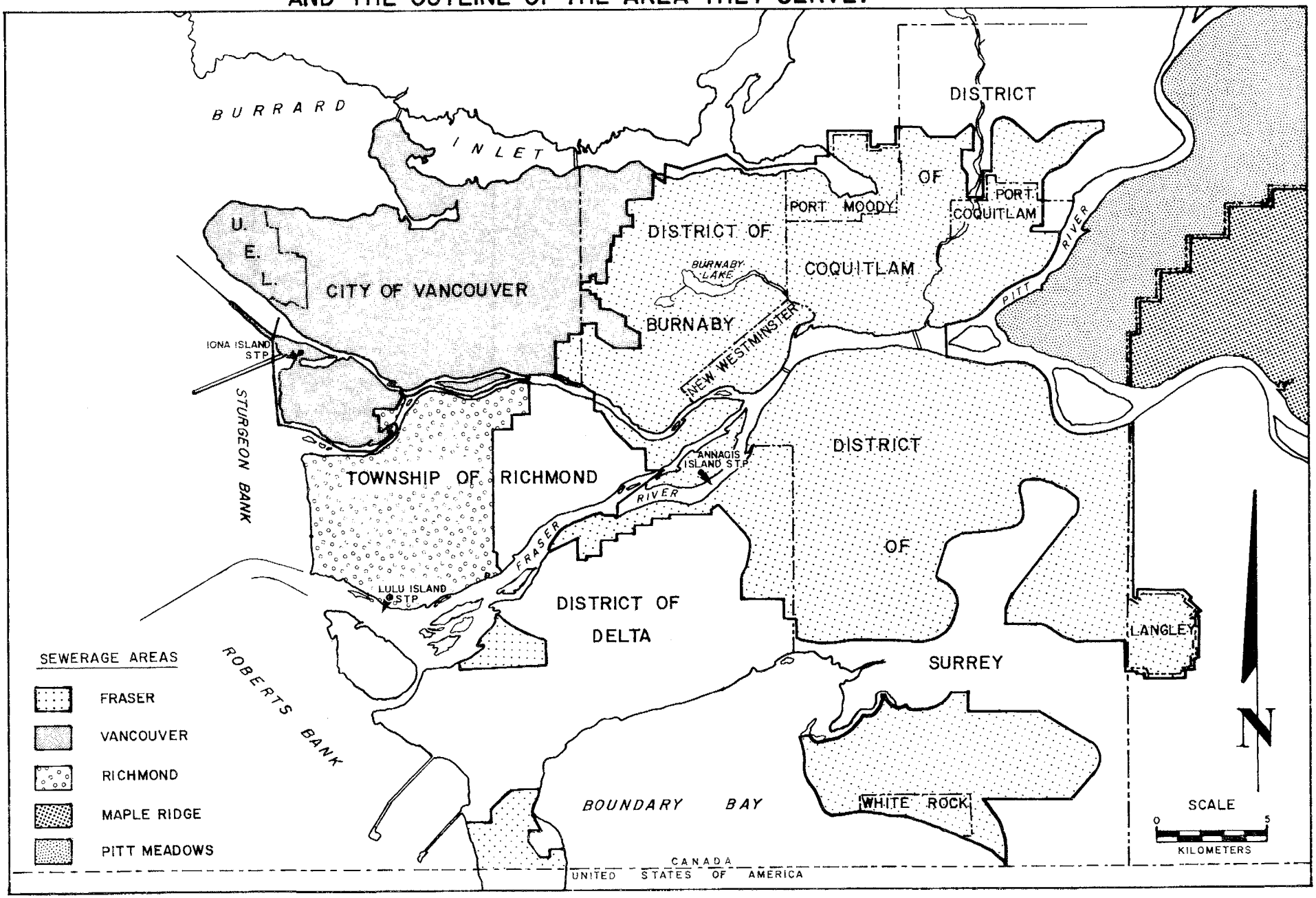
*Lion's Gate STP lies outside the study area.

FIGURE 1.
THE LOCATION OF THE MUNICIPAL TREATMENT PLANTS
AND THE OUTLINE OF THE AREA THEY SERVE.



2.0 METHOD OF ANALYSIS

Effluent samples were collected March 8, 1978 from each of the three municipal STP's, these samples taken from the 24 hour composite collected daily by GVRD. Metal capped acid winchester bottles, thoroughly rinsed with distilled water, were used to transport the effluent samples to the Can Test laboratories in Vancouver.

Can Test utilized their gas chromatography/mass spectrometry techniques to determine the trace organic constituents in the STP's effluent. In brief, the procedure followed closely to that given in "Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants", published by the U.S. Environmental Protection Agency (An excerpt from this report follows in Appendix I). The extraction procedure involved a base-neutral extraction with methylene chloride, followed by an acid extraction. The resulting extracts were concentrated by Kuderna-Danish evaporation and analyzed by gas chromatography/mass spectrometry.

A separate aliquot taken from each sample was analyzed by gas chromatography (electron capture detection) for organo-chlorine pesticides and polychorinated biphenyls. Additionally, the acid extract was analyzed for chlorinated phenols, as described in Section 2.0 (page 18).

Note that the above procedure was not applicable to volatiles such as trihalomethanes.

3.0 RESULTS AND DISCUSSIONS

Fifty-seven trace organic compounds were detected in the effluents from the three STP's. Of the fifty-seven compounds found, fifteen have been quantified, thirteen have been tentatively identified, twenty-five have been identified as to class and one has remained unidentified. The results are presented in Appendix II. A summary of the results is presented in Table 1 (page 13).

A variety of trace organic compounds were found in all the STP's. The compounds identified can be generally categorized as drugs, steroids, phthalates (plasticizers), phenolics, fatty acids, terpenes and chlorinated hydrocarbons. The compounds will be discussed by class in the following sections.

3.1 Drugs

Caffeine and nicotine were identified in the effluent samples. Caffeine was present in each of the STP's. The highest concentration of caffeine (60 µg/L*) was found in the Lulu Island STP. Nicotine was only found in the Lulu Island STP, but was not quantified.

The sources of these drugs are obvious (coffee, tobacco, etc.) and both are commonly observed in effluents from municipal treatment facilities (Can Test 1977). Reportedly nicotine is toxic to fish at concentrations above 3 mg/L (Mckee and Wolf, 1963).

3.2 Steroids

Coprostanol and cholesterol were identified and quantitated in all of the STP's. The highest concentrations for coprostanol (450 µg/L) and cholesterol (400 µg/L), were found in the Lulu Island STP. Human excreta

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* µg/L = micrograms per litre

is the major contributor of both cholesterol and coprostanol. Cholesterol is not only present in excreta, but also in eggs, milk, lard, wool, grease, etc., and therefore cannot be considered a specific indicator of fecal pollution; coprostanol, on the other hand, is a characteristic fecal organic compound. It is converted by microbial action from cholesterol in the large intestines of mammals. However, field surveys by the U.S. Environmental Protection Agency have shown that coprostanol does not correlate with either fecal or total coliform levels (Singley 1974).

Cholesterol and coprostanol are degraded by microbial action in the environment. More than 1,000 bacterial strains are capable of degrading cholesterol (Singley 1974). Coprostanol is structurally almost identical to cholesterol and can be assumed to be degraded as easily. Neither steroid seems likely to endanger the estuarine environment.

3.3 Phthalate Esters

Phthalate esters have been identified in all of the STP's. Of the five phthalate esters identified, four were found in appreciable quantities in the wastewater discharge from the Iona sewage treatment plant. Diethyl phthalate was identified in all three STP's.

The phthalate esters are used in the chemical industry, being used extensively in the manufacture of dyes, plastics, and plasticizing agents. The presence of phthalates is probably due to the widespread use of phthalate-containing products.

Phthalate esters have been found to persist in unadapted soil for greater than eighteen months (Abrams 1975). Reportedly, they can be both degraded or concentrated by various biological organisms (Abrams 1975). To keep these compounds in proper perspective, they do not appear to be especially toxic, but they are in very widespread use, slow to degrade, and are now appearing throughout the global environment.

The U.S. Environmental Protection Agency (EPA) has published a list of "Priority Pollutants", those contaminants considered most dangerous to man or his environment. Of the six phthalate esters listed by EPA, five have been identified in the effluents from STP's. However, there is very little knowledge of environmental effects of phthalates.

In 1976, the joint DFE/NH&W (Department of Fisheries and the Environment/Department of National Health and Welfare) Environment Contaminants Committee began development of a list of priority chemical substances. As of March 1977, the phthalate esters had been classified as category three compounds on this list. In part, category three stated the following:

> "Those substances which the government believes may pose a significant danger to the environment or human health, or about which further detailed information (toxicology, amount used, etc.) is required."

For phthalates, the latter comment regarding further research is pertinent, particularly with regard to accumulation in estuarine sediments and biota.

3.4 Phenolics

Tetrachlorophenol (TCP) and pentachlorophenol (PCP) were detected in the low µg/L range in samples from all of the STP's and p-cresol was identified in a sample from the Lulu Island STP. All three substances are widely used as fungicides or bactericides and as preservatives for many materials, particularly wood products.

The sources of these substances are difficult to pinpoint. A study of municipal STP's in three Oregon cities found the highest levels of PCP during the daytime, reflecting probable industrial discharges (Buhler 1973). A similar study on the STP's in Vancouver would be necessary before one could conclude that industrial discharges are the source of these materials, though this seems likely.

PCP is a highly toxic compound which affects the biota in very low concentrations. The long term tolerance for some fish has been estimated at 0.04 parts per million (ppm). Similarly, lower plants and micro-organisms respond adversely to concentrations in the 0.1 ppm range (Howard 1973). Also, PCP has been shown to persist in unadapted soil for longer than eighteen months. The discharge of this toxic and persistent compound could be hazardous to the environment in locations where accumulation occurs,

either in the sediments or biological organisms. PCP is on the U.S.E.P.A. Priority Pollutant list. Also, the chlorophenols in general are classified as category three compounds by the DFE/NH&W Committee. TCP, like PCP, degrades slowly in the environment and is of similar environmental concern. P-cresol is of less concern at the levels (less than 50 ppb) likely to be discharged from STP's, although levels in excess of 4,000 ppb are acutely toxic to fish. All three substances can be associated with the tainting of fish flesh.

3.5 Fatty Acids and Their Methyl Esters

Five fatty acids and three fatty acid methyl esters were identified in the effluent samples. Lauric, arachidic, palmitic, stearic and myristic acids were identified. Palmitic and stearic acids were an order of magnitude higher in concentration in the Lulu Island STP than in the Iona and Annacis Island STP's. This may be attributed to large quantities of fats being discharged from the canneries that are on line to the Lulu Island STP during the herring season. Three fatty acid methyl esters were detected but not quantified in two of the three STP's.

Fatty acids are found throughout nature and are to be observed in virtually all living systems. Industry makes full use of them, particularly the soap industry. Some of these substances are toxic to invertebrates and fungi; soapy solutions have been used in home garden sprays long before artificial pesticides were developed. The lethal dose of the sodium salts of several fatty acids to fish is 5 mg/L (McKee and Wolf, 1971). Additional notes concerning some common fatty acids are tabulated in Appendix III. Fatty acids are not known to cause any environmental problems at the low concentrations observed. However it should be kept in mind that they form monolayer films very readily, and such films hypothetically may slow reaeration, and concentrate various toxicants.

3.6 Terpenes

A number of terpenoids were identified in the effluent samples, but none were quantified. One terpenoid identified was α-terpineol, which is associated with the essential oils which cause the fragrant odours of many plants. The manufacturing industry uses the terpenoids frequently in

perfumes and cosmetics. They are also employed as solvents in paints, as preservatives, as artificial flavouring in foodstuffs and to a small extent in medicine (Templeton 1969). Also, α-terpineol is the main active ingredient in pine oil, and is a bactericide, the active ingredient in household cleansing formulations.

A study of the effluent from a hardboard plant discharging into the Fraser River has identified α-terpineol in the effluent (Rogers 1979).

3.7 Chlorinated Hydrocarbons

The chlorinated hydrocarbons, including polychlorinated biphenyls (PCB's) and Hexachlorobenzene (HCB), were identified and quantitated in all the STP's effluent samples. The concentration of PCB (Arochlor 1260) was generally two orders of magnitude higher than HCB. Urban sewage outfalls are well established as sources of PCB's (Schmidt et al 1971).

PCB's have been used as dieletric fluids, fire retardants, heat transfer agents, and plasticizers (adhesives, textiles, surface coating, sealants, copy paper) (Hutzinger 1974). Their chemical properties of lipid solubility and resistance to degradation have been the cause of PCB accumulation in the food chain and therefore further use of PCB's has been discontinued in Canada, except for existing electrical equipment.

HCB has been found as a trace contaminant in the environment. It is a very stable, unreactive compound. There is no evidence that it is degraded by physical or chemical processes in the environment (Mumma 1975).

HCB and PCB's are on the EPA Priority Pollutant list. Also, the PCB's are classified as category one compounds by the DFE/NH&W. Category one, in part, states the following, "Those substances which the government is satisfied pose a significant danger to the environment or human health and for which regulations are being developed."

In the past HCB was used widely for its fungicidal properties. Due to evidence of its persistence in the environment and uptake in biota such use is now restricted.

The lower chlorinated benzenes have also been used extensively as solvents, lubricants, chemical intermediates, insecticides, fungicides, and germicides. Tri-chlorobenzene has recently been suggested as a replacement fluid for PCB's in transformers. Though the lower chlorinated benzenes are most likely more rapidly degraded in the environment than PCB, nonetheless bio-accumulation may occur. Also, these substances sometimes are observed in higher concentrations than PCB in STP's (Young and Husen, 1978).

TABLE 1

SUMMARY OF COMPOUNDS FOUND IN THREE MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENTS BY GC-MS ANALYSIS

(ug/L)

	Annacis Island Effluent	Iona Island Effluent	Lulu Island Effluent
FATTY ACIDS			
Dodecanoic Acid (Lauric)			?
Eicosanoic Acid (Arachidic)			40
Hexadecanoic Acid (Palmitic)	270	100	3000
Octadecanoic Acid (Stearic)		200	5000
Tetradecanoic Acid (Myristic)			110
FATTY ACID METHYL ESTERS			
Hexanedioic Acid Ester	*		
Methyl Hexadecanoate	?		?
Methyl Octadecanoate			?
PHTHALATE ESTERS			
Dibutylphthalate	2	20	
Diethylphthalate	4	2	40
Dimethylisophthalate		50	
Dimethylphthalate		10	
Dioctylphthalate	?	?	?
DRUGS			
Caffeine	20	10	60
Nicotine			*
TERPENES			
Alpha-Terpineol	*		*
Terpineol Isomer			*
3,7, Dimethyl-1,6-Octadien-3-ol		?	?
3,7,11-Trimethyl-2,6,10-Dodecatrien-1-ol	?	?	?
STEROIDS			
Cholesterol	110	70	400
Coprostanol	90	70	450
PHENOLICS			
p-Cresol			*
Pentachlorophenol	9	6	8
Tetrachlorophenol	9	30	1

TABLE 1 (con't.)

SUMMARY OF COMPOUNDS FOUND IN THREE MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENTS BY GC-MS ANALYSIS

	Annacis Island Effluent	Iona Island Effluent	Lulu Island Effluent
CHLORINATED HYDROCARBONS			
Hexachlorobenzene	0.006	0.004	0.005
Polychlorinated Biphenyls	0.24	0.3	0.13
HYDROCARBONS			
C_3 Benzenes			*
C_4 Benzene			?
Long Chain Alkyl Benzene	-		
OTHERS			
6,10,14-Trimethyl-2-Pentanone	?		

NOTE: ? = Tentatively Identified
* = Identified but not Quantitated
- = Only Identified to Class
() = Denotes Synonymous Name
Concentration is measured in ppb

PART II

TRACE PHENOLIC COMPOUNDS FOUND IN SOME DISCHARGES FROM THE GREATER VANCOUVER AREA

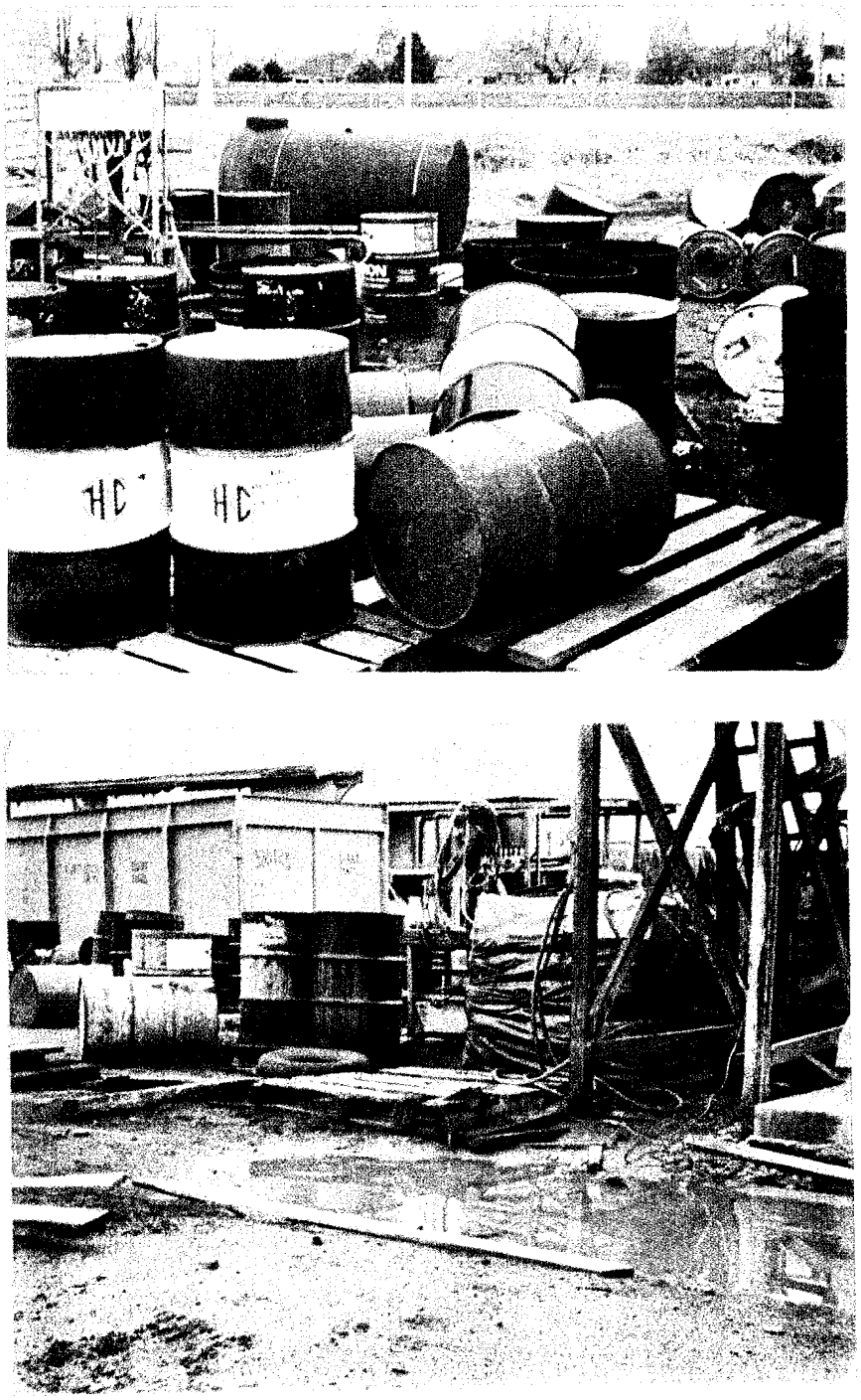
1.0 DESCRIPTION OF SAMPLING LOCATIONS

A number of discharges in the Vancouver area have been investigated for the presence of fifty-one phenolic compounds. A total of forty-five water samples were collected and analysed. The types of water samples collected were as follows:

1) Seventeen samples from industrial effluents or drainage ditches near industrial locations;
2) Six influent and nine effluent samples from three municipal sewage treatment plants;
3) Twelve samples from drainage ditches associated with landfill sites and
4) One sample from a sewage lagoon.

The dates, locations and conditions of the sampling programme are given in Table II. The compounds analysed for and the minimum detection limits are listed in Table III. There are photographs showing an industrial yard in Figure 2.

FIGURE 2: Two Photographs of the Yard Conditions at Later Chemical (March 9, 1978)



2.0 METHOD OF ANALYSIS

Forty-five water samples were collected in one-half gallon glass bottles (supplied by Can Test Ltd.) and submitted to the Can Test Laboratories for analysis. Can Test had no knowledge of where the samples were taken nor which samples were replicates. The samples were investigated for trace phenolic compounds by a procedure developed by Can Test Ltd. In general, the procedure involved an extract being prepared by passing a water sample through an ion exchange resin followed by elution with an organic solvent. A portion of the extract was derivatized and analyzed for chlorinated phenols by gas-liquid chromatography using electron-capture detection. The remainder of the extract was analyzed for non-chlorinated phenols by gas-liquid chromatography with flame-ionization detection. The detailed procedure can be obtained from the Can Test Laboratories in Vancouver.

3.0 RESULTS AND DISCUSSION

The trace levels of phenols found in the water samples are presented in Table IV. Seventeen phenolic compounds were identified in the forty-five water samples. The compounds found most prevalent were pentachlorophenol, 2,3,4,6-tetrachlorophenol, 2,4,6-trichlorophenol and 2,4,5-trichlorophenol. It should be noted that the detection limits for these compounds were lower than for most of the other compounds investigated. As a result the compounds with the higher detection limits may be present in similar concentrations but because of the higher detection limits cannot be detected. The four replicate samples inserted as a quality control aid (sample numbers 2,4; 8,9; 11,13; 18,22) indicated similar results between the pairs of samples.

Pentachlorophenol (PCB) was detected in forty-two of the forty-five water samples. The median concentration for the forty-two samples was 1.8 ppb*, but levels of over 1,000 ppb were found in two different locations. General sources and the toxicity of PCP have been discussed in the earlier section on phenolics. It should be emphasized though, that the widespread occurrence of PCP indicated by these results, should not be overlooked and further investigation into this problem is necessary.

2,3,4,6-tetrachlorophenol (TCP) was identified in thirty-nine of the forty-five water samples. The median concentration for the thirty-nine samples was 1.0 ppb. The possible sources of tetrachlorophenol contamination have been discussed earlier in the section on phenolics.

2,4,6-trichlorophenol was identified in twenty-five of the forty-five water samples. Generally, it was found in much lower concentrations than either PCP or TCP. 2,4,6-trichlorophenol has been used as a germicide, a wood preservative, glue preservative, insecticide ingredient, bactericide, and an antimildew treatment for textiles (Howard 1973). It has been found to be slow to degrade in the environment.

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*ppb - parts per billion

2,4,5-trichlorophenol was identified in nineteen of the forty-five effluent samples. It was found only in trace concentration in over half of these nineteen samples.

The results shown in Table IV indicate that there may be a few point sources of toxic phenolics. Water samples twenty-nine and forty-three were taken from the drainage ditches around the Later Chemical plant. The levels of both phenolic and chlorinated phenolic compounds found in these ditches were much higher than elsewhere. Can Test noted that there were also many other organic compounds. The presence of these chemicals seems to be due to poor housekeeping at the Later Chemical plant (Figure 2). It should be noted that Later Chemical has subsequently relocated. The fate of chemicals at their former location (320 Lysander Lane, Richmond) should be viewed with concern. Another water sample with very high levels of chlorinated phenolics was taken from a ditch fronting Coast Laminated Timber in Delta. Accidental overflows of washwater drain from the property to this drainage ditch.

TABLE II

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb. /78	Location	Field Notes
1	21	Scott Paper New Westminster - effluent sample - PE-335	ground wood mill - mostly cotton woods - tissues - one combined outfall - composite sample 7:00 a.m. to 8:30 a.m. (1½ hrs.)
2,4	21	Annacis Island STP - effluent sample - PE-387	- duplicate analyses - samples provided by laboratory technician at STP - composite samples from 7:30 a.m. Feb. 20 to 7:30 a.m. Feb. 21 - bottle #4 only 2/3 full due to insufficient sample - there is prechlorination for odour control (about 900 lbs/day) - there was no post chlorination or dechlorination
3	21	- influent sample	- grab sample just after bar screens and pre-chlorination - there was a light oil film on the surface of the sample collected in the bucket
5	21	MacMillan Bloedel Ltd. Fine Paper Mill - Annacis Island - PE-135 - effluent sample	- grab sample just before mill composite sampler

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb./78	Location	Field Notes
6	21	MacMillan Bloedel Ltd. Sawmill - PE-1664	- grab sample of cooling water, discharges to drainage ditch
7	21		- grab sample after retention tank and just before discharge to river - may not be typical sample as 1/3 of their treatment system out for repairs - oil and grease floating on surface waters and draining to storm sewers
8,9	21	Iona Island STP - effluent sample - PE-23	- duplicate analyses - grab samples (11:35 a.m.) as composite thrown out - grab taken at discharge to channel just after their small lagoon
10		- influent sample	- grab sample taken just after bar screens - no prechlorination or post chlorination
11,13	21	Lulu Island STP - effluent sample - PE-233	- duplicate analyses - composite samples saved by technician (7:30 a.m. Feb. 20 to 7:30 a.m. Feb. 21)
12		- influent sample	- grab sample 1355 at inlet to plant - no pre or post-chlorination

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb. /78	Location	Field Notes
14	21	Ladner Sewage Lagoon - PE-64	- grab sample of effluent at discharge pipe from lagoon to Fraser River (1435 hrs.)
15	21	Dow Chemical Phenol Plant	- grab sample between biological treatment plant and lagoon - their lagoon has 60 day retention - also chlorination tank
16	22	Reichold Chemicals Ltd. - Port Moody	- grab sample of discharge to creek which discharges to Burrard Inlet. Mostly cooling water. Light hydrocarbon film on surface - processed water is sewered with 1 → 40 ppm phenolics to Annacis Is. STP at about 30 GPM. Presently biological treatment plant is down and therefore about 40 ppm phenols sewered in process water.
17	22	BCFP - Hammond Division Sawmill - Haney - PE-2756	- grab sample from open pit where discharge streams come together. Taken just before outlet pipe. Discharge to Fraser River. - cedar wood sawmill (935 hrs.)

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb./78	Location	Field Notes
18,22	22	Ioco Imperial Oil Enterprises Ltd. - Port Moody - Esso	- duplicate analyses - grab sample from main discharge pipe, after biological treatment plant and separator. Discharge to Burrard Inlet
19			- grab sample taken after #4 separator. Contains yard drainage (1035 hrs.)
20	22	Crown Zellerbach - Coast Wood Products Division - PE-412	- grab sample from outlet pipe which discharges to Fraser River - closed glue system in veneer plant - collected fly ash, waste from glue collection system, other solid-sludge wastes dumped on hog fuel pile.
21	22	Domtar Northwest Wood Preservers - New Westminster - PE-3410	- grab sample from ditch beside railroad. Warm water appears "clean" - See sample #40.
23	22	Annacis Island STP - influent	- composite sample - 0800 hrs. to 0800 hrs. Feb. 21 - 22
24		- effluent	- composite sample as above
25	22	Lulu Island STP - influent sample	- composite sample - 0800 to 0800 Feb. 21 - 22

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb./78	Location	Field Notes
26	22	Lulu Island STP - effluent sample	- composite sample - 0800 to 0800 Feb. 21 - 22
27	22	Iona Island STP - Influent sample	- composite sample - 0800 to 0800 Feb. 21 - 22
28		- effluent sample	- composite sample - 0800 to 0800 Feb. 21 - 22
29	22	Later Chemicals - 320 Lysander Lane - (Sea Island)	- grab sample from ditch SW corner of property - spills go to drainage ditch as rainwater flushes them from the yard - poor housekeeping practices
30	22	Crown Zellerbach - Richmond Lumber Mill - Mitchell Island	- grab sample - essentially riverwater with fiber-wood - sawmill - lots of cedar
31	22	Belkin Packaging Paper Board Mill - PE-17	- grab sample from overflow from clarifier - they buy their pulp and recycle waste paper
32	23	Fraser River Harbour Commission - Richmond Landfill	- grab sample from drainage ditch

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb./78	Location	Field Notes
33	23	Burns Bog Landfill	- grab sample from NW drainage ditch
34			- grab sample from ditch after NW and SE drainage ditches come together
35	23	8931 River Road	- illegal dump of hog fuel - grab sample of standing water N. of landfill
36	23	Vito Steel Boat and Barge Co. Ltd. - River Road	- bog water associated with gyproc and hog fuel landfill - grab sample
37	23	PR-2752	- ditch at 133 St. and 116 A associated with PR-2752 Lougheed Industrial - 2 ditches; came together, one is clear from residential area, one is black which flows by landfill.
38	23	Lougheed Hwy. Ditch	- grab sample from ditch on Lougheed Hwy., between schoolhouse and King Edward (Mill Creek) - downstream of Vendev Ent. PR-4745

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Feb./78	Location	Field Notes
39	23	PR-4385	- GVS & DD Refuse Site - leachate sample from swamp at toe of landfill
40	23	N.W. Preservers - PR-3417	- refuse site adjacent to above site - dead seagull in ditch
41	23	GVS & DD - PR-4385	- combined collected leachate - sampled at pumphouse - discharges to Annacis Is. STP
42			- ditch on west side of landfill; possible contamination by phenol; a top completed section
43	Mar 9 11:05	Later Chemical 320 Lysander Lane, Richmond, British Columbia	- grab sample from ditch, NW corner of property - poor housekeeping - ground literally oozing with chemicals - sample has appearance of diluted orange juice
44	9 12:45	Ditch from Richmond landfill, just above direct discharge to Fraser	- good flow in ditch - sample has thick black appearance

TABLE II (con't.)

SAMPLING OF DISCHARGES IN GREATER VANCOUVER AREA FOR PHENOLIC ANALYSIS

Sample No.	Date Mar./78	Location	Field Notes
45	9 13:20	Coast Laminated Timber - Delta	- appears to be accidental overflow of washwater; drains from property to drainage ditch along road. - Sample from ditch. - little water flow in ditch - sample has appearance of cherry cider

TABLE III

ANALYSIS OF WATER SAMPLES FOR PHENOLICS

Compounds Analysed For	Minimum Detection Limits
1. Phenol	50. ppb
2. o-cresol	50.
3. m-cresol	50.
4. p-cresol	50.
5. 2,3-dimethyl phenol	50.
6. 2,4-dimethyl phenol	50.
7. 2,5-dimethyl phenol	50.
8. 2,6-dimethyl phenol	50.
9. 3,4-dimethyl phenol	50.
10. 3,5-dimethyl phenol	50.
11. 0-ethyl phenol	50.
12. m-ethyl phenol	50.
13. p-ethyl phenol	50.
14. o-chlorophenol	0.2
15. m-chlorophenol	0.2
16. p-chlorophenol	0.2
17. 2,3,5-trimethyl phenol	50.
18. 2,3,6-trimethyl phenol	50.
19. 2,4,6-trimethyl phenol	50.
20. 2-nitrophenol	50.
21. 3-nitrophenol	
22. 4-nitrophenol	
23. 2-chloro - 5-methyl phenol	0.2
24. 4-chloro - 2-methyl phenol	0.2
25. 4-chloro - 3-methyl phenol	0.2
26. 2,3,5,6-tetramethyl phenol	50.
27. 2,3-dichlorophenol	0.2
28. 2,4-dichlorophenol	0.2
29. 2,5-dichlorophenol	0.2
30. 2,6-dichlorophenol	0.2
31. 3,4-dichlorophenol	0.2
32. 3,5-dichlorophenol	0.2
33. 0-bromophenol	50.
34. m-bromophenol	50.
35. p-bromophenol	50.
36. 2,4-dinitrophenol	100.
37. 2,5-dinitrophenol	100.
38. 2,6-dinitrophenol	100.
39. 3,4-dinitrophenol	100.

TABLE III (con't.)

ANALYSIS OF WATER SAMPLES FOR PHENOLICS

Compounds Analysed For	Minimum Detection Limits
40. 2,3,4-trichlorophenol	0.02
41. 2,3,5-trichlorophenol	0.02
42. 2,3,6-trichlorophenol	0.02
43. 2,4,5-trichlorophenol	0.02
44. 2,4,6-trichlorophenol	0.02
45. 3,4,5-trichlorophenol	0.02
46. 2,3,4,5-tetrachlorophenol	0.02
47. 2,3,5,6-tetrachlorophenol	0.02
48. 2,4-dibromophenol	50.
49. 2,6-dibromophenol	50.
50. pentachlorophenol	0.02
51. 2,3,4,6-tetrachlorophenol	0.02

TABLE IV

LEVEL OF PHENOLIC COMPOUNDS FROM DISCHARGES IN THE GREATER VANCOUVER AREA

		ANNACIS IS. STP			MACMILLAN AND BLOEDEL			IONA IS. STP			LULU IS. STP			
Sample Identification	SCOTT PAPER	EFFLUENT	INFLUENT	EFFLUENT (REPLICATE)	PE-135	PE-1664	PE-1664	EFFLUENT	EFFLUENT (REPLICATE)	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT (REPLICATE)	LADNER LAGOON
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Phenol			tr											
2. p-cresol			tr											
3. 2,4-dimethyl phenol														
4. 2,5-dimethyl phenol														
5. p-chlorophenol														
6. 2,3,6-trimethyl phenol		tr												
7. 4-chloro-2-methyl phenol		tr												
8. 2,4-dichlorophenol														
9. 2,6-dichlorophenol														
10. 2,3,4-trichlorophenol													tr	
11. 2,4,5-trichlorophenol											tr	tr	tr	
12. 2,4,6-trichlorophenol	5.4	.7	.7	.7		tr		tr			tr	.09	.06	
13. 3,4,5-trichlorophenol											tr	tr		
14. pentachlorophenol	.2	4.5	7.8	4.8	.2	1.2		1.3	1.4	1.3	1.0	4.5	1.2	.5
15. 2,3,4,6-tetrachlorophenol	.2	28.8	8.7	27.8	.2	6.0		.9	1.0	1.4	.5	.6	.6	
16. 2,3,4,5-tetrachlorophenol														
17. 2,3,5,6-tetrachlorophenol														

NOTE: Concentration is measured in ppb
tr = trace
blank = less than detection limit
Refer to Table II for location and description of sample number.
Many phenolic compounds were not observed for any samples and have been excluded from Table IV.

TABLE IV (con't.)

LEVEL OF PHENOLIC COMPOUNDS FROM DISCHARGES IN THE GREATER VANCOUVER AREA

Sample Identification	DOW CHEMICAL 15	REICHOLD CHEMICAL 16	BCFP 17	IOCO OIL REFINERY 18	IOCO OIL REFINERY 19	CROWN ZELLERBACH 20	DOMTAR 21	REPLICATE OF #18 22	ANNACIS IS STP INFLUENT 23	ANNACIS IS STP EFFLUENT 24	LULU IS STP INFLUENT 25	LULU IS STP EFFLUENT 26	IONA IS STP INFLUENT 27	IONA IS STP EFFLUENT 28	LATER CHEMICAL 29
1. Phenol															tr
2. p-cresol															tr
3. 2,4-dimethyl phenol															600
4. 2,5-dimethyl phenol															600
5. p-chlorophenol															150
6. 2,3,6-trimethyl phenol															1000
7. 4-chloro-2-methyl phenol															300
8. 2,4-dichlorophenol															330
9. 2,6-dichlorophenol															220
10. 2,3,4-trichlorophenol															
11. 2,4,5-trichlorophenol								tr				tr			2400
12. 2,4,6-trichlorophenol	tr			.3				tr		1.2	.9	.1			3120
13. 3,4,5-trichlorophenol															
14. pentachlorophenol	1.4	.3	.2	4.9	3.6	1.3		4.0	12.0	1.2	2.8	3.0	2.0	1.2	2520
15. 2,3,4,6-tetrachlorophenol	.2	.3	.7	.4		3.0		.6	10.8	13.2	10.0	1.7	1.1	0.7	96
16. 2,3,4,5-tetrachlorophenol															
17. 2,3,5,6-tetrachlorophenol															

NOTE: Concentration is measured in ppb
tr = trace
Blank = less than detection limit
Refer to Table II for location and description of sample number.

TABLE IV (con't.)

LEVEL OF PHENOLIC COMPOUNDS FROM DISCHARGES IN THE GREATER VANCOUVER AREA

Sample Identification	CROWN ZELLERBACH 30	BELKIN PACK. 31	LEACHATE 32	BURNS BOG LEACHATE 33	BURNS BOG LEACHATE 34	LEACHATE 35	LEACHATE 36	LEACHATE PR-2762 37	LEACHATE 38	LEACHATE PR-4385 39	N.W. PRESERVERS 40	GVS & DD PR-4385 LEACHATE 41	GVS & DD PR-4385 LEACHATE 42	LATER CHEMICAL 43	LEACHATE RICHMOND LANDFILL 44	COAST LAMINATED TIMBER 45
1. Phenol																
2. p-cresol													tr			
3. 2,4-dimethyl phenol													tr	tr		
4. 2,5-dimethyl phenol													tr	tr		
5. p-chlorophenol																
6. 2,3,6-trimethyl phenol														tr		
7. 4-chloro-2-methyl phenol																
8. 2,4-dichlorophenol														51		tr
9. 2,6-dichlorophenol												1.2	5.6		2.0	2.4
10. 2,3,4-trichlorophenol					tr								.3	3.6		.2
11. 2,4,5-trichlorophenol	tr	tr	tr	tr	tr			.7		1.7	4.2	.4	1.5	135.	.8	2.3
12. 2,4,6-trichlorophenol	tr	tr	tr	tr	tr					1.0			.4	81.		1.0
13. 3,4,5-trichloropnenol								.3		.5			.8			.7
14. pentachlorophenol	1.6	5.4	1.2	.6	1.6	6.0		2.4	.9	7.2	120	15.0	42.5	1125	1.4	6000
15. 2,3,4,6-tetrachlorophenol	.8	7.2	.3	.2		.4	.5	1.2	.8	3.2	38.6	1.8	7.4	166		2100
16. 2,3,4,5-tetrachlorophenol										.6		.3	1.4	12.	0.09	tr
17. 2,3,5,6-tetrachlorophenol											35.0	1.5			1.2	tr

CONCLUSIONS AND RECOMMENDATIONS

It is clear that STP's, industrial effluents and urban runoff are sources of pentachlorophenol, PCB's and other trace organic pollutants discharged to the Fraser River. The long term implications of the discharge of these substances at present concentrations are not certain, but should be viewed with concern.

Further measurements are necessary to identify additional contaminants, to estimate better the quantity discharged, and to locate site-specific sources. This work should be interfaced with studies of contaminants in the sediment and biota, along with studies on the lethal and sub-lethal impacts of these pollutants on aquatic life. The importance of laboratory quality assurance programmes for all such projects cannot be overemphasized.

Detailed monitoring programs are required at identified sources, including the STP's, to delineate more precisely the concentration ranges and loadings being discharged.

REFERENCES

ABRAMS, E.F. et al. 1975. Identification of Organic Compounds in Effluents from Industrial Sources. U.S. Environmental Protection Agency Report EPA-560/3-75-002.

B.C. RESEARCH. 1978. Summary of The Effects of The Annacis Island Sewage Discharge on Water Quality in The Fraser River. Prepared For The Greater Vancouver Sewerage and Drainage District.

BUHLER, D.R., M.E. RASMUSSON and H.S. NAKAUE. 1973. Occurrence of Hexachlorophene and Pentachlorophenol in Sewage and Water. Environment Science and Tech. 7(10): 929-934.

CAIN, R.T., L. G. Swain. 1980. Fraser River Estuary Study, Water Quality: Municipal Effluents, Ministry of Environment, Victoria.

CAN TEST. 1977. Trace Organic Analysis of Kelowna Sewage Treatment Plant Effluent By Computerized Gas-Chromatography Mass Spectrometry. Prepared for The Pollution Control Branch, Victoria, B.C.

GREATER VANCOUVER REGIONAL DISTRICT. 1977. Annual Report GVRD Vancouver, B.C.

HOWARD, P.H. and P.R. Durkin. 1973. Preliminary Environmental Hazard Assessment of Chlorinated Haphthalenes, Silicones, Fluorocarbons, Benzene Polycarboxylates, and Chlorophenols. U.S. Environmental Protection Agency Report EPA-560/2-74-001.

HUTZINGER, O., S. SAFE and V. ZITKO. 1974. The Chemistry of PCBs. CRC Press, Inc. U. CRC Press, Inc. U.S.

MCKEE, J.E. and H.W. WOLF. ed. 1971. Water Quality Criteria, second edition. Publication 3-A. State Water Resources Control Board, California.

MUMMA, C.E. and E.W. LAWLESS. 1975. Survey of Industrial Processing Data:-Task I-Mexachlorobenzene and Hexachlorobutadiene Pollution From Chlorocarbon Processing. U.S. Environmental Protection Agency Report EPA-560/3-75-003.

POLLUTION ENGINEERING. Dec. 1977. EPA Effluent Guidelines Division List of Priority Pollutants for B.A.T. Revision Studies.

ROGERS, I. H., H. W. Mahood, J. A. Servizi and R. W. Gordon. 1979. Identifying extractives toxic to aquatic life. Pulp and Paper Canada 80 (9), T286 - 290.

SCHMIDT, T.T., R.W. Risebrough and F. Gress. 1971. Input of Polychlorinated Biphenyls into California Coastal Waters from Urgan Sewage Outfalls. Bulletin of Envir. Contam. and Toxicology, Volume 6, pp. 235 - 243.

SINGLEY, J.E., G.J. Kirchmer and R. Miura. 1974. Analysis of Coprostanol, An Indicator of Fecal Contamination. U.S. Environmental Protection Agency Report EPA 660/2-74-021.

TEMPLETON, W. 1969. An Introduction to the Chemistry of Terpenoids and Steroids. Butterworth and Co. Ltd. London.

YOUNG, D.R. and T.C. Heesen. DDT, PCB, and Chlorinated Benezenes in the Marine Ecosystem off Southern California in Water Chlorination - Environmental Impact and Health Effects, Vol. 2, Gorchev and Hamilton, eds., Ann Arbor Science Publ. Inc., Ann Arbor, Mich., pp. 267 - 290, (1978).

APPENDIX I

EXCERPT FROM "SAMPLING AND ANALYSIS PROCEDURES FOR SCREENING OF INDUSTRIAL EFFLUENTS FOR PRIORITY POLLUTANTS"

Published by U.S. E.P.A.

1.0 ORGANICS BY LIQUID-LIQUID EXTRACTION - GAS CHROMATOGRAPHY

1.1 Scope

This method is designed to determine those "unambiguous priority pollutants" associated with the Consent Decree, that are solvent extractable and amenable to gas chromatography. These compounds are listed in Tables III of this section. Except for the pesticides, it is a gas chromatographic-mass spectrometric method intended for qualitative and semi-quantitative determination of these compounds during the survey phase of the industrial effluent study. Pesticides are initially determined by electron capture-gas chromatography and, qualitatively, confirmed by mass spectrometry.

1.2 Special Apparatus and Materials

Separatory funnels - 2 and 4-liter with Teflon stopcock Continuous liquid-liquid extractors - any such apparatus designed for use with solvents heavier than water and having a capacity of 2 to 5-liters. Connecting joints and stopcocks must be of Teflon or glass with no lubrication.

1.3 Procedure

Sample Preparation for GC-MS Survey - Blend the composite sample to provide a homogeneous mixture including a representative portion of the suspended solids that are present. No specific method is required but a motor driven mechanical stirrer with a propeller type blade is suggested. Stirring with metal devices is acceptable for organic sampling.

Transfer the sample from the composite container through a glass funnel into a 2-liter graduated cylinder and measure the volume. Then transfer to a 4-liter separatory funnel or a continuous extractor as described below. Rinse the cylinder with several portions of the first volume of extracting solvent. Note: (Either separatory funnel or continuous extraction is acceptable for isolation of the organics. Continuous extraction must be used when emulsions cannot be broken. See discussion under Emulsions.)

1.4 Base-Neutral Extraction

Separatory Funnel Extraction - Adjust the pH of the sample with 6 N NaOH to 11 or greater. Use multirange pH paper for the measurement. Serially extract with 250 x 100 x 100 mL portions of distilled-in-glass methylene chloride. (About 40 mL of the first 250 mL portion will dissolve in the sample and not be recovered.) Shake each extract for at least 2 min by the clock.

Dry and filter the solvent extract by passing it through a short column of sodium sulfate. Concentrate the solvent by Kuderna-Danish (K-D) evaporation (distillation). The sodium sulfate should be prewashed in the column with methylene chloride. (Note: Check sodium sulfate blank and, if necessary, heat in an oven at 500^0C for 2 hours to remove interfering organics.) After drying the extract, rinse the sodium sulfate with solvent and add to the extract.

Evaporate the extract to 5-10 mL in a 500 mL K-D apparatus fitted with a 3-ball macro-Snyder column and a 10 mL calibrated receiver tube. Allow the K-D to cool to room temperature. Remove the receiver, add fresh boiling chips, attach a two-chamber micro-Snyder column and carefully evaporate to 1.0 mL or when active distillation ceases. Remove the micro-Snyder column and add the internal standard: 10 µL of 2 µg/µL d_{10}-anthracene (per each mL of extract). Mix thoroughly.

If it is to be overnight or longer before the extract is run by GC-MS, transfer it from the K-D ampul with a disposable pipet to a solvent tight container. The recommended container is a standard 2 mL serum vial with a crimp cap lined with Teflon coated rubber. These are inert and methylene chloride can be held without evaporation loss for months if caps are unpierced. When the extracts are not being used for analysis, store them with unpierced caps in the dark and at refrigerator or freezer temperatures.

Acid (Phenols) Extraction - Adjust the pH of the base-neutral extracted water with 6 N HCl to 2 or less. Serially extract with 200 x 100 x 100 mL portions of distilled-in-glass methylene chloride. (Note that only 200 mL is used for the first extraction). Proceed as described for the base-neutral extract, including the addition of the internal standard.

APPENDIX II

THE TRACE ORGANIC CONSTITUENTS IDENTIFIED IN THREE MUNICIPAL SEWAGE TREATMENT PLANTS

COMPOUNDS IDENTIFIED IN IONA ISLAND SEWAGE TREATMENT PLANT EFFLUENT

ACID FRACTION

COMPOUND	CONCENTRATION (µg/L)
Tetrachlorophenol	30
Hexadecanoic Acid	100
Octadecanoic Acid	200

BASE NEUTRAL FRACTION

Dimethylphthalate	10
Dimethylisophthalate	50
Diethylphthalate	2
Dibutylphthalate	20
Caffeine	10
Phthalate Diester (Tentatively identified as 3,7,11-Trimethyl-2,6,10-Dodecatrien-1-ol)	*
Coprostanol	70
Cholesterol	70

PESTICIDE FRACTION

Polychlorinated Biphenyls (Arochlor 1260)	0.30
Hexachlorobenzene	0.004

CHLORINATED PHENOL FRACTION

Tetrachlorophenol	30
Pentachlorophenol	6

NOTE: "*" - compound identified but not quantitated

"_" - compound identified as to class only

COMPOUND IDENTIFIED IN ANNACIS ISLAND SEWAGE TREATMENT PLANT EFFLUENT

ACID FRACTION

COMPOUND	CONCENTRATION (µg/L)
Hydrocarbon	-
Hydrocarbon	-
Hydrocarbon	-
Ketone (Tentatively identified as 6,10, 14-Trimethyl-2-Pentanone)	*
Fatty Acid Methyl Ester (Tentatively identified as Methyl Hexadecanoate)	*
Hexadecanoic Acid	270

BASE NEUTRAL FRACTION

Unidentified Terpene	-
Alpha-Terpineol	*
Unidentified Terpene	-
Alkyl Benzene (Long Chain)	-
Hydrocarbon	-
Diethylphthalate	4
Hydrocarbon	-
Hydrocarbon	-
Hydrocarbon	-
Hydrocarbon	-
Dibutylphthalate	2
Caffeine	20
Hydrocarbon	-
Hydrocarbon	-
Hexanedioic Acid Ester	*
Hydrocarbon	-
Hydrocarbon	-

COMPOUND IDENTIFIED IN ANNACIS ISLAND SEWAGE TREATMENT PLANT EFFLUENT

BASE NEUTRAL FRACTION (Con't.)

COMPOUND	CONCENTRATION (µg/L)
Phthalate Diester (Tentatively identified as Dioctyl Phthalate)	*
Terpene (Tentatively identified as 3,7,11-Trimethyl-2,6,10-Dodecadatrien-1-ol)	*
Coprostanol	90
Cholesterol	110

PESTICIDE FRACTION

Polychlorinated Biphenyls (Arochlor 1260)	0.24
Hexachlorobenzene	0.006

CHLORINATED PHENOL FRACTION

Tetrachlorophenol	9
Pentachlorophenol	9

COMPOUNDS IDENTIFIED IN LULU ISLAND SEWAGE TREATMENT PLANT EFFLUENT

ACID FRACTION

COMPOUND	CONCENTRATION (µg/L)
p-Cresol	*
Fatty Acid (Tentatively identified as Dodecanoic Acid)	*
Tetradecanoic Acid	110
Hexadecanoic Acid	3000
Octadecanoic Acid	5000
Eicosanoic Acid	40

BASE NEUTRAL FRACTION

Hydrocarbon	-
C_3 Benzene	*
C_3 Benzene	*
Hydrocarbon	-
Terpineol Isomer	*
C_4 Benzene and Terpene (Tentatively identified as 3,7-Dimethyl-1,6- Octadien-3-ol)	*
Unidentified Terpene	-
Alpha - Terpineol	*
Unidentified Terpene	-
Nicotine	*
Hydrocarbon	-
Diethylphthalate	40
Septum Bleed	-
Fatty Acid Methyl Ester (Tentatively identified as Methyl Hexadecanoate)	*
Unidentified	-
Hydrocarbon	-
Fatty Acid Methyl Ester (Tentatively identified as Methyl Octadecanoate)	*

COMPOUNDS IDENTIFIED IN LULU ISLAND
SEWAGE TREATMENT PLANT EFFLUENT

BASE NEUTRAL FRACTION (con't.)

COMPOUND	CONCENTRATION (µg/L)
Caffeine	60
Unidentified Terpene	-
Unidentified Terpene	-
Hydrocarbon	-
Phthalate Diester (Tentatively identified as Dioctylphthalate)	*
Terpene (Tentatively identified as 3,7,11-Trimethyl-2,6,10-Dodectrien-1-ol)	*
Hydrocarbon	-
Hydrocarbon	-
Coprostanol	450
Cholesterol	400
Hydrocarbon	-
Unidentified Steroid	*
Unidentified Steroid	*
Hydrocarbon	-
Hydrocarbon	-

PESTICIDE FRACTION

Polychlorinated Biphenyls (Arochlor 1260)	0.13
Hexachlorobenzene	0.005

CHLORINATED PHENOL FRACTION

Tetrachlorophenol	1
Pentachlorphenol	8

APPENDIX III

NOTES CONCERNING SOME COMMON FATTY ACIDS

TABLE OF SOME COMMON FATTY ACIDS

A. SATURATED ACIDS

NAME	SYNONYMS	COMMENTS
Archidic Acid	Eicosanoic Acid Eicosoic Acid	Found in natural waxes.
Behenic Acid	Docosanoic Acid Docosoic Acid	Found in natural waxes.
Capric Acid	Decanoic Acid Decoic Acid	Gylceryl ester in goats milk.
Caproic Acid	Hexanoic Acid Hexoic Acid	Glyceryl ester in goats milk
Caprylic Acid	Octanoic Acid Octoic Acid	Glyceryl ester in goats milk.
Cerotic Acid	Hexacosanoic Acid Hexacosoic Acid	Found in natural waxes.
Lauric Acid	Dodecanoic Acid Dodecosoic Acid	Glyceryl ester in several vegetable oils.
Lignoceric Acid	Tetracosanoic Acid Tetracosoic Acid	Found in natural waxes.
Margaric Acid	Heptadecanoic Acid	Artifically synthesized from stearic acid; widely used as artificial fat; occurs naturally in mutton fat.
Melissic Acid	**Triacontanoic Acid** Triacontoic Acid	Found in natural waxes.
Myristic Acid	Tetradecanoic Acid Tetradecoic Acid	Glyceryl ester in several vegetable oils.

(Con't)

TABLE OF SOME COMMON FATTY ACIDS (CONTINUED)

A. SATURATED ACIDS (CONTINUED)

NAME	SYNONYMS	COMMENTS
Palmitic Acid	Hexadecanoic Acid Hexadecoic Acid	Glyceryl ester widely distributed in most animal and vegetable oils; also Na and K salts are constituents of ordinary soap.
n-Pentadecanoic Acid	Pentadecyclic Acid	Occurs in butter.
Stearic Acid	Octadecanoic Acid Octadecoic Acid	Glyceryl ester widely distributed in most animal and vegetable oils; also Na and K salts are constituents of ordinary soap.
n-Tridecanoic Acid	--	Occurs in butter.

* Note that the "...anoic" convention is in more common use than the "...oic" convention.

Also an ester has the "...ic" for an acid replaced by "...ate", for example methyl stearate = methyloctadecanoate.

TABLE OF SOME COMMON FATTY ACIDS (CONTINUED)

B. UNSATURATED FATTY ACIDS

NAME	SYNONYMS	COMMENTS
Acrylic Acid	Prop-2-enoic Acid 2-Propenoic Acid	Artificial.
Angelic Acid	2-methylbut-2-enoic Acid 2-methyl-2-butenoic Acid (cis)	Geometric isomer of tiglic acid; occurs naturally.
Crotonic Acid	But-2-enoic Acid 2- Butenoic Acid (Trans)	Cis and Trans both artificial.
Erucic Acid	Heneicos-12-ene-1-carboxylic Acid 13-Docosenoic Acid (cis)	Occurs in various vegetable oils.
Linoleic Acid	Heptadeca-8:11-Diene-1-carboxylic Acid 9,12-Octadecadienoic Acid	Occurs in a number of vegetable oils, common uses of which (e.g., linseed oil) are used as drying oils.
Linolenic Acid	Heptadeca-8:11:14-Triene-1-carboxylic Acid 9,12,15-Octadecatrienoic Acid	Nature's most common triene acid.
Nervonic Acid	Tricos-14-ene-1-carboxylic Acid 15-Tetracosenoic Acid	Occurs in human brain tissue and in fish oils.
Methacrylic Acid	2-Methylprop-2-enoic Acid 2-Methylpropenoic Acid	Artificial; important commercially.
Oleic Acid	Cis-heptadec-8-ene-1-carboxylic Acid 9-Octadecenoic Acid	Occurs as glyceryl ester in many oils and fats.
Propiolic Acid	Propargylic Acid Prop-2-ynoic Acid 2-Propynoic Acid	Artificial.

(Con't)

TABLE OF SOME COMMON FATTY ACIDS (CONTINUED)

B. UNSATURATED FATTY ACIDS

NAME	SYNONYMS	COMMENTS
Ricinoleic Acid	11-Hydroxyheptadec-8-ene-1 carboxylic Acid 12-Hydroxy-9-octadecenoic Acid (cis) α-12-hydroxyloeic Acid	Occurs as glyceryl ester in castor oil.
Tiglic Acid	2-Methylbut-2-enoic Acid Trans-2,3-dimethylacrylic Acid Methyl-2-butenoic Acid	Geometric isomer of angelic acid; occurs naturally.
Undecylenic Acid	10-Undecenoic Acid 10-Hendecenoic Acid 9-Undecylenic Acid Dec-9-ene-1-carboxylic Acid	Artificially; used as cure for athlete's foot.

ADDENDUM

Subsequent to the drafting of this report, portions of the acid and base-neutral extracts were received from Can Test Ltd. Dr. H. Rogers of the Pacific Environment Institute then carried out several qualitative GC-MS analyses on these extracts. His preliminary results are presented tabulated in this addendum.

The wood-derived substances at Annacis should be particularly noted.

Reference: Rogers, I. H., Private Communication, June 15, 1978.

Compounds identified for Sample 1A (Iona STP effluent - acid fraction)

- bis (2-ethylhexyl phthalate)
- fatty acid methyl esters
    - arachidate
    - behenate
    - laurate
    - margarate
    - myristate
    - oleate
    - palmitate
    - palmitoleate
    - pentadecanoate
- tetrachloroanisole
- methyl 2,4-dichlorobenzoate

Notes:
- acid fraction
- glass capillary column
- hexane solvent used so no solvent impurities present
- methyl 2,4-dichlorobenzoate may be a breakdown product of protein metabolism which has been chlorinated
- reran in SIM mode, scanning for di-, tri-, tetra, and pentachloroanisole and for tri, and tetrachloroveratrole

Compounds identified for Sample 2A (Lulu STP effluent - acid fraction)

- **methyl 2,4-dichlorobenzoate**
- all other compounds were fatty acid esters

  - behenate
  - heptadecanoate (= margarate)
  - heptadecanoate isomer
  - laurate
  - linoleate
  - linolenate isomer
  - myristate
  - oleate
  - palmitate
  - palmitoleate
  - pentadecanoate
  - pentadecanoate isomer
  - stearate

Notes:
- acid fraction
- glass capillary column
- "... unmethylated or poorly methylated sample so we re-methylated the extract with diazomethane"
- "... we found our pesticide grade methylene dichloride solvent had a number of chlorinated hydrocarbon impurities..."

Compounds identified for Sample 3A (Annacis STP effluent - acid fraction)

- bis (2 ethyl-hexyl phthalate)
- fatty acid methyl esters
    - laurate
    - myristate
    - oleate
    - palmitate
    - pentadecanoate
    - stearate
- methyl cis-dehydrotodomatuate
- methyl dehydroabietate
- methyl isopimarate
- methyl todomatuate
- methyl 4-p-tolylvalerate

Notes:
- acid fraction
- glass capillary column
- extract re-methylated since poorly methylated as received
- chlorinated hydrocarbon impurities found in methylene dichloride solvent
- "... besides fatty acids, a number of wood derived substances from Douglas-fir were present..."
- "... also a showing of dehydroabietic acid on the single ion monitor..."

Compounds identified for Sample 3B (Annacis STP effluent - base neutral fraction)

Compounds identified - cholesterol
- coprostanol
- dibutyl phthalate
- dioctyl phthalate
- caffeine

Notes:
- packed glass column
- 2 unidentified sterols, with molecular weight > 400
- other unidentified peaks
- great deal of background junk -- sample cleanup required