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A PRELIMINARY STUDY on WASTEWATER CHARACTERISTICS of KAMLOOPS STORMWATER DISCHARGE

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A PRELIMINARY STUDY on WASTEWATER CHARACTERISTICS of KAMLOOPS STORMWATER DISCHARGE

by

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ABSTRACT

Prior to this study only limited information was available regarding the concentrations of heavy metals, chemical pollutants and piscian toxicity of Kamloops stormwater. Bioassay results show that the majority of the storm sewers tested were non-toxic to juvenile coho salmonids (Oncorhynchus kisutch). Storm Sewers No. 8, 18 and 38 were intermittently toxic. Metal and other toxic chemical concentrations of Storm Sewer No. 8 were significantly higher than the others.

The results of this study will provide some of the information required in the development of adequate standards and/or guidelines for environmental controls applicable to municipal wastewater quality.

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1. INTRODUCTION

During 1971 and 1972 Environment Canada conducted a number of specific wastewater characteristics of discharge from the Greater Vancouver Sewage treatment plants and major sewers. The study was undertaken to provide baseline data required to assist Environment Canada in the development of reasonable and attainable standards or guidelines with respect to domestic and municipal wastes.

To supplement the information collected in the Vancouver area, a study on the Kamloops area was conducted during the last half of 1973. As with the Vancouver study, the Kamloops study is essentially an extensive sampling and testing program to document existing characteristics of local storm sewers. A total of eleven effluent quality parameters were measured including heavy metals BOD, COD, solids, pH, temperature and toxicity.

2. STUDY AREA

During the time of this survey the City of Kamloops had a population of approximately 55,000 people.

A total of 45 storm sewer outfalls were located. In the South Kamloops area storm sewers service both industrial and residential areas; in the North Kamloops area storm sewers service primarily residential areas. As far as could be determined, stormwater discharges consisted of yard drainage and street runoff. Information on connections to storm sewers was not available at the time of the study. All stormwater discharges are either to the Thompson or North Thompson Rivers.

It was not possible to sample all storm sewers because flows ceased during dry weather.

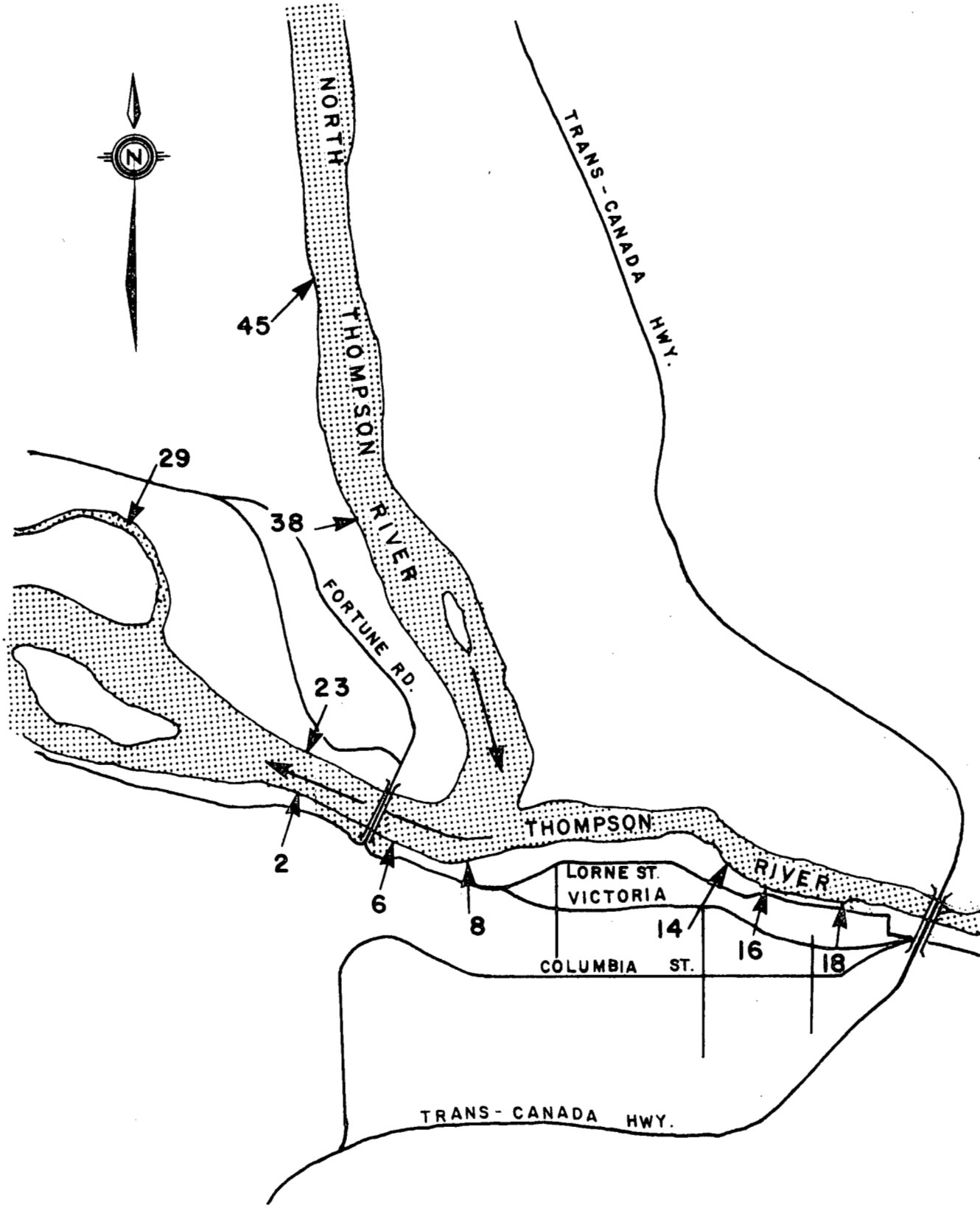

FIGURE 1 LOCATION OF SAMPLE STATIONS

TABLE 1 Storm Sewer Sampling Stations

Sample Station	Description*
2	Beside trailer court in Mission Flats Road. Discharge is primarily from residential area. Continuously flowing.
6	Same general location as Hasler's Ready Mix. Discharge is primarily runoff from residential and possibly includes industrial yard drainage. Usually flowing.
8	Foot of MacKintosh Street. Discharge primarily runoff from residential areas. Occasionally flowing.
14	Foot of 8th Street at Thompson River. Discharge is primarily runoff from residential areas. Occasionally flowing.
16	Same general location as the veterinary clinic. Discharge primarily runoff from residential areas. Occasionally flowing.
18	Foot of 13th Avenue beside water intake plant. Discharge and runoff from both residential and commercial areas. Continuously flowing.
23	West of new bridge. Discharge primarily runoff from residential areas. Continuously flowing.
29	Foot of Kenora Street. Discharge is primarily runoff from residential area. Occasionally flowing.
38	Foot of Sidney Street. Discharge is runoff from residential and commercial areas. Usually flowing.
45	Foot of Kingston Street. Discharge is primarily runoff from residential areas and includes some runoff from commercial areas. Occasionally flowing.

Note: Due to variability in weather conditions which affected flows of storm sewers, flow volumes were not estimated.

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* Information from personal communication with City of Kamloops, Engineering Department.

3. MATERIALS and METHODS

The 1973 preliminary effluent quality survey of the Kamloops stormwater discharges was carried out during the period July 31 - November 6.

3.1 Sample Stations

The designated study area included the monitoring of 10 storm sewer outfalls. The locations of the sampling sites are illustrated in Figure 1, and described in Table 1.

3.2 Sampling Program

Because of the variability of sewage, and stormwater characteristics, irregular sampling dates and times were scheduled in attempts to obtain more representative results. All sampling procedures and techniques were as prescribed by "Standard Methods", 13th Edition. All samples collected were grab samples and were collected over a period of approximately 10 minutes.

In spite of the limitations inherent in such a brief sampling program, the data does provide some measure of the concentrations of contaminants and toxicity levels to be expected.

3.3 Notes on Analytical Methods

The following notes are added for clarification of methods outlined in Standard Methods, 13th Edition.

3.3.1 Metals. Samples for metal analyses may be classified under four distinct categories, namely dissolved, suspended, total and extractable metals. The metal results reported in this study are dissolved and extractable. Dissolved metals are known to be responsible for much of the

toxicity of wastewater to fish (McKee & Wolf, 1963) while extractable metals are more of a potential threat to the fishery resources and therefore must be controlled very carefully.

For the measurement of the dissolved portion of metals, each sample upon collection was acidified with nitric acid to pH 5. Since proper equipment was not available for field filtration the sample was filtered upon arrival in the Vancouver Laboratory and was further acidified to pH 1.5 with concentrated nitric acid.

For the measurement of the extractable portion of metals, each sample was acidified directly in the field with concentrated nitric acid down to a pH of 1.5.

Method: The following table gives detailed information on the laboratory procedure used for specific metals analysis. All metal analysis were carried out with a Jarrell-Ash Model 82-800 atomic absorption spectrophotometer.

TABLE 2: INSTRUMENT PARAMETERS

Metal	Method	Primary	Band Pass	Back Ground Correction	Band Pass	Oxidant Fuel
Pb	AA,APDC-MIBK	2170A	10A	2204 (Pb)	10A	C_2H_2/air
Zn	AA	2139A	10A	Continuous	10A	C_2H_2/air
Cd	AA	2288A	10A	Continuous	10A	C_2H_2/air
Cu	AA	3247A	10A	-	-	C_2H_2/air
Cr	AE	4254A	0.5A	4254A	0.5A	C_2H_2/N_2O
Ni	AA	2320A	2A	2316A	2A	C_2H_2/air

Results

The symbol N/A indicated that the specific metal was not detected. The limits indicated below are not necessarily detection limits but are levels which are meaningfully determined with direct aspiration and background correction techniques. The limits are in micrograms/ml and apply to fresh water samples only.

Cu - 0.01	Pb - 0.1 (extraction 0.02)
Cr - 0.02	Zn - 0.01
Cd - 0.01	Ni - 0.1

The following table gives some indication of how well a metal sample can be preserved at various pH values.

TABLE 3: Concentration of Ions in Solution Versus pH*
(measured 24 hours after preparation of solutions)

Element	Concentration present initially/ ug ml-1	Concentration of ions in the range 0.2 to 1 ug ml-1 in solution measured at various pH values 24 hours after preparation of solutions							
		pH	1.5	3.5	5.0	6.5	8.0	9.5	11.0	12.0
Pb	1.0		1.0	1.0	ND	ND	ND	ND	ND	ND
Cr	1.0		1.0	1.0	0.25	0.15	0.15	0.20	0.20	0.20
Cu	1.0		1.0	1.0	0.95	0.45	0.15	ND	ND	ND
Ni	1.0		1.0	1.0	1.0	0.90	0.75	0.05	ND	ND
Zn	0.50		0.50	0.50	0.50	0.45	0.25	ND	ND	0.25
Cd	0.20		0.20	0.20	0.20	0.20	0.06		0.06	

3.3.2 Phenols. Phenols are defined as hydroxy derivatives of aromatic compounds. The 4 aminoantipyrine test currently used to quantitate phenols, measures only those phenols which react with the reagent readily and which are initially co-distillable with water.

Method: The sample is co-distilled with water and the distillate reacts with 4 aminoantipyrine at pH of 10 in the presence of potassium ferricyanide. This forms a yellow or orange antipyrine dye. This dye is extracted into chloroform and its absorbance is measured at 460 mu. It should be noted that this method of analysis does not measure

*Analyst, March, 1973, Vol. 98

all forms of phenols and only gives an indication of the amount of phenols present in the sample.

Results: The result is reported in mg/l of phenol or phenol equivalents present in the sample.

Detection Limit: 0.015 mg/l phenol (measured for phenol itself). Results are reported as "less than" (<) when it appeared as if some phenols were present but the concentration was below the level for which meaningful values could be taken but was above the detection limit. N/D indicates that phenols were not detected.

3.3.3 Petroleum Ether Extractable Substances

Large quantities of petroleum ether extractables are found in wastes from packing plants, slaughter houses, rendering plants, refineries, cotton seed processing plants, textile mills, milk processing plants and chemical works.

Petroleum oil may be found in water wherever an agency is engaged in production, transportation, oil loading points, refineries, civic dumps, salvage dumps, garages and industries.

Method: The acidified sample is filtered and the residue dried. Using a Soxlet Extractor, the ether extractable portion is removed by continuous extraction.

Results: Expressed as mg/litre petroleum ether extractable oil.

Detection Limit: 5 mg/l.

3.3.4 Cyanide. Cyanide (CN) occurs in effluents from gas works and coke ovens; from scrubbing of gases at seal plants; from metal cleaning and electroplating processes; and from chemical industries. If present in water, it is usually in the form of hydrogen cyanide (HCN) at lower pH's.

Method: The sample containing concentrated sulfuric acid and a catalyst is refluxed and distilled. The simple and complex cyanides are converted into HCN gas, which is bubbled through a

sodium hydroxide (NaOH) solution. The resultant sodium cyanide is chlorinated with chloramine T and reacted with a solution of pyridine-pyrozolone to form a blue complex dye. This is measured colorimetrically.

Results: Reported in mg/litre CN.

Detection Limit: 0.006 mg/l CN.

3.3.5 Residue Analysis. (a) Total Residue (TR)

The term "total residue" refers to the material left in the vessel after evaporation of all water. All natural waters have some residue left after evaporation and any effluent discharged into a stream or lake will likely change this natural total residue content. Total residue includes all inorganic salts, organic substances not volatilized at 103°C, and suspended matter.

Method: 100 mls of sample are placed in a pre-weighed evaporating dish and the sample is evaporated to dryness at 90°C. The temperature is then increased to 103°C for 2 hours and the dish is desiccated and weighed. The increase in weight is used to calculate the total residue.

Results: Expressed in mg/litre.

Detection Limit: 2.5 mg/l per 100 ml sample.

(b) Non-Filterable Residue (NFR)

NFR is that portion of the total residue retained by a specific filter. The filter type and size must be specified. Non-filterable residue is also called "suspended matter".

Method: Samples with high NFR values are filtered through a pre-weighed buchner funnel, containing a CF/C paper. The funnel is dried at 103°C and re-weighed. The increase in weight is used to calculate the NFR value in mg/litre. Samples with low NFR values are run for total residue and filterable residue. The difference is taken to be the NFR value.

Results:

Detection Limit: 2.5 mg/l per 100 ml sample.

3.3.6 Residual Chlorine. Chlorine is not a normal constituent of natural waters. Chlorine may be present in water as free available chlorine in the form of hypochlorous acid and/or hypochlorite ion, or as a chloramine. Chlorine is a bactericidal agent used in swimming pools, disinfection of water and wastewater and is also used to improve water quality.

Free available chlorine may also be found in industrial processes employing bleaching, e.g. pulp mills.

Method: Amperometric titration method was used to determine chlorine residuals. Chlorine is titrated in the presence of potassium iodide in the pH range of 3.5 - 4.5. The proper pH range was carefully maintained to eliminate interferences. The instrument used was a Wallace & Tiernan Amperometric Titrator Series A - 790013.

Results: Expressed as mg/litre Cl.

Detection Limit: 0.02 mg/l.

3.3.7 Bioassay. The bioassay test employed by E.P.S. gives an approximate value of the biological toxicity of an effluent to salmonids. Bioassays are useful in determining the harmful effects of pesticides, cleaning agents, oil dispersants, effluents, or any deleterious substance.

Bioassay results are not absolute values. The results should be viewed as guides only and are subject to water temperature, test concentration, the species of fish, size, age and condition of fish, as well as other parameters at the time of testing.

Method: The Bioassays at the Environment Canada Laboratory in West Vancouver are performed in twenty-two litre glass aquaria using five to twenty coho fry depending on their size. The aquaria are placed in a constant temperature bath and are aerated through the ninety-six hour test period.

In the bioassay lab two different tests are commonly performed -96 hr LC_{50}'s and 96 hr LT_{50}'s.

96 hour LC_{50} - This term refers to Median Lethal Concentration

or that level of a measurable lethal agent required to kill the 50th percentile in a group of test organisms, over the time period of 96 hours. The 50th percentile is meant to represent the average organism. The LC_{50} consists of a series of dilutions which allow a semi-log plot of the percent mortality for each concentration. From the plot it is determined at which concentration the 50th percentile organism would die. The terms 96 hour LC_{50}, TL_{50} and TL_m give the same numerical value, and can be used interchangeably.

96 hour LT_{50} - This term refers to Median Lethal Time or the time to death of the 50 percentile organism in a specific concentration or level of measurable lethal agent (used interchangeably with MST, Median Survival Time). The exposure time must be specified, and, in this case is 96 hours. The LT_{50} consists of a single concentration on which frequent observations of mortalities are made. A semi-log plot of the percent mortalities determines the time to death of the 50th percentile organism.

For the foregoing tests, fish loading density is important and it should be noted that for high fish loading densities (i.e. greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been underestimated. No fewer than 5 fish were used per concentration with 10-20 being desirable to achieve a statistically valid result. The fish stock is acclimated to the test temperature and dilution water at least two weeks before being used in a bioassay. The temperature during any single bioassay is not varied more than 2 degrees and is maintained within the range of 7 to 15 degrees centigrade for survival of cold water fish species.

If aeration is used, it is kept to a minimum to reduce the volatization of toxicants such as phenols, chlorides, hydrogen sulfide etc.

Results: Reported at 96 hr TL (used interchangeably with 96 hour LC_{50}), threshold, and/or 96 hr LT_{50}. For example: TL_m96 - 32% (also 96 hr LC_{50} = 32%) means that at a concentration containing 32% effluent, the median test fish would die in 96 hours.

A reported threshold value of 10% means that at a concentration containing 10% effluent, no test fish would die over the exposure

period of 96 hours.

In a concentration of 32% effluent a 96 hr LT_{50} = 60 hrs means that at the specified concentration (32%) the median of the test fish would die in 60 hours over a total test period of 96 hours.

4.1 BIOASSAY DETERMINATIONS

TABLES 4 - 13

TABLE 4 BIOASSAY DETERMINATIONS - STORM SEWER NO. 2

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
31/7/73							0
1/8/73	1145	8.50	8.55	Non-toxic	1.49*	10.0	0
3/7/73							0
3/8/73	0730	8.50	8.50	Non-toxic	1.49*	11.5	0
2/10/73							0
3/10/73	0945	8.50	8.40	Non-toxic	2.67*	10.0	0
3/10/73	1640	8.55	8.50	Non-toxic	2.67*	10.0	0

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 5 BIOASSAY DETERMINATIONS - STORM SEWER NO. 6

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
31/7/73							0
1/8/73	1230	8.25	8.30	Non-toxic	1.49*	10.0	0
2/8/73							0
3/8/73	0945	8.39	8.39	Non-toxic	1.49*	11.5	0
1/10/73							0.04
2/10/73	1030	8.25	8.30	Non-toxic	2.67*	10.0	0
4/11/73							Trace
5/11/73	1525	8.23	8.31	Non-toxic	2.21*	10.0	Trace
5/11/73	2030	8.20	8.32	Non-toxic	2.21*	10.0	Trace

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 6 BIOASSAY DETERMINATIONS - STORM SEWER NO. 8

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
31/7/73							0
1/8/73	1300	8.50	7.30	Non-toxic	1.49*	10.0	0
2/8/73							0
3/8/73	0925	7.82	7.64	20% mort. at 32% in 24 hr.	1.49*	11.5	0
2/10/73	No flow						
3/10/73	No flow						
5/10/73	No flow						
5/11/73	No flow						
6/11/73	No flow						

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 7 BIOASSAY DETERMINATIONS - STORM SEWER NO. 14

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
1/8/73							0
2/8/73	0820	7.17	7.17	Non-toxic	1.49*	12.0	0
2/8/73							0
3/8/73	0800	7.27	7.27	Non-toxic	1.49*	11.5	0
2/10/73	No flow						
4/11/73							Trace
5/11/73	1555	7.86	7.41	Non-toxic	2.21*	10.0	Trace
5/11/73							Trace
6/11/73	1430	7.40	7.68	Non-toxic	2.21*	10.0	0.02

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 8 BIOASSAY DETERMINATIONS - STORM SEWER NO. 16

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
1/8/73							0
2/8/73	0925	7.48	7.48	Non-toxic	1.49*	12.0	0
3/8/73	0840	7.49	7.49	Non-toxic	1.49*	11.5	0
2/10/73	No flow						
3/10/73	No flow						
5/10/73	No flow						
6/11/73	No flow						

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 9 BIOASSAY DETERMINATIONS - STORM SEWER NO. 18

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
31/7/73							0
3/8/73	0900	8.34	8.34	Non-toxic	1.49*	11.5	0
1/10/73							0.04
2/10/73	1130	9.70	9.00	Non-toxic	2.67*	10.0	0
3/10/73	0915	7.50	7.20	Non-toxic	2.67*	10.0	0
3/10/73	1615	8.00	7.20	Non-toxic	2.67*	10.0	0
4/11/73							Trace
5/11/73	2100	8.47	7.31	20% mort. at 32% in 24 hr.	2.21*	10.0	Trace

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 10 BIOASSAY DETERMINATIONS - STORM SEWER NO. 23

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
31/7/73							0
2/8/73	1035	7.21	7.21	Non-toxic	1.49*	12.0	0
1/10/73							0.04
2/10/73	1230	7.00	7.20	Non-toxic	2.67*	10.0	0
3/10/73	1110	7.00	7.05	Non-toxic	2.67*	10.0	0
3/10/73	1700	7.10	7.20	Non-toxic	2.67*	10.0	0

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 11 BIOASSAY DETERMINATIONS - STORM SEWER NO. 29

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
1/8/73							0
2/8/73	1105	7.29	7.29	Non-toxic	1.49*	12.0	0
2/10/73	No flow						
3/10/73	No flow						
5/11/73	No flow						
6/11/73	No flow						

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 12 BIOASSAY DETERMINATIONS - STORM SEWER NO. 38

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
1/8/73							0
2/8/73	1130	7.18	6.97	LC_{50}=75%	1.49*	11.5	0
1/10/73							0.04
2/10/73	1320	7.30	7.10	LC_{50}=69%	2.67*	10.0	0
3/10/73	No flow						
5/11/73	No flow						
6/11/73	No flow						

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been under-estimated.

TABLE 13 BIOASSAY DETERMINATIONS - STORM SEWER NO. 45

Date	Time	pH		Toxicity	Fish Loading Density[1] (gm/l)	Bioassay Temp. (°C)	Precip.[2] (in)
		Initial	Final				
1/8/73							0
2/8/73	1150	7.50	7.50	Non-toxic	1.49*	12.0	0
2/10/73	No flow						
3/10/73	No flow						
5/11/73	No flow						
6/11/73	No flow						

1 Grams of fish per litre of bioassay solution.

2 Data from Atmospheric Environment Service. Readings taken from gauging station for Kamloops.

* It should be noted for high fish loading densities (i.e.: greater than 0.5 - 1.0 gm/l) the toxicity of the sample may have been un-er-estimated.

4.2 HEAVY METAL ANALYSIS

TABLES 14 - 23

TABLE 14 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 2

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
1/8/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
3/8/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
3/10/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
3/10/73*	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03

* P.M.

TABLE 15 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 6

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
1/8/73	Dissolved	0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	0.04	<0.03	<0.03	<0.06	<0.03	<0.10
3/8/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	<0.03	0.50	<0.03	<0.06	<0.06	<0.10
2/10/73	Dissolved	<0.06	0.03	1.0	<0.06	<0.03	<0.03
	Extractable	<0.06	0.04	3.6	<0.06	<0.04	<0.3
5/11/73	Dissolved	0.04	0.07	<0.03	<0.06	<0.03	<0.03
	Extractable	0.03	<0.03	<0.03	<0.06	<0.03	<0.03
5/11/73*	Dissolved	<0.03	0.07	<0.03	<0.06	<0.03	<0.03
	Extractable	0.03	<0.03	<0.03	<0.06	<0.03	<0.03

* P.M.

TABLE 16 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 8

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
01/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
03/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	<0.03	<0.03	<0.05	<0.06	<0.06	<0.10

TABLE 17 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 14

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.01	Ni ±0.01	Cd ±0.01	Pb ±0.01
02/08/73	Dissolved	0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	0.13	<0.03	<0.03	<0.06	<0.03	<0.10
03/08/73	Dissolved	0.05	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	<0.03	<0.03	<0.03	0.07	<0.06	<0.10
05/11/73	Dissolved	0.04	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	0.03	0.10	<0.03	<0.06	<0.03	<0.03
06/11/73	Dissolved	0.06	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	0.05	<0.03	<0.03	<0.06	<0.03	<0.03

TABLE 18 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 16

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
02/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
03/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10

TABLE 19 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 18

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
03/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.06	<0.10
	Extractable	0.04	0.25	<0.03	<0.06	<0.06	0.70
02/10/73	Dissolved	0.06	<0.03	1.5	0.07	<0.03	1.3
	Extractable	0.12	<0.03	4.5	<0.06	<0.03	2.3
03/10/73	Dissolved	<0.03	0.04	4.5	<0.06	<0.03	<0.03
	Extractable	0.11	0.59	5.0	<0.06	<0.03	0.09
03/10/73*	Dissolved	0.04	0.03	1.10	<0.06	<0.03	0.25
	Extractable	0.06	0.16	1.10	<0.06	<0.03	0.12
05/11/73	Dissolved	0.21	0.91	0.90	<0.06	<0.03	2.1
	Extractable	0.13	0.64	1.3	<0.06	<0.03	6.0

*P.M.

TABLE 20 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 23

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
02/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	0.03	<0.03	<0.03	<0.06	<0.03	<0.10
02/10/73	Dissolved	<0.06	<0.03	<0.06	<0.06	<0.03	<0.30
	Extractable	<0.06	<0.03	0.06	<0.06	<0.03	<0.30
03/10/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
03/10/73*	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03

*PM

TABLE 21 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 29

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
02/08/73	Dissolved	<0.03	0.05	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	0.06	<0.03	<0.06	<0.03	<0.10

TABLE 22 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 38

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.1
02/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	<0.03	<0.03	0.06	<0.03	<0.10
02/10/73	Dissolved	<0.06	<0.03	0.07	0.06	<0.03	<0.03
	Extractable	<0.06	0.09	0.03	0.06	<0.03	<0.3

TABLE 23 HEAVY METAL CONCENTRATIONS - STORM SEWER NO. 45

Date		Concentration mg/l					
		Cu ±0.01	Zn ±0.01	Cr ±0.02	Ni ±0.01	Cd ±0.01	Pb ±0.01
02/08/73	Dissolved	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10
	Extractable	<0.03	<0.03	<0.03	<0.06	<0.03	<0.10

4.3 ADDITIONAL ANALYTICAL RESULTS

TABLES 24 - 33

TABLE 24 CHEMICAL RESULTS - STORM SEWER NO. 2

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
01/08/73	11.5	8.50	-	<1	20	2765	4	N/D	<5	<0.006
03/08/73	10.0	8.50	-	<1	43	2446	39	<0.015	<5	<0.006
03/10/73	16.0	8.50	-	<1	28	2500	<2.5	<0.015	<5	<0.006
03/10/73*	8.0	8.55	-	<1	17	2500	<2.5	<0.015	<5	<0.006

* P.M.

TABLE 25 CHEMICAL RESULTS - STORM SEWER NO. 6

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
01/08/73	12.0	8.25			167	4297	6	N/D	<5	<0.006
03/08/73	8.0	8.39	-	<1	35	4330	43	<0.015	<5	<0.006
02/10/73	8.0	8.25	-	<5	41	7320	23	0.019	<5	0.01
05/11/73	3.0	8.23	-	<10	35	63	1.5	-	<5	<0.006
05/11/73*	1.5	8.20	-	<10	24	6220	9.5	<0.015	<5	<0.006

* P.M.

TABLE 26 CHEMICAL RESULTS - STORM SEWER NO. 8

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
01/08/73	14.0	8.50	-	-	20	540	204	<0.015	<5	<0.006
03/08/73	11.0	7.82	-	<5	128	339	207	<0.015	<5	<0.006

TABLE 27 CHEMICAL RESULTS - STORM SEWER NO. 14

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	14.0	7.17	-	-	27	118	2.3	<0.015	18	<0.006
03/08/73	14.5	7.27	-	<5	346	68	9	<0.015	<5	<0.006
05/11/73	8.5	7.86	-	<5	28	6200	12	<0.015	<5	<0.006
06/11/73	8.0	7.40	12	(3-22)	71	82	10	<0.015	<5	<0.006

TABLE 28 CHEMICAL RESULTS - STORM SEWER NO. 16

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	11.5	7.48	-	-	19	152	12	N/D	19	<0.006
03/08/73	11.0	7.49	-	<5	62	124	84	<0.015	<5	<0.006

TABLE 29 CHEMICAL RESULTS - STORM SEWER NO. 18

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	15.0	8.34	15	(14-16)	592	149	60	<0.015	153	<0.006
02/10/73	14.0	9.70	22	(10-33)	146	293	23	<0.015	26.3	<0.006
03/10/73	14.0	7.50	30	(27-34)	262	250	150	<0.015	96	<0.006
03/10/73*	15.0	8.00	45	(37-52)	164	140	14	<0.015	26.2	<0.006
05/11/73	8.0	8.49	-	>250	1000	101	58	0.07	52	0.03

* P.M.

TABLE 30 CHEMICAL RESULTS - STORM SEWER NO. 23

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	16.5	7.21	-	<1	55	90	3	N/D	15	<0.006
02/10/73	16.5	7.00	-	-	4	116	<2.5	0.069	<5	<0.006
03/10/73	17.0	7.00	-	<1	9	55	<2.5	<0.015	<5	<0.006
03/10/73*	17.5	7.10	-	<5	3	87	6	<0.015	<5	<0.006

* P.M.

TABLE 31 CHEMICAL RESULTS - STORM SEWER NO. 29

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	14.0	7.29	-	-	101	147	10	<0.015	19	<0.006

TABLE 32 CHEMICAL RESULTS - STORM SEWER NO. 38

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	8.5	7.18	-	<5	19	79	5	≃10	<5	<0.006
02/10/73	14.0	7.30	-	-	32	85	18	<0.015	13.1	<0.006

TABLE 33 CHEMICAL RESULTS - STORM SEWER NO. 45

Date	Temp. (°C)	pH	BOD_5 (mg/l)		COD (mg/l)	TR (mg/l)	NFR (mg/l)	Phenols (mg/l)	Oils (mg/l)	Cyanide (mg/l)
			Avg.	Range						
02/08/73	14.5	7.50	-	-	8	60	3	0.035	14	0.006

5. Summary of Results

Results of the bioassay determinations indicate that several of the storm sewer discharges were periodically toxic to fish. However, concrete conclusions cannot be reached due to the few numbers of bioassay samples collected due to time and flow restrictions.

Several of the storm sewer discharges showed signs of containing high chemical and metal contaminants. Particularly storm sewer #18; Oils - 153 ppm; COD - 1000 ppm; Cr - 5.0 ppm; Pb - 6.0 ppm.

6. Observations

Future extensive studies with more emphasis on makeup of each storm sewer flow are needed to get a more accurate understanding for the toxicity and high chemical and metal contaminants of some of the storm sewers.

7. ACKNOWLEDGEMENTS

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