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SHELLFISH GROWING WATER SANITARY SURVEY

OF

COWICHAN BAY

BRITISH COLUMBIA, 1973

by

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and

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ABSTRACT

A sanitary survey of the waters of Cowichan Bay including the tidal foreshore of Saanich Inlet between Cherry Point and Whiskey Point was conducted during November and December 1973, by personnel of the Environmental Protection Service, Pacific Region.

The purpose of the survey was to validate the existing Schedule J closure of Cowichan Bay. With the exception of the western tidal foreshore of Sansum Narrows, all the waters of Cowichan Bay were subject to continuous bacterial pollution from the Cowichan and Koksilah Rivers and their tributaries.

A recommendation is made to extend the Cowichan Bay closure to include all of the waters in Cowichan Bay, and to declare as contaminated the tidal foreshore of Saanich Inlet lying between Cherry Point and Whiskey Point.

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1. INTRODUCTION

The purpose of the sanitary survey is to identify and evaluate those factors influencing the sanitary quality of a shellfish growing area. Factors normally investigated include: sources of pollution and the distance of such sources from the growing area; effectiveness and reliability of sewage treatment facilities; the presence of industrial wastes or pesticides which would constitute a health hazard to the consumer of shellfish; and the effect of wind, stream flows, and tidal currents on the distribution of pollutants over the growing area. The thoroughness with which each element must be investigated varies greatly and would be determined by the sources of pollution influencing each growing area.

Growing areas may be designated as approved when the three following criteria are met:

(i) The area is not so contaminated with fecal material that consumption of the shellfish might be harzardous.

(ii) The area is not so contaminated with pesticides or industrial wastes that consumption of the shellfish might be hazardous.

(iii) The coliform median MPN of the water does not exceed 70 per 100 ml, and not more than 10 percent of the samples ordinarily exceed an MPN of 230 per 100 ml for a five tube decimal dilution test in those portions of the area most probably exposed to fecal contamination during the most unfavourable hydrographic and pollution conditions.

The Shellfish Water Quality Program requires that all actual or potential shellfish growing areas be classified as to their suitability for shellfish harvesting on the basis of sanitary quality as defined above. Satisfactory compliance requires that all areas not subjected to sanitary surveys be closed to the harvesting of shellfish. Accordingly, Cowichan Bay was classified as a closed area and included in Schedule J of the October 1972, amended British Columbia Fishery Regulations. The closure area was dictated by known sources of sewage, and the closure line drawn between easily recognized geographical features.

In order to confirm the Cowichan Bay closure, a sanitary survey was carried out by personnel of the Shellfish Water Quality Program from November 20 to December 11, 1973. Surveys of other inlets on the east coast of Vancouver Island had indicated that the most unfavourable conditions exist during winter months, coincident with heavy rainfalls and strong southeast winds.

The shellfish resource of Cowichan Bay consists mainly of Native Littleneck and Manila clams. Clam beds are located in Genoa Bay and along the southern tidal foreshore to Whiskey Point.

2. POLLUTION SOURCES

The four main sources of pathogenic organisms to the shellfish growing waters of Cowichan Bay are as follows:

(i) The discharge of 800,000 Imperial gallons per day (average annual) of unchlorinated sewage effluent from the two cell facultative

lagoon servicing the City of Duncan. The effluent is discharged to the Cowichan River approximately 2,000 feet upstream from its confluence with Somenos Creek.

(ii) The discharge of 300,000 Imperial Gallons per day (average annual) of chlorinated sewage effluent from the two cell facultative lagoon servicing the District of North Cowichan. The effluent is discharged to the Cowichan River approximately 500 feet upstream from its confluence with Somenos Creek.

(iii) The discharge of 60,000 Imperial gallons per day (average annual) of chlorinated sewage effluent from the extended aeration package treatment plant servicing the District of Cowichan Valley. The effluent is discharged to Cowichan Bay through an outfall approximately 2,500 feet in length, terminating east of the CN Wharf about 30 feet below the surface at mean low water.

(iv) Landwash from the watersheds of the Cowichan and Koksilah Rivers and their tributaries.

The significance of these pollution sources and other direct and indirect sewage contributions to the rivers, estuary and marine foreshore would be determined by the results of bacteriological analyses. There are no known significant sources of chemical or pesticide contamination to the Cowichan River.

3. SAMPLE STATION LOCATIONS

Cowichan Bay sample station locations are shown in Figure 1. Sample stations 1 through 17 were established to verify the accuracy of the Skinner Point to Cherry Point closure line. Sample stations 18, 21 and 22 along the foreshore of Sansum Narrows and 19, 20, 23 and 24 along the western tidal foreshore toward Whiskey Point, were established as a result of higher than acceptable bacteriological results obtained at the initial seventeen sample stations. Freshwater stations S7 and S8 were established to determine the bacterial densities being contributed by Garnett and Manley Creeks respectively.

Cowichan Valley sample station locations are shown in Figure 2. Sample stations S1 and S2 were located on the Somenos and Quamichan Creeks respectively, immediately upstream of their entry into the Cowichan River. Stations S3, S4 and S9 were positioned on the Cowichan River at convenient locations upstream and downstream of the sewage lagoon discharges. Stations S5, S6 and S10 were located on the Koksilah River. Stations L1 and STP, at the chlorine contact tank outlets of the District of North Cowichan sewage lagoon and the Regional District of Cowichan Valley sewage treatment plant respectively, were established to measure the efficacy of chlorination in reducing the coliform levels of these effluents. Station L2, at the effluent outlet of the City of Duncan sewage lagoon, was established to determine the coliform densities of this unchlorinated effluent.

A complete description of sample station locations is presented in Tables 9 and 10 of Appendix I.

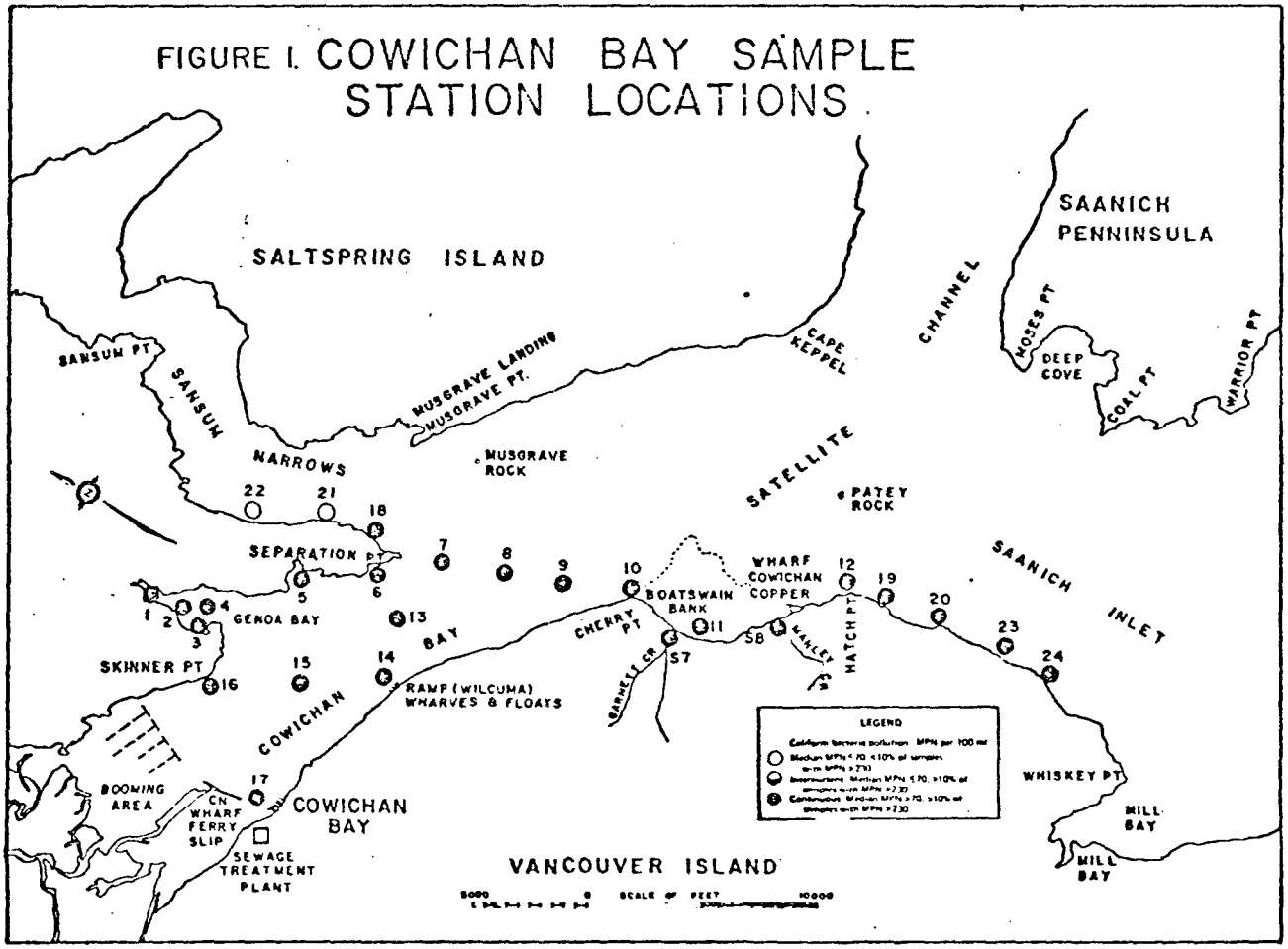
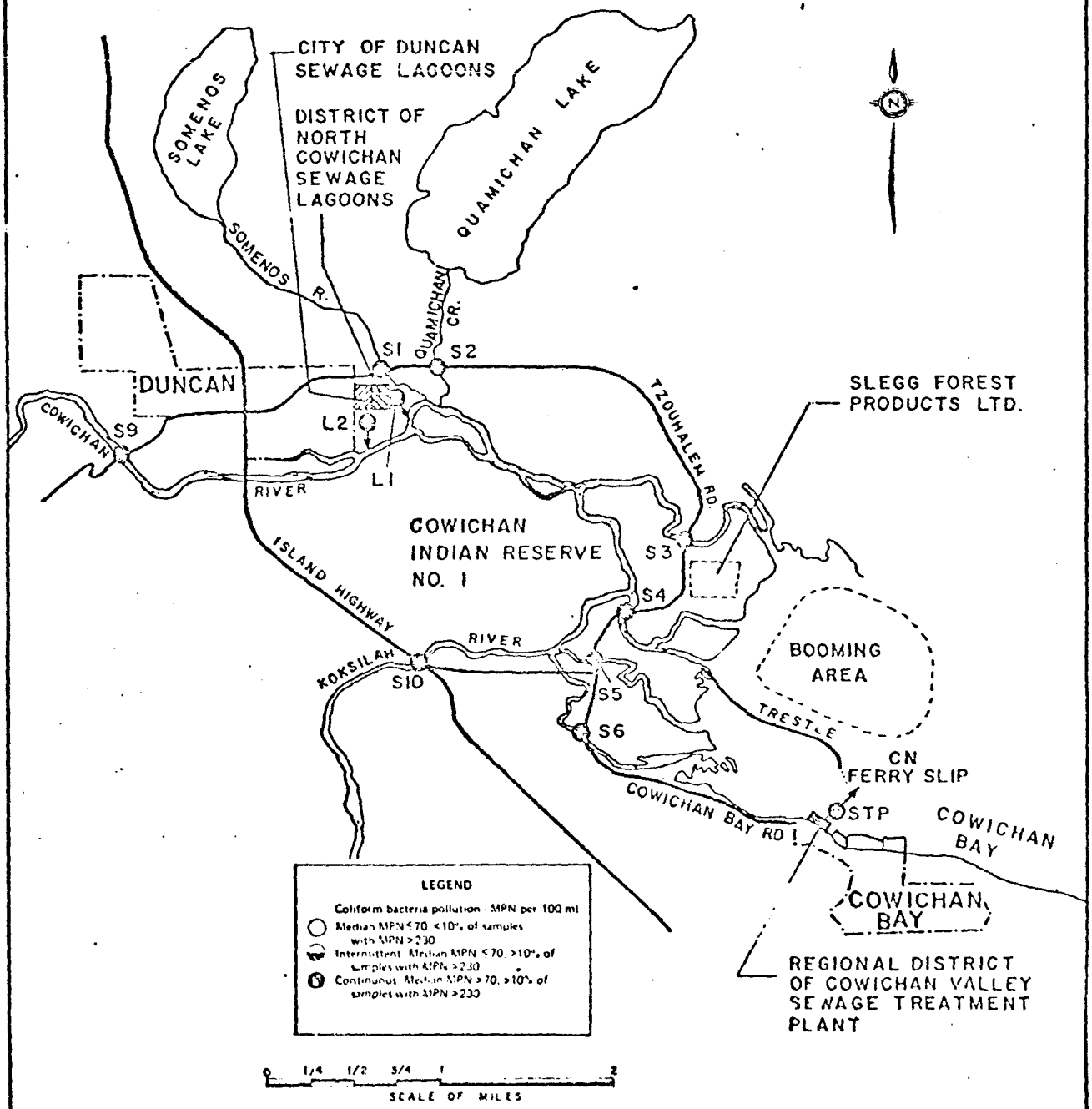


FIGURE I. COWICHAN BAY SAMPLE STATION LOCATIONS

FIGURE 2. COWICHAN VALLEY SAMPLE STATION LOCATIONS



4. FIELD PROCEDURES AND METHODS

4.1. Bacteriological Sampling and Analyses

All samples for bacteriological analyses were collected in sterile 6-ounce wide-mouth bottles approximately 6 inches to one foot below the water surface. Samples were collected by boat or on foot and stored in coolers at temperatures not exceeding 10°C until processed. Analyses were carried out in the Environmental Protection Service mobile laboratory located 30 minutes travel time from the sampling area and were performed within 2.5 hours of collection. The total confirmed coliform MPN was obtained using the multiple-tube fermentation technique (3 decimal dilutions of five tubes each) as described in Part 407A of the 13th edition of Standard Methods for the Examination of Water and Wastewater. Fecal coliform results were obtained as described in Part 407C of Standard Methods.

4.2. Physical Testing Equipment and Analyses

Temperature and salinity measurements at marine sample stations were made at a depth of 6 inches to one foot below the water surface using test equipment carried in the boat. Temperatures were measured using a standard immersible thermometer and salinity readings were taken with a Beckman Model RB3-349 Solubridge Electrolytic Conductivity Meter. Wind speeds were recorded on a hand-held Casella windmill. Temperature readings at freshwater sample stations were taken using a Precision Scientific Company Oxygen Analyzer thermistor attachment. Chlorine

residuals were measured at sample stations L1 and STP using a Hach Chlorine Test Kit (Orthotolidine method).

4.3. Freshwater Discharge Determinations

Freshwater discharges, the product of measured stream velocities and calculated cross-sectional areas of flow, were determined at sample stations S1 through S8, excluding S4.* Stream velocities were measured using a Gurley Current Meter. Cross-sectional areas of flow were calculated from river bottom contour and daily water level readings. A bottom contour was graphed for each station on the basis of depth readings taken at intervals across the stream widths. Daily water levels were superimposed upon the contour graph for each station, and the area of flow calculated by means of a planimeter. Discharge data for stations S9 and S10 on the Cowichan and Koksilah Rivers respectively, was provided by the Inland Waters Directorate, Department of the Environment.

5. DISCUSSION OF RESULTS

Daily bacteriological results and sampling conditions for individual sample stations are presented in Tables 11 and 12 of Appendix II. Total and fecal coliform results are summarized in Tables 1 through 6. The results of discharge determinations made at freshwater sample stations are presented in Table 7.

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* Discharges at sample station S4 could not be accurately determined due to tidal influence.

TABLE 1: SUMMARY OF STANDARD TOTAL COLIFORM MPN DATA FOR SEWAGE LAGOON AND TREATMENT PLANT SAMPLES.

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml
L1	5	3500 - $>1.6 \times 10^5$	$>1.6 \times 10^4$
L2	5	$>1.6 \times 10^6$ - 5.4×10^6	3.5×10^6
STP	6	3.3×10^6 - 9.2×10^6	4.1×10^6

TABLE 2: SUMMARY OF FECAL COLIFORM MPN DATA FOR SEWAGE LAGOON AND TREATMENT PLANT SAMPLES.

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml
L1	5	40 - $>1.6 \times 10^5$	140
L2	5	2.2×10^5 - 1.7×10^6	1.6×10^6
STP	6	6.8×10^5 - 4.9×10^6	2.2×10^6

TABLE 3: SUMMARY OF STANDARD TOTAL COLIFORM MPN DATA FOR FRESHWATER SAMPLES.

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml
S1	6	1100 - 9200	~2250
S2	6	1300 - 1.6×10^4	~2850
S3	6	1110 - 5400	2250
S4	6	490 - 2200	1205
S5	6	220 - 5400	855
S6	5	350 - 2800	1400
S7	6	920 - 9200	~2000
S8	6	1600 - 4900	4200
S9	5	78 - 1700	140
S10	5	22 - 1.6×10^4	490

TABLE 4: SUMMARY OF FECAL COLIFORM MPN DATA FOR FRESHWATER SAMPLES.

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml
S1	6	45 - 9200	135
S2	6	120 - 3500	340
S3	6	130 - 540	280
S4	6	68 - 700	265
S5	6	20 - 490	87.5
S6	5	79 - 330	200
S7	6	220 - 5400	~1450
S8	6	240 - 5400	2400
S9	5	20 - 130	33
S10	5	7.8 - 170	<18

TABLE 5: SUMMARY OF STANDARD TOTAL COLIFORM MPN DATA FOR SHELLFISH GROWING WATER SAMPLES.

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml	% over 230 MPN per 100 ml
1	9	49 - 2400	540	66.6
2	9	27 - 2400	280	55.5
3	6	17 - 790	225	33.3
4	6	40 - 1400	290	50.0
5	9	33 - 1600	220	44.4
6	14	4.5 - >1600	475	64.3
7	6	4.5 - 790	96	33.3
8	16	13 - 2200	420	75.0
9	6	<18 - 920	195	50.0
10	11	13 - 1600	240	63.6
11	13	<18 - 1600	220	46.2
12	13	4.5 - 920	140	46.2
13	6	33 - 2400	340	66.6
14	6	45 - 1300	285	50.0
15	6	<18 - 1600	420	66.6
16	6	49 - 1600	280	50.0
17	6	240 - 1600	640	100.0
18	12	6.8 - 920	89.5	33.3
19	12	33 - 350	220	33.3
20	12	33 - 1600	125	41.6
21	10	2.0 - 130	15	0.0
22	10	<1.8 - 220	17	0.0
23	10	49 - 1600	150	40.0
24	10	17 - 920	135	40.0

TABLE 6: SUMMARY OF FECAL COLIFORM MPN DATA FOR SHELLFISH GROWING WATER SAMPLES

Sample Station	Number of Samples	MPN Range	Median MPN per 100 ml
1	9	4.5 - 170	49
2	9	2.0 - 1300	110
3	6	2.0 - 220	47
4	6	2.0 - 230	62
5	9	2.0 - 350	68
6	14	<1.8 - 540	64
7	6	2.0 - 790	~26
8	16	2.0 - 490	135
9	6	2.0 - 140	64
10	11	7.8 - 350	49
11	13	11 - 140	33
12	13	2.8 - 210	27
13	6	7.8 - 270	64
14	6	20 - 490	108
15	6	13 - 220	50.5
16	6	11 - 170	45
17	6	13 - 170	155
18	12	<1.8 - 170	17.5
19	12	4.5 - 170	28
20	12	4.0 - 130	32.5
21	10	<1.8 - 17	3.0
22	10	<1.8 - 14	1.8
23	10	7.8 - 110	27
24	10	2.0 - 79	22

TABLE 7: FRESHWATER AND SEWAGE EFFLUENT DISCHARGES DURING BACTERIOLOGICAL SAMPLING PERIOD.

Date	Discharge (cfs)					
	Station S1	Station S2	Station S3	Station S5	Station S6	Station S7
Nov. 22	210	2.80	2470	160	197	3.10
23	229	2.65	3220	102	172	—
26	245	2.72	2860	125	180	3.25
27	173	4.60	2050	188	214	3.90
28	1920	10.2	2970	2700	3460	12.6
Mean	555	4.59	2710	687	845	5.71
	Station S8	Station[1] S9	Station[1] S10	Station[2] L1	Station[2] L2	Station[3] STP
Nov. 22	1.75	3050	364	—	—	0.126
23	—	2920	331	—	—	0.132
26	1.45	2600	348	—	—	0.114
27	3.60	2880	527	—	—	0.162
28	18.0	6880	5860	—	—	0.098
Mean	6.20	3670	1490	0.55	1.48	0.126

Notes:

1. Discharge data provided by Inland Waters Directorate. Cowichan River (Station S9) gauge station is located 0.4 miles S.W. of Duncan on Allenby Road. Koksilah River gauge station is located at Cowichan Station, 5 miles S. of Duncan, 1.4 miles from Island Highway.

2. Average annual discharges as stated on Pollution Control Branch permits.

3. Calculated from daily pump records provided by sewage treatment plant personnel for December 3, 4, 5, 7 and 10.

To facilitate the interpretation of freshwater and sewage effluent bacterial densities, the mean coliform population equivalent* was calculated for each sample station.

Results of population equivalent calculations are presented in Table 8.

The arithmetic means of freshwater and sewage effluent discharges (Table 1) and of total coliform results (Table 12), formed the basis of these calculations.

5.1. Sewage Lagoon and Treatment Plant Samples

The median coliform results for sewage lagoon and treatment plant samples (Table 1 and 2), confirm that these discharges provided a continuous source of bacterial contamination. The results of population equivalent calculations (Table 8), show the relative significance of each of these discharges.

The unchlorinated effluent from the City of Duncan lagoon (station L2) exhibited a mean population equivalent of 781. The chlorinated effluent from the District of North Cowichan lagoon (station L1) showed a mean population equivalent of only 3.41. Corresponding median fecal coliform MPN's obtained at stations L2 and L1 were 1.6×10^6 and 140 respectively. The individual coliform test results for station L1 are shown in Table 12, and although low fecal coliform counts were obtained on the effluent

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* A quantity of effluent having a coliform population equivalent of 1.00 contains approximately 1.60 x 10" coliform group bacteria, the per capita per day contribution of coliforms as determined in a metropolitan sewerage system.

TABLE 8: POPULATION EQUIVALENTS (Coliform) OF FRESHWATER AND SEWAGE EFFLUENT DISCHARGES.

Sample Station	Column 1 Mean Discharges (ft^3/sec)	Column 2 Mean Discharges (ft^3/day)	Column 3 Mean Total Coliform MPN (coliforms/100 ml)
S1	555	4.80×10^7	3.13×10^3
S2	4.59	3.97×10^5	5.63×10^3
S3	2710	2.34×10^8	2.68×10^3
S5	687	5.94×10^7	2.16×10^3
S6	845	7.30×10^7	1.33×10^3
S7	5.71	4.93×10^5	3.52×10^3
S8	6.20	5.36×10^5	3.96×10^3
S9	3670	3.17×10^8	5.14×10^2
S10	1490	1.29×10^8	3.80×10^3
L1	0.550	4.75×10^4	4.07×10^4
L2	1.48	1.28×10^5	3.46×10^5
STP	0.126	1.09×10^4	5.16×10^6

Notes:
1. Column 1 data was produced from Table 7.
2. Column 2 data = column 1 x 86400 seconds per day.
3. Column 3 data was calculated from Table 12.

TABLE 8: Continued --

Sample Station	Column 4 Mean Total Coliform MPN (Coliforms/ft^3)	Column 5 Mean Total Coliform MPN (Coliforms/day)	Column 6 Mean Population Equivalent
S1	8.86×10^5	4.25×10^{13}	266
S2	1.59×10^6	6.31×10^{11}	3.94
S3	7.58×10^5	1.77×10^{14}	1110
S5	6.11×10^5	3.63×10^{13}	227
S6	3.76×10^5	2.74×10^{13}	171
S7	9.96×10^5	4.91×10^{11}	3.07
S8	1.12×10^6	6.00×10^{11}	3.75
S9	1.45×10^5	4.60×10^{13}	287
S10	1.08×10^6	1.39×10^{14}	868
L1	1.15×10^7	5.46×10^{11}	3.41
L2	9.79×10^8	1.25×10^{14}	781
STP	1.46×10^9	1.59×10^{13}	99.3

Notes: Column 4 = column 3 x 283 100 mls per cubic foot.

Column 5 = column 4 x column 2.

Column 6 = column 5 divided by 1.60×10^{11} coliforms per capita per day (N.S.S.P. Manual of Operations).

samples taken November 21, 22, 23 and 26, the high fecal count of 1.6×10^5 per 100 ml. obtained on November 27 would indicate a failure in the chlorination system. The chlorine residual results shown at station L1 (Table 12) were obtained by the orthotolidine method. Standard Methods states that this method is unreliable on sewage samples and this is indicated by a comparison of chlorine residuals versus fecal coliform counts at station L1.

The Regional District of Cowichan Valley treatment plant chlorinator was not operating during the survey period, resulting in this effluent having a mean population equivalent of 99.3.

It is important to note that population equivalent calculations on sewage lagoon effluents were based on permit stated average annual discharges which may not be representative of discharges which occurred during the sampling period. The sewage treatment plant, for example, with a permit stated average annual discharge of 60,000 gallons per day, had flows in excess of 100,000 gallons per day on several occasions during the survey period. Such a variation in flow is usually a result of storm water sewer infiltration.

Heavy rainfall was experienced on almost every day of the survey. The effect of this precipitation on river and sewage treatment plant flows is shown in Figure 3. The extreme flow recorded at the sewage treatment plant on November 25 was due to a localized storm which did not affect the watersheds of the Cowichan and Koksilah Rivers.

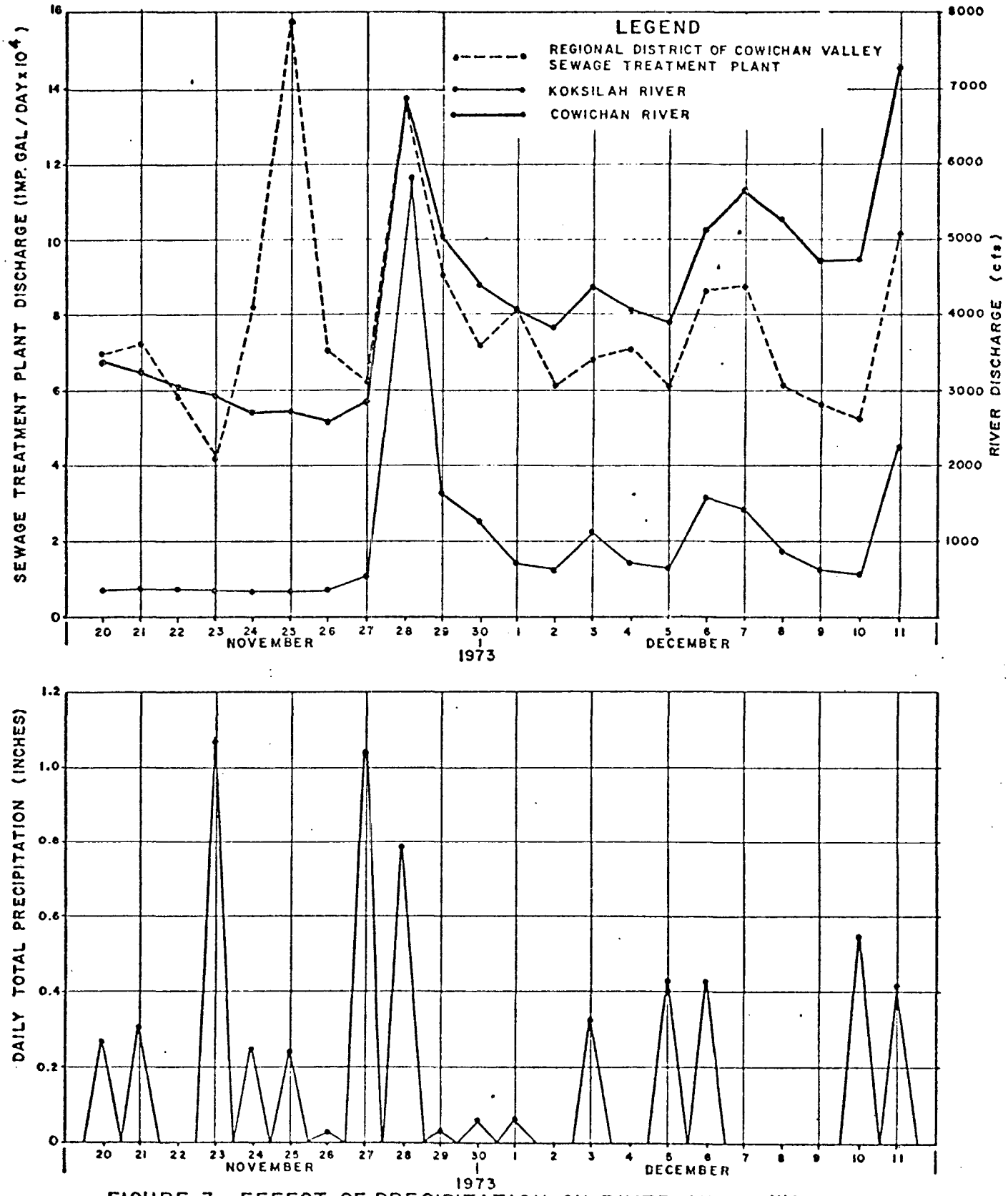

FIGURE 3. EFFECT OF PRECIPITATION ON RIVER AND SEWAGE TREATMENT PLANT DISCHARGES

5.2. Freshwater Samples

The median coliform results for freshwater samples (Tables 3 and 4) confirm that these streams provide a continuous source of bacterial contamination. In addition, median fecal coliform results indicate that this contamination is of public health significance. Mean population equivalents calculated for the Cowichan River ranged from 287 at station S9 to 1110 at station S3. Bacterial densities measured at station S9, above the sewage lagoon discharges, are attributed to landwash and domestic sewage discharges to Cowichan Lake and upstream Cowichan River. The higher densities obtained at station S3 near the mouth of the Cowichan River are due to pollution contributions from Somenos Creek, the sewage lagoons and runoff from pasture lands contiguous to the lower reaches of the river. Bacterial densities obtained at station S1 (Somenos Creek) are attributed to landwash from the unsewered Somenos Lake watershed.

It is interesting to note that although the median total and fecal coliform results at station S2 (Quamichan Creek) were higher than those measured at station S1 (Somenos Creek), the resulting mean population equivalents were 3.94 and 266 respectively. This points out the importance of considering stream flows in evaluating the significance of pollution sources.

Mean population equivalents calculated for Koksilah River sample stations ranged from 868 at S10 to 227 and 172 at S5 and S6 respectively. The discrepancy between the population equivalent at S10 and the total of S5 and S6 is due to the considerable portion of the Koksilah River below S10 which discharges into the south arm of the Cowichan River. This

stretch of the Koksilah River was inaccessible. Landwash from the unsewered watershed is the only known source of bacterial contamination above S10. The median fecal coliform results obtained at S5 and S6 were significantly higher than those obtained at S10, attributable to the approximately 280 head of beef cattle which grazed on the delta between the middle and south arms of the Koksilah River.

Median fecal coliform MPN's of 1450 and 2400 and mean population equivalents of 3.07 and 3.75 were calculated for stations S7 and S8 respectively. Possible sources of fecal contamination to Garnett Creek (station S7) are landwash and the 15 homes at Cherry Point serviced by on-site disposal systems. The Greenfield farm cattle barns and pasture lands located in the Manley Creek watershed, are the probable sources of high fecal coliform densities obtained at station S8.

Extensive flooding of Somenos Creek and the Cowichan and Koksilah Rivers occurred on November 28 and December 11 following heavy rainfalls on previous days. Department of Highways personnel reported that flooding during winter months, coincident with heavy rainfalls and large tides, was a frequent occurrance. The flooded areas observed during the survey period were the following:

(i) The area east of Somenos Creek and the Cowichan River containing the sewage lagoons. Flood waters encompassed the lagoons and covered most of the field area between Tzouhalem Road and Somenos Lake.

(ii) The delta between the lower reaches of the north and south arms of the Cowichan River. Most of the Slegg Forest Products Ltd. property, including the septic tank absorption fields serving the company office and the mill site, was inundated by flood waters.

(iii) The low-lying section of land between the middle and south arms of the Koksilah River, containing the cattle barns and grazing pastures of the Craig-Leith farm.

As a result of this increased landwash, fecal coliform MPN's obtained at stations S1, S2, S4 and S5 on November 28 were higher than those obtained on the previous five days (Table 12). Fecal coliform MPN's obtained at most Cowichan Bay sample stations were significantly higher as well.

5.3. Marine Samples

With the exception of stations S1 and S2, all marine sample stations were subject to continuous bacterial pollution. Median total coliform results (Table 5) show that only the waters at stations 21 and 22 met the approved shellfish growing water quality standards.

Bacterial pollution of the Cowichan Bay waters is mainly due to the influence of the Cowichan and Koksilah Rivers. As a result, the significance of local pollution sources such as the sewage treatment plant and landwash to the tidal foreshore between Cherry Point and Whiskey Point, could not be assessed.

Turbidity and salinity observations at stations 12, 19, 20, 23 and 24

indicated that the Cowichan and Koksilah Rivers influenced these stations only on the flood tide cycle. These observations were verified by the total and fecal coliform results of samples collected at varying tidal stages. Samples collected during flood tide cycles gave consistently higher MPN's than those collected on ebb tide cycles (Table 11).

Genoa Bay contains a small marina (station 3) and is a popular mooring site for summer recreational boaters with as many as 50 toilet equipped vessels occupying the bay at any time during the summer months. Increased bacterial contamination of Genoa Bay could be expected during these periods.

Wilcuma Lodge located on the southern tidal foreshore of Cowichan Bay (station 14) is serviced by an on-site sewage disposal system. The lodge facilities include a small marina with moorage for approximately 12 boats. During summer months it is probable that the waters at this sample station would exhibit high bacterial densities.

Westcan Terminals, at the head of Cowichan Bay (booming area), is a finished lumber loading facility. The on-site sewage disposal system of the complex serves approximately 20 employees. Ocean going vessels without sewage holding tanks would be a periodic source of bacterial contamination in this area. No ships were moored at the terminal during the survey period.

6. CONCLUSIONS

(i) The waters of Cowichan Bay and the western tidal foreshore of Saanich Inlet from Cherry Point to Whiskey Point are subject to bacterial pollution resulting primarily from the discharges of the Cowichan and Koksilah Rivers and their tributaries.

(ii) The major sources of bacterial pollution to the aforementioned rivers are the effluents from the City of Duncan and District of North Cowichan facultative lagoons, and landwash from the river watersheds.

(iii) The chlorination facilities of the District of North Cowichan facultative lagoon and the Regional District of Cowichan Valley sewage treatment plant, can not be depended upon for continuous effective disinfection.

(iv) The bacteriological impact on the waters of Cowichan Bay of the Regional District of Cowichan Valley sewage treatment plant effluent and other estuarine pollution sources could not be assessed due to the high level of pollution emanating from the Cowichan and Koksilah river systems, during the survey period.

7. RECOMMENDATIONS

(i) Contaminated area 18-1 in Schedule J of the British Columbia Fishery Regulations should be amended to read "the waters and tidal foreshore of Cowichan Bay, Area 18, lying inside a straight line drawn from Separation Point to Cherry Point".

(ii) Contaminated area 18-2 should be added to Schedule J and defined as follows -- "That portion of the western tidal foreshore of Saanich Inlet lying between Cherry Point and Whiskey Point".

ACKNOWLEDGEMENTS

B. Kay, Bacteriologist, and M. Gaetner, Bacteriological Technician, conducted the bacteriological analyses in the Environmental Protection Service mobile laboratory located at Duncan for the duration of the survey.

D. Low, Engineering Technician, and G. Derksen, Biological Technician, conducted the sanitary survey, carried out the sampling program and determined freshwater discharges.

Mr. Kay compiled the bacteriological data and Mr. Derksen compiled the hydrographical data. Mr. Low assembled all other data and prepared the report for printing.

Mr. T. Tevendale, Senior Project Engineer, provided overall direction and substantially contributed to the final narrative.

APPENDIX I

SAMPLE STATION LOCATION DESCRIPTIONS

TABLE 9	MARINE SAMPLE STATION LOCATIONS.
TABLE 10	FRESHWATER AND SEWAGE EFFLUENT SAMPLE STATION LOCATIONS.

TABLE 9: MARINE SAMPLE STATION LOCATIONS.

Sample Station	Latitude	Longitude	Location
1	48°46.0'N	123°35.8'W	Genoa Bay
2	48°45.9'N	123°35.8'W	Genoa Bay
3	48°45.6'N	123°35.9'W	Genoa Bay
4	48°45.6'N	123°35.6'W	Genoa Bay
5	48°45.2'N	123°34.9'W	Cowichan Bay
6	48°44.7'N	123°34.4'W	Separation Point
7	48°44.3'N	123°34.0'W	Cowichan Bay
8	48°44.0'N	123°33.8'W	Cowichan Bay
9	48°43.6'N	123°33.6'W	Cowichan Bay
10	48°43.0'N	123°33.2'W	Cherry Point
11	48°42.3'N	123°33.2'W	Boatswain Bank
12	48°41.7'N	123°32.0'W	Hatch Point
13	48°44.4'N	123°34.7'W	Cowichan Bay
14	48°44.2'N	123°35.4'W	Wilcuma Wharf
15	48°44.8'N	123°35.8'W	Cowichan Bay
16	48°45.3'N	123°36.2'W	Skinner Point
17	48°44.6'N	123°34.6'W	Cowichan Bay
18	48°44.9'N	123°34.1'W	Sansum Narrows
19	48°41.4'N	123°32.0'W	Saanich Inlet
20	48°41.0'N	123°31.9'W	Saanich Inlet
21	48°45.2'N	123°34.2'W	Sansum Narrows
22	48°45.8'N	123°34.6'W	Sansum Narrows
23	48°40.5'N	123°31.9'W	Saanich Inlet
24	48°40.2'N	123°31.8'W	Saanich Inlet

TABLE 10: FRESHWATER AND SEWAGE EFFLUENT SAMPLE STATION LOCATIONS.

Sample Station	Location
S1	Somenos Creek at Tzouhalem Road.
S2	Quamichan Creek at Tzouhalem Road.
S3	North arm of Cowichan River at Tzouhalem Road.
S4	South arm of Cowichan River at Tzouhalem Road.
S5	Centre arm of Koksilah River at Tzouhalem Road.
S6	South arm of Koksilah River at Cowichan Bay Road.
S7	Mouth of Garnett Creek.
S8	Mouth of Manley Creek.
S9	Cowichan River at Allenby Road.
S10	Koksilah River at Island Highway.
L1	District of North Cowichan sewage lagoon chlorine contact pond outlet.
L2	City of Duncan sewage lagoon effluent outlet.
STP	Regional District of Cowichan Valley sewage treatment plant chlorine contact tank outlet.

APPENDIX II

BACTERIOLOGICAL RESULTS AND SAMPLING CONDITIONS

TABLE 11	BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES.
TABLE 12	BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER AND SEWAGE EFFLUENT SAMPLES.

TABLE 11: BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES.

Sample Station: 1 Location: Genoa Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1115	0750 1325	8.5 11.1	5.0	0.31	S @ 4	ripple	9.5	540	49
Nov. 22	1450	1345 2120	10.9 2.4	7.0	nil	nil	calm	29.0	49	4.5
Nov. 23	1125	1000 1405	9.7 10.8	7.5	1.07	SE @ 5	ripple	--	490	45
Nov. 26	1300	1240 1525	10.2 10.5	6.5	0.03	nil	calm	--	220	6.8
Nov. 27	1005	0810 1310	12.0 10.1	---	1.04	SE @ 9	ripple	--	2400	150
Nov. 28	1415	0850 1420	12.0 9.8	7.5	0.79	SE @ 10	light chop	3.0	790	170
Dec. 4	1350	1140 1905	11.4 5.0	5.5	trace	nil	calm	29.0	7.9	17
Dec. 5	0905	0510 1150	8.2 11.4	6.5	0.43	nil	calm	24.0	540	49
Dec. 6	0845	0625 1210	9.1 11.5	7.5	0.43	SE @ 2	ripple	--	920	170

TABLE 11: (Cont'd)

Sample Station: 2 Location: Genoa Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1120	0750 1325	8.5 11.1	5.5	0.31	S @ 4	ripple	17.0	280	130
Nov. 22	1455	1345 2120	10.9 2.4		nil	nil	calm		27	7.8
Nov. 23	1130	1000 1405	9.7 10.8	7.0	1.07	SE @ 5	ripple		1100	220
Nov. 26	1305	1240 1525	10.2 10.5	8.0	0.03	nil	calm		34	2.0
Nov. 27	1007	0810 1310	12.0 10.1		1.04	SE @ 9	light calm		490	110
Nov. 28	1415	0850 1420	12.0 9.8	7.5	0.79	SE @ 10	heavy chop	4.6	1300	790
Dec. 4	1350	1140 1905	11.5 5.0	5.5	trace	nil	calm	23.0	140	17
Dec. 5	0910	0510 1150	8.2 11.4	8.0	0.43	nil	calm	24.5	130	6.1
Dec. 6	0850	0625 1210	9.1 11.5	7.5	0.43	SE @ 2	ripple		2400	1300

TABLE 11: (Cont'd)

Sample Station: 3 Location: Genoa Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1125	0750 1325	8.5 11.1	6.0	0.31	S @ 4	ripple	15.2	350	49
Nov. 22	1455	1345 2120	10.9 2.4	--	nil	nil	calm	--	79	2.0
Nov. 23	1135	1000 1405	9.7 10.8	8.0	1.07	SE @ 5	ripple	--	230	45
Nov. 26	1308	1240 1525	10.2 10.5	6.0	0.03	nil	calm	--	17	7.8
Nov. 27	1010	0810 1310	12.0 10.1	--	1.04	SE @ 9	calm	--	220	220
Nov. 28	1420	0850 1420	12.0 9.8	7.0	0.79	SE @ 10	heavy chop	5.6	790	130

TABLE 11: (Cont'd)

Sample Station: 4 Location: Genoa Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1130	0750 1325	8.5 11.1	5.5	0.31	S @ 4	ripple	13.2	350	79
Nov. 22	1500	1345 2120	10.9 2.4	--	nil	nil	calm	--	46	2.0
Nov. 23	1140	1000 1405	9.7 10.8	7.8	1.07	SE @ 5	heavy chop	--	230	45
Nov. 26	1310	1240 1525	10.2 10.5	8.0	0.03	nil	calm	--	40	11
Nov. 27	1013	0810 1310	12.0 10.1	--	1.04	SE @ 9	heavy chop	--	790	170
Nov. 28	1420	0850 1420	12.0 9.8	7.0	0.79	SE @ 10	heavy chop	5.2	1400	230

TABLE 11: (Cont'd)

Sample Station: 5 Location: Separation Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/100 ml Total	Coliform MPN/100 ml Fecal
Nov. 21	1135	0750 1325	8.5 11.1	6.0	0.31	S @ 4	ripple	24.5	1600	350
Nov. 22	1500	1345 2120	10.9 2.4	--	nil	nil	calm	--	33	2.0
Nov. 23	1140	1000 1405	9.7 10.8	7.2	1.07	SE @ 15	heavy chop	--	310	13
Nov. 26	1312	1240 1525	10.2 10.5	6.0	0.03	SE @ 4	ripple	--	220	68
Nov. 27	1018	0810 1310	12.0 10.1	--	1.04	SE @ 9	heavy chop	--	68	68
Nov. 28	1430	1420 1640	9.8 9.8	7.0	0.79	SE @ 10	heavy chop	3.8	1300	330
Dec. 4	1355	1140 1905	11.5 5.0	5.5	trace	nil	calm	28.0	33	11
Dec. 5	0915	0510 1150	8.2 11.4	6.5	0.43	S @ 2	ripple	21.0	170	130
Dec. 6	0855	0625 1210	9.1 11.5	8.0	0.43	SE @ 20	heavy chop	--	240	130

TABLE 11: (Cont'd)

Sample Station: 6 Location: Separation Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1140	0750 1325	8.5 11.1	6.0	0.31	S @ 4	ripple	4.6	920	27
Nov. 22	1505	1345 2120	10.9 2.4	--	nil	nil	calm	--	4.5	< 1.8
Nov. 23	1145	1000 1405	9.7 10.8	7.5	1.07	SE @ 15	heavy swell	--	68	20
Nov. 26	1318	1240 1525	10.2 10.5	7.5	0.03	S @ 4	ripple	--	130	9.3
Nov. 27	1020	0810 1310	12.0 10.1	--	1.04	SE @ 9	heavy chop	--	78	< 1.8
Nov. 28	1435	1420 1650	9.8 9.8	7.0	0.79	SE @ 10	heavy chop	3.2	460	310
Nov. 30	0750	0120 0955	3.1 12.0	6.0	0.06	S @ 6	ripple	13.0	490	490
Dec. 3	1245	1110 1845	11.6 6.1	7.0	0.33	nil	calm	--	920	350
Dec. 4	0910	0355 1140	7.0 11.5	5.0	trace	nil	calm	16.2	540	79

TABLE 11: (Cont'd)

Sample Station: 6 Location: Separation Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 4	1400	1140 1905	11.5 5.0	6.0	trace	nil	calm	29.0	350	49
Dec. 5	0917	0510 1150	8.2 11.4	7.0	0.43	SW @ 6	ripple	19.0	540	540
Dec. 6	0900	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	heavy chop	--	95	17
Dec. 7	0855	0740 1255	9.8 11.6	7.5	trace	SW @ 9	light chop	6.2	540	240
Dec. 11	1000	0720 1155	12.3 10.4	7.5	0.42	SE @ 16	heavy chop	7.0	> 1600	350

TABLE 11: (Cont'd)

Sample Station: 7 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1145	0750 1325	8.5 11.1	6.0	0.31	S @ 4	ripple	24.0	350	34
Nov. 22	1510	1345 2120	10.9 2.4	--	nil	nil	calm	--	22	4.0
Nov. 23	1150	1000 1405	9.7 10.8	--	1.07	SE @ 15	heavy swell	--	20	< 1.8
Nov. 26	1320	1240 1525	10.2 10.5	7.0	0.03	S @ 4	ripple	--	170	110
Nov. 27	1025	0810 1310	12.0 10.0	--	1.04	SE @ 9	heavy swell	--	4.5	2.0
Nov. 28	1435	1420 1650	9.8 9.8	6.0	0.79	SE @ 2	ripple	4.8	790	790

TABLE 11: (Cont'd)

Sample Station: 8 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1150	0750 1325	8.5 11.1	6.0	0.31	S @ 4	ripple	5.0	> 1600	220
Nov. 22	1510	1345 2120	10.9 2.4	--	nil	nil	calm	--	110	11
Nov. 23	1200	1000 1405	9.7 10.8	--	1.07	SE @ 15	heavy swell	--	45	< 18
Nov. 26	1323	1240 1525	10.2 10.5	7.5	0.03	S @ 4	ripple	--	350	170
Nov. 27	1030	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy swell	--	13	2.0
Nov. 28	1440	1420 1650	9.8 9.8	6.0	0.79	SE @ 2	ripple	5.8	790	140
Nov. 29	1412	0920 1530	12.0 9.4	8.5	0.03	SE @ 12	light chop	16.5	330	20
Nov. 30	0800	0120 0955	3.1 12.0	6.0	0.06	S @ 6	ripple	9.0	790	490

TABLE 11: (Cont'd)

Sample Station: 8 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1300	1110 1845	11.6 6.1	7.0	0.33	nil	calm	--	1600	130
Dec. 4	0925	0355 1140	7.0 11.5	6.0	trace	nil	calm	13.0	2200	210
Dec. 4	1412	1140 1905	11.5 5.0	6.5	trace	nil	calm	22.0	350	70
Dec. 5	0930	0510 1150	8.2 11.4	6.5	0.43	SW @ 6	ripple	13.0	490	220
Dec. 6	0920	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	heavy chop	--	33	11
Dec. 7	0910	0740 1255	9.8 11.6	7.2	trace	SW @ 9	light chop	2.6	790	330
Dec. 10	1400	1050 1445	10.6 11.7	7.0	0.55	S @ 2	calm	8.0	330	170
Dec. 11	1025	0720 1155	12.3 10.4	8.0	0.42	SE @ 16	heavy chop	12.5	920	17

TABLE 11: (Cont'd)

Sample Station: 9 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1200	0750 1325	8.5 11.1	6.5	0.31	SE @ 4	ripple	13.5	920	130
Nov. 22	1515	1345 2120	10.9 2.4	--	nil	nil	calm	--	220	49
Nov. 23	1205	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy swell	--	< 18	< 18
Nov. 26	1325	1240 1525	10.2 10.5	7.2	0.03	S @ 4	ripple	--	170	79
Nov. 27	1033	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy swell	--	49	2.0
Nov. 28	1445	1420 1650	9.8 9.8	6.0	0.79	SE @ 2	ripple	11.0	490	140

TABLE 11: (Cont'd)

Sample Station: 10 Location: Cherry Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1205	0750 1325	8.5 11.1	6.2	0.31	SE @ 2	ripple	11.0	1600	350
Nov. 22	1520	1345 2120	10.9 2.4	--	nil	nil	calm	--	70	33
Nov. 23	1210	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy swell	--	110	40
Nov. 26	1328	1240 1525	10.2 10.5	7.8	0.03	S @ 4	ripple	--	240	7.8
Nov. 27	1035	0810 1310	12.0 10.1	--	1.04	SE @ 12	heavy swell	--	49	49
Nov. 28	1445	1420 1650	9.8 9.8	6.0	0.79	S @ 2	calm	4.0	1300	340
Dec. 3	1305	1110 1845	11.6 6.1	8.0	0.33	nil	calm	--	240	49
Dec. 4	0930	0355 1140	7.0 11.5	5.0	trace	nil	calm	8.0	1300	110
Dec. 4	1505	1140 1905	11.5 5.0	6.0	trace	nil	calm	9.0	1100	170
Dec. 5	1015	0510 1150	8.2 11.4	6.5	0.43	SE @ 6	ripple	15.0	540	130
Dec. 6	0925	0625 1210	9.1 11.5	9.0	0.43	SE @ 20	heavy chop	--	13	13

TABLE 11: (Cont'd)

Sample Station: 11 Location: Boatswain Bank

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1230	0750 1325	8.5 11.1	6.0	0.31	nil	calm	11.2	1600	130
Nov. 22	1525	1345 2120	10.9 2.4	--	nil	nil	calm	--	240	33
Nov. 23	1215	1000 1405	9.7 9.8	--	1.07	SE @ 18	heavy swell	--	130	20
Nov. 26	1345	1240 1525	10.2 10.5	7.0	0.03	S @ 4	calm	--	110	13
Nov. 27	1048	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy chop	--	< 18	< 18
Nov. 28	1500	1420 1650	9.8 9.8	8.0	0.79	S @ 2	ripple	27.0	130	130
Nov. 29	1425	0920 1530	12.0 9.4	8.0	0.03	S @ 2	ripple	22.0	70	46
Nov. 30	0806	0120 0955	3.1 12.0	6.0	0.06	SE @ 4	ripple	--	950	140

TABLE 11: (Cont'd)

Sample Station: 11 Location: Boatswain Bank

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1310	1110 1845	11.6 6.1	8.0	0.33	nil	calm	--	280	11
Dec. 4	0935	0355 1140	7.0 11.5	6.0	trace	nil	calm	14.8	220	79
Dec. 4	1453	1140 1905	11.5 5.0	6.0	trace	nil	calm	30.0	540	33
Dec. 5	1010	0510 1150	8.2 11.4	8.0	0.43	SE @ 2	calm	26.0	350	12
Dec. 6	0930	0625 1210	9.1 11.5	9.2	0.43	SE @ 15	heavy chop	--	22	17

TABLE 11: (Cont'd)

Sample Station: 12 Location: Hatch Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1300	0750 1325	8.5 11.1	7.0	0.31	SE @ 2	calm	20.0	540	14
Nov. 22	1540	1345 2120	10.9 2.4	--	nil	nil	calm	--	350	7.8
Nov. 23	1220	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy chop	--	130	45
Nov. 26	1400	1240 1525	10.2 10.5	7.0	0.03	S @ 4	calm	--	130	27
Nov. 27	1058	0810 1310	12.0 10.1	--	1.04	SE @ 16	medium chop	--	4.5	2.0
Nov. 28	1505	1420 1650	9.8 9.8	8.0	0.79	SE @ 2	calm	27.5	79	17
Nov. 29	1430	0920 1530	12.0 9.4	7.8	0.03	SE @ 5	ripple	22.0	49	11
Nov. 30	0810	0120 0955	3.1 12.0	5.5	0.06	SE @ 4	ripple	--	700	210
Dec. 3	1315	1110 1845	11.6 6.1	8.0	0.33	S@ 2	ripple	--	140	7.8
Dec. 4	0940	0355 1140	7.0 11.5	5.0	trace	nil	ripple	16.0	920	79
Dec. 4	1435	1140 1905	11.5 5.0	5.5	trace	SE @ 2	ripple	16.0	920	49
Dec. 5	1000	0510 1150	8.2 11.4	7.5	0.43	SE @ 2	calm	23.0	920	79
Dec. 6	0935	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	heavy chop	--	140	33

TABLE 11: (Cont'd)

Sample Station: 13 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1310	0750 1325	8.5 11.1	6.5	0.31	SE @ 4	calm	10.0	1600	70
Nov. 22	1550	1345 2120	10.9 2.4	--	nil	nil	ripple	--	350	49
Nov. 23	1235	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy swell	--	45	< 18
Nov. 26	1410	1240 1525	10.2 10.5	7.0	0.03	SE @ 4	calm	--	330	78
Nov. 27	1107	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy chop	--	33	7.8
Nov. 28	1513	1420 1650	9.8 9.8	6.0	0.79	SE @ 5	light chop	2.6	2400	270

TABLE 11: (Cont'd)

Sample Station: 14 Location: Wilcuma Lodge

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1315	0750 1325	8.5 11.1	7.0	0.31	SE @ 4	calm	21.0	350	180
Nov. 22	1555	1345 2120	10.9 2.4	--	nil	nil	ripple	--	220	46
Nov. 23	1240	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy swell	--	45	20
Nov. 26	1412	1240 1525	10.2 10.5	6.5	0.03	SE @ 4	calm	--	1300	170
Nov. 27	1110	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy chop	.	79	33
Nov. 28	1515	1420 1650	9.8 9.8	5.5	0.79	SE @ 5	light chop	3.7	490	490

TABLE 11: (Cont'd)

Sample Station: 15 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1320	0750 1325	8.5 11.1	7.0	0.31	SE @ 4	calm	4.5	1600	33
Nov. 22	1600	1345 2120	10.9 2.4	--	nil	nil	ripple	--	350	70
Nov. 23	1245	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy swell	--	< 18	< 18
Nov. 26	1415	1240 1525	10.2 10.4	6.5	0.03	SE @ 4	calm	--	790	68
Nov. 27	1112	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy chop	--	130	13
Nov. 28	1520	1420 1650	9.8 9.8	5.5	0.79	SE @ 5	light chop	1.6	490	220

TABLE 11: (Cont'd)

Sample Station: 16 Location: Skinner Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1325	0750 1325	8.5 11.1	7.0	0.31	nil	calm	3.2	1600	79
Nov. 22	1440	1345 2120	10.9 2.4	6.5	nil	nil	calm	30.2	49	11
Nov. 23	1115	1000 1405	9.7 10.8	7.0	1.07	SE @ 18	heavy	--	170	45
Nov. 26	1255	1240 1525	10.2 10.8	7.0	0.03	nil	calm	--	330	45
Nov. 27	0955	0810 1310	12.0 10.1	7.5	1.04	SE @ 16	heavy chop	--	230	45
Nov. 28	1410	1420 1650	9.8 9.8	7.0	0.79	nil	calm	5.0	330	170

TABLE 11: (Cont'd)

Sample Station: 17 Location: Cowichan Bay

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 21	1330	1325 2050	11.1 2.9	6.0	0.31	nil	calm	10.5	1600	140
Nov. 22	1620	1345 2120	10.9 2.4	--	nil	nil	calm	--	240	13
Nov. 23	1250	1000 1405	9.7 10.8	--	1.07	SE @ 18	heavy chop	--	490	140
Nov. 26	1418	1240 1525	10.2 10.5	6.0	0.03	nil	calm	--	490	170
Nov. 27	1115	0810 1310	12.0 10.1	--	1.04	SE @ 16	heavy chop	--	790	170
Nov. 28	1525	1420 1650	9.8 9.8	5.0	0.79	nil	calm	0.4	790	170

TABLE 11: (Cont'd)

Sample Station: 18 Location: Separation Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 29	1408	0920 1530	9.4 9.4	8.0	0.03	SE @ 12	light chop	20.5	490	170
Nov. 30	0755	0120 0955	3.1 12.0	7.5	0.06	S @ 6	ripple	19.0	330	170
Dec. 3	1250	1110 1845	11.6 6.1	9.0	0.33	S @ 2	ripple	--	350	22
Dec. 4	0915	0355 1140	7.0 11.5	8.0	trace	S @ 2	ripple	29.0	17	13
Dec. 4	1402	1140 1905	11.5 5.0	8.5	trace	nil	calm	30.5	49	< 1.8
Dec. 5	0920	0510 1150	8.2 11.4	8.5	0.43	S @ 6	calm	25.0	6.8	< 1.8
Dec. 5	1530	1150 1935	11.4 3.8	8.5	0.43	E @ 10	medium swell	29.0	17	2.0
Dec. 6	0903	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	heavy chop	--	34	1.8

TABLE 11: (Cont'd)

Sample Station: 18 Location: Separation Point'

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 7	0900	0740 1255	9.8 11.6	7.8	trace	S @ 5	ripple	14.2	170	31
Dec. 7	1200	0740 1255	9.8 11.6	8.2	trace	S @ 2	ripple	2.0	130	49
Dec. 10	1345	1050 1445	10.6 11.7	8.5	0.55	S @ 2	calm	16.0	17	2.0
Dec. 11	1005	0720 1155	12.3 10.4	7.9	0.42	SE @ 16	heavy	13.5	920	79

TABLE 11: (Cont'd)

Sample Station: 19 Location: Hatch Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Nov. 29	1433	0920 1530	9.4 9.4	8.0	0.03	SE @ 5	ripple	23.5	33	17
Nov. 30	0815	0120 0955	3.1 12.0	6.5	0.06	S @ 6	ripple	--	330	170
Dec. 3	1315	1110 1845	11.6 6.1	8.0	0.33	S @ 2	ripple	--	49	4.5
Dec. 4	0940	0355 1140	7.0 11.5	6.0	trace	S @ 2	ripple	20.0	170	79
Dec. 4	1433	1140 1905	11.5 5.0	6.5	trace	nil	calm	19.0	350	79
Dec. 5	0955	0510 1150	8.2 11.4	6.5	0.43	SE @ 6	calm	19.5	220	22
Dec. 5	1615	1150 1935	11.4 3.8	7.0	0.43	E @ 10	heavy chop	22.5	79	17
Dec. 6	0935	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	light chop	--	220	17

TABLE 11: (Cont'd)

Sample Station: 19 Location: Hatch Point

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 7	0920	0740 1255	9.8 11.6	8.0	trace	SE @ 5	calm	14.5	33	13
Dec. 7	1230	0740 1255	9.8 11.6	7.8	trace	S @ 2	ripple	10.5	350	23
Dec. 10	1405	1050 1445	10.6 11.7	7.0	0.55	SE @ 2	calm	14.5	220	33
Dec. 11	1100	0720 1155	12.3 10.4	7.5	0.42	SE @ 16	heavy chop	--	240	49

TABLE 11: (Cont'd)

Sample Station: 20 Location: Saanich Inlet

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/100 ml Total	Coliform MPN/100 ml Fecal
Nov. 29	1437	0920 1530	9.4 9.4	8.0	0.03	SE @ 5	ripple	22.0	49	23
Nov. 30	0818	0120 0955	3.1 12.0	6.5	0.06	S @ 6	ripple	--	1110	70
Dec. 3	1320	1110 1845	11.6 6.1	8.0	0.33	S @ 2	ripple	--	110	4.0
Dec. 4	0945	0355 1140	7.0 11.5	6.0	trace	S @ 2	ripple	18.0	540	79
Dec. 4	1430	1140 1905	11.5 5.0	6.5	trace	nil	ripple	23.0	79	33
Dec. 5	0955	0510 1150	8.2 11.4	6.5	0.43	SE @ 6	calm	18.0	920	130
Dec. 5	1610	1150 1935	11.4 3.8	7.0	0.43	E @ 10	heavy chop	21.0	140	32
Dec. 6	0940	0625 1210	9.1 11.5	8.0	0.43	SE @ 20	light chop	--	33	23

TABLE 11: (Cont'd)

Sample Station: 20 Location: Saanich Inlet

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 7	0920	0740 1255	9.8 11.8	8.0	trace	SE @ 5	calm	14.5	33	23
Dec. 7	1225	0740 1255	9.8 11.6	7.5	trace	N @ 2	ripple	11.5	350	130
Dec. 10	1410	1050 1445	10.6 11.7	7.0	0.55	SE @ 2	calm	14.5	110	23
Dec. 11	1055	0720 1155	12.3 10.4	7.5	0.42	SE @ 16	heavy chop	--	1600	33

TABLE 11: (Cont'd)

Sample Station: 21 Location: Sansum Narrows

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht. (Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1255	1110 1845	11.6 6.1	9.0	0.33	S @ 2	ripple	--	130	4.5
Dec. 4	0915	0355 1140	7.0 11.5	8.0	trace	S @ 2	ripple	29.0	7.8	2.0
Dec. 4	1405	1140 1905	11.5 5.0	8.5	trace	nil	calm	30.5	4.5	< 1.8
Dec. 5	0922	0510 1150	8.2 11.4	8.5	0.43	nil	calm	25.0	17	< 1.8
Dec. 5	1530	1150 1935	11.4 3.8	8.5	0.43	E @ 10	medium swell	29.0	2.0	2.0
Dec. 6	0905	0625 1210	9.1 11.5	9.0	0.43	SE @ 20	heavy chop	--	22	7.8
Dec. 7	0905	0740 1255	9.8 11.6	8.2	trace	S @ 5	ripple	15.0	46	17
Dec. 7	1200	0740 1255	9.8 11.6	8.4	trace	S @ 2	ripple	22.0	49	4.0
Dec. 10	1350	1050 1445	10.6 11.7	9.0	0.55	S @ 2	calm	16.0	6.8	< 1.8
Dec. 11	1010	0720 1155	12.3 10.4	9.0	0.42	SE @ 10	light chop	17.0	13	4.5

TABLE 11: (Cont'd)

Sample Station: 22 Location: Sansum Narrows

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1258	1110 1845	11.6 6.1	8.0	0.33	SE @ 2	ripple	--	220	9.3
Dec. 4	0920	0355 1140	7.0 11.5	8.0	trace	SE @ 5	ripple	30.0	17	< 1.8
Dec. 4	1405	1140 1905	11.5 5.0	8.5	trace	nil	calm	30.5	11	< 1.8
Dec. 5	0925	0510 1150	8.2 11.4	8.5	0.43	nil	calm	26.0	11	< 1.8
Dec. 5	1535	1150 1935	11.4 3.8	8.5	0.43	E @ 10	medium swell	29.0	< 1.8	< 1.8
Dec. 6	0910	0625 1210	9.1 11.5	8.5	0.43	SE @ 20	heavy chop	--	79	11
Dec. 7	0905	0740 1255	9.8 11.6	8.5	trace	S @ 5	ripple	15.0	130	14
Dec. 7	1205	0740 1255	9.8 11.6	8.5	trace	N @ 3	ripple	23.5	23	4.5
Dec. 10	1355	1050 1445	10.6 11.7	8.5	0.55	S @ 2	calm	17.0	7.8	< 1.8
Dec. 11	1015	0720 1155	12.3 10.4	8.4	0.42	SE @ 16	light chop	12.5	17	1.8

TABLE 11: (Cont'd)

Sample Station: 23 Location: Saanich Inlet

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1320	1110 1845	11.6 6.1	8.0	0.33	S @ 2	ripple	--	350	13
Dec. 4	0950	0355 1140	7.0 11.5	6.0	trace	S @ 2	ripple	20.0	1600	26
Dec. 4	1430	1140 1905	11.5 5.0	6.5	trace	nil	ripple	22.5	170	13
Dec. 5	0950	0510 1150	8.2 11.4	6.5	0.43	SE @ 6	calm	18.0	540	79
Dec. 5	1608	1150 1935	11.4 3.8	7.0	0.43	E @ 10	heavy chop	21.0	79	49
Dec. 6	0940	0625 1210	9.1 11.5	8.0	0.43	SE @ 20	light chop	--	130	79
Dec. 7	0925	0740 1255	9.8 11.6	8.0	trace	SE @ 5	calm	14.0	79	27
Dec. 7	1225	0740 1255	9.8 11.6	8.4	trace	N @ 2	ripple	23.5	49	7.8
Dec. 10	1415	1050 1445	10.6 11.7	7.0	0.55	SE @ 2	calm	14.0	130	27
Dec. 11	1055	0720 1155	12.3 10.4	7.5	0.42	SE @ 16	medium chop	--	1600	110

TABLE 11: (Cont'd)

Sample Station: 24 Location: Saanich Inlet

Date (1973)	Sample Time	Tide Conditions Time	Tide Conditions Ht.(Ft.)	Water Temp. (°C)	Total Precip. (in.)	Wind (mph)	Local Sea Cond.	Salinity (ppt)	Coliform MPN/ 100 ml Total	Coliform MPN/ 100 ml Fecal
Dec. 3	1325	1110 1845	11.6 6.1	8.0	0.33	S @ 2	ripple	--	48	2.0
Dec. 4	0950	0355 1140	7.0 11.5	6.0	trace	S @ 2	ripple	20.0	540	79
Dec. 4	1425	1140 1905	11.5 5.0	6.5	trace	NE @ 5	ripple	18.0	140	22
Dec. 5	0945	0510 1150	8.2 11.4	6.5	0.43	SE @ 6	calm	16.5	920	79
Dec. 5	1600	1150 1935	11.4 3.8	7.0	0.43	E @ 10	medium chop	19.0	79	22
Dec. 6	0945	0625 1210	9.1 11.5	8.0	0.43	SE @ 20	light chop	--	540	49
Dec. 7	0925	0740 1255	9.8 11.6	7.8	trace	SE @ 5	calm	14.8	130	6.8
Dec. 7	1215	0740 1255	9.8 11.6	8.2	trace	N @ 2	ripple	24.0	17	4.5
Dec. 10	1417	1050 1445	10.6 11.7	7.0	0.55	SE @ 2	calm	14.5	130	33
Dec. 11	1045	0720 1155	12.3 10.4	--	0.42	SE @ 16	medium chop	--	920	6.1

TABLE 12: BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER AND SEWAGE EFFLUENT SAMPLES.

Sample Station: S1 Location: Somenos Creek at Tzouhalem Road

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	0915	6.0	0.31	2400	230
Nov. 22	0915	4.5	nil	>1600	70
Nov. 23	0915	5.0	1.07	2300	200
Nov. 26	0910	4.5	0.03	2200	45
Nov. 27	0855	5.0	1.04	1100	45
Nov. 28	0915	6.0	0.79	9200	9200

TABLE 12: continued —

Sample Station: S2 Location: Quamichan Creek at Tzouhalem Road

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	0930	6.0	0.31	9200	490
Nov. 22	0920	3.5	nil	>1600	350
Nov. 23	0920	3.5	1.07	3300	180
Nov. 26	0855	4.0	0.03	1300	330
Nov. 27	0915	5.5	1.04	2400	720
Nov. 28	0910	6.5	0.79	1.6×10^4	3500

TABLE 12: continued —

Sample Station: S3 Location: N. Arm of Cowichan R. at Tzouhalem Rd.

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	0945	7.0	0.31	5400	130
Nov. 22	0930	6.5	nil	>1600	540
Nov. 23	0930	6.5	1.07	230	200
Nov. 26	0850	6.5	0.03	1110	230
Nov. 27	0930	6.5	1.04	3500	330
Nov. 28	0855	5.0	0.79	2200	330

TABLE 12: continued —

Sample Station: S4 Location: S. Arm of Cowichan R. at Tzouhalem Rd.

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	0950	6.5	0.31	1400	68
Nov. 22	0935	6.0	nil	540	70
Nov. 23	0935	6.5	1.07	1300	200
Nov. 26	0845	6.0	0.03	490	330
Nov. 27	0935	6.5	1.04	1110	700
Nov. 28	0850	—	0.79	2200	700

TABLE 12: continued —

Sample Station: S5 Location: Centre Arm of Kokislah R. at Tzouhalem Rd.

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1005	5.0	0.31	240	130
Nov. 22	0940	4.0	nil	920	23
Nov. 23	0945	4.0	1.07	790	20
Nov. 26	0840	3.5	0.03	220	45
Nov. 27	0940	4.0	1.04	5400	490
Nov. 28	0845	4.0	0.79	5400	490

TABLE 12: continued —

Sample Station: S6 Location: S. Arm of Koksilah R. at Cowichan Bay Rd.

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1015	5.5	0.31	2800	230
Nov. 22	0945	4.0	nil	350	79
Nov. 23	0950	4.0	1.07	1400	200
Nov. 26	0835	3.5	0.03	700	130
Nov. 27	0945	4.0	1.04	1400	330
—	—	—	—	—	—

TABLE 12; continued --

Sample Station: S7 Location: Mouth of Garnett Creek

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1220	---	0.31	920	220
Nov. 22	1005	4.5	nil	>1600	>1600
Nov. 26	1335	---	0.03	5400	5400
Nov. 27	1045	---	1.04	9200	2200
Nov. 28	1455	---	0.79	2300	1300
Dec. 4	1500	5.0	trace	1700	230

TABLE 12: continued --

Sample Station: S8 Location: Mouth of Manley Creek

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1240	---	0.31	4900	780
Nov. 22	1530	3.5	nil	3500	2400
Nov. 26	1350	---	0.03	3500	2400
Nov. 27	1055	---	1.04	5400	5400
Nov. 28	1505	---	0.79	4900	4900
Dec. 4	1445	5.0	trace	1600	240

TABLE 12: continued —

Sample Station: S9 Location: Cowichan R. at Allenby Rd.

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 22	1105	7.0	nil	540	33
Nov. 23	0835	6.5	1.07	78	20
Nov. 26	0820	6.0	0.03	140	20
Nov. 27	0840	7.0	1.04	110	68
Nov. 28	0810	5.0	0.79	1700	130
—	—	—	—	—	—

TABLE 12: continued —

Sample Station: S10 Location: Koksilah R. at Island Highway

Date (1973)	Time of Collection	Water Temp. (°C)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 22	1620	—	nil	22	7.8
Nov. 23	0955	4.5	1.07	490	18
Nov. 26	0830	3.5	0.03	70	11
Nov. 27	0950	4.5	1.04	16,000	130
Nov. 28	0940	4.2	0.79	2400	170
—	—	—	—	—	—

TABLE 12: continued —

Sample Station: L1 Location: District of N. Cowichan sewage lagoon outlet.

Date (1973)	Time of Collection	Chlorine Residual (ppm)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1645	0.2	0.31	$>1.6 \times 10^4$	40
Nov. 22	0900	<0.1	nil	$>1.6 \times 10^4$	140
Nov. 23	0900	<0.1	1.07	7900	<180
Nov. 26	0900	0.1	0.03	3500	<18
Nov. 27	1010	<0.1	1.04	$>1.6 \times 10^5$	$>1.6 \times 10^5$
—	—	—	—	—	—

TABLE 12: continued —

Sample Station: L2 Location: City of Duncan sewage lagoon outlet.

Date (1973)	Time of Collection	Chlorine Residual (ppm)	Total Precip. (in.)	Coliform MPN/100 ml	
				Total	Fecal
Nov. 21	1700	—	0.31	3.5×10^6	2.2×10^5
Nov. 22	0910	—	nil	$>1.6 \times 10^6$	1.6×10^6
Nov. 23	0905	—	1.07	3.3×10^6	4.5×10^5
Nov. 26	0905	—	0.03	3.5×10^6	1.7×10^6
Nov. 27	1020	—	1.04	5.4×10^6	7.9×10^5
—	—	—	—	—	—