

ENVIRONMENTAL PROTECTION SERVICE
ENVIRONMENTAL PROTECTION BRANCH
PACIFIC REGION

ENVIRONMENTAL REVIEW
OF THE CRESTBROOK PULP MILL
AT SKOOKUMCHUK, BRITISH COLUMBIA

Regional Program Report No. 81-24

by

G. Derksen
and
M. Lashmar

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ABSTRACT

The Environmental Protection Service initiated a program to compile and review environmental information on the pulp and paper mills in British Columbia. With the co-operation of various other government agencies and the pulp and paper industry, EPS compiled relevant resource and receiving environment monitoring information. After reviewing and evaluating the existing information, the environmental quality of each area was assessed and the need for additional monitoring studies determined. This report represents an assessment of the Crestbrook Forest Industries pulp mill at Skookumchuk, B. C.

RESUME

Le Service de la protection de l'environnement a entrepris de compiler et d'étudier les renseignements recueillis sur l'environnement et concernant les usines de pâte à papier de la Columbi- Britannique. Grace a la collaboration de plusieurs autres agences gouvernementales et de l'industrie de la pâte à papier, le Service de la protection de l'environnement a compilé les données et les résultats de l'effet de la pollution sur l'environnement. Après avoir étudié et évalué les données obtenues, on a pu établir la qualité de l'environnement de chaque zone et déterminer dans quelle mesure on avait besoin de nouvelles études susceptibles de fournir d'autres données. Le présent rapport consiste en une évaluation portant sur l'usine de pâte à papier Crestbrook Forest Industries (Skookumchuk, C.-B.).

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SUMMARY AND CONCLUSIONS

The Crestbrook pulpmill as of November 1981 started discharging to a new rapid infiltration treatment system. Biologically treated effluent is discharged to the ground where it eventually infiltrates to the groundwater level. A discharge to the Kootenay River is still permitted, but only under specified river flow conditions and such that the colour of the river downstream of the outfall does not exceed background levels by 15 colour units. The information presented herein on the effluent pertains to the discharge prior to 1981.

Over the period 1976 to 1980, the yearly average BOD₅ loading from the Crestbrook pulpmill to the Kootenay River ranged between 2127 kg/day in 1976 to 4280 kg/day in 1980. For TSS, the yearly average loading ranged from 2918 kg/day in 1978 to 7109 kg/day in 1979. The 1979 and 1980 averages exceeded the Crestbrook pollution control permit limit of 3720 kg/day BOD₅ and 4950 kg/day TSS. The increased loadings could be related to the increased production seen at the pulpmill over 1976 to 1980.

The toxicity removal performance of the Crestbrook biological treatment system has not been successful. A substantial reduction in toxicity removal performance was evident in 1978, 1979 and 1980. At the 100% effluent toxicity standard, the annual percent of samples passing declined from 100% and 69% for 1976 and 1977 respectively, to 26%, 33% and 27% for 1978, 1979 and 1980 respectively. The noticeable reduction in toxicity removal performance could be related to the increase in production seen over 1976 to 1980.

For the Kootenay River, peak spring freshet occurs over May to July and accounts for approximately 65% to 75% of the mean annual flow. There is a gradual reduction in river flow through the summer and fall and minimum flows generally occur over December to March. The lowest potential dilutions of pulpmill effluent occur over this period. A diversion of up to approximately two-thirds of the average annual flow of the Kootenay River at Canal Flats, to Columbia Lake, has been proposed by B.C. Hydro. If the maximum diversion of 170 m³/s were implemented, the March mean pulpmill

effluent dilution of 35:1 would be reduced to 14:1. Permit PE-240 now allows for an effluent discharge to the Kootenay river only during river flows above $130\text{m}^3/\text{s}$, $170\text{m}^3/\text{s}$, $210\text{m}^3/\text{s}$ and $250\text{m}^3/\text{s}$ for 1982, 1983, 1984 and 1985 (and thereafter) respectively. River flows in excess of $130\text{m}^3/\text{s}$ would normally be expected to occur between May and August and flows in excess of $250\text{m}^3/\text{s}$ between June and July. If the Kootenay diversion proceeds, at a maximum diversion of $170\text{m}^3/\text{s}$, a river flow of $420\text{m}^3/\text{s}$ would be required to meet the $250\text{m}^3/\text{s}$ criteria and on an average flow basis this would only occur in June.

Recreationally, the most important species of game fish in the Kootenay River are cutthroat trout, Dolly Varden, Rocky Mountain whitefish, freshwater ling and rainbow trout. Organoleptic tests have demonstrated that the Crestbrook pulpmill discharge has had a significant effect on fish taste and odour of cutthroat trout and Rocky Mountain whitefish.

Water quality and biological monitoring of the Kootenay River downstream of the Crestbrook pulpmill has documented an impact on both the water quality and biological condition of the river. The most apparent alteration in water quality has been documented to include increased levels of colour, dissolved sodium, dissolved chloride, phenol, total phosphorous, organic nitrogen and tannin and lignin like compounds. Reductions in dissolved oxygen, large increases in dissolved solids or increases in dissolved nutrients have not been reported to occur downstream of the outfall. The Kootenay River downstream of the pulpmill has been described as having a "pulp mill" odour. It has been reported that water quality results show that there is little extra dilution capability gained between a sample station 2.5 km downstream of the pulpmill and one 18 km downstream. Changes in the attached algae and benthic invertebrate community have been reported to have occurred since the pulpmill started discharging effluent. The pulpmill discharge has increased algal growth downstream of the outfall and has altered the benthic invertebrate community from one supporting pollution sensitive aquatic invertebrates such as mayflies and stoneflies to one supporting a large dipteran fauna. The exact nature of the components of

the effluent responsible for these changes has not been documented. However, it is evident that changes in water quality have altered the biological character of the Kootenay River downstream of the pulpmill.

In light of flow diversion plans for the Kootenay River at Canal Flats by B.C. Hydro and the documented impact of the present discharge, the rapid infiltration effluent disposal system now in place at Crestbrook should be a significant step in improving the water quality of the Kootenay River. The ground water monitoring program now required of Crestbrook should determine the effect of the disposal system on that component. Monitoring by Crestbrook of the Kootenay River water colour levels, periphton and benthic invertebrates should document any improvement in the environmental quality of the river as a result of the new disposal system.

1 INTRODUCTION

The Skookumchuk pulpmill operated by Crestbrook Forest Industries Limited is located approximately 50 km north of Cranbrook, B.C., (Figure 1). The pulpmill is situated on the west side of the Kootenay River just south of Skookumchuk Creek (Figure 2). The pulpmill effluent receives biological treatment prior to being discharged to a new rapid infiltration disposal system which came online in November, 1981, or to the Kootenay River under specified river flow conditions.

The Kootenay River supports several important species of game fish including cutthroat trout, Dolly Varden, Rocky Mountain whitefish and rainbow trout. Of these, mountain whitefish are the principal species caught.

This review is restricted to information available prior to the use of the new rapid infiltration system. It includes an assessment of the effluent quality of the pulpmill discharge for the period 1976 to 1980, as it relates to BOD₅, total suspended solids (TSS) and toxicity, to the fishery resources of the Kootenay River and to the aquatic impact of the discharge. Effluent quality data has been derived primarily from mill monitoring results submitted to the Environmental Protection Service (EPS). Resource information on the Kootenay River fishery was obtained primarily from a B.C. Fish and Wildlife (1) and a B.C. Hydro consultant's report (2). The impact of the Crestbrook pulpmill on the Kootenay River has been primarily derived from several provincial government reports (3-7, 30-31), data supplied by the Inland Water Directorate (8) and several consultants' studies (2,9-11).

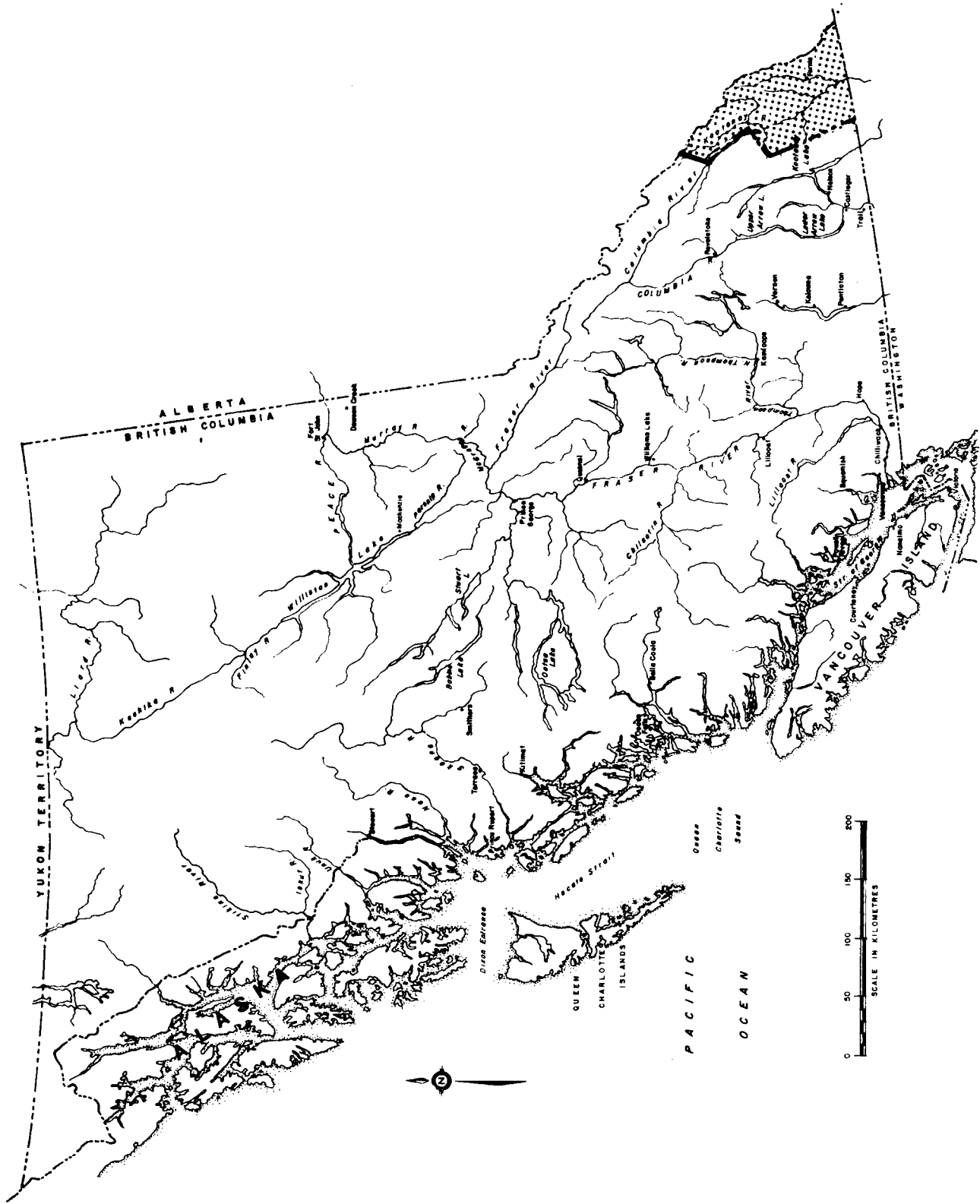


FIGURE 1 LOCATION MAP OF THE KOOTENAY RIVER DRAINAGE BASIN

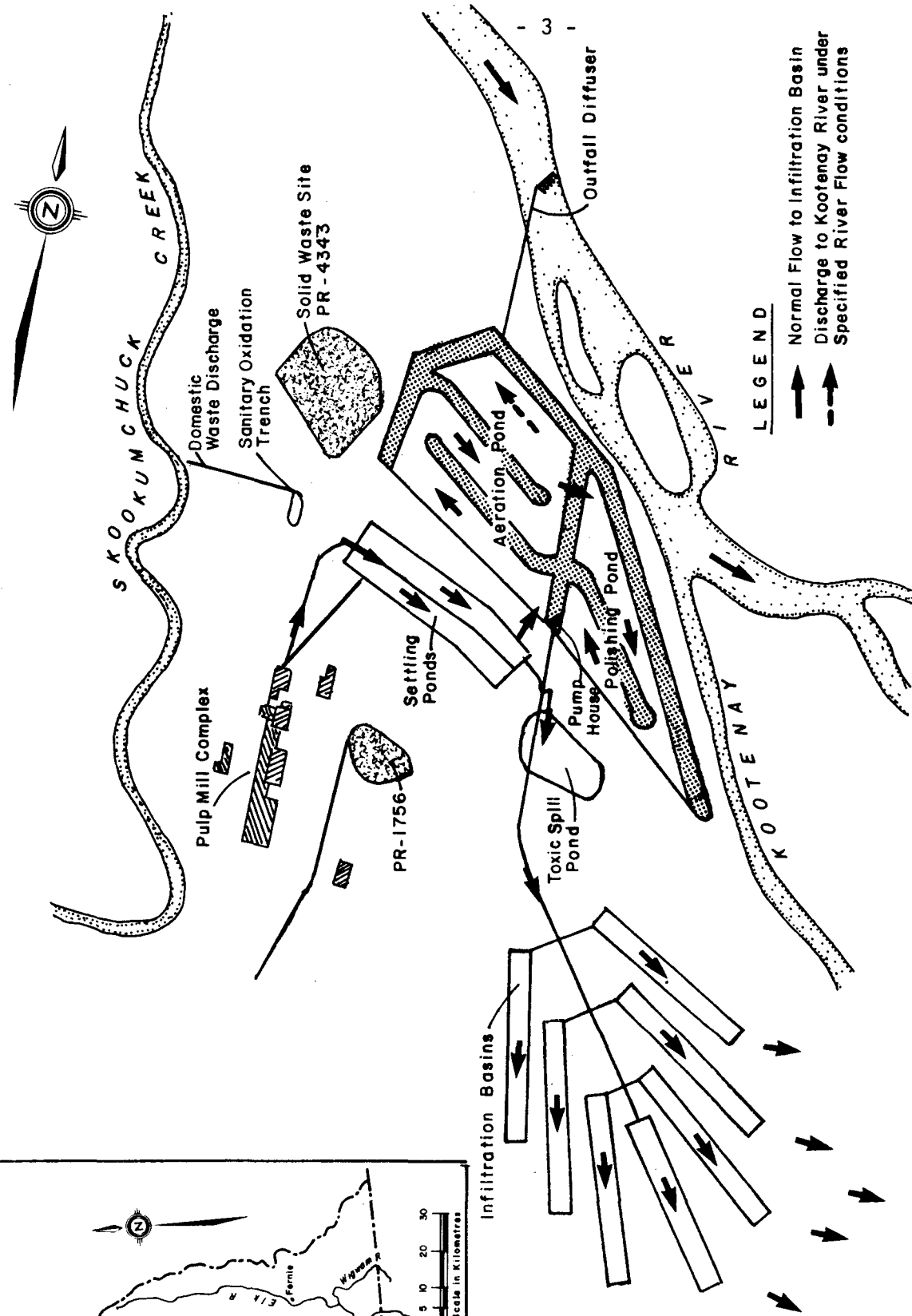
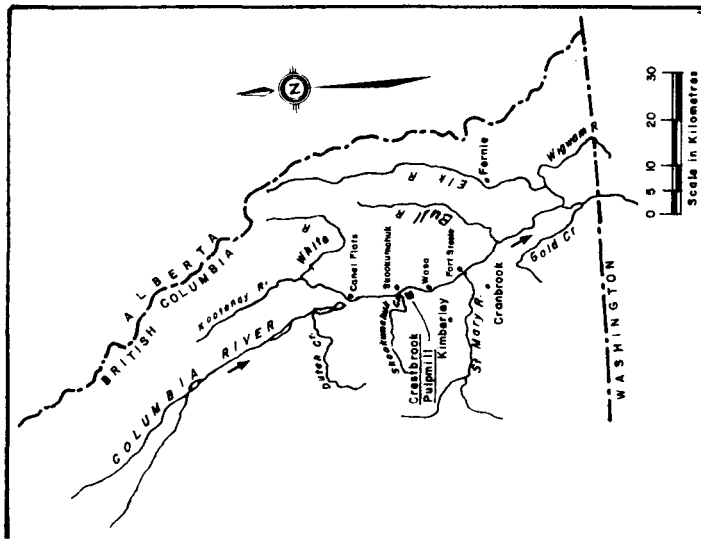


FIGURE 2 CRESTBROOK PULPMILL - SITE PLAN

2 PULP MILL OPERATIONS

2.1 Operational History

The Crestbrook pulpmill at Skoomchuck started operations in late 1968 with a production rating of approximately 390 ADt/day. The construction of a new bleach plant was completed in August 1977. The new bleach plant included replacement of the diffusion washers with drum washers. The average annual production has increased from 332 ADt/day in 1976 to 425 ADt/day in 1980 (Table 1). Wood furnish is obtained from area sawmills and process water for the pulpmill is obtained from Skookumchuk Creek.

Crestbrook have identified the possibility of an expansion depending on fibre availability (17). An expansion to a production of 650 to 750 ADt/day has been indicated and construction of a Thermo Mechanical Pulpmill (TMP) is being considered.

2.2 Effluent Treatment Facilities

The outplant treatment facilities associated with the rapid infiltration system are shown in Figure 2 and the inplant effluent collection system is shown in a simplified version in Figure 3. Inplant, three main sewers collect process effluent for treatment (7). The acid sewer accounts for approximately 30% of the total effluent volume and the alkali sewer approximately another 25%. The general sewer carries approximately another 40% of the total mill effluent and is composed mainly of washwater from the unbleached white water tank (7). The acid sewer is partially neutralized before mixing with the alkali sewer and the general sewer.

All three sewers merge into the process sewer which in turn empties into one of two settling basins. These are used alternately, one being filled while the second is being cleaned. Overflow from the settling basin is piped to the aeration basin and subsequently to the polishing pond. The final treated effluent is discharged to the rapid infiltration system or

TABLE 1: MILL DESCRIPTION

| MILL TYPE | AVERAGE PRODUCTION (ADt/day) | AVERAGE ANNUAL FLOW (m ³ /s) | WOOD FURNISH |
|-----------------|---------------------------------|---|---------------------|
| Kraft producing | 1976-330 | 1976-0.57 | Spruce.....55% |
| bleached kraft | 1977-360 | 1977-0.57 | Pine.....30% |
| market pulp | 1978-410 | 1978-0.58 | Miscellaneous...15% |
| | 1979-423 | 1979-0.60 | |
| | 1980-425 | 1980-0.57 | |

TABLE 2: TREATMENT FACILITIES

| TREATMENT FACILITIES PRIOR TO ADDITION OF RAPID INFILTRATION SYSTEM | | | |
|---|---|--|--|
| <u>SETTLING POND</u> | | <u>AERATION BASIN</u> | |
| -two in parallel, each 46m x 427m, mean depth of 3 meters | | -13.4 hectares -approximately 7 days retention -26 x 25 h.p. aerators as of the end of 1980 | |
| TREATMENT FACILITIES WITH RAPID INFILTRATION SYSTEM | | | |
| <u>SETTLING POND</u> | <u>AERATION BASIN</u> | <u>POLISHING POND</u> | <u>INFILTRATION BASINS</u> |
| - as above, and connected to a toxic spill pond | - 13.4 hectares - approximately 4.5 days retention - 35x25 hp aerators (875 hp) | - 7.9 hectares - approximately 2.25 days retention | - 7 individual 1.8 hectare basins each measuring 46m x 396m |

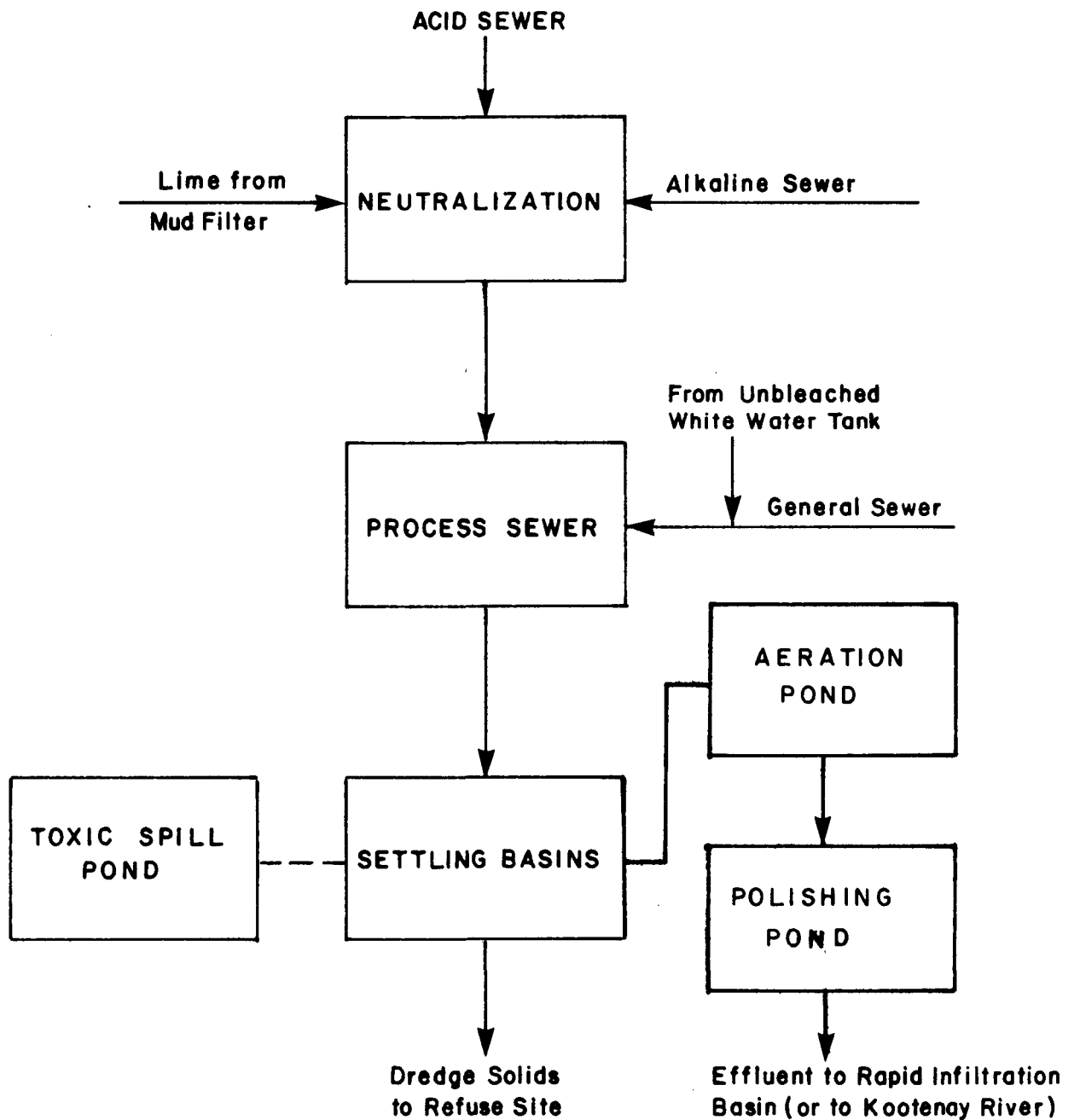


FIGURE 3 SIMPLIFIED FLOW DIAGRAM OF THE CRESTBROOK PULPMILL EFFLUENT TREATMENT PROCESSES

under specified river flow conditions, through a diffuser extending across 80% the width of the Kootenay River. Effluent from the settling ponds can be diverted directly to a toxic spill pond if needed. The treatment facilities in place prior to the modifications made with the rapid infiltration system are summarized in Table 2.

3 FEDERAL AND PROVINCIAL ABATEMENT REQUIREMENTS

Federal Pulp and Paper Regulations (13,14) were introduced in 1971. The Provincial Pollution Control Objectives for the Forest Products Industry of B.C. were first introduced in 1971 (15) and revised in 1977 (16).

3.1 Federal Requirements for Effluent

Under federal regulations, total suspended solids (TSS), biochemical oxygen demand (BOD₅) and toxic wastes are prescribed as deleterious substances under the Fisheries Act. To-date, the federal approach to regulation implementation has been to achieve compliance via the Provincial Waste Management Branch (formerly Pollution Control Branch) permit system. This approach has generally been workable for mills discharging to fresh water where provincial and federal requirements are comparable. The parameters of TSS, BOD₅ and toxicity have been assessed in Section 4 on that basis.

3.2 Provincial Requirements for Effluent and Solid Waste

The Crestbrook pulpmill is required to meet the effluent requirements outlined in permit PE-240. Permit PE-240 was ammended July 3, 1979 to reflect the 1977 Pollution Control objectives and more recently (October 15, 1981) to reflect the inclusion of the rapid infiltration treatment system. The permit allows for an effluent discharge of 68 200 m³/d to the rapid infiltration basin and under specified conditions to the Kootenay River. Effluent characteristics prescribed on permit PE-240 for TSS, BOD₅ and toxicity are listed in Appendix I. The permit calls for the permitte to control the pulpmill effluent discharge by October 31, 1981 such that the increase in colour of the Kootenay River above background does not exceed 15 colour units.

Industrial solid waste disposal requirements for the pulpmill are stipulated in permit PR-4343 issued December 17, 1976. Refuse includes settling pond sludge containing fibrous material and lime mud and the quantity

which may be discharged is 1015 m³/d for 35 days per year. Office garbage and shop wastes (3.8 m³/d) are authorized under permit PR-1756 issued July 4, 1978.

Domestic sewage from the pulpmill is discharged to an oxidation ditch for treatment and then through a secondary clarifier before being released into Skookumchuk Creek (Figure 2). This discharge is authorized under permit PR-188 last amended October 11, 1977. The maximum daily discharge is for 136.5 m³/day to Skookumchuk Creek which has an average flow of 933271m³/d (37).

4 EFFLUENT ASSESSMENT

4.1 TSS and BOD₅ for 1976 to 1980

Discharges of TSS and BOD₅ from the final aerated lagoon to the Kootenay River have been calculated for 1976 to 1980 (Table 3). The values reflect an approximate daily loading for a given month calculated from a representative number of individual daily production and effluent quality results for that month.

The yearly average loading for BOD₅ ranged between 2127 kg/day in 1976 to 4280 kg/day in 1980 (Table 3). BOD₅ loadings have progressively increased (doubled) over 1976 to 1980. The yearly average BOD₅ loadings for 1979 and 1980 surpassed the permit limit of 3720 kg/day. For TSS, the yearly average loading ranged from 2918 kg/day in 1978 to 7109 kg/day in 1979. The 1979 and 1980 average TSS loadings exceeded the permit limit of 4950 kg/day. The increased loadings are likely related to the increased production seen over 1976 to 1980 (Table 1).

As of November 1, 1981 Crestbrook stopped discharging pulpmill effluent to the Kootenay River and started discharging to a rapid infiltration system. A discharge to the Kootenay River is still permitted under specific high river flow conditions. The removal of the above loadings at least during lower river flows, is a positive step to ensuring protection of the environmental quality of the river.

4.2 Toxicity for 1974 to 1980

Provincial objectives (15) in force until 1977, specified a static bioassay test in which 50% of the test fish survive a 96-hour exposure to a specific effluent concentration. A 90% effluent concentration was to be used where the final effluent dilution was greater than 20:1 and a 100% concentration where dilution was less than 20:1 in the receiving water. Effluent testing was required quarterly, with a provision for weekly testing in the event of failure to meet the specified toxicity criteria. The 1977 objectives (16) specify 50% survival during a 96 hour bioassay of 100%

TABLE 3: CRESTBROOK PULP MILL EFFLUENT TSS AND BOD₅ LOADINGS (kg/d)
FOR 1976 to 1980

| | 1976 | | 1977 | | 1978 | | 1979 | | 1980 | |
|-----------|------------------|------|------------------|------|------------------|------|------------------|-------|------------------|------|
| | BOD ₅ | TSS | BOD ₅ | TSS | BOD ₅ | TSS | BOD ₅ | TSS | BOD ₅ | TSS |
| January | 1809 | 4073 | 2391 | 4036 | 5536 | 3727 | 3664 | 3482 | 2890 | 5040 |
| February | 2427 | 3991 | 2573 | 4036 | 5691 | 2945 | 5554 | 7264 | 4780 | 4370 |
| March | 2818 | 4218 | 2282 | 4000 | 5264 | 3445 | 5609 | 8245 | 4560 | 5140 |
| April | 2482 | 2218 | 2736 | 3254 | 4100 | 3518 | 6245 | 7218 | 6470 | 8780 |
| May | 2164 | 2345 | 2127 | 1891 | 5418 | 3945 | 4800 | 8318 | 6640 | 4730 |
| June | 2291 | 3345 | 1264 | 2209 | 3045 | 2109 | 3936 | 9527 | 3960 | 6200 |
| July | 2064 | 3954 | 1109 | 1436 | 4273 | 1500 | 3773 | 13254 | 2640 | 5470 |
| August | 2082 | 5009 | 2273 | 3118 | 4090 | 2500 | 3364 | 6227 | 2780 | 4360 |
| September | 2073 | 3709 | - | - | 2427 | 2854 | 1873 | 3818 | 3530 | 7240 |
| October | 2254 | 5309 | 4800 | 4000 | 1654 | 1400 | 3736 | 4945 | 4540 | 5270 |
| November | 1791 | 2445 | 2891 | 4600 | 3009 | 3254 | 3254 | 4100 | 3270 | 5040 |
| December | 1291 | 1291 | 3345 | 5173 | 1900 | 3845 | 2882 | 8945 | 5270 | 5110 |
| Average | 2127 | 3491 | 2464 | 3309 | 3873 | 2918 | 4054 | 7109 | 4280 | 5560 |

effluent, irrespective of dilution potential. A monthly monitoring frequency is suggested in the 1977 objectives and if a failure is detected, the frequency should be every two weeks until the objective is met.

Walden et al. (18) reported that the provincial objective of 50% survival in a 90% effluent concentration over 96 hours exposure (static test) to be slightly more stringent than the federal routine monitoring bioassay of 80% survival in a 65% effluent concentration over 96 hours exposure (static test).

On December, 1975 the EPS initiated an effluent monitoring program to determine the extent of compliance of B.C. pulpmills with federal standards. Under the program, each mill sent effluent samples to the EPS laboratory for bioassay. The effluent concentrations tested at 90% and 100% directly related to provincial objectives and those at 65% with federal routine monitoring requirements.

A listing of all bioassays conducted on the Crestbrook pulpmill over 1974 to 1980 are included in Appendix II and a summary of those results is provided in Table 4.

The results show that the toxicity removal performance of the aerated lagoon was much better over the period 1974 to 1977 than 1978 to 1980. A substantial reduction in toxicity removal performance is evident for the period 1978 to 1980. At the 100% effluent standard, the annual percent of samples passing declined from 100% and 69% for 1976 and 1977 respectively, to 26%, 33% and 27% for 1978, 1979 and 1980 respectively. The noticeable reduction in toxicity removal performance could be related to the increased production seen over 1976 to 1980 (Table 1). Permit PE-240 requires continued bioassay monitoring of the effluent discharged into the rapid infiltration system and on the mill effluent if it is discharged directly to the Kootenay River. The removal of this generally toxic discharge from the Kootenay River is a positive step in improving the environmental quality of the river.

Should the reader wish to review acute toxicity bioassay monitoring in detail he is referred elsewhere (19, 20, 21, 22, 23). For

TABLE 4: ANNUAL PERCENT PASS TO FEDERAL (65% Effluent - 80% Survival)
AND PROVINCIAL (90% and 100% Effluent - 50% survival) TOXICITY
REQUIREMENTS FROM 1974 to 1980

| YEAR | ANNUAL PERCENT PASSING | | | | |
|----------------------------|------------------------|-----------------|----------|---|---|
| | FEDERAL | PROVINCIAL | | | |
| | <u>STANDARD</u> | <u>STANDARD</u> | | | |
| | 65% | 90% | 100% | | |
| <u>Crestbrook Pulpmill</u> | | | | | |
| 1974 | 85 (20) | - | - | - | - |
| 1975 | 70 (10) | - | - | - | - |
| 1976 | 90 (10) | 90 (10) | 100 (9) | | |
| 1977 | 83 (6) | 69 (13) | 69 (13) | | |
| 1978 | 14 (14) | 32 (19) | 26 (19) | | |
| 1979 | 45 (11) | 44 (18) | 33 (18) | | |
| 1980 | 50 (8) | 36 (11) | 27 (11) | | |

() = number of bioassays at that effluent concentration.

detailed information on the toxic fractions in pulpmill effluents the reader is also referred elsewhere (20, 24, 25, 26).

4.3 Monitoring and Miscellaneous Studies

On a monthly basis, the Crestbrook pulpmill submits effluent quality results to the Waste Management Branch and EPS. Crestbrook initially conducted experiments on the rapid infiltration technique prior to its official use. A trial site was operated over 1977 and 1978 to evaluate the potential of the system to treat fully bleached kraft mill effluent (12). The benefits of the system based on the trial experiments included approximately 90% colour reduction plus a reduction in BOD₅ and the elimination of effluent toxicity (12).

5 RECEIVING WATER FEATURES

5.1 Kootenay River Drainage Basin

The Kootenay River at Skookumchuk lies within the Rocky Mountain Trench, bordered on the west by the Purcell Mountains and on the east by the Rockies. The Trench runs in a northwest-southwest direction with an elevation of approximately 760 metres at Skookumchuk. The area is dominated by a semi-arid climate and sparse vegetation in sharp contrast to the mountainous areas on either side which are cooler, wetter and more heavily timbered (7). The Rockies rise abruptly from the valley floor while in the west the Purcells begin as rounded, wooded foothills before changing to a more rugged topography at higher elevations (7).

The Kootenay River, for approximately 12 km downstream from Skookumchuk Creek, is characterized by a rapid flow and a bottom covered with material ranging from boulders to sand. Below that point to Wasa Bridge, the river enters an older channel and starts to slow down and the channel has silty and sandy areas interspersed with a rocky bottom (11).

5.1.1 Hydrology. Of the 19 916 km² area of the Kootenay River drainage lying north of the international boundary, 7228 km² lies upstream of Skookumchuk. The average mean, maximum and minimum daily streamflow from Water Survey of Canada records for 1972 to 1976 (27) are shown on Figure 4. Peak spring freshet occurs between May and July and is followed by a gradual reduction in flow through the summer and fall and with minimum flows generally occurring in the December to March period. The Water Resources Service (7) estimated that 65% to 75% of the mean annual flow occurs in the May to July period. They reported a mean annual discharge of 117 m³/s and a minimum daily recorded discharge of 13.3 m³/s in December 1956. The maximum daily discharge recorded was 1139 m³/s in June 1974.

Although actual diffusion studies on Crestbrook's effluent are not available, calculated ratios of stream flow versus effluent discharge give

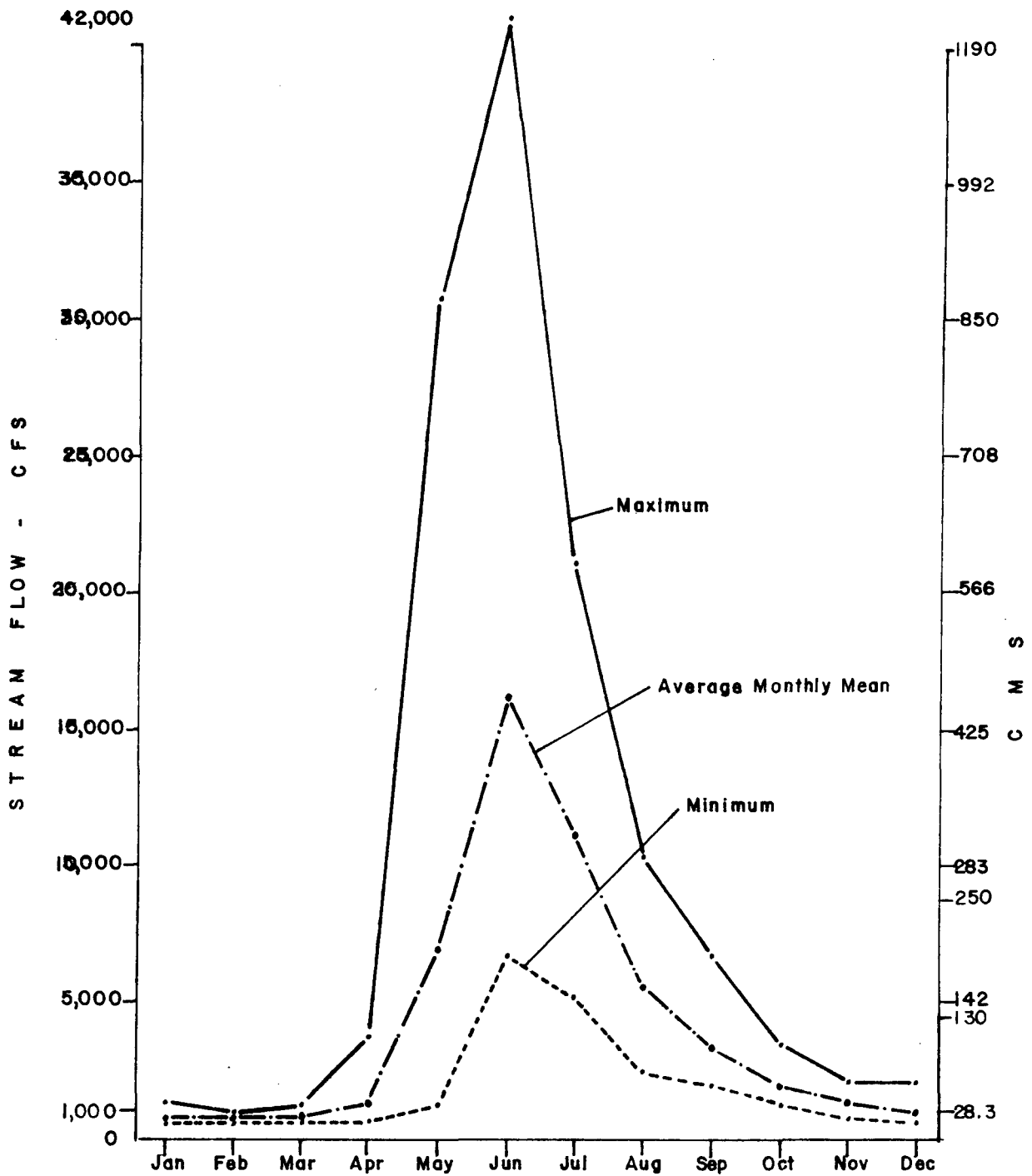


FIGURE 4 AVERAGE MONTHLY MEAN, MAXIMUM AND MINIMUM FLOWS FOR THE KOOTENAY RIVER NEAR SKOOKUMCHUK FROM 1972 TO 1976

some indication of potential dilution (Table 5). The lowest potential dilutions occur over the November to April period. Based on minimum recorded river flows and maximum recorded mill flows, the ratio of river flow to pulpmill flow drops below 20:1 during March and April (Table 5). It must be emphasized that the values may not represent daily flow fluctuations and that the ratios assume instant complete mixing and which is not the case.

Under Article XIII(2) of the Columbia River Treaty between Canada and the United States of America (ratified in 1964), Canada has the right after September 1984 to divert up to 1845 million cubic meters of water annually from the Kootenay River to the Columbia River in the vicinity of Canal Flats, British Columbia (2). An initial environmental evaluation of alternative Kootenay River diversion schemes has been made for British Columbia Hydro and Power Authority (2). The diversion of 1845 million cubic meters of water annually is equivalent to a mean annual daily flow of $58.6\text{m}^3/\text{s}$ or two thirds the average annual flow of the Kootenay River at Canal Flats (2). Under the Columbia River Treaty, any diversion is limited such that the flow in the Kootenay River downstream of the diversion is not reduced below the lesser amount of $5.7\text{m}^3/\text{s}$ or the natural flow. During the fall and winter months Kootenay River flows are generally much less than $56.7\text{m}^3/\text{s}$, thus, to achieve close to full Treaty entitlement, it would be necessary to divert higher flows during the spring and summer when the natural flow is already high (2). The maximum diversion being considered at Canal Flats is $170\text{m}^3/\text{s}$ (2). WRS (7) reported that the average flow of the Kootenay River at Skookumchuk could be reduced by as much as 47% by the Kootenay River diversion of two-thirds the average annual flow at Canal Flats (Figure 5). Entech (2) reported that the March mean dilution ratio of pulpmill effluent to river flow of 35:1 would be reduced to 14:1 if the maximum diversion of $170\text{m}^3/\text{s}$ were implemented. A $170\text{m}^3/\text{s}$ diversion would reduce minimum monthly flows at Canal Flats and Skookumchuck to $5.7\text{m}^3/\text{s}$ and $11.3\text{m}^3/\text{s}$ respectively, for the period August through April (2). WRS (7) reported that the proposed diversion would probably require an

TABLE 5: CALCULATED RATIO OF KOOTENAY RIVER FLOW VERSUS PULP MILL
DISCHARGE FOR 1972 to 1976

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEP | OCT | NOV | DEC |
|----|------|------|------|------|-------|-------|-------|-------|-------|-------|------|------|
| 1. | 47:1 | 40:1 | 32:1 | 64:1 | 347:1 | 816:1 | 502:1 | 267:1 | 180:1 | 109:1 | 77:1 | 63:1 |
| 2. | 31:1 | 31:1 | 28:1 | 27:1 | 96:1 | 330:1 | 276:1 | 173:1 | 91:1 | 78:1 | 44:1 | 35:1 |
| 3. | 25:1 | 25:1 | 14:1 | 13:1 | 53:1 | 256:1 | 204:1 | 94:1 | 40:1 | 58:1 | 25:1 | 26:1 |

1. Average of the monthly mean flows for the Kootenay River over 1972-1976
Average of the monthly mean flows for the Crestbrook Pulpmill over 1972-1976
2. Average of the monthly minimum flows for the Kootenay River over 1972-1976
Average of the monthly maximum flows for the Crestbrook Pulpmill over 1972-1976
3. Minimum reported daily river flow for the month over 1972-1976
Maximum reported daily mill flow for the month over 1972-1976

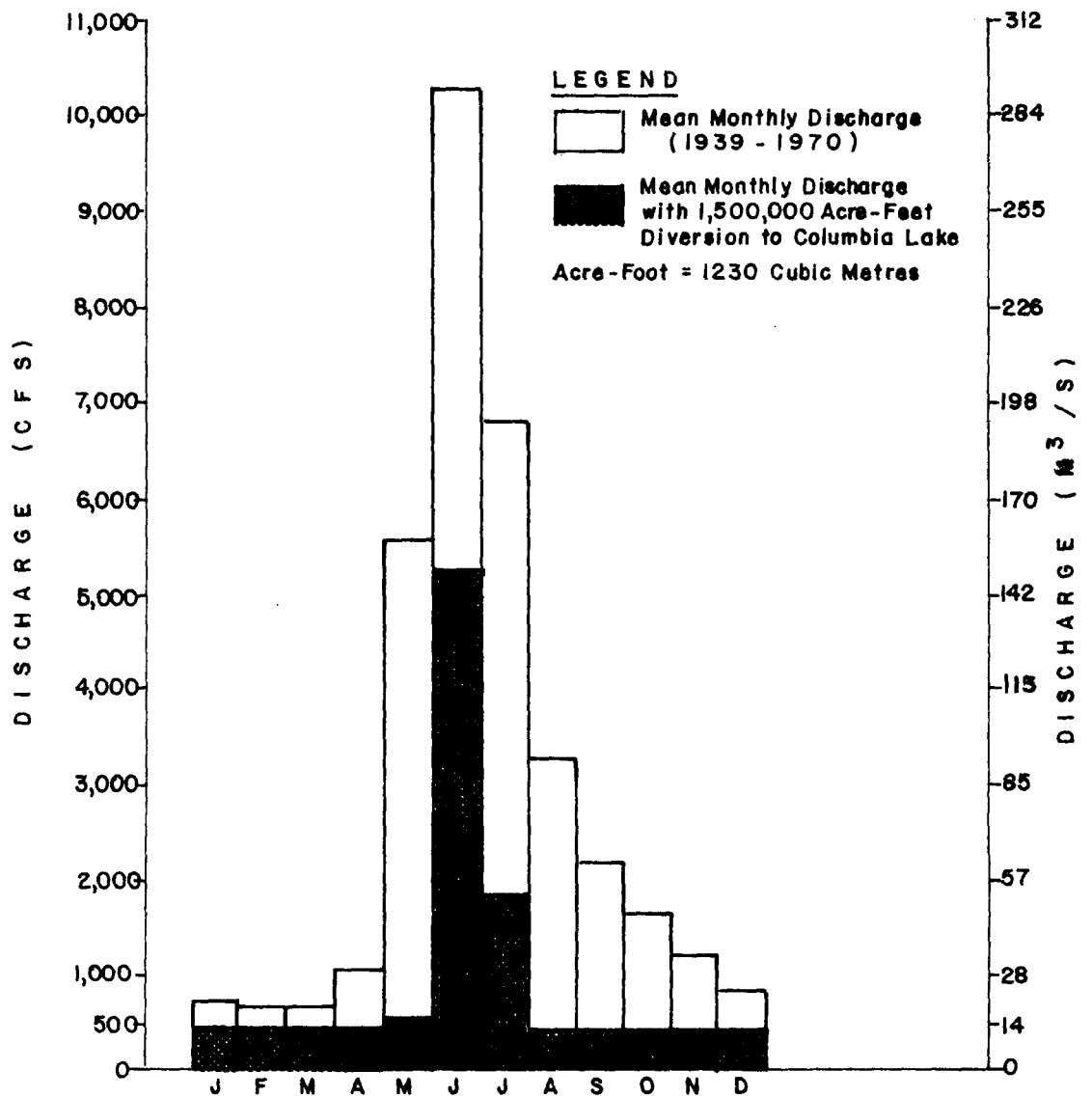


FIGURE 5 EFFECT OF PROPOSED KOOTENAY DIVERSION ON THE DISCHARGE IN THE KOOTENAY RIVER BELOW CANAL FLATS (After WRS (7))

improvement in the quality of discharges to the Kootenay River and of particular concern was the Crestbrook pulpmill discharge.

With the activation of Crestbrook's rapid infiltration system dilution concerns expressed in the past have been reduced. A discharge of pulpmill effluent to the Kootenay River is still permitted based on the 15 units above background levels colour criteria and specified minimum river flow conditions. The river flow conditions are $130\text{m}^3/\text{s}$, $170\text{m}^3/\text{s}$, $210\text{m}^3/\text{s}$ and $250\text{m}^3/\text{s}$ for 1982, 1983, 1984 and 1985 (and thereafter) respectively. At the permitted effluent discharge rate of approximately $0.79\text{m}^3/\text{s}$ and a river flow of $130\text{m}^3/\text{s}$, the potential dilution is 164:1. From Figure 4 it can be seen that flows in excess of $130\text{m}^3/\text{s}$ would normally be expected to occur between May and August and flows in excess of $250\text{m}^3/\text{s}$ only in June and July. From Figure 5 it can be seen that under average flow conditions, flows as high as $250\text{m}^3/\text{s}$ could conceivably not occur at all if the Kootenay River diversion proceeds. At a maximum diversion rate of $170\text{m}^3/\text{s}$, a river flow of $420\text{m}^3/\text{s}$ would be required to achieve the $250\text{m}^3/\text{s}$ minimum flow criteria and on an average flow basis this only occurs in June (Figure 4), (37).

5.2 Fisheries Resources

5.2.1 Species Present. Table 6 lists the indigenous East Kootenay fish species described by Whately (1) and Entech (2). Recreationally, the most important species of game fish are cutthroat trout, Dolly Varden, Rocky Mountain whitefish, freshwater ling (burbot) and rainbow trout. The most common non-game species include two species of sucker, reidside shiner, northern squawfish, peamouth chub and torrent sculpin. Quantitative species distribution data for the Canal Flats to Skookumchuk area has been collected by Entech Environmental Consultants (2). Beach seines and drifting gill net sets were carried out in October 1975 and June 1976 at seven stations upstream of the Crestbrook pulpmill. A total of nine sets (including one gill net set) yielded 100 mountain whitefish and 8 torrent sculpins.

TABLE 6: FISH SPECIES INDIGENOUS TO THE EAST KOOTENAY AREA

| COMMON NAME | SCIENTIFIC NAME |
|-----------------------------|----------------------------------|
| <u>Game Fish</u> | |
| Mountain whitefish | <i>Prosopium williamsoni</i> |
| Dolly Varden | <i>Salvelinus malma</i> |
| Eastern brook trout | <i>Salvelinus fontinalis</i> |
| Yellowstone cutthroat trout | <i>Salmo clarki lewisi</i> |
| Rainbow trout | <i>Salmo gairdneri</i> |
| Burbot (ling) | <i>Lota lota</i> |
| <u>Non-Game Fish</u> | |
| Largescale sucker | <i>Catostomus macrocheilus</i> |
| Longnose sucker | <i>Catostomus catostomus</i> |
| Redside shiner | <i>Richardsonius balteatus</i> |
| Northern squawfish | <i>Ptychocheilus oregonensis</i> |
| Peamouth chub | <i>Mylocheilus caurinus</i> |
| Torrent sculpin | <i>Cottus rhotheus</i> |
| Slimy sculpin | <i>Cottus cognatus</i> |
| Prickly sculpin | <i>Cottus asper</i> |
| Longnose dace | <i>Rhinichthys cataractae</i> |

5.2.2 Spawning and Life History. All the game fish probably utilize the mainstream Kootenay to some extent for spawning, although in general, Dolly Varden, rainbow trout, mountain whitefish and cutthroat migrate to the tributaries and headwaters of the Kootenay River.

The following general life history information for the major game species is taken from Scott and Crossman (28). Of the spring spawners, cutthroat migrate upstream in late autumn or early winter to the headwaters of the Kootenay River, spawning from February to May in small, gravel bottomed streams (preferred temperature around 10°C). Eggs hatch within six to seven weeks, with fry emerging one to two weeks later, usually in August. Rainbow trout appear to spawn somewhat later (from mid April to late June) in small tributaries when water temperatures are around 10.0 to 15.5°C. Gravel nests are often constructed, generally in riffle areas located above pools. Eggs hatch four to seven weeks later with fry emerging from the gravel three to seven days later.

Of the two fall spawners, mountain whitefish and Dolly Varden, the latter may spawn as early as September while the former begins several weeks later. The favorable temperature for Dolly Varden is approximately 7.8°C. Spawning is usually completed by early November for both species. Dolly Varden eggs hatch in March to April, with the alevin remaining in the gravel for up to three weeks before emergence. Mountain whitefish eggs hatch in early March and the fry hold in shallow water for several weeks.

Ling (or burbot) spawn under the ice in mid-winter (January to March) over sand or gravel substrates. Lakes are the preferred site, but rivers may occasionally be utilized. The eggs hatch in about thirty days followed eventually by a migration of the young into the tributaries. Entech (7) reported that all of the more common non-game species (redside shiner, northern squawfish, peamouth chub, torrent sculpin and two sucker species) are spring spawners.

Of the two major spawning periods (spring and fall) the latter (including the mid-winter run of ling) is potentially the most sensitive due to the characteristically low stream flows which prevail. Mountain whitefish, the most important game fish and possibly the most abundant species in this area also spawns at this time.

6 ENVIRONMENTAL IMPACT AND ASSESSMENT STUDIES

6.1 River Studies

The physical, chemical and biological characteristics of the Kootenay River have been documented or reviewed by several agencies. An assessment of information available on the water quality of the lower Kootenay River Basin to the end of 1974 has been made by the Water Resources Service (7). An initial environmental evaluation of the impact of the proposed Kootenay River Diversion on the Columbia River and Kootenay River drainages has been made for B.C. Hydro (2). The Inland Waters Directorate (IWD) conducted a biological (periphyton and aquatic invertebrates) and water quality survey on the Kootenay River in 1975. This data has not as yet been published but the water quality data is on the IWD, NAQUADAT system and has been made available for this review (8). IWD are presently (1980-1981) involved in a water quality program on the lower Kootenay River and it includes stations upstream and downstream of the Crestbrook pulpmill (per. comm., P. Whitfield, 1980). The Waste Management Branch (WMB), formerly the Pollution Control Branch (PCB), have collected water quality samples in March of 1979 and 1980 to assess the influence of the Crestbrook pulpmill (6, 30). The Water Investigation Branch (WIB) has presently in preparation a Phase II assessment of water quality data collected over 1975 to 1978 by the WMB (per. comm., R. Rocchini, 1981). B.C. Research have studied the sublethal effects to fish of effluent from the Crestbrook pulpmill but these findings are not presently available (per. comm., COFI, 1981).

6.1.1 Water Quality. WRS (7) summarized the water quality data collected from the lower Columbia River over the period 1969 to 1974. They reported that for many parameters the concentration appeared to depend on flow and they summarized the data into high and low flow periods. For the three stations summarized (referred to as WRS-20, WRS-48 and WRS-19 in this report, see Figure 6), they reported lower concentrations occurred during high flow, with the exception of turbidity. WRS (7) reported the parameters

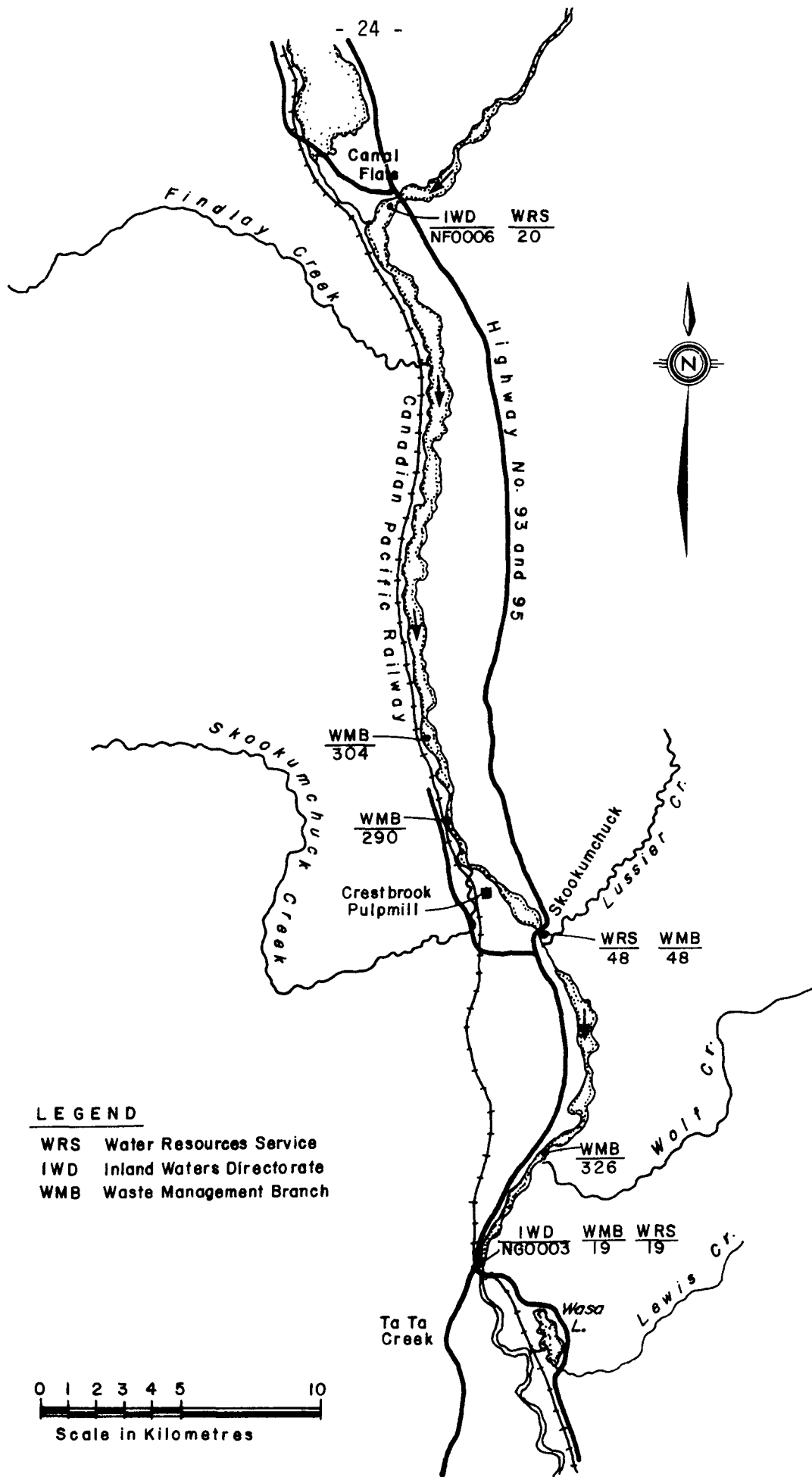


FIGURE 6 APPROXIMATE LOCATION OF VARIOUS KOOTENAY RIVER WATER QUALITY SAMPLE STATIONS

that changed significantly from upstream to downstream were: colour, turbidity, phenols, total phosphorus, tannin and lignin like compounds and fecal coliforms. During low flows, colour, tannin and lignin and phenols remained as high at station WRS-19, 16 km downstream of the pulpmill as at station WRS-48, 3.2 km downstream (7). WRS (7) reported that except for colour, phenol and coliforms and possibly tannin and lignin, the pulpmill did not have a major effect on water quality. However, they further reported that biological data has shown changes have occurred and that these changes are thought to be due to the salts of resin and fatty acids, or to mercaptans, chlorinated organics and other toxic constituents discharged by the pulpmill.

A review of the IWD (NAQUADAT) water quality data for 1975 generally supports the results reported by WRS. Elevated levels of apparent colour were evident at Wasa Bridge (JWD-NG0003, Figure 6) as were dissolved sodium and dissolved chloride (Appendix III). The largest increases downstream of the pulpmill were evident during the spring period when low river flows occur.

Crozier (30, 6) has reported on water quality surveys made in 1979 and 1980 respectively to monitor the effect of the Crestbrook pulpmill during March low flows. A summary of his findings is provided in Appendix IV and the stations are referred to as WMB-304, WMB-48, WMB-326 and WMB-19 in this report (Figure 6). Crozier (30) reported that the water quality of the Kootenay River continues to be adversely affected by the Crestbrook pulpmill during low flow conditions. He indicated colour and phenol were the parameters of most concern. Crozier (30) reported that colour levels increased in 1979 compared to those reported by WRS (7) and speculated that the colour increase might be due to the increased production of bleached pulp which occurred in 1977. Based on increased colour and dissolved sodium levels, he felt that very little extra dilution capability is gained between the stations 2.5 km downstream (WMB-48) of the mill to that 18 km downstream (WMB-19). He indicated that the high phenol concentrations downstream of the pulpmill (0.012 - 0.025 mg/l) greatly exceeded the background concentration of less than 0.002 mg/l. The phenol levels were thought to contribute

to the pulpmill odour evident at the downstream stations and possibly could result in fish tainting. He also indicated that the various types of phenolics in the Kootenay River are not known and different phenolics effect fish palatability at different concentrations. The 1979 water quality data indicated that solids and BOD₅ loadings from the pulpmill had very little effect on the river water quality. Crozier (30) reported a slight downstream increase in suspended solids and turbidity but no decrease in dissolved oxygen. Dissolved nutrient concentrations were not thought to be affected by the pulpmill discharge (30). However, visual observations did indicate there was increased periphyton growth downstream of the pulpmill in the 1979 survey period. Total phosphorus and organic nitrogen levels did appear to increase downstream of the outfall, but were in a particulate form and the availability of these as nutrients to algae was not known.

Crozier (6) monitored an extra station (WMB-326) in 1980 to establish background levels at a location as close as possible to the proposed rapid infiltration area and still allow for complete mixing. He reported that the water quality problems identified in 1979 continued to exist in 1980 (Appendix IV). Phenol concentrations in the pulpmill effluent and in the Kootenay River were much less in 1980 compared to 1979 but were still detectable downstream of the pulpmill and the river had a very noticeable "pulpmill" odour.

Permit PE-240 requires Crestbrook to conduct a groundwater monitoring program for colour, pH, BOD₅, dissolved sodium, dissolved calcium and dissolved magnesium and a Kootenay River colour monitoring program to determine the effects of the rapid infiltration system. The results are to be submitted annually to the Waste Management Branch. The three Kootenay River sample stations are shown on Figure 6 as WMB-290, WMB-48 and WMB-326.

6.1.2 Biological. WRS (7) reviewed the available biological data respective to the Crestbrook pulpmill up to the end of 1974. There has not apparently been any additional benthos or periphyton data published since that review.

6.1.2.1 Periphyton. Several authors (5, 7, 31) have reported, for varying time periods, on periphyton samples collected over a period of 1971 to 1974 at stations referred to in this report as WRS-20, WRS-48 and WRS-19 (Figure 6). Attached algae samples were collected on glass slides attached to basket type benthic invertebrate samplers. WRS (7) reported that at station WRS-20 (Canal Flats) the cell numbers and biomass were low. Downstream of the pulpmill, stations WRS-48 and WRS-19, there was a progressive increase in biomass and one or two species generally accounted for more than 90% of the total number of cells. Langford (5) reported that the periphyton data indicated that a substantial change in water quality occurs downstream of the pulpmill. This was indicated by an increase in diatom numbers, cell density, dry weight and chlorophyll a. Langford (5) was not able to pin-point the specific substances causing the density and speciation changes but indicated that such changes are indicative of altered water quality. He identified alterations in phosphate and nitrate levels as the most frequently blamed cause for changes in algal communities as well as the importance of the relationship between electrolytes and salts and aquatic populations. Crozier and Leinweber (31) reported that station WRS-48 would be under the influence of the pulpmill discharge, plus sewage discharged to Skookumchuk Creek and the sewage discharge at Canal Flats. They felt that the addition of nutrients to the Kootenay River by these discharges was not great and didn't feel increased nutrient levels were primarily responsible for the increase in attached algae. At station WRS-48, the diatoms Diatoma elongatum and Diatoma vulgare were responsible for 80-90% of the algae and Diatoma elongatum was especially present in large numbers. Crozier and Leinweber (31) felt it was probable that these species were more tolerant to the toxic constituents of the pulpmill effluent. This was supported by the fact Diatoma elongatum has been classified as an indicator of salt waste and it could reflect the sodium loadings or other constituents of the effluent. Diatoma elongatum was responsible for the majority of the algae (80%) at station WRS-19 (Wasa) and this was thought to indicate that recovery from the effects of the pulpmill

were not complete (31). Langford (5) thought it imperative to determine the interrelationship of periphyton and the components of the pulpmill effluent. Reid (11) reported that for April-May, 1970, the river substrate upstream of the pulpmill was clean and with only a few strands of green filamentous algae evident but downstream of the outfall, the rocks were coated with a solid mat of grey-green coloured algae.

Permit PE-240 requires Crestbrook to monitor periphyton bioamass and diversity upstream from the mill and at several stations downstreams as far south as the Wasa Bridge. A final report on the biological program is to be submitted to the Waste Management Branch.

6.1.2.2 Benthos. Pre- and post-pulpmill benthos samples have been collected on the Kootenay River. Bull et al. (3) reported that basket samplers revealed that a slight drop in the number of pollution sensitive organisms (especially mayflies) occurred at Skookumchuk after the pulpmill began operation. Surber samples were also collected and confirmed the basket sampler results. Reid (11) collected benthos samples over April-May, 1970 and utilized both basket and Surber samplers. He reported that mayflies were much more abundant upstream of the outfall than downstream and indicated it was a significant change. The abundance of stoneflies and caddisflies remained relatively constant throughout the river, but blackflies were much more abundant downstream of the outfall. The average biomass of macroinvertebrates was reported to drop immediately downstream of the diffuser but increased rapidly after that and it appeared the effluent enhanced the development of bottom fauna (11). The loss of mayfly dominance downstream of the outfall was reported to be due to the disappearance of the mayfly Cynigmula (11). Reid (11) thought that the more probable reason for the disappearance of Cynigmula, other than effluent toxicity, was the increased amount of algae downstream of the outfall and that the mayfly wasn't able to survive under such circumstances. Langford (5) reported that basket samplers placed downstream of the Crestbrook pulpmill over September-October, 1973 had a significant decrease in both the volume and dry weight of benthic invertebrates compared to upstream samples.

In addition, he reported that upstream of the pulpmill, the orders of mayflies and stoneflies predominated while downstream of the pulpmill dipterans predominated. Mayflies and stoneflies were virtually absent at the study site below the pulpmill. Langford (5) reported that benthic invertebrate data collected by the PCB in March-April, 1972 also showed decreased numbers of mayflies and stoneflies and an increase in the number of dipterans downstream of the pulpmill. He reported his data verified the contention that gross pollution is present and that severe degradation of the river habitat is continuing. Crozier and Leinweber (31) reported on benthic invertebrate data collected over the fall of 1971 through to the fall of 1972. They reported that the aquatic insect population at Canal Flats was composed of 90% stoneflies and mayflies, whereas at Skookumchuk, dipteran larvae made up 65% of the insects found. The sample station at Wasa also had a substantial percentage (34%) of dipterans (31).

Permit PE-240 requires Crestbrook to monitor benthic invertebrate biomass and diversity upstream from the mill and at several stations downstream as far south as the Wasa Bridge.

6.1.3 Fish Tainting and Sublethal Toxicity. During the winter months of 1970-71, the Fish and Wildlife Branch received numerous complaints that fish taken downstream of Skookumchuk were unfit for consumption and that fishing success had declined significantly (29). In order to assess the validity of the complaints, organoleptic tests were conducted on mountain whitefish collected in March, 1971 (29). Bull and Vernon (29) reported that the mountain whitefish caught below the pulpmill were unacceptable as edible fish because of offensive tastes and odors. Langford (5) reported that organoleptic tests on fish have demonstrated a significant effect of Crestbrook pulpmill effluent on fish taste and odour. Significantly lower flavour scores indicating tainting were reported for cutthroat trout and Rocky Mountain whitefish caught below the outfall. Additional organoleptic tests on Kootenay River fish have not been made since those reported by Langford.

Crozier (6) felt that based on the criterion of 0.05 of the

effluent's 96 hr LC₅₀ (a level for which no contrary evidence exists to substantiate any sublethal stress due to bleached kraft mill effluent) and a combination of river and pulpmill discharge rates that a definite potential for sublethal effects in the Kootenay River exists. Davis (32) suggested that for neutralized whole bleached kraft mill effluent some sublethal effects will be present at a discharge dilution of 0.1 of the 96 hr LC₅₀, few at 0.05 of the 96 hr LC₅₀ and only rarely at 0.02 of the 96 hr LC₅₀. He also indicated that even at a dilution of 0.02 of the 96 hr LC₅₀, flesh tainting or colour effects on the food chain may remain. He considered that the criteria are tentative, subject to revision and that they do not necessarily ensure protection of aquatic communities or sensitive food-chain organisms. Based on laboratory experiments on the stress and chronic effects of untreated and treated bleached kraft pulpmill effluent on coho salmon, McLeay and Brown (33) indicated their findings showed that the effluent constituents and/or the site of toxic effect resulting in the observed changes due to chronic exposure are, in fact, different from those that result in acute lethal (and conceivably sublethal) effects. They reported their data suggested that conventional treatment methods used by pulpmills, that are successful in detoxifying their wastes according to conventional standards, do not necessarily ensure protection and that the use of application factors for predicting safe discharge limits is not valid if based on acute lethal and sublethal data alone. McLeay and Brown (33) indicated further examination of the chronic effects of pulpmill effluent, including life-cycle studies, on the well-being of fish is warranted.

Entech (2) reported that the proposed diversion of water at Canal Flats would substantially reduce the Kootenay River flows downstream of Skookumchuk from late fall to early spring (November-April). The reduced flows would significantly reduce the dilution capacity of the river relative to the effluent discharged from the Crestbrook pulpmill. Entech (2) reported that the increased concentration of toxic components associated with the pulpmill effluent would aggravate the present deterioration of the river's biota and fishery.

B.C. Research have studied the sublethal effects to fish of treated, partially treated and untreated effluent from the Crestbrook pulpmill. However, this information is not presently available (per.comm.,COFI, 1981). With the activation of Crestbrook's rapid infiltration system, tainting and sublethal toxicity concerns expressed in the past may no longer be of concern.

6.1.4 Organic Pollutants. There is no data available on the levels of the toxic organic chemical constituents (resin acids, chlorinated organics) in the Crestbrook kraftmill effluent, in the river sediments or in the resident biota of the Kootenay River. While research into documenting such constituents would have seemed appropriate prior to the activation of the rapid infiltration system, this would not seem to be necessary now unless groundwater monitoring indicates some contamination problem exists. Thus, the information presented here is of general interest.

Holmbom (34) reported that although resin acids and chlorinated phenolics constitute key groups of compounds in pulpmill effluents which are acutely toxic to fish, little is known about the fate of these fish-toxic compounds in effluent treatment systems and in the receiving waters. Lander et al (36) reported that a few chlorinated phenols that are present in sulphate pulpmill bleachery effluents were also found in fish caught in the vicinity of a pulpmill producing fully bleached kraft pulp. They indicated this in itself didn't tell anything about their possible detrimental effects on fish or other parts of the aquatic ecosystem. Holmbom (34) sampled fish caged in a lake system receiving biologically treated bleach kraft pulpmill effluent. He reported that significant bioaccumulation of resin acids in fish (plasma and bile) was found to occur in water containing only 20 ug/l and that there appeared to be a threshold level for bioaccumulation of resin acids between 5 ug/l and 20 ug/l. This concentration range in water might also constitute a threshold for physiological stress on the fish (34). Holmbom (34) reported that there was no indication of any threshold for

bioaccumulation of tetrachloroquinol down to the 0.5 ug/l level. He reported that the study results indicated that resin acids did not have any appreciable effects 3.5 km from the pulpmill whereas chlorinated phenolics still had noticeable effects 6 km from the pulpmill. Study of fish bioaccumulation may be one possible approach for determination of how far, in distance, from a pulpmill that the stress of toxicants is extended (34). Kruzynski (35) reported on the uptake of dehydroabiatic acid (DHA) in laboratory exposed sockeye salmon smolts, mature rainbow trout and the marine amphipod Anisogammarus. Kruzynski (35) reported that laboratory exposure experiments established that salmon can rapidly accumulate DHA in major organs such as the brain, liver and kidney and that these high residue levels are probably related to the observed physiological dysfunctions in the test fish.

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APPENDIX I

PROVINCIAL POLLUTION
ABATEMENT REQUIREMENTS

APPENDIX I: PROVINCIAL POLLUTION ABATEMENT REQUIREMENTS

| PRODUCTION RATING | BOD ₅ | TSS | TOXICITY |
|--------------------------------|------------------|-----------|--|
| <u>Crestbrook</u> ¹ | | | |
| 495 ADt/d | 3720 kg/d | 4950 kg/d | 50% survival in 100% effluent concentration over a 96 hour exposure time. |

1 Based on 1977 Objectives for the Forest Products Industry of B.C. of TSS (10 kg/ADt) and BOD5 (7.5 kg/ADt).

NOTE: Daily loads reflect permitted values when discharging directly to the Kootenay River. Normally effluent will be discharged to the rapid infiltration basins, however, commencing October 31, 1981 a discharge of effluent to the Kootenay River is authorized only when the river flow exceeds: 130m³/s, 170m³/s, 210m³/s and 250m³/s for 1982, 1983, 1984 and 1985 (and thereafter) respectively. During any discharge period, the increase in colour above background in the Kootenay River should not exceed 15 colour units at Station WMB 326.

APPENDIX II

CRESTBROOK PULP AND PAPER BIOASSAY
RESULTS FOR 1974 to 1980

APPENDIX II: CRESTBROOK PULP AND PAPER BIOASSAY RESULTS FOR 1974 to 1980

| YEAR | SAMPLE DATE | SPECIES | LOADING DENSITY (gm/l) | % SURVIVAL (65% concentration) |
|----------------------------------|-------------|---------------------------------|------------------------------|-----------------------------------|
| <u>B.C. Research Bioassays</u> | | | | |
| 1974 | January 7 | Coho Salmon | 1.45 | 30 |
| | January 21 | (<u>Oncorhynchus kisutch</u>) | 1.54 | 0 |
| | January 28 | | 1.68 | 100 |
| | February 4 | | 1.68 | 90 |
| | February 11 | | 1.72 | 100 |
| | February 18 | | 1.76 | 100 |
| | February 26 | | 1.76 | 100 |
| | March 4 | | 1.44 | 100 |
| | March 11 | | 1.96 | 100 |
| | March 18 | | 1.98 | 100 |
| | March 25 | | 1.98 | 100 |
| | March 31 | | 2.22 | 100 |
| | June 3 | | .33 | 100 |
| | July 9 | | .50 | 60 |
| | July 23 | | .80 | 100 |
| | August 6 | | .63 | 100 |
| | September 5 | | .73 | 90 |
| | October 7 | | .80 | 100 |
| <u>Beak Consultants Bioassay</u> | | | | |
| 1975 | November 4 | Rainbow Trout | L1.00 | 100 |
| | December 3 | (<u>Salmo gairdneri</u>) | .40 | 80 |
| | January 13 | Rainbow Trout | .40 | 10 |
| | January 29 | | .40 | 100 |
| | February 3 | | .40 | 100 |
| | February 10 | | .40 | 0 |
| | March 3 | | .60 | 100 |
| | April 28 | | .21 | 100 |
| | May 9 | | .40 | 90 |
| | June 3 | | .21 | 60 |
| | November 10 | | .90 | 100 |
| | December 8 | | .19 | 100 |

L Less than
- Concentration not tested

Note: All bioassays are for final effluent samples. The procedure to the end of 1975 was for a 96 hour static bioassay without solution replacements at 65% v/v effluent. As of 1976, the effluent concentration was raised to provincial levels. Federal pass/fail reported only if 65% v/v effluent reported.

APPENDIX II: CRESTBROOK PULP AND PAPER BIOASSAY RESULTS FOR 1974 to 1980

| YEAR | SAMPLE DATE | SPECIES | LOADING DENSITY (gm/l) | % SURVIVAL | | | 96 hr LC50 % |
|--|--------------|---------------|------------------------------|-------------------------|------------|----------------------|-----------------|
| | | | | PROVINCIAL 90% conc. | 100% conc. | FEDERAL 65% conc. | |
| <u>Environmental Protection Service Monitoring</u> | | | | | | | |
| 1976 | January 4 | Rainbow Trout | .49 | 100 | 100 | 100 | |
| | January 25 | | .48 | 100 | - | 100 | |
| | February 1 | | .49 | 100 | 85.7 | 100 | |
| | February 29 | | .38 | 100 | 90 | 100 | |
| | March 28 | | .50 | 100 | 80 | 100 | |
| | July 5 | | .50 | 100 | 100 | 100 | |
| | September 13 | | .68 | 100 | 80 | 100 | |
| | October 4 | | .15 | 40 | 60 | 90 | |
| | November 1 | | 1.19 | 80 | 60 | 60 | |
| | December 5 | | .46 | 100 | 100 | 100 | |
| 1977 | January 2 | | .53 | 100 | 100 | - | |
| | February 6 | | .58 | 100 | 80 | - | |
| | March 6 | | .55 | 80 | 60 | - | |
| | April 4 | | .62 | 80 | 80 | 100 | |
| | July 27 | | .57 | 100 | 100 | - | |
| | August 10 | | .50 | 0 | 0 | - | |
| | August 23 | | .45 | 20 | 40 | 100 | |
| | August 24 | | .45 | 0 | 0 | 100 | 76 |
| | September 6 | | .60 | 100 | 100 | 100 | |
| | October 11 | | .87 | 0 | 0 | - | |
| | October 25 | | .30 | 100 | 60 | 70 | |
| | November 7 | | .15 | 80 | 70 | 100 | |
| | December 5 | | .40 | 80 | 80 | - | |
| | 1978 | | January 9 | | 0.50 | 0 | 0 |
| January 23 | | 0.50 | 0 | | 0 | 40 | 63 |
| February 5 | | 0.60 | 0 | | 0 | 0 | 30-65 |
| February 19 | | 0.70 | 0 | | 0 | 0 | 30-65 |
| March 5 | | 0.20 | 0 | | 0 | 0 | 44 |
| March 19 | | 0.40 | 0 | | 0 | 0 | 44 |
| April 2 | | 0.40 | 0 | | 0 | 0 | 44 |
| April 19 | | 0.40 | 60 | | 40 | 40 | |
| May 14 | | 0.40 | 0 | | 0 | 0 | 22-30 |
| May 28 | | 0.50 | 0 | | 0 | 0 | 20-30 |
| | June 18 | | 0.30 | 100 | 90 | 100 | |

APPENDIX II: CRESTBROOK PULP AND PAPER BIOASSAY RESULTS FOR 1974 to 1980

| YEAR | SAMPLE DATE | SPECIES | LOADING DENSITY (gm/l) | % SURVIVAL | | | 96 hr LC50 % | |
|--|-------------|---------|------------------------------|-------------------------|------------|----------------------|-----------------|-------|
| | | | | PROVINCIAL 90% conc. | 100% conc. | FEDERAL 65% conc. | | |
| Environvironmental Protection Service Monitoring | | | | | | | | |
| 1978 | July | 16 | Rainbow Trout | 0.30 | 40 | 0 | - | |
| | July | 30 | | 0.50 | 0 | 0 | 0 | 44 |
| | August | 20 | | 0.80 | 0 | 0 | 0 | 27 |
| | September | 3 | | 2.20 | 0 | 0 | 0 | 36 |
| | September | 17 | | 2.20 | 100 | 100 | 100 | |
| | Ocotber | 1 | | 0.40 | 100 | 100 | - | |
| | November | 5 | | 0.50 | 100 | 87.5 | - | |
| | December | 3 | | 0.60 | 100 | 87.5 | - | |
| | January | 7 | | 0.50 | 100 | 71 | - | |
| | February | 4 | | 0.50 | 0 | 0 | 0 | |
| | February | 18 | | 0.50 | 0 | 0 | 0 | 10-30 |
| | March | 4 | | 0.50 | 17 | 33 | 100 | 87 |
| | March | 18 | | 0.50 | 0 | 0 | 0 | 45 |
| | April | 1 | | 0.50 | 0 | 0 | 0 | 10 |
| | April | 17 | | 0.45 | 0 | 0 | 0 | 17 |
| | April | 29 | | 0.50 | 33 | 33 | 100 | |
| | May | 14 | | 0.50 | 0 | 0 | 100 | 77 |
| | May | 27 | | 0.50 | 0 | 0 | 37.5 | 61 |
| | 1979 | July | 1 | | 0.50 | 20 | 40 | - |
| July | | 10 | | 0.50 | 100 | 66 | - | |
| July | | 15 | | 0.60 | 80 | 20 | 100 | 94 |
| August | | 6 | | 0.60 | 100 | 100 | 100 | |
| September | | 19 | | 0.80 | 100 | 100 | - | |
| October | | 3 | | 0.40 | 100 | 100 | - | |
| November | | 13 | | 0.40 | 100 | 100 | - | |
| December | | 5 | | 0.52 | 62.5 | 12.5 | - | |

APPENDIX II: CRESTBROOK PULP AND PAPER BIOASSAY RESULTS FOR 1974 to 1980

| YEAR | SAMPLE DATE | SPECIES | LOADING | % SURVIVAL | | | 96 hr LC50 |
|--|-------------|---------------|---------|------------|------------|-----------|------------|
| | | | DENSITY | PROVINCIAL | | FEDERAL | |
| | | | (gm/l) | 90% conc. | 100% conc. | 65% conc. | |
| <u>Environmental Protection Service Monitoring</u> | | | | | | | |
| 1980 | February 5 | Rainbow Trout | 0.6 | 0 | 0 | 100 | 80 |
| | February 19 | | 0.4 | 80 | 50 | 100 | |
| | March 5 | | 0.5 | 100 | 100 | 100 | |
| | April 1 | | 0.5 | 80 | 30 | -- | |
| | April 23 | | 0.5 | 0 | 0 | 0 | 10, 30 |
| | May 7* | | 0.5 | 0 | 0 | 0 | 10 |
| | June 4 | | 0.5 | 0 | 0 | 0 | 10, 30 |
| | October 15 | | 0.5 | 0 | 0 | -- | |
| | October 30 | | 0.5 | 100 | 83 | 100 | |
| | November 11 | | 0.5 | 0 | 0 | -- | |
| | December 10 | | 0.4 | 0 | 0 | 20 | 52, 65 |

* Oxygenated at 3L/min. for 3 minutes.

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APPENDIX III

KOOTENAY RIVER WATER QUALITY DATA FOR 1975

APPENDIX III: KOOTENAY RIVER WATER QUALITY DATA FOR 1975
Data supplied by Inland Waters Directorate (NAQUADAT)

| SAMPLE DATE | APPARENT COLOUR (Rel. Units) | | | SPECIFIC CONDUCTANCE (umhos/cm) | | TOTAL ALKALINITY (mg/l CaCO ₃) | | TOTAL HARDNESS (mg/l) | |
|----------------|---------------------------------|------|--|------------------------------------|------|---|------|--------------------------|------|
| | Canal | | | Canal | | Canal | | Canal | |
| | Flats | Wasa | | Flats | Wasa | Flats | Wasa | Flats | Wasa |
| March 12 | 14 | 48 | | 419 | 438 | 146 | 140 | 200 | 190 |
| April 28 | 7 | 31 | | 378 | 380 | 153 | 134 | 180 | 190 |
| April 29 | 9 | 26 | | 380 | 378 | 151 | 136 | 180 | 170 |
| April 30 | 7 | 30 | | 387 | 380 | 150 | 135 | 190 | 170 |
| May 1 | 6 | 30 | | 389 | 384 | 152 | 136 | 190 | 170 |
| June 26 | 7 | 7 | | 216 | 199 | 99 | 85 | 110 | 97.8 |
| July 24 | L5 | L5 | | 240 | 238 | 101 | 95 | 120 | 120 |
| July 25 | - | L5 | | - | 236 | - | 93 | - | 110 |
| July 26 | L5 | L5 | | 241 | 231 | 101 | 93 | 120 | 110 |
| September 4 | L5 | L5 | | 271 | 256 | 114 | 105 | 130 | 130 |
| October 16 | L5 | L5 | | 328 | 316 | 129 | 117 | 160 | 150 |
| November 12 | L5 | 10 | | 331 | 337 | 132 | 124 | 170 | 160 |
| \bar{x} | 6.8 | 17.2 | | 325 | 314 | 130 | 116 | 159 | 146 |
| S.D. | 2.7 | 14.9 | | 72 | 79 | 22 | 21 | 33 | 31 |
| n | 11 | 12 | | 11 | 12 | 11 | 12 | 11 | 12 |

NOTE :Pulpmill not operational August and September, 1975
:Canal Flats (BC08NF006), Wasa (BC08NG003)

L = less than

APPENDIX III: KOOTENAY RIVER WATER QUALITY DATA FOR 1975

(Continued) Data supplied by Inland Waters Directorate (NAQUADAT)

| SAMPLE DATE | | DISSOLVED SODIUM (mg/l) | | DISSOLVED CHLORIDE (mg/l) | | DISSOLVED SULPHATE (mg/l) | | pH | |
|----------------|----|----------------------------|------|------------------------------|------|------------------------------|------|-------|------|
| | | Canal | | Canal | | Canal | | Canal | |
| | | Flats | Wasa | Flats | Wasa | Flats | Wasa | Flats | Wasa |
| March | 12 | 7.4 | 14.6 | 10.7 | 21.0 | 63.0 | 59.5 | 8.2 | 8.2 |
| April | 28 | 6.5 | 10.9 | 9.0 | 14.3 | 40.0 | 40.0 | 8.1 | 8.1 |
| April | 29 | 6.3 | 10.2 | 8.7 | 13.1 | 48.5 | 40.0 | 8.1 | 8.1 |
| April | 30 | 6.5 | 10.0 | 8.8 | 17.0 | 40.0 | 40.0 | 8.1 | 8.1 |
| May | 1 | 6.4 | 10.1 | 8.8 | 13.3 | 40.0 | 49.5 | 8.1 | 8.1 |
| June | 26 | 1.7 | 2.1 | 2.5 | 2.9 | 15.6 | 17.5 | 8.2 | 8.3 |
| July | 24 | 1.5 | 1.6 | 3.8 | 3.7 | 19.8 | 20.0 | 8.2 | 8.0 |
| July | 25 | - | 2.7 | - | 3.4 | - | 20.0 | - | 8.2 |
| July | 26 | 2.6 | 2.6 | 3.0 | 3.0 | 20.0 | 20.0 | 8.2 | 8.2 |
| September | 4 | 2.6 | 2.6 | 3.8 | 3.0 | 24.5 | 27.5 | 8.2 | 8.3 |
| October | 16 | 4.4 | 5.7 | 5.8 | 5.8 | 32.5 | 36.0 | 8.4 | 8.3 |
| November | 12 | 4.6 | 6.9 | 6.3 | 9.0 | 40.0 | 39.0 | 8.3 | 8.3 |
| \bar{x} | | 4.6 | 6.7 | 6.5 | 9.1 | 34.9 | 34.1 | 8.2 | 8.2 |
| S.D. | | 2.2 | 4.4 | 2.5 | 6.4 | 14.2 | 13.2 | 0.1 | 0.1 |
| n | | 11 | 12 | 11 | 12 | 11 | 12 | 11 | 12 |

APPENDIX III: KOOTENAY RIVER WATER QUALITY DATA FOR 1975
(Continued) Data supplied by Inland Waters Directorate (NAQUADAT)

| SAMPLE DATE | NO ₃ -NO ₂ (ug/l) | | NH ₃ (ug/l) | | TOTAL DISSOLVED PHOSPHOROUS (ug/l) | | TOTAL PHOSPHOROUS (ug/l) | |
|----------------|--|------|---------------------------|------|---------------------------------------|------|-----------------------------|------|
| | Canal Flats | Wasa | Canal Flats | Wasa | Canal Flats | Wasa | Canal Flats | Wasa |
| March 12 | 121 | 107 | 31 | 12 | - | - | - | - |
| April 28 | 130 | 81 | - | - | 6 | 4 | 22 | 24 |
| April 29 | 130 | 96 | - | - | 3 | 7 | 22 | 22 |
| April 30 | 130 | 93 | - | - | 7 | 7 | 10 | 20 |
| May 1 | 130 | 96 | - | - | 2 | 5 | 12 | 16 |
| June 26 | 187 | 234 | 10 | 6 | 6 | 4 | 242 | 150 |
| July 24 | 104 | 84 | 106 | 23 | 6 | 2 | 11 | 41 |
| July 25 | - | 86 | - | 24 | - | 3 | - | 22 |
| July 26 | 86 | 76 | 21 | 40 | 3 | 5 | 11 | 25 |
| September 4 | 93 | 75 | 28 | 32 | 18 | 12 | 6 | 9 |
| October 16 | 127 | 82 | 194 | 116 | - | - | 14 | - |
| November 12 | 143 | 153 | 44 | 49 | - | - | 4 | 16 |
| \bar{x} | 125 | 105 | 62 | 38 | 6 | 5 | 35 | 34 |
| S.D. | 27 | 46 | 66 | 35 | 5 | 3 | 73 | 41 |
| n | 11 | 12 | 7 | 8 | 8 | 9 | 10 | 10 |

APPENDIX IV

RANGE OF VALUES FOR WASTE MANAGEMENT BRANCH
WATER QUALITY DATA COLLECTED
IN MARCH OF 1979 AND 1980

APPENDIX IV: RANGE OF VALUES FOR WASTE MANAGEMENT BRANCH WATER QUALITY DATA COLLECTED IN MARCH OF 1979 AND 1980

[After Crozier(6)] Stations shown on Figure 6.

| PARAMETER | WMB-304 - 5km upstream of Skookumchuk Creek | | WMB-48 - 2.5km downstream of outfall | | WMB-326 - 12.5km downstream of outfall | | WMB-19 - 18km downstream of outfall | |
|------------------------------------|--|-------------|---|------------|---|------------|--|------------|
| | Period One* | Period Two* | Period One | Period Two | Period One | Period Two | Period One | Period Two |
| pH | 8.1-8.2 | 8.1-8.2 | 8.0-8.2 | 8.0-8.1 | - | 8.0-8.1 | 8.1-8.2 | 8.1 |
| Non-Filterable Residue (mg/l) | 3-8 | 2-4 | 6-12 | 5-7 | - | 5-6 | 5-13 | 5-6 |
| Specific Conductance (unhos/cm) | 350-321 | 380-384 | 401-435 | 430-472 | - | 429-450 | 410-425 | 422-450 |
| Temperature (°C) | 2.0-3.2 | 0.0 | 2.0-4.1 | 0.5-2.0 | - | 0.5-2.0 | 3.1-6.5 | 1.0-2.0 |
| Dissolved Oxygen (mg/l) | 11.3-12.8 | 11.6-13.0 | 12.1-12.7 | 12.0-13.2 | - | 11.6-12.7 | 11.7-12.5 | 11.5-13.0 |
| % Saturation | - | 89-98 | - | 94-105 | - | 91-102 | - | 91-104 |
| True Colour | - | L5 | - | 40-80 | - | 40-80 | - | 40-80 |
| Colour (T.A.C.) | L1-2 | L1-2 | 61-69 | 36-61 | - | 33-57 | 51-58 | 32-55 |
| N-Ammonia (ug/l) | L5-21 | L5-10 | L5-11 | L5-16 | - | 5-23 | 5-30 | L5-10 |
| N-Organic (ug/l) | 10-110 | L10-170 | 190-650 | 120-380 | - | 120-350 | 10-220 | 130-250 |
| N-Nitrate + Nitrite (ug/l) | 120-140 | 130-160 | 110-130 | 110-180 | - | 120-190 | 100-140 | 110-140 |
| N-Kjeldahl (ug/l) | 10-110 | 10-170 | 190-660 | 120-380 | - | 120-350 | 40-230 | 130-260 |
| Phenol (ug/l) | L2 | L2 | 17-25 | L2-8 | - | L2-5 | 12-18 | L2-10 |
| Total Phosphate (ug/l) | 5-6 | 3-4 | 18-23 | 16-29 | - | 18-25 | 16-22 | 16-24 |
| Ortho Phosphate (ug/l) | L3-4 | L3 | L3-6 | L3 | - | L3 | L3-6 | L3 |
| Tannin & Lignin (mg/l) | L1.0-1.0 | L0.1 | 3.6-4.5 | 2.6-3.8 | - | 2.6-5 | 3.0-4.0 | 2.4-3.6 |
| Dissolved Sodium (mg/l) | 5.8-8.5 | 6.0-6.5 | 17.6-22.5 | 16.7-23.9 | - | 13.0-16.9 | 14.3-16.8 | 12.5-16.2 |

Period One = March 5 - 15, 1979

Period Two = March 10 - 13, 1980

L = Less Than

* = Daily Grab Samples.