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PHASE II

Water Quality in the Upper Columbia River Basin

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Copies of this report may be obtained from the Library, Assessment and Planning Division, Ministry of Environment, Parliament Buildings, Victoria, B.C.

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1. INTRODUCTION

This report describes the water quality of the Upper Columbia River Basin from 1975 to May, 1978. The basin is located in the north-eastern part of the Kootenay region, as shown in Figure 1.

The water quality of the Upper Columbia River Basin, prior to 1975, was evaluated in a Phase I report[1]. The Phase I study found that the water quality in the basin was generally good, apart from a few localized problem areas. In this report we update the water quality of the basin, and present results of further investigations of the problem areas.

The Upper Columbia River Basin has an area of 5 100 km^2. The Columbia River originates in this basin, in Columbia Lake, and flows northward along the bottom of the Rocky Mountain trench. The trench separates the Purcell Mountains on the west from the Kootenay ranges of the Rocky Mountains on the east.

The population of this mountainous area is concentrated along the river, and is estimated to have been 5 400 in 1976. The village of Invermere, with a 1976 population of 1 194, is the largest settlement in the basin[2]. The major economic activity is the forest industry, with lesser but important contributions from tourism, agriculture and mining[1].

For data presentation the basin was divided into five sub-basins, shown in more detail in Figure 2. These are:

- The Columbia River, including Columbia and Windermere Lakes
- Toby Creek
- Sinclair Creek
- Fairmont Creek
- Windermere Creek

2. COLUMBIA RIVER INCLUDING COLUMBIA AND WINDERMERE LAKES

2.1 Introduction

The Columbia River orginates in Columbia Lake (Figure 2) and follows a meandering course for 10 km to Windermere Lake. Flows at Fairmont Hot Springs range from 1.5 m^3/s during winter to 85 m^3/s during spring freshet[3]. The mean water residence time in Windermere Lake is relatively short (74 days). From Windermere Lake the Columbia follows a sluggish meandering course through the Columbia River marshes for 55 km until it leave the Kootenay Study region near Harrogate, 65 km south of Golden. Flows in the Columbia River at Edgewater range from 11 m^3/s in winter to 280 m^3/s during spring freshet[3].

2.2 Effluents

The only significant discharge of effluent to the Columbia River is from the Radium Waterworks District's sewage treatment plant at Radium Hot Springs.

Domestic sewage from the Radium Hot Springs area, including Kootenay National Park, is treated in a plant consisting of a winter and summer oxidation chamber, a clarifier, an outfall to the Columbia River and sludge drying beds. The plant began operation in December 1976, replacing two overloaded sewage lagoons located next to Sinclair Creek (PE-132) and individual septic tank and tile field systems. The 1975 permanent population of Radium Hot Springs was estimated to be 600, but the tourist population in the area increased the population to an equivalent of 1 000 during the winter and 3 200 during the summer[1]. The plant was designed to treat sewage from equivalent populations of 1 600 in winter and 4 400 in summer, to satisfy needs up to 1986[4].

The discharge is authorized by Pollution Control Permit PE-4422, which allows the discharge of a maximum of 2 090 m^3/d of effluent with a BOD_5 of 45 mg/L and suspended solids of 60 mg/L. The minimum dilution of effluent in the Columbia River is about 500 to 1 during winter and 1 000 to 1 during summer[4]. Chlorination of the effluent is not required because there is a large dilution available for the effluent, and there are no downstream water users that would be affected. Chlorine can be toxic to aquatic life and can form chlorinated organic compounds that are also toxic. Thus chlorination is not advocated unless it is necessary to protect public health[5].

The effluent monitoring data for the sewage treatment plant is summarized in Table 1. Effluent quality was poor during the first six months of operation (January to June, 1977). The BOD_5 and suspended solids exceeded the permit limits and fecal coliform levels were high (>240 000/100 mL). Effluent quality improved after mid-1977, meeting permit limits for BOD_5 and suspended solids, and containing reduced levels of fecal coliforms.

2.3 Water Quality

2.3.1 Presentation of Data

The Ministry of Environment monitored water quality at 14 sites on the Columbia River and Windermere and Columbia Lakes, between August 1975 and May 1978. The sites are shown in Figure 3 and described in Table 2. The data for these sites are summarized in Tables 3, 4, 5, 6 and 7. The Columbia and Windermere Lake data were summarized for all sampling depths since the lakes were not stratified when sampled and there was little or no variation with depth.

2.3.2 Discussion of Water Quality Data

The water in Columbia Lake (Table 3) was alkaline and medium hard to hard[6]. The waters were well oxygenated, clear, and very low in color, nutrients, suspended solids and turbidity. Data collected by consultants for B.C. Hydro's proposed Kootenay Diversion at Canal Flats[7] were similar to those collected by the Ministry of Environment.

The water quality of the Columbia River, between Columbia and Windermere Lakes (Table 4), was similar to that in Columbia Lake. Suspended solids and turbidity were somewhat greater than in Columbia Lake (presumably due to the greater velocity in the river and the inflow of more turbid water from Dutch Creek[7], but were still quite low. Metals and fecal coliforms were also very low in this reach of the river. The inflow of Fairmont Creek which drains the Fairmont Hot Springs resort area, had no significant effect on the water quality of the Columbia River.

The water quality of Windermere Lake (Table 5) and of the Columbia River at Athalmer (Table 6, site 0200009) was similar to that upstream in the river and in Columbia Lake. The chlorophyll a measurements suggest that Windermere Lake was oligotrophic[8], or had a low biological productivity.

The water quality of the Columbia River deteriorated somewhat downstream from Toby Creek (Table 6, sites 0200225, 0200232 and 0200233) due to natural and man-made influences. Suspended solids and turbidity were higher, particularly during spring freshet (up to 280 mg/L and 23 J.T.U., respectively) probably due to the inflow of more turbid water from Toby, and Horsethief Creeks[7]. Total phosphorus levels also increased (up to 135 μg/L) during freshet due to the phosphorus content of the suspended solids, but dissolved phosphorus remained very low (<3 μg/L). Fecal coliforms increased (up to 240/ 100 mL) during the first half of 1977 because of the poor quality effluent being discharged from the Radium Waterworks District's sewage treatment plant (Section 2.2). The effluent improved after mid-1977 and fecal coliforms dropped to low levels (≤31/100 mL).

On September 20, 1977, anomalous total lead levels (78-100 μg/L) were measured at sites 0200225 and 0200233 (Figure 3). The recommended level for domestic water supply is 50 μg/L, and for aquatic life is 30 μg/L[8,9,10]. However, results for September 20, 1977 maybe in error for several reasons. There are no significant sources of lead in the upper Columbia basin and lead levels have never exceeded 14 μg/L on any other sampling occasion. Also, lead levels in Toby Creek (sites 0200054 and 0200055, Figure 2) and in the Columbia River upstream (site 0200009) and at site 0200232 (between sites 0200225 and 0200233, Figure 3) were all very low on September 20, 1977.

Total cadmium was also higher than normal (1.1-1.8 μg/L) at the sites 0200225 and 0200233 on this day, but natural cadmium levels in this range have been measured in the basin in the past[1].

2.3.3 Possible Effects of the Proposed Kootenay River Diversion on Water Quality

Environmental studies by B.C. Hydro and its consultants on the proposed

Kootenay River Diversion to the Columbia River system at Canal Flats were still in progress at the time of publication of this report[26]. Preliminary results from these studies indicate that the water temperatures at the southern end of Columbia Lake may be lowered by 6-8^{o}C, but that at the north end of Columbia Lake and in Windermere Lake, the main body of the lake may be lowered by only 1-2^{o}C. The beach temperatures in Windermere Lake and at the north end of Columbia Lake are expected to be relatively unchanged by the diversion, from the temperatures currently experienced[26,27].

Preliminary results also indicate that most of the suspended sediments in the Kootenay River water would settle out within the first few kilometres of Columbia Lake. The average suspended solids and turbidity would increase slightly in Columbia and Windermere Lakes, although turbidity would likely be within drinking water standards by the time the Kootenay water reached the north end of Columbia Lake[27].

2.4 Conclusions and Recommendations

2.4.1 Conclusions

The water quality of the upper Columbia system was very good from Columbia Lake to Toby Creek. Water quality deteriorated somewhat downstream from Toby Creek due to the inflow of natural suspended sediment from Toby and possibly Horsethief Creeks. There was also some fecal contamination from the Radium sewage treatment plant during the first half of 1977.

Preliminary study results suggest that the main water temperature, turbidity and sedimentation impacts of the Kootenay Diversion would be on the southern part of Columbia Lake.

2.4.2 Recommendations

The only effluent and water quality monitoring recommended in the upper Columbia system is related to the Radium Waterworks District's treated sewage discharge, as shown in Table 8.

3. TOBY CREEK

3.1 Introduction

Toby Creek drains an area of 622 km^2 on the eastern slopes of the Purcell Mountains. There are numerous glaciers and icefields in its headwaters. The creek enters the Columbia River just north of Lake Windermere, and flows near the mouth have ranged from 106 m^3/s during spring freshet to 1.3 m^3/s in winter[3]. There are no water licences on Toby Creek, but the Village of Invermere has filed an application with the Water Rights Branch to withdraw 0.53 m^3/s for a public water supply[1]. The creek supports a fishery for whitefish, cutthroat trout and Dolly Varden char[11].

3.2 Effluents and Non-point Sources

Effluents and non-point sources in the Toby Creek basin include treated domestic sewage from the Village of Invermere and Panorama Ski Hill Co. Ltd., tailing pond effluent from the Mountain Minerals barite concentrating plant, and drainage from old mines and logging.

3.2.1 Village of Invermere

Domestic sewage from the Village of Invermere (1976 population of 1 194) was disposed of via individual septic tank and tile field systems until May 1976. A new sewage treatment system consisting of two aerated lagoons, chlorination, 20 day aerated holding lagoon, and an outfall to Toby Creek began operation in May 1976, and the first discharge of effluent to Toby Creek occurred in June 1977. The discharge was authorized by Pollution Control Permit PE-3094 for a maximum flow of 1 710 m^3/d of effluent with BOD_5 of 45 mg/L and suspended solids of 60 mg/L. The minimum dilution for the effluent in Toby Creek was 65 to 1 (assuming a creek flow of 1.3 m^3/s and an effluent flow of 1 710 m^3/d)[12].

The sewage treatment plant effluent was of good quality (Table 1), but profuse algal growth in Toby Creek downstream from the outfall was noticed in October 1977. Subsequent studies by the Waste Management Branch attributed this growth to the biologically available phosphorus in the effluent. To remedy the algal growth problems, the effluent was removed from Toby Creek, in March, 1981 and discharged to infiltration ponds located about 450 m from Toby Creek. Discharge to Toby Creek is only allowed under emergency conditions[12]. The effectiveness of the infiltration system in preventing nuisance algal growth in Toby Creek has not yet been evaluated[28].

3.2.2 Panorama Ski Hill Co. Ltd.

Domestic sewage from this skiing and condominium resort complex, located about 16 km upstream from Invermere, is treated and discharged to ground adjacent to Toby Creek. Treatment consists of rotary drum filters, rotating biological contactors, clarifiers, multimedia filters, 10-day storage lagoon and discharge to tile fields located 35 m from Toby Creek. The discharge is authorized by Pollution Control Permit PE-5193 (as amended September 14, 1979) which allows the discharge to ground of a maximum of 1 090 m^3/d with BOD_5 of 10 mg/L and suspended solids of 10 mg/L[29].

The impact of this rapidly expanding resort development on Toby Creek is being closely watched by the Waste Management Branch. Algal growth in Toby Creek is phosphorus limited and any continuous phosphorus discharge to the creek will likely result in nuisance algal growth, such as occurred at Invermere[28] (see Section 3.2.1).

3.2.3 Mountain Minerals Limited

Mountain Minerals Limited operates a 325 t/d barite (barium sulphate) concentrating plant at the confluence of Toby and Jumbo Creeks, as shown in Figure 2. Mountain Minerals is extracting the barite from the old tailing left by the Mineral King silver-lead-zinc mine. There was about a two to three year reserve (136 000 t) of old tailing left at the end of 1977[13,14]. The operation was described in detail in the Phase I Report[1].

Effluent from the Mountain Minerals tailing pond is discharged to Toby Creek. The discharge is authorized by Pollution Control Permit PE-315, which allows the discharge of 1 310 m^3/d (average) of tailing and supernatant from

May 15 to November 15[14]. The effluent characteristics specified by the permit are shown in Table 9 along with the Pollution Control Objectives for the mining, smelting and related industries[15]. The data show that the effluent met the most stringent objective level with the exception of manganese and zinc. Permit levels were met with the exception of sulphate. Barium levels in the effluent were low.

The minimum dilution available for the Mountain Mineral tailing pond effluent occurs in November and is estimated to be about 50 to 1 (assuming a streamflow of 0.7 m^3/s and an effluent flow of 1 310 m^3/d). This dilution ensures that the contaminants measured in the effluent will be diluted in Toby Creek to levels that are safe for aquatic life and other water uses. Water quality monitoring in Toby Creek downstream from Mountain Minerals (Section 3.3) indicates that water quality has been good.

3.2.4 Mine Drainage

The Phase I report[1] indicated that mine drainage containing mainly zinc was entering Jumbo and Toby Creeks from the old Mineral King Mine and perhaps from the old Paradise Mine. The Paradise Mine was visited on several occasions during 1975 and 1976, but no drainage to Toby Creek was observed. A berm had been constructed around the old tailing pile to control erosion.

Underground drainage from the old Mineral King Mine (portal No. 9 level) to Jumbo Creek and surface drainage from the old Mineral King tailing pile (that Mountain Minerals Ltd. is reprocessing) to Toby Creek were monitored a few times in 1976. The results are presented in Table 10. Underground drainage reported from portal No. 7 level[1] could not be found. The Mineral King drainage (Table 10) contained elevated zinc levels, but flows were relatively small, and thus zinc loadings were only about 0.6-1.3 kg/d. This is about one sixth to one third of the zinc loading allowed from the Mountain Minerals Ltd.'s tailing pond. During the period of minimum dilution (November) in Toby Creek, the zinc loadings from the mine drainage would be even lower, and thus would not significantly contribute to the zinc loading to Toby Creek. Water quality monitoring in Toby Creek, downstream from the Mineral King Mine and Mountain Minerals Ltd., has shown that zinc levels have been low (section 3.3).

3.2.5 Logging

Logging has been conducted in the headwaters of Toby and Jumbo Creeks as reported in the Phase I report[1]. The logging activities were not monitored during Phase II, but water quality monitoring in upper Toby Creek (Section 3.3) indicated that suspended solids, nutrients and turbidity levels were not particularly high, suggesting that logging had little effect on water quality.

3.3 Water Quality

3.3.1 Presentation of Data

Water quality was monitored at five sites on Jumbo and Toby Creeks during Phase II. The sites are shown in Figures 2 and 3 and described in Table 2.

The data for these sites are summarized in Tables 10, 11 and 12.

3.3.2 Discussion

The water in Toby Creek was alkaline and medium hard to hard[6]. Water of this hardness can be classed as good to fair for domestic uses[9]. Metals and nutrients were low. Tables 10 and 11 show that Mountain Minerals Ltd. and the old Mineral King Mine had little effect on Toby Creek water quality. There were slight increases in zinc, the principal contaminant discharged to Toby Creek, but the resulting levels were low. Barium increased between sites upstream and downstream from the mines, and approached the maximum permissible limit for drinking water (1.0 mg/L)[9] at the downstream site (0200054). Further monitoring is required to assess barium levels in raw and treated water from Toby Creek prior to domestic use. Total barium should be measured since barite ($BaSO_4$), the probable source of the barium, is highly insoluble[10]. Suspended solids in Toby Creek were lower downstream from the mines than upstream, probably because of the inflow of Jumbo Creek water with low suspended solids.

Eight pairs of samples taken upstream and downstream from the Invermere sewage treatment plant outfall (Table 12) show that except for small increases in ammonia and phosphorus during winter low flows, the effluent had no measureable effect on Toby Creek. The phosphorus in the effluent did, however, cause profuse nuisance algal growth downstream from the outfall in certain seasons[12]. The effluent discharge has been removed from Toby Creek, but an evaluation of effect on algal growth has not yet been done[28] (see Section 3.2.1). Table 12 appears to show that there were fairly large increases in suspended solids, turbidity and total phosphorus between the sites upstream and downstream from the Invermere outfall. This is due to one sample taken downstream during spring freshet for which there was no corresponding upstream sample. The somewhat high levels of these parameters at the downstream site were probably due to natural suspended sediment levels during spring freshet. Removal of suspended solids and turbidity from Toby Creek water would be required prior to domestic use during the spring freshet.

3.4 Conclusions and Recommendations

3.4.1 Conclusions

Treated sewage from the Village of Invermere caused nuisance algal growth in lower Toby Creek.

Tailing pond effluent from Mountain Minerals Ltd. and drainage from old mines had no significant effect on the water quality of Toby Creek. A possible exception was barium, which approached the maximum permissible limit for drinking water.

Toby Creek water would require suspended solids removal prior to domestic use during spring freshet.

3.4.2 Recommendations

Barium levels in raw and treated Toby Creek water should be determined prior to domestic use.

Effluent and water quality monitoring in the Toby Creek basin should include the monitoring outlined in Table 8.

Algal growth in Toby Creek should be monitored to determine the effectiveness of the Invermere infiltration basins and of the Panorama Ski Hill sewage disposal system.

4. SINCLAIR CREEK

4.1 Introduction

Sinclair Creek drains a relatively small area (92 km^2) on the western slopes of the Brisco and Stanford Ranges (Figures 2 and 4). Virtually all of the basin lies in Kootenay National Park. The creek flows into the Columbia River at Radium Hot Springs and flows near the mouth have ranged from 11 m^3/s during spring freshet to 0.2 m^3/s during winter(3). There are four water licences on Sinclair Creek, totalling 292 dam^3/a for irrigation, 6.8 m^3/d for domestic purposes and 0.7 m^3/s for power generation(1).

The Phase I report(1) indicated that there were high levels of fecal contamination in Sinclair Creek, downstream from the Radium sewage lagoons. Preliminary data indicated that there may also be abnormal arsenic levels in Sinclair Creek.

4.2 Effluents and Non-point Sources

The Radium sewage lagoon's discharge to Sinclair Creek (Pollution Control Permit PE-132) was replaced in December 1976 by a sewage treatment plant discharging directly to the Columbia River. The new sewage treatment plant (PE-4422) is described in Section 2.2.

The only other discharge to Sinclair Creek is from the hot spring swimming pools in Kootenay National Park. The effluent from these pools was monitored by the Water Quality Branch of Environment Canada. Their data show that the pool effluents were highly mineralized (calcium, sulphate), very hard, and contained high levels of dissolved arsenic (0.2-0.5 mg/L)(16,17). The arsenic is coming from the ore body where the hot springs originate(18). Water quality monitoring in the Sinclair Creek basin (Section 4.3) indicates that the pools are partly responsible for relatively high arsenic levels found in lower Sinclair Creek.

4.3 Water Quality

4.3.1 Presentation of Data

The Ministry of Environment monitored two sites on Sinclair Creek, shown on Figure 4 and described in Table 2.

The data from these sites are summarized in Table 13.

The Water Quality Branch of Environment Canada monitored nine sites in the Sinclair Creek basin, shown in Figure 4. Their arsenic data for these sites are summarized in Table 14. The Water Quality Branch has prepared an interim water quality report on the Sinclair Creek basin[16], and is now preparing a final report[19].

4.3.2 Discussion

The water in Sinclair Creek and its tributaries is alkaline and could be described as very hard[6], or as of poor quality with respect to hardness[9]. Table 14 shows that arsenic in lower Sinclair Creek (from above John McKay Creek to the mouth) usually exceeded the acceptable limit for arsenic in drinking water (10 µg/L), and exceeded the maximum permissible limit (50 µg/L) during winter low flows (January-March). The headwaters and tributaries of Sinclair Creek were low in arsenic. Included in this category is John McKay Creek, which provides the water supply for Radium Hot Springs and Kootenay National Park. Table 14 indicates that the hot spring swimming pools contribute substantially to the arsenic levels in Sinclair Creek, but that there are other natural arsenic sources upstream from the pools.

Prior to December 1976, the effluent from the Radium sewage lagoons (PE-132) caused high levels of fecal contamination (over 2 400/100 mL) and minor increases in ammonia and phosphorus in Sinclair Creek downstream from the lagoons (Table 13). The lagoons ceased discharging to Sinclair Creek in December 1976, and fecal coliform densities downstream from the lagoons have been low (21 /100 mL or less) since then.

4.4 Conclusions and Recommendations

4.4.1 Conclusions

Effluent from the Radium Hot Spring swimming pools and other natural sources caused arsenic in Sinclair Creek to exceed drinking water standards.

The sanitary quality of lower Sinclair Creek has been good since the closure of the Radium sewage lagoons in late 1976.

4.4.2 Recommendations

Lower Sinclair Creek should not be used for domestic water supply without the permission of the Ministry of Health.

Further monitoring of Sinclair Creek is not recommended.

5. FAIRMONT CREEK

5.1 Introduction

Fairmont Creek drains a small area (6.5 km^2) on the western slope of Fairmont Ridge in the Stanford Range (Figure 3). The minimum flow recorded in the creek was 0.034 m^3/s in August 1966[1]. The only development in the basin is the Fairmont Hot Springs Resort, consisting of a lodge, cabins, trailer parks, campground, hot spring swimming pools, golf course and ski hill. Four water licences have been issued on Fairmont Creek for irrigation (golf course) and industrial purposes, but the points of water diversion are above the discharges from Fairmont Hot Springs Resort Ltd.[1]. There is no fishery in Fairmont Creek[1,20].

5.2 Effluents

Chlorinated hot spring swimming pool water from the resort (PE-2057, maximum of 1 410 m^3/d) is discharged to Fairmont Creek. Septic tank and sauna bath effluents (PE-1619, maximum of 136 m^3/d) are discharged to the ground, 75 m north of Fairmont Creek[20]. The monitoring data for these effluents are summarized in Table 15 and are similar to those reported in Phase I[1]. The swimming pool effluents were hot, highly mineralized and very low in fecal coliforms. They contained a chlorine residual. As expected, the septic tank effluent was high in fecal coliforms.

An arsenic survey by the Water Quality Branch of Environment Canada[16] showed that the Roman Bath hot springs at the resort contained a high level of arsenic (0.11 mg/L). The drinking water supply for the resort (from Cold Spring Creek) was very low in arsenic (0.5 μg/L).

5.3 Water Quality

The Waste Management Branch monitored two sites on Fairmont Creek as shown in Figure 3 and described in Table 2.

The water quality data for these sites are summarized in Table 16.

The water quality situation in Fairmont Creek remained the same as reported in the Phase I report[1]. The water upstream from the resort was very hard, but would be suitable for most purposes. High levels of total organic carbon, phosphorus and suspended solids were measured at site 0200122 on one occasion, because of construction upstream from the site[21], but generally these parameters were at very low levels.

The water downstream from the resort (site 0200123, Table 16) was highly mineralized and extremely hard because of the natural characteristics of the hot spring swimming pool water. The water would be unsuitable for domestic use and some industrial uses, and may be unsuitable for irrigation of sensitive crops[9,10]. Fecal coliform densities continued to be low downstream from the resort. Levels of chlorine that are toxic to aquatic life probably occur downstream from the hot spring pool discharges. However, a combination of natural factors, such as steep gradient, large increases in water temperature and precipitation of carbonates in the streambed due to the hot spring water, serves to make the creek unsuitable for aquatic life[1].

5.4 Conclusions and Recommendations

5.4.1 Conclusions

Arsenic was high in the Fairmont Resort hot spring water, and thus may also be high in Fairmont Creek.

The highly mineralized hot spring water renders lower Fairmont Creek unsuitable for domestic use, some industrial uses, and perhaps for the irrigation of salt-sensitive crops.

There may be chlorine residuals in lower Fairmont Creek that are toxic to aquatic life, but natural factors make the creek unsuitable for aquatic life.

5.4.2 Recommendations

An arsenic survey should be conducted during low flow to determine arsenic levels in the hot spring water and Fairmont Creek.

Routine monitoring for the effluents should include flow, fecal coliforms and chlorine residual for the swimming pool effluents. Monitoring of Fairmont Creek downstream from the resort should include fecal coliforms and total chlorine residual. Creek monitoring should be done during low flows. The recommended effluent and water quality monitoring program for the Fairmont Creek Basin is presented in Table 8.

6. WINDERMERE CREEK

6.1 Introduction

Windermere Creek drains a relatively small area (85 km^2) on the western slopes of the Stanford Range (Figure 3). The Stanford Range is notable for a large gypsum deposit centered on the Windermere Creek drainage[22]. The creek flows into Windermere Lake at Windermere. Flows near the mouth have ranged from 3 m^3/s during the spring freshet to 0.2 m^3/s during winter[3]. The creek is heavily used for water supply. There are 39 water licences totalling 2 814 dam^3/a for irrigation and 15.4 dam^3/a for domestic purposes.

6.2 Effluents and Non-point Sources

Western Gypsum Limited operates a gypsum quarry on the north side of Windermere Creek, as shown in Figure 3. The gypsum is drilled, blasted and reduced in a primary crusher at the quarry. The ore is then trucked to a plant for secondary crushing, screening and loading into railcars, just north of Invermere. Gypsum production was 556 000 t in 1976 and 653 000 t in 1977[23]. There is potential for increased gypsum production if additional markets can be found[24].

The only effluent from the quarry is surface runoff. Water quality monitoring on Windermere Creek (Section 6.3) showed that runoff from the quarry was causing high levels of dissolved and suspended gypsum in the creek in April 1976. This runoff is now settled in two small settling ponds (authorized by the Water Management Branch), prior to discharge to Windermere Creek[21]. Surface runoff from above the quarry is now diverted around the quarry.

Logging has also been conducted in the headwaters of Windermere Creek[1].

6.3 Water Quality

6.3.1 Presentation of Data

The Ministry of Environment monitored three sites on Windermere Creek, beginning in April 1976. The sites are described in Table 2 and their locations are shown in Figure 3.

The water quality data collected at these sites between April 1976 and April 1978 are summarized in Table 17.

6.3.2 Discussion

Table 17 shows that Windermere Creek contained relatively high levels of dissolved solids, hardness (mainly due to calcium) and sulphate. These results are caused by dissolved gypsum (calcium sulphate) from the large gypsum deposit in the Winderemere Creek basin. Dissolved solids were in the 500-1 000 mg/L range, and at that level they could have detrimental effects if used to irrigate salt-sensitive crops (8,10). Dissolved solids and sulphates exceeded the objective limits for drinking water (<500 mg/L, <250 mg/L respectively) and approached or exceeded the acceptable limit (1 000 mg/L, 500 mg/L respectively(9)). The limits for dissolved solids and sulphate in drinking water are based on the possibility of laxative effects and undesirable taste(8,9,10).

Windermere Creek water was very hard (415-855 mg/L as $CaCO_3$) and may be unsuitable for domestic or some industrial uses. For consumer acceptability, it is desirable to reduce hardness below 120 mg/L as $CaCO_3$(9,10).

During the spring freshet in April 1976, runoff from the Western Gypsum Limited gypsum quarry caused high levels of turbidity, phosphorus, sulphate and hardness (mainly due to calcium) in Windermere Creek (site 0200237). The runoff from the quarry is reported to be under control now with the diversion of surface runoff around the quarry and the installation of settling ponds(21). Occasional monitoring during the 1977 and 1978 freshets indicated that the quarry was not having an effect on Windermere Creek's water quality.

All the other parameters monitored in Windermere Creek were at acceptable levels. There were some abnormal Kjeldahl nitrogen (i.e., organic plus ammonia nitrogen) levels (0.5-2.0 mg/L) at all three sites on one occasion, in November 1976. There is no apparent explanation for these anomalous values. Kjeldahl nitrogen can be high when there are appreciable quantities of suspended organic matter containing organic nitrogen, but suspended solids were very low on this occasion (1-5 mg/L). If the nitrogen were present as organic nitrogen, it would be of no particular significance, but if present as ammonia, it could be harmful to aquatic life and could make the water unsuitable for domestic purposes. The abnormal Kjeldahl nitrogen levels were not due to residual ammonium nitrate explosives (used for blasting in the quarry) in drainage from the quarry, because the abnormal levels were measured both upstream and downstream from the quarry. In addition, nitrate, the main constituent in drainage containing residual explosives, was low at all sites.

6.4 Conclusions and Recommendations

6.4.1 Conclusions

Windermere Creek had high dissolved solids, sulphate and hardness due to drainage from the large gypsum (calcium sulphate) deposit in its drainage basin.

The levels of dissolved solids, sulphate and hardness may make the water unsuitable for domestic purposes, some industrial purposes, and for irrigation of salt-sensitive crops.

Runoff from the Western Gypsum Limited quarry caused high turbidity in Windermere Creek in the spring of 1976, but the runoff now appears to be under control.

Anomalous Kjeldahl nitrogen concentrations (organic plus ammonia nitrogen) were measured in Windermere Creek on one occasion.

6.4.2 Recommendations

Surveillance of the effectiveness of erosion and sediment control measures at the Western Gypsum Limited quarry should continue during the spring snowmelt period. If monitoring is deemed necessary, it should include sediment sources (suspended solids and flow) and Windermere Creek upstream and downstream from the sediment sources (suspended solids and turbidity). Source and stream monitoring should all be conducted at approximately the same time.

If resources permit, further investigation of the anomalous nitrogen values in Windermere Creek should be conducted during low flows. The recommended monitoring program for the Windermere Creek Basin is presented in Table 8.

7. RECOMMENDED MONITORING PROGRAM

The recommended effluent and water quality monitoring program for the Upper Columbia River Basin is summarized in Table 8. It is assumed that the water quality monitoring will be conducted by the Ministry of Environment and that the effluent monitoring will be conducted predominantly by the industries and municipalities, with occasional check-monitoring by the Ministry.

The water quality portion of the recommended program represents a substantial decrease in monitoring from the past program. This reduction is achieved by eliminating sites and parameters that are not significantly affected by existing waste discharges. We would also discontinue data collection at sites where there are adequate data available to define existing water quality.

8. WATER AVAILABILITY

8.1 Introduction

This chapter documents some of the water supply availability problems encountered in the Upper Columbia River basin.

Water availability problems may be caused by actual water shortages or by poor water quality, where the water is unfit or undesirable for the intended use. Water supplies are usually available, but their use may not be feasible because of the costs of pipelines, pumping, storage, drilling, treatment, etc.

The availability of water where there are water shortages often changes with time. Cancellation or abandonment of water rights, more efficient use of water, or more accurate flow records may result in water becoming available for further licencing. Consequently, persons interested in obtaining water rights on the water sources mentioned in this section should contact the Water Rights Branch, now known as the Water Management Branch, for the latest information on these sources.

The information on water shortages was compiled using the following sources: the water registers, water rights maps and files of the Water Rights Branch in Victoria; discussions with the staff of the Regional Office of the Water Rights Branch in Nelson; and water supply reports prepared by consultants and the Ministry of Environment.

8.2 Water Shortages

Water sources in the Upper Columbia River basin that have had or may have water shortages are shown in Figure 5 and listed in Table 18.

The water-short sources are the relatively small creeks, lakes and springs that are adjacent to the settlements and irrigable agricultural lands along the Columbia River valley. Irrigation and domestic use are the major uses of most of these sources.

Of the 30 water-short sources listed in Table 18, 15 are very small and provide less than 100 cubic decametres per annum (dam^3/a) of water. Goldie (3 346 dam^3/a), Windermere (2 830 dam^3/a) and Shuswap Creeks (2 146 dam^3/a plus 4 465 dam^3/a reserved for the fishery) are the most important water-short sources in the basin. Opportunities may exist for increasing the water supply capability of some of the water-short sources by increasing the storage capacity on the sources. The water in the Spillimacheen River and Bugaboo Creek, above the Spillimacheen hydro-electric development, is reserved for power generation, but the Water Act provides that water for domestic use and land improvement may still be obtained. Power generation is a non-comsumptive water use and thus there is ample water available in these two streams downstream from the power project.

The small water-short sources have been the most economical to develop because they are generally of good quality, gravity-supplied and close to water users. They have therefore been utilized to capacity. The large water sources in the basin, the Columbia River and its major tributaries (e.g., Dutch, Toby, Horsethief, Forster, Frances and Bugaboo Creeks, and the Spillimacheen River) have been used only relatively lightly for water supply. These larger sources may be distant from water users and may require pumping and treatment prior to use.

8.3 Water Quality

This section highlights the water quality problem areas in the upper Columbia River basin and their influence on water supply availability. The water quality of the basin is discussed in detail in sections 2.3, 3.3, 4.3, 5.3 and 6.3.

The Columbia system has low turbidity levels from Columbia Lake to Toby Creek. Downstream from Toby Creek turbidity increases, particularly during spring freshet, due to the inflow of turbid water from tributaries such as Toby and Horsethief Creeks. Treatment for removal of turbidity would probably be required prior to domestic and some industrial uses, at least during spring freshet, for Toby Creek, Horsethief Creek, and the Columbia River downstream from Toby Creek. Toby Creek may also have abnormal barium levels and further barium monitoring should be conducted before the water is used for domestic purposes. Sporadic episodes of fecal contamination in the Columbia River downstream from the Radium Waterworks District sewage treatment plant might necessitate partial or complete water treatment prior to domestic use. The proposed Kootenay River diversion at Canal Flats would increase turbidity in Columbia Lake, and could thus impose the removal of turbidity prior to certain uses of lake water.

Windermere Creek has high dissolved solids, sulphate and hardness due to drainage from a large gypsum deposit in its drainage basin, and may be unsuitable for domestic use, some industrial uses, and the irrigation of salt-sensitive crops. Lower Fairmont Creek is also highly mineralized (due to hot spring water) and is unsuitable for domestic use, some industrial uses and perhaps for the irrigation of salt-sensitive crops. Hot spring water and other natural sources have caused arsenic in lower Sinclair Creek to exceed drinking water standards and the water should not be used for drinking without the permission of the Ministry of Health. Goldie Creek, the water supply for the Village of Invermere, is reported to be turbid during the spring freshet, and Sixty-two Mile Creek, which supplies Edgewater, is alleged to be of poor quality due to contamination by cattle in the watershed[25].

AUTHORS

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FIGURE I
KOOTENAY REGION SHOWING THE UPPER COLUMBIA RIVER BASIN

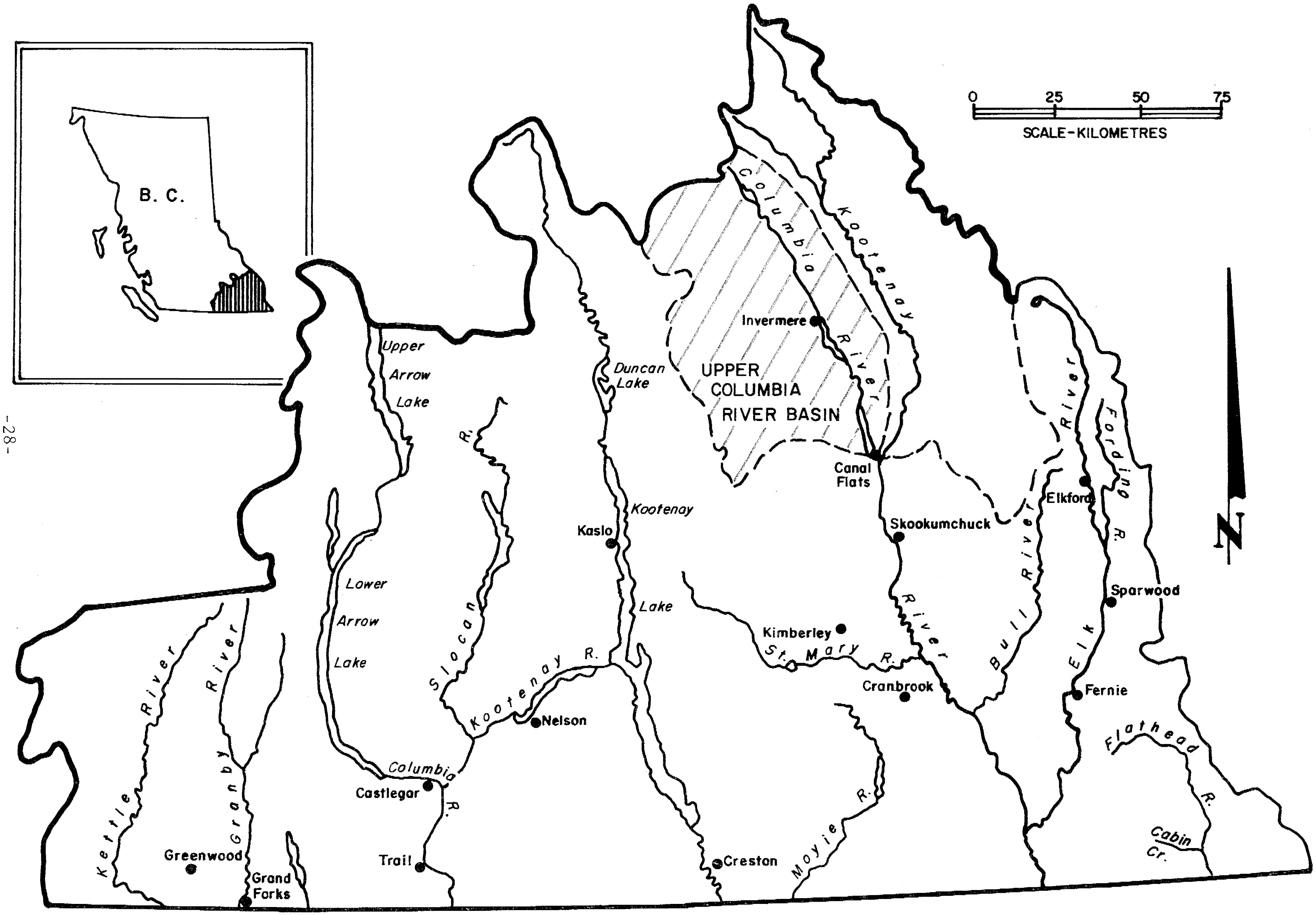
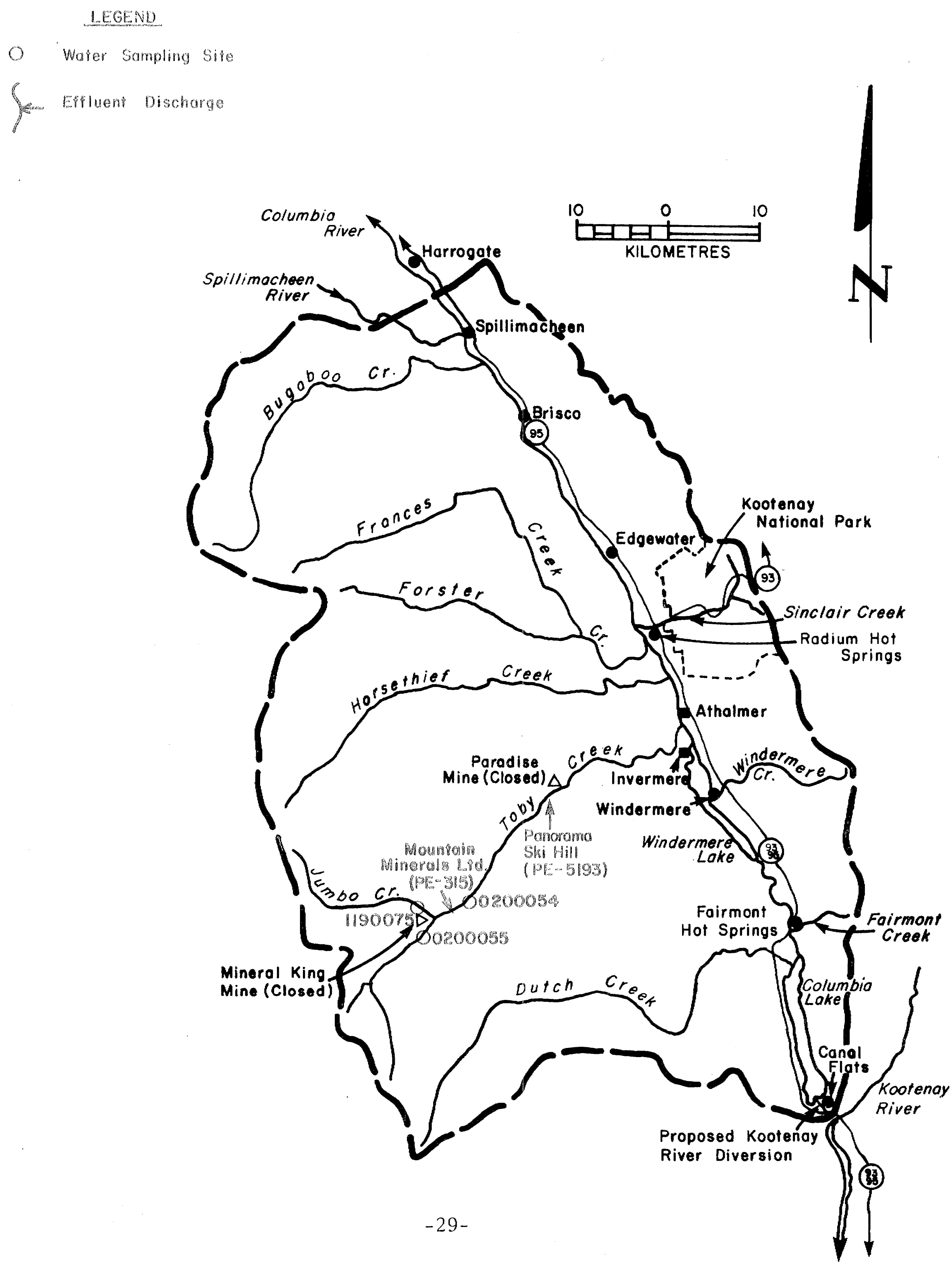


FIGURE 2
UPPER COLUMBIA RIVER BASIN



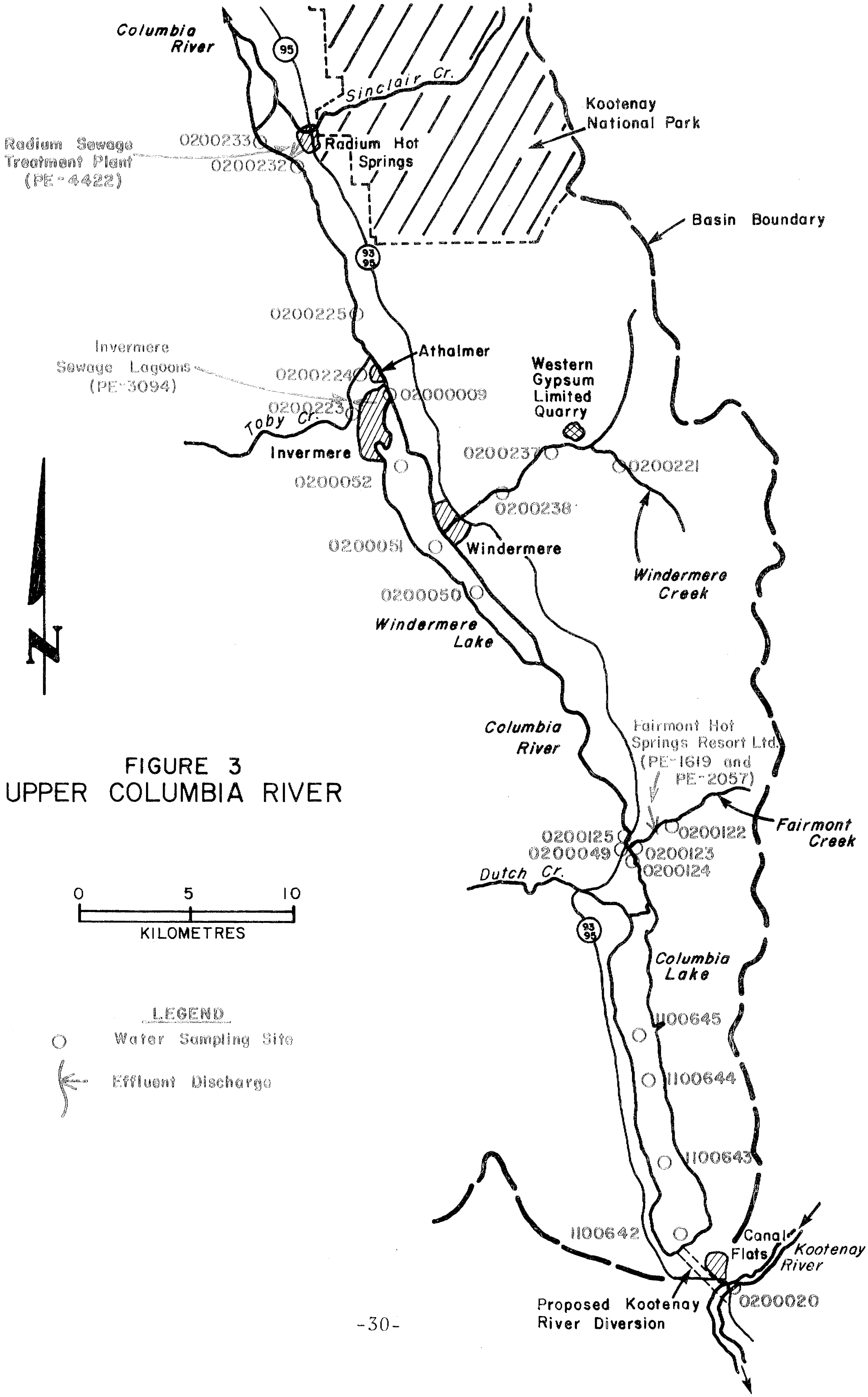


FIGURE 3
UPPER COLUMBIA RIVER

FIGURE 4
SINCLAIR CREEK BASIN

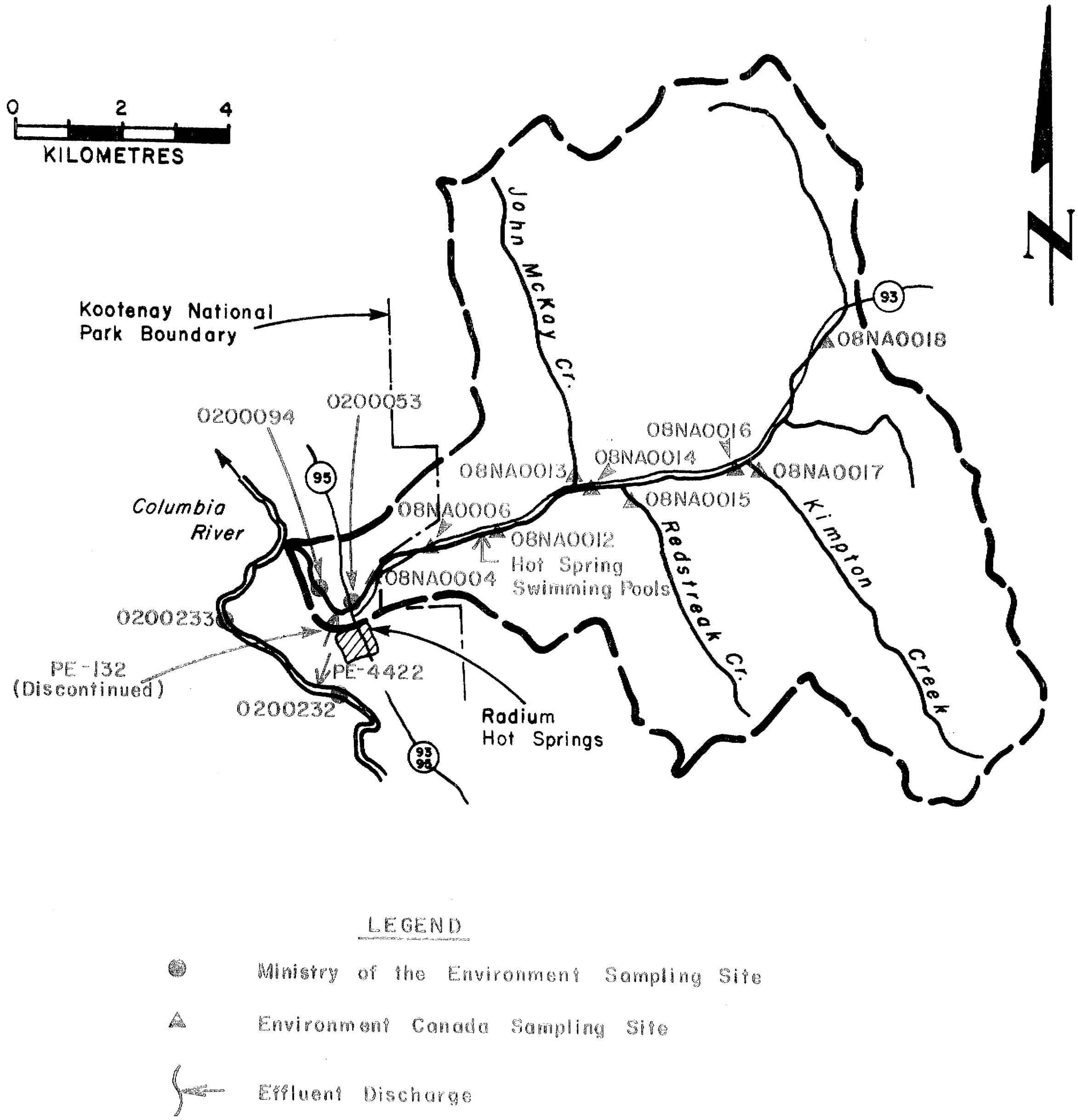


FIGURE 5

WATER SOURCES IN THE UPPER COLUMBIA RIVER BASIN WITH LIMITED WATER AVAILABILITY

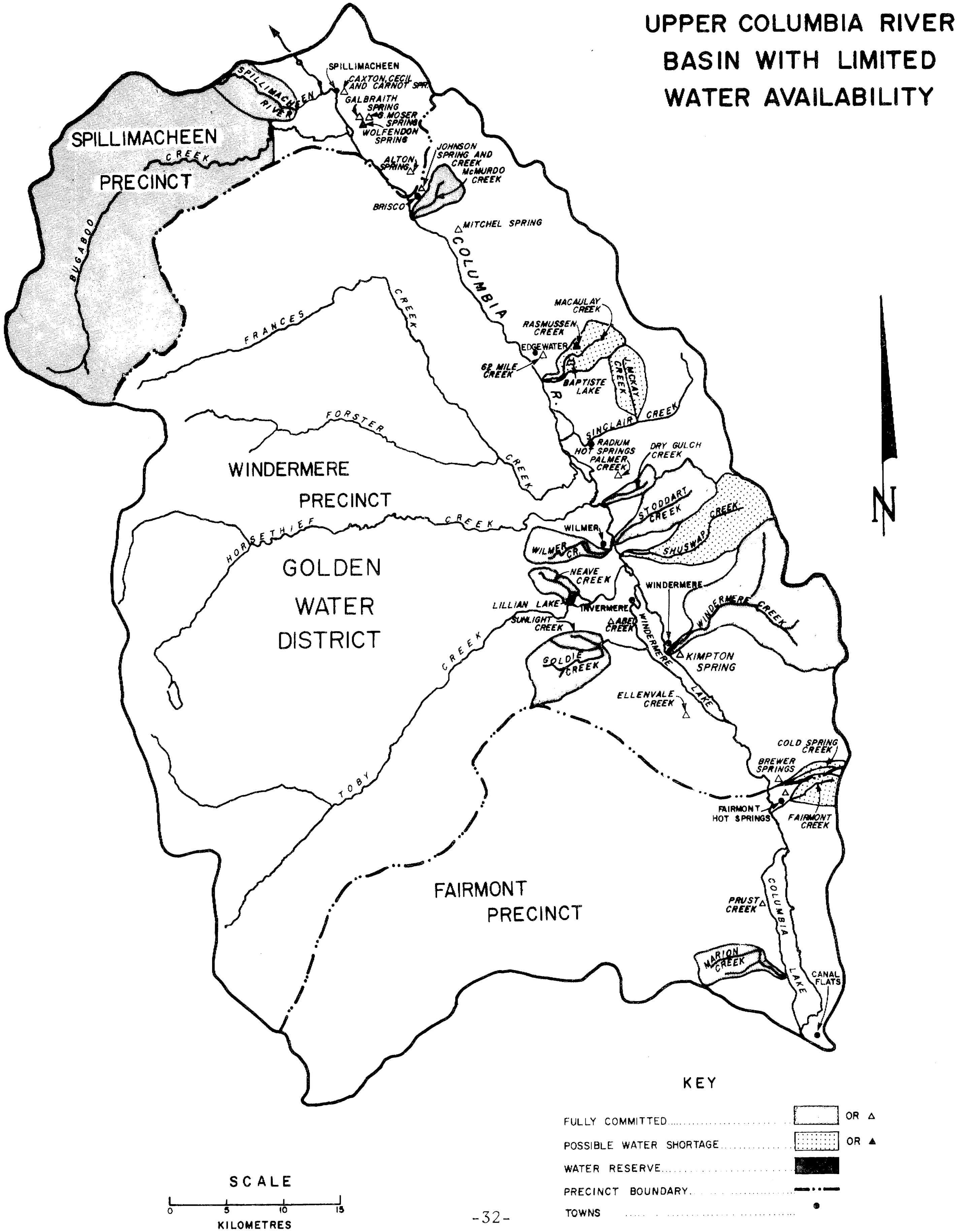


TABLE 1

EFFLUENT MONITORING RESULTS FOR INVERMERE AND RADIUM WATERWORKS DISTRICT SEWAGE TREATMENT PLANTS

Effluent		Invermere PE0309401				Radium Waterworks District PE0442201			
Sampling Period		Mar 77 - April 78				Jan 77 - April 78			
Parameter / Type of Value		Max.	Min.	Mean	N	Max.	Min.	Mean	N
BOD_5	mg/L	<10	<10	<10	8	96	29	59	9
Carbon, Total Organic	mg/L	22	15	18	3	92	44	67	6
Chlorine Residual	mg/L	0.1	0		4				
Coliforms, Fecal	MPN/ 100mL	>2 400	<2	29*	9	>240 000	2 400	38 000*	5
Flow Rate	m^3/d	572	545	558	2	662	303	428	3
Nitrogen, Ammonia	mg/L	16.5	0.2	7.4	8				
Nitrite/Nitrate	mg/L	5.1	0.9	3.2	8	0.13	<0.02	0.04	5
Organic	mg/L	2.5	0.8	1.7	5				
Total	mg/L	22.6	10.1	15.2	5	31	23	26	5
pH	pH Units	8.4	7.6	7.9	8	7.8	7.3	7.6	9
Phosphorus, Dissolved	mg/L	6.6	4.0	5.6	8	5.5	2.8	4.2	6
Total	mg/L	6.9	4.3	5.8	8	6.8	4.0	5.4	6
Solids, Dissolved	mg/L	488	377	462	8	435	342	406	6
Suspended	mg/L	18	1	5	8	117	25	62	9

All data are from Ministry of Environment's Data Bank, EQUIS.

N = Number of values.

* = Geometric mean.

TABLE 2

DESCRIPTION OF WATER SAMPLING SITES IN THE UPPER COLUMBIA RIVER BASIN

Site Number	Description
	Columbia Lake
1100642	Columbia Lake, south end, midlake.
1100643	Columbia Lake, south third, midlake.
1100644	Columbia Lake, midlength, midlake.
1100645	Columbia Lake, north third, midlake.
	Columbia River Between Columbia and Windermere Lakes
0200124	Columbia River just upstream from Fairmont Creek.
0200049	Columbia River at the Highway 93/95 bridge south of Fairmont Hot Springs (downstream Fairmont Creek).
0200125	Columbia River 0.2 miles west of Highway 93/95 bridge south of Fairmont Hot Springs (downstream Fairmont Creek).
	Windermere Lake
0200050	Windermere Lake, south end, midlake (opposite Johnson Creek).
0200051	Windermere Lake, mid length, midlake (opposite Windermere Stolen Church).
0200052	Windermere Lake, north end, midlake (opposite Abel Creek).
	Columbia River Downstream from Windermere Lake
0200009	Columbia River at Athalmer bridge (outlet of Windermere Lake).
0200225	Columbia River 2.5 km downstream from Toby Creek.
0200232	Columbia River just upstream Radium Waterworks District sewage treatment plant.
0200233	Columbia River 2 km downstream from Radium Waterworks District sewage treatment plant.

TABLE 2 (CONTINUED)

DESCRIPTION OF WATER SAMPLING SITES IN THE UPPER COLUMBIA RIVER BASIN

Site Number	Description
	Toby Creek
1190075	Jumbo Creek upstream from old Mineral King Mine.
0200055	Toby Creek upstream from old Mineral King Mine and Mountain Minerals Ltd.
0200054	Toby Creek downstream from old Mineral King Mine and Mountain Minerals Ltd.
0200223	Toby Creek upstream from Invermere sewage lagoons.
0200224	Toby Creek downstream from Invermere sewage lagoons.
	Sinclair Creek
0200053	Sinclair Creek upstream from the Radium sewage lagoons at the highway 95 crossing.
0200094	Sinclair Creek downstream from the Radium sewage lagoons.
	Fairmont Creek
0200122	Fairmont Creek upstream from Fairmont Hot Springs Resort Ltd. (150 m above culvert in road to trailer park).
0200123	Fairmont Creek at the confluence with the Columbia River.
	Windermere Creek
0200221	Windermere Creek upstream from Western Gypsum Ltd.'s quarry.
0200237	Windermere Creek just downstream from Western Gypsum Ltd.'s quarry.
0200238	Windermere Creek 3 km downstream from Western Gypsum Ltd.'s quarry.

TABLE 3

COLUMBIA LAKE WATER QUALITY, OCTOBER 1975 TO AUGUST 1976

Sampling Site		South End, Midlake 1100642				South Third, Midlake 1100643			
Parameter / Type of Value		Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	136	117	129	4	132	113	121	4
Carbon, Total Organic	mg/L	2	<1	1.3	3	3	<1	1.7	3
Color, TAC	T.A.C.			1	1			1	1
True	Color Units	5	<5	5	3	5	<5	5	3
Depth, Extinction	m	>3.7	>1.4		4	>4.6	2.7		3
Hardness, Total	mg/L	160	138	149	4	154	123	136	4
Nitrogen, Ammonia	µg/L	12	9	11	4	11	8	9	4
Nitrite/Nitrate	mg/L	<0.02	<0.02	<0.02	4	<0.02	<0.02	<0.02	4
Organic	mg/L	0.20	0.13	0.16	4	0.16	0.13	0.15	4
Total	mg/L	0.21	0.14	0.17	4	0.17	0.14	0.16	4
Oxygen, Dissolved	mg/L	11.6	9.0	10.5	4	12	8.5	10.4	4
pH	pH Units	8.5	7.8	8.2	5	8.5	8.2	8.3	5
Phosphorus, Dissolved	µg/L	<3	<3	<3	5	<3	<3	<3	5
Total	µg/L	9	4	6	4	8	4	6	4
Solids, Dissolved	mg/L	188	162	178	4	180	150	162	4
Suspended	mg/L	4	2	3	4	4	2	3.5	4
Temperature	°C	16	6.5	12.4	4	16.5	6	12.4	4
Turbidity	JTU	1.6	0.7	1.1	4	2.6	0.7	1.3	4

TABLE 3 (CONTINUED)

COLUMBIA LAKE WATER QUALITY, OCTOBER 1975 TO AUGUST 1976

Sampling Site		Midlength, Midlake 1100644				North Third, Midlake 1100643			
Parameter \ Type of Value		Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L			102	1	110	98	104	2
Carbon, Total Organic	mg/L			<1	1			2	1
Color, TAC	TAC							1	1
True	Color Units			<5	1			5	1
Depth, Extinction	m			5.8	1	>4.7	3.7		2
Hardness, Total	mg/L			103	1	129	105	117	2
Nitrogen, Ammonia	μg/L			6	1	21	10	16	2
Nitrite/Nitrate	mg/L			<0.02	1	<0.02	<0.02	<0.02	2
Organic	mg/L			0.03	1	0.13	0.11	0.12	2
Total	mg/L			0.04	1	0.14	0.13	0.14	2
Oxygen, Dissolved	mg/L			11.4	1	12	8.8	10.4	2
pH	pH Units			8.2	1	8.5	8.2	8.3	3
Phosphorus, Dissolved	μg/L			<3	1	3	<3	3	3
Total	μg/L			4	1	6	4	5	2
Solids, Dissolved	mg/L			124	1	148	122	135	2
Suspended	mg/L			1	1	2	2	2	2
Temperature	^{o}C			13	1	16.5	6.5	11.5	2
Turbidity	JTU			1	1	0.9	0.6	0.8	2

Data are from the Ministry of Environment's Data Bank, EQUIS.

N = Number of Values.

TABLE 4

COLUMBIA RIVER WATER QUALITY,
BETWEEN COLUMBIA AND WINDERMERE LAKES

Sampling Period		Aug. 75 - May 78				Dec. 75 - Aug. 76				Aug. 75 - May 78			
Sampling Site		Columbia River Upstream Fairmont Creek 0200124				Columbia River Downstream Fairmont Creek 0200049				Columbia River Downstream Fairmont Creek 0200125			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	153	88	116	6	144	86	107	5	158	96	118	12
Cadmium, Dissolved	μg/L									<0.5	<0.5	<0.5	6
Carbon, Total Organic	mg/L	8	<1	2.6	8	1	<1	1	3	7	<1	2.1	7
Coliforms, Fecal	MPN/ 100 mL			<2	1			7	1	8	<2	2.8*	6
Color, TAC	T.A.C.	2	1	1.5	2			2	1	1	<1	1	3
True	Color Units					5	5	5	3	5	<5	5	7
Copper, Dissolved	μg/L									<1	<1	<1	6
Hardness, Total	mg/L	176	96	126	10	162	92	118	5	183	111	136	8
Iron, Dissolved	mg/L									<0.1	<0.1	<0.1	6
Lead, Dissolved	μg/L									<1	<1	<1	6
Manganese, Dissolved	μg/L									30	<20	22	6
Nitrogen, Ammonia	μg/L	39	12	26	2	15	7	10	5	28	6	16	9
Nitrite/Nitrate	mg/L	0.05	<0.02	0.04	10	0.12	0.02	0.05	5	0.07	0.02	0.05	9
Organic	mg/L	0.15	0.15	0.15	2	0.13	0.01	0.05	5	0.12	<0.01	0.08	9
Total	mg/L	0.23	0.20	0.22	2	0.16	0.05	0.11	5	0.20	0.06	0.14	9
Oxygen, Dissolved	mg/L			12.6	1	11.2	9.4	10.6	4	12.6	8.3	10.5	5
% Saturation										101	86	94	4

TABLE 4 (CONTINUED)

COLUMBIA RIVER WATER QUALITY,

BETWEEN COLUMBIA AND WINDERMERE LAKES

Sampling Period		Aug. 75 - May 78				Dec. 75-Aug. 76				Aug. 75 - May 78			
Sampling Site		Columbia River Upstream Fairmont Creek 0200124				Columbia River Downstream Fairmont Creek 0200049				Columbia River Downstream Fairmont Creek 0200125			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
pH	pH Units	8.8	7.8	8.2	15	8.4	7.8	8.1	7	8.4	7.6	8.0	14
Phosphorus, Dissolved	µg/L	<3	<3	<3	2	<3	<3	<3	6	<3	<3	<3	9
Total	µg/L	18	5	11	10	11	4	7	5	15	5	8	9
Solids, Dissolved	mg/L	192	114	144	10	186	102	136	5	212	126	166	9
Suspended	mg/L	28	2	12	10	24	4	11	5	28	2	12	9
Temperature	°C	16	2	7.5	8	13	1	7.2	5	12.5	2.5	6.5	7
Turbidity	J.T.U.	8.4	1.9	5.2	2	10	1.8	4.4	5	10	2	5.8	5
Zinc, Dissolved	µg/L									<5	<5	<5	6

Data are from the Ministry of Environment's Data Bank, EQUIS.

N = Number of values.

* = Geometric mean.

TABLE 5

WINDERMERE LAKE WATER QUALITY, OCTOBER 1975 TO SEPTEMBER 1977

Sampling Site		South End Midlake, 0200050				Midlength, Midlake, 0200051				North End, Midlake, 0200052			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	117	92	103	11	118	89	107	11	124	98	109	10
Carbon, Total Organic	mg/L	4	<1	2.1	8	5	<1	2.4	8	5	<1	2.5	8
Chlorophyll a	µg/L	1.7	0.8	1.2	2	2.8	0.9	1.8	2	2	1.1	1.6	2
Coliforms, Fecal	MPN/ 100 mL	<2	<2	<2	2	<2	<2	<2	2	<2	<2	<2	2
Color, TAC	T.A.C.	6	2	3.7	3	4	<1	2.7	3	5	2	3.5	2
True	Color Units	5	<5	5	6	10	<5	5.8	6	5	<5	5	6
Copper, Dissolved	µg/L	2	<1	1	5	4	<1	2	6	<1	<1	<1	6
Total	µg/L	1	<1	1	2	2	1	2	2	1	<1	1	2
Depth, Extinction	m	>3.4	1.5		3	>4.3	2.4		3	5.8	3.7	5.0	3
Hardness, Total	mg/L	140	105	119	9	147	107	132	9	152	122	132	8
Iron, Dissolved	mg/L	<0.1	<0.1	<0.1	5	<0.1	<0.1	<0.1	6	<0.1	<0.1	<0.1	6
Total	mg/L	0.1	<0.1	0.1	2	<0.1	<0.1	<0.1	2	<0.1	<0.1	<0.1	2
Lead, Dissolved	µg/L	<1	<1	<1	5	<1	<1	<1	6	4	<1	2	6
Total	µg/L	<1	<1	<1	2	<1	<1	<1	2	<1	<1	<1	2
Manganese, Dissolved	µg/L	<20	<20	<20	2	<20	<20	<20	2	<20	<20	<20	2

Data are from the Ministry of Environment's Data Bank, EQUIS.

N = Number of values

TABLE 5 (CONTINUED)

WINDERMERE LAKE WATER QUALITY, OCTOBER 1975 TO SEPTEMBER 1977

Sampling Site		South End, Midlake. 0200050				Midlength, Midlake. 0200051				North End, Midlake, 0200052			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Nitrogen, Ammonia	µg/L	19	8	13	9	22	9	16	9	13	7	10	8
Nitrite/Nitrate	mg/L	0.04	<0.02	0.02	9	<0.02	<0.02	<0.02	9	<0.02	<0.02	<0.02	8
Organic	mg/L	0.53	0.03	0.18	9	0.25	0.01	0.15	9	0.27	0.07	0.14	8
Total	mg/L	0.59	0.04	0.20	9	0.27	0.03	0.16	9	0.28	0.08	0.16	8
Oxygen, Dissolved	mg/L	11.2	8.9	9.9	7	11.2	8.3	9.4	7	10.4	8.3	9.4	6
% Saturation		86	85	86	2	85	80	82	2	97	88	92	2
ph	pH Units	8.9	8.1	8.4	12	8.8	8.2	8.4	12	8.6	8.3	8.4	10
Phosphorus, Dissolved	µg/L	<3	<3	<3	9	<3	<3	<3	9	<3	<3	<3	8
Total	µg/L	11	5	7	9	8	5	7	9	9	5	7	8
Solids/Dissolved	mg/L	164	120	138	9	180	132	162	9	186	146	160	8
Suspended	mg/L	4	2	2.2	9	2	2	2	9	4	2	2.2	8
Temperature	°C	20	6	12.2	9	19	7	12.5	9	19	10	13.6	8
Turbidity	J.T.U.	4.3	0.4	1.3	9	3.2	0.5	1.2	9	1.5	0.4	0.8	8
Zinc, Dissolved	µg/L	<5	<5	<5	5	<5	<5	<5	6	<5	<5	<5	6
Total	µg/L	<5	<5	<5	2	<5	<5	<5	2	<5	<5	<5	2

TABLE 6

COLUMBIA RIVER WATER QUALITY DOWNSTREAM FROM WINDERMERE LAKE,

Sampling Site		Columbia River at Athalmer 0200009				Columbia River Downstream Toby Creek 0200225				Columbia River Upstream Radium Sewage Treatment Plant 0200232				Columbia River Downstream Sewage Treatment Plant 0200233			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	185	100	130	17	150	84	110	7	158	76	112	7	157	67	104	9
Cadmium, Dissolved	µg/L	<0.5	<0.5	<0.5	7	<0.5	<0.5	<0.5	3	<0.5	<0.5	<0.5	4	<0.5	<0.5	<0.5	5
Total	µg/L	<0.5	<0.5	<0.5	2	1.8	<0.5	1.1	2			<0.5	1	1.1	<0.5	0.8	2
Carbon, Total Organic	mg/L	3	<1	1.6	8	3	<1	1.7	7	5	<1	2.1	7	5	<1	1.8	9
Coliforms, Fecal	MPN/100 mL	11	<2	3.8*	4	49	<2	4.0*	6	17	2	4.1*	3	240	2	19*	8
Color, TAC	T.A.C.	3	1	2	4	3	2	2.5	2	3	2	2.3	3	3	2	2.3	3
True	Color Units	5	<5	5	9	5	<5	5	5	5	<5	5	4	5	<5	5	6
Copper, Dissolved	µg/L	4	<1	1	7	<1	<1	<1	3	<1	<1	<1	4	<1	<1	<1	5
Total	µg/L	<1	<1	<1	2	8	1	4	2			<1	1	4	1	2	2
Hardness, Total	mg/L	216	121	160	12	182	105	126	6	178	96	127	5	178	77	115	7
Iron, Dissolved	mg/L	0.1	<0.1	0.1	7	<0.1	<0.1	<0.1	3	<0.1	<0.1	<0.1	4	<0.1	<0.1	<0.1	5
Total	mg/L	0.1	<0.1	0.1	2	0.6	0.4	0.5	2			0.3	1	1.0	0.4	0.7	2
Lead, Dissolved	µg/L	4	<1	1	7	2	<1	1	3	<1	<1	<1	4	<1	<1	<1	5
Total	µg/L	5	<1	3	2	100	4	52	2			5	1	78	4	41	2
Manganese, Dissolved	µg/L	70	<20	32	7	<20	<20	<20	2	<20	<20	<20	4	<20	<20	<20	5
Total	µg/L	30	<20	25	2	30	<20	25	2			<20	1	20	20	20	2

Data are from the Ministry of Environment's Data Bank, EQUIS.

N = Number of values

* = Geometric mean

TABLE 6 (CONTINUED)

COLUMBIA RIVER WATER QUALITY DOWNSTREAM FROM WINDERMERE LAKE,

AUGUST 1975 to APRIL 1978

Sampling Site		Columbia River at Athalmer 0200009				Columbia River Downstream Toby Creek 0200225				Columbia River Upstream Radium Sewage Treatment Plant 0200232				Columbia River Downstream Sewage Treatment Plant 0200233			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Nitrogen, Ammonia	μg/L	109	7	29	13	35	8	10	7	36	<5	14	7	39	<5	14	9
Nitrite/Nitrate	mg/L	0.06	<0.02	0.02	13	0.13	0.03	0.06	7	0.2	0.05	0.09	7	0.2	0.05	0.08	9
Organic	mg/L	0.21	0.05	0.14	13	0.21	0.01	0.14	7	0.19	0.02	0.10	7	0.32	0.01	0.10	9
Total	mg/L	0.32	0.06	0.17	13	0.30	0.05	0.21	7	0.41	0.08	0.20	7	0.53	0.08	0.20	9
Oxygen, Dissolved	mg/L	12	8.2	10.1	7	10.7	9.5	10.1	2			12.6	1			12.2	1
% Saturation		95.8	74.5	87.4	5	103	74.2	88.6	2			103	1			102	1
pH	pH Units	8.6	7.6	8.2	19	8.3	7.8	8.1	8	8.3	8.1	8.2	7	8.3	8.1	8.2	9
Phosphorus, Diss.	μg/L	<3	<3	<3	11	3	<3	3	7	<3	<3	<3	7	<3	<3	<3	9
Total	μg/L	14	<3	9	13	57	6	18	7	90	6	24	7	135	6	31	9
Solids, Dissolved	mg/L	256	148	197	13	224	120	163	7	244	122	175	7	234	94	157	9
Suspended	mg/L	16	2	5.5	13	144	2	29	7	212	4	44	7	280	2	55	9
Temperature	°C	17	1	7.7	9	12	1	7.3	3			3.5	1	12	4	8.3	3
Turbidity	J.T.U.	3.6	0.5	1.8	9	22	1.4	8.8	3	3.2	0.9	2.3	3	23	1.9	7.8	4
Zinc, Dissolved	μg/L	<5	<5	<5	7	6	<5	5	3	<5	<5	<5	4	<5	<5	<5	5
Total	μg/L	7	<5	6	2	6	6	6	2			<5	1	9	5	7	2

TABLE 7

RANGE OF MAJOR IONS IN COLUMBIA LAKE, WINDERMERE LAKE AND THE COLUMBIA RIVER

Parameter	Range mg/L	Number of Values
Calcium, Dissolved	18 - 47	91
Chloride. Dissolved	<0.5 - 4.8	77
Fluoride, Dissolved	<0.1 - 0.1	57
Magnesium, Dissolved	7.6 - 24	90
Potassium, Dissolved	0.1 - 1.0	66
Silica, Dissolved	2.6 - 6.8	57
Sodium, Dissolved	0.9 - 4.8	68
Sulphate, Dissolved	10 - 55	79

Data are from the Ministry of Environment's Data Bank, EQUIS, using sites 0200009, 0200225, 0200232, 0200233, 0200050, 0200051, 0200052, 0200124, 0200049, 0200125, 1100642, 1100643, 1100644 and 1100645.

TABLE 8

RECOMMENDED EFFLUENT AND WATER QUALITY MONITORING FOR THE UPPER COLUMBIA RIVER BASIN

Sites \ Parameters	Arsenic, Total	Barium, Total	BOD_5	Chloride, Total Residual	Coliforms, Fecal	Flow Rate	Nitrogen, Ammonia	Nitrogen, Organic	pH	Solids, Suspended	Temperature	Turbidity	Zinc, Dissolved	Frequency	Period	Comments
<u>Fairmont Creek Basin</u>																
Fairmont Creek (0200122)	√				√										Low Flows, During Heavy Use of Pools	Arsenic monitoring may be stopped once arsenic sources and levels are established
Fairmont Creek (0200123)	√			√	√									3-4 Times/a		
Hot Spring Swimming Pool Effluent (PE 02057)	√			√	√	√										
<u>Windermere Creek Basin</u>																
Windermere Creek (0200221, 0200237 and 0200238)										√		√		As Required	Spring Snowmelt	Continued surveillance of suspended sediment from Gypsum Quarry
Gypsum Quarry Runoff						√				√						
Windermere Creek (0200221, 0200237 and 0200238)							√	√	√	√	√			Occasionally	Low Flows	Investigate anomalous nitrogen values
<u>Toby Creek Basin</u>																
Toby Creek (0200055) (0200054)		√							√	√	√	√	√	3-4 Times/a	Low Flows, Spring Snowmelt	Re Mountain Minerals discharge

TABLE 8 (CONTINUED)

RECOMMENDED EFFLUENT AND WATER QUALITY MONITORING FOR THE UPPER COLUMBIA RIVER BASIN

Sites \ Parameters	Arsenic, Total	Barium, Total	BOD_5	Chlorine, Total Residual	Coliforms, Fecal	Flow Rate	Nitrogen, Ammonia	Nitrogen, Organic	pH	Solids, Suspended	Temperature	Turbidity	Zinc, Dissolved	Frequency	Period	Comments
Toby Creek Basin (con'd)																
Mountain Minerals Ltd. Tailing Pond Effluent (PE00315)		✓				✓			✓	✓			✓	3 Times/a (Flow Daily) (Plus During Water Quality Monitoring)	June, August, October	Permit requirements
Toby Creek (0200223, 0200224)					✓									6 Times/a	Low Flows	Re Invermere sewage lagoons correlate with effluent monitoring
Toby Creek (0200223)		✓							✓	✓	✓	✓		Occasionally	Low Flows, Spring Freshet	Re suitability for domestic water supply
Invermere Sewage Lagoon Effluent (PE03094)			✓	✓	✓	✓				✓				Monthly (Flow Daily)	All Year	Permit requirements
Columbia River Basin																No further monitoring recommended
Columbia River (0200232, 0200233)					✓									6 Times/a	All Year	Re Radium Waterworks District Sewage Treatment Plant Discharge correlate with effluent monitoring
Radium Waterworks District Sewage Treatment Plant Effluent (PE04422)			✓		✓	✓				✓				Twice/Month (Flow Daily)	All Year	Permit requirements

TABLE 9

MOUNTAIN MINERALS LTD.'S TAILING POND EFFLUENT MONITORING RESULTS, JULY 1975 TO MAY 1978

Site Number		PE-0031501				Permit Limits PE-315	Pollution Control[15] Objective Levels
Parameter	Type of Value	Max.	Min.	Mean	No. of Values		Range
Alkalinity, Total	mg/L	100	64.5	80	4		
Barium, Dissolved	mg/L	<0.5	<0.5	<0.5	4		
Total	mg/L	1.3	<0.5	0.7	4		
Cadmium, Dissolved	µg/L	10	1.5	4.2	4		10-100
Total	µg/L			5.5	1		
Chloride, Dissolved	mg/L	0.5	<0.5	0.5	5		
Copper, Dissolved	µg/L	3	<1	2	4	50	50-300
Total	µg/L			10	1		
Flow Rate	m^3/d	6 100	980	3 200	3	1 310 Average May 15-Nov. 15	
Fluoride, Dissolved	mg/L	<0.1	<0.1	<0.1	5		2.5-10
Iron, Dissolved	mg/L	<0.1	<0.1	<0.1	4	0.30	0.3-1.0
Total	mg/L			0.2	1		

TABLE 9 (CONTINUED)

MOUNTAIN MINERALS LTD.'S TAILING POND EFFLUENT MONITORING RESULTS,
JULY 1975 TO MAY 1978

Site Number		PE-0013501				Permit Limits PE-315	Pollution Control[15] Objective Levels
Parameter	Type of Value	Max.	Min.	Mean	No. of Values		Range
Lead, Dissolved	µg/L	35	1	26	4	50	50-200
Total	µg/L			100	1		
Manganese, Dissolved	mg/L	1.32	0.15	0.52	4		0.1-1.0
Total	mg/L			0.34	1		
Nickel, Dissolved	µg/L	30	10	20	2		200-1 000
Total	µg/L			60	1		
Nitrogen, Nitrite/Nitrate	mg/L			0.13	1		10-25
pH	pH Units	8.0	7.7	7.9	9	6.5-8.5	6.5-10
Phosphorus, Total	mg/L			0.007	1		2-10
Solids, Dissolved	mg/L	908	290	446	8	2 500	2 500-5 000
Suspended	mg/L	23	2	11	8	50	25-75
Sulphate, Dissolved	mg/L	533	121	253	5	250	
Zinc, Dissolved	mg/L	1.12	0.61	1.05	5	3.0	0.2-1.0
Total	mg/L	3.59	0.61	1.62	4		

Data are from the Ministry of Environment's data bank, EQUIS or the Water Investigations Branch.

TABLE 10

JUMBO CREEK AND MINERAL KING MINE DRAINAGE MONITORING RESULTS

Site Description		Jumbo Creek Upstream Mineral King Mine 1190075		Mineral King Mine Drainage Portal #9 Level			Mineral King Mine Tailing Drainage	
Parameter	Date	Oct. 21/75	Aug. 4/76	May 25/76	June 29/76	Aug. 4/76	May 25/76	June 29/76
Alkalinity, Total	mg/L	76	45	265	146	265	203	108
Barium, Dissolved	mg/L						<0.5	
Total	mg/L						<0.5	
Calcium, Dissolved	mg/L	22	12	89				
Copper, Dissolved	µg/L	<1	<1					
Total	µg/L		<1					
Flow Rate	m^3/d			1200	1200	600	700	500
Hardness, Total	mg/L	94	50	451				
Lead, Dissolved	µg/L	<1	<1					
Total	µg/L		<1					
pH	pH Units	7.1	8.1	7.9	8.2	8.4	8.1	8
Solids, Dissolved	mg/L	102	62	564	614	668	246	260
Suspended	mg/L	2	16	2	4	4	8	4
Turbidity	J.T.U.	0.4	6.2					
Zinc, Dissolved	mg/L	<0.005	<0.005	0.96	0.84	0.80	0.20	0.18
Total	mg/L		<0.005	0.97	0.85	0.80	0.22	0.19
Magnesium, Dissolved	mg/L	9.6	4.9	56				

TABLE 11

UPPER TOBY CREEK WATER QUALITY, JULY 1975 to MAY 1978

Site Number		0200055				0200054			
Site Description		Toby Creek Upstream Mountain Minerals Ltd.				Toby Creek Downstream Mountain Minerals Ltd.			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	95	31	60	9	103	32	65	10
Barium, Dissolved	mg/L			<0.5	1	<0.5	<0.5	<0.5	3
Total	mg/L			<0.5	1	0.7	<0.5	0.6	3
Cadmium, Dissolved	μg/L	<0.5	<0.5	<0.5	6	<0.5	<0.5	<0.5	6
Chloride, Dissolved	mg/L	0.9	<0.5	0.6	6	0.5	<0.5	0.5	6
Copper, Dissolved	μg/L	4	<1	1	9	5	<1	1	9
Total	μg/L	5	<1	2	4	4	<1	2	5
Fluoride, Dissolved	mg/L	<0.1	<0.1	<0.1	6	<0.1	<0.1	<0.1	6
Hardness, Total	mg/L	105	48	75	4	128	52	82	4
Iron, Dissolved	mg/L	0.1	<0.1	0.1	5	<0.1	<0.1	<0.1	5
Lead, Dissolved	μg/L	1	<1	1	9	1	<1	1	10
Total	μg/L	7	<1	2	4	4	<1	3	4
Manganese, Dissolved	μg/L	<20	<20	<20	4	<20	<20	<20	6
Nickel, Dissolved	μg/L	<50	<10		3	<10	<10	<10	3
Nitrogen, Nitrite/ Nitrate	mg/L	0.36	0.07	0.16	5	0.34	0.08	0.15	6
pH	pH Units	8.7	7.3	8.0	15	8.6	7.4	8.0	16
Phosphorus, Total	μg/L	50	3	26	5	28	<3	12	8
Solids, Dissolved	mg/L	128	54	89	10	142	60	94	11
Suspended	mg/L	98	2	40	10	46	2	18	11
Sulphate, Dissolved	mg/L	25.5	8.8	14.8	6	23.7	9.3	15.2	6
Temperature	°C	9	1.5	5	8	8	0	4	9
Turbidity	J.T.U.	34	0.4	9.3	5	18	0.5	5.2	6
Zinc, Dissolved	μg/L	5	<5	5	9	7	<5	5	9
Total	μg/L	8	6	7	4	13	<5	9	5

All data are from the Ministry of Environment's Data Bank, EQUIS

N = Number of values

TABLE 12

LOWER TOBY CREEK WATER QUALITY, JUNE 1976 TO APRIL 1978

Site Description		Toby Creek Upstream Invermere Lagoons 0200223				Toby Creek Downstream Invermere Lagoons 0200224			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	133	115	124	6	133	90	120	7
Calcium, Dissolved	mg/L	32.8	14.5	24.9	4	30.4	14.2	20.5	5
Carbon, Total Organic	mg/L	2	<1	1.1	9	2	<1	1.1	10
Chloride, Dissolved	mg/L	0.5	<0.5	0.5	4	0.7	<0.5	0.5	5
Coliforms, Fecal	MPN/ 100 mL	2	<2	2*	7	8	<2	2.5*	11
Color, TAC	T.A.C.	3	<1	1.5	6	7	<1	2.3	6
True	Color Units	5	<5	5	3	5	<5	5	4
Hardness, Total	mg/L	152	68	115	4	137	67	93	5
Magnesium, Dissolved	mg/L	17.1	7.7	12.8	4	14.9	7.7	10.3	5
Nitrogen, Ammonia	μg/L	7	<5	5	9	56	<5	11	10
Nitrite/Nitrate	mg/L	0.18	0.09	0.14	9	0.18	0.04	0.12	10
Organic	mg/L	0.1	<0.01	0.04	9	0.12	<0.01	0.04	10
Total	mg/L	0.25	0.11	0.17	9	0.31	0.08	0.18	10
Oxygen, Dissolved	mg/L	14.8	11.1	12.6	4	13.1	11	12	5
pH	pH Units	8.2	8.0	8.1	9	8.3	7.6	8.1	11
Phosphorus, Dissolved	μg/L	<3	<3	<3	9	20	<3	8	10
Total	μg/L	30	<3	7	9	95	8	24	10
Potassium, Dissolved	mg/L			0.7	1			0.7	1
Sodium, Dissolved	mg/L			2.5	1			2.8	1
Solids, Dissolved	mg/L	192	78	161	9	196	82	147	10
Suspended	mg/L	54	1	9	9	130	1	24	10
Sulphate, Dissolved	mg/L	35.6	11.5	25.8	4	32.1	10.8	18.6	5
Temperature	^oC	6	0	1.6	4	8	0	3.7	6
Turbidity	J.T.U.	2.2	0.5	1.3	6	26	0.8	5.1	7

Data are from the Ministry of Environment's Data Bank, EQUIS.
N = Number of values
* = Geometric mean

TABLE 13

SINCLAIR CREEK WATER QUALITY, MARCH 1975 TO MAY 1978

Site Description		Upstream Radium Sewage Lagoons (Hwy. 95) 0200053				Downstream Radium Sewage Lagoons 0200094			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	178	110	151	6	178	130	161	5
Arsenic, Dissolved	µg/L	34	8	15	5				
Total	µg/L	15	8	11	3				
Calcium, Dissolved	mg/L	68	41	56	8	71	41	57	8
Carbon, Total Organic	mg/L	3	<1	1.4	7	3	<1	1.4	7
Chloride, Dissolved	mg/L	11.5	1.2	4.2	8	6.8	1.4	3.6	8
Coliforms, Fecal	MPN/ 100 mL	21	<2	3.8*	7	>2 400	7	102 *	8
Color, True	Color Units	5	<5	5	8	5	<5	5	7
Hardness, Total	mg/L	260	145	213	8	268	146	215	8
Magnesium, Dissolved	mg/L	22	10	18	8	22	10	18	8
Nitrogen, Ammonia	µg/L	11	<5	6	8	183	7	88	8
Nitrite/Nitrate	mg/L	0.13	0.06	0.09	8	0.14	0.06	0.09	8
Organic	mg/L	0.09	<0.01	0.04	8	0.10	<0.01	0.05	8
Total	mg/L	0.18	0.07	0.13	8	0.40	0.09	0.23	8
Oxygen, Dissolved	mg/L	12	10.4	10.9	6	11.7	10.1	10.8	4
% Saturation		101	95	98	4	101	91	98	4
pH	pH Units	9.1	8.1	8.5	14	9.1	8.1	8.5	13
Phosphorus, Dissolved	µg/L	5	<3	3	8	37	5	21	8
Total	µg/L	33	5	10	8	45	7	29	8
Sodium, Dissolved	mg/L	5.3	2.0	3.5	3	5.5	1.7	3.5	3
Solids, Dissolved	mg/L	328	164	260	8	340	162	261	8
Suspended	mg/L	22	2	5	8	36	2	9	8
Sulphate, Dissolved	mg/L	84	17	54	8	92	17	55	8
Temperature	°C	10	5.5	7.3	7	8.5	5	6.9	5
Turbidity	J.T.U.	12	0.5	3.8	4	11	0.5	3.2	5

Data are from the Ministry of Environment's Data Bank, EQUIS.
N = Number of values
* = Geometric mean

TABLE 14

DISSOLVED ARSENIC LEVELS IN THE SINCLAIR CREEK BASIN

Sampling Site	µg/L Range	Average	Number of Values
Sinclair Creek above Kimpton Creek (08NA0018)	<0.5-3.4	1.4	11
Kimpton Creek near mouth (08NA0017)	1 -7.6	3.7	11
Sinclair Creek below Kimpton Creek (08NA0016)	1.3-11	4.2	12
Redstreak Creek near mouth (08NA0015)	4.5-6.7	5.6	11
Sinclair Creek above John McKay Creek (08NA0014)	8 -52	23	11
John McKay Creek at mouth (08NA0013)	0.7-1.4	1.1	12
Sinclair Creek above hot spring pools (08NA0012)	8 -58	22	12
Sinclair Creek below hot spring pools (08NA0006)	14-100	44	12
Sinclair Creek at Canyon Campground (08NA0004)	15-83	43	14

Data provided by the Water Quality Branch, Environment Canada, References 16 and 17.

TABLE 15

FAIRMONT HOT SPRINGS RESORT LTD.'S EFFLUENT MONITORING RESULTS,

AUGUST 1975 TO FEBRUARY 1978

Sampling Site		Septic Tank and Sauna Bath Effluent PE 0161901				Hot Spring Swimming Pool Effluent PE 0205701				Hot Spring Swimming Pool Effluent PE 0205702			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L					450	525	437	4				
BOD_5	mg/L	159	72	115	5								
Carbon, Total Organic	mg/L	121	27	67	6	48	2	14	6	12	2	6	4
Chloride, Dissolved	mg/L							26	1				
Chlorine, Residual	mg/L					0.7	0	0.2	8	0.6	0.1	0.3	4
Coliforms, Fecal	MPN/ 100 mL	>2.4 x 10^6	>0.24 x 10^6	1.1 x 10^6*	4	<2	<2	<2	6	<2	<2	<2	3
Flow Rate	m^3/d	223	73	135	4	418	110	274	4	396	110	226	4
Mercury, Total	µg/L							<0.05	1				
Nitrogen, Ammonia	mg/L	24.2	9.1	17.0	6								
Nitrite/Nitrate	mg/L	<0.02	<0.02	<0.02	6			0.1	1				
pH	pH Units	7.6	6.9	7.2	8	7.8	6.9	7.3	12	7.9	7.6	7.8	4
Solids, Dissolved	mg/L	1 445	266	512	6	1 760	1 466	1 557	6	1 948	1 590	1 780	4
Suspended	mg/L	104	29	65	7	24	1	6.2	6	384	2	12.5*	4
Sulphate, Dissolved	mg/L							623	1				
Temperature	°C	33	15	22	3	34	28	31	6	37	29	33	2
Turbidity	J.T.U.					0.6	0.2	0.3	6				

Data are from the Ministry of Environment's data bank, EQUIS.
N = Number of values
* = Geometric mean

TABLE 16

FAIRMONT CREEK WATER QUALITY, AUGUST 1975 TO MAY 1978

Sampling Site		Upstream Fairmont Hot Springs Resort 0200122				Downstream Fairmont Hot Springs Resort 0200123			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	178	115	142	4	218	206	212	4
Calcium, Dissolved	mg/L	116	24	50	9	226	125	158	9
Carbon, Total Organic	mg/L	38	<1	1.6*	8	2	<1	1.4	8
Chloride, Dissolved	mg/L	9.6	<0.5	2.9	9	29	13	18	9
Chlorine, Residual	mg/L							0	1
Coliforms, Fecal	MPN/ 100 mL	5	<2		2	5	<2		2
Hardness, Total	mg/L	453	119	217	9	938	495	638	9
Magnesium, Dissolved	mg/L	40	14	22	9	91	44	59	9
Nitrogen, Ammonia	μg/L			<5	1			6	1
Nitrite/Nitrate	mg/L	0.14	0.06	0.12	9	0.09	0.02	0.06	9
Organic	mg/L			<0.01	1			0.10	1
Total	mg/L	0.15	0.14	0.14	2			0.18	1
pH	pH Units	8.5	7.0	7.9	13	8.3	8.0	8.1	13
Phosphorus, Dissolved	μg/L			<3	1			3	1
Total	μg/L	624	<3	6*	9	15	<3	6	9
Sodium, Dissolved	mg/L	1.7	0.9	1.3	2	15	11	13	2
Solids, Dissolved	mg/L	632	128	265	9	1 338	734	904	9
Suspended	mg/L	1 284	2	6.3*	9	37	2	8	9
Sulphate, Dissolved	mg/L	217	6.2	61	9	712	292	415	9
Temperature	°C	18	2	7.6	8	17	5	11	7

Data are from the Ministry of Environment's data bank, EQUIS.

N = Number of values

* = Geometric mean

TABLE 17

WINDERMERE CREEK WATER QUALITY, APRIL 1976 TO APRIL 1978

Sampling Site		Upstream Gypsum Quarry 0200221				Just Downstream Gypsum Quarry 0200237				3 km Downstream Gypsum Quarry 0200238			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	171	164	168	4	166	161	164	4	165	156	162	4
Aluminum, Dissolved	µg/L	<10	<10	<10	4	<10	<10	<10	4	<10	<10	<10	4
Arsenic, Dissolved	µg/L	<5	<5	<5	4	<5	<5	<5	4	<5	<5	<5	4
Cadmium, Dissolved	µg/L	<0.5	<0.5	<0.5	4	<0.5	<0.5	<0.5	4	<0.5	<0.5	<0.5	4
Calcium, Dissolved	mg/L	122	144	118	6	282	139	187	7	192	145	166	5
Total	mg/L	122	114	118	5	411	140	208	6	178	148	162	4
Carbon, Total Organic	mg/L	2	<1	1.2	4	3	<1	1.8	4	1	<1	1	4
Chloride, Dissolved	mg/L	0.9	0.6	0.8	4	1.1	0.7	0.9	4	1.1	0.7	0.9	4
Color, True	Color Units	5	<5	5	5	5	<5	5	6	<5	<5	<5	4
Copper, Dissolved	µg/L	<1	<1	<1	4	<1	<1	<1	4	<1	<1	<1	4
Fluoride, Dissolved	mg/L	0.36	0.26	0.32	4	0.39	0.27	0.33	4	0.39	0.29	0.34	4
Hardness, Total	mg/L	443	415	429	5	855	477	606	6	600	502	546	4
Iron, Dissolved	mg/L	<0.1	<0.1	<0.1	4	<0.1	<0.1	<0.1	4	<0.1	<0.1	<0.1	4
Lead, Dissolved	µg/L	<1	<1	<1	4	<1	<1	<1	4	2	<1	1	4
Magnesium, Dissolved	mg/L	34	31	33	5	37	32	35	6	38	34	35	4
Manganese, Dissolved	µg/L	<20	<20	<20	4	<20	<20	<20	4	<20	<20	<20	4
Nickel, Dissolved	µg/L	<10	<10	<10	4	<10	<10	<10	4	<10	<10	<10	4

Data are from the Ministry of Environment's data bank, EQUIS.
N = Number of values

TABLE 17 (CONTINUED)

WINDERMERE CREEK WATER QUALITY, APRIL 1976 TO APRIL 1978

Sampling Site		Upstream Gypsum Quarry 0200221				Just Downstream Gypsum Quarry 0200237				3 km Downstream Gypsum Quarry 0200238			
Parameter	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Nitrogen, Nitrite/Nitrate	mg/L	0.14	0.06	0.11	4	0.13	0.10	0.12	4	0.12	0.08	0.10	4
Kjeldahl	mg/L	2.0	0.01	0.5	4	0.52	0.01	0.15	4	2.0	0.02	0.5	4
Total	mg/L	2.1	0.07	0.6	4	0.65	0.11	0.27	4	2.1	0.11	0.6	4
pH	pH Units	8.3	8.0	8.1	6	8.3	8.1	8.2	7	8.3	8.1	8.2	4
Phosphorus, Total	µg/L	4	<3	3	5	270	<3	52	6	5	<3	4	4
Potassium, Dissolved	mg/L	1	0.7	0.8	4	0.8	0.6	0.7	4	0.9	0.7	0.8	4
Silica, Dissolved	mg/L	8.3	5.9	6.9	5	6.9	6.1	6.4	6	7	6.3	6.6	4
Sodium, Dissolved	mg/L	2	1.6	1.9	4	2.1	1.6	2.0	4	2.2	1.8	2.0	4
Solids, Dissolved	mg/L	606	548	575	4	848	634	746	4	822	710	760	4
Suspended	mg/L	5	1	2.2	5	3	2	2.4	5	6	1	3	5
Sulphate, Dissolved	mg/L	268	236	259	6	697	300	446	7	454	334	392	5
Turbidity	J.T.U.	1	0.3	0.5	5	464	0.4	72	7	2.2	0.6	1.2	5
Zinc, Dissolved	µg/L	<5	<5	<5	4	<5	<5	<5	4	<5	<5	<5	4

TABLE 18

WATER SOURCES WITH LIMITED WATER AVAILABILITY IN THE UPPER COLUMBIA RIVER BASIN

Locality	Water Source†	No. of Licences	Quantity*	Purpose	Comments
Columbia Lake	Marion Creek	3	3.3 789	Domestic Irrigation	Fully committed during irrigation season, 2 refusals of irrigation water.
	Prust Creek	2	1.7 44	Domestic Irrigation	Fully committed, except for small domestic licences.
Fairmont Hot Springs	Fairmont Creek	4	93 211	Irrigation Industrial	Possible water shortage in summer, licenced demand approximately equal to low flow in creek, supplies Fairmont Hot Springs Resort development.
	Cold Stream Creek	9	344 216	Domestic Irrigation	Possible water shortage in summer, licenced demand approximately equal to low flow in creek, some irrigation water refused, supplies Fairmont Hot Springs Resort development.
	Fairmont Hot Springs	2	763	Mineral Baths	Fully committed, Fairmont Hot Springs Resort.
	Brewer Springs	1	1.2	Domestic	Fully committed, except for domestic purposes, one refusal of irrigation water.
Windermere Lake	Ellenvale Creek	1	16.6 74	Domestic Irrigation	Fully committed.
Windermere	Windermere Creek	39	15.4 2 814	Domestic Irrigation	Fully committed during April, May and June, water quality is poor for domestic purposes (hardness & turbidity).
	Kimpton Spring	1	5	Domestic	Fully committed, one refusal of domestic water.
Invermere	Goldie Creek	9	2 820 526	Domestic Irrigation	Fully committed from July 15 to May 15, Village of Invermere & Westside Irrigation District are major licencees, water turbid during spring freshet.
	Sunlight Creek	3	2.5 307	Domestic Irrigation	Fully committed, 3 refusals of water for domestic and irrigation purposes.
	Abel Creek	1	16.6	Domestic	Fully committed

TABLE 18 (CONTINUED)

WATER SOURCES WITH LIMITED WATER AVAILABILITY IN THE UPPER COLUMBIA RIVER BASIN

Locality	Water Source†	No. of Licences	Quantity*	& Purpose	Comments
Windermere Lake (Con'd)	Lillian Lake and Tributaries (Neave Creek)	5	3.3 95	Domestic Irrigation	Fully committed except for limited domestic use, 3 refusals of irrigation water.
Wilmer	Wilmer Creek and Lake	4	1.7 598	Domestic Irrigation	Fully committed except for freshet (May 15 to June 30).
	Stoddart Creek	25	64 360	Domestic Irrigation	Fully committed, 893 dam^3/a reserved for fishery, one refusal of water.
	Shuswap Creek	5	18.2 2 128	Domestic Irrigation	Possible water shortage, licenced demand plus water reserved for fishery (4 465 dam^3/a) approximately equal to average low flow in summer
Radium Hot Springs	Dry Gulch Creek	30	46 1.5 893	Domestic Irrigation Land Improvment	Fully committed, 4 refusals of water.
	Palmer Creek	3	3.3 36	Domestic Irrigation	Fully committed.
	John McKay Creek	No Licences in National Park	Water supply for Kootenay National Park and Radium Waterworks District		Possible water shortage at low flow.
Edgewater	62 Mile Creek	10	107	Domestic	Fully committed, 2 refusals of domestic water, water quality alleged to be poor due to contamination by cattle, supplies Edgewater Improvement District.
	MacAulay Creek (and Baptiste Lake)	12	333 356	Domestic Irrigation	Fully committed, storage provided in Baptiste Lake, supplies Edgewater Improvement District.

TABLE 18 (CONTINUED)

WATER SOURCES WITH LIMITED WATER AVAILABILITY IN THE UPPER COLUMBIA RIVER BASIN

Locality	Water Source†	No. of Licences	Quantity*	Purpose	Comments
	Rasmussen Spring	1	3.3 3.1	Domestic Irrigation	Possible water shortage, storage necessary.
Brisco	McMurdo Creek	7	1.7 464.	Domestic Irrigation	Fully committed, except for freshet flows, storage must be provided with diversion from storage only.
	Johnson Spring and Creek	3	0.8 17.7	Domestic Irrigation	Fully committed, one refusal of irrigation water.
	Alton Spring	4	1.7 3.2	Domestic Irrigation	Fully committed.
	Mitchell Spring	1	37.	Domestic and Irrigation	Fully committed, insufficient water for irrigation.
Spillimacheen	Spillimacheen River, Bugaboo Creek and Their Tributaries	3	498. 290 200.	Industrial Power	Unrecorded water reserved for Spillimacheen River Power Project (1953), Bugaboo Creek diverted to Spillimacheen River. Water may be obtained with the consent of the Minister of Environment.
	Galbraith Spring	2	1.7	Domestic	Fully committed.
	Wolfendon Spring	1	0.6	Irrigation	Possible water shortage.
	Gmoser Spring	1	0.8	Domestic	Fully committed, one refusal of domestic and irrigation water.
	Caxton, Cecil and Carnot Springs	1	1.7 4.9	Domestic Irrigation	Fully committed.

† Water sources are located in the Golden Water District, Fairmont, Windermere and Spillimacheen Precints.

* Values are in cubic decametres per annum (dam^3/a).