MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

FINLAY-OMINECA AREA

LOWER FINLAY SUB-BASIN WATER QUALITY ASSESSMENT

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SUMMARY

This report reviews existing water quality data for the Lower Finlay Sub-basin in the Finlay-Omineca area (refer to Figures 1 and 2 for location). Information was available on Haworth, Chesterfield, and Quentin Lakes in Kwadacha Park, the lower Finlay River below Ware, and its main tributaries (Paul River, Akie River, and Del Creek). The sub-basin is sparsely populated and undeveloped at present. Sizable mineral and timber development plans have been scheduled to commence in the near future, although delays can be expected due to the current economic slow-down.

The main issues relating to water quality in the Lower Finlay Sub-basin are the naturally high mercury content in some fish and the potential for increases in heavy metals and other substances as a result of proposed industrial development. Extensive logging activity and Cyprus Anvil's Cirque project, a proposed lead-zinc mine on the Paul River, are specific concerns. There are no licensed water withdrawals or permitted waste discharges in the sub-basin at present.

The levels of mercury in water, fish, and humans in the Williston Lake watershed have been under investigation by Health and Welfare Canada since 1976. Data obtained in 1981 resulted in this agency issuing a precautionary warning against local native Indian consumption of Dolly Varden from the Finlay River. The recommendation was directed primarily at native Indians who traditionally consume large quantities of fish. Results of the 1981 Health and Welfare Canada surveillance program in the Williston Lake area also showed that no medical anomalies existed with respect to the local inhabitants. Mercury levels should be monitored in fish tissue in any area of the sub-basin that is scheduled for development (e.g., Paul River drainage). The responsibility for mercury analysis should be that of the developer.

Other investigations that should be conducted during impact assessments include:

- Effects of nitrogen losses from explosives use as outlined in Pommen (1983)[1].
- Acid producing potential of the underground workings, waste rock, and tailings.
- Existing and potential radiation levels.
- Groundwater quality.

No water quality monitoring by the Ministry of Environment is recommended at this time.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

The Lower Finlay Sub-basin is one of three priority locations in the Finlay-Omineca area (Figure 1) which have been selected for water quality assessments and the development of water quality objectives. The Upper Finlay Sub-basin and Williston Lake within the Mackenzie District Municipality are examined in separate reports. The locations of the assessment areas are shown in Figure 2.

The Finlay River below the village of Ware drains a mountainous area of 8000 km^2 located in a remote region of the Williston Lake watershed (Figure 3). Flowing southward, the lower Finlay River divides the sub-basin into two areas. The largest portion of the drainage lies to the east within the Muskwa Range of the Rocky Mountains, while the remainder drains the Finlay Range to the west. The region is very sparsely populated and virtually undeveloped at this time. The village of Ware, with less than two hundred inhabitants, is the only settlement. No public roads exist, although an industrial road was constructed along the lower Finlay River in 1981. This road can be reached only by a secondary road from Ingenika on Williston Lake during the summer months. The planned development of forest and mineral resources will likely provide access to much of the sub-basin over the next decade.

A belt of barite-sulphide occurrences with associated lead-zinc-silver mineralization has been identified within a north-westerly oriented trough extending over 80 km through the sub-basin. Deposits in the northern-most section of the drainage lie within the confines of Kwadacha Provincial Park. Further south, several large barite deposits are currently under exploration in what is now known as the Akie lead-zinc district (Figure 3). The main activity is now being directed at Cyprus Anvil Mining Corporation's Cirque property in the headwaters of the Paul River, which enters the Finlay River 18 km downstream from Ware.

2. HYDROLOGY

The Finlay River flows southeast through the Lower Finlay Sub-basin into the north end of Williston Lake. The main tributaries are (north to south) the Kwadacha River, Paul River, Akie River, and Pesika Creek.

Hydrometric data from Water Survey of Canada are available from three locations in the sub-basin: the Kwadacha River near Ware, the Finlay River above the Akie River confluence, and the Akie River (for station locations refer to Figure 4). Approximately 40 percent of the total Finlay River discharge entering Williston Lake originates from the Lower Finlay Sub-basin. The mean annual daily discharge at the Finlay River station (1600 km^2 drainage area) is 267 m^3/s, with a range of 34 m^3/s to 1320 m^3/s[2]. The seasonal flow pattern shows a period of low run-off during winter (November to May), followed by peak flows during spring melt which typically begins in May.

Recent baseline environmental studies for the proposed Cyprus Anvil lead-zinc mine in the upper Paul River watershed included monitoring stream flow approximately 1 km above the mine at site G-9 shown on Figure 4 (site planned for a reservoir). The headwater location of the minesite is demonstrated by the Paul River drainage area upstream of this point being only 63.3 km^2. Hence, the capacity of the receiving waters for accepting mine wastes and maintaining desired water quality may be low.

SIGMA Environmental Consultants, for Cyprus Anvil, monitored flow on the Paul River from March 1981 to May 1982. However, a continuous daily record is only available for the period June 1981 to December 1981. In 1981, the minimum daily discharge recorded was 168 L/s (December 31) and the lowest monthly mean was 221 L/s (also for December). SIGMA suggested that the similarity of low flows found in both monitoring years demonstrated that extended periods of unusually cold temperatures (as occurred in the winter

3. WATER USES

3.1 INTRODUCTION

The present level of water use within the Lower Finlay Sub-basin is minimal due to the lack of development and an exceptionally low population density. There are a few residents near the mouths of the Paul River and the Akie River, and there are likely several other trappers, prospectors, and guide-outfitters in the area on a permanent or part-time basis. Domestic water withdrawals from these and other sources (e.g., Cyprus Anvil's Finbow base camp on the Finlay River) are negligible. The people associated with mining and logging companies may eventually be the principal users of water resources in the sub-basin.

Existing and potential water uses in the sub-basin are discussed below.

3.2 RECREATION

Water based recreational activity is limited to fishing in the several lakes and major tributaries within the drainage. Understandably, angling pressure is relatively light due to the restricted access to the region. As resource development progresses, however, worker influx and a new network of roads will result in a sharp increase in sport fishery demand. Secondary roads now exist along the lower Finlay River and Paul River systems to facilitate exploration of Cyprus Anvil's Cirque property (these routes are not generally accessible from other areas except with the use of specialized vehicles).

The importance of fisheries stocks as a food source for the local natives is also evident and is addressed in Section 3.3.

the exception of the large unnamed tributary to the north, 9 km upstream from the confluence of the Paul River and Finlay River. Fish sampling was done by electro-shocker in May and September, 1981. Dolly Varden char was the most abundant fish species and was also most widely distributed throughout the river system[(3)].

SIGMA also investigated the extent of native food fishing in the Paul River area. According to Ware Band Chief, Mr. E. McCook, most of the routine food fishing takes place in the small local lakes, and to a lesser extent in the lower Finlay River and its tributaries[(3)]. The lakes are fished year-round, while the Finlay River and tributaries are usually fished from September to freeze-up. Recently, native consumption of fish has been of some concern because of higher than normal mercury levels identified in several fish species within the Williston Lake drainage, particularly in Dolly Varden from the lower Finlay River. In 1981, Health and Welfare Canada advised local native Indians, whose diet can contain a large quantity of fish, that Dolly Varden taken from the Finlay River should not be consumed[(5)]. The level of compliance with this precautionary warning is unknown, although the Chief of the Ware Band has reported a reduction in fishing effort in the river.

The mercury issue is discussed in more detail in Section 5.2.1.

3.4 WITHDRAWALS

There are no existing water licenses or applications within the Lower Finlay Sub-basin. Although there may be some minor withdrawal associated with an active placer lease immediately downstream from Ware (Figure 4), the absence of a water license, approval, or application implies that this is a small, hand operation. The only future withdrawals expected to be of any significance will likely be located in the headwaters of major tributaries to the lower Finlay River to service mine operations within the Akie lead-zinc district.

4. WASTE DISCHARGES

There are no licensed waste discharges in the Lower Finlay Sub-basin. However, as proposed mining and logging schemes are activated, industrial and associated domestic waste discharges are expected to increase markedly.

4.1 CYPRUS ANVIL MINING CORPORATION: CIRQUE PROJECT

Five sizable lead-zinc deposits were identified in the sub-basin in 1977, by a joint venture between Cyprus Anvil Mining Corporation and Hudson's Bay Oil and Gas Company Limited (for locations see Figure 3). One of these deposits lies within Kwadacha Park, and although the economic potential appears to be good, development is prohibited at this time. Exploration drilling has been most extensive on the Cirque property and has indicated ore reserves in excess of 40 million tonnes(6). Cyprus Anvil has compared the potential magnitude of the Cirque project and nearby properties with their sizable lead-zinc operation at Faro in the Anvil District of Yukon(7).

An environmental impact assessment data report was submitted to Cyprus Anvil by SIGMA Environmental Consultants at the completion of their 1981 field studies. Stage I and Stage II reports necessary for mine approval have not been prepared as yet. These investigations, along with the original mine construction schedule calling for full operation by 1986, are being held in abeyance due to depressed metal prices(6).

4.1.1 DESCRIPTION OF PROPOSED OPERATION

The Cirque property is located within the headwaters of Cirque Creek, a tributary to the Paul River. However, the proposed points of underground access and the mine site would be situated further south within the Paul River drainage (portal locations are shown on Figure 4). The baritic/pyritic deposit lies 80 m below the surface at its uppermost edge. The during mine site preparation (completion of road access, land clearing for construction of portal facilities, mill structures, out-buildings etc.). SIGMA has already identified encroachment problems on the Paul River from the recently constructed secondary road connecting Finbow airstrip with the Cirque property. Stream bank slumping has occurred just upstream from the single river crossing, and erosion could be accelerated by further road upgrading. This area is near water quality station G-20 and has been identified as the most valuable spawning habitat within the Paul River drainage(3). Excessive suspended solids are known to interfere with respiration in fish and the development of fish eggs, and to eliminate habitat for aquatic insects(8).

Turbidity and suspended solids are also expected to originate from the proposed mine operation and waste rock dumps. Preliminary plans indicate that suspended solids from milling and flotation processes are to be contained in a tailings pond (the location of this facility will likely be near the waste dump shown on Figure 4).

b. Acid Drainage

Acid drainage is a common occurrence in mining. Pyritic ore such as that found in the Cirque deposit can be oxidized during recovery and storage, producing ferrous sulphate and sulphuric acid. The accompanying drop in pH can be toxic to aquatic life and promote dissolution of heavy metals. Acid drainage may not be a serious problem in the Paul River because preliminary water quality data indicate that the river's buffering capacity is high. Table 1 shows that the Paul River and its tributaries are alkaline (pH of 7.2 to 8.4) and well buffered (total alkalinity of 101 to 250 mg/L). The overall geology of the region and the relatively high alkalinity of the Paul River suggest that the host rock in the basin will also be well buffered, thus reducing the possibility of acid mine drainage. Site-specific acid production potential tests must be conducted during the impact assessment.

are typically ammonium nitrate/fuel oil compounds or slurry/water gels. Both are, in large part, nitrogen-based (ammonium nitrate, calcium nitrate, sodium nitrate) and release ammonium (NH_{4+}) and nitrate (NO_{3-}) ions during use. Studies at the Fording Coal Limited mine in southeastern British Columbia found that NO_{3-}, NO_{2-} (nitrite), and NH_3(ammonia) in mine drainage were almost entirely due to explosives use, and concentrations at times exceeded water quality criteria for drinking water and aquatic life[(1)]. NO_{3-} is usually the principal species present under aerobic conditions. NH_4^+, NH_3, NO_{2-}, and NO_{3-} can promote excessive growth of algae and aquatic plants if other factors such as phosphorus, light, and substrate are suitable. Un-ionized ammonia and NO_{2-} can also be toxic to aquatic organisms. The actual quantity of nitrogen residuals which enters receiving waters will depend on site-specific factors such as the type and quantity of explosives used, hydrology, climate, groundwater conditions, the degree of water recycling, and effluent treatment.

e. Processing Reagents

Another source of contaminants often associated with a mine/milling operation is the processing reagents used to concentrate the ore. Cyprus Anvil has indicated that metallurgical testing is incomplete, although favourable processing results have been obtained by concentrating the lead and zinc in the presence of cyanide and soda ash[(7)]. Presumably, flocculating agents may be used. These should be a type known to be of no environmental concern, especially if a polyelectrolyte variety is considered[(9)]. Subsequent extraction of silver from a pyrite concentrate in a separate cyanide leaching plant is also planned. Cyanide is very toxic to fish, and contamination of receiving waters must be minimized. Other compounds which are in common use at lead-zinc operations elsewhere in the province include various acids, copper and zinc sulphates, and xanthates. Background levels of some of these compounds (copper, cyanide, sulphate, and zinc) in the Paul River have been investigated and are discussed in Section 5.2.2.

determined that the principal source of sediment to Centennial Creek was a section of haul road located on sloping deposits of silt, fine sand, and clay. Clearcut stream channels and sloping deposits of unstable materials in cutting units were secondary sources[11]. Soil erosion resulting from road construction near stream banks, skidding logs, removal of the stablilizing effect of vegetation, and the acceleration of runoff could similarly degrade fish habitat in the Lower Finlay Sub-basin. The region of concern around the lower Finlay River and its major tributaries is typically steeply sloped (sensitive to erosion) and situated on the windward side of a major mountain range where the amount of precipitation is relatively high. Utilizing forest harvesting techniques which minimize soil disturbance, leaving wind-firm reserve strips of vegetation along stream banks, and studying landforms to locate haul roads in the most stable locales should be encouraged.

A further complication resulting from soil disrupting logging practices in the Finlay River watershed could be the introduction of even greater quantities of mercury into streams and the subsequent accumulation of this element in aquatic organisms. The naturally high background levels of mercury in the water and some fish (discussed in Section 5), are thought to originate from the soils in this region.

Quentin Lake also exceeded the criterion (0.3 mg/L) for freshwater organisms and drinking water[14]. It is difficult to determine whether these values indicate a problem, as turbidity and suspended solids measurements were not taken and dissolved metals fractions are unknown. Notes which accompanied the field data made mention of very high turbidity resulting from glacial runoff (there are several large ice fields in the park). This would suggest that heavy metals were associated with suspended particulates and not readily available for uptake by aquatic life.

5.2 AKIE LEAD-ZINC DISTRICT

SIGMA monitored water quality during 1981 on the Finlay River and three of its tributaries (Paul River, Del Creek, and the Akie River), for a total of 10 sampling sites within the Akie lead-zinc district. The locations of these sites are shown in Figure 4. Five sets of monthly grab samples were collected (March, May, June, September, and November), and the properties which are considered to be relevant to this report are summarized in Table 1. The metals and other contaminants discussed below are those that may be released in mine drainage and/or came close to or exceeded working criteria considered safe for aquatic organisms and drinking water.

5.2.1 FINLAY RIVER

Site G-1: near Finbow airstrip/camp, 5 km downstream from the Paul River confluence.

The Finlay River at this location is downstream from possible future mine effluent which could be discharged to the Paul River. Available water quality data are derived from a few samples and should only be considered as preliminary.

Levels of suspended solids (<1 to 76 mg/L) and turbidity (0.6 to 32 N.T.U.) were relatively low compared to nearby tributary values. Finlay River water was also only moderately hard (52 to 133 mg/L as $CaCO_3$) and somewhat less alkaline (pH 7.7 to 8.1; total alkalinity 65.2 to 100 mg/L as $CaCO_3$) than its much smaller tributaries.

and newborns showed acceptable levels in all cases (no levels approached or exceeded the desirable limit of 20 ppb organic blood mercury). Mercury levels in fish taken from the lower Finlay River (32 km south of Ware, 5 km below Cyprus Anvil's camp/airstrip at Finbow) were the highest in all fish taken in the North East Zone during 1981 (including Weissener Lake in the Upper Finlay Sub-basin, and Great Beaver Lake and Kazchek Lake in the Takla-Nechako Strategic Planning Unit). Unfortunately, no fish were obtained from Rainbow Lake and only 13 samples were collected in the Finlay River. Of the food fish, Dolly Varden (two samples) had organic mercury levels in muscle tissue that were three times the acceptable commercial fishing limit of 0.5 ppm wet weight, and two samples exceeded the medically significant value of 0.2 ppm wet weight. The two samples higher than 0.5 ppm were from the larger (greater than 5 kg) and presumably older fish, while all other fish weighed 1 kg or less (see Table 3). Lake whitefish (five samples) were within acceptable limits. White sucker (three samples) showed levels higher than the medically significant level of 0.2 ppm, but not greater than 0.5 ppm, although this fish is not used for food.

It is important to make a correct interpretation of the results of the medical studies. The public's perception of mercury issues in general has been sensitized by past events. The recommended commercial fishing limit of 0.5 ppm organic mercury content in food fish applies to individuals who have normal blood equivalent mercury levels (less than 20 ppb). The medically significant level of 0.2 ppm organic mercury in fish tissue is a potential concern where consumers of fish have a blood organic mercury level over 20 ppb. In 1979, Health and Welfare Canada tested hair samples from 138 residents of Ingenika on Williston Lake (Figure 2), and 32 (23.2 percent) of these cases presented blood organic mercury levels greater than 20 ppb. Local public awareness of the mercury issue since then appears to have brought about a marked decline in mercury levels in the human population within the test area. Health and Welfare Canada found only one case in the Williston Lake area (Ingenika) in 1980 where the medically significant level in a blood sample had been exceeded (an incidence rate of only 1.6 percent), a marked reduction from the 1979 test results[5].

Water quality data collected by SIGMA for the five Paul River Stations are summarized in Table 1. As mentioned in Secton 4.1.2, Paul River water was alkaline (pH of 7.2 to 8.4; total alkalinity of 101 to 250 mg/L), thus reducing metal toxicity and the potential for future acid mine drainage. Total water hardness ranged from 121 to 310 mg/L as $CaCO_3$, which is considered hard (another limiter of metal toxicity).

Turbidity was found to be quite high (up to 402 N.T.U.) during spring runoff in May and June, and lower during the rest of the year (0.1 to 20 N.T.U.). High turbidity and suspended solids levels were particularly evident in the mid-section of the drainage (Figure 4; Sites G-3, G-20). A maximum concentration of 770 mg/L non-filterable residue (suspended solids) was recorded in May on Cirque Creek, a tributary to the Paul River. SIGMA reported that the relatively high suspended solids levels during snowmelt were primarily due to actively eroding slopes in lacustrine silt and clay deposits(3). Water quality objectives for suspended solids, turbidity, or sedimentation in the Paul River can be developed once more information on these variables, and important water uses such as spawning habitat, are obtained during the impact assessment process. These water quality objectives can then assist in determining allowable suspended solids levels in mine effluents.

Nutrient levels (nitrogen and phosphorus compounds) in the Paul River, reported in Table 1, are below limits recommended for the protection of all water uses. In future, nitrate and nitrite should be analyzed separately. Total ammonia nitrogen in the Paul River reached a maximum concentration of 0.36 mg/L and averaged 0.05 mg/L over the sampling period (Table 1). At a pH of 8.3 and a temperature of 4.1°C (September, 1981), the toxic component of ammonia (un-ionized NH_3-N)(15) would not have exceeded 0.009 mg/L. This is below the 0.03 mg/L maximum working criterion recommended for aquatic life (salmonids), although slightly above the 0.007 mg/L limit for continuous exposure(1).

Aluminum is commonly a fuel source in explosives used in mining, and this may be an additional source of aluminum in future mine effluents.

b. Cadmium

Three out of 22 values for dissolved cadmium and five out of 22 values for total cadmium in the Paul River were reported as 0.001 mg/L, which was the minimum detection limit used. This value is within the range of working limits (0.0002 to 0.004 mg/L total cadmium) recommended to protect aquatic life[13]. The upper limit of 0.004 mg/L has been suggested for very hard water (greater than 360 mg/L total hardness as $CaCO_3$). This limit may also be applicable to moderately hard water (e.g., 121 to 310 mg/L as $CaCO_3$) such as occurs in the Paul River, although further evidence should be obtained. Cadmium has a high toxicity which is very dependent on pH and hardness. The element also accumulates in most organisms and can act in synergism with cyanide and metals such as lead and zinc.

Further cadmium monitoring using lower detection limits (0.5 µg/L or lower) should be conducted in the vicinity of the Cirque project to establish the natural levels more accurately. The possibility of cadmium induced stress in fish should also be checked by measuring the levels of this metal and metallothionein in fish livers.

c. Copper

Copper concentrations were generally below the 0.002 mg/L recommended upper limit for the protection of aquatic life[13]. This working criterion applies to total copper due to the difficulty in determining the speciation of copper with current analytical methods. Therefore, a margin of safety is incorporated except where soft water is involved. Copper can become more toxic in the presence of some metals such as cadmium and zinc.

Three values out of 22 values for total copper in the Paul River exceeded 0.002 mg/L. Two of these occurred in May when levels of suspended

f. Lead

Cyprus Anvil geologists found "kill zones" on the Cirque property where vegetation would not grow due to the amount of lead in the soil[6]. Water quality data (Table 1) indicated that only one total lead value (0.058 mg/L) out of 22 samples exceeded the 0.01 mg/L total lead working criterion used for hard water containing sensitive species of fish[14]. The single high value is suspect because suspended solids levels were not high; all remaining total lead values were less than 0.006 mg/L, and dissolved lead did not exceed 0.003 mg/L.

g. Sulphate

The relatively abundant sulphate ion is not biologically active and will not impair water quality for aquatic life, although it can be a useful indicator of acid mine drainage. Present levels of sulphate in the Paul River are typically low (17 to 53 mg/L; Table 1).

h. Mercury

As discussed in Section 3.2, mercury levels in fish tissue which exceed the limit set for commercial fish, have been identified in some Dolly Varden from the Lower Finlay Sub-basin. The source of this mercury probably relates to the geology of the immediate area. Mercury is frequently found in soils and rocks around mineralized areas, particularly where shales are common. In addition, groundwater in regions of metallic sulphides such as those found in the Akie lead-zinc district, may contain more than 1 ppm mercury[18]. The working criteria for mercury in freshwater are stringent; 0.1 µg/L total mercury is the recommended limit for the protection of aquatic life where fish may be consumed[14]. SIGMA consultants found that 16 of 22 samples indicated detectable amounts of total mercury (more than 0.1 µg/L), exceeding the above criterion for aquatic life. The maximum total mercury concentration was 1.9 µg/L and the average was 0.4 µg/L. Samples collected during the period of heaviest recommended[19]. The implication of elevated background radiation in surface water is the potential for increase through release of natural radioisotopes (radionuclides) in a mining operation. Also, radiation in groundwater may be significant if used as a source of drinking water (radionuclides are usually more concentrated in groundwaters). The significance of the baseline radiation levels and the potential for increases due to mining, should be assessed by an expert during future studies of the Cirque project.

5.2.3 DEL CREEK AND AKIE RIVER

Site G-10: Del Creek, at road crossing near mouth.
Site G-12: Fluke Creek, headwater tributary to Del Creek.
Site G-14: Akie River, 1 km upstream from the Finlay River.
Site G-18: Elf Creek (tributary), 3 km upstream from confluence with the Akie River.

Del Creek and the Akie River are examined together because of their close proximity and comparable water quality. The upstream monitoring site in both watersheds is situated near major lead-zinc deposits (Cyprus Anvil) which reportedly show good potential for development (Fluke and Elf properties; Figure 3).

Table 1 shows that levels of most water quality properties investigated were similar to ambient conditions of the Paul River. Four out of 11 total aluminum values in the Akie River and Del Creek were above the 0.1 mg/L limit suggested for protection of fish[13]. Because the high aluminum concentrations (maximum of 5 mg/L) corresponded closely to high suspended solids levels in May, the high values were probably due to the aluminum content of the suspended sediment, and not a problem. Two out of 19 values for dissolved cadmium and five out of 19 values for total cadmium in these river systems were within the working range (0.0002 to 0.004 mg/L total cadmium) recommended to protect aquatic life[14]. Six out of 19 total copper values exceeded the 0.002 mg/L limit recommended for aquatic

6. CONCLUSIONS AND RECOMMENDATIONS

The main issues relating to water quality in the Lower Finlay Sub-basin are mercury content in some food fish, the Cirque project (proposed lead-zinc mine near the Paul River), and widespread logging operations scheduled to commence in 1985.

6.1 MERCURY IN FISH TISSUE

Health and Welfare Canada has identified higher than normal mercury levels in some fish species taken from several locations in the Williston Lake watershed since 1976. This work resulted in Health and Welfare Canada issuing a precautionary warning in 1981 against consumption of Dolly Varden from the Finlay River. The recommendation was directed primarily at native Indians who traditionally consume large quantities of fish. Results of the 1981 Health and Welfare Canada surveillance program in the Williston Lake area also showed that no medical anomalies existed with respect to the local inhabitants. All individuals tested had levels of organic mercury in the blood which were below the medically significant level of 20 ppb.

It is recommended that mercury levels in fish tissue be monitored in any area of the sub-basin that is scheduled for development. A comprehensive mercury analysis of all food fish species in the Paul River drainage (includes Rainbow Lake and Pretzel Lake) should be conducted for Cyprus Anvil's Cirque project. The responsibility for mercury analysis should be that of the developer.

6.2 CIRQUE PROJECT: PROPOSED LEAD-ZINC MINE

Several lead-zinc-silver deposits within the Paul River, Del Creek, and Akie River basins have been identified by Cyprus Anvil Mining Corporation. The Cirque property near the Paul River has been scheduled for development, although currently depressed metal markets have prompted the company to halt

Water quality objectives for the Cirque project area cannot be proposed at this time. It is recommended that site-specific objectives for the Paul River basin be developed after the impact assessment for the project when considerably more information will be available on water uses, natural water quality, and projected impacts on water quality. The Ministry can designate the water uses to be protected in the Paul River basin if sufficient information is currently available, but the establishment of numerical objectives to protect those water uses must await better site-specific information.

6.3 PROPOSED LOGGING ACTIVITIES

Large-scale logging operations could commence for the first time in the Lower Finlay Sub-basin as early as 1985, and continue well into the next decade. The impacts from this activity are expected to be increased water temperatures, soil erosion, increased runoff, and sedimentation of the streams in the basin. Increased soil disturbance may also promote the release of greater amounts of nutrients and heavy metals (e.g., mercury levels can already exceed water quality criteria). Forestry related water quality effects could add to those resulting from potential mining operations in the region.

It is recommended that harvesting techniques employed be of a type which minimize surface disturbance. For example, using an elevated log retrieval system such as a skyline cable would be preferable to skidding in the Paul River watershed. Other useful soil management techniques include leaving reserve strips of wind-firm vegetation along stream banks and locating roads in the most stable locations.

To establish water quality objectives in areas to be logged, site-specific information about the basins to be logged, the natural water quality, and the water uses to be protected would be required. If the Ministry wishes to establish water quality objectives for the main variables that could be affected by logging (temperature, suspended solids, turbidity, sedimentation, and nutrients-algal growth), this information could be

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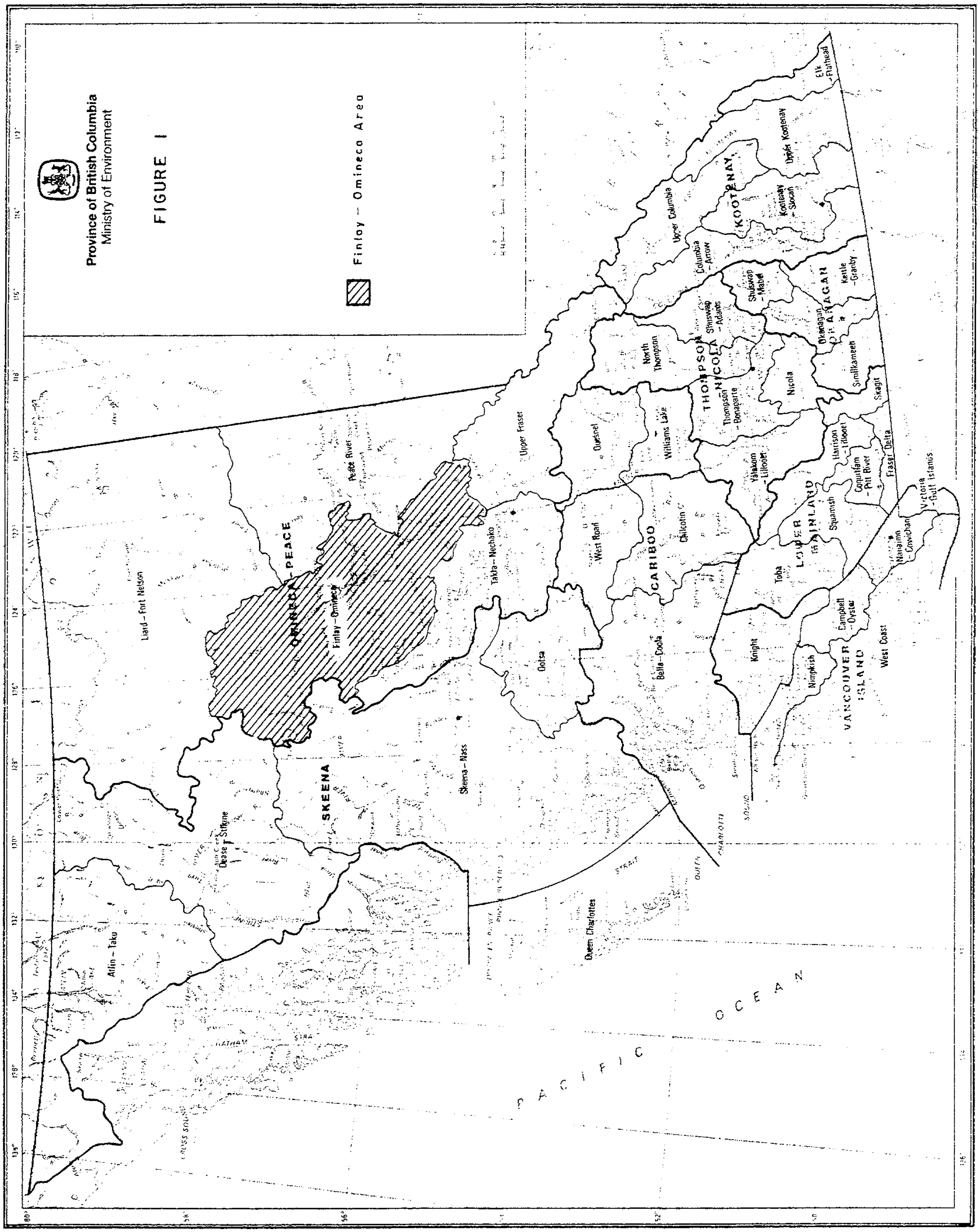
Province of British Columbia
Ministry of Environment
FIGURE I
Finlay – Omineca Area
OMINECA – PEACE
Finlay – Omineca
Liard – Fort Nelson
Peace River
Takla – Nechako
Upper Fraser
SKEENA
Skeena – Nass
Stikine
Dease
Atlin – Taku
Queen Charlottes
CARIBOO
West Road
Chilcotin
Quesnel
Williams Lake
Bella – Coola
Dolsa
THOMPSON – NICOLA
North Thompson
Thompson – Bonaparte
Nicola
Shuswap – Adams
Shuswap – Mabel
OKANAGAN
Okanagan
Similkameen
Kettle – Granby
KOOTENAY
Upper Columbia
Columbia – Arrow
Kootenay – Slocan
Upper Kootenay
Elk – Flathead
LOWER MAINLAND
Toba
Squamish
Harrison – Lillooet
Yalakom – Lillooet
Coquitlam – Pitt River
Fraser Delta
Skagit
VANCOUVER ISLAND
Knight
Nimpkish
Campbell – Oyster
West Coast
Nanaimo – Cowichan
Victoria – Gulf Islands
PACIFIC OCEAN

FIGURE 3. POTENTIAL INDUSTRIAL DEVELOPMENT WITHIN THE LOWER FINLAY SUB-BASIN

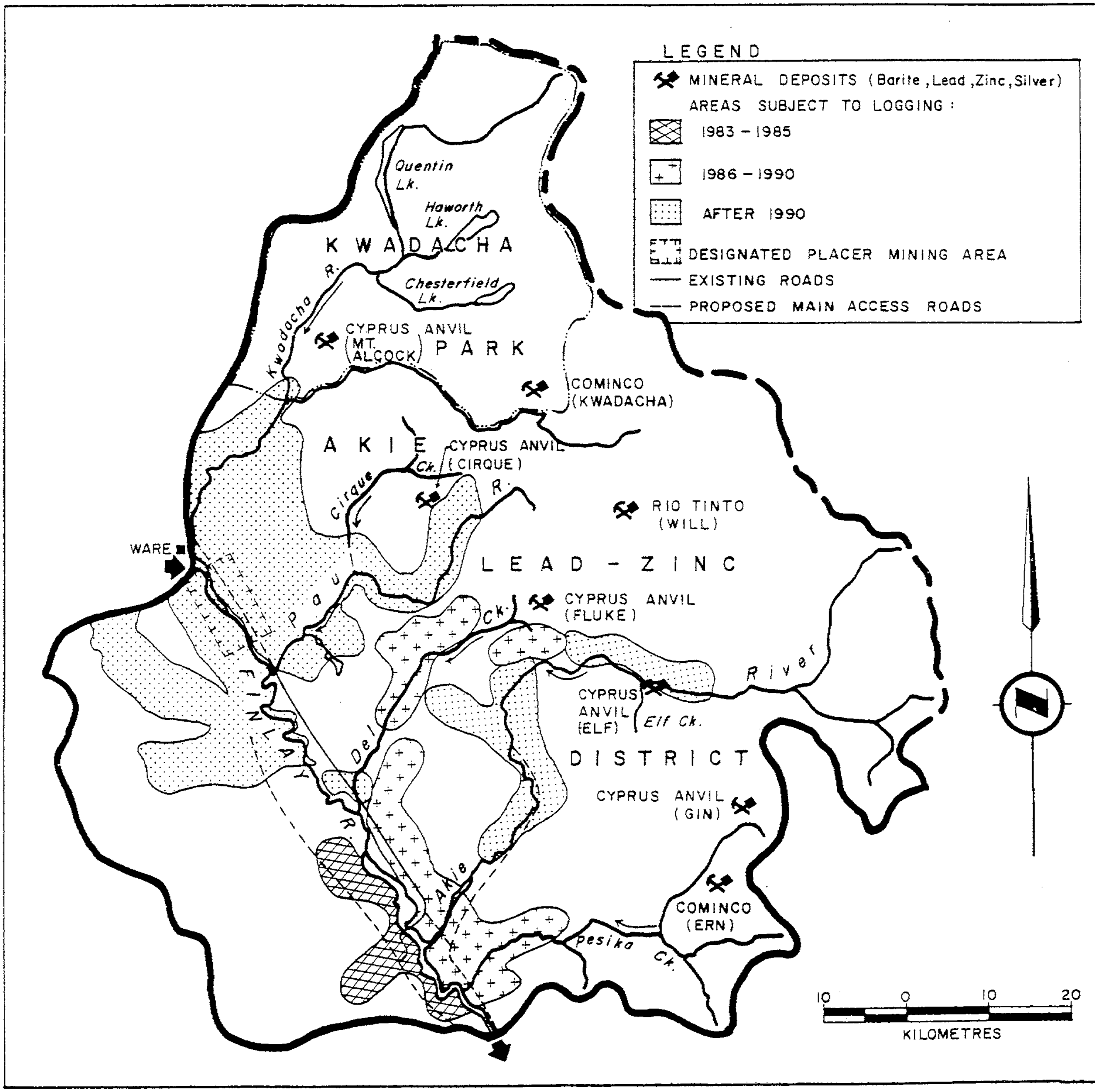

TABLE 1
LOWER FINLAY SUB-BASIN WATER QUALITY, MARCH TO NOVEMBER, 1982
(Cyprus Anvil Mining Corporation Data)

Sampling Site		G-1 Finlay River at Finbow Camp/Airstrip				G-3,7,8,9,20 Paul River and Tributaries				G-10,12 Del Creek				G-14,18 Akie River			
Variable	Type of Value	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean
Alkalinity - Total	mg/L	5	100	65.2	85.4	22	250	101	193	9	253	147	202	10	220	161	177
Aluminum - Total	mg/L	3	0.2	0.03	0.11	12	10	<0.05	1.5	5	1.5	<0.03	0.34	6	5	<0.05	0.99
Antimony - Total	mg/L	3	<0.01	<0.005	<0.008	12	<0.05	<0.01	<0.02	5	<0.015	<0.01	<0.012	6	<0.05	<0.01	<0.019
Arsenic - Dissolved	mg/L	5	0.0004	0.0001	0.0002	22	0.0005	<0.0001	0.0002	7	0.0004	<0.0001	0.0002	10	0.0007	<0.0001	0.0002
- Total	mg/L	5	0.0004	0.0001	0.0002	22	0.012	<0.0001	0.0009	9	0.0004	<0.0001	0.0003	10	<0.002	<0.0001	<0.0006
Barium - Total	mg/L	3	0.02	0.005	0.012	12	0.5	0.02	0.1	5	0.07	0.015	0.035	6	0.07	0.015	0.034
Beryllium - Total	mg/L	3	<0.0005	<0.0002	<0.0004	12	<0.002	<0.0005	<0.001	5	<0.0007	<0.0005	<0.0006	6	<0.002	<0.0005	<0.0009
Cadmium - Dissolved	mg/L	5	0.001	<0.001	0.001	22	0.001	<0.001	0.001	9	0.001	<0.001	0.001	10	0.001	<0.001	0.001
- Total	mg/L	5	0.001	<0.001	0.001	22	0.001	<0.001	0.001	9	0.001	<0.001	0.001	10	0.001	<0.001	0.001
Chloride - Dissolved	mg/L	5	0.5	0.1	0.2	22	0.6	<0.1	0.2	9	0.3	<0.1	0.2	10	0.5	0.1	0.3
Chromium - Dissolved	mg/L	5	<0.025	<0.025	<0.025	22	<0.025	<0.025	<0.025	9	<0.025	<0.025	<0.025	10	<0.025	<0.025	<0.025
- Total	mg/L	5	<0.025	<0.025	<0.025	22	<0.025	<0.025	<0.025	9	<0.025	<0.025	<0.025	10	<0.025	<0.025	<0.025
Cobalt - Total	mg/L	3	<0.002	<0.001	<0.002	12	<0.01	<0.002	<0.005	5	<0.003	<0.002	<0.002	6	<0.01	<0.002	<0.004
Copper - Dissolved	mg/L	5	0.001	<0.001	0.001	22	0.002	<0.001	0.001	9	0.002	<0.001	0.001	10	0.001	<0.001	0.001
- Total	mg/L	5	0.003	<0.001	0.002	22	0.025	<0.001	0.003	9	0.006	<0.001	0.002	10	0.012	<0.001	0.003
Cyanide - Total	mg/L	2	<0.02	<0.01	<0.02	10	0.06	<0.01	0.02	4	<0.02	<0.01	<0.02	4	<0.02	<0.01	<0.02
Fluoride	mg/L	5	0.54	0.05	0.15	22	1.1	0.05	0.24	9	0.67	<0.05	0.17	10	0.67	0.05	0.19
Hardness - Total	mg/L	5	133	52	92	22	310	121	224	9	265	164	223	10	246	165	210
Iron - Dissolved	mg/L	5	0.06	0.03	0.04	22	0.6	0.01	0.09	9	0.06	0.025	0.038	10	0.75	0.02	0.11
Lead - Dissolved	mg/L	5	0.002	<0.001	0.001	22	0.003	<0.001	0.002	9	0.002	<0.001	0.001	10	0.005	<0.001	0.002
- Total	mg/L	5	0.004	0.001	0.002	22	0.058	0.001	0.005	9	0.008	0.001	0.004	10	0.012	<0.001	0.004
Manganese - Dissolved	mg/L	5	<0.02	<0.005	<0.011	22	<0.02	<0.005	<0.01	9	<0.02	<0.005	<0.012	10	<0.02	<0.005	<0.011
- Total	mg/L	3	0.002	0.001	0.002	12	0.05	<0.001	0.009	5	0.015	<0.0005	0.0037	6	0.05	0.0015	<0.0108
Mercury - Total	g/L	5	1.4	<0.1	0.6	22	1.9	<0.1	0.4	9	2.1	<0.1	0.6	10	1.4	<0.1	0.4
Molybdenum - Total	mg/L	3	<0.01	<0.005	<0.008	12	<0.05	<0.01	<0.02	5	<0.015	<0.01	<0.012	6	<0.05	<0.01	<0.019
Nickel - Total	mg/L	3	<0.002	<0.001	<0.002	12	<0.05	<0.0015	<0.0082	5	<0.003	<0.0015	<0.0019	6	<0.01	<0.001	<0.004
Nitrogen - Ammonia	mg/L	5	0.08	<0.02	0.03	22	0.36	<0.02	0.05	9	0.1	<0.02	0.04	10	0.08	<0.02	0.03
- Nitrate/Nitrite	mg/L	5	2	0.01	0.73	21	0.14	<0.01	0.05	9	0.09	0.01	0.04	10	4.1	0.02	0.46
Oxygen - Dissolved	mg/L	5	13.2	9.5	11.5	21	13.5	10.9	12.2	9	14.4	11.5	12.5	10	13.1	10.6	12
pH		9	8.1	7.7	7.9	41	8.4	7.2	8.1	13	8.4	7.8	8.15	18	8.3	7.6	8.1
Phenol	mg/L	5	<0.05	<0.05	<0.05	22	<0.05	<0.05	<0.05	9	<0.05	<0.05	<0.05	10	<0.05	<0.05	<0.05
Phosphorus - Ortho	mg/L	5	0.02	<0.001	0.012	22	0.14	<0.001	0.019	9	0.09	<0.001	0.021	10	0.03	<0.001	0.021
- Total	mg/L	5	0.09	<0.01	0.04	20	0.28	<0.01	0.06	9	0.17	<0.01	0.06	10	0.26	<0.01	0.1
Residue - Filterable 105° C	mg/L	6	230	5	135	24	730	4	289	9	430	188	301	10	490	194	327
- Non-Filterable 105° C	mg/L	5	76	<1	24	22	770	<1	63	9	140	<1	33	10	270	<1	49

TABLE 2
LOWER FINLAY SUB-BASIN WATER QUALITY, JULY, 1982
(MINISTRY OF ENVIRONMENT DATA)

Sampling Site		1130647 Haworth Lake (All Depths)				1130648 Chesterfield Lake (All Depths)				1130327 Quentin Lake (All Depths)			
Variable	Type of Value	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean
Alkalinity - Total	mg/L	1	91.76	91.76	91.76	2	137.4	127.5	132.5		87.5	80.8	84.2
Aluminum - Total	mg/L	2	0.06	<0.02	0.04	2	0.02	<0.02	0.02	2	1.14	0.92	1.03
Arsenic - Total	mg/L	2	<0.25	<0.25	<0.25	2	<0.25	<0.25	<0.25	2	<0.25	<0.25	<0.25
Cadmium - Total	mg/L	2	<0.0005	<0.0005	<0.0005	2	<0.0005	<0.005	<0.0005	2	<0.01	<0.25	<0.25
Calcium - Total	mg/L	2	36.7	30.6	33.7	2	46.1	39.8	43	2	39	31.5	35.3
Chromium - Total	mg/L	2	<0.1	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01
Cobalt - Total	mg/L	2	<0.1	<0.1	<0.1	2	<0.1	<0.1	<0.1	2	<0.1	<0.1	<0.1
Copper - Total	mg/L	2	0.001	<0.001	0.001	2	0.001	0.001	0.001	2	0.007	0.007	0.004
Iron - Total	mg/L	2	<0.001	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	1.4	1.05	1.23
Lead - Total	mg/L	2	0.1	<0.001	<0.001	2	<0.001	<0.001	<0.001	2	0.002	0.002	0.002
Magnesium - Total	mg/L	2	8.69	7.25	7.97	2	15.7	14.2	15	2	5.85	4.66	5.26
Manganese - Total	mg/L	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	0.03	0.02	0.03
Molybdenum - Total	mg/L	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01
Nickel - total	mg/L	2	<0.1	<0.1	<0.1	4	<0.1	<0.1	0.03	2	<0.01	<0.01	<0.01
Nitrogen - Ammonia	mg/L	2	<0.005	<0.005	<0.005	2	<0.005	<0.005	<0.005	2	0.005	<0.005	<0.005
- Nitrite/Nitrate	mg/L	2	0.07	0.03	0.05	2	0.06	0.02	0.04	2	0.1	0.04	0.07
- Kjeldahl	mg/L	2	0.01	<0.01	0.01	2	0.05	0.04	0.05	2	0.08	0.07	0.08
- Organic	mg/L	2	0.01	<0.01	0.01	2	0.05	0.04	0.05	2	0.08	0.06	0.07
- Total	mg/L	2	0.08	0.03	0.06	2	0.11	0.06	0.09	2	0.17	0.12	0.15
Oxygen - Dissolved	mg/L	19	10.3	7.3	9	18	10.9	8.6	10.3	1	8	8	8
Phosphorus - Ortho	mg/L	2	<0.003	<0.003	<0.003	2	<0.003	<0.003	<0.003	2	<0.003	<0.003	<0.003
- Total	mg/L	4	0.007	0.005	0.006	4	0.007	0.003	0.005	4	0.054	0.004	0.025
pH		1	8.3	8.3	8.3	2	8.4	8.4	8.4	2	8.3	8.1	8.2
Residue - Filterable 105°C	mg/L	2	142	128	135	2	192	182	187	2	108	102	105
Specific Conductance	µs/cm	2	230	215	222	2	340	310	325	2	184	162	173
Temperature	°C	19	12	4	8	18	13	4	9	23	10.1	5.5	8
Vanadium - Total	mg/L	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01
Zinc - Total	mg/L	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01	2	<0.01	<0.01	<0.01

N = Number of values.

TABLE 4

ADDITIONAL MONITORING RECOMMENDED FOR THE CIRQUE PROJECT

	Alkalinity
	Flow
	Hardness
	pH
	Suspended solids
	Temperature
	Turbidity
	Aluminum, Dissolved and Total
	Cadmium, Dissolved and Total (detection limit of 0.5 µg/L or lower)
	Copper, Dissolved and Total (detection limit of 1 µg/L)
	Cyanide, Total (detection limit of 5 µg/L or lower)
	Lead, Dissolved and Total
	Mercury, Total (detection limit of 0.05 µg/L)
	Silver, Dissolved and Total (detection limit of 0.1 µg/L lower)
	Zinc, Dissolved and Total
	Radionuclides; radium-266, strontium-90, iodine-129, iodine-131
(outlined in Pommen, 1983)(1)	Nitrogen - Ammonia - Nitrate - Nitrite Phosphorus - Ortho-phosphorus, Dissolved (detection limit of 3 µg/L or lower) - Total Dissolved - Total Nitrogen:Phosphorus ratio in periphyton tissue

Notes:

The levels of important metals such as those listed above should also be considered for measurement in periphyton, benthic invertebrates, stream sediments, groundwater, and fish tissue (mercury only). Metallothionein measurements in fish livers should be considered with regard to the other heavy metals. Aquatic life and sediments are generally more sensitive indicators of increasing metal levels in the environment than water.