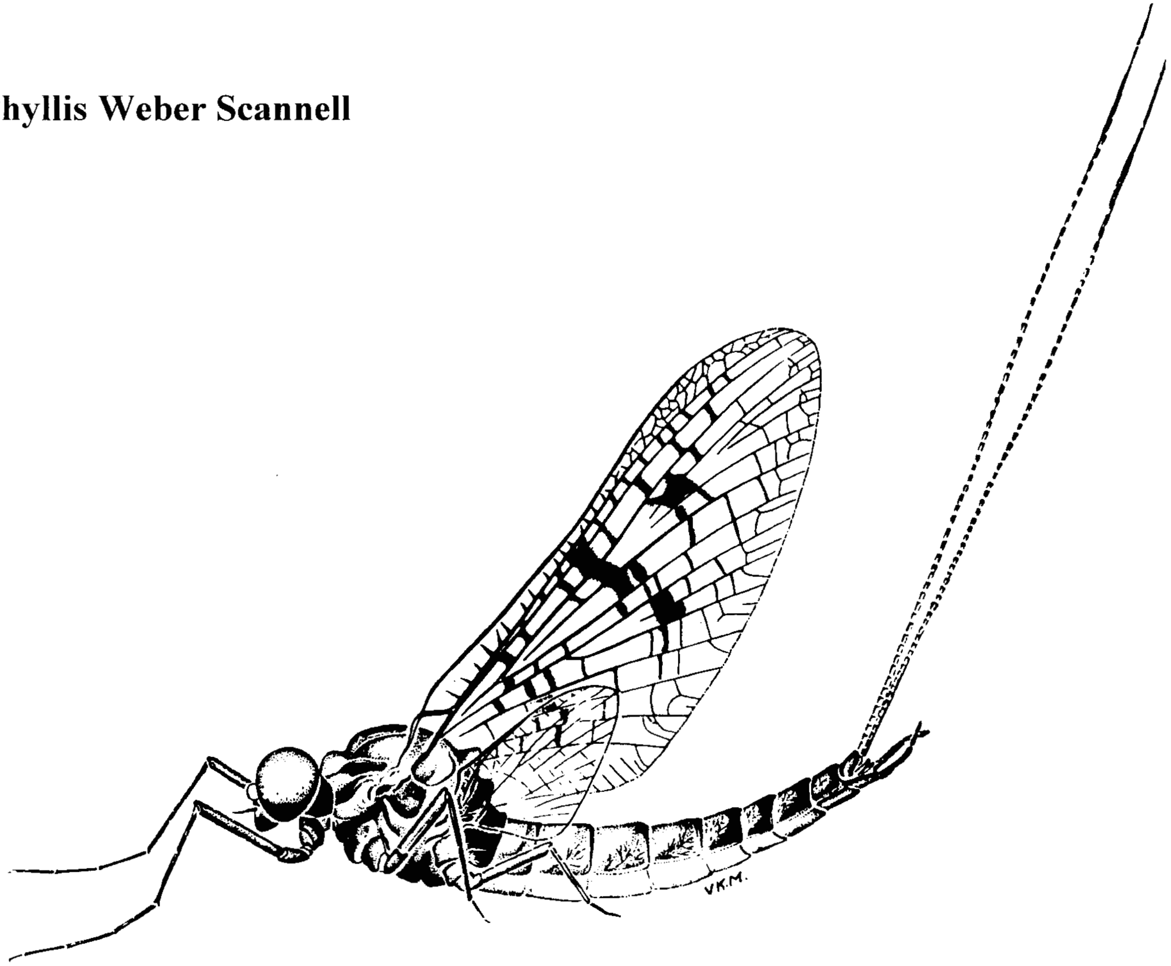
Technical Report No. 97-3

Red Dog Creek Use Attainability Analysis Aquatic Life Component

A Reconsideration of Shelly, Connie, Rachael, and Sulfur Creeks

by Phyllis Weber Scannell



March 1997

Alaska Department of Fish and Game
Habitat and Restoration Division

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Acknowledgements

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Introduction

In 1995, the Alaska Department of Fish and Game (ADF&G) conducted field surveys of streams in the Wulik River drainage to determine if these systems support the currently designated uses for aquatic life. We considered natural background water quality and metals concentrations that may have limited aquatic communities before development of the Red Dog Mine, existing use by fish, and the presence of macroinvertebrate, microinvertebrate, periphyton, and macrophyton communities. We used the following US Environmental Protection Agency (Karr and Dudley 1981) definition of a community:

> Biotic integrity is a balanced, integrated, adaptive community of organisms having species composition diversity and functional organization comparable to that of natural habitat of the region.

Weber (1981) presents an argument for the inclusion of periphyton, macrophyton, macroinvertebrates, and fish in the definition of aquatic communities:

> The concept of "biological integrity" is not as clearly defined as that of "toxicity" in the CWA [Clean Water Act of 1977], but can be inferred from the frequent use of terminology such as "the protection and propagation of shellfish, fish, and wildlife," "balanced indigenous populations of shellfish, fish, and wildlife," and "ecosystem diversity, productivity, and stability, and species and community (structure)." Further clarification of the intent of the Congress in using the term "biological integrity" is found in Paragraph

> 502(15) of the CWA, where the definition of "biological monitoring" includes the determination of the effects (of pollution) on (all types of) aquatic life, which, together with terminology used in other sections of the CWA, can only be interpreted to include all communities of aquatic organisms, such as the phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish.
>
> The concept of biological integrity is easily defined in terms of the basic properties of communities of aquatic organisms, which are (1) the standing crop or abundance (expressed in terms of numbers of organisms, weight, size, or biomass), (2) community structure (the kinds of organisms present and the relative abundance of each kind), and (3) community metabolism and condition (rates of physiological processes, such as photosynthesis and nitrogen fixation, accumulation of toxic substances, disease, histopathological conditions, parasitism, and flesh tainting).

In the determination of existing uses, we used the following definitions

18 AAC.70.990 (20):

> "existing uses" means those uses actually attained in a water body on or after November 28, 1975.

and 40 CFR Sec. 131 E:

> "existing uses" means those uses actually attained in the water body on or after November 28, 1975.

Results of the 1995 ADF&G survey were presented in ADF&G's Technical Report 96-1 (Weber Scannell 1996). In 1996 we resampled Shelly, Sulfur, Connie, and Rachael Creeks, which are tributary streams to Red Dog Creek. The purpose of this study was to confirm a high level of certainty that ADF&G was recommending the correct aquatic life use classification. Results of the 1996 aquatic surveys and our revised recommendations are presented in this document.

Description of Streams Considered for 1996 Reconsideration

All streams considered for reclassification in the Wulik River drainage are located in northwest Alaska, approximately 95 km (59 mi) north of Kotzebue (Figure 1). Middle Fork Red Dog Creek flows adjacent to the Red Dog ore body, a large lead - zinc deposit that is mined by Cominco Alaska Inc. Tributary streams considered in this study were located with a Global Positioning System (GPS) (Table 1, Figure 1).

Table 1. Latitude and longitude of mouths of study streams.

Sulfur Creek at mouth	N68°4.52'	W162°50.43'
Shelly Creek at mouth	N68°4.319'	W162°49.585'
Connie Creek at mouth	N68°4.034'	W162°49.276'
Rachel Creek at mouth	N68°3.778'	W162°49.348'

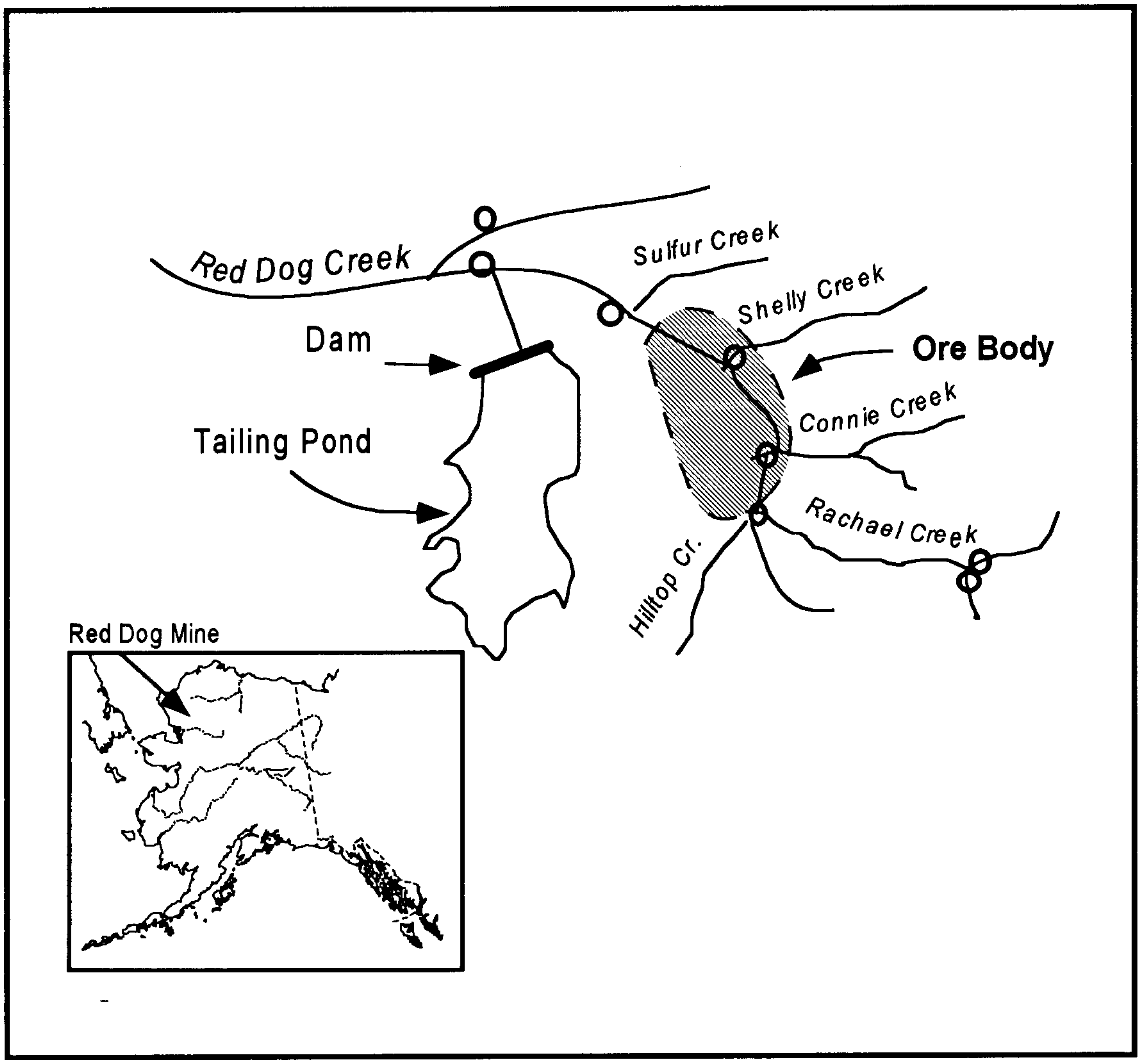

Figure 1. Locations of streams considered for reclassification of aquatic life use. Water quality sampling stations are shown on the map.

Existing Classification

The State of Alaska classified all streams and rivers in the Wulik River drainage, including the Wulik River, Ikalukrok Creek, and Red Dog Creek and its tributaries for all uses under 40 CFR, Chapter 1, part 131, 131.10, and 18 AAC 70.055.

Wastewater Dischargers

The Red Dog Mine is currently the only industrial development in the Wulik River drainage that discharges to waters of the state. Discharge from the Red Dog Mine is below the tributaries examined in this report. No industrial development currently affects these tributaries.

Problem Definition

Studies to date have shown that Middle Fork Red Dog Creek has not supported fish or other aquatic populations. The absence of aquatic communities is because of natural mineralization, naturally occurring high concentrations of metals, and low pH. Intermittent flows and poor water quality in tributaries to Middle Fork Red Dog Creek probably limit aquatic life. Fish use in tributary streams also is limited by lack of overwintering habitat and inability to access these tributaries through the naturally degraded water quality of Middle Fork Red Dog Creek.

Stream Flow Evaluation

Hydrology and Water Quality

Tributaries to Middle Fork Red Dog Creek freeze in late October; by mid-winter there is no flowing surface water. Fish could not survive in these conditions.

When breakup occurs (usually in late May), water flows in all of the tributaries. Sulfur Creek flows until the snow has melted and then surface flow subsides. In July 1996 no subsurface water was visible in Sulfur Creek at the base of the falls to Middle Fork Red Dog Creek, a vertical drop of approximately 4 m. The three other tributaries, Shelly, Connie, and Rachael Creeks, flow throughout the summer.

Tributaries flowing into the northeast side of the ore body are not affected by mineral development. Except during periods of high rainfall, these creeks were reported in baseline studies to have clear water with low turbidity. Turbidity ranged from 0.37 to 24 NTU. The high value (24 NTU) was measured at station 38 in July when flow was high. Baseline data on Shelly, Sulfur, Connie, and Rachael Creeks is limited to a few measurements of water quality collected in the baseline studies (Dames and Moore 1983; EVS and Ott Water Engineers 1983). These are small tributaries of <1 to <10 cfs summer flow. Dames and Moore (1983) described the tributaries:

> Many of the tributaries exhibited high quality water compared to the mainstem. Water at stations 34 [Sulfur Creek], 38 [Shelly Creek], 40 [Connie Creek], and 47 (Rachael Creek) during summer was highly oxygenated with 11.0 to 13.0 mg/L of dissolved oxygen. . . . Conductivity levels ranged from 70 to 330 *u*mho/cm at 25°C. pH was slightly low, ranging from 6.3 to 7.1, and alkalinity concentrations were generally low (7.9 to 74 mg/L).

Shelly Creek

Shelly Creek flows into Middle Fork Red Dog Creek from the northeast. The creek is small, its banks densely vegetated by willows, and the streambed stained with iron precipitate (Figure 2). Few water quality samples have been collected from Shelly Creek.

There were no baseline data collected on hardness, TDS, flow, dissolved oxygen, or other water quality factors in Shelly Creek. Baseline contaminant water samples were limited to one sample in 1981 and four in 1982. Concentrations of both Cd and Zn exceeded Maximum Allowable Concentrations in all of the samples collected (USEPA 1980, USEPA 1985a); Pb was not elevated (EPA 1985b). The maximum concentration of Cd was 28 ug/L, of Pb 80 ug/L, and Zn 2300 ug/L (Weber Scannell 1996).

In 1995, Shelly Creek had moderately hard water and elevated concentrations of Al and Cd that were above the reported chronic/acute toxicity levels (79% samples for Al and 36% of samples for Cd). Seventy nine percent of the water samples contained concentrations of Cd that were above the Maximum Allowable Concentration and 93% of the samples exceeded the Maximum Allowable Concentration for Zn. Concentrations of Fe ranged from 190 to 1220 ug Fe/L (Weber Scannell 1996). Median concentrations of Al, Cd, Cu, Fe, Pb, and Zn were lower in 1996 than 1995; there are no human-caused reasons for decreases in metals. Concentrations of Al and Pb were low throughout summer 1996, except for two peaks, one in June and one in July (Figures 3 and 5). Concentrations of Cd and Zn increased throughout the summer, and reached highest concentrations in September. In late summer, concentrations of Cd reached approximately 9 times the acute limit for aquatic life and Zn was approximately 4.5 times the aquatic life limit (Figures 4 and 6).

Figure 2. Shelly Creek.

Table 2. Water Quality in Shelly Creek, 1995 and 1996.

	Al ug/L	Cd ug/L	Cu ug/L	Fe ug/L	Pb ug/L	Zn ug/L	pH
1995							
median	271	13.7	14	403	49.6	1,620	6.8
maximum	549	44.7	23.5	1,220	604	5,100	7.3
minimum	77	0.6	1.6	190	5.2	90	6.4
count	14	14	13	13	14	14	6
1996							
median	228	9.1	8.3	568	27.6	1,480	
maximum	6,830	30.9	25.5	12,400	2,630	3,470	
minimum	94	2.16	2.2	206	6.02	250	
count	13	13	13	13	13	13	

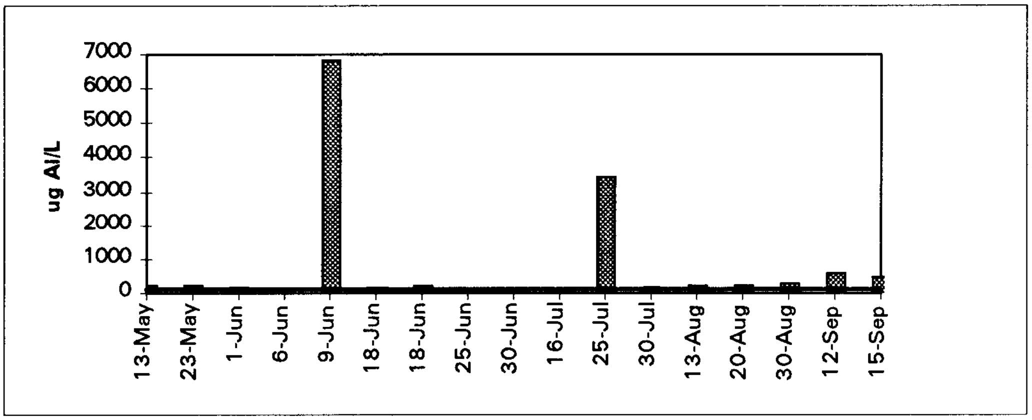

Figure 3. Concentration of Al in Shelly Creek, 1996. Line on bottom of graph shows water quality limit for Al from Canadian Water Quality Guidelines (1995).

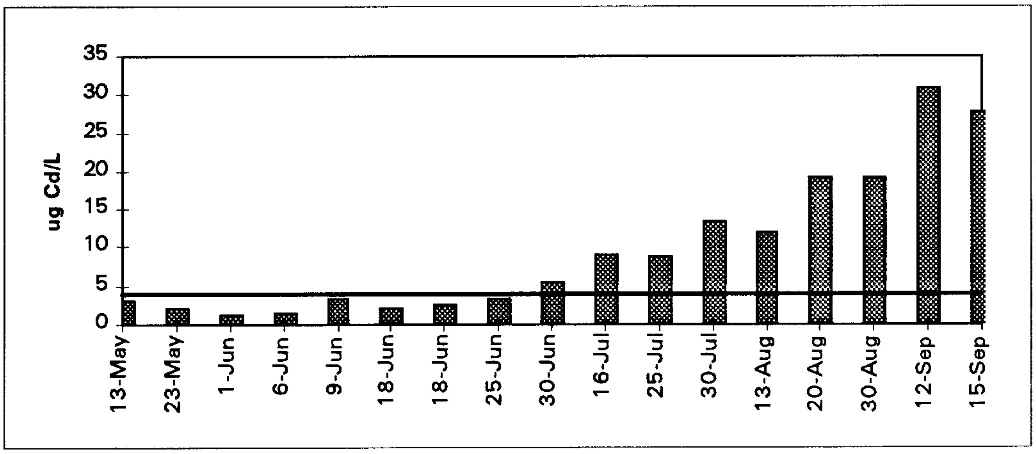

Figure 4. Concentration of Cd in Shelly Creek, 1996. Line on bottom of graph shows USEPA acute water quality limit for Cd.

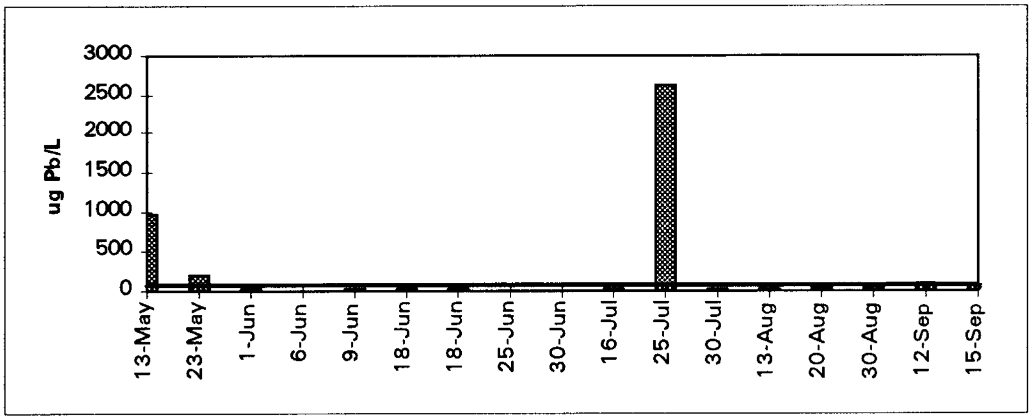

Figure 5. Concentration of Pb in Shelly Creek, 1996. Line on bottom of graph shows USEPA acute water quality limit for Aquatic Life for Pb.

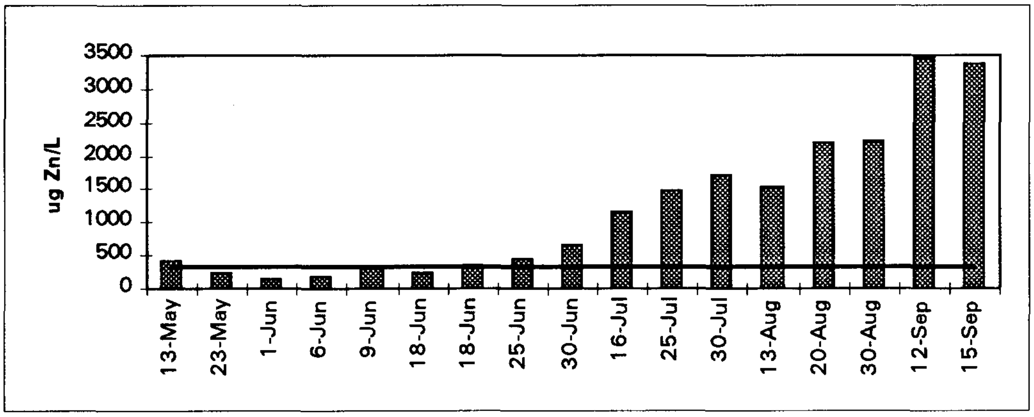

Figure 6. Concentration of Zn in Shelly Creek, 1996. Line on bottom of graph shows USEPA acute water quality limit for Zn.

Connie Creek

Connie Creek is the largest of the tributaries examined in this study. The creek flows down a long valley, then through a wide, shallow channel and empties into the clean water bypass channel of Red Dog Creek. Water depths usually are less than 20 cm during summer flows. The creek bottom is medium cobble with some iron staining (Figure 7).

Limited water quality and metals data (Dames and Moore 1983) collected in Connie Creek during baseline studies showed this creek to have moderately good water quality for most analytes. Cd concentrations were above, but close to, the Maximum Allowable Concentration for aquatic life, and ranged from 0.002 to 0.021 mg/l.

Figure 7. Connie Creek.

In 1995 and 1996, Connie Creek contained the best water quality of any of the tributaries to Middle Fork Red Dog Creek (Table 3). If fish were not excluded from this tributary by poor water quality in Middle Fork Red Dog Creek, it is possible fish could inhabit this creek for summer rearing. During winter, Connie Creek freezes and fish would be excluded. Connie Creek has moderately hard water and in 1995 and 1996, metals concentrations were generally lower than reported chronic/acute toxicity levels for Cd, Cu, Pb, and Zn (Table 3). In 1996, concentrations of Al, Cd, and Pb exceeded acute limits for aquatic life in only a few of the water samples (Figures 8, 9, and 10) and Zn exceeded limits for aquatic life in about 50% of the samples (Figure 11).

Table 3. Water Quality in Connie Creek, 1995 and 1996.

	Al ug/L	Cd ug/L	Cu ug/L	Fe ug/L	Pb ug/L	Zn ug/L	pH
1995							
median	90	<10	<5	90	10	120	6.85
maximum	370	190	600.06	1,220	270	36,800	7.40
minimum	50	<10	<5	50	<0.2	<10	6.60
count	12	12	12	11	12	12	6
1996							
median	76	1.95	4.6	366	10.4	313	
maximum	2,600	12.6	42.5	2,270	220	1,320	
minimum	20	0.57	0.89	68	1.89	91	
count	13	13	13	13	13	13	

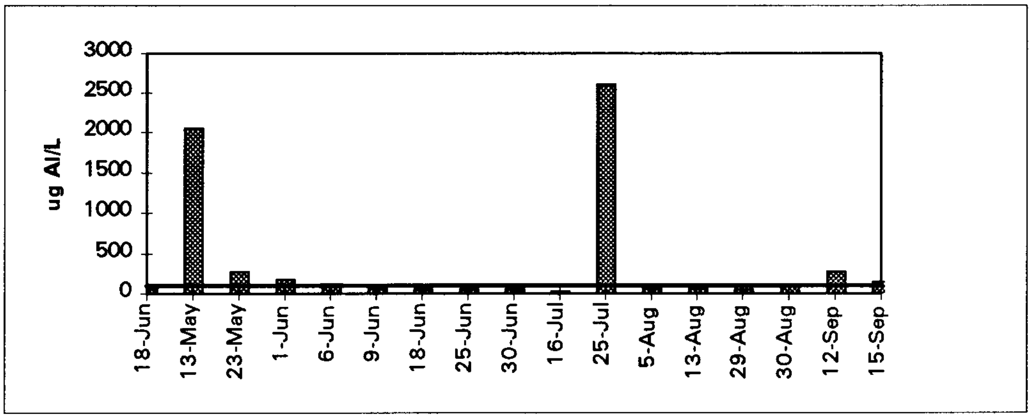

Figure 8. Concentration of Al in Connie Creek, 1996. Line on graph is Aquatic Life Limit from the Canadian Water Quality Guidelines.

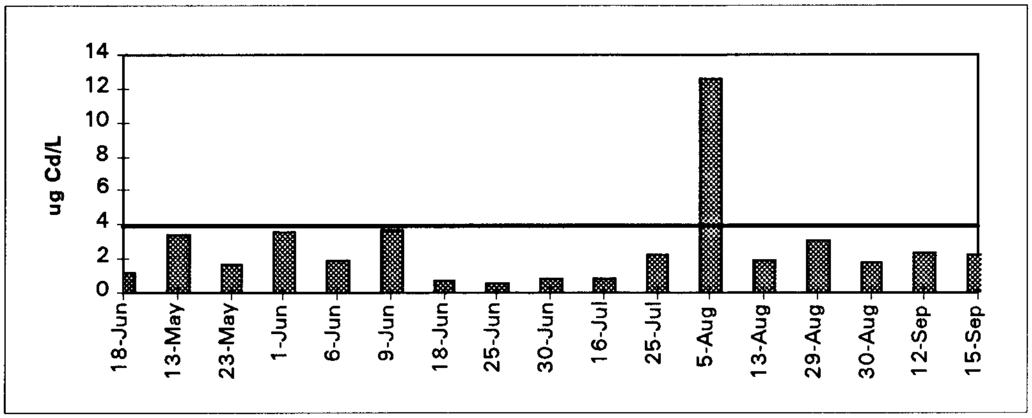

Figure 9. Concentration of Cd in Connie Creek. Line on graph is the USEPA acute limit for Aquatic Life.

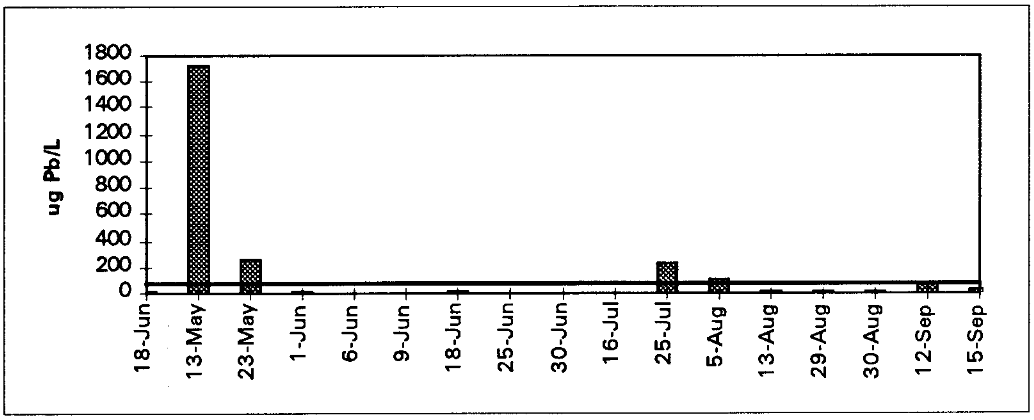

Figure 10. Concentration of Pb in Connie Creek. Line on graph is the USEPA acute limit for Aquatic Life.

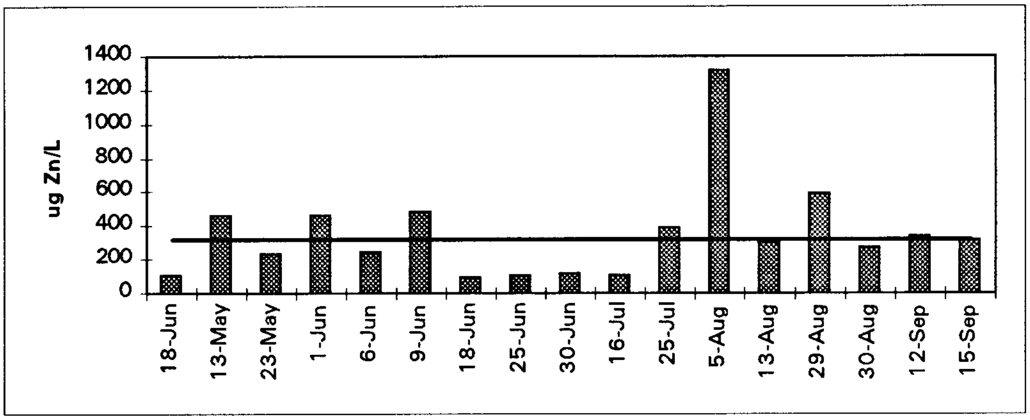

Figure 11. Concentration of Zn in Connie Creek. Line on graph is the USEPA acute limit for Aquatic Life for Zn.

Rachael Creek

Rachael Creek, at the headwaters of Middle Fork Red Dog Creek is a small, partially undercut stream flowing from the base of Deadlock Mountain. In 1994 the creek contained high concentrations of Al and Zn. Elevated Al and Zn concentrations in the bypass ditch (Station 140) and in Rachael Creek in August 1994 followed a prolonged period of high rainfall.

Rachael Creek forks at N68°3.776', W162°47.905', the left fork (defined when facing downstream) contains elevated concentrations of iron and is heavily stained (Figure 13), the right fork contains high concentrations of aluminum. Aproximately 50' above the fork, the input of aluminum ceases and the water is clear above this point.

Baseline water sampling in Rachael Creek was limited to four samples in 1982 (Dames and Moore 1983). The water was described by Dames and Moore (1983) as clear, of low turbidity, and with high dissolved oxygen concentrations. Cd and Zn concentrations were low, ranging from 2 to 8 ug Cd/L and 79 to 142 ug Zn/L. No baseline data on Al concentrations were found.

In 1995 and 1996, Rachael Creek contained extremely high concentrations of Al (from 1170 to 3270 ug/L) and Cu (from 40 to 60 ug/L) and low pH (from 4.7 to 5.9) (Table 4). Changes in water quality from baseline conditions are believed to result from high rainfall and flood events during late summer 1994. Precipitation of Al onto the substrate was prevalent following 1994 floods (Figure 12). According to the Canadian Water Quality Guidelines (CWQG), Al is extremely toxic to aquatic life at $pH < 6.5$. The CWQG suggests a maximum Al concentration of 5 ug/L to protect aquatic life ($pH < 6.5$). The median Al concentration in Rachael Creek during 1995 was 340 times the CWQG toxic level and the maximum more than 650 times; pH was less than 6. Al was consistently elevated in 1996 (Figure 14). The combination of high concentrations of Al and low pH would exclude most, if not all, aquatic species from Rachael Creek. Concentrations of Cu (Table 4) and Zn (Figure 17) also were elevated above the Maximum Allowable Concentrations in 100% of the samples. Concentrations of Cd (Figure 15) and Pb (Figure 16) were frequently below USEPA acute limits.

Figure 13. Left and right forks of Rachael Creek.

Table 4. Water Quality in Rachael Creek, at mouth, 1995 and 1996.

	Al	Cd	Cu	Fe	Pb	Zn	pH
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	
1995							
median	1,700	3	61.0	2,800	0.8	707	5.45
maximum	3,270	3.81	84.0	4,280	4.8	838	5.90
minimum	1,170	2.14	42.7	250	0.3	202	4.70
count	10	11	11	9	11	11	4
1996							
median	800.5	4.395	35.6	1,740	59.4	616	
maximum	10,600	30.7	86.1	25,700	223	1,530	
minimum	109	1.28	11.7	133	1.42	178	
count	16	16	16	16	16	16	

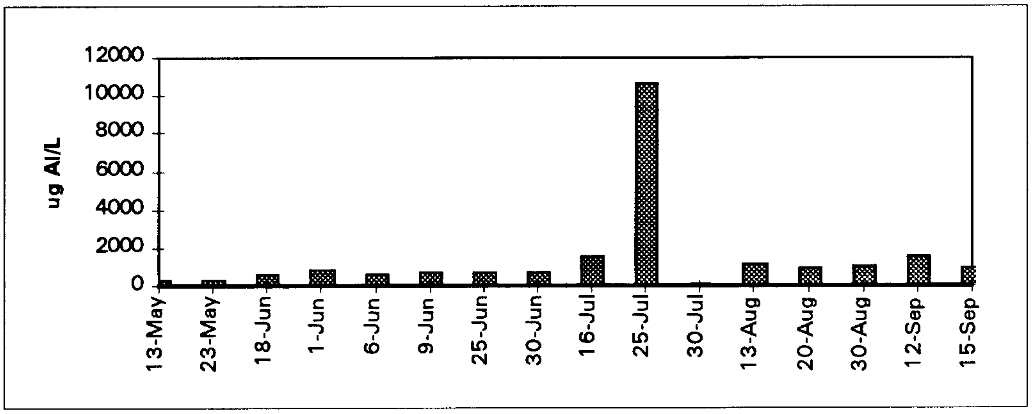

Figure 14. Concentration of Al in Rachael Creek, 1996. Line on graph is Aquatic Life Limit for Al (guideline for pH<6.5) from the Canadian Water Quality Guidelines.

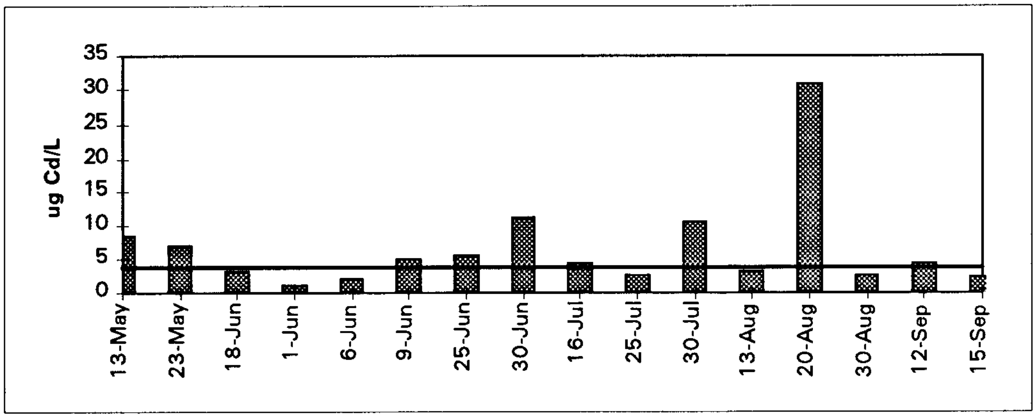

Figure 15. Concentration of Cd in Rachael Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Cd.

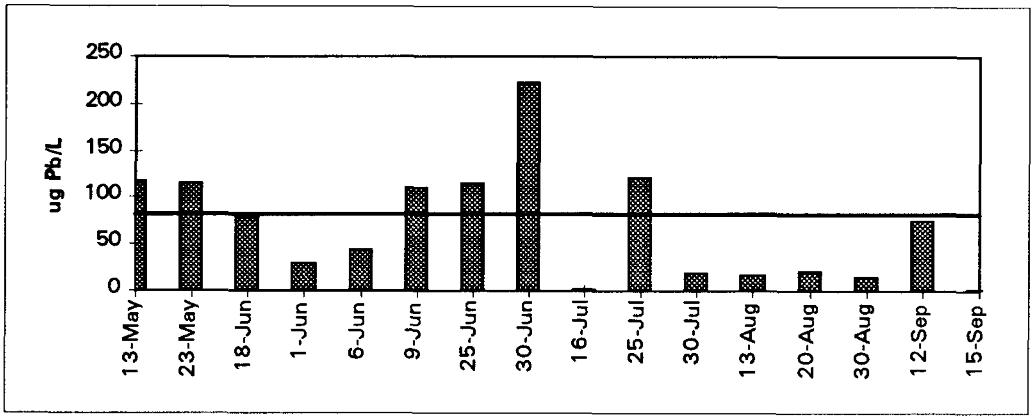

Figure 16. Concentration of Pb in Rachael Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Pb.

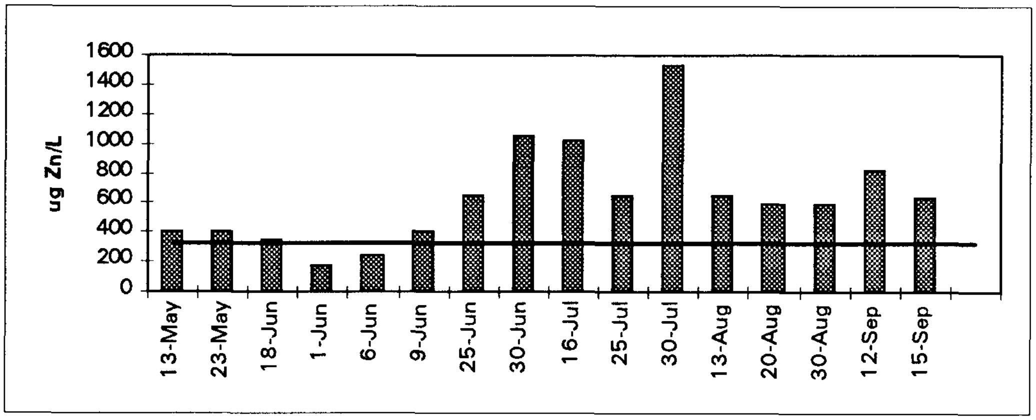

Figure 17. Concentration of Zn in Rachael Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Zn.

Sulfur Creek

Sulfur Creek is a small, intermittent stream flowing into the northwest side of the ore body (Figure 18). The creek is steep, with stair-step pools when water is flowing. Water in Sulfur Creek is high in iron and other metals.

Limited water quality data collected by Dames and Moore (1981) describe Sulfur Creek as having elevated concentrations of Pb and Zn (average of three samples = 128 ug Pb/L and 754 ug Zn/L) and slightly elevated concentrations of Cd (average of three samples = 7 ug/L) (Weber Scannell 1996). Flow ranged from 0.07 to 1.2 cfs, dissolved oxygen concentrations were near saturation, and pH was slightly acidic. The highest zinc concentration measured (of 3 samples) was 1,167 ug/L.

Investigations in 1995 and 1996 showed Sulfur Creek to be a small, intermittent tributary with an estimated summer flow of less than 3 cfs. The creek contains small step pools. Sulfur Creek typically stops flowing in mid-summer after snow melt and when overland flow has ceased. The creek remains dry until periods of heavy rainfall, usually intermittently in August. There does not appear to be subsurface flow; no water emerged from the 4 m drop between Sulfur Creek and the clean water bypass ditch.

Sulfur Creek has moderately hard water (Weber Scannell 1996) and in 1995 and 1996, water contained elevated concentrations of Cd, Pb, and Zn (Table 5 and Figures 19 through 22). High metals concentrations and the poor water quality in Middle Fork Red Dog Creek, along with the small size of Sulfur Creek, its steep step pools, and intermittent flows, probably exclude fish from using this tributary.

Figure 18. Sulfur Creek.

Table 5 . Water Quality in Sulfur Creek, 1995 and 1996.

	Al ug/L	Cd ug/L	Cu ug/L	Fe ug/L	Pb ug/L	Zn ug/L	pH
1995							
median	50	7	6.4	58	91.3	971	7.0
maximum	5970	11.8	20	20,100	2120	1900	7.4
minimum	50	3	1.2	36	65.8	399	6.5
count	6	6	6	5	6	6	4
1996							
median	102	5.46	2.6	215	475	784	
maximum	2150	19.9	9.7	5880	6890	2770	
minimum	29	1.67	1.2	50	133	201	
count	13	13	13	13	13	13	

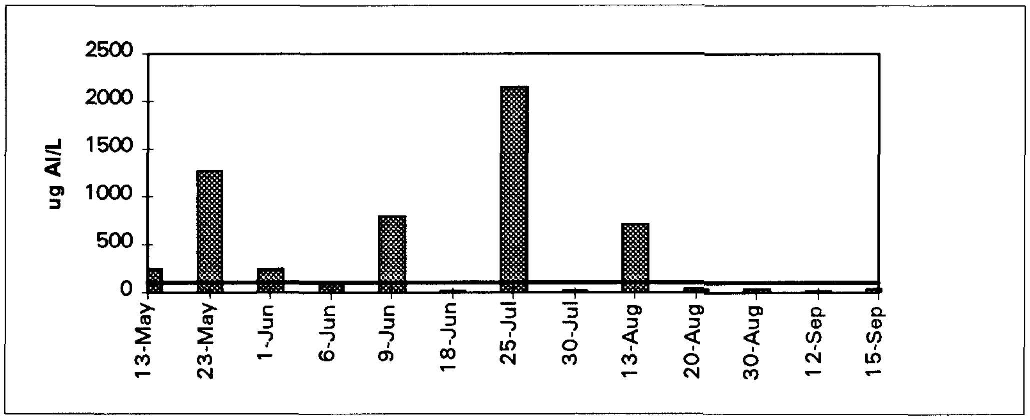

Figure 19. Concentration of Al in Sulfur Creek, 1996. Line on graph is the Aquatic Life Limit from the Canadian Water Quality Guidelines (for pH >6.5).

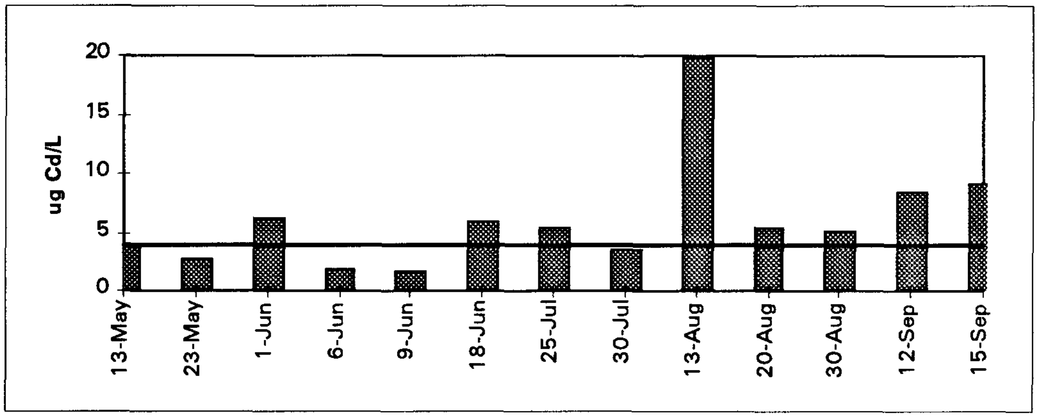

Figure 20. Concentration of Cd in Sulfur Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Cd.

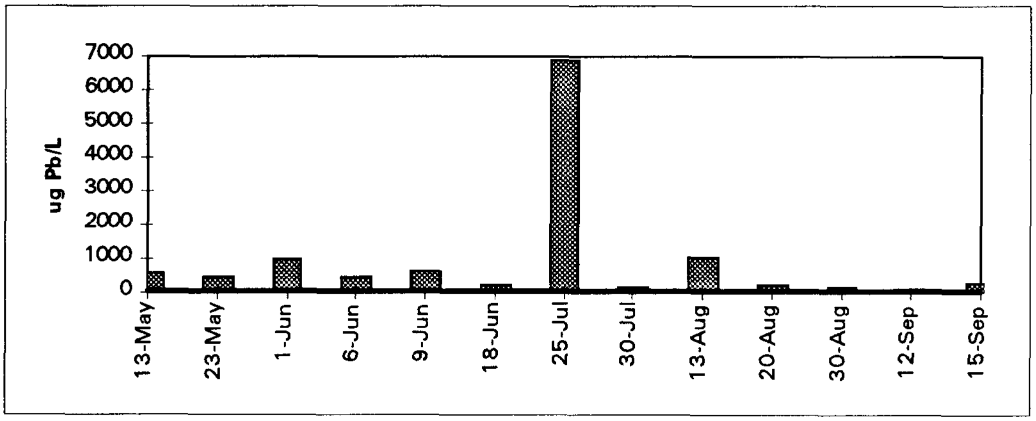

Figure 21. Concentration of Pb in Sulfur Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Pb.

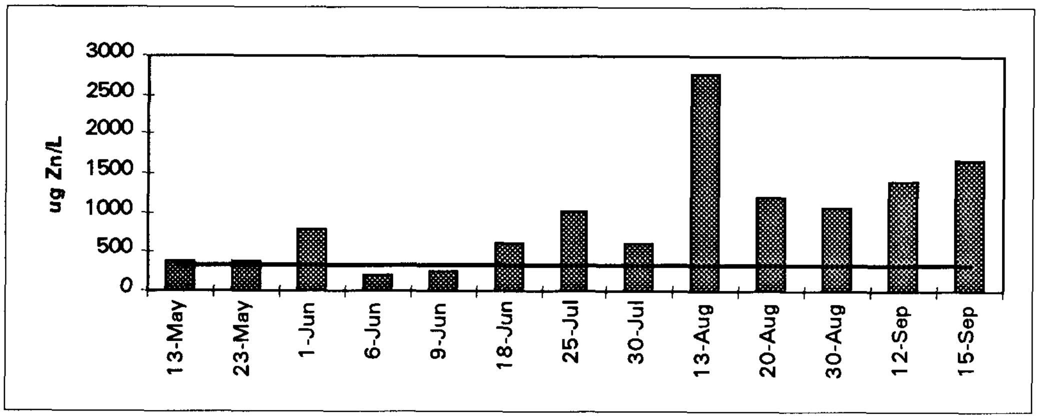

Figure 22. Concentration of Zn in Sulfur Creek in 1996. Line on graph is the USEPA acute limit for Aquatic Life for Zn.

Biological Evaluations

Benthic Macroinvertebrates: Baseline Studies

No baseline data on aquatic invertebrate populations are available for Shelly Creek, Connie Creek, Sulfur Creek, or Rachael Creek.

Macroinvertebrates: Current Study

Methods

Aquatic invertebrate communities were sampled in 1995 and 1996 to determine abundance and taxonomic richness of communities in tributary streams to Red Dog Creek. Communities were sampled in July 1995 and in mid-July and early August 1996. In 1995, we collected five semi-quantitative samples with a kick net in each of the creeks. In 1996 we set three drift nets in each creek. July 1996 samples were left overnight because flows were sufficiently low that nets did not seal with debris. In August 1996, during high flows, nets were left in each creek for approximately 2 hr. In 1996, Rachel Creek was sampled in July only. Drift nets were placed in the right fork, upstream of the visible upwelling of Al. The left fork contained high concentrations of Fe. After extensive hand sampling of benthic substrate in this fork, we found no evidence of aquatic invertebrates. Therefore, drift sampling was not done in these regions of Rachael Creek. Sulfur Creek was dry in July and not sampled; in August, following several days of heavy rain, Sulfur Creek had high velocity flows that washed out the drift nets. Flows in Sulfur Creek continued for several days until surface runoff subsided.

Samples were washed through a plankton bucket into whirl-pack bags, preserved in 70% ETOH, and labeled. Samples were sorted from rocks and organic debris, identified to lowest practical taxonomic level, (usually genus) and counted. All invertebrate samples were permanently preserved and stored at Alaska Department of Fish and Game, Fairbanks.

Results and Discussion

Drift sampling, even for the short duration used in August, collected samples with both higher abundance and higher taxonomic richness than kick samples in 1995 (Tables 6 and 7). Although Sulfur Creek was not sampled, we used a shovel to excavate a 1.5 m deep hole and confirm that subsurface flow was not present. We examined several shovelsfull of stream substrate and found no evidence of aquatic invertebrates.

The mainstem and left fork of Rachael Creek were not sampled in 1996 because after careful examination of the substrate we found no invertebrates in either portion of this creek. Kick samples collected in mainstem Rachael Creek in 1995 found one Chironomidae in one of the samples. There was no sign of in-situ productivity in either of these sites.

Table 6. Aquatic invertebrate communities collected by kick nets, 1995.

	Invertebrate Abundance		Taxonomic Richness	
Creek	average #/sample	maximum #/sample	average #/sample	maximum #/sample
Sulfur Creek	36.6	74	1.8	3
Shelly Creek	4.2	7	1.6	2
Connie Creek	40.6	47	2.6	3
Rachael Creek	0.2	1	0.2	1

Table 7. Aquatic invertebrate communities collected by drift sampling, 1996.

	Invertebrate Abundance		Taxonomic Richness	
	average #/sample	maximum #/sample	average #/sample	maximum #/sample
July 1996				
Shelly Creek	3103	5416	4.7	6
Connie Creek	1375	1424	5	8
Rachael Creek rt. fork, u/s N68°3.527', W162°48.263'	610	908	6.7	7
August 1996				
Shelly Creek	1255	2144	4	4
Connie Creek	1493	2000	6.7	8

July drift net sampling in Rachael Creek was done in the right fork, upstream of the upwelling that contained high concentrations of Al (see explanation in the text).

Shelly Creek

In 1995, we found few invertebrates in Shelly Creek (Weber Scannell 1996). The aquatic benthic community included a small leach (Hirudinea), Nematoda, the Diptera Chironomidae, and the Plecoptera: Nemouridae. The average number of invertebrates per sample was 4.2 and the maximum number was 7.

Drift samples collected in July and August 1996 contained much higher invertebrate abundance and taxonomic richness than kick samples in 1995. We found a higher proportion of Plecoptera and Ephemeroptera and a more diverse community overall (Table 8) than in 1995. Differences in results between 1995 and 1996 are probably due more to the increased efficiency of drift nets used in 1996 than to biological changes in the stream community.

Connie Creek

Connie Creek supports an abundant, however not diverse, invertebrate community. Invertebrate abundance was similar to that found in the North Fork Red Dog Creek in 1995; however, the community had lower taxonomic richness than found in the North

Fork Red Dog Creek. In order of abundance, taxa found in 1995 were Diptera: Chironomidae, Ephemeroptera: Heptagenidae, Diptera: Tipulidae, and Plectoptera: Nemouridae. Drift samples collected in 1996 contained far higher abundance and taxonomic richness (Tables 6 and 7) than found in 1995.

Sulfur Creek

In 1995, we found that Sulfur Creek supported an invertebrate community with low taxonomic richness: 95% Nematoda and 5% Chironomidae. Exuvia from Plecoptera: Nemouridae were found; they did not appear to be pre-emergent.

Table 8. Percent of Ephemeroptera, Plecoptera, and Diptera found in the study streams, 1995 and 1996.

	% Ephemeroptera	% Plecoptera	% Diptera	% Other Orders
July 1995 Kick nets				
Sulfur Creek	0%	0%	5%	95%
Shelly Creek	0%	9%	38%	53%
Connie Creek	0%	1%	0%	99%
Rachael Creek[1]	0%	100%[2]	0%	0%
July, 1996 Drift nets				
Shelly Creek	0%	2%	97%	1%
Connie Creek	1%	3%	94%	2%
Rachael Creek[3]	0%	11%	88%	1%
August, 1996 Drift nets				
Shelly Creek	33%	54%	12%	1%
Connie Creek	67%	4%	28%	1%

[1] In 1995, Rachael Creek was sampled below the confluence of the two forks, in the region of Al precipitate.

[2] Only two adults of aquatic invertebrates, and no larval forms, were found in Rachael Creek in 1995.

[3] In 1996, Rachael Creek was sampled in the right fork, above the inflow of metals (N68°3.527', W162°48.263').

Rachael Creek

The invertebrate community in Rachael Creek below the forks was virtually non-existent: in 1995 only two Chironomidae adults were found. It is unlikely these insects were produced in Rachael Creek. In 1996 we conducted visual inspections of lower Rachael Creek and the left fork by examining rocks; no invertebrates were found. The right fork, above the inflow of Al, contains a rich and abundant invertebrate community (Tables 7 and 8).

Conclusions

Invertebrate communities, as demonstrated by both taxonomic richness (more than 2 orders represented) and abundance (more than 1 invertebrate per sample) were documented in Connie Creek and Shelly Creek and the right fork of Rachael Creek. Sulfur Creek could not be sampled because there was no water; inspection of the substrate by digging with a shovel did not reveal any invertebrates.

Periphyton

Methods

In 1995 we collected five rocks at each sample site within a riffle section to sample for periphyton. In 1996, we sampled at least 5 and up to 10 rocks within each study site (Table 9). A 5 cm x 5 cm square of high density foam was placed on the rock. Using a small tooth brush, all material around the foam square was removed and rinsed away with clean water. The foam was removed from the rock and the rock was brushed with a clean tooth brush and rinsed onto a 0.45 *u*m glass fiber filter, held by a magnetic filter holder connected to a hand vacuum pump. Excess water was pumped through the filter, and approximately 1 ml saturated $MgCO_3$ was added to the filter to prevent acidification. The dry filter was wrapped in a large filter (to absorb any additional water, labeled, and placed in a zip-lock bag and packed over desiccant. Filters were frozen in a light-proof container with desiccant.

Filters were cut into small pieces and placed in an extraction tube with 10 ml of 90% buffered acetone. Extraction tubes were covered with aluminum foil and were held in a dark refrigerator for 24 hours. After extraction, samples were read on a Shimadzu UV-1601 Spectrophotometer (1995) and a Turner Model 10 Fluorometer (1996). Trichromatic equations (according to Standard Methods, APHA 1992) were used to convert spectrophotometric optical densities to total chlorophyll-a. The Turner Fluorometer was calibrated with USEPA standards according to Standard Methods (APHA 1992). A calibration curve was developed with chlorophyll-a standards using a spectrophotometer.

Results and Discussion

In 1995, periphyton communities (i.e., detecting chlorophyll-a in at least 3 of the 5 samples) were documented in Sulfur Creek, Shelly Creek, and Connie Creek (Weber Scannell 1996); no chlorophyll-a was detected in samples from Rachael Creek (Weber Scannell 1996).

In 1996 we were unable to sample Sulfur Creek because there was no surface flow and the substrate was dry. Periphyton was collected in the right fork of Rachael Creek in the region of Al precipitate (below N68°3.527', W162°48.263'), in the left fork of Rachael Creek, in Connie Creek, and in Shelly Creek. The highest chlorophyll-a concentrations were found in Left Fork Rachael Creek (maximum = 1.27 mg/m2) and the lowest concentrations in Right Fork Rachael Creek (minimum = 0.02 mg/m2) (Table 9). Concentrations of chlorophyll-a measured in both July and August 1996 in Connie Creek and Shelly Creek were lower than amounts measured in 1995.

Table 9. Concentrations of Chlorophyll-a, mg/m^2, in 1995 and 1996.

	Median mg/m^2	maximum mg/m^2	minimum mg/m^2	count
July 1995				
Shelly Cr.	0.645	1.360	0.265	5
Connie Creek	1.222	1.387	0.713	5
Sulfur Creek	5.574	7.997	3.212	5
Rachael Creek	0.054	0.293	0.014	5
July 1996				
Shelly	0.206	0.46	0.174	5
Connie	0.689	1.19	0.222	10
Rachael LF	1.189	1.27	0.618	5
Rachael RF	0.095	0.38	0.021	5
August 1996				
Shelly Cr.	0.158	0.87	0.055	8
Connie Cr.	0.504	0.76	0.058	8

Fish

Fish have not been found in Middle Fork Red Dog Creek or in any of the tributaries to Middle Fork Red Dog Creek. Therefore, the tributary streams examined in this study are not considered to support fish.

Conclusions and Recommendations

Information from baseline studies and from post-mining studies were used to document the presence of a community of aquatic invertebrates (exhibiting both abundance and taxonomic richness), periphyton (as measured by concentrations of chlorophyll-a) and fish (Table 10). Based upon this information, we believe the following streams, or stream segments, support communities of aquatic invertebrates and aquatic plants:

Connie Creek
Shelly Creek
Rachael Creek from the headwaters of the right fork to the beginning of Al input, at 50' upstream of N68° 3.776', W 162° 47.905'.

and that the following streams or stream segments do not support aquatic communities:

Sulfur Creek
Rachael Creek, entire left fork and right fork, downstream of the beginning of Al input, from 50' upstream of N68° 3.776', W 162° 47.905'.

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Appendix I. Taxonomic list of invertebrates collected in study creeks.

Ephemeroptera

Baetidae	Baetis
Heptagenidae	Cyngmula

Plecoptera

Nemouridae	Nemoura
Capnidae	Capnia
Perlodidae	Alloperla

Diptera

Chironomidae larvae	
Chironomidae pupae	
Tipulidae	Tipula
Tipulidae	unident. immature
Simulidae	Simulium
misc. adults	(terrestrial sp.)

Miscellaneous

Nematoda	
Collembola	Podura

Coleoptera

Staphylinidae L	Stenus
Hydrophilidae L	Hydrochus