

*Laberge*

ENVIRONMENTAL SERVICES  
P.O. Box 21072  
Whitehorse, Y.T.  
Y1A 6P7

Office Phone: 867-668-6838  
Cell Phone: 867-668-1043  
Fax: 867-667-6956

**BIOLOGICAL AND SEDIMENT MONITORING PROGRAM**

**AT**

**ROSE AND ANVIL CREEKS, FARO, Y.T.  
2004**

Submitted to:

**DELOITTE & TOUCHE INC**

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Prepared by:

**B.E. Burns  
LABERGE ENVIRONMENTAL SERVICES  
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## **1.0 INTRODUCTION**

On August 16, 1994, Anvil Range Mining Corporation (Anvil) was officially assigned Licence Number IN89-001, which was originally issued to Curragh Resources Inc, by the Yukon Territory Water Board. On December 21, 1996, mining temporarily ceased but the mill continued to operate until March 1997. In late August 1997, mining resumed with milling commencing in October. However both operations shut down in late January 1998. Low metal prices (zinc and lead) and financial difficulties experienced by Anvil indicated that this closure had the potential to be long term. An amended water licence, number QZ95-003 was issued to Anvil on January 30, 1998. In April 1998, Deloitte and Touche Inc became the interim receivers for the Faro Mine property, operations and assets. They have also acted as caretakers of the site bearing responsibility for the requirements under the water licence. On March 30, 2004, Deloitte and Touche Inc was issued licence QZ03-059 to continue care and maintenance of the site, and to conduct and/or manage additional studies and plans, for another five years.

To comply with Part G, Section 64, of the new licence, a biological and sediment monitoring program is to be undertaken every two years on the Rose Creek system. The Licence states that three replicate samples of benthic macro-invertebrate fauna are to be collected from seven sites located on Rose and Anvil Creeks. These benthic organisms are to be identified, enumerated and the data evaluated. Stream sediment and water samples are to be collected concurrently.

Deloitte & Touche Inc contracted Laberge Environmental Services (LES) to conduct the biological and sediment monitoring surveys. This report contains all data collected during the 2004 program. Some comparisons with past monitoring programs have been included.

## 2.0 STUDY AREA

The Faro mine and mill are located approximately 20 road kilometres north of the Town of Faro at approximately 62° 20' N and 133° 25' W (Figure 1).

The study area lies within the ecoregion Yukon Plateau - North. The mean annual temperature for this region is approximately -4°C with a summer mean of 10.5°C and a winter mean of -20°C. Northern boreal forests exist at elevations up to 1500 m asl. White and black spruce form the most common forest types with aspen and balsam poplar occupying disturbed areas. (Ecological Stratification Working Group, 1995).

The biological monitoring sites are established on Rose and Anvil Creeks at the following locations (Figure 2):

- R1 Upstream of the confluence of the North and South Forks of Rose Creek.
- R2 In the mixing zone downstream of the intersection of the Rose Creek diversion canal and the outlet of the tailings pond.
- R3 Rose Creek approximately half way between the tailings pond outlet and Anvil Creek.
- R4 Rose Creek just upstream of Anvil Creek.
- R5 Anvil Creek approximately 150 metres downstream of Rose Creek.
- R6 Anvil Creek immediately upstream of Rose Creek.
- R7 North Fork of Rose Creek upstream of the confluence with the Faro Creek diversion.

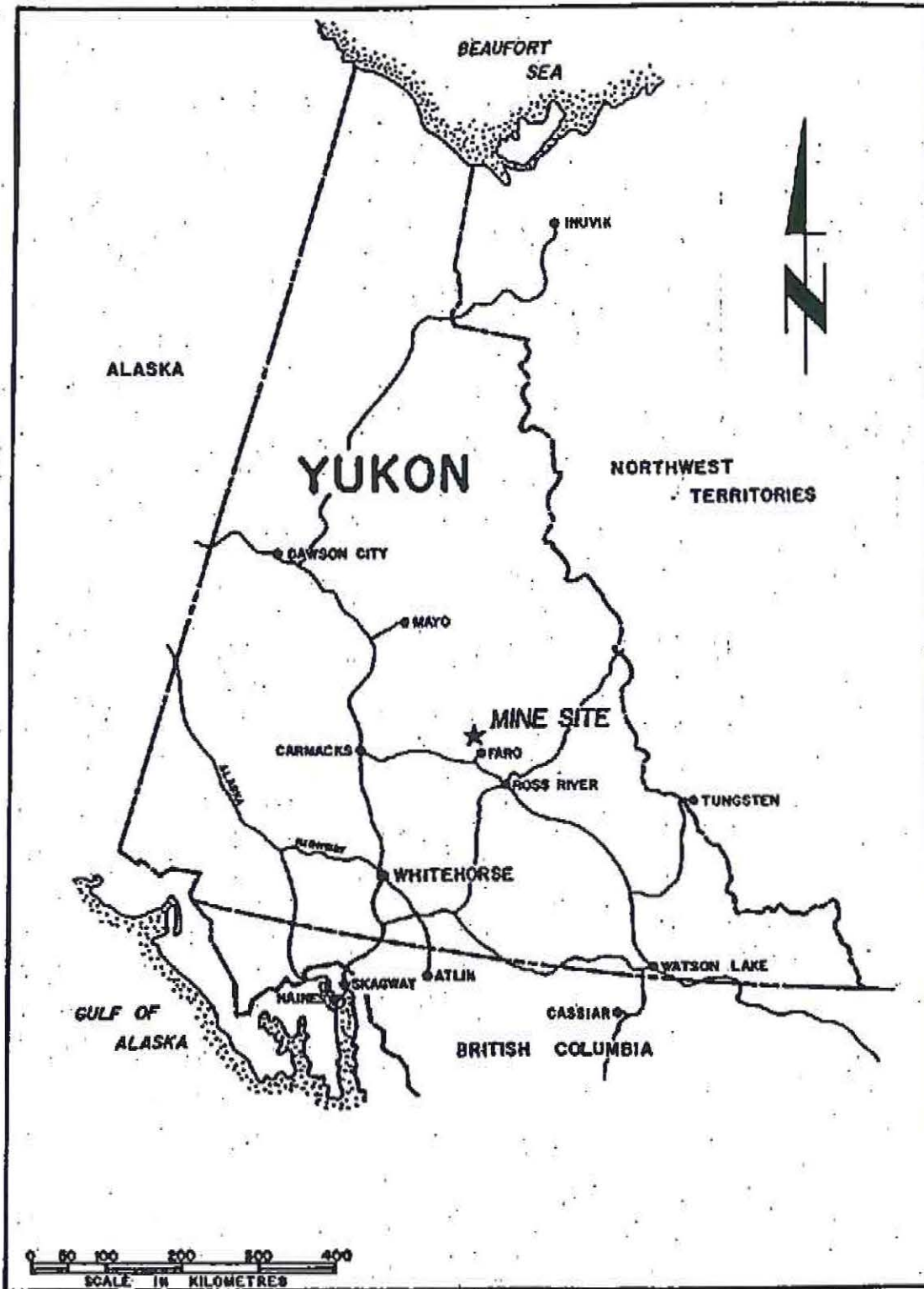


Figure 1 Location of Faro Mine



**ANVIL CREEK/ROSE CREEK**

FIGURE 2 - LOCATION OF SAMPLE SITES



SCALE: 1:250,000

### **3.0 METHODS**

The 2004 biological monitoring program consisted of two field surveys conducted on July 19<sup>th</sup> and 20<sup>th</sup>, and on August 23<sup>rd</sup> and 24<sup>th</sup>. Helicopter access was required for the sites situated on the lower mainstem of Rose Creek and the sites on Anvil Creek. The remaining sites were accessed by vehicle and on foot.

#### **3.1 Water Quality**

Water quality samples were collected at each site in July and in August. The samples were collected in a fast flowing section of the stream upstream of the sediment and benthic sampler locations.

##### **3.1.1 Field Measurements**

In-situ measurements were taken at each site during both surveys. Conductivity and temperature were determined with an Orion conductivity meter model 126. Dissolved oxygen readings were obtained using an Orion oxygen meter model 820 and pH measurements were taken using an Accumet Portable AP61 pH meter.

##### **3.1.2 Chemical Analyses**

All sample bottles were supplied by Cantest Laboratories of Burnaby, B.C. and were provided to LES personnel at the Faro Mine Security Office. At each site, the sample bottles were rinsed three times with the sample water prior to filling. Samples were collected in two litre plastic bottles for sulphates, alkalinity, ammonia, hardness, colour, turbidity and nonfilterable residue analyses. Ammonia samples were collected in 500 mL plastic bottles and preserved with sulphuric acid. Samples to be analyzed for total metals and dissolved metals were collected in 250 mL acid washed plastic bottles. The total metals samples were preserved with nitric acid. The dissolved metals samples were left unpreserved to be filtered and treated at the lab. Samples were kept cool prior to shipment to Cantest.

#### **3.2 Water Quantity**

Discharge was measured at each of the sites, where possible, on both visits. An area with a uniform cross section was chosen and the velocity and depth were measured using a AA Price velocity meter. Ten or more readings were taken across the profile of the stream. Total discharge was calculated as the sum of these individual discharges (area x velocity).

### **3.3 Stream Sediment Sampling**

Triplicate stream sediment samples were collected from each site in July. Sample sites were selected from areas of deposition along the stream bank, generally characterized by the finest grain size evident at the site. Samples were collected with a stainless steel trowel and placed in zip-lock plastic bags. The samples were packed with ice packs when shipped to Cantest.

At the lab, the samples were dried and passed through a 100 mesh (0.15 mm) stainless steel sieve. The portion passing through the sieve was run through an ICP scan for the determination of total metal concentrations.

### **3.4 Benthic Invertebrate Sampling**

#### **3.4.1 Field Collection**

Artificial substrate samplers were used for benthic invertebrate sampling. The basket samplers were cylindrical in shape, measured 26 cm long with a diameter of 17 cm, and were constructed of galvanized wire with a one centimetre mesh. Each substrate sampler was filled with washed indigenous gravels collected from the stream bed or the bank at each sample site. The surface area provided by this 'artificial substrate' was approximately  $6000 \pm 1000 \text{ cm}^2$  (Baker 1979).

Three rock filled samplers were submerged in riffle areas of the stream at each site on July 19<sup>th</sup> or 20<sup>th</sup>. These samplers were left to colonize for five weeks. On August 23<sup>rd</sup> and 24<sup>th</sup>, 2004, the artificial substrate samplers were retrieved by placing a screened bucket with a 300 micron mesh, downstream and under the basket. On shore the basket was opened in the bucket. Individual rocks were then carefully washed in the screened bucket to remove and collect all invertebrates from that sample. The detritus and benthic invertebrates remaining in the bucket were placed in a one litre nalgene bottle and preserved with 10% formalin. These samples were sent to Charles Low PhD, an entomologist in Victoria, B.C. for enumeration and identification.

#### **3.4.2 Laboratory Analysis**

All samples were washed through two screens with mesh sizes 1 millimetre and 180 microns. All of the organisms retained by the coarse screen were counted and identified, whereas the organisms on the 180 micron screen were subsampled as necessary. A Folsom plankton splitter was used for the subsampling. The split fraction that was analyzed is indicated underneath the station number in Appendix C. The majority of the benthos were identified to the genus level.

## 4.0 RESULTS AND DISCUSSION

### 4.1 Water Quality

Water quality samples were collected at each of the sites on both visits during the summer of 2004. The analytical results are presented in Appendix A. Sixteen parameters (Sb, As, Be, Bi, B, Cr, Hg, P, Se, Ag, Te, Ti, Th, Sn, V and Zr) were below the method detection limit in all of the samples on both occasions in the dissolved and total states.

Part 3 of Schedule B specifically requests the analysis of total hardness, alkalinity, sulphate, suspended solids, ammonia, and total and dissolved copper, iron, lead and zinc. The results for these parameters and the in-situ data are presented in Table 1, with discussion per parameter presented below.

#### 4.1.1 Temperature

The temperature values reflected the diurnal and seasonal timing of the sampling, ranging from 5.8°C at R6 on August 24<sup>th</sup> to 13.2°C at R2 on July 23<sup>rd</sup>.

#### 4.1.2 Conductivity and Total Hardness

Calcium and magnesium are considered to be the primary contributors to hardness but other cations such as strontium, barium, manganese, iron and aluminum also contribute to total hardness. The upstream Rose Creek sites R1 and R7 were medium soft and the rest of the sites medium hard. The downstream sites on Rose Creek (R2, R3 and R4) were very hard during the August sampling. Conductivity, which is a measure of the ionic constituents in water, had a similar trend to total hardness with lower values in the upstream sites and considerably higher values in the downstream sites.

#### 4.1.3 pH and Alkalinity

All pH values were slightly alkaline ranging from 7.90 at R2 to 8.48 at R5. Alkalinity is a measure of the buffering capacity of natural waters against changes in pH relating to the carbonate system. Alkalinity values were fairly consistent throughout. Generally sites R5 and R6 had the highest alkalinity. There was an anomalous low value of 4.3 documented at R1. This is highly inconsistent with other readings collected here over time and it is suspected to be lab error.

#### 4.1.4 Dissolved Oxygen

All sites were well aerated.

**TABLE 1**  
**WATER QUALITY DATA, 2004**

Sample Site	R1		R2		R3		R4		R5		R6		R7	
	July 19	Aug 23	July 19	Aug 23	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24
Date, 2004	July 19	Aug 23	July 19	Aug 23	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24	July 20	Aug 24
Flow, m <sup>3</sup> /sec	1.364	1.081	1.467	1.112	1.816	1.317	2.159	1.729	4.639	3.465	2.480	1.726	0.582	0.477
Temp °C	11.8	9.5	12.6	13.2	13.1	8.8	11.8	7.6	8.8	6.3	8.3	5.8	10.3	6.5
Conductivity (uS/cm)	194	209	292	571	287	501	288	448	253	275	254	272	168	172
pH (In-situ)	8.12	7.94	7.90	8.04	8.22	8.27	8.22	8.34	8.36	8.48	8.40	8.43	8.08	8.11
D.O. (mg/L)	—	9.0	7.8	8.1	8.9	9.2	8.5	8.4	9.3	9.4	9.9	10.1	9.1	9.3
Alkalinity mg/L as CaCO <sub>3</sub>	4.3	99.4	111	123	113	124	112	121	133	142	135	143	92.1	85.0
Sulphate	17.3	19.9	58.3	240	49.4	180	54.1	148	21.4	26.7	21.6	21.3	7.8	7.2
Ammonia	<0.01	0.02	0.02	0.26	0.02	0.11	0.01	0.03	0.01	<0.01	0.01	<0.01	0.07	<0.01
NFR	<1	<1	<1	3	<1	<1	<1	<1	<1	3	<1	<1	<1	<1
Copper - total	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.002	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
- dissolved	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron - total	0.18	<b>0.33</b>	<b>0.38</b>	<b>0.51</b>	0.27	<b>0.32</b>	0.14	0.20	0.07	0.20	0.11	0.18	0.10	0.19
- dissolved	<0.05	0.27	0.18	<b>0.43</b>	0.14	0.32	0.11	0.17	<0.05	0.19	<0.05	0.18	0.07	0.12
Lead - total	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
- dissolved	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc - total	0.010	0.011	0.018	<b>0.058</b>	0.012	<b>0.039</b>	0.008	0.013	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
- dissolved	0.006	0.007	0.015	<b>0.067</b>	0.010	0.034	0.007	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Hardness mg/L as CaCO <sub>3</sub>	102	102	144	296	151	255	153	222	134	155	140	152	87	81

NOTES: All units in mg/L unless otherwise indicated. Values in bold indicate the CCME guideline has been exceeded.

#### 4.1.5 Sulphate

Sulphate concentrations were low (7.8 to 58.3 mg/L) throughout the system in July. In August concentrations ranged from 7.2 mg/L at R7 to 240 mg/L at R2. The sulphate concentration at R2 was 58.3 mg/L on July 19<sup>th</sup>. The significant increase over the five weeks is due to the fact that there was no discharge from the tailings impoundments (X5) during the July sampling but effluent was flowing in August. Elevated concentrations are also evident to a lesser degree at the downstream sites of R3 and R4. Sulphate concentrations normally vary from 10 to 80 mg/L in surface waters (CCREM, 1987).

#### 4.1.6 Ammonia

Ammonia was detected at most of the sites but was well below the CCME recommended guideline of 0.7 mg/L NH<sub>3</sub>.

#### 4.1.7 Non Filterable Residue (NFR)

All waters were very clear with an occasional reading of 3 mg/L, otherwise concentrations were below the method detection limit of 1 mg/L.

#### 4.1.8 Total and Dissolved Metals

The values in bold in Table 1 indicate that the CCME guideline for the protection of freshwater aquatic life was exceeded for that parameter in that sample. The toxicity of some metals varies with the hardness of the sample waters (Table 2). Generally, toxicity of several metals to freshwater aquatic organisms increases as the hardness of the water decreases. Copper and lead concentrations were very low when sporadically detected. The CCME guidelines were met at all sites for these two metals.

Iron was detected at all sites and slightly exceeded the guideline at R1, R2, and R3.

Zinc was detected throughout and the CCME guideline was slightly exceeded at R2 and R3 in the August samples.

The above metal concentrations have been discussed in relation to the CCME guidelines. It is important to note that the limits as set out under the Water Licence issued by the Yukon Territory Water Board apply to the discharge point and there is no obligation to meet the CCME criteria in the receiving waters at this time.

HARDNESS as CaCO <sub>3</sub> mg/L	COPPER mg/L	LEAD mg/L	IRON mg/L	ZINC mg/L
0 - 60    soft	0.002	0.001	0.3	0.03
60 - 120    medium soft	0.002	0.002	0.3	0.03
120 - 180    hard	0.003	0.004	0.3	0.03
>180    very hard	0.004	0.007	0.3	0.03

#### 4.2            Water Quantity

Water flow was measured at each of the sites in July and August. These data are presented in Table 1 with the water quality data. The summer of 2004 was hot and dry. Water levels were very low in August.

#### 4.3            Stream Sediments

Triplicate stream sediment samples were collected from all sites during the July visit. The results for the metals analyses were averaged and the standard deviation was calculated to determine the variability of metal concentrations at each site (Appendix B). A few metals, especially those with high concentrations, showed some variability. Of the 30 metals analyzed, only beryllium was below the method detection limit.

Six metals (arsenic, cadmium copper, mercury, lead and zinc) known to be toxic to the aquatic environment were examined in detail. The mean concentrations of these metals were compared to the CCME (1999) interim freshwater sediment quality guidelines (ISQG) and to the probable effects levels (PEL) (Table 3). Generally, concentrations greater than the PEL have a 50% incidence of creating adverse biological effects.

The highest concentrations of metals in the stream sediments occurred at R2. Since this site is immediately downstream of the tailings facility, it would receive the greatest impact from mining related activity. The PEL for arsenic, lead and zinc was exceeded at R2. Although concentrations were not quite as high, the PEL for lead and zinc was also exceeded at R1, R3 and R4. The ISQG was exceeded for arsenic, cadmium and copper at most sites but concentrations were generally well below the PEL. The ISQG for mercury was exceeded at R2 only.

**TABLE 3**  
**SUMMARY OF STREAM SEDIMENT METAL CONCENTRATIONS**

STATION NUMBER	STATION DESCRIPTION	ARSENIC (ppm)	CADMIUM (ppm)	COPPER (ppm)	MERCURY (ppm)	LEAD (ppm)	ZINC (ppm)
R1	Rose Creek upstream	<b>12.1</b>	0.7	18.3	0.09	125	203
R7	North Fork of Rose Creek	11.9	0.5	17.3	0.03	15	76
R2	Rose Creek d/s tailings ponds	<b>12.5</b>	1.3	<b>58.3</b>	0.18	207	482
R3	Rose Cr midway between R2 & R4	<b>15.5</b>	0.8	48.7	0.12	185	378
R4	Rose Cr just u/s of Anvil Creek	14.2	0.7	38.7	0.11	154	293
R6	Anvil Creek u/s Rose Creek	12.2	0.6	20.0	0.01	11	68
R5	Anvil Creek d/s Rose Creek	11.4	0.0	42.3	0.04	89	212

Note: ISQG = Interim Freshwater Sediment Quality Guidelines. Values in bold indicate exceedences.  
 PEL = Probable Effects Level (>50% of adverse effects occur above this level. Values *italicized* and in bold indicate exceedences.

Concentrations of most of the metals were very low at R6 and R7, which are representative of background conditions. Although R1 is located upstream of the tailings facility, concentrations of several of the target metals were relatively high, and did exceed the PEL as mentioned earlier.

#### 4.3.1 Comparisons with Past Data

Limited data exists on the geochemistry of the stream sediments in the Rose Creek system. Metals in sediments have not been a licensed requirement for this system until the issuance of Licence # QZ03-059 in March 2004. In 1996, stream sediment samples were voluntarily collected and analyzed for metals during the Rose Creek biological monitoring program (Burns, 1997). Environment Canada conducted environmental impact surveys downstream of the tailings impoundment in 1983 (Godin and Osler, 1985) and in 1973 (Hoos and Holman, 1973). Table 4 shows comparisons of selected metal concentrations upstream on Rose Creek, R1, and at the downstream sites of R2 to R5. All data represents the mean of triplicate samples (N=3) except in 1983 which is the average of two sets of triplicate samples collected in July and August (N=6). Environment Canada did not collect samples at R5 resulting in only two sets of temporal data. Arsenic was not one of the six metals analyzed in 1973. The detection limit for cadmium was very high in 1973 and this set of data has been excluded. Each parameter has also been graphed (Figures 3 to 6) and includes either the PEL or the ISQG, which ever is more meaningful for that data set.

In March of 1975, a tailings spill released 245,000 cubic metres of tailings slurry into Rose Creek (Godin and Osler, 1985). The 1983 data for arsenic and lead was consistently high at the downstream sites (R2, R3 and R4), and were the highest documented to date. Concentrations of zinc were also elevated in 1983 at R2 and R3. These elevated levels could represent lingering effects from the tailings spill of 1975.

**TABLE 4**  
**COMPARISONS OF METAL CONCENTRATIONS IN SEDIMENTS, 1973, 1983, 1996 AND 2004**

	Arsenic (ppm)				Cadmium (ppm)				Lead (ppm)				Zinc (ppm)			
	1973	1983	1996	2004	1973	1983	1996	2004	1973	1983	1996	2004	1973	1983	1996	2004
R1		15	6	12		0.8	0.6	0.7	280	124	74	125	270	280	221	203
R2		86	32	20		1.2	1.6	1.3	83	775	310	207	180	918	617	482
R3		104	31	16		1.1	1.0	0.8	280	681	244	165	440	996	581	376
R4		51	32	14		1.1	2.1	0.7		585	267	153		885	908	293
R5			14	11			0.8	0.9			20	69			161	212

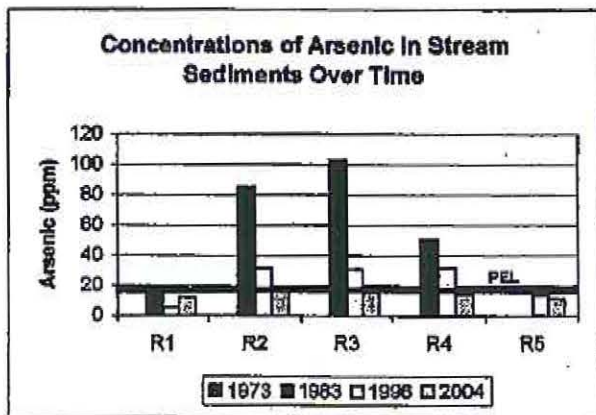


Figure 3

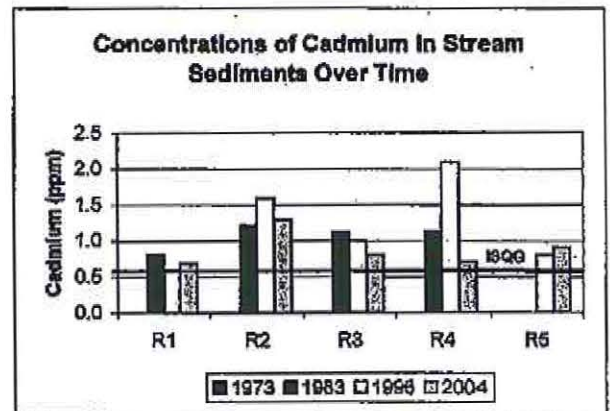


Figure 4

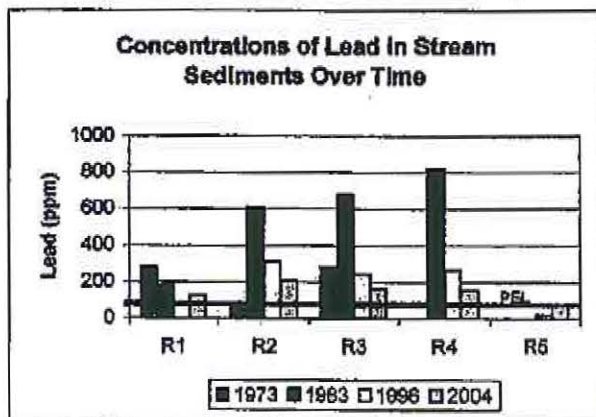


Figure 5

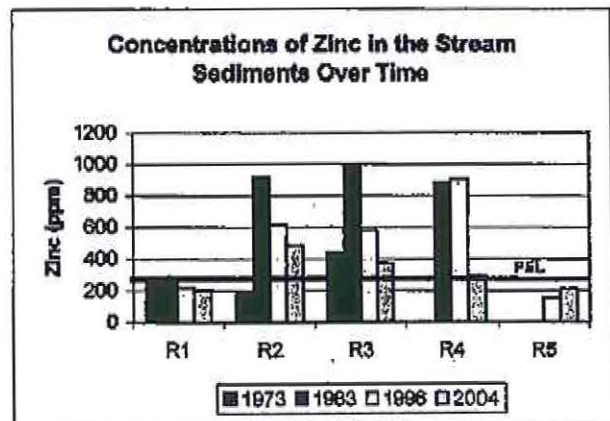


Figure 6

Metals in sediments are difficult to interpret because levels vary widely as a function of natural mineralization of local soils within a given watershed. Based on the current data set, it appears that concentrations of various metals have been decreasing since 1983. Concentrations of the selected metals at R5 are very similar to those at the upstream site R1. Lead levels however have consistently been greater at R1 than at R5.

#### **4.4 Benthic Invertebrates**

Five phyla were found in Rose and Anvil Creeks; Arthropoda, Annelida, Nematoda, Mollusca and Cnidaria. A total of 74 different taxonomic groups were identified within these five phyla. These data are presented in Appendix B.

##### **4.4.1 Abundance and Taxonomic Richness**

The total number of organisms for the triplicates at each site was summed to give a total abundance value for that site. Populations at most of the sites were high and ranged from 2,206 individuals at R5 to 55,191 individuals at R1.

Taxonomic richness was determined for each site by enumerating all taxonomic groups identified from species to phylum, as a measure of community diversity. All communities were diverse with 41 different taxonomic groups identified at R2 to 49 identified at R1.

Abundance and diversity were plotted and are displayed in Figure 7. To aid in interpretation, the stations were arranged on the X-axis to demonstrate where the tributaries, R7 and R6, enter the mainstem of Rose Creek. In comparison to the other sites, the populations at R4 and R5, the sites on lower Rose and Anvil Creeks, and R6, upstream on Anvil Creek, were low, however the communities here were equally diverse.

##### **4.4.2 Distribution**

The composition of the benthos communities was calculated as a percentage of the major taxonomic orders present with pie charts generated for each site (Figure 8). The grouping "Other" is made up of invertebrates from Coleoptera, Nematoda, Cnidaria, Copepoda, Gastropoda, Bivalva, Hirudinea, Homoptera, Hydracarina and/or Ostracoda. Based on this, taxa were then classified with respect to their dominance within the community (Table 5).

Diptera was the dominant order at all of the sites. Ephemeroptera shared dominance at R3 and R6. Within these two groups, the family Chironomidae formed the majority of Dipterans and the family Baetidae formed the majority of Ephemeropterans. Not a lot is known about the specific life cycles of insects inhabiting the north. However, the family Baetidae has frequently been found in large numbers in the Rose Creek system in the past, with a record number of over 23,000

SITE	SITE DESCRIPTION	ABUNDANCE	TAXONOMIC RICHNESS
R1	Rose Creek upstream	55,191	49
R7	North Fork of Rose Creek	32,360	44
R2	Rose Creek d/s tailings ponds and diversion canal	38,042	43
R3	Rose Creek midway between R2 and R4	30,826	41
R4	Rose Creek just u/s of Anvil Creek	4,964	44
R6	Anvil Creek just u/s of Rose Creek	8,759	46
R5	Anvil Creek d/s of Rose Creek	2,206	44

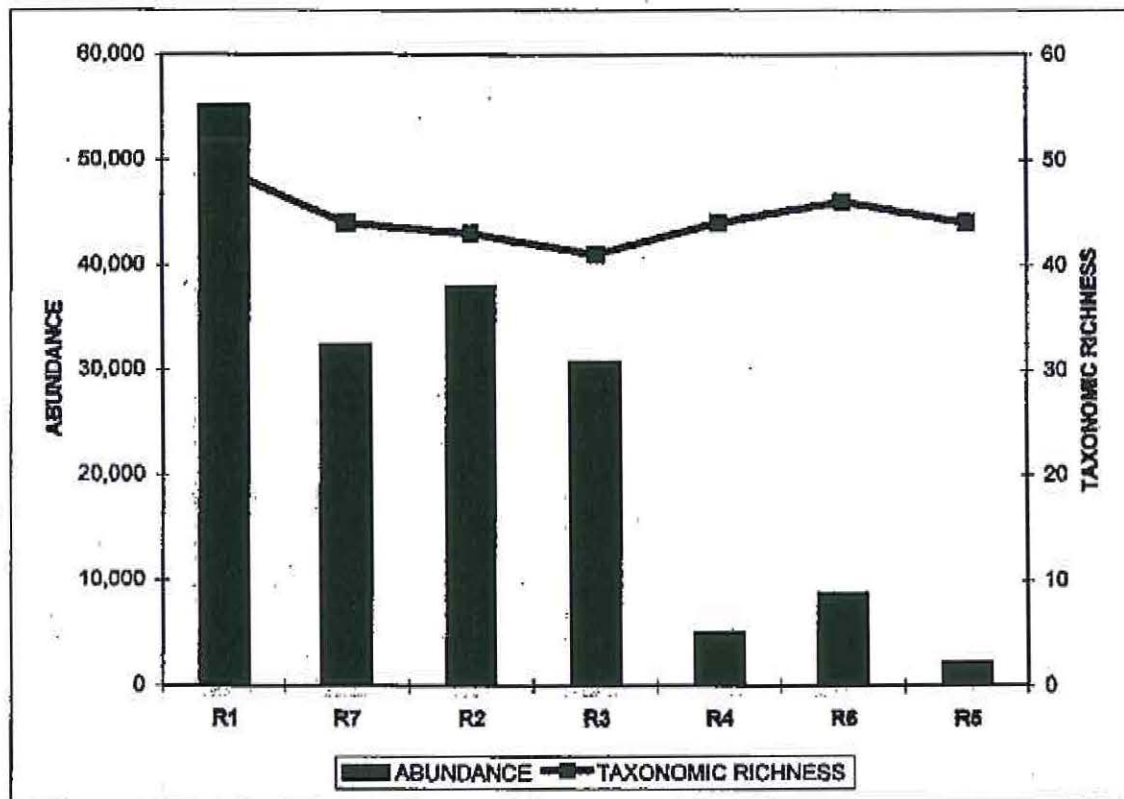
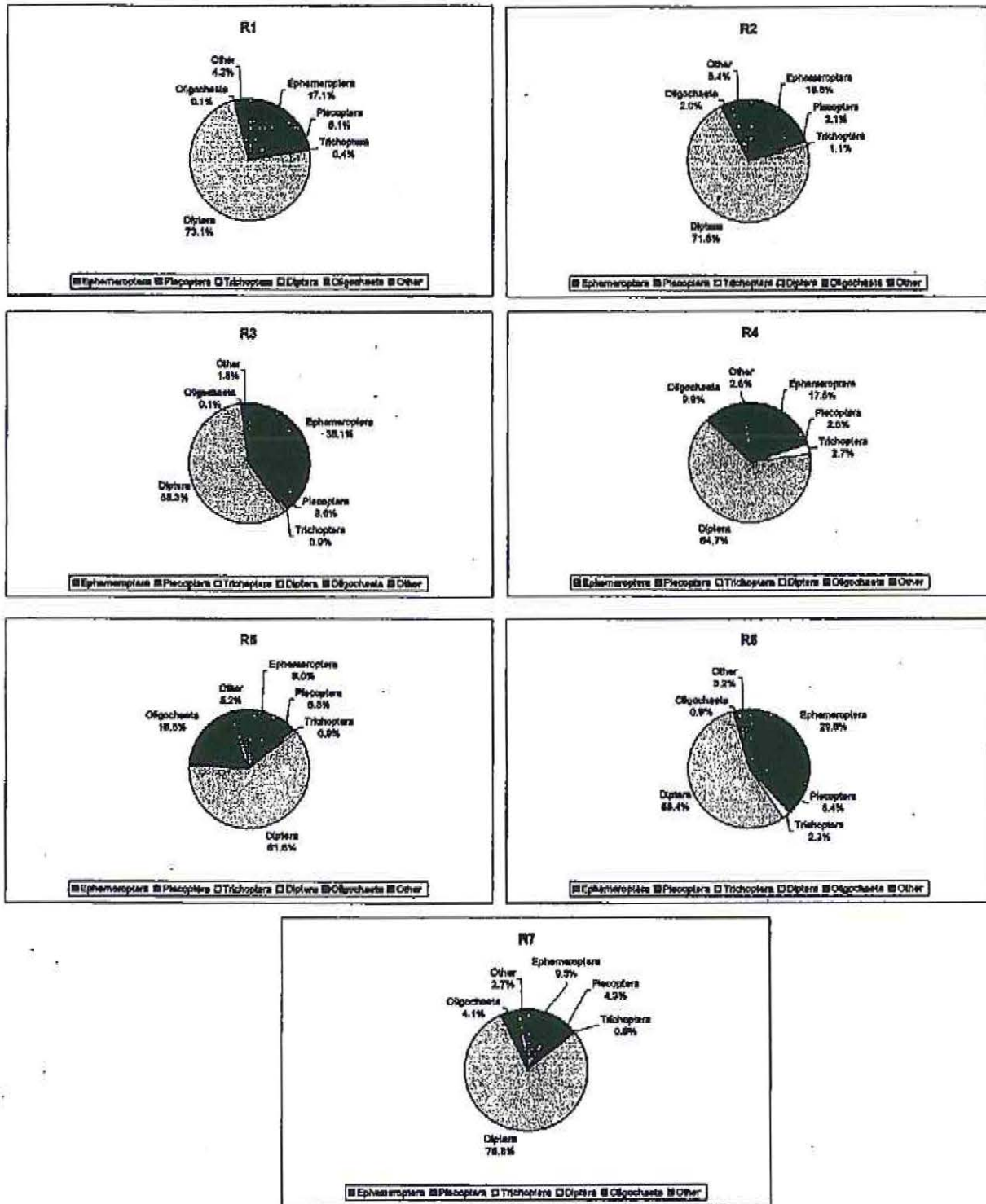


FIGURE 7 Abundance and Taxonomic Richness at Rose and Anvil Creeks, 2004

Figure 8 The Composition of the Benthic Invertebrata Community at Each Site, 2004



Baetidae collected at R3 in 1994. Chironomids have consistently been collected in the study area and generally have been the dominant group at the sites.

Ephemeroptera was subdominant at the other sites except at R5 where Oligochaeta was subdominant. Oligochaeta was either common or rare at the rest of the sites. Plecoptera and "Other" were common at all sites and Trichoptera was either common or rare.

In general, the composition of the seven benthic communities was similar.

**TABLE 5  
TAXONOMIC DISTRIBUTION OF BENTHIC INVERTEBRATES**

SITE	DOMINANT (≥25%)	SUBDOMINANT (10% to 24.9%)	COMMON (1.0% to 9.9%)	RARE (0.1% to 0.9%)
R1	Diptera	Ephemeroptera	Plecoptera Other	Trichoptera Oligochaeta
R2	Diptera	Ephemeroptera	Other Plecoptera Oligochaeta Trichoptera	
R3	Diptera Ephemeroptera		Plecoptera Other	Trichoptera Oligochaeta
R4	Diptera	Ephemeroptera	Oligochaeta Trichoptera Plecoptera Other	
R5	Diptera	Oligochaeta	Ephemeroptera Plecoptera Other	Trichoptera
R6	Diptera Ephemeroptera		Plecoptera Other Trichoptera	Oligochaeta
R7	Diptera		Ephemeroptera Plecoptera Oligochaeta Other	Trichoptera

The insect orders Ephemeroptera, Trichoptera and Plecoptera are sensitive to most types of pollution (Rosenberg and Resh, 1993). Lehmkuhl (1979) has identified several groups within these insect orders that have very low tolerance to chemical pollution. Eleven of these taxa (six taxa within Plecoptera, three taxa within Ephemeroptera and two taxa within Trichoptera) have been identified in the Rose and Anvil Creek study area. Table 6 summarizes the presence or absence of each of these taxa per site. All of the sensitive taxa were present at R3. Ten out of eleven taxa were present at R4, nine at R2, R5 and R7, and eight at R1 and R6.

All sites had good representation of pollution sensitive insects although interestingly, the background sites R1 and R6 had the least number of sensitive species present.

**TABLE 6**  
**Presence (+) and Absence (-) of Sensitive Taxa at Rose and Anvil Creeks**

Sensitive Taxa	R1	R2	R3	R4	R5	R6	R7
<b>Plecoptera</b>							
Nemouridae	+	+	+	+	+	+	+
Perlodidae	+	+	+	+	+	+	+
Capniidae	+	+	+	+	+	+	+
Taeniopterigidae	+	+	+	+	+	+	+
Chloroperlidae	-	+	+	+	+	-	+
Leuctridae	-	-	+	-	-	-	-
<b>Ephemeroptera</b>							
Epeorus	-	-	+	+	+	+	+
Ephemerellidae	+	+	+	+	+	+	+
Rithrogena	+	+	+	+	+	+	+
<b>Trichoptera</b>							
Brachycentriidae	+	+	+	+	-	-	-
Rhyacophilidae	+	+	+	+	+	+	+
<b>Total # of sensitive taxa:</b>	<b>8</b>	<b>9</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>	<b>9</b>
After Lehmkuhl (1979)							

#### 4.4.3 Comparisons with Past Data

Several studies to assess the health of ecosystems have been conducted using benthic macroinvertebrates (Rosenberg and Resh, 1993). Using benthic invertebrates in biomonitoring offers many advantages for the following reasons; they are ubiquitous, they are abundant and easy to collect, there are a large number of species offering a spectrum of responses to environmental stress, they are generally sedentary and therefore are representative of local conditions, and they have long life cycles compared to other groups (i.e. periphyton). As such,

benthic macroinvertebrates act as continuous monitors of the water they inhabit. Assessments are often based on taxa richness and the abundance of pollution sensitive insect orders.

The data collected in 2004 represent some of the highest populations recorded since sampling first began in 1973. The warm temperatures experienced during the summer of 2004 may have increased algal and periphyton production, major food resources for scrapers, filtering and collector functional feeding groups, such as several genera of Ephemeroptera, Trichoptera and Chironomidae. Hatching is triggered by warm temperatures and the warm dry summer experienced in 2004 could have contributed to the emergence of higher numbers of several insect species. However, this does not explain the unusually low population numbers documented at R4 and R5 in 2004.

Over the years various agencies and companies have collected benthic data from the Rose Creek system using various sampling methods at varying times of the open water season. Summaries of the past sixteen years of Company (Anvil Range and Curragh Resources) monitoring data have been tabulated (Table 7). In each of these nine surveys, artificial substrate samplers were used, the same sample site locations were employed and the sampling personnel were consistent. In addition, the quality of the habitat (riparian vegetation and stream substrate) at each of these sites has changed relatively little over the past sixteen years. Consequently, some temporal and spatial comparisons can appropriately be made.

The populations of the benthic communities at each of the sites fluctuated significantly over the sixteen years examined, with a general trend to an increase in numbers in recent years. Figure 9 shows the abundance at each site for the nine surveys examined. The highest population at R1 and R2 was documented in 2004, at R5 and R6 in 2000, at R4 and R7 in 1998 and at R3 in 1994. Population numbers were generally low in the late 80s and early 90s.

Based on the abundance data it appears that the benthic populations are recovering and improving at R2 over time, the site receiving the greatest potential impact from the tallings facility. The stream sediments here contained the highest concentration of metals with several parameters exceeding the probable effects levels (refer back to Table 3). These concentrations would indicate a high incidence of adverse effects to the biotic community; however population numbers were high at R2, the community was diverse and there was good representation of chemical sensitive organisms. These data would indicate that although high concentrations of metals exist in the stream sediments, they presumably are not in a bioavailable form.

Although population numbers were relatively low at R4 over the years, the taxonomic richness and high numbers of sensitive taxa documented in recent years, indicate a healthy benthic community.

Table 7  
Comparison of Benthic Data over a 16 Year Period

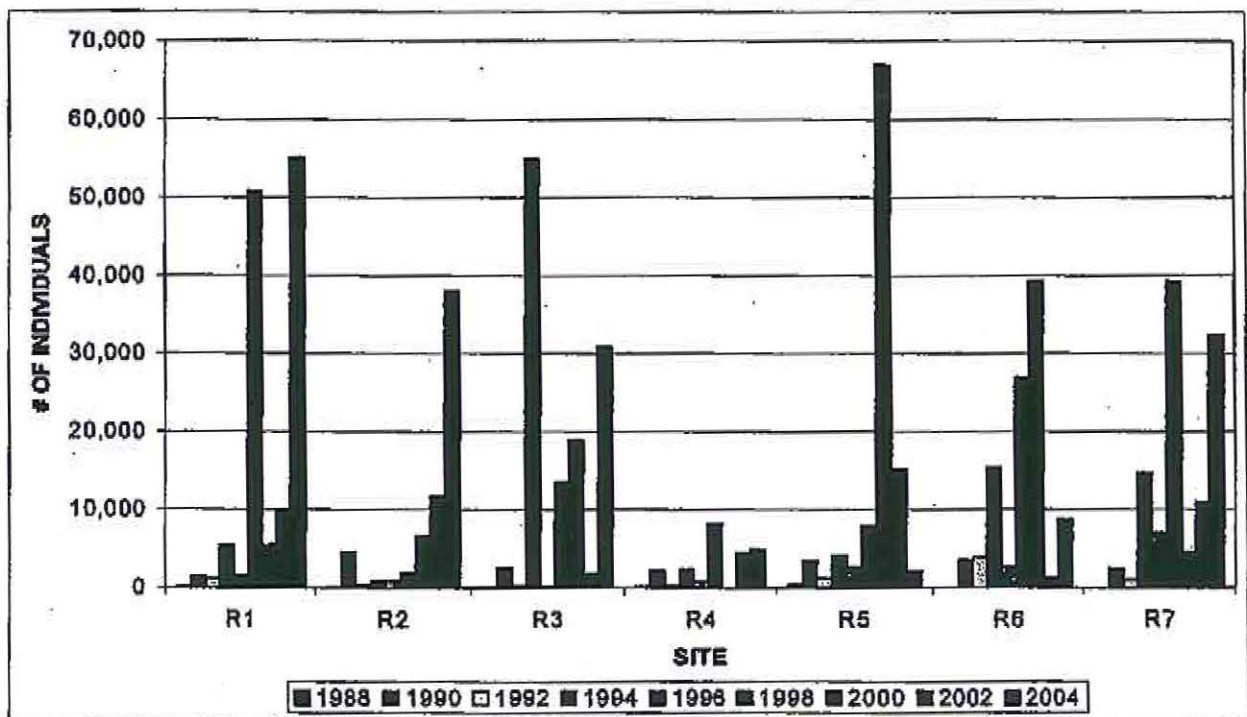
Site	Year	Total Abundance	Taxonomic Richness	Number of Sensitive Taxa	Dominant Taxa
R1	1988	120	24	6	Plecoptera & Ephemeroptera
	1990	1,373	21	8	Diptera & Ephemeroptera
	1992	1,141	27	7	Diptera
	1994	8,489	60	9	Ephemeroptera
	1996	1,629	57	8	Diptera
	1998	50,808	57	10	Diptera & Ephemeroptera
	2000	5,368	57	10	Diptera
	2002	9,988	60	8	Diptera
	2004	65,191	49	8	Diptera
R2	1988	116	24	6	Diptera
	1990	4,664	20	4	Annelida & Diptera
	1992	400	14	3	Diptera
	1994	920	47	8	Ephemeroptera & Diptera
	1996	891	37	9	Diptera & Ephemeroptera
	1998	1,945	47	8	Diptera & Ephemeroptera
	2000	6,611	48	7	Diptera & Ephemeroptera
	2002	11,639	64	8	Diptera & Oligochaeta
	2004	36,042	43	9	Diptera
R3	1988	32	8	1	Diptera
	1990	2,456	20	6	Annelida & Diptera
	1992	321	12	2	Diptera
	1994	64,676	49	9	Ephemeroptera & Plecoptera
	1996	144	26	7	Diptera
	1998	13,491	39	10	Diptera
	2000	16,929	42	7	Ephemeroptera
	2002	1,808	40	6	Oligochaeta & Diptera
	2004	30,826	41	11	Diptera & Ephemeroptera
R4	1988	116	16	2	Diptera
	1990	2,176	20	4	Diptera
	1992	312	14	1	Diptera
	1994	2,366	53	8	Ephemeroptera & Diptera
	1996	686	35	9	Ephemeroptera
	1998	6,146	48	10	Ephemeroptera & Diptera
	2000	N.D.	N.D.	N.D.	N.D.
	2002	4,430	62	9	Diptera
	2004	4,864	44	10	Diptera
R5	1988	425	22	7	Diptera & Plecoptera
	1990	3,470	28	7	Diptera
	1992	1,263	25	6	Diptera & Acarina
	1994	4,115	56	7	Diptera
	1996	2,726	43	9	Diptera
	1998	7,674	44	10	Diptera & Ephemeroptera
	2000	66,975	64	10	Diptera
	2002	15,088	46	8	Diptera
	2004	2,208	44	8	Diptera
R6	1988	N.D.	N.D.	N.D.	N.D.
	1990	3,477	26	8	Diptera
	1992	3,911	31	7	Diptera
	1994	16,431	46	7	Diptera & Ephemeroptera
	1996	2,741	46	8	Diptera
	1998	26,944	43	9	Diptera & Ephemeroptera
	2000	39,344	56	10	Diptera
	2002	1,232	36	6	Diptera
	2004	8,789	46	8	Diptera & Ephemeroptera
R7	1988	N.D.	N.D.	N.D.	N.D.
	1990	2,467	26	6	Diptera
	1992	1,053	22	4	Diptera
	1994	14,766	44	6	Diptera
	1996	7,029	46	8	Diptera
	1998	39,292	44	9	Diptera
	2000	4,574	40	8	Diptera
	2002	10,865	37	7	Diptera
	2004	32,360	44	9	Diptera

N.D. = not done

It is apparent from Table 7 that taxonomic richness has increased significantly at all sites since 1994, indicating that communities have become more diverse and thus healthier. The same holds true for the number of sensitive taxa documented at the sites over time. The communities at R3 and R4 appear to have been negatively impacted from 1988 to 1994, but have improved considerably since then.

Dominance has usually been Diptera and one of the pollution sensitive orders, at most of the sites over time. R7 has always been dominated by Diptera and appears to be a stable population.

Figure 9 Abundance of Benthic Invertebrates at Rose and Anvil Creeks over a Sixteen Year Period



## **5.0 SUMMARY**

Overall, the water samples collected at the sites in this study and analyzed for the selected parameters, indicated good water quality for the support of aquatic life. The waters tested were clear, slightly alkaline and well aerated. Concentrations of total and dissolved metals were generally very low where detected. Iron and zinc concentrations slightly exceeded the CCME guidelines at R2 and R3 in August.

The summer of 2004 was hot and dry resulting in low flows at all of the sites, especially during August.

The highest concentration of metals occurred in the stream sediments at R2 where several parameters exceeded the CCME probable effects levels. This has made no apparent effect on the benthic community dwelling here however, as population numbers were high (the highest documented to date at R2), the community was diverse and there were several pollution sensitive species present.

The composition of the benthic macroinvertebrate populations was similar at all of the sites and appeared healthy and diverse. The presence of numerous pollution sensitive insects throughout the study area indicates healthy habitats (water and sediment quality).

Based on data collected in 2004, and comparisons with historic data, it appears that effluent from the tailings system currently has minimal, if any, impact on the receiving environment.

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**APPENDIX A**

**WATER QUALITY DATA**

**JULY AND AUGUST 2004**











**APPENDIX B**

**SEDIMENT DATA, 2004**



## APPENDIX B

## STREAM SEDIMENT METALS DATA 2004, CANTEST LABORATORY

Sample ID	pH	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl
R-1A	7.6	0.7	18	252	<1	1.2	39	17	27	249	0.18	1.4	35	0.9	0.3	0.3
R-1B	7.7	<0.1	8.9	137	<1	0.5	32	9	15	69.5	0.05	1.1	24	0.4	0.1	0.2
R-1C	7.6	<0.1	9.4	136	<1	0.5	24	10	13	57.3	0.04	0.7	24	0.5	0.1	0.2
Mean:	7.6	0.7	12.1	175.0		0.7	31.7	12.0	18.3	125.3	0.1	1.1	27.7	0.6	0.2	0.2
S.D.	0.06		5.12	66.69		0.40	7.51	4.36	7.57	107.33	0.08	0.35	6.35	0.26	0.12	0.06
R-2A	7.6	1.3	16	238	<1	0.8	37	14	39	142	0.16	1.3	36	0.5	0.3	0.3
R-2B	8	1.1	18.6	566	<1	1.4	38	19	47	216	0.22	1	47	1	0.4	0.4
R-2C	8.1	1.4	24.3	586	<1	1.7	33	18	89	264	0.16	1.4	48	1.1	0.4	0.5
Mean:	7.9	1.3	19.6	463.3		1.3	36.0	17.0	58.3	207.3	0.2	1.2	43.7	0.9	0.4	0.4
S.D.	0.3	0.2	4.2	195.4		0.5	2.6	2.6	26.9	61.5	0.0	0.2	6.7	0.3	0.1	0.1
R-3A	8	1.3	15.2	390	<1	1	33	20	48	174	0.15	1.4	43	0.6	0.3	0.4
R-3B	7.6	2	13	329	<1	0.8	27	21	39	171	0.06	1.9	40	0.5	0.3	0.4
R-3C	7.4	1.7	18.5	121	<1	0.5	21	10	53	151	0.16	0.8	23	0.7	0.5	0.2
Mean:	7.7	1.7	15.6	280.0		0.8	27.0	17.0	48.7	165.3	0.1	1.4	35.3	0.7	0.4	0.3
S.D.	0.3	0.4	2.8	141.0		0.3	6.0	8.1	7.1	12.5	0.1	0.6	10.8	0.2	0.1	0.1
R-4A	7.6	1.5	16.1	210	<1	0.7	28	12	51	155	0.14	1.1	31	0.5	0.4	0.2
R-4B	7.8	1.3	12.6	307	<1	0.8	33	12	32	166	0.08	1.7	33	0.6	0.3	0.3
R-4C	8	1.2	13.8	284	<1	0.6	26	11	33	140	0.12	1.1	30	0.6	0.3	0.3
Mean:	7.8	1.3	14.2	267.0		0.7	29.0	11.7	38.7	153.7	0.1	1.3	31.3	0.6	0.3	0.3
S.D.	0.2	0.2	1.8	50.7		0.1	3.6	0.6	10.7	13.1	0.0	0.3	1.5	0.1	0.1	0.1
R-5A	8	0.8	9.5	242	<1	0.6	26	9	17	24.7	0.01	1.2	26	0.6	<0.1	0.1
R-5B	8	1	16.8	396	<1	1.5	39	14	68	152	0.06	2.2	42	1.5	0.2	0.3
R-5C	7.9	0.8	8	120	<1	0.6	41	10	22	31.2	<0.01	2.4	31	0.5	<0.1	0.2
Mean:	8.0	0.9	11.4	252.7		0.9	35.0	11.0	42.3	69.3	0.0	1.9	33.0	0.9	0.2	0.2
S.D.	0.1	0.1	4.7	136.3		0.5	8.7	2.6	39.6	71.7	0.0	0.6	8.2	0.6		0.1
R-6A	8	1	14.3	163	<1	0.8	28	11	21	12.2	<0.01	1.9	32	0.6	<0.1	0.1
R-6B	8.1	1.1	13.4	156	<1	0.7	21	9	25	12.8	0.01	1.8	27	0.6	<0.1	0.1
R-6C	8.2	0.7	8.9	107	<1	0.4	15	6	14	7.9	<0.01	1.9	16	0.5	<0.1	<0.1
Mean:	8.1	0.9	12.2	142.0		0.6	21.3	8.7	20.0	11.0	0.0	1.7	25.7	0.6		0.1
S.D.	0.1	0.2	2.0	30.5		0.2	6.5	2.5	5.8	2.7		0.3	7.1	0.1		0.0
R-7A	7.9	1.2	14.5	156	<1	0.6	28	11	21	12.3	<0.01	1.5	33	0.5	<0.1	0.1
R-7B	7.5	0.6	11.9	181	<1	0.6	19	9	20	19.1	0.03	0.8	20	0.7	0.1	0.2
R-7C	7.9	<0.1	9.3	150	<1	0.4	17	7	11	12.7	0.02	0.6	17	0.6	<0.1	0.1
Mean:	7.8	0.9	11.9	162.3		0.5	21.3	9.0	17.3	14.7	0.0	1.0	23.3	0.6	0.1	0.1
S.D.	0.2	0.4	2.6	16.4		0.1	5.9	2.0	5.5	3.8	0.0	0.5	8.5	0.1		0.1

## APPENDIX B

## STREAM SEDIMENT METALS DATA 2004, CANTEST LABORATORY

Sample ID	Sn	V	Zn	Al	B	Ca	Fe	Mg	Mn	PO4	K	Na	Sr	Ti	Zr
R-1A	<5	32	336	13400	<1	5840	26800	5670	2520	2770	1260	201	43	335	1
R-1B	<5	20	139	10200	<1	3880	16400	4360	1080	1910	949	218	38	246	1
R-1C	<5	21	135	11000	<1	3670	18800	4810	1170	1580	1030	205	42	284	2
Mean:		24.3	203.3	11533.3		4463.3	20666.7	4946.7	1590.0	2066.7	1079.7	208.0	41.0	281.7	1.3
S.D.		6.66	114.91	1665.33		1196.84	5445.49	665.61	206.66	614.36	161.34	8.89	2.65	47.06	0.58
R-2A	<5	29	301	12900	<1	5400	25500	7280	1560	2150	1190	209	34	286	2
R-2B	<5	33	539	15100	1	7530	29500	6830	3310	2300	1580	201	42	416	1
R-2C	14	29	607	11700	2	11000	27500	5110	2660	2090	1320	179	50	335	2
Mean:	14.0	30.3	482.3	13233.3	1.5	7976.7	27500.0	6406.7	2576.7	2176.7	1363.3	196.3	42.0	345.7	1.7
S.D.		2.3	160.7	1724.3	0.7	2826.6	2000.0	1146.3	906.8	112.4	198.6	15.5	8.0	65.7	0.6
R-3A	<5	29	502	12700	<1	6660	26200	5900	6410	2140	1210	186	40	309	1
R-3B	<5	26	400	11700	<1	4120	23800	5950	5120	1700	1200	170	35	224	3
R-3C	<5	24	227	8070	<1	8240	22400	3960	923	9040	579	121	26	275	1
Mean:		26.3	376.3	10823.3		6340.0	24133.3	5170.0	4161.0	4293.3	996.3	169.0	33.7	269.3	1.7
S.D.		2.5	139.0	2436.3		2078.6	1921.8	1134.8	2869.0	4116.6	361.5	33.9	7.1	42.8	1.2
R-4A	<5	30	300	9830	<1	5290	22900	5100	2180	3860	780	150	29	359	<1
R-4B	<5	24	294	9730	<1	4230	19000	4830	2610	2130	975	179	33	239	1
R-4C	<5	25	287	10100	<1	4950	19500	5020	2460	2670	811	178	32	281	1
Mean:		26.3	293.7	9896.7		4823.3	20466.7	4983.3	2483.3	2866.7	855.3	169.0	31.3	293.0	1.0
S.D.		3.2	6.5	191.4		541.2	2122.1	138.7	315.6	885.1	104.8	16.5	2.1	60.9	0.0
R-5A	<5	37	83	10000	1	4490	17900	4980	925	3170	799	141	27	291	2
R-5B	40	38	242	11600	1	7630	23600	5330	2630	3090	1030	148	36	326	1
R-5C	<5	33	311	8570	<1	4230	19300	4120	1000	2860	1160	121	20	575	3
Mean:	40.0	36.0	212.0	10056.7	1.0	5450.0	20266.7	4810.0	1519.3	3040.0	996.3	136.7	27.7	397.3	2.0
S.D.		2.6	116.9	1513.8	0.0	1892.4	2970.4	622.7	963.5	180.9	182.8	14.0	8.0	154.9	1.0
R-6A	<5	40	82	10700	<1	7270	23100	5210	1150	3380	897	153	33	275	2
R-6B	<5	40	71	9120	<1	3860	19600	4580	911	2790	889	123	23	183	2
R-6C	<5	29	46	6630	<1	2940	13400	3090	608	2240	676	96	18	135	2
Mean:		36.3	66.3	8816.7		4690.0	19700.0	4293.3	899.7	2893.3	820.7	124.0	24.7	197.7	2.0
S.D.		6.4	18.4	2051.9		2281.2	4912.2	1088.7	271.6	570.1	125.3	28.5	7.6	71.1	0.0
R-7A	<5	41	82	11600	<1	4360	22900	5670	924	3270	1120	147	25	243	3
R-7B	<5	27	86	11200	<1	4710	19400	4050	861	2590	1280	101	30	403	1
R-7C	<5	25	67	9410	<1	4180	15800	3140	621	3120	978	97	25	320	1
Mean:		31.0	78.3	10703.3		4410.0	19398.7	4286.7	808.7	2993.3	1126.0	115.0	26.7	322.0	1.7
S.D.		8.7	10.0	1130.1		278.4	3550.1	1281.5	163.9	367.3	151.1	27.6	2.9	80.0	1.2

## **APPENDIX C**

### **BENTHIC INVERTEBRATE DATA, 2004**



## APPENDIX C

## BENTHIC MARCO-INVERTEBRATE DATA, 2004

Sample Site: Fines split to: Coarse split to:	R1a 1/32	R1b 1/84	R1c 1/84	R2a 1/32	R2b 1/32	R2c 1/64	R3a 1/16	R3b 1/16	R3c 1/32	R4a 1/2	R4b 1/4	R4c 3/4
<b>PHYLUM ARTHROPODA</b>												
<b>Class Insecta</b>												
<b>Order Ephemeroptera</b>												
<b>Family Siphonuridae</b>												
Amelatus sp									1		3	1 1
<b>Family Baetidae</b>												
Baetis sp	3824	1420	3472	1893	1230	3172	2148	2051	6457	514	24	61
<b>Family Heptageniidae</b>												
Clygmula sp	72	4	69			1		32		15	8	14
Epeorus (Iron) sp							6		36	58	8	16
Heptagenia sp			1	2	3							2
Rhithrogena sp		1	1		2	4	15	9	36	29	66	6
<b>Family Ephemerellidae</b>												
Drunella doddsi	24	3	18	3	3	3	6	3	3			
Drunella flavilinea	72	4	19									
Drunella grandis		14	10							1	2	4
Ephemerella sp	216	27	163	44	12	25	16	1	1	32	11	20
<b>Order Plecoptera</b>												
<b>Family Capniidae</b>												
Capnia sp	16	1	1		33		18	1		29	18	10
<b>Family Perlodidae</b>												
Isoptera sp	80	24	78	13	33	27	17	68	28			3
Skwala curvata			1		1	4						1
Skwala parvella		1					1	7	2			
Megarcys sp												
<b>Family Leuctridae</b>												
Leuctra sp									1			
<b>Family Chloroperlidae</b>												
Swetsea sp gp					1	1		1	2			1
<b>Family Taeniopterygidae</b>												
Taeniopteryx sp	256	198	459	34	1	65	3	17	98	6	2	
<b>Family Nemouridae</b>												
Zapada sp	864	332	523	240	242	465	51	342	519	29	10	17
<b>Order Trichoptera</b>												
<b>Family Limnephilidae JD</b>												
										20	77	24
<b>Family Hydropsychidae</b>												
Arctopsyche sp	112	40	41	224	38	25	5	9	4			2
<b>Family Brachycentridae</b>												
Brachycentrus sp	8		2	33	1	2	23	41	6	1	3	
<b>Family Limnephilidae</b>												
Dicosmoecus sp	8			6	7	9		1				
<b>Family Rhyacophilidae</b>												
Rhyacophila acropedes or veo		2	3	8	3	11	13	17	20		2	1
Rhyacophila angelita			1									
Rhyacophila hyalinata			1				1	1	2			1
Rhyacophila sp J				33	32	1	65	33	33	4		
<b>Order Diptera</b>												
<b>Diptera Unid L (terr.)</b>												
Diptera Unid A		1										1
<b>Family Chironomidae</b>												
Chironomidae Unid L	10064	7690	8028	4777	3718	9130	1878	2689	4739	720	270	883
Chironomidae Pupae		2	4			1	18		34			
Chironomidae Adult	8									1		
<b>Sub Family Orthocladiinae</b>												
Brillia sp												
Cardiocladius sp	1000	1256	1067	243	154	439	85	211	304	181	44	116
Corynoneura sp												
Cricotopus sp	672	446	616	772	557	1783	384	989	981	348	169	222
Eukiefferiella sp	40	129	453	33	32	4	109	49	71	4	2	12
Euryhapala sp	8				32							
Synorthocladius sp												

Unid = unidentified J = juvenile P = pupae L = Larvae A = adult D = damaged

## APPENDIX C

## BENTHIC MACRO-INVERTEBRATE DATA, 2004

Sample Site: Fines split to: Coarse split to:	R1a 1/32	R1b 1/164	R1c 1/64	R2a 1/32	R2b 1/32	R2c 1/64	R3a 1/16	R3b 1/16	R3c 1/32	R4a 1/2	R4b 1/4	R4c 3/4
Thienemanniella sp	64	128	130							20		8
Sub Family Diamesinæ												
Diamesa sp	2264	1665	3274	576	480	1030	1334	528	2087	20	26	42
Sub Family Chironominae												
Micropsectra sp	8		64	64	32	64				24	8	6
Pagastella sp					32							
Rhectanytarsus sp	280	257	384	1058	320	1162	16			63	20	12
Sub Family Tanypodinae												
Thienemannimyia sp			1	302	108	78		34		1	3	18
Family Ceratopogonidae												
Culicoides sp												
Mallochocheila sp	8	1		69	37	132	2	1	2			5
Family Empididae												
Chelifera sp	72		1		32		1				1	
Family Muscidae												
Limnophora sp				1		2						
Family Psychodidae												
Pericoma sp	24	3	65				1	16	1			
Family Sclmyzidae L									9			
Family Simuliidae												
Prosimulium sp L							48					
Prosimulium sp P												
Simulium sp L	48		1		1	1	551	115	672		4	
Simulium sp P												
Family Tipulidae												
Dicranota sp	60	1	68						32			
Order Homoptera												
Homoptera Unid Terr												
Family Aphididae				1								
Order Coleoptera Unid L												
Class Arachnida												
Order Hydracarina												
Hydracarina Unid J/D	192	64	128	384	160	2	32	48	224	8	6	6
Lebertia sp	72	68	3	129	64	130	18	16		4		4
Noumannia sp												1
Sperchon sp	8		3	35	34			2	1	6	3	11
Torrenticola sp	4	64				1						
Untoncola sp	736	256	321	320	64	390	33	96	66	12	20	6
Class Crustacea												
Sub Class Copepoda												
Sub Order Cyclopoida												
Sub Class Ostracoda												
Candona sp												1
PHYLUM ANNILIDA												
Class Hirudinea												
Piscola sp				1	1							
Class Oligochaeta												
Family Enchytraeidae	8	1		35	1	64						
Family Naididae												
Chaetogaster sp	8		64	128	288	266		16		152	200	138
Class Archiannelida												
cf Trogochetus sp				1								
PHYLUM NEMATODA	64	64	192	128	32	128				21	2	12
PHYLUM MOLLUSCA												

Unid = unidentified J = juvenile P = pupae L = Larvae A = adult D = damaged

APPENDIX C

BENTHIC MACRO-INVERTEBRATE DATA, 2004

Sample Site:	R1a	R1b	R1c	R2a	R2b	R2c	R3a	R3b	R3c	R4a	R4b	R4c
Fines split to:	1/32	1/64	1/64	1/32	1/32	1/64	1/16	1/16	1/32	1/2	1/4	3/4
Coarse split to:												
<b>Class Bivalvia</b>												
Family Psididae												
Sphaerium sp.		8										
<b>Class Gastropoda</b>												
Order Prosobranchia												
Family Valvatidae												
Valvata sincera		8										
<b>PHYLUM CNIDARIA</b>												
Class Hydrozoa												
Order Hydroida												
Hydra sp.												4
<b>Fish (vertebrate)</b>												
Cottus cognatus												1
<b>TOTAL PER SAMPLE:</b>	21300	14167	10724	11620	7789	18633	6895	7433	16498	2309	995	1881
<b>TOTAL PER SITE:</b>	42800	28334	39448	23240	15578	37286	13790	14866	32998	4618	1890	3322
<b>TAXONOMIC RICHNESS PER SAMPLE:</b>	37	32	39	33	38	34	30	32	30	30	29	35
<b>TAXONOMIC RICHNESS PER SITE:</b>	49			43			41			44		

## BENTHIC MACRO-INVERTEBRATE DATA, 2004

Sample Site: Fines split to: Coarse split to:	R5a	R5b	R5c 1/2	R6a	R6b 3/32	R6c 1/4	R7a 3/84	R7b 1/16 11/4	R7c 1/32 1/8
<b>PHYLUM ARTHROPODA</b>									
<b>Class Insecta</b>									
<b>Order Ephemeroptera</b>									
<b>Family Siphonuridae</b>									
Ameletus sp	1	3	4	1	2		5	4	9
<b>Family Baetidae</b>									
Baetis sp	16	6	4	44	1257	323	1110	852	712
<b>Family Heptageniidae</b>									
Cinygmula sp	15	19	29	73	50	67	101	60	56
Epeorus (Iron) sp	3	5	2	2	53	1	44	32	
Heptagenia sp		1							
Rhythrogena sp	2	2	2	111	69	180	9		16
<b>Family Ephemerellidae</b>									
Drunella doddei	1	3		7	35	13	4	4	
Drunella flavilinea									
Drunella grandis	1	9	4	2	27	14	2		
Ephemerella sp	13	14	17	32	160	99	17	36	8
<b>Order Plecoptera</b>									
<b>Family Capniidae</b>									
Capnia sp	8	6	2	49	50	60	5	4	
<b>Family Perlodidae</b>									
Isoperla sp	2	1	1		1		2		
Skwala curvata		1		3	2		4	4	24
Skwala parallela			2	1	1				
Megarcys sp				1	1				
<b>Family Leuctridae</b>									
Leuctra sp									
<b>Family Chloroperlidae</b>									
Sweltsa sp gp		1					1		
<b>Family Taeniopterygidae</b>									
Taenionema sp	1			6	23	17	31	16	24
<b>Family Nemouridae</b>									
Zapada sp	17	40	39	65	313	147	389	412	488
<b>Order Trichoptera</b>									
<b>Family Limnephilidae J/D</b>									
<b>Family Hydropsychidae</b>									
Arctopsyche sp	2			6	149	29	77	12	80
<b>Family Brachycentridae</b>									
Brachycentrus sp									
<b>Family Limnephilidae</b>									
Dicoemoecus sp	4	1	4	2		2	3	4	
<b>Family Rhyacophilidae</b>									
Rhyacophila acropedes or var		1	2	1	5	2	2		
Rhyacophila angelita							2		
Rhyacophila hyalinata									
Rhyacophila sp J		1	4		1				
<b>Order Diptera</b>									
<b>Diptera Unid L (terr.)</b>									
Diptera Unid A	1			3	2	1			
<b>Family Chironomidae</b>									
<b>Chironomidae Unid L</b>									
Chironomidae Pupae	172	220	361	84	1751	856	5283	4444	5248
Chironomidae Adult		1	1	28	46	41	9	4	8
<b>Sub Family Orthocladinae</b>									
Brillia sp								16	
Cardiocladius sp	15	11	42	13	205	91	839	124	224
Corynoneura sp								16	
Cricotopus sp	89	189	173	74	547	493	1035	2072	968
Euklefferiella sp	3	2	6	3	331	34	869	766	2072
Euryhapeta sp									
Synorthocladus sp				1					

Unid = unidentified J = juvenile P = pupae L = Larvae A = adult D = damaged

## APPENDIX C

## BENTHIC MACRO-INVERTEBRATE DATA, 2004

Sample Site: Fines split to: Coarse split to:	R6a	R6b	R5c 1/2	R6a	R6b 3/32	R6c 1/4	R7a 3/84	R7b 1/16 11/4	R7c 1/32 1/8
Thienomanniella sp	3	3	4		11	20	21	68	
Sub Family Diamesinae									
Diamesa sp	12	12	2	5	61	32	243	220	208
Sub Family Chironominae									
Micropsectra sp	1	2	2				21	15	
Pagastrella sp	4								
Rheotanytarsus sp	4	5	6		58	10	129	80	160
Sub Family Tanyptodinae									
Thienomannimyia sp	5	3	6			4	1	4	8
Family Ceratopogonidae									
Culicoides sp		1							
Mallochobella sp									
Family Empididae									
Chelifera sp					1	1	1	4	8
Family Muscidae									
Linnophora sp									
Family Psychodidae									
Pericoma sp				1		1	1		
Family Scimyziidae L									
Family Simuliidae									
Prosimulium sp L					11		43		64
Prosimulium sp P					2	2		8	
Simulium sp L					16	1	2	28	
Simulium sp P					15				
Family Tipulidae									
Dicranota sp								4	
Order Homoptera									
Homoptera Unid Terr									
Family Aphididae				1			1		
Order Coleoptera Unid L		1							
Class Arachnida									
Order Hydracarina									
Hydracarina Unid J/D	3	3			11		1		
Lebertia sp	1		1		2	4	79	20	16
Neumannia sp			1						16
Sperchon sp	1	7	7	3	13	13	16	32	40
Torrenticola sp									
Unloncola sp	22	18	34	10	132	57	270	264	96
Class Crustacea									
Sub Class Copepoda									
Sub Order Cyclopoida		1							
Sub Class Ostracoda									
Candona sp.	1	1							
PHYLUM ANNELIDA									
Class Hirudinea									
Pisicola sp									
Class Oligochaeta									
Family Enchytraeidae		9	2		1				
Family Naididae									
Chaetogaster sp	193	89	121		64	12	768	240	320
Class Archiannelida									
cf Trogochaeta sp									
PHYLUM NEMATODA	1	7	5	7	21	4	24	4	16
PHYLUM MOLLUSCA									

Unid = unidentified J = juvenile P = pupae L = Larvae A = adult D = damaged

APPENDIX C

BENTHIC MARCRO-INVERTEBRATE DATA, 2004

Sample Site:	R5a	R5b	R5c	R6a	R6b	R6c	R7a	R7b	R7c
Fines split to:			1/2		3/32	1/4	3/64	1/16	1/32
Coarse split to:							11/4	1/8	
<b>Class Bivalvia</b>									
<b>Family Psidliidae</b>									
<b>Sphaerium sp</b>									
<b>Class Gastropoda</b>									
<b>Order Prosobranchia</b>									
<b>Family Valvatidae</b>									
<b>Valvata sincera</b>									
<b>PHYLUM CNIDARIA</b>									
<b>Class Hydrozoa</b>									
<b>Order Hydrozoa</b>									
<b>Hydra sp</b>									
<b>Fish (vertebrate)</b>									
<b>Coitus cognatus</b>									
<b>TOTAL PER SAMPLE:</b>	618	699	889	628	5488	2935	11567	9904	10889
<b>TOTAL PER SITE:</b>	1236	1398	1778	1256	10992	5270	23174	19808	21778
	4412			17518			64760		
<b>TAXONOMIC RICHNESS PER SAMPLE:</b>	32	37	31	30	41	33	40	33	25
<b>TAXONOMIC RICHNESS PER SITE:</b>	44			46			44		