ECCLES CREEK
BENTHIC INVERTEBRATE
MONITORING

OCTOBER 2002

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INTRODUCTION

In August of 2001 an aquifer tapped by Skyline Mine, near Scofield, Utah, significantly increased the discharge from the mine into Eccles Creek. The mine discharge has maintained the stream at approximately bank full levels since that time. This report summarizes results of monitoring of the benthic invertebrate community in Eccles Creek for fall, 2002. The project was undertaken for Canyon Fuel Company and is a continuation of benthic invertebrate monitoring initiated in November 2001 to determine the impact of the increased flows on the stream community.

METHODS

Quantitative samples were taken from Eccles Creek on October 25, 2002. The three stations sampled were Eccles Creek, above South Fork (EC2: N 39^0 40.970', W 111.11.579', 8406 feet elevation), Eccles Creek at Whisky Canyon (EC-4: N 39^0 40.908', W 111.10.747', 8234 feet elevation), and Lower Eccles Creek (EC-5: N 39^0 41.001', W 111.10.031', 8074 feet elevation). These three stations have been sampled intermittently since 1979 (Table 1). The October 2002 samples and were taken from the same locations sampled in July of 2002. Five replicate samples were taken per station. All samples were taken from locations in the stream where rubble or cobble substrates were present to reduce induced variability. A box sampler with a net mesh of 250 microns was used to collect the samples. The substrate was stirred to a depth of approximately 5 cm. All rocks within the area of the sampler were removed and individually washed to insure quantitative collection of the invertebrates.

The samples were concentrated on a screen with a mesh of 64 microns and field preserved in ethyl alcohol. A GPS unit was used to record the locations of the sample stations.

In the laboratory the samples were sorted in illuminated pans. All invertebrates were removed and identified to the lowest possible taxonomic level using the keys of Merritt and Cummins (1996). The mean density per sample was calculated for each taxon and these values were used to determine the density per square meter.

Baseline data from previous studies were included to aid in the interpretation of the results. Mean biomass estimates were also generated so that future changes in standing crop could be documented.

Analysis included comparison of the number of taxa and mean densities in the October 2002 samples with those generated from samples taken November 24, 2001 (Shiozawa 2002a) and July 2, 2002 (Shiozawa 2002c) and with previous samples taken in 1979 (Winget 1980) and1992 (Ecosystems Research Institute,1992). These comparisons allow a general evaluation of changes that have occurred since the most recent perturbation, the increased discharge of water into the stream channel from the mine, and help place the results in perspective relative to other perturbations and baseline conditions.

The community tolerance quotient (CTQ; Winget and Mangum 1979) was used to gain insight into the condition of the stream relative to idealized system predicted from slope, water chemistry, and substrate. Water chemistry for Eccles Creek was provided EarthFax Engineering (2001). The following estimates were used for alkalinity and sulfate levels: Eccles Creek alkalinity recorded levels at 264 mg/l and sulfate estimated at 49 mg/l. The gradient in Eccles Creek it is approximately 3.3. Eccles Creek had a number of well sorted substrates, including sand, gravel, boulder, and rubble. With its combination of physical properties, it had a predicted community tolerance quotient (CTQp) of 80

(Winget and Mangum 1979). The Biotic Condition Index was used to further interpret the data generated with this procedure.

Table 1. Station designations for studies on Eccles Creek.

Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
South Fork tributary above mine, upper site (USF2)			SF02	SF02				
South Fork tributary above mine (USF)			SF01	SF01	SF01			
Middle Fork tributary above mine (UMF)			MF1	MF1				
Eccles Creek below mine (EC1)			EC04	EC04				
Eccles Creek above south Fork (EC2)		EC-02	EC03		EC03		EC2	EC2
South Fork Eccles Creek (SF)	EC-SF	EC-SF	SFF01					
Eccles Creek below South Fork (EC3)	EC-03	EC-03						
Eccles Creek at Whisky Canyon (EC4)	EC-04	EC-04	EC02	EC02	EC02	Eccles	EC4	EC4
Lower Eccles Creek (EC5)	EC-05	EC-05	EC01	EC01	EC01		EC5	EC5

Diversity was calculated for the stations using the Shannon-Weiner index (Pieliou 1977). This allows a general comparison of the number of taxa and their relative densities among sample stations and dates. Finally, the data were clustered with the UPGMA algorithm using the Bray-Curtis measure of dissimilarity (Poole 1974, Krebs 1989). The NTSYSpc package was utilized to generate the cluster dendrograms (Rolf 2000).

RESULTS AND DISCUSSION

Number of Taxa

Twenty-three taxa were collected from Eccles Creek in the fall 2002 samples, eleven taxa each in EC2 and EC5 and seven taxa in EC4 (Table 2). Only five taxa (*Baetis*, *Hydropsyche*, *Pedicia*, chironomids, and ostracods) were collected from Eccles Creek, station EC4, in the 2001 sampling series. The July, 2002 samples at station EC4 found 14 taxa. Six taxa were collected in July, 2002, at the two other sites, Eccles Creek above South Fork (EC2) and Lower Eccles Creek (EC5). The number of taxa increased to eleven at both EC2 and EC5 in the fall 2002, but the seven taxa at EC4 was half of the number collected in July of 2002. The reduction in taxa at EC4 may be related to seasonal cycles and, if so, additional sampling should help clarify the interpretation of this reduction in densities.

Table 2. Number of taxa reported for the existing studies on Eccles Creek.

Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
South Fork tributary above mine, upper site (USF2)			20	11				
South Fork tributary above mine (USF)			12	9	21			
Middle Fork tributary above mine (UMF)			14	18				
Eccles Creek below mine (EC1)			4	2				
Eccles Creek above south Fork (EC2)		42	6		6		6	11
South Fork Eccles Creek (SF)	36	35	12					
Eccles Creek below South Fork (EC3)	27	30						
Eccles Creek at Whisky Canyon (EC4)	35	37	7	17	15	6	14	7
Lower Eccles Creek (EC5)	28	21	12	13/11	14		6	11

While the overall number of taxa has increased since the initial sampling in the fall of 2001, the numbers are still quite far from the baseline of 20 to over 40 taxa at these same sites in 1979. It should also be noted that following the perturbation in the early 1990's the taxa fell to a third to a seventh of the 1979 baseline numbers. In 2002 Eccles Creek was near the same condition as in the early 1990's. It is not known if the stream had fully or even partially recovered before the increased discharge in 2001.

The increase in taxa from 2001 to October of 2002 indicates that the Eccles Creek stream community is beginning to gain in complexity, but as noted above, it is not near baseline conditions. As has been discussed in previous reports (Shiozawa 2002a, 2002b, 2002c), it is unlikely that the stream will recover to those early baseline estimates because of the presence of the road, the higher, sustained discharge, and the other perturbations that have occurred in the system over the last 20 years.

Total Density Comparisons

Total density of invertebrates in the October, 2002 sampling series was 1877 per square meter. This is about a third lower than was obtained in July 2002, when the average per square meter was 5796. This change, as also noted for the total number of taxa, is likely reflecting seasonal dynamics in community structure since early instars of many invertebrates can pass through a 250 micron mesh net. The October 2002 total density was still significantly higher than that of the fall of 2001 when 61 organisms per square meter were collected.

Table 3. Total invertebrate densities per square meter for selected studies on Eccles Creek.

Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
South Fork tributary above mine, upper site (USF2)			1089	528				
South Fork tributary above mine (USF)			1144	216	2455			
Middle Fork tributary above mine (UMF)			1503	3812				
Eccles Creek below mine (EC1)			164	16				
Eccles Creek above south Fork (EC2)		73,181	267		89		3703	1260
South Fork Eccles Creek (SF)	9321	17,773	1356					
Eccles Creek below South Fork (EC3)	18,093	23,247						
Eccles Creek at Whisky Canyon (EC4)	11,634	25,273	1719	3928	1419	61	8757	1491
Lower Eccles Creek (EC5)	18,661	2526	2212	4104/ 2863	1468		4927	2879

The October 2002 density estimates were generally much lower than the estimates for August 1979 where densities were 17 to almost 60 fold higher at stations EC2 and EC4. Interestingly, the density estimate for EC5 was almost the same in August 1979 as it was in the October, 2002 samples. Yet the May/June 1979 densities in station EC5 were similar to those in the other stations for that same month (Table 3). As noted in a previous report (Shiozawa 2002c) the invertebrate densities should be around 15,000 per square meter if total numbers were to approximate the 1979 baseline conditions. That requires approximately a ten fold increase from the densities collected in the October 2002 survey. Based upon that measure the stream is still far from recovery.

Site Specific Densities - October 2002

Hydropsychids were the dominant taxon in the October 2002 samples, being present in densities ranging from 1000 to 1300 per square meter (Table 4). Their numbers were about twice those recorded from the July 2002 samples and well over 20 fold higher than the 45 per square meter in the November 2001 samples. Baetis densities, averaging 566 per square meter, were higher than in the July 2002 samples (average in July: 311 per square meter), but no Baetis were collected in the upstream site (EC2) in October of 2002. This may reflect a propensity to drift downstream by *Baetis*, a situation that could be enhanced by a lack of food deposits in the benthic environment. The relatively constant densities of *Hydropsyche* in the three stations suggest that suspended food is available for filter feeders.

Other benthic invertebrates in the upper station include oligochaetes, triclads, and tipulids. Triclads are predators and tipulids are shredders. Oligochaetes are deposit feeders. Both oligochaetes and tipulids would be found in areas with depositional microhabitats, in the case of riffles, as sampled in this study, this would be either leaf packs or concentrations of organic debris behind rocks. These taxa were absent from the downstream samples. Sample number 2 from EC2 may represent this particular habitat type since both tipulids and oligochaetes were more abundant in that sample. Chironomids were in low density in October. They averaged just 40 individual per square meter in the three stations. While this is higher than the density of eight per square meter recorded in 2001, it is also significantly lower than the 4,276 recorded from the July 2002 samples. This suggests that the midge community is made up of relatively few species and that their life history may be such that the population in October consisted of early instars, which pass through a net mesh of 250 microns. An alternative explanation would be that an undocumented perturbation between July and October 2002

catastrophically reduced the density of midges in the stream. If this were the case the same factor could have reduced densities of Baetis as well, but one would expect that the reduction would have proceeded downstream through the other two sample stations.

As in the July samples, vagrant taxa (*Baetis, Hydropsyche,* chironomids) tend to predominate in the three stations. The presence of additional functional groups (Cummins 1974), *Brachycentrus*, *Arctopsyche*, tipulids, triclads, etc. are signs of increasing trophic structure in the system. Both the densities of invertebrates in Eccles Creek in 2002 as compared to 2001 and the higher number of taxa in 2002 suggest that the stream is undergoing a recovery. The most likely explanation for the reduction in densities and taxa from July 2002 to October 2002 is a seasonal signal due to life histories of the invertebrates. Still the total number of taxa and densities of various functional groups will need to increase substantially before the community can be considered to have recovered. As emphasized in a previous report (Shiozawa 2002c) the community will probably not return to the structure that existed in 1979 unless the sustained discharge is eliminated. If and when that occurs, the trajectory of the recovering community will resume towards the 1979 state.

Table 4 Sample data and invertebrates per square meter.

	Eccles Creek above South Fork, Site 1, Oct 2002 (EC2)						Eccles Creek at Whisky Canyon, Site 2, October 2002 (EC4)						Lower Eccles Creek, Site 3, October 2002 (EC5)					
Taxa	1	2	3	4	5	**#/m²**	1	2	3	4	5	**#/m²**	1	2	3	4	5	**#/m²**
Ephemeroptera																		
Baetis	0	0	0	0	0	**0**	14	25	23	1	3	**400**	110	34	31	34	5	**1297**
Drunella grandis	0	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	1	0	0	**6**
Plecoptera																		
Isoperla	0	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	3	0	0	**18**
Trichoptera																		
Brachycentrus sp.	6	3	0	1	0	**61**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Brachycentrus echo	0	0	0	0	0	**0**	1	0	0	0	0	**6**	0	0	2	2	0	**24**
Arctopsyche	0	0	0	0	0	**0**	0	1	0	0	0	**6**	0	0	0	0	0	**0**
Hydropsyche	50	25	9	35	51	**1030**	32	54	62	10	11	**1024**	35	9	67	94	13	**1321**
Oligophlebodes	0	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	1	0	0	**6**
Rhyacophila	0	0	0	0	0	**0**	0	0	2	0	0	**12**	0	0	0	0	0	**0**
Coleoptera																		
Optioservus	0	0	0	0	0	**0**	1	0	0	0	0	**6**	0	0	4	0	0	**24**
Diptera																		
Chironomidae	0	0	0	2	0	**12**	0	2	0	0	0	**12**	4	0	4	8	0	**97**
Tipulidae *Tipula*	0	2	0	0	0	**12**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Tipulidae *Antocha*	0	1	0	0	0	**6**	0	0	1	1	0	**12**	2	0	2	5	2	**67**
Stratiomyidae *Allognasa*	1	0	0	0	0	**6**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Empididae *Chelifera*	0	0	1	0	0	**6**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Stratiomyidae *Allognasta*	1	0	0	0	0	**6**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hemiptera	0	0	0	0	0	**0**	0	1	0	0	0	**6**	0	0	1	0	0	**6**
Saldidae	1	0	0	0	0	**6**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ostracoda	0	0	1	0	1	**12**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hydracarina	0	0	1	0	1	**12**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Oligochaeta	1	11	1	0	0	**79**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hirudinea	1	0	0	1	0	**12**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Tricladida Planariidae	0	0	0	0	1	**6**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
totals	**60**	**42**	**13**	**40**	**53**	**1260**	**48**	**81**	**47**	**11**	**14**	**1491**	**145**	**43**	**104**	**130**	**18**	**2879**

Biomass

Total biomass for each site (Table 5) was determined so that long term trends can be followed. No clear association between density and biomass appears to exist with the October 2002 samples. Since no previous estimates are available, it is not known how this standing crop would correspond to pre-mining levels.

Table 5. Biomass Charts Fall 2002 Samples

	Upper Eccles (EC2)	**Middle Eccles (EC4)**	**Lower Eccles (EC5)**
Sample 1	.58 g	.24 g	.21 g
Sample 2	.34 g	.40g	.04 g
Sample 3	.07 g	.27 g	.40 g
Sample 4	.31g	.05 g	.43 g
Sample 5	.29 g	.07 g	.10 g
Total	**1.59 g**	**1.03 g**	**1.18 g**
	16.06 g/m^2	**10.40 g/ m^2**	**11.92 g/m^2**

Biotic Condition Index

Community tolerance quotients are a part of the biotic condition index developed by Winget and Mangum (1979). The community tolerance quotients are of two types, the actual community tolerance quotient, CTQa, and the predicted community tolerance quotient, CTQp. The predicated community tolerance quotient is based on water chemistry, substrate, and gradient. CTQa values are a simple arithmetic mean of preassigned index values for the taxa present at a given station (see Winget and Mangum 1979). The CTQa indices for the October 2002 samples, with the CTQa for the November, 2001 Eccles Creek samples and an idealized stream, based on a combination of taxa collected from

Boardinghouse Creek in November of 2001 and all taxa collected in Eccles Creek in 2001-2002 were generated (Table 6).

Generally CTQa values less than 65 represent high quality waters, while those between 65 and 80 represent situations where moderate to high quality systems. CTQa values greater than 80 represent low quality or stressed systems. The October 2002 samples had CTQa values of 86.2 in Eccles Creek above South Fork (EC2), 68.6 in Eccles Creek at Whisky Canyon (EC4), and 69.0 at Lower Eccles Creek (EC5; Table 6). Thus the upper site was more stressed than the other two. Both EC4 and EC5 had moderate to high quality conditions. These values are an improvement over the 93.6 CTQa for the fall of 2001. If the ideal CTQa is 62.2 then both EC 4 and EC5 are beginning to approach that level. However the number of taxa in October of 2002 compared with the ideal system (Table 6), indicates that a wide array of taxa are still absent in Eccles Creek.

Table 6 Tolerance quotients and biotic condition index values.

	Eccles Creek 2001	Eccles Creek above South Fork (Site 1) Oct 2002 (EC2)	Eccles Creek at Whisky Canyon (Site 2) Oct 2002 (EC4)	Lower Eccles Creek (Site 3) Oct 2002 (EC5)	Ideal stream (species list, including Boarding-house Creek)
Taxa	TQ	TQ	TQ	TQ	TQ
Ephemeroptera					
Baetis	72	0	72	72	72
Cinygmula	0	0	0	0	21
Drunella sp.	0	0	0	48	48
Drunella dodsei	0	0	0	0	4
Seratella	0	0	0	0	48
Ephemerella	0	0	0	0	48
Paraleptophlebia	0	0	0	0	24
Plecoptera					
Early instar Plecoptera	0	0	0	0	36
Malenka californica	0	0	0	0	36
Isoperla	0	0	0	48	48
Zapada	0	0	0	0	16
Trichoptera					
Brachycentrus	0	24	24	24	24
Micrasema	0	0	0	0	24
Dicosmecus	0	0	0	0	24
Arctopsyche	0	0	18	0	18
Hydroptila	0	0	0	0	108
Hydropsyche	108	108	108	108	108
Neothremma alica	0	0	0	0	8
Oligoplebodes	0	0	0	24	24
Rhyacophila	0	0	18	18	18

Coleoptera					
Optioservus	0	0	108	108	108
Diptera					
Ceratopogonidae	0	0	0	0	108
Chironomidae	108	108	108	108	108
Empidae *Chelifera*	0	108	0	0	108
Simuliidae *Simulium*	0	0	0	0	108
Tipulidae *Dicranota*	0	0	0	0	24
Tipulidae *Limnophila*	0	0	0	0	72
Tipulidae *Tipula*	0	36	0	0	36
Tipulidae *Pedicea*	72	0	0	0	72
Tipulidae *Antocha*	0	24	24	24	24
Stratiomyidae *Allognasa*	0	108	0	0	108
Collembola	0	0	0	0	108
Hemiptera Saldidae	0	108	0	0	108
Hydracarnia	0	108	0	0	108
Ostracoda	108	108	0	0	108
Copepoda	0	0	0	0	108
Mollusca: Sphaerium	0	0	0	0	108
Oligochaeta	0	0	0	108	108
Tricladida Planariidae	0	108	0	0	108
totals	468	948	480	690	2425
n	5	11	7	11	39
CTQa	**93.6**	**86.2**	**68.6**	**69.0**	**62.2**

The three sites, EC2, EC4, and EC5, sampled in July of 2002 had CTQa values of 73.5, 67.6 and 74.3 (Shiozawa 2002c) respectively. Between the July and October sampling, stations EC4 and EC5 stayed about the same, but Station EC2 had an increase in CTQa. This shift was not expected from the number of taxa, which increased from July to October (Table 2), and is related to the presence of a number of taxa with high tolerance quotients at station EC2 in the October sampling period.

CTQa values for Eccles Creek detected the impact in the 1990s in three stations below the mine (EC1, EC2 and EC4; Table 7). This impact did not reach the lowest station, EC5. Beginning in 2001 the average CTQa for the stream jumped to 94 and stayed above 70 in 2002, supporting the increased flow as having a negative impact on the stream. Still, the low CTQa for EC4 and EC5 in July 2002 indicates that the Community Tolerance Quotient is not an absolute predictor of the state of the system

Table 7. Community Tolerance Quotient (CTQa) and Biotic Condition Index (BCI) for selected studies on Eccles Creek.

Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI
South Fork tributary above mine, upper site (USF2)			59/136	53/151				
South Fork tributary above mine (USF)			49/163	59/136	45/178			
Middle Fork tributary above mine (UMF)			54/148	49/163				
Eccles Creek below mine (EC1)			67/119	108/74				
Eccles Creek above south Fork (EC2)		65/123			73/110		99/81	86/93
South Fork Eccles Creek (SF)	59/136	64/125	55/145					
Eccles Creek below South Fork (EC3)	65/123	55/145						
Eccles Creek at Whisky Canyon (EC4)	63/127	61/131	69/116	70/114	63/127	94/85	52/154	69/116
Lower Eccles Creek (EC5)	59/136	74/108	53/151	55/145 57/140	58/138		66/121	69/116
Mean CTQa/BCI	62/131	64/126	59/140	64/132	60/138	94/85	72/119	75/108

The biotic condition index (BCI) is simply CTQp/CTQa X 100. This measure, according to Winget and Mangum (1979), can be used in conjunction with CTQa to generate a broader interpretation of the state of the stream system. Ideally, if all predictors are accurate, a pristine system will have a BCI of 100. BCI values below 100 represent a condition where fewer clean water taxa than predicted are

present and thus indicate a reduction in the quality of the habitat. Any BCI value above 100 represents communities whose clean water taxa are in greater abundance than predicted. In 29 of the 32 sample stations presented in this report (Table 7) the BCI was over 100. The mean value, of the 29 CTQp's that exceeded 100, was 135, with a standard deviation of 17.44. The highest BCI value was 178. This implies that the BCI is not accurately measuring the ideal community composition.

This can be further evaluated by examining BCI values for unimpacted stations (all 1979 sites and the 1990 series of USF2, USF, UMF and SF sites). These generate a measure of error in the CTQp and BCI indices. Nineteen stations/date combinations fit this criterion. The mean BCI for these 19 samples is 138.5 and the standard deviation is 16.8. The 95 % confidence interval is between 103.1 and 173.9. This is significantly greater than 100, suggesting a systematic bias in the BCI values for Eccles Creek. The predicted community tolerance quotient consistently underestimates the actual community tolerance quotient. This could be associated with variability in water chemistry over time, but more likely it is due to non-linearities in the relationships between organisms and physical parameters on which the CTQp values were based.

One additional habitat measure based on the BCI can be explored, although the limitation in the BCI itself must be considered in interpreting the data. Winget and Mangum (1979, page 14) classify habitat quality based on the combination of the CTQa and BCI values (Table 8). The table provided on page 14 by Winget and Mangum, 1979 has an error, condition 4 should list the BCI as >70 rather than <70). These habitat quality designations can be used as general BCI generated statements of the condition of the stream in 1979, 1990-91 and 2001-02.

Table 8. Habitat quality based on CTQa and BCI values for selected studies on Eccles Creek.

Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI
South Fork tributary above mine, upper site (USF2)			high	high				
South Fork tributary above mine (USF)			high	high	high			
Middle Fork tributary above mine (UMF)			high	high				
Eccles Creek below mine (EC1)			low	high-moderate				
Eccles Creek above south Fork (EC2)		low			low		high-moderate	high-moderate
South Fork Eccles Creek (SF)	high	high	high					
Eccles Creek below South Fork (EC3)	low	high						
Eccles Creek at Whisky Canyon (EC4)	high	high	low	low	high	high - moderate	high	low
Lower Eccles Creek (EC5)	high	low	high	high/ high	high		low	low

The habitat quality measures for Eccles Creek in 1990-91 do appear to have detected the impact of the mine spill and sedimentation. Streams reaches and tributaries outside of the influence of the mine are rated as high quality habitats while those below (EC1, EC2, and EC4) show signs of impact, being rated as low or high to moderate habitat quality. Additionally, the 2001 and 2002 data are generally showing high-moderate habitat quality or low habitat quality. Unfortunately one station (EC4), in July of 2002, has high habitat quality, yet based on the number of taxa and densities, the site has been heavily impacted. Station EC2 in both July 2002 and October 2002 has high-moderate habitat quality, yet the number of taxa and densities are far from the baseline states for both dates. In addition the November 2001 samples, which have a total of just six taxa (Table 2) and a density of 61 per square meter (Table 3), is rated as having high-moderate habitat quality. Finally three of the baseline sites have a rating of low habitat quality – EC3 in the May-June 1979 sampling period and EC2 and EC5 in the August 1979 sampling period. These discrepancies, when coupled with the problems with the BCI

estimate, suggest that both the BCI values and the associated habitat quality index are too inaccurate to be relied upon.

Diversity Index

Diversity indices are a way of combing both number of taxa and relative densities into a single measurement. High diversity index values indicate more taxa and a greater number of individuals per taxon. Low diversity values generally reflect a depauperate fauna in both species and somewhat in numbers. The baseline stations (the 1979 samples; Table 9) had diversity values ranging between about 2 to 3. The areas impacted in 1990-91 had diversities values around 1. But in September 1991 the values fell to around 0.5. However in that same sample series, the Upper South Fork had a diversity of 0.7, considerably lower than in the previous year.

Diversity from 2001-2002 was below 1 for all sampled stations. It has increased in EC2, remained about the same through 2002 in EC4, and had shown a significant decline in station EC5. Just how these temporal changes relate to recovery is not clear. As discussed above, seasonality may be involved but in this case no pattern is obvious in either the baseline samples or the 1990-91 samples. It can be concluded that diversity has been reduced by the increased discharge in the stream and that the community has shown some improvement, but it is still far from the baseline conditions that would be reflected in a diversity value of 2 to 3.

Cluster Analysis

The final analysis utilized in this study was clustering. This is a multivariate approach that generates a

visual representation of the relationships among samples. The dissimilarity index utilized in the study considers both quantitative counts of individuals within each taxon and the relative densities of those organisms. The cluster results (Figure 1) separate the majority of the spring-summer samples, including all of the reference samples, into one cluster while the fall samples are part of a second cluster. The exceptions are the six samples taken in the summer of 1990. These are in the fall cluster but show a high dissimilarity to other members of the group.

The July 2002 samples clearly are associated with a cluster containing the baseline samples of 1979, but are highly dissimilar to the other samples in that cluster. Their classification with the baseline stations is likely influenced by season, but their lower diversity and densities separate them from the other samples. The July 2002 samples are most closely associated with the August 1979 sample from EC-5. This station had the lowest number of taxa (Table 2), the lowest total density (equivalent to the Fall 2002 samples; Table3), and a low habitat quality rating by the BCI/CTQa comparisons (Table 8).

Table 9. Diversity Indices (based on natural logs) for selected studies on Eccles Creek.

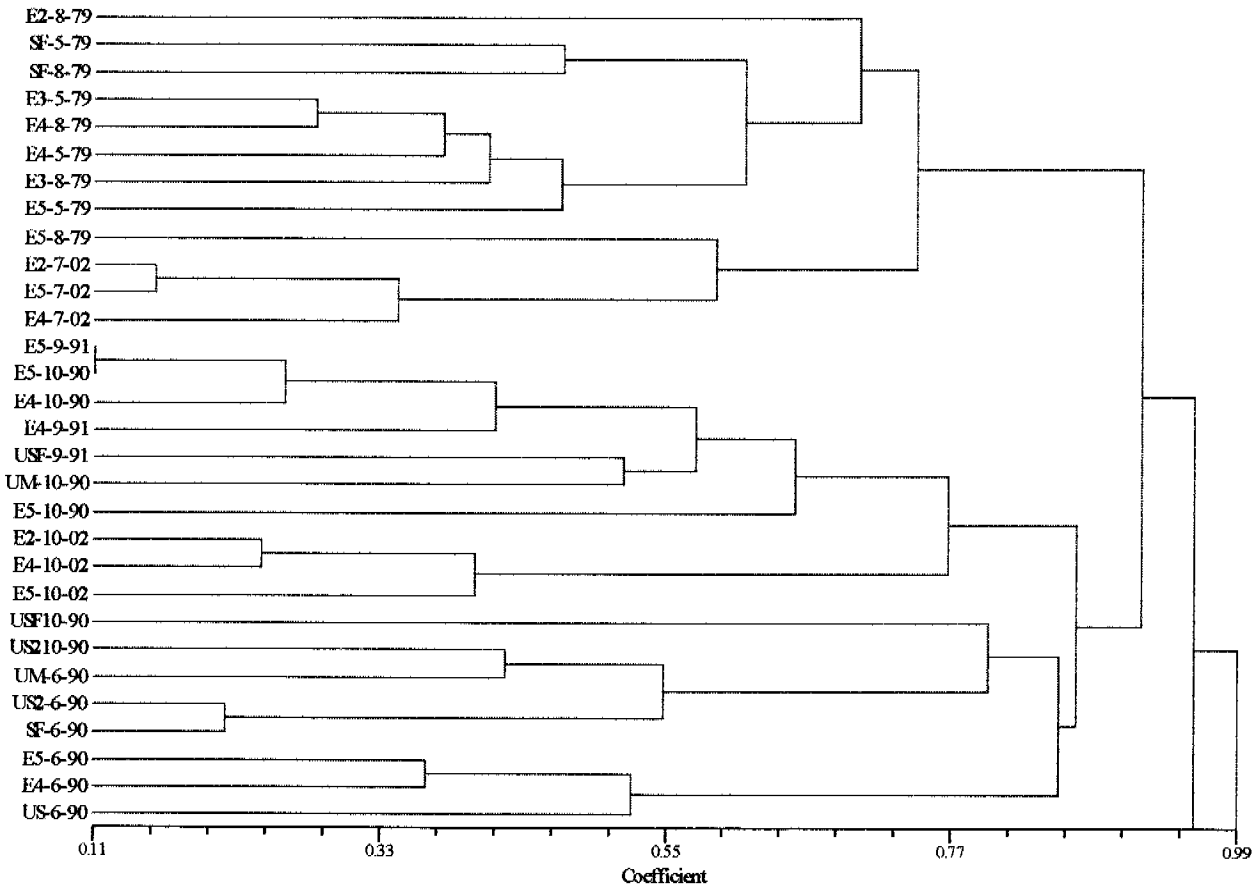
Station descriptions	Winget (1980)		Ecosystems Research Institute (1992)			Shiozawa (2002a)	Shiozawa (2002c)	Shiozawa this report
Sampling date	May – June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002
South Fork tributary above mine, upper site (USF2)			1.63	1.9				
South Fork tributary above mine (USF)			1.72	1.9	0.702			
Middle Fork tributary above mine (UMF)			1.66	1.9				
Eccles Creek below mine (EC1)			1.06	0.7				
Eccles Creek above south Fork (EC2)		1.964	1.58		0.400		0.398	0.836
South Fork Eccles Creek (SF)	3.510	3.322	1.62					
Eccles Creek below South Fork (EC3)	2.450	2.743						
Eccles Creek at Whisky Canyon (EC4)	2.450	3.060	1.22	1.6	0.666	0.757	0.957	0.835
Lower Eccles Creek (EC5)	2.280	2.590	1.24	1.8/ 1.4	0.416		0.829	0.341

The October 2002 sample stations are part of a second cluster. This second cluster includes all of the 1990-91 data and its structure also suggests that a slight seasonal signal is imbedded in it. The Fall 2002 samples are a part of the fall portion of the 1990-91 sample series. The six June samples from 1990 are in a separate, more dissimilar subcluster.

The baseline data utilized in the above comparisons did not include any October 1979 samples since the actual densities of individual taxa were not available in the copy of the Winget (1980) report obtained for the summary report (Shiozawa 2002b). If these data were available and were added to the analysis the strength of the seasonal signal could be appraised. As it is, confounding of seasons with perturbations complicates the clarity of the seasonality issue. However the shifting of the July 2002 and October 2002 samples into the two clusters strongly supports the role of season in generating some of the differences between the two sampling dates. This being the case, the July 2002 stations

grouping as a distinct subcluster of the 'spring-summer' cluster indicates that the stream had not yet recovered in 2002.

Figure 1. UPGMA Cluster dendrogram of the relationships among invertebrate communities in the selected stations



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The Macrobenthos of James Canyon Creek, Tributaries to Electric Lake, Huntington Creek Drainage.

Fall 2002

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The Macrobenthos of James Canyon Creek, Tributary to Electric Lake, Huntington Creek Drainage

Fall 2002

Introduction

Community composition can be impacted by acute, transient perturbations or by chronic, long term changes in environmental conditions. In stream systems the macrobenthic communities have been widely used for monitoring both acute and chronic impacts in watersheds (Resh and McElravy 1993). Temperate stream organisms often have annual or biennial life cycles and many species have specific habitat requirements. Thus, while transient perturbations, such as a slug flow of a contaminant, may only be detected chemically in the stream for a short period of time, significant impacts on the stream benthic communities can remain detectable for a much longer period. Sometimes several generations are required before numbers and/or biomass recover to pre-impact levels. Chronic impacts, such as sedimentation, may eliminate certain habitats or may reduce densities of sensitive species and invertebrate monitoring can document such changes.

Purpose

This report covers the results of samples taken in the fall of 2002 from James Canyon Creek. Prior monitoring efforts in the Huntington Creek drainage included sampling both James Canyon Creek and Burnout Creek twice a year, beginning in the fall of 2000. The spring of 2002 sample

series was the last required for the review of impacts of mine induced subsidence on the two streams. However changes in community composition noted for James Canyon Creek in the fall of 2001 resulted in the continuation of monitoring at this station.

Methods

Quantitative samples were taken on October 25, 2002 with a modified box sampler (Shiozawa 1986) using a capture net with a net mesh of 253 microns. Three samples were taken at James Canyon Creek, as prescribed to Canyon Fuels Corporation by the Utah Division of Wildlife Resources. These were preserved in the field with ethyl alcohol and were returned to the laboratory for processing. The samples were sorted in an illuminated pan. Organisms were identified to the lowest taxonomic unit possible. Small specimens and those of questionable identity were further examined under magnification. Identification was based on the keys of Merritt and Cummins (1994). The mean and standard deviation were calculated for each taxon and the mean values were used to determine the density per square meter. Standing crop was estimated from wet weights of total invertebrates collected at the station.

The USFS Biotic Condition Index (Winget and Mangum 1979) was calculated with the community tolerance quotient (CTQa). The predicted community tolerance quotient (CTQp), based on water chemistry data provided in Winget (1972) for the Huntington Creek drainage, was 80.

Cluster analysis was run with NTSYS-pc, using the Bray-Curtis dissimilarity index with the

UPGM clustering algorithm. Data from all sampling periods (fall 2000 through fall 2002) and from both Burnout Creek and James Canyon Creek were included in the cluster analysis.

Results

Twenty seven taxonomic categories (including larvae and adults and unidentifiable immature insects as separate taxa) were identified in the fall 2002 samples from James Canyon Creek (Table 1), one less than found in the spring of 2002, nine fewer than were recorded in the spring of 2001, and five less than in the fall of 2001. Most of the differences were associated with rare taxa (Table 2). James Canyon Creek had a density of 40,158 organisms per square meter, approximately 40% higher than in the spring of 2002 (28,886 per square meter), and approximately 3.4 times higher than the fall 2001 density estimate (11716 per square meter; Table 2). The densities are also higher than recorded in the fall of 2000, when 34,757 per sq. meter were collected. This reinforces the suggestion made in the spring 2002 report, that the fall of 2001 decline was transient and that the James Canyon fauna is recovering.

James Canyon Creek biomass (wet weight) in the fall 2002 sampling series was 44.95 grams/ square meter. This is up from the previous spring when James Canyon Creek had a wet weight of 36.87 grams per square meter and was much higher than the biomass estimates of the previous fall, of 23.6 grams pre square meter. The increased biomass in James Canyon indicates that the invertebrate community biomass has recovered from the perturbations that impacted it in 2001

Spatial Distribution

Variance to mean ratios were used to determine the number of taxa having contagious distributions (Elliott 1977). A Chi Square value of 8 or above indicates that a taxon is contagiously distributed. Ten taxa demonstrated contagious distributions (Table 1), and much of the contagion for total taxa was generated by two abundant taxa, *Baetis* and midges. Six taxa, showing contagious distributions, *Baetis*, *Ephemerella*, *Zapada*, chironomids, simuliids, and planarians were most abundant in the second sample, JC2F2002 while the other four contagiously distributed taxa, *Malenka*, *Lepidostoma*, *Neothremma*, and Ostracods were most abundant in the first sample. Neothremma is a scraper, feeding on epilithic algae, and requires relatively clean substrates for refuge. The taxa in the second sample tend to be collector gatherers and shredders, implying that the second sample had more detritus than the first sample.

Table 1. Fall 2002 statistics for James Canyon Creek.

		1	2	3	mean	S. D.	Chi Sq.	#/m^2
Ephemeroptera	*Baetis*	181	441	47	22333	200.33	359.93	6756.9
	Cinygmula	0	0	0	0	0	0	0
	Drunella grandis	0	0	0	0	0	0	0
	Epeorus iron	4	14	10	9.33	5.03	5.43	282.8
	Ephemerella	58	108	75	80.33	25.42	16.09	2434.1
	Paraleptophlebia	3	4	2	3	1.00	0.67	90.9
	Rhithrogena	0	0	0	0	0	0	0
Plecoptera	Early instar Plecoptera	4	8	3	5	2.65	2.8	151.5
	Isoperla	5	11	5	7	3.46	3.43	212.1
	Malenka	12	0	0	4	6.93	24	121.2
	Skwalla parallela	0	0	0	0	0	0	0
	Zapada	3	54	18	25.0	26.21	54.96	757.5
Trichoptera	*Arctopsyche*	0	1	1	0.67	0.58	1	20.2
	Brachycentrus echo	0	0	0	0	0	0	0
	Dicosmoecus	0	1	0	0.33	0.58	2.04	10.1
	Hydropsyche	0	1	0	0.33	0.58	2.04	10.1
	Lepidostoma	10	4	3	5.67	3.79	14.33	171.7
	Micrasema	0	0	0	0	0	0	0
	Neothremma alicia	137	63	45	81.67	48.76	58.22	2474.5
	Oligophlebodes sp	0	0	0	0	0	0	0
	Rhyacophila (larvae).	23	22	10	18.33	7.23	5.71	555.5
	Rhyacophila (pupae)	0	0	0	0	0	0	0
Coleoptera	*Heterlimnius* (larvae)	0	0	0	0	0	0	0
	Heterlimnius (adult)	0	0	0	0	0	0	0
	Optioservus (larvae)	11	14	3	9.33	5.69	6.93	282.8
	Optioservus (adult)	0	3	2	1.67	1.53	2.8	50.5
	Staphylinidae	0	0	0	0	0	0	0
Diptera	*Antocha* (Tipulidae)	2	3	0	1.67	1.53	2.8	50.5
	Ceratopogonidae	0	0	0	0	0	0	0
	Chelifera	0	0	0	0	0	0	0
	Chironomidae (larvae)	396	1103	473	657.33	387.87	457.76	19917.2
	Chironomidae (pupae)	0	0	2	.67	1.15	4.0	20.2
	Dicranota	0	0	0	0	0	0	0
	Euparyphus	1	4	2	2.33	1.53	2	70.7
	Hemerodromia	0	0	0	0	0	0	0
	Pericoma (Psychodidae)	0	0	0	0	0	0	0
	Simulium (larvae)	36	51	6	31	22.91	33.87	939.3
	Simulium (pupae)	0	0	0	0	0	0	0
	Tipula	0	6	0	2	3.46	12	60.6
Crustacea	Cladocera	0	0	0	0	0	0	0
	Copepoda	0	0	0	0	0	0	0
	Ostracoda	62	24	33	39.67	19.86	19.88	1201.9
Arachnida	Hydracarina	2	0	0	0.67	1.15	4.00	20.2
Mollusca	*Sphaerium*	0	0	0	0	0	0	0
Annelida	Hirudinea	1	0	0	0.33	0.58	2.04	10.1
	Oligochaeta	5	1	1	2.33	2.31	4.57	70.7
Misc.	Planariidae	86	159	93	112.67	40.28	28.80	3413.8
Total		1042	2100	834	1325.33	678.89	695.52	40157.6

Table 2. Summary of densities (#/m^2) for James Canyon Creek.

		Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002
Ephemeroptera	*Baetis*	2848	1030	2444	404	6757
	Cinygmula	313	384	404	485	0
	Drunella doddsi	0	0	30	0	0
	Drunella grandis	0	1030	0	1485	0
	Epeorus iron	0	0	0	10	283
	Ephemerella	980	20	10	91	2434
	Early instar *Ephemerella*	30	0	495	0	0
	Heptagenia	30	0	0	0	0
	Paraleptophlebia	40	0	81	20	91
	Rhithrogena	0	51	0	0	0
Plecoptera	Early instar Plecoptera	646	879	30	293	152
	Diura knowltoni	0	0	0	0	0
	Isoperla	71	0	51	10	212
	Malenka californica	10	0	142	0	121
	Megarcys signata	0	0	10	0	0
	Paraperla	0	10	0	0	0
	Skwalla parallela	0	414	0	61	0
	Sweltsa	0	10	30	0	0
	Zapada	242	111	182	111	758
Trichoptera	*Allomyia*	131	0	0	0	0
	Amiocentrus	0	0	0	0	0
	Arctopsyche grandis	51	10	10	0	20
	Brachycentrus echo	0	171	0	0	0
	Dicosmoecus	10	0	0	30	10
	Ecclisocosmoecus	0	0	0	0	0
	Hydropsyche	0	0	0	0	10
	Lepidostoma	0	30	10	0	172
	Micrasema	81	0	30	0	0
	Moselyana	0	0	0	0	0
	Neothremma alicia	3000	1384	758	727	2475
	Oligophlebodes	0	364	153	20	0
	Platycentropus	0	0	0	0	0
	Rhyacophila (larvae)	394	798	293	576	556
	Rhyacophila (pupae)	0	30	0	20	0
Coleoptera	*Heterlimnius* (larvae)	30	192	51	0	0
	Heterlimnius (adult)	0	20	0	40	0
	Optioservus (larvae)	10	0	0	293	283
	Optioservus (adult)	0	0	0	0	51
	Staphylinidae	0	10	10	0	0
Diptera	*Antocha* (Tipulidae)	10	0	0	10	51
	Antocha (pupae)	0	0	0	10	0
	Atherix	10	0	0	0	0
	Caloparyphus	0	51	20	0	0
	Ceratopogonidae	40	61	0	10	0
	Chelifera	51	81	0	40	0
	Chironomidae (larvae)	23533	20614	4464	21947	19917
	Chironomidae (pupae)	20	455	10	323	20
	Dicranota	20	0	0	0	0
	Dixa	0	10	0	0	0
	Euparyphus	10	0	0	0	71

	Hemerodromia	0	0	0	10	0
	Limnophila	0	20	0	0	0
	Pericoma (Psychodidae)	30	0	0	0	0
	Phoridae	0	0	10	0	0
	Ptychoptera	0	0	10	0	0
	Simulium (larvae)	91	10	111	0	939
	Simulium (pupae)	0	0	0	0	0
	Tipula	0	10	0	0	61
	Trichoclinocera	0	10	0	0	
	Wiedemannia	81	0	20	0	0
Crustacea	*Asellus*	0	0	0	0	0
	Cladocera	0	51	0	343	0
	Copepoda	10	0	0	0	0
	Ostracoda	1778	858	323	162	1202
Arachnida	Hydracarina	10	101	20	81	20
Mollusca	*Sphaerium*	20	353	71	141	0
Annelida	Hirudinea	0	0	0	0	10
	Oligochaeta	202	192	40	394	72
Misc.	Planariidae	0	828	1343	1020	3414
Total		34757	30805	11716	28886	40158

The number of contagiously distributed taxa in the fall 2002 James Canyon Creek samples was slightly more than the eight taxa in the spring 2002 samples, and close to the nine taxa in both the fall of 2000, and the fall of 2001. As in previous years, with the notable exception of the spring of 2002, the most abundant taxa had the contagious distributions. The only exception in the fall 2002 series was the predator, *Rhyacophila*, which was abundant, yet randomly distributed. It was also randomly distributed in the spring 2002 samples.

Biotic Condition Index

The community tolerant quotient (CTQa) was generated using the ratings for individual invertebrate taxa (Table 3) provided by Winget and Mangum (1979). James Canyon Creek, in the spring of 2002 had a CTQa rating of 66, while James Canyon Creek for the fall of 2002 had a CTQa rating of 59 (Table 4). Lower values represent higher habitat quality under this measure. The previous fall (2001) the CTQa was about 10 points higher (Table 4) that the fall 2002 value, suggesting that the stream has begun to recover from the impacts of the previous fall. The BCI value for James Canyon Creek, fall 2002, was calculated at 136 (CTQp/CTQa). According to this index the stream has high habitat quality (Winget and Mangum 1979).

Table 3. Tolerance Quotients for taxa collected in James Canyon (after Winget and Mangum 1979).

			James Canyon
Ephemeroptera	*Baetis*	72	72
	Cinygmula	21	
	Drunella doddsi	24	
	Drunella grandis	24	
	Epeorus iron	21	21
	Ephemerella	48	21
	Early instar *Ephemerella*	48	
	Heptagenia	48	
	Paraleptophlebia	24	24
	Rhithrogena	21	
Plecoptera	Early instar Plecoptera	48	45
	Diura knowltoni	24	
	Isoperla	48	48
	Malenka californica	36	36
	Megarcys signata	24	
	Paraperla	48	
	Skwalla parallela	18	
	Sweltsa	24	
	Zapada	16	16
Trichoptera	*Allomyia*	108	
	Amiocentrus	24	
	Arctopsyche grandis	18	18
	Brachycentrus echo	24	
	Dicosmoecus	24	24
	Hydropsyche	108	108
	Ecclisocosmoecus	108	
	Lepidostoma	18	18
	Micrasema	24	
	Moselyana	108	
	Neothremma alicia	8	8
	Oligophlebodes	24	24
	Platycentropus	108	
	Rhyacophila (larvae).	18	18
	Rhyacophila (pupae)	18	--
Coleoptera	*Heterlimnius* (larvae)	108	
	Heterlimnius (adult)	108	
	Optioservus (larvae)	108	108
	Optioservus (adult)	108	--
	Staphylinidae	108	
Diptera	*Antocha* (Tipulidae)	24	24
	Antocha (pupae)	24	
	Atherix	24	
	Caloparyphus	108	
	Ceratopogonidae	108	
	Chelifera	108	
	Chironomidae (larvae)	108	108
	Chironomidae (pupae)	108	--
	Dicranota	24	
	Dixa	108	

	Euparyphus	108	108
	Hemerodromia	108	
	Limnophila	108	
	Pericoma (Psychodidae)	108	
	Phoridae	108	
	Ptychoptera	108	
	Simulium (larvae)	108	108
	Simulium (pupae)	108	
	Tipula	36	36
	Trichoclinocera	108	
	Wiedemannia	108	
Crustacea	*Asellus*	108	
	Cladocera	108	
	Copepoda	108	
	Ostracoda	108	108
Arachnida	Hydracarina	108	108
Mollusca	*Sphaerium*	108	
Annelida	Hirudinea	108	108
	Oligochaeta	108	108
Misc.	Planariidae	108	108
Total score			1719
No. of Taxa			26
Mean score	CTQa		58.96

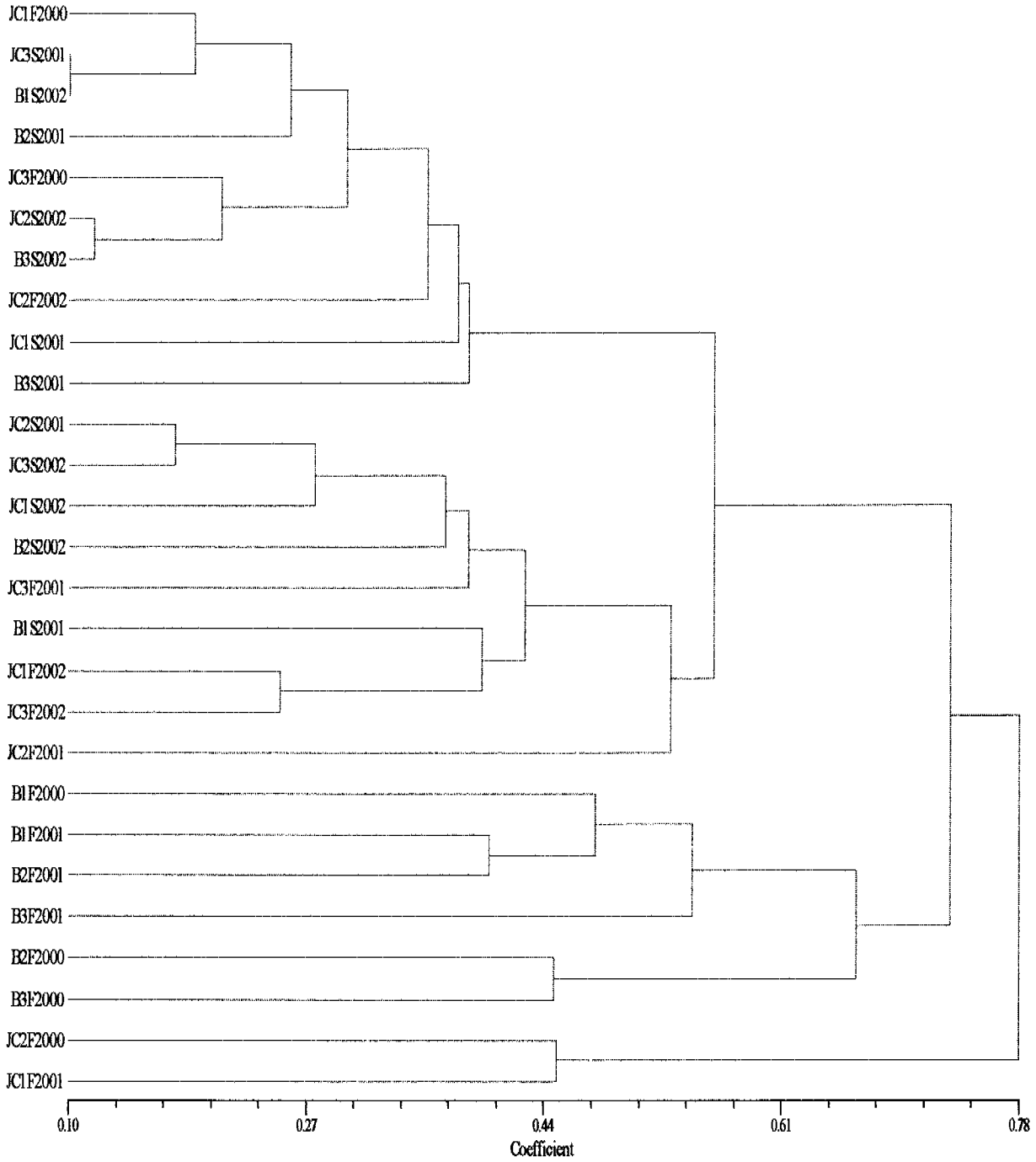
Table 4. Summary of CTQa values for the two Electric Lake tributaries.

CTQa	fall 2000	spring 2001	fall 2001	spring 2002	fall 2002
James Canyon Creek	65.64	72.00	68.72	66.12	58.96
Burnout Creek	58.32	60.77	60.00	64.14	--

Cluster Analysis

Cluster analysis (Figure 1) of the total data set (2000-2002) generated, at a dissimilarity level of approximately 0.68, three clusters among the two streams, James Canyon Creek and Burnout Creek. These were similar to those seen with the Spring 2002 cluster analysis. The most dissimilar cluster now contains just two fall samples from James Canyon, JC2F2000 and JC1F2001. JC2F2001, which was a member of that particular cluster in the spring 2002 analysis, has been pulled into the third (uppermost) cluster. The remaining two samples, JC2F2000 and JC1F2001 also formed a separate cluster in the fall 2001 report, indicating that these two samples were consistently different from all other samples.

Figure 1. Cluster dendrogram for all samples taken at James Canyon Creek(JC) and Burnout Creek (B) since the fall of 2000.



The second (middle) cluster still contains the fall samples from Burnout Creek reinforcing the conclusion of the last report that Burnout Creek has a strong seasonal signal. Since Burnout Creek is not a part of this particular sample series, the second cluster will not be reviewed further.

The third cluster contains the three samples from the fall 2002 sampling period. It also contains the spring samples from both streams plus four James Canyon fall samples, two from 2000 and two from 2001, including JC2F2001, which was in the first (lower) cluster in the spring 2002 analysis. Two subclusters (Figure 1) occur within this third cluster.

The lower subcluster contains nine samples. Two of these are from Burnout Creek (B1S2001 and B2S2002), and the remaining seven are from James Canyon Creek. Six of the seven James Canyon Creek samples were taken after the summer 2001 impact on the stream; two from the fall of 2001, two from the fall of 2002, and two from the spring of 2002. The fall 2001 sample (JC2F2001), which was pulled into the lower subcluster, is the most weakly associated member of the lower subcluster.

The upper subcluster contains ten samples. Of these, four are from Burnout Creek spring samples. Two of the remaining six samples are from the fall of 2000 and two from the spring of 2001. These were taken before the perturbation documented in the fall samples of 2001. The remaining two samples from James Canyon Creek are from 2002 samples, one spring and one fall.

The general pattern in the third cluster suggests that the upper subcluster contains what would be considered the base line (unimpacted) state for James Canyon Creek, while the lower subcluster contains the impacted communities. It should be noted that membership of a given sample in either cluster is not an absolute measure of recovery, but one would expect the majority of the samples (two of three) to be in the upper subcluster under baseline conditions. Using that criterion, James Canyon Creek has been recovering since the spring of 2002, but had not returned to the 2000 condition as of the fall, 2002 sampling period.

The taxa that have been separating the two subclusters were *Baetis* (higher in the upper subcluster), chironomid larvae and pupae (both higher in the upper subcluster), and planaria (higher in the lower subcluster). The fall 2002 samples in the lower subcluster had lower numbers of both *Baetis* and chironomid larvae, as expected, relative to the single sample in the upper subcluster (JC2F2002). However the upper subcluster sample also contained more planaria than the other two samples. The high densities of both *Baetis* and chironomids were sufficient to pull that sample into the first subcluster.

Conclusions

The fall 2002 James Canyon Creek samples generated the highest total density collected in that stream since the initiation of sampling in the fall of 2000 (Table 2). Fifteen taxa were in their highest recorded densities. Of those, the most notable were *Baetis*, *Ephemerella*, *Zapada*, *Lepidostoma*, Simuliidae, and Planaria. These taxa represent collector-gatherers, shredders,

predators, and filterers. Chironomids were the exception, being in densities below that collected at other times.

One factor that may be involved in the increased density of invertebrates is the change in density of fish. We were not asked to conduct a population estimate for the trout in the stream during 2002, but in 2001 the trout density was down significantly and the low water in the spring of 2002 likely discouraged, if not prevented, spawning access to James Canyon Creek. A significant reduction in juvenile fish could result in changes in the benthic community since reduced predation pressure should allow invertebrate prey to increase. *Baetis*, for instance, is a primary prey item for stream dwelling trout.

Without the top vertebrate predators, invertebrate predators should also increase. That is the case with Planaria. This group was not collected in the fall of 2000, but in comparison with density estimates for the spring of 2001, they had increased over four fold by the fall 2002 sampling period. Their foraging, as ambush predators, would be expected to especially impact those organisms less capable of rapid escape, and chironomid larvae which often reside in silken tubes, may be strongly affected by flatworm predation.

Based on the BCI, the stream can be considered to be in good condition, and the CTQa shows steady improvement over that last two sampling periods. The impact recorded in the fall of 2001 in James Canyon Creek appears to be dissipating, but the stream benthic community has not yet converged to the structure it had prior to that impact. Trophic cascades, which are likely drought influenced, may be complicating the recovery to baseline conditions.

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