Benthic Community Reference Condition Sites in Thunder Bay, 2004

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Study Our Streams
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Introduction

EcoSuperior's goal was to choose ten Reference Condition Sites from habitats that were minimally impacted according to the criteria outlined by the Ontario Benthos Biomonitoring Network (Jones *et al.*, 2004). The factors we considered included:

-point-source contamination
-dams, impoundments, regulation of water level
-loss of natural riparian vegetation
-catchment deforestation
-aquatic habitat disruption (dredging, stream channel alteration)
-development of urban land use in catchment
-agricultural land use in catchment
-artificial drainage/ imperviousness (asphalt) in catchment
-anthropogenic acidification, and
-water chemistry.

The sites we chose were representative of unimpaired, diverse stream habitat within four of the watersheds that drain through the City of Thunder Bay, and were of variable size, stream order, substrate and other physiographic features.

Procedure

We examined all sites accessible by road on the Neebing River, the McIntyre River, McVicar Creek and the Current River. We identified one candidate site on the Neebing River, two candidate sites on McVicar Creek, three candidate sites on the McIntyre River and four candidate sites on the Current River (Fig. 1).

The benthos (bottom macroinvertebrates) were sampled at each site according to OBBN protocols (Jones *et al.*, 2004), using a traveling kick-and-sweep with a 500-micron D-net. Three sub-samples were collected at each of the ten sites during October 2004. Each sub-sample was preserved in 70% ethanol.

Approximately 100 benthic macroinvertebrates were randomly picked from each of the sub-samples using the 'teaspoon method' (Jones *et al.*, 2004) under magnification with either a Nikon SMZ645 at 8X magnification or a Nikon SMZ1500 at 10X magnification. The specimens were identified at genus-level (Appendix 1- Appendix 4b), when possible, using Merritt and Cummins (1996) and Wiggins (1996). The Biotic Indices for the sites were calculated based on 27 taxa as outlined by the OBBN (Jones *et al.*, 2004).

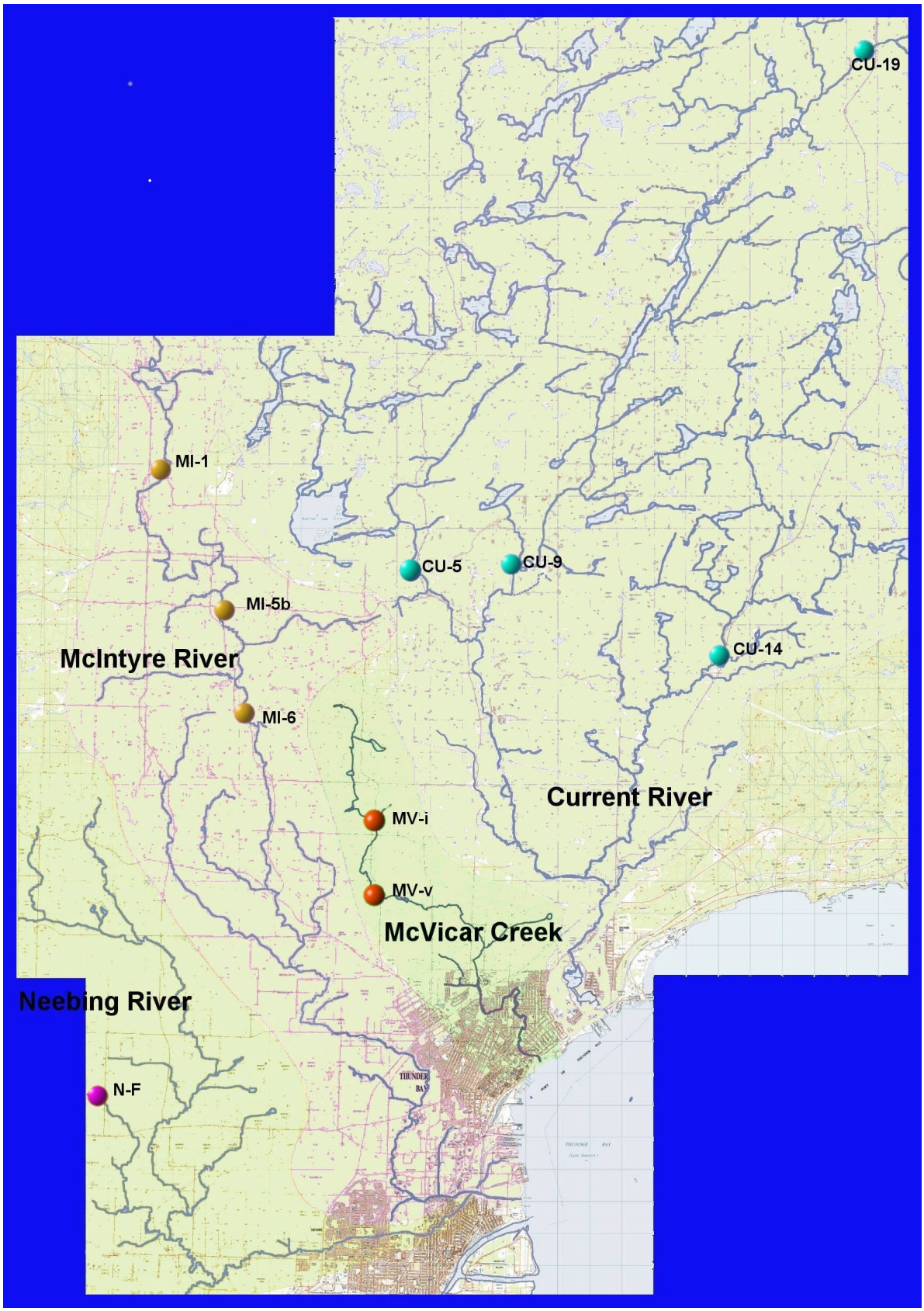

Figure 1. Location of candidate Reference Condition Sites, 2004.

Evaluation of the Sites

The OBBN Biotic Indices (Table 1) (Jones *et al.,* 2004) used to analyse the 27 taxa identified from the candidate sites provide an insight into the present and past conditions experienced by the aquatic macroinvertebrate communities. Some of the Biotic Indices (% Worms, % Chironomids) are useful for characterising sites that are heavily impacted by nutrient enrichment. Nutrient enrichment will cause premature eutrophication resulting in low dissolved oxygen in the water, with consequent degradation of the habitat. Other biotic indices (% EPT, Hilsenhoff's Biotic Index) help to confirm high water quality at the site. Each Biotic Index provides a separate insight about the quality of the habitat; the combination of several indices makes it possible to evaluate the relative, long-term health of the site. However, not all Biotic Indices are necessary to determine whether a site is impaired, or whether it should be considered a Reference Condition Site.

The Biotic Indices that we used to evaluate the potential Reference Condition Sites were: Richness, Shannon's H' Diversity, Hilsenhoff's Biotic Index, % Dominant, % EPT, % Chironomids, and % Worms (Table 1). These Biotic Indices were compared with results from southern Ontario (CEW Data Manual, 2005).

Neebing River site (N-F) (Table 2) had a low Richness (6.00) and low Shannon's H' Diversity (1.04) which could indicate an impaired site; however, Hilsenhoff's Biotic Index (5.65) was below the cut-off value of 6.0 (Table 1), indicating a community of organisms from a healthy ecosystem. The % Dominant was high (57.72); however, examination of the detailed taxa (Appendix 1) indicated that the dominant taxon was Ephemeroptera, which indicates a healthy ecosystem. The % Chironomids was high (33.81) by southern Ontario standards (CEW Data Manual, 2005), which could indicate eutrophication; however, the % Worms (1.88) was low, ruling out the possibility of nutrient enrichment. The % EPT (61.85) was extremely high indicating a healthy ecosystem, which means that this site should be included in the OBBN Reference Condition data bank.

McVicar Creek sites (MV-i and MV-v) (Table 2) had a moderate Richness (8.00 & 9.67) and moderate Shannon's H' Diversity (1.40 at both sites) for the sites examined in this survey in northern Ontario. Hilsenhoff's Biotic Index was below 6.0 indicating a healthy ecosystem. The % Dominant (54.01 & 46.11) was high for southern Ontario but not unusually high for this study (Table 2). The % EPT (26.67 & 49.86) was indicative of a healthy ecosystem. The % Chironomids was high (54.01 & 41.09), but the % Worms (3.32 & 2.86) was again low. These sites should be included in the OBBN Reference Condition data bank.

McIntyre River sites (MI-1,MI-5b, and MI-6) were unusual in this survey because they were silty, contained woody debris and had rooted vegetation which extended into the stream from the banks. The other sites that were surveyed had gravel, rocky, or boulder bottoms. The McIntyre River sites (Table 2) had the highest Richness (MI-1,11.67) to a

Table 1. Biotic Indices: calculations and descriptions.

Subcatagory	Index	How to Calculate:	Indication
Richness/Diveristy	ABUNDANCE	Sum of Organisms	possibly impaired if extremely low or high value
	RICHNESS	Count of taxa found in a sample	the greater the number of taxa the higher the quality of the habitat
	INSECT RICHNESS	Count of Chironomidae+Culicidae +Ceratopogonidae +Tipulidae +Tabanidae +Simuliidae+Odonates(Zygoptera and Anisoptera) + Coleoptera + Ephemeroptera + Hemiptera + Lepidoptera + Megaloptera + Plecoptera + Trichoptera + misc Dipterans	the greater the number of taxa the higher the quality of the habitat
	DIPTERIAN RICHNESS	Count of Chironomidae+Culicidae +Ceratopogonidae+Tipulidae+Tabanidae+ Simuliidae	the greater the number of taxa the higher the quality of the habitat
	SIMPSON'S INDEX	Proportion of species *i* relative to the total number of species (p_i), squared Squared proportions for all the species summed, and the reciprocal is taken	probability that two individuals will belong to the same taxon
	SHANNON'S H' DIVERSITY	H'= -Sum(p_i * ln(p_i) where p_i =proportion of the count of each taxa	high values indicate increased evenness of the counts among the taxa and higher quality habitat
Composition	%AMPHIPODA	Sum of amphipoda /abundance *100	asociated with eutrophic conditions
	%CHIRONOMIDAE	Sum of Chironomidae / Abundance*100	extremely abundant in highly eutrophic situations, but present in all habitats
	%CRUSTACEANS and MOLLUSCA	(Sum of Amphipoda+Decapoda+Isopoda + Gastropoda + Pelecypoda) /Abundance*100	associated with eutrophic conditions, but present in many habitats
	%CRUSTACEANS	(Sum of Amphipoda+Decapoda+Isopoda) /abundance*100	associated with eutrophic conditions, but present in many habitats
	%EPHEMEROPTERA	Sum of Ephemeroptera /abundance*100	the greater the value the higher the quality of the habitat
	%GASTROPODS	Sum of Gastropoda /abundance*100	associated with eutrophic conditions, but present in many habitats
	%HIRUDINEA	Sum of Hirudinea /abundance*100	associated with eutrophic conditions, but present in many habitats
	%ISOPODA	Sum of Isopoda /abundance*100	asociated with eutrophic conditions
	%MOLLUSCA	(Sum of Gastropoda + Pelcypoda) /abundance*100	associated with eutrophic conditions, but present in many habitats
	%ODONATES	(Sum of Anisoptera and Zygoptera) /abundance*100	the greater the value the higher the quality of the habitat
	%OLIGOCHAETES	Sum of Oligochaetes /abundance*100	abundant in highly eutrophic situations, but present in many habitats
	%PELECYPODA	Sum of Pelecypoda /abundance*100	the greater the value the healthier the habitat
	%TIPULIDAE	Sum of Tipulidae /abundance*100	possibly impaired if extremely high value, but present in many habitats
	%TABANIDAE	Sum of Tabanidae /abundance*100	possibly impaired if extremely high value, but present in many habitats
	%SIMULIDAE	Sum of Simuliidae /abundance*100	possibly impaired if extremely high value, but present in many habitats
	%DIPTERA	(Sum of Chironomidae+Culicidae +Ceratopogonidae +Tipulidae+Tabanidae+Simuliidae +misc Dipterans) / Total Abundance* 100	possibly impaired if extremely low or high value
	%INSECTS	(Sum of abundance of Chironomidae+Culicidae +Ceratopogonidae +Tipulidae+Tabanidae+Simuliidae+Odonates (Zygoptera and Anisoptera) + Coleoptera + Ephemeroptera + Hemiptera + Lepidoptera + Megaloptera + Plecoptera + Trichoptera + misc Dipterans)/ Total Abundnce* 100%	possibly impaired if extremely low or high value
	%NON-DIPTERIAN INSECTS	(Sum of Zygoptera + Anisoptera + Coleoptera + Ephemeroptera + Hemiptera + Lepidoptera + Megaloptera + Plecoptera + Trichoptera)/Total Abundance* 100	a high value indicates higher water quality than a lower value
	%EPT	(Sum of Ephemeroptera + Plecoptera + Trichoptera) / Abundance * 100	a high value indicates higher water quality than a lower value
	%EOT	(Sum of Ephemeroptera + Anisoptera + Zygoptera + Trichoptera) / Total Abundance * 100	a high value indicates higher water quality than a lower value
Tolerance	%DOMINANT	Abundance of the Most Common Taxon / abundance * 100	the dominance of a pollution tolerant group indicates an impaired site
	HILSENHOFF'S BIOTIC INDEX	=SUM($x_i.t_i$)/Total abundance where x_i =abundance of each taxa and t_i = tolerance value for each taxa.	a low value implies low nutrient conditons. Values above 6.0 are of concern

Table 2. Summary of Biotic Indices at Candidate Reference Condition Sites, Thunder Bay, October 2004.

Site Name	Site Code	Subsample Number	Sampling Date	Total Abundance	Richness	H' Diversity	Hilsenhoff's Biotic Index	% Dominants	% EPT	% Chironomids	% Worms
Neebing River	N-F	Mean	4-Oct-04	108	6.00	1.04	5.65	52.72	61.85	33.81	1.88
McVicar Creek	MV-I	Mean	7-Oct-04	108	8.00	1.40	5.92	54.01	26.67	54.01	3.32
McVicar Creek	MV-V	Mean	7-Oct-04	117	9.67	1.40	5.58	46.11	49.86	41.09	2.86
McIntyre River	MI-1	Mean	8-Oct-04	106	11.67	1.92	4.75	28.95	63.77	16.08	5.65
McIntyre River	MI-5b	Mean	15-Oct-04	112	10.00	1.55	5.67	37.55	48.60	37.55	3.13
McIntyre River	MI-6	Mean	14-Oct-04	137	8.67	1.10	6.19	64.83	27.89	64.83	3.07
Current River	CU-5	Mean	15-Oct-04	103	10.67	1.62	5.33	46.08	38.45	42.06	2.91
Current River	CU-9	Mean	14-Oct-04	120	8.00	1.65	5.36	36.23	46.47	29.02	4.71
Current River	CU-14	Mean	12-Oct-04	106	10.67	1.85	5.43	32.12	48.64	29.46	5.38
Current River	CU-19	Mean	12-Oct-04	115	9.33	1.41	5.52	49.13	55.63	36.25	3.50

moderate (MI-5b,10.00), and a lower Richness (MI-6, 8.67) with a correspondingly higher Shannon's H' Diversity (1.92, 1.55, and 1.10) than the other sites that were examined. Hilsenhoff's Biotic Index was again below 6.0 at Site MI-1 and Site MI-5b. However, Site MI-6 had a Hilsenhoff's Biotic Index of 6.19 , the only site that we surveyed with a value above 6.0. The % Dominant was low to moderate (28.95 and 37.55) at the first two sites; however, the highest % Dominant in this survey was obtained at site MI-6 (64.83). The % EPT (63.77, 48.60, and 27.89) indicated healthy ecosystems; however, the value for MI-6 was the second-lowest obtained during this survey. The % Chironomids (16.08, 37.55, and 64.83) was moderate in first two sites and very high in site MI-6. The % Worms (5.65, 3.13, and 3.07) was moderate in all three sites. These sites should be included in the OBBN Reference Condition data bank; however, MI-6 might be marginal.

Current River sites (CU-5, CU-9, CU-14, and CU-19) (Table 2) had a moderate Richness (10.67, 8.00, 10.67, and 9.33), a moderate Shannon's H' Diversity (1.62, 1.65, 1.85, and 1.41), a Hilsenhoff's Biotic Index (5.33, 5.36, 5.43, and 5.52) all below 6.0, a moderate % Dominant (46.08, 36.23, 32.12, and 49.13), a % EPT (38.45, 46.47, 48.64, and 55.63) which indicated healthy ecosystems, a moderate % Chironomids (42.06, 29.02, 29.46, and 36.25), and a moderate % Worms (2.91, 4.71, 5.38, and 3.50). The fast flowing, highly oxygenated water of the Current River has made this a popular destination for trout fishing with local anglers. The Current River sites should be included in the OBBN Reference Condition data bank.

Conclusion

All the sites that were examined fit the criteria to warrant inclusion in the OBBN Reference Condition data bank; however, site MI-6 was considered marginal and requires further examination. The communities of macroinvertbrates in this survey obviously differ from those of southern Ontario. The Richness and Shannon's H' are lower, whereas the % Dominant seems consistently higher than found in southern Ontario. As well, the % EPT is very high as is the % Chironomids. The Hilsenhoff's Biotic Index was almost consistently below 6.0. These differences require further investigation to ensure that they are valid and indicative of healthy benthic macroinvertebrate communities of northern Ontario.

Literature Cited

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Appendix 1. Benthic macroinvertebrates from Neebing River, 2004.

		Neebing River Site NF #1 riffle 4-Oct	Neebing River Site NF #2 pool 4-Oct	Neebing River Site NF #3 riffle 4-Oct
PLATYHELMINTHES				
NEMATODA				
MOLLUSCA				
Gastropoda				
Ancylidae				2
Hydrobiidae				
Physidae				
Planorbidae				
Valvatidae				
Bivalvia				
Sphaeriidae				
ANNELIDA				
Oligochaeta		4		2
Hirudinea				1
ARTHROPODA				
Hydracarina		1	2	
Amphipoda				
Hyalellidae	*Hyalella*			
Insecta				
Ephemeroptera				
Baetidae	Juvenile/damaged	9		5
	Baetis	1		2
Heptageniidae	Juvenile/damaged	17		12
	Cinygmula			
	Epeorus (Iron)			
	Leucrocula			
	Stenacron	3		
	Stenonema	1	2	13
Ephemerellidae	Juvenile/damaged			
	Attenella			
	Ephemerella			
	Eurylophella (s str.)	3	11	
	Serratella			
	Timpanoga			
Caenidae	*Caenis*	6	32	2
Leptophlebiidae	Juvenile/damaged	2	17	3
	Leptophlebia	7	23	2
Ephemeridae	*Ephemera*			
	Hexagenia			
Odonata				
Gomphidae	Juvenile/damaged			
	Dromogomphus			
	Gomphus			
	Ophiogomphus			
Aeshnidae	*Boyeria*			

Appendix 1 cont'd. Benthic macroinvertebrates from Neebing River, 2004.

		Neebing River Site NF #1 riffle 4-Oct	**Neebing River Site NF** #2 pool 4-Oct	**Neebing River Site NF** #3 riffle 4-Oct
Odonata				
Cordulegastridae	*Cordulegaster*			
Corduliidae	Juvenile			
	Epitheca (Tetragoneuria)			
Calopterygidae	*Calopteryx*			
Plecoptera	Juvenile/damaged			
Taeniopterygidae	*Oemopteryx*			
	Strophopteryx			
	Taeniopteryx			
Nemouridae	Juvenile/damaged			
	Nemoura			1
	Shipsa			
Leuctridae	Juvenile/damaged			
	Despaxia			
	Leuctra			
Capniidae	Juvenile/damaged			
	Allocapnia			
	Paracapnia			
Perlidae	Juvenile/damaged			
	Acroneuria			
	Agnetina			1
	Paragnetina			
	Perlinella			
Perlodidae	Juvenile/damaged			
	Isoperla			
Hemiptera				
Corixidae				
	Hesperocorixa			
Megaloptera				
Sialidae	*Sialis*			
Corydalidae	Juvenile/damaged			
	Nigronia			
Coleoptera				
Dytiscidae				
Elmidae	Juvenile/damaged			
	Dubiraphia	1		
	Gonielmis			
	Optioservus		1	
	Ordobrevia			
Trichoptera	Juvenile/damaged/ Pupa			
Philopotamidae	pupa			
	Dolophilodes			
	Chimarra			

Appendix 1 cont'd. Benthic macroinvertebrates from Neebing River, 2004.

		Neebing River Site NF #1 riffle 4-Oct	**Neebing River Site NF** #2 pool 4-Oct	**Neebing River Site NF** #3 riffle 4-Oct
Trichoptera				
Polycentropodidae	Damaged	1		
	Polycentropus			
Dipseudopsidae	*Phylocentropus*			
Hydropsychidae	*Hydropsyche*	1		16
Glossosomatidae	*Glossosoma*			4
Hydroptilidae	*Hydroptila*	2		
	Oxyethira			
Phryganeidae	*Agyrpnia*			
	Fabria			
Brachycentridae	Juvenile			
	Micrasema			
Lepidostomatidae	*Lepidostoma*			
Limnephilidae	Juvenile/damaged			
	Platycentropus			
	Pycnopsyche			
Leptoceridae	Juvenile/damaged			
	Ceraclea	1		
	Mystacides		2	
	Oecetis			
Diptera	Damaged/pupa			1
Ceratopogonidae	Juvenile/damaged			
	Bezzia/Palpomyia			
	Probezzia			
Chironomidae		47	23	39
Simuliidae	*Prosimulium*			
Tipulidae	Juvenile/damaged			
	Antocha			
	Dicronata			
Athericidae	*Atherix*	1		
Empididae	*Chelifera*			
	Hemerodromia	1		
Tabanidae				
Ephydridae	Juvenile			
Total number of individuals		109	113	106

Appendix 2. Benthic macroinvertebrates from McVicar Creek, 2004.

		McVicar Creek Site MV-i #1 riffle 7-Oct	McVicar Creek Site MV-i #2 pool 7-Oct	McVicar Creek Site MV-i #3 riffle 7-Oct		McVicar Creek Site MV-v #1 riffle 7-Oct	McVicar Creek Site MV-v #2 pool 7-Oct	McVicar Creek Site MV-v #3 riffle 7-Oct
PLATYHELMINTHES						1		1
NEMATODA								1
MOLLUSCA								
Gastropoda								
Ancylidae								
Hydrobiidae								
Physidae								
Planorbidae						4	1	
Valvatidae						1		
Bivalvia								
Sphaeriidae			1			1	1	
ANNELIDA								
Oligochaeta		2	3	3		3	1	6
Hirudinea								
ARTHROPODA								
Hydracarina			2	3		2	3	1
Amphipoda								
Hyalellidae	*Hyalella*							
Insecta								
Ephemeroptera								
Baetidae	Juvenile/ damaged	27	7	3		3	3	2
	Baetis					3		3
Heptageniidae	Juvenile/ damaged					4	14	5
	Cinygmula							
	Epeorus (Iron)					2		1
	Leucrocula							
	Stenacron					2		
	Stenonema		1	2		7	3	13
Ephemerellidae	Juvenile/damaged		1					
	Attenella		1			2		
	Ephemerella							
	Eurylophella (s str.)	1	2					
	Serratella	1		4		20	14	28
	Timpanoga							
Caenidae	*Caenis*		3					
Leptophlebiidae	Juvenile/damaged		3					
	Leptophlebia	1	1	1		1		
Ephemeridae	*Ephemera*							
	Hexagenia							
Odonata								
Gomphidae	Juvenile/damaged							
	Dromogomphus							
	Gomphus							
Gomphidae	*Ophiogomphus*							
Aeshnidae	*Boyeria*					2		

Appendix 2 cont'd. Benthic macroinvertebrates from McVicar Creek, 2004.

		McVicar Creek Site MV-i #1 riffle 7-Oct	**McVicar Creek Site MV-i** #2 pool 7-Oct	**McVicar Creek Site MV-i** #3 riffle 7-Oct		**McVicar Creek Site MV-v** #1 riffle 7-Oct	**McVicar Creek Site MV-v** #2 pool 7-Oct	**McVicar Creek Site MV-v** #3 riffle 7-Oct
Odonata								
Cordulegastridae	*Cordulegaster*							
Corduliidae	Juvenile							
	Epitheca (Tetragoneuria)							1
Calopterygidae	*Calopteryx*							
Plecoptera	Juvenile/damaged							
Taeniopterygidae	*Oemopteryx*							
	Strophopteryx							
	Taeniopteryx		1					
Nemouridae	Juvenile/damaged							
	Nemoura					1		
	Shipsa							
Leuctridae	Juvenile/damaged							
	Despaxia							
	Leuctra		1			4	13	8
Capniidae	Juvenile/damaged	4	3				1	1
	Allocapnia							
	Paracapnia			1		2		
Perlidae	Juvenile/damaged							
	Acroneuria							
	Agnetina							
	Paragnetina					1		1
	Perlinella							
Perlodidae	Juvenile/damaged							
	Isoperla							
Hemiptera								
Corixidae								
	Hesperocorixa							
Megaloptera								
Sialidae	*Sialis*							
Corydalidae	Juvenile/damaged							
	Nigronia							
Coleoptera								
Dytiscidae								
Elmidae	Juvenile/damaged		2					
	Dubiraphia							
	Gonielmis							
	Optioservus	8	14	14			1	1
	Ordobrevia							
Trichoptera	Juvenile/damaged/ Pupa		1				1	1
Philopotamidae	Pupa							
	Dolophilodes							
	Chimarra							

Appendix 2 cont'd. Benthic macroinvertebrates from McVicar Creek, 2004.

		McVicar Creek Site MV-i #1 riffle 7-Oct	**McVicar Creek Site MV-i** #2 pool 7-Oct	**McVicar Creek Site MV-i** #3 riffle 7-Oct		**McVicar Creek Site MV-v** #1 riffle 7-Oct	**McVicar Creek Site MV-v** #2 pool 7-Oct	**McVicar Creek Site MV-v** #3 riffle 7-Oct
Trichoptera								
Polycentropodidae	Damaged							
	Polycentropus							
Dipseudopsidae	*Phylocentropus*							
Hydropsychidae	*Hydropsyche*	1		8		4	1	4
Glossosomatidae	*Glossosoma*							
Hydroptilidae	*Hydroptila*		1					
	Oxyethira	1						
Phryganeidae	*Agyrpnia*							
	Fabria							
Brachycentridae	Juvenile							
	Micrasema		1					
Lepidostomatidae	*Lepidostoma*		2			1		
Limnephilidae	Juvenile/damaged	1						
	Platycentropus							
	Pycnopsyche							
Leptoceridae	Juvenile/damaged							
	Ceraclea							
	Mystacides							
	Oecetis		1					
Diptera	Damaged/pupa							
Ceratopogonidae	Juvenile/damaged							
	Bezzia/Palpomyia	2	2					
	Probezzia	1	1	1				
Chironomidae		57	59	58		55	54	35
Simuliidae	*Prosimulium*							
Tipulidae	Juvenile/damaged							
	Antocha							
	Dicronata							
Athericidae	*Atherix*							
Empididae	*Chelifera*	2		1		1	3	
	Hemerodromia			1				
Tabanidae								
Ephydridae	Juvenile							
Total number of individuals		109	115	100		128	113	114

Appendix 3A. Benthic macroinvertebrates from McIntyre River, 2004.

		McIntyre River Site MI-1 #1 riffle 8-Oct	McIntyre River Site MI-1 #2 pool 8-Oct	McIntyre River Site MI-1 #3 riffle 8-Oct		McIntyre River Site MI-5b #1 riffle 5-Oct	McIntyre River Site MI-5b #2 pool 5-Oct	McIntyre River Site MI-5b #3 riffle 5-Oct
PLATYHELMINTHES								
NEMATODA		2		1				
MOLLUSCA								
Gastropoda								
Ancylidae						1	1	2
Hydrobiidae								
Physidae			1			1		
Planorbidae			2					1
Valvatidae								
Bivalvia								
Sphaeriidae		11		1				1
ANNELIDA								
Oligochaeta		5	9	4		4	6	1
Hirudinea								
ARTHROPODA								
Hydracarina		2	1			2		
Amphipoda								
Hyalellidae	*Hyalella*						1	
Insecta								
Ephemeroptera								
Baetidae	Juvenile/damaged	6	4	3		5	1	1
	Baetis							
Heptageniidae	Juvenile/damaged	1		2		1		1
	Cinygmula							
	Epeorus (Iron)							
	Leucrocula							
	Stenacron							
	Stenonema			1		1		
Ephemerellidae	Juvenile/damaged	3						
	Attenella							
	Ephemerella	1		4				
	Eurylophella (s str.)	3	5					
	Serratella	1						
	Timpanoga							
Caenidae	*Caenis*					8	14	8
Leptophlebiidae	Juvenile/damaged	7	4	6		9	7	12
	Leptophlebia	1		1		4	12	12
Ephemeridae	*Ephemera*						2	
	Hexagenia	6	23	4				
Odonata								
Gomphidae	Juvenile/damaged							
	Dromogomphus	1						
	Gomphus							
Gomphidae	*Ophiogomphus*							
Aeshnidae	*Boyeria*			1				

Appendix 3A cont'd. Benthic macroinvertebrates from McIntyre River, 2004.

		McIntyre River Site MI-1 #1 riffle 8-Oct	McIntyre River Site MI-1 #2 pool 8-Oct	McIntyre River Site MI-1 #3 riffle 8-Oct		McIntyre River Site MI-5b #1 riffle 5-Oct	McIntyre River Site MI-5b #2 pool 5-Oct	McIntyre River Site MI-5b #3 riffle 5-Oct
Odonata								
Cordulegastridae	*Cordulegaster*	1	1					
Corduliidae	Juvenile			1				
	Epitheca (Tetragoneuria)		1					
Calopterygidae	*Calopteryx*						2	1
Plecoptera	Juvenile/damaged							
Taeniopterygidae	*Oemopteryx*							
	Strophopteryx							
	Taeniopteryx							1
Nemouridae	Juvenile/damaged							
	Nemoura	7						
	Shipsa							
Leuctridae	Juvenile/damaged							
	Despaxia							
	Leuctra	2	1	13				
Capniidae	Juvenile/damaged	4	9					
	Allocapnia		6					
	Paracapnia			8				
Perlidae	Juvenile/damaged							
	Acroneuria							
	Agnetina							
	Paragnetina							
	Perlinella							
Perlodidae	Juvenile/damaged							
	Isoperla		1	3				
Hemiptera								
Corixidae						2		2
	Hesperocorixa							
Megaloptera								
Sialidae	*Sialis*					3		
Corydalidae	Juvenile/damaged							
	Nigronia							
Coleoptera								
Dytiscidae		1		1				
Elmidae	Juvenile/damaged							
	Dubiraphia	1	1			4	4	2
	Gonielmis					2		
	Optioservus	1						
	Ordobrevia							
Trichoptera	Juvenile/damaged/ pupa	1						
Philopotamidae	Pupa							
	Dolophilodes							
Philopotamidae	*Chimarra*	1		6				

Appendix 3A cont'd. Benthic macroinvertebrates from McIntyre River, 2004.

		McIntyre River Site MI-1 #1 riffle 8-Oct	McIntyre River Site MI-1 #2 pool 8-Oct	McIntyre River Site MI-1 #3 riffle 8-Oct		McIntyre River Site MI-5b #1 riffle 5-Oct	McIntyre River Site MI-5b #2 pool 5-Oct	McIntyre River Site MI-5b #3 riffle 5-Oct
Trichoptera								
Polycentropodidae	Damaged							
	Polycentropus							
Dipseudopsidae	*Phylocentropus*	1						1
Hydropsychidae	*Hydropsyche*	15		11				
Glossosomatidae	*Glossosoma*							
Hydroptilidae	*Hydroptila*		1			1		2
	Oxyethira	2				12	33	6
Phryganeidae	*Agyrpnia*		1	1		1	1	
	Fabria							
Brachycentridae	Juvenile							
	Micrasema							
Lepidostomatidae	*Lepidostoma*	4	6	8				
Limnephilidae	Juvenile/damaged							1
	Platycentropus		3	1		4	2	1
	Pycnopsyche							
Leptoceridae	Juvenile/damaged							
	Ceraclea							
	Mystacides							
	Oecetis							
Diptera	Damaged/pupa							
Ceratopogonidae	Juvenile/damaged							
	Bezzia/Palpomyia					1		1
	Probezzia	3	1	3				
Chironomidae		13	24	14		41	43	41
Simuliidae	*Prosimulium*	3		2				
Tipulidae	Juvenile/damaged	2	1					
	Antocha							
	Dicronata							
Athericidae	*Atherix*							
Empididae	*Chelifera*							
	Hemerodromia							
Tabanidae								1
Ephydridae	Juvenile							
Total number of individuals		112	106	100		107	129	100

Appendix 3B. Benthic macroinvertebrates from McIntyre River, 2004.

		McIntyre River Site M1-6 #1 riffle 14-Oct	McIntyre River Site Site M1-6 #2 pool 14-Oct	McIntyre River Site Site M1-6 #3 riffle 14-Oct
PLATYHELMINTHES				
NEMATODA		1		
MOLLUSCA				
Gastropoda				
Ancylidae		1		1
Hydrobiidae				
Physidae				
Planorbidae				
Valvatidae				
Bivalvia				
Sphaeriidae				
ANNELIDA				
Oligochaeta		7	2	4
Hirudinea				
ARTHROPODA				
Hydracarina		1		1
Amphipoda				
Hyalellidae	*Hyalella*			
Insecta				
Ephemeroptera				
Baetidae	Juvenile/damaged	7	1	3
	Baetis			
Heptageniidae	Juvenile/damaged	2		
	Cinygmula			
	Epeorus (Iron)			
	Leucrocula			
	Stenacron			
	Stenonema	9		3
Ephemerellidae	Juvenile/damaged			
	Attenella	6		4
	Ephemerella			
	Eurylophella (s str.)		2	
	Serratella			
	Timpanoga			
Caenidae	*Caenis*		1	
Leptophlebiidae	Juvenile/damaged	25	1	
	Leptophlebia	9		6
Ephemeridae	*Ephemera*			
	Hexagenia			
Odonata				
Gomphidae	Juvenile/damaged			
	Dromogomphus			
	Gomphus			
Gomphidae	*Ophiogomphus*		1	
Aeshnidae	*Boyeria*	2		

Appendix 3B cont'd. Benthic macroinvertebrates from McIntyre River, 2004

		McIntyre River Site M1-6 #1 riffle 14-Oct	**McIntyre River Site Site M1-6** #2 pool 14-Oct	**McIntyre River Site Site M1-6** #3 riffle 14-Oct
Odonata				
Cordulegastridae	*Cordulegaster*			
Corduliidae	Juvenile	1		
	Epitheca (Tetragoneuria)			
Calopterygidae	*Calopteryx*			
Plecoptera	Juvenile/damaged			1
Taeniopterygidae	*Oemopteryx*			
	Strophopteryx			
	Taeniopteryx			1
Nemouridae	Juvenile/damaged			
	Nemoura	11		
	Shipsa			
Leuctridae	Juvenile/damaged	1		
	Despaxia			
	Leuctra			
Capniidae	Juvenile/damaged			
	Allocapnia			
	Paracapnia			
Perlidae	Juvenile/damaged			
	Acroneuria			
	Agnetina			
	Paragnetina			
	Perlinella			
Perlodidae	Juvenile/damaged			
	Isoperla			
Hemiptera				
Corixidae				
	Hesperocorixa			
Megaloptera				
Sialidae	*Sialis*	1		
Corydalidae	Juvenile/damaged			
	Nigronia			
Coleoptera				
Dytiscidae				
Elmidae	Juvenile/damaged	1 J/ 3 D		
	Dubiraphia		3	
	Gonielmis			
	Optioservus			1
	Ordobrevia			
Trichoptera	Juvenile/damaged/ pupa			4
Philopotamidae	Pupa			
	Dolophilodes			
	Chimarra			

Appendix 3B cont'd. Benthic macroinvertebrates from McIntyre River, 2004

		McIntyre River Site M1-6 #1 riffle 14-Oct	**McIntyre River Site Site M1-6** #2 pool 14-Oct	**McIntyre River Site Site M1-6** #3 riffle 14-Oct
Trichoptera				
Polycentropodidae	Damaged	1	1	
	Polycentropus			
Dipseudopsidae	*Phylocentropus*			
Hydropsychidae	*Hydropsyche*	9		10
Glossosomatidae	*Glossosoma*			
Hydroptilidae	*Hydroptila*			
	Oxyethira		1	
Phryganeidae	*Agyrpnia*			
	Fabria			
Brachycentridae	Juvenile	8	1	
	Micrasema	1		
Lepidostomatidae	*Lepidostoma*			
Limnephilidae	Juvenile/damaged			
	Platycentropus			
	Pycnopsyche			
Leptoceridae	Juvenile/damaged			
	Ceraclea			
	Mystacides		1	
	Oecetis			
Diptera	Damaged/pupa			
Ceratopogonidae	Juvenile/damaged	1		
	Bezzia/Palpomyia			
	Probezzia			
Chironomidae		92	92	65
Simuliidae	*Prosimulium*			
Tipulidae	Juvenile/damaged			
	Antocha			
	Dicronata			
Athericidae	*Atherix*	2	1	4
Empididae	*Chelifera*			1
	Hemerodromia			
Tabanidae				
Ephydridae	Juvenile			
Total number of individuals		192	108	109

Appendix 4A. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU5 #1 riffle 15-Oct	Current River Site CU5 #2 pool 15-Oct	Current River Site CU5 #3 riffle 15-Oct		Current River Site CU9 #1 riffle 14-Oct	Current River Site CU9 #2 pool 14-Oct	Current River Site CU9 #3 riffle 14-Oct
PLATYHELMINTHES								
NEMATODA			1					
MOLLUSCA								
Gastropoda								
Ancylidae								
Hydrobiidae		1						
Physidae								
Planorbidae				1				
Valvatidae								
Bivalvia								
Sphaeriidae							4	
ANNELIDA								
Oligochaeta		2	5	2			15	2
Hirudinea								
ARTHROPODA								
Hydracarina				1				
Amphipoda								
Hyalellidae	*Hyalella*		1					
Insecta								
Ephemeroptera								
Baetidae	Juvenile/damaged					4	4	
	Baetis			1			6	
Heptageniidae	Juvenile/damaged		1			4	5	4
	Cinygmula							
	Epeorus (Iron)							1
	Leucrocula							
	Stenacron							
	Stenonema					4		4
Ephemerellidae	Juvenile/damaged			3				3
	Attenella					15	2	1
	Ephemerella	1	1	7		13	1	6
	Eurylophella (s str.)						3	
	Serratella	11		16				2
	Timpanoga							
Caenidae	*Caenis*		5					
Leptophlebiidae	Juvenile/damaged	1		1		1		1
	Leptophlebia			2		2	2	4
Ephemeridae	*Ephemera*							
	Hexagenia							
Odonata								
Gomphidae	Juvenile/damaged		2	1				
	Dromogomphus	1						
	Gomphus							
	Ophiogomphus							
Aeshnidae	*Boyeria*			1				

Appendix 4A cont'd. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU5 #1 riffle 15-Oct	Current River Site CU5 #2 pool 15-Oct	Current River Site CU5 #3 riffle 15-Oct		Current River Site CU9 #1 riffle 14-Oct	Current River Site CU9 #2 pool 14-Oct	Current River Site CU9 #3 riffle 14-Oct
Odonata								
Cordulegastridae	*Cordulegaster*		1			2	1	
Corduliidae	Juvenile							
	Epitheca (Tetragoneuria)							
Calopterygidae	*Calopteryx*							
Plecoptera	Juvenile/damaged							
Taeniopterygidae	*Oemopteryx*					1		
	Strophopteryx	2						
	Taeniopteryx							
Nemouridae	Juvenile/damaged	1						
	Nemoura		2	10				
	Shipsa					11	1	9
Leuctridae	Juvenile/damaged							
	Despaxia							
	Leuctra			3		2		
Capniidae	Juvenile/damaged	6		1				
	Allocapnia							
	Paracapnia						14	
Perlidae	Juvenile/damaged							
	Acroneuria			2				
	Agnetina							
	Paragnetina							
	Perlinella							
Perlodidae	Juvenile/damaged							
	Isoperla							
Hemiptera								
Corixidae								
	Hesperocorixa							
Megaloptera								
Sialidae	*Sialis*							
Corydalidae	Juvenile/damaged							
	Nigronia			1				
Coleoptera								
Dytiscidae								
Elmidae	Juvenile/damaged							
	Dubiraphia		5	2				
	Gonielmis	2						
	Optioservus			7				
	Ordobrevia							
Trichoptera	Juvenile/damaged/ Pupa		1					
Philopotamidae	Pupa							
	Dolophilodes	1						
Philopotamidae	*Chimarra*							

Appendix 4A cont'd. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU5 #1 riffle 15-Oct	Current River Site CU5 #2 pool 15-Oct	Current River Site CU5 #3 riffle 15-Oct		Current River Site CU9 #1 riffle 14-Oct	Current River Site CU9 #2 pool 14-Oct	Current River Site CU9 #3 riffle 14-Oct
Trichoptera								
Polycentropodidae	Damaged							
	Polycentropus			1				
Dipseudopsidae	*Phylocentropus*							
Hydropsychidae	*Hydropsyche*	2		3		9		12
Glossosomatidae	*Glossosoma*					2	1	
Hydroptilidae	*Hydroptila*	2	1	4				
	Oxyethira		4	1				
Phryganeidae	*Agyrpnia*							
	Fabria						1	
Brachycentridae	Juvenile							
	Micrasema							
Lepidostomatidae	*Lepidostoma*		1	16		3	3	4
Limnephilidae	Juvenile/damaged					1	3	
	Platycentropus							
	Pycnopsyche							
Leptoceridae	Juvenile/damaged							
	Ceraclea							
	Mystacides		3					
	Oecetis		2	1				
Diptera	Damaged/pupa						1	
Ceratopogonidae	Juvenile/damaged							
	Bezzia/Palpomyia	1	1					
	Probezzia	1	2				4	1
Chironomidae		46	64	19		19	46	41
Simuliidae	*Prosimulium*	16		1		16	2	40
Tipulidae	Juvenile/damaged							
	Antocha							
	Dicronata					2	1	
Athericidae	*Atherix*							
Empididae	*Chelifera*	1				1		1
	Hemerodromia	3		3				3
Tabanidae								
Ephydridae	Juvenile						1	
Total number of individuals		103	103	111		112	121	138

Appendix 4B. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU14 #1 riffle 12-Oct	Current River Site CU14 #2 pool 12-Oct	Current River Site CU14 #3 riffle 12-Oct		Current River Site CU19 #1 riffle 12-Oct	Current River Site CU19 #2 pool 12-Oct	Current River Site CU19 #3 riffle 12-Oct
PLATYHELMINTHES						2	1	
NEMATODA								
MOLLUSCA								
Gastropoda								
Ancylidae		2						
Hydrobiidae								1
Physidae								
Planorbidae			1					
Valvatidae			1					
Bivalvia								
Sphaeriidae			14	14				
ANNELIDA								
Oligochaeta		5	6	6		3	5	4
Hirudinea								
ARTHROPODA								
Hydracarina			3	1				1
Amphipoda								
Hyalellidae	*Hyalella*						2	
Insecta								
Ephemeroptera								
Baetidae	Juvenile/damaged					1		
	Baetis							3
Heptageniidae	Juvenile/damaged	5	4	6		5		4
	Cinygmula			1				
	Epeorus (Iron)			3				4
	Leucrocula			1				
	Stenacron			1				
	Stenonema	4		7		3		3
Ephemerellidae	Juvenile/damaged			1		3		1
	Attenella					8	4	2
	Ephemerella	6				1	3	2
	Eurylophella (s str.)	3	7				13	7
	Serratella			2		4		15
	Timpanoga			1				
Caenidae	*Caenis*							
Leptophlebiidae	Juvenile/damaged	6	7	3		3	2	3
	Leptophlebia		2	5		3	5	8
Ephemeridae	*Ephemera*							
	Hexagenia							
Odonata								
Gomphidae	Juvenile/damaged			1				
	Dromogomphus							
	Gomphus		1					
	Ophiogomphus					1		
Aeshnidae	*Boyeria*							1

Appendix 4B cont'd. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU14 #1 riffle 12-Oct	Current River Site CU14 #2 pool 12-Oct	Current River Site CU14 #3 riffle 12-Oct		Current River Site CU19 #1 riffle 12-Oct	Current River Site CU19 #2 pool 12-Oct	Current River Site CU19 #3 riffle 12-Oct
Odonata								
Cordulegastridae	*Cordulegaster*							
Corduliidae	Juvenile							
	Epitheca (Tetragoneuria)							
Calopterygidae	*Calopteryx*							
Plecoptera	Juvenile/damaged							
Taeniopterygidae	*Oemopteryx*		1			1		1
	Strophopteryx							
	Taeniopteryx	1						
Nemouridae	Juvenile/damaged							
	Nemoura							1
	Shipsa			2				
Leuctridae	Juvenile/damaged			1				
	Despaxia							
	Leuctra	7	3	1		4	1	3
Capniidae	Juvenile/damaged		2	4				
	Allocapnia			2				
	Paracapnia	5	3					
Perlidae	Juvenile/damaged					1		2
	Acroneuria					1		1
	Agnetina							
	Paragnetina							
	Perlinella	3						
Perlodidae	Juvenile/damaged					1		
	Isoperla							
Hemiptera								
Corixidae								
	Hesperocorixa						1	
Megaloptera								
Sialidae	*Sialis*							
Corydalidae	Juvenile/damaged					1		
	Nigronia	1						
Coleoptera								
Dytiscidae								
Elmidae	Juvenile/damaged							
	Dubiraphia						1	
	Gonielmis							
	Optioservus	1	1			1		
	Ordobrevia	1						
Trichoptera	Juvenile/damaged/ Pupa					1		
Philopotamidae	Pupa							
	Dolophilodes							
Philopotamidae	*Chimarra*	1		1		4		5

Appendix 4B cont'd. Benthic macroinvertebrates from Current River Sites, 2004.

		Current River Site CU14 #1 riffle 12-Oct	**Current River Site CU14** #2 pool 12-Oct	**Current River Site CU14** #3 riffle 12-Oct		**Current River Site CU19** #1 riffle 12-Oct	**Current River Site CU19** #2 pool 12-Oct	**Current River Site CU19** #3 riffle 12-Oct
Trichoptera								
Polycentropodidae	Damaged							
	Polycentropus	2						
Dipseudopsidae	*Phylocentropus*							
Hydropsychidae	*Hydropsyche*	5		2		10		2
Glossosomatidae	*Glossosoma*							1
Hydroptilidae	*Hydroptila*		9			1		
	Oxyethira		5	1			2	2
Phryganeidae	*Agyrpnia*							
	Fabria							
Brachycentridae	Juvenile	2						
	Micrasema							
Lepidostomatidae	*Lepidostoma*		5	5		6	4	2
Limnephilidae	Juvenile/damaged							1
	Platycentropus							
	Pycnopsyche						1	
Leptoceridae	Juvenile/damaged	2						
	Ceraclea							
	Mystacides						2	
	Oecetis		2			1		
Diptera	Damaged/pupa							
Ceratopogonidae	Juvenile/damaged	2						
	Bezzia/Palpomyia							
	Probezzia					1		
Chironomidae		32	39	23		29	67	30
Simuliidae	*Prosimulium*	1		1				
Tipulidae	Juvenile/damaged	1						
	Antocha		1					
	Dicronata							
Athericidae	*Atherix*					3		2
Empididae	*Chelifera*	2				2		1
	Hemerodromia	4	1	2				5
Tabanidae								
Ephydridae	Juvenile							
Total number of individuals		105	119	101		113	116	118