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Little Ouse, Thetford

Final report of post-restoration monitoring

ECRC Research Report Number 172

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Final report of post-restoration monitoring

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Cover photo: Little Ouse backwater, Murray Thompson

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1. Summary

Habitat and invertebrate assessment has been undertaken in an upstream control and compared to restored and backwater stretches of the Little Ouse (Figure 1). This approach has enabled a post-assessment of ecological restoration following the remeandering restoration works in 1994. We have combined data from multiple stream restorations in order to assess how the project on the L. Ouse is performing. Relative to other streams in the database, the L. Ouse had the highest invertebrate species richness. Species richness was also significantly elevated in the restored backwater habitat relative to the main channel. However, invertebrate density was low relative to other stream restorations highlighting the potential for future habitat restoration.

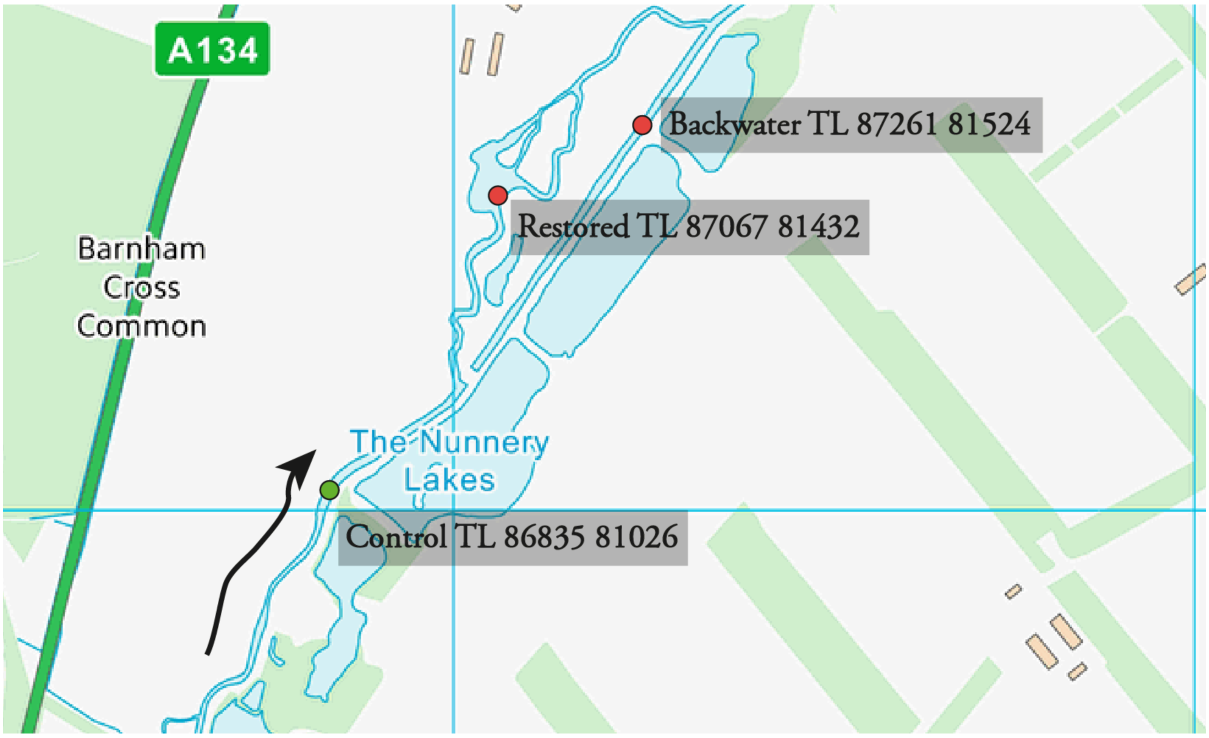

Figure 1. The Little Ouse monitoring design uses a control, restored and backwater site (arrow = water flow). Contains OS data © Crown copyright [and database right] (2016)

2. Methods

Sampling took place on 24/02/16. Substrate proportions (i.e. %silt relative to other substrate), coarse (<10cm) and large (>10cm) wood and plant percentage volume infested (PVI) were estimated at each invertebrate survey point (Figure 2).

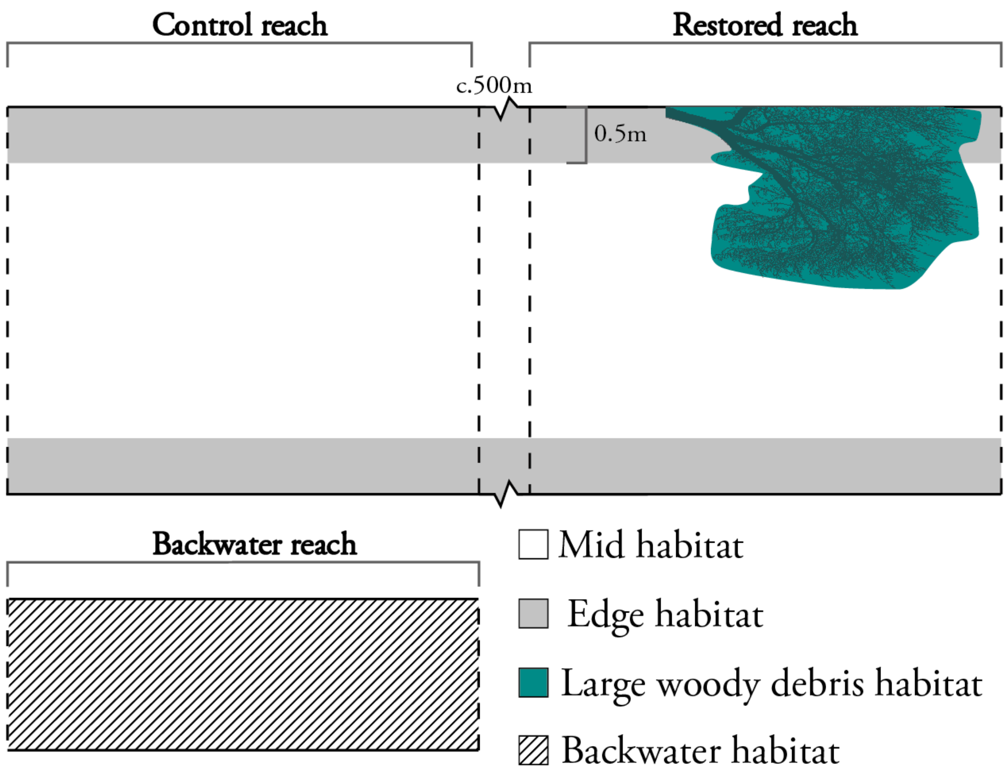

Figure 2. Plan view of the sampling design. Habitat measures were recorded and invertebrate samples taken randomly from the three habitats (where present) across three reaches before and after restoration.

2.1. Biotic characterisation

A bespoke 152.4mm diameter Hess sampler with 335 microns mesh was used to collect invertebrates. Unlike a kick net survey, Hess samples are quantitative meaning population densities can be estimated. A row of teeth at the base of the Hess and robust handles enabled it to cut through branches when used within woody structures. Samples were immersed immediately in 70% IMS to preserve contents for identification in the laboratory. Invertebrates were identified to species in most cases using a dissecting microscope with 40-100x magnification and counted to give the density per sample.

2.2. Statistical methods

In order to place the results form the L. Ouse in context we compare results with those collected from eight other chalk streams. We then focus on whether the restored stretch and backwater differ from one another, an upstream unrestored control site. We also assess local within-site differences between woody debris habitat, adjacent mid and edge habitat and backwater habitat (see Fig. 2). This combination of analyses provides key information on across and within site variation in invertebrate measures caused by changes in habitat.

We use principal components analysis (PCA) and non-metric multidimensional scaling (NMDS) with the Bray–Curtis dissimilarity index to assess differences in environmental parameters and invertebrate composition, respectively. Estimates of species richness were made using recently developed methodology published as the R package iNEXT [1]. This approach provides information on the sampling efficiency (i.e. estimates what percentage of the community we are capturing) and provides a robust means of comparing samples where different sample sizes occur. “Reach” and “habitat” were fixed terms and “sample” was a random term in general linear mixed effects models (GLMM) in assessments of differences in invertebrate density. In comparisons of habitats across streams “habitat” was a fixed term and “stream” and “sample” were random terms in GLMM.

3. Monitoring Results

In total we made 18 habitat recordings and processed 18 corresponding invertebrate samples. Samples contained a total of 2735 individuals and 63 unique taxa (e.g. Fig 3). Sampling efficiency was high with an estimated 86%, 95% and 96% coverage of invertebrate species in the backwater, control and restored reaches, respectively. Oligochaetes, *Pisidium*, *Hydracarina* and Chironomids* were not identified to species and so were removed from analyses of species richness.

Figure 3. Larvae of *Nemoura avicularis* (left) and *Ephemera vulgata* (right). Both are notable in that they are indicators of good water quality and, although widespread, are relatively rare (see records at https://data.nbn.org.uk/Taxa/NBNSYS0000022419; https://data.nbn.org.uk/Taxa/NBNSYS0000010899).

PCA of environmental data revealed that differences between restored, control and backwater reach habitat were not significant, nor were invertebrate communities different between these reaches (Figs. 4a, b). However, there were significant differences between habitat-types and invertebrate communities within these habitats (Figs. 4c, d).

* although we have provided informal identifications of Chironomid taxa, i.e. the morphotypes defined in Table 1 would need to be mounted and cross-checked using high power microscopy which was not included in the project remit.

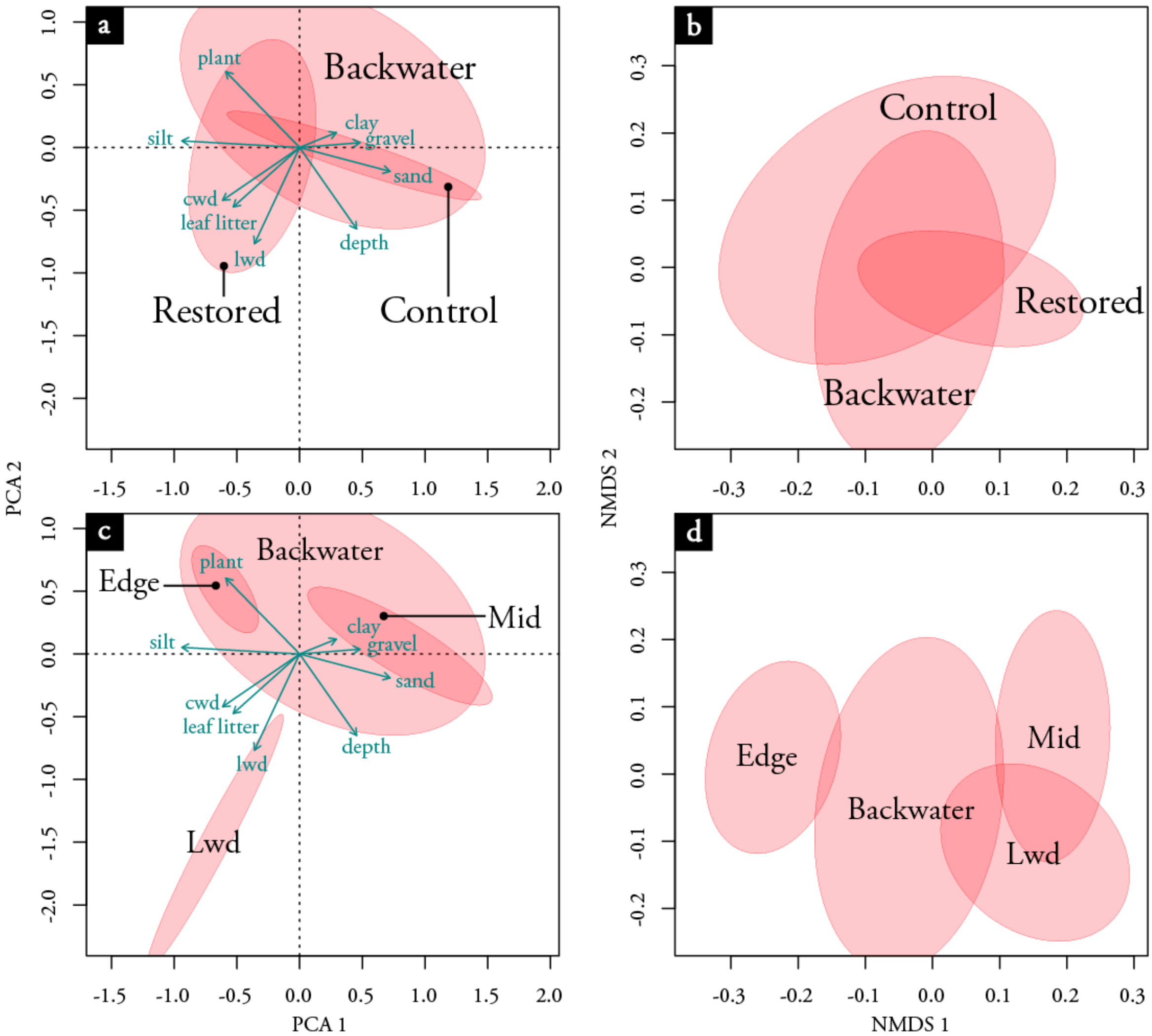

Fig. 4. Multivariate analyses of environmental and invertebrate composition data: (a) environmental differences between reaches (lwd = large woody debris volume, cwd = coarse woody debris volume); (b) invertebrate community composition between reaches; (c) environmental differences between habitats; (d) invertebrate community composition between habitats.

Ellipses in Fig. 4 represent standard error: a) there were no statistical differences between reaches; b) and there were no significant differences between invertebrate communities; c) there were significant differences between habitat-types caused primarily by increasing silt and woody debris in the edge and large woody debris habitat, respectively; (d) invertebrate community composition was also different between habitats.

Invertebrate species richness was significantly higher in the L. Ouse when compared to other chalk streams (Fig. 5a). A meta-analysis revealed that invertebrate richness was usually highest in Edge relative to Lwd and Mid habitat. However, invertebrate species richness was highest in the Backwater of the L. Ouse – a habitat we have not regularly sampled so cannot compare across rivers - when compared to other habitats and reaches.

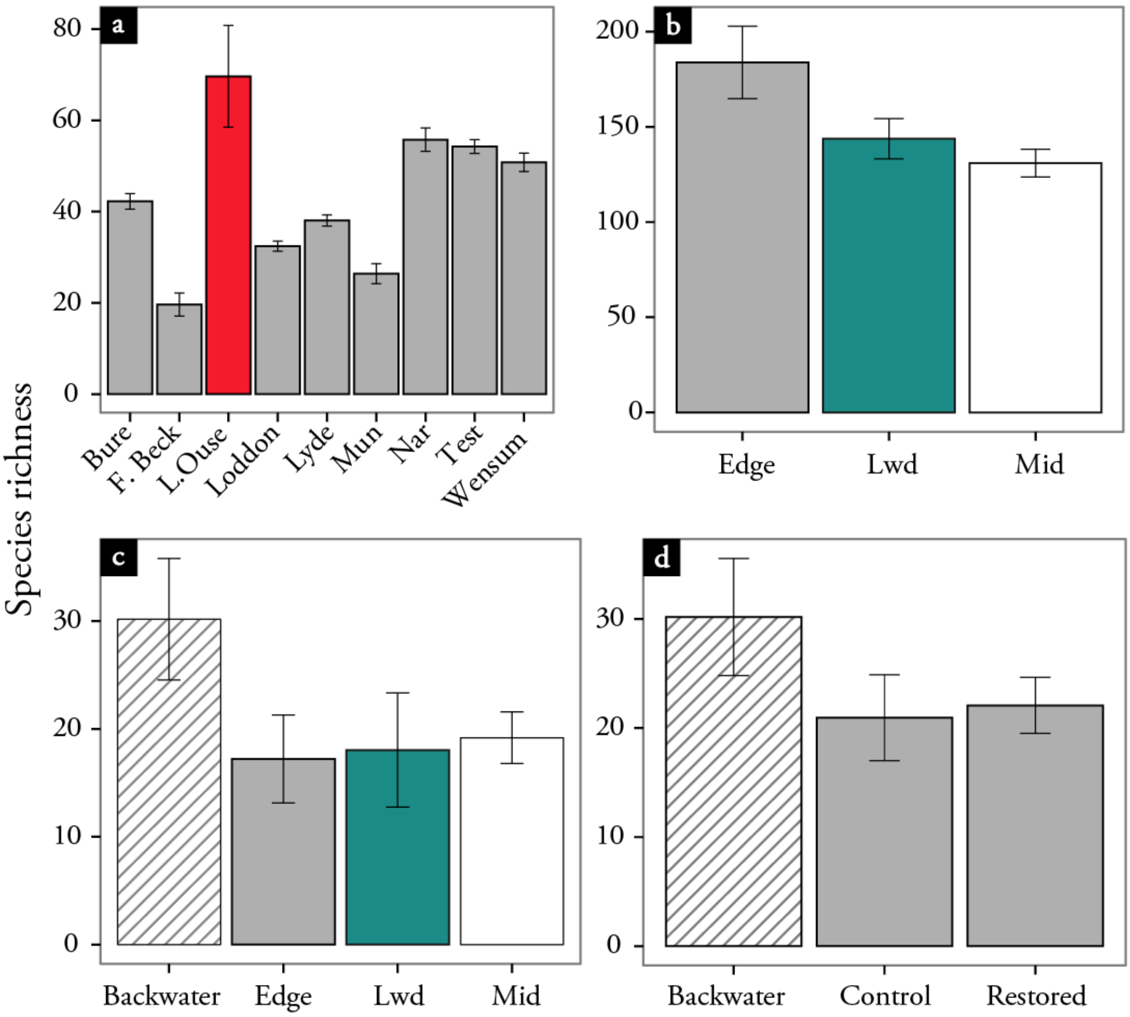

Figure 5. Invertebrate species richness data were combined across restorations to demonstrate the relative effectiveness of the L. Ouse project using rarefaction and extrapolation[1], error bars represent 95% confidence intervals

The data presented in Figure 5 show: a) significantly elevated species richness within the L. Ouse relative to other chalk streams; b) data combined across streams reveals that Edge habitat typically has the highest species richness; c) however, in the L. Ouse Backwater habitat had the highest species richness relative to other habitats; d) species richness was also highest in the Backwater relative to other reaches and comparable between the restored and control reaches. We have not collected backwater data from other streams so cannot provide a comparison across projects in this instance.

The data presented in Fig. 6 show that: a) relative to other chalk stream restorations, the restored reach on the L. Ouse had the lowest density of invertebrates per sample; b) when data were combined across streams Lwd habitat had the highest density of invertebrates; c) however, invertebrate density in the L. Ouse was not different between Mid, Backwater and Lwd habitat, but rather lowest in Edge compared to Mid and Backwater habitat; d) neither the restored reach nor the backwater had elevated invertebrate densities relative to the control reach.

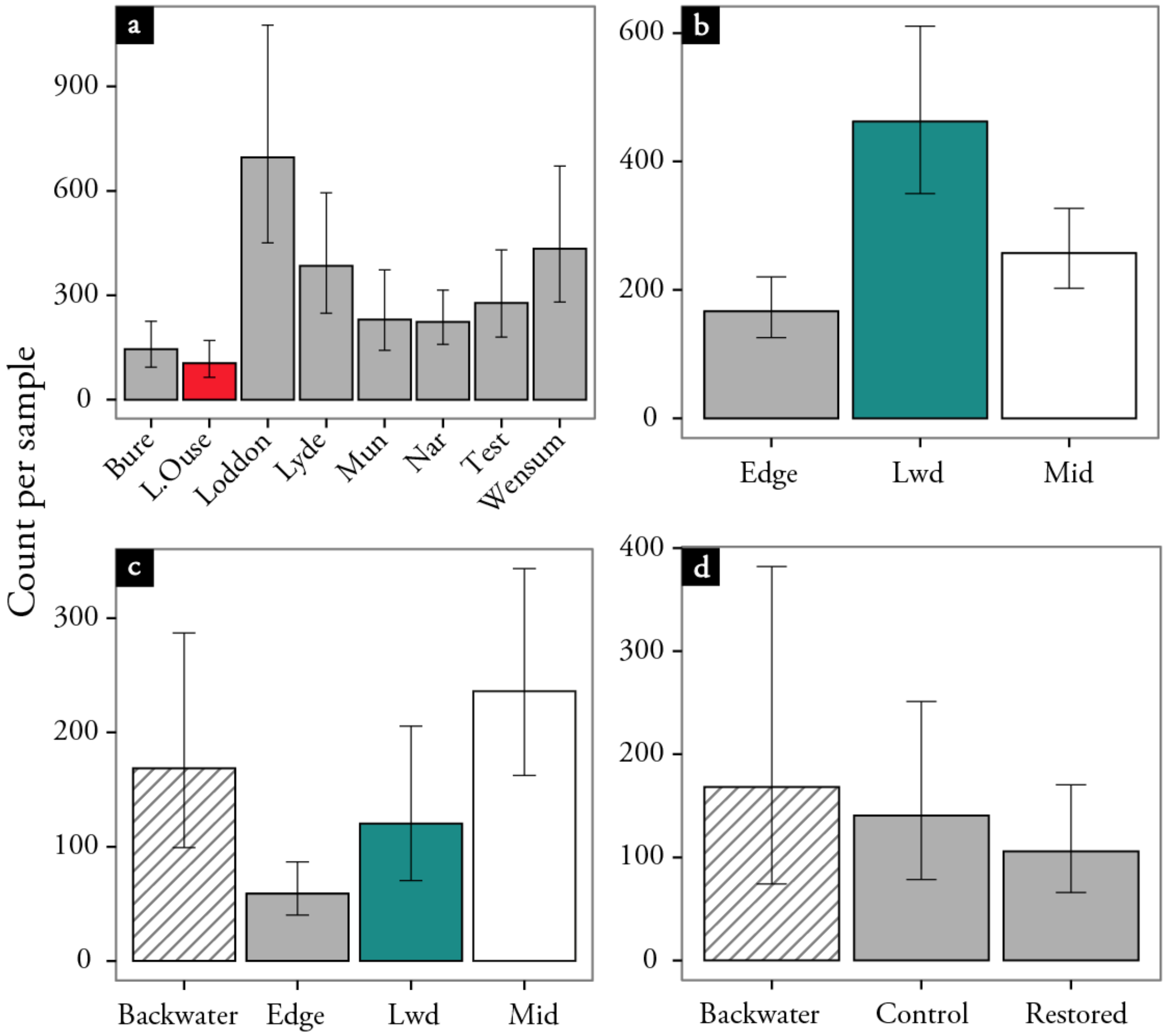

Figure 6 Results from general linear mixed effects models, error bars represent 95% confidence intervals:

4. Comments and Recommendations

Changes to the invertebrate community across the L. Ouse site clearly demonstrate the importance of the restored backwater habitat at supporting elevated numbers of species (Figs. 5c, d). This provides clear evidence of the effectiveness of the conservation work undertaken by the British Trust for Ornithology which could be used to support any future restoration funding applications. Invertebrate density was low compared to other streams and did not increase in Lwd likely due to the small size of the woody structures and the high proportion of silt across all habitats, particularly in the restored reach (Fig 4a). This highlights the potential for future habitat restoration - we recommend that any future restoration aim to increase the area of backwater habitat and narrow the main channel with more substantial woody debris structures in order to increase scour in mid-stream and redistribute silt. This would increase the range of in-stream habitats, provide additional Lwd habitat for invertebrates, and thus likely increase their population densities, as has been shown across other sites (Fig 6b). If future restorations are planned we would be keen to assist with their design and implementation, and monitor them in order to continue developing the evidence base for effective ecological restoration.

5. References

1. Chao, A. *et al.* Rarefaction and extrapolation with Hill numbers: a framework for sampling and estimation in species diversity studies. *Ecological Monographs* **84,** 45–67 (2014).

6. Supplementary information

Table 1 Species list and total count per reach (Con = Control, Back = Backwater, Res = Restored). *indicates Chironomid taxa which would require identification using high power microscopy to formally verify.

Taxa	Con	Back	Res
Acroloxus lacustris	4		
Agapetus fuscipes	3		
Anabolia nervosa	16		4
Ancylus fluviatilis	1		
Asellus meridianus		1	
Bathyomphalus contortus		2	
Bezzia solstitalis	39	38	104
Bithynia leachii		1	1
Brychius sp		1	
Caenis horaria		3	2
Caenis lactuosa	8	1	31
Calopteryx splendens	1		
Centroptilum luteolum	1		1
Ceraptopogonidae sp	1		1
Clinocera stagnalis	1	1	14
Diptera sp3	1		
Diptera sp4		1	
Diptera sp5		1	
Diptera sp6		4	
Elmis aenea	8		13
Elmis eanea			1
Ephemera vulgata	4		14
Erpobdella octoculata	1	1	
Galba trancatula			1
Gammarus pulex	18	11	18
Glossiphonia complanata		1	3
Gyraulus albus		1	

Taxa	Con	Back	Res
Halesus radiatus	3		2
Helius sp	1		
Hemerodromias sp		1	
Hydracarina	29		17
Hydroptila sp	7	2	9
Lepidostoma hirtum	3		1
Limnephilus lunatus	31	7	11
Limnephilus marmoratus		1	
Limnius volchmari	2		1
Muscidae sp		3	
Mystacides longicornis	3		4
Nemoura avicularis	1		4
Oligochaeta	94	43	124
Orectochilus villosus			1
Oulimnius sp	4		9
Pisidium	120	41	64
Polycelis tenuis		2	
Polycentropus flavomaculatus			2
Potamopyrgus antipodarum	62		10
Psychoda cinerea			1
Psychodidae sp2			2
Psychodidae sp1		2	
Psychodidae sp3		1	
Radix baltica	1	3	
Serratella ignita			2
Serricostoma personatum			1
Sialis lutaria			1
Simulium angustipes		3	
Simulium aureum		1	
Simulium lundstromi		1	
Simulium ornatum		3	
Theromyzon tessulatum			1
Valvata cristata	1		
Valvata piscinalis	1	2	4
Apsectrotanypus	1	1	8
*Brillia longifurca**			3
*Brillia modesta**			1
*Cricotopus (bicinctus)**		1	3
*Corynoneura**		3	15
*Cryptochironomus**	2		2
Eukiefferiella (*Tvetenia*)*	2	1	
*Microtendipes pedellus**	1	1	63
*Nanocladius rectinervis**		1	1

Taxa	Con	Back	Res
*Polypedillum**			1
*Prodiamesa olivacea**	4	1	36
*Pseudorthocladius**		1	
*Synorthocladius semivirens**		1	
*Tanytarsini**	5	11	108
*Thienemanniella**	1	12	9
(*Macropelopia*?)*	2	6	14
(*Parametriocnemus stylatus*?)*			1
(*Thienemannimyia*?)*	1	10	12
x.Baetis indet			1
x.Chironomid indet	626	300	287
x.Gastropod indet		2	
x.Hydroptilidae indet	12		9
x.indet			2
x.Plecoptera indet	2		1
x.Simulium indet		2	
x.Springtail			2
x.Tanypod indet	5	1	3
x.Trichoptera indet	2		1

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