VIKING WIND FARM:

FRESHWATER INVERTEBRATES

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Aquaterra Ecology

   

Aquaterra Ecology Crombie Cottage, Aberchirder, Huntly, Aberdeenshire AB54 7QU

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Viking Wind Farm, Shetland: Freshwater Invertebrate Surveys 2008

1 Summary

1.1 Background

The Viking Energy Partnership (VEP: a partnership between Scottish & Southern Energy (SSE) and Viking Energy Limited) is developing a proposal for a 554MW, 154 turbine wind farm on Mainland, Shetland. The planning application will be accompanied by an Environmental Statement (ES) and this report provides information for the ES on the freshwater invertebrates in catchments within the proposed development area.

Macroinvertebrate communities were sampled using standard kick sampling methods (SEPA 2001) from thirty sites in eleven catchments (Figure 1). Sampling took place in the period 23rd – 28th August 2008 mainly in conditions of low flow. Samples were identified to family level and indices of water quality (BMWP, ASPT scores) were produced.

At each site three Surber samples were taken to provide quantitative measures of invertebrate abundance and biomass. Major groups were identified to species level to identify presence of rare species and to provide data for production of biological indices: Water Chemistry Status and Index of Acidity.

Environmental variables including bed width, depth, flow and substrate profile were recorded at each site and GPS generated grid references and photographs taken to enable future site identification.

1.2 Main findings

- Invertebrate communities largely consisted of species common and widespread in Scottish watercourses and no rarities were identified.
- The relative proportions of invertebrate groups indicated moderately clean and well-oxygenated conditions with no significant organic enrichment.
- Diversity was low in all watercourses, probably as a result of Shetland's isolation. Abundance and biomass were low to moderate.
- ASPT scores indicated that 22 sites had good (A2) water quality and 8 sites had fair (B) water quality.
- Water Chemistry Status Scores indicated that 18 sites were slightly acidic, 11 circum-neutral and one possibly significantly acidic.
- Overall the water quality, invertebrate communities and productivity should support sustainable salmonid populations if other environmental factors are suitable.

2 Introduction

2.1 Bio-monitoring

Many aquatic invertebrates have specific habitat requirements, including a limited range of water chemistry, and these species can be used as biological indicators to both broadly assess the general quality of freshwater burns and rivers, and to assess more specific chemical status, for example acidity. The production of biotic indices to assess water quality is an established method using the BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scoring system. These scores were primarily developed for identifying organic pollution, but they are widely used as indicators of general stream health.

Biotic indices can be used to overcome the difficulties associated with direct monitoring of pH, which tends to fluctuate markedly in acidic streams. Macroinvertebrates integrate recent (weeks to months) pH conditions at a site (Davy-Bowker *et al* 2005) and are therefore well suited for bio-monitoring where the sampling frequency is constrained. In general the relationship between the tolerance of most acid-sensitive invertebrates and that of salmonid fish is fairly close, although trout can survive slightly more acid conditions than some of the invertebrate indicators (Patterson and Morrison 1993).

Assessment of macroinvertebrates can therefore both augment the interpretation of chemical analysis of water quality and monitor the biological consequences of changes in water chemistry.

Quantitative assessments of macroinvertebrates will also provide accurate characterisations of the community, and a measure of biodiversity and productivity of the watercourse. Total invertebrate biomass will be used as an indication of total productivity of invertebrate fauna, potentially important in sustaining salmonid populations.

2.2 Objectives

The freshwater invertebrate survey of the Shetland watercourses provides:

i) A description of the macroinvertebrate community including species level identification in most major groups (Malacostraca, Ephemeroptera, Trichoptera, Plecoptera, Mollusca [excepting Sphaeriidae], Odonata and adult Coleoptera)

ii) BMWP and ASPT scores as an assessment of water quality (SEPA 2001)

iii) Indices of acidity: Water Chemistry Status (Patterson & Morrison 1993) and Index of Acidity (Clyde River Purification Board 1995)

iv) Quantitative sampling to assess invertebrate abundance and to provide a measure of biodiversity and productivity

v) A description of the environmental variables at each monitoring site including depth, width, flow, substrate profile, estimates of in-stream vegetation and canopy cover.

3 Methods

3.1 Field sampling

Kick

Sampling was based on standard kick sampling methodologies employed by Scottish Environment Protection Agency (SEPA). A 25cm wide kick sample net with a 1mm mesh was used at all sites. Kick sampling at all sites was conducted in riffle-type habitat.

The sampling procedure involved a total of 3 minutes of kick sampling at each site. Sampling covered the whole width of the stream. The net was held vertically, downstream from the sampler's feet and resting on the river bed. The sampler disturbed the river bed vigorously with the heels, by kicking or rotating, to dislodge the substrate to a depth of about 10cm. Dislodged invertebrates were washed into the sampling net.

A further 1 minute period of hand sampling was carried out at all sites, searching on and under stones and rocks for attached invertebrates such as molluscs and cased caddis.

Samples from kicking and hand collecting were preserved together in 70% Industrial Methylated Spirits (IMS) in sealed plastic containers.

Surber

Surber samples were taken to quantitatively assess invertebrate abundance. A standard Surber sampler with an area of approximately 0.1m² and a 500µm mesh net was placed in a suitable riffle-type habitat, on hard substrates with a depth of 5-20cm. The leading edge of the net of the sampler was made level with the substrate, to prevent loss of invertebrates, after which the entire sampler frame was established in the substrate. If stones restricted placement of the sampler they were moved and included in the sample if >50% of the stone was in the sample area.

Sampling involved the removal of any invertebrates from surface stones followed by agitation of the substrate, the disturbed invertebrates being swept by the current into the net. Plants present were either picked over and washed or included in the sample for laboratory invertebrate searching. The sampling procedure ceased when all substrates within the sampler frame had been thoroughly washed into the net. Surber sampling was conducted at riffle areas. Invertebrate distribution can be very patchy at all scales and therefore three samples were taken at each site.

3.2 Sites

Eleven catchments with potential for impacts from proposed development activities were identified. These were selected primarily where new road or track crossings would be constructed over watercourses within the catchment.

Sample sites were selected with riffle habitat wherever possible. Riffles are one of the most productive habitats in rivers and streams and are the standard habitat for water quality bio-monitoring (SEPA 2001). Sites were mainly chosen in downstream parts of the catchment to both provide suitable habitat unavailable in small upstream channels and to reduce the number of sample sites required. Sampling at these points would therefore in many cases monitor the cumulative effects of multiple crossings in the catchment.

Sites were coded in a downstream direction (Table 1) and accurately recorded using photographs and ten figure GPS grid references (Garmin etrex, accuracy of <15 metres RMS). Physical environmental factors including stream width, depth, flow and substrate profiles (using Wentworth scale) were recorded for both the kick habitat and the sample area within the Surber samplers (Tables 3 & 4). Water temperature and pH were recorded with a portable meter Hannah HI 98129, resolution 0.1ºC and 0.01 pH, accuracy ± 0.5ºC and ± 0.1 pH. Data was recorded on standard fieldsheets (Appendix 7).

3.3 Invertebrate identification

Invertebrates were examined using a Wild binocular microscope at 6-50X magnification and a Brunel compound microscope at 100X. Identification used standard keys (Brooks & Lewington 1999, Edington & Hildrew 1995, Elliot, Humpesch & Macan 1988, Elliot, & Mann 1979, Friday 1988, Hynes 1977, Killeen *et al* 2004, Macan 1959, Macan 1977, Nilsson 1996, 1997, Reynoldson & Young 2000, Timm & Veldhuijzen van Zanten 2002 and Wallace, Wallace & Philipson 1990).

Specimens from kick samples were identified to the appropriate taxonomic level to provide a biological assessment of water quality using BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scores. Specimens from Surber samples were identified to species level in major groups and the total abundance was recorded.

3.4 BMWP and ASPT Indices

These scores were primarily developed for identifying organic pollution, but they are widely used as indicators of general stream health.

Biological Monitoring Working Party (BMWP) scores were calculated for each invertebrate sample from each site. The scoring system is based on the pollution sensitivity of each invertebrate family. The scale is 1-10 and a score of 1 is allocated to the most pollution tolerant families and 10 to the most pollution sensitive (Appendix 1). The BMWP score is the sum of the group scores for the sample. The ASPT (Average Score Per Taxon) score is the average score for each group present in the sample.

Low BMWP or ASPT scores indicate possible pollution, high scores indicate good water quality. A simplified version of the Scottish River Classification Scheme (1997) used by SEPA is set out below.

The physical nature of the watercourse and the sampling effort of different individual samplers can influence the BMWP score. ASPT is viewed as a more stable and reliable index of pollution.

The number of scoring taxa is also an indicator of water status. A fall in the number of taxa is a general index of ecological damage, including overall pollution encompassing organic, toxic and physical pollution such as siltation, and damage to the habitats or the river channel, (General Quality Assessment of Rivers, Environment Agency website).

Simplified Scottish River Classification Scheme as used by SEPA.

Class	Description	BMWP	ASPT	Comments
A1	Excellent	≥85	≥6.0	Sustainable* salmonid population
A2	Good	70-84	5.0-5.9	Sustainable* salmonid population
B	Fair	50-69	4.2-4.9	Salmonids may be present
C	Poor	15-49	3.0-4.1	Fish may be present
D	Seriously Polluted	<15	<3.0	Fish absent or seriously restricted

* If other environmental variables are suitable

3.5 *Water Chemistry Status*

Patterson and Morrison (1993) developed a Definition of Classes for water chemistry status based on the presence of invertebrate indicator groups. Two indicator groups are used: Group 1 taxa with a normal minimum pH of 6.0 and Group 2 with a normal minimum pH of 5.5 (Appendix 2). Three classes were defined:

Class	**Description**	**Comment**
Class 1	Circumneutral	Group 1 taxa present. The water chemistry is suitable for the great majority of plants and animals. Alkalinity should be sufficient to buffer against most acid spate waters and the mean pH is ≥6.0 and unlikely to drop below 5.6. Salmonid fish are not stressed by the water chemistry.
Class 2	Not significantly acidified	Group 1 absent, group 2 present. The water chemistry is suitable for all except the most sensitive taxa. The mean pH is likely to be 5.6 or above. Where heavy metal and aluminium levels are low and/or organic content is high mean pH could be as low as 5.3. The water chemistry is likely to be suitable for salmonid fish but such streams may be vulnerable to future acidification.
Class 3	May be acidified	Groups 1 and 2 absent. Water chemistry may be acid to the point where wildlife is significantly affected including reduction of invertebrate diversity and reduction of salmonid fish populations, especially salmon. Further survey and chemical analysis is recommended to improve the diagnosis.

3.6 *Index of Acidity*

An Index of Acidity Classes was developed by the Clyde River Purification Board as an indication of the probability and likely magnitude of acidification of freshwaters (Clyde River Purification Board 1995). Although developed for streams in Ayrshire and Argyll, the system has been applied by SEPA for more northern rivers and has shown good correspondence with juvenile salmon densities (Ian Milne, SEPA Dingwall, pers. comm.). As with the index of Water Chemistry Status, this index is based on the presence or absence of taxa with varying degrees of acid sensitivity from two lists, A and B (Appendix 2.). For samples collected between May and October the definitions used are:

Class	**Description**	**Comment**
Class I	Non-acid or slightly acid	At least three taxa from both Lists A and B present. Salmonid populations probably undamaged.

Class II	Intermediate	One or two List A taxa present or if List A taxa absent more than two List B taxa are present. Salmonid populations may show some signs of acid damage, for example reduced densities and missing or weak age classes.
Class III	Acid	List A absent and two or fewer List B taxa present. Trout populations reduced or absent and probably unable to sustain juvenile salmon.

3.7 Biomass

Invertebrate samples were dried in glass vials at a constant temperature of 60ºC for 48 hours in a Binder drying oven. The dried sample was then weighed on an Ohaus Explorer Pro analytical balance (readability 0.1mg) to produce a biomass gm/m² (dry weight) (Table 2).

4 Results and Discussion

4.1 Sites: Environmental Factors

The grid references and sampling dates for sites are found in Table 1. Environmental factors recorded at kick sample sites, and within the Surber samplers are recorded in Tables 3 and 4.

Overview

The proposed development area is largely sited on metamorphic Dalradian rocks with bands of limestone running in an approximately north to south direction. Erosion of these limestone bands has produced Petta Dale and the Valley of Kergord. The Burn of Pettawater flows through Petta Dale and the Wester Filla Burn is located at the northern end of the valley. Both the Burn of Weisdale and the Burn of Kirkhouse flow through the Valley of Kergord. Rocks are usually overlaid with peat through which the water permeates. These solid and drift geologies are important in determining the characteristics of the stream chemistries. Land use in the area is mainly sheep grazing and the intensification of this with the associated use of fertilisers and the possible erosion from high stocking densities have been identified as two areas of concern for water quality (Hardy 2004).

The watercourses surveyed were small to medium burns varying in bed width from 0.9 metres (North Burn NB1) to 8.5 metres (Laxo Burn LB2), with a mean width of 3.4 metres. Depth in the centre of the channel at sample sites was less than 30cm varying from 2cm in the Burn of Flamister to 30cm in the Seggie Burn (mean 10.8cm).

Substrate

At 28 sites the main component of stream substrate was cobbles (40%-70%, mean 59%). The exceptions were the two Burn of Pettawater sites where pebbles were the main component (mean 60%). Silt was only recorded at two sites, North Burn NB1 and the upstream site of Burn of Crookadale BC1. Most substrates appeared to be stable.

Macrophytes and Canopy Cover

A characteristic feature of the watercourses was the lack of canopy cover at all sites. The absence of riparian woodland allows light into the burns promoting growth of macrophytic in-stream vegetation where other factors are suitable. Macrophyte cover varied from 2% in the Burn of Flamister and Burn of Lunklet to 65% in the Burn of Weisdale BW2 (mean 26%).

The main constituent of the macrophyte cover was either vascular plants, bryophytes or algae. Vascular plants were prominent at Laxo Burn LB1 with 30% cover of *Juncus sp*. and *Potamogeton sp*. and Burn of Pettawater with 60% cover of *Myriophylum alterniflorum*, *Iris pseudocarus* and *Caltha palustris.* The open structure of Myriophylum can provide good attachment points for invertebrates including the pupal stages of Simulidae.

The most widespread and abundant bryophyte was *Fontinalis antipyretica*, with smaller amounts of *Platyhypnidium riparioides* and *Scapania undulata*. *Fontinalis* had 40% coverage at North Burn and 50% coverage at Burn of Pettawater PW2. Mosses provide a microhabitat within the riffle and have a proportionately different invertebrate community to uncovered areas (Egglishaw 1969). Englund (1991) found that overturning moss covered stones to mimic spate events resulted in thirteen of sixteen invertebrate taxa present decreasing their density.

Significant algal cover was found at several sites, 50% at burn of Weisdale BW1 and BW2, 40% at Wester Filla Burn and Burn of Crookadale BC2, and 30% at Burn of Kirkhouse BK1 and BK2. The growth and subsequent decay of algae can be a significant organic input to the system.

The watercourses were open and bank-side vegetation consisted mainly of herbaceous vascular plants. The allochthonous (from outside the system, i.e. terrestrial) input of organic matter from bank-side vegetation is an important source of food for invertebrates and positive correlations between food abundance and benthic consumer densities are a common result of comparisons between streams (Richardson 1993). Input is the lowest for herbaceous habitats compared to trees or shrubs (Delong & Brusven 1994) but is still considered an important food resource (Menninger & Palmer 2007). In small watercourses, such as the majority of the Shetland burns allochthonous input is proportionately higher than large watercourses (Conners & Naiman 1984). This input of leaf litter provides the detritus that many invertebrates feed on and Egglishaw (1964) showed that plant detritus in a stream was a causal factor in determining the distribution of some invertebrates including *Baetis rhodani*, abundant in many of the Shetland burns.

4.2 Invertebrate Communities

The groups recorded from each kick sample are shown in Appendix 3. The numbers of invertebrate species present in the Surber samples are shown in Appendix 6.

Overview

One important characteristic of the burns was the low biodiversity of the invertebrate communities. The main reason for this in lotic waters is probably the isolation of Shetland (Hardy 2004). Low diversity was present in most groups, only one species of Ephemeroptera (mayflies) was present, two genera of Plecoptera (stoneflies) and seven species of Trichoptera (caddis flies). Many of the taxa associated with the fast flowing well-oxygenated water of riffles on the Scottish mainland were absent. These included the Plecoptera families Perlidae and Perlodidae, the Ephemeroptera family Heptageniidae and the riffle beetles Elmidae.

Interpretation of the invertebrate community data in Shetland has therefore to be viewed with some caution, in particular when used for the generation of biotic indices.

Relative Proportions of Invertebrate Groups

The proportional abundances of invertebrate groups in Surber samples (mean of three) are shown in Figure 2 (expressed as percentages of the total population).

The categories in Figure 2 represent the groups Ephemeroptera, Plecoptera, Trichoptera, Diptera and Other. Diptera contains the chironomids which are very tolerant of organic pollution or enrichment. The 'Other' Category contains a wide mixture of groups including Coleoptera (beetles), Mollusca, Oligochaeta (worms) and Hirudinea (leeches). They are mainly moderately tolerant of organic pollution.

Macroinvertebrate communities of flowing water typical of large areas of upland Britain are dominated by the aquatic stages of the insect orders Ephemeroptera, Plecoptera and Trichoptera (Ormerod *et al* 1993).

Stoneflies are generally found in fast flowing, clean, cold well oxygenated streams and an abundance of mayflies is generally a sign of reasonably healthy and productive water (FIN Abundance and Indicator Taxa, Environmental Change Network website).

The families Heptageniidae and Baetidae and species from these families are consistently used as acid sensitive indicators and are known to be vulnerable to both chronic and episodic acidification (Merret *et al* 1991, Ormerod *et al* 1993, Patterson & Morrison 1993 and Rutt *et al* 1990).

Ephemeroptera, Plecoptera and Trichoptera (EPT) combined were dominant (>50% total invertebrates) at half of the sites (LX1, LX2, SD1, SD2, WF1, GW1, EF1, BG1, BF2, BQ1, BC1, FL1, BB1, BB3, BL1) indicating well-oxygenated clean conditions. In most of these 15 sites the largest component of EPT was Plecoptera. Plecoptera was the largest component group overall at 12 sites and since some species of this order can tolerate a pH of 4.0 or less they are usually dominant in the fauna of acid streams (Patterson & Morrison 1993). The nymphs were mainly small early stage Leuctra and species level identification was not possible with confidence.

Diptera dominated one site on the Burn of Burrafirth (59%, BB2) and were a large proportion of the community at both Burn of Pettawater sites (49% & 47%), Burn of Quoys BQ2 (45%), Burn of Kirkhouse BK1 (44%) and Burn of Weisdale BW1(42%). The main component of the Dipteran community was Chironomids indicating some limited organic enrichment.

The Burn of Laxobigging LX1 site was atypical with the 'Other' category dominant (82%). This was a result of the presence of large numbers of the amphipod *Gammarus zaddachi*. However this can be attributed to the site being just below the normal tidal limit (NTL).

In general the invertebrate communities present were indicative of clean watercourses with good water quality and a small degree of organic enrichment.

<u>Invertebrate Abundance, Diversity and Biomass</u>
The number of taxa, total numbers of invertebrates and biomass of invertebrates present in Surber samples are shown in Table 2. Invertebrate abundance (per m^2) and biomass are also shown graphically in Figures 3 and 4.

The invertebrate abundance varied from 363 per m^2 in the Burn of Quoys BQ2 to 4347 per m^2 in the Wester Filla Burn (mean 1397 per m^2). This suggests a low to moderate abundance. The burns of Petta Dale and the Valley of Kergord all had abundances at the high end and this may be partly a result of buffering from underlying limestone.

The number of taxa per site at the level of identification used in this study varied from 7.3 (mean of three Surber samples) Burn of Quoys BQ2 to 21.7 Burn of Kirkhouse BK2. The mean of all Surber samples was 13.1. Direct comparison with other work is not possible as different levels of taxonomic identification are used in different studies but the invertebrate diversity appears low. This is supported by the low BMWP scores, see below.

Biomass is seasonally variable but it can give an indication of productivity of watercourses. The biomass at sites (mean of three Surber samples) varied from 0.047gm dry weight per m^2 at Burn of Quoys BQ2 to 1.558gm dry weight per m^2 at Burn of Kirkhouse BK2. The mean biomass was quite low at 0.456gm dry weight per m^2. At sites where biomass was highest the main components were either Lumbricid worms or caseless caddis, in particular *Rhyacophila dorsalis* and *Hydropsyche siltalai*. Larval caddis flies often represent the highest biomass of the macroinvertebrate communities of streams (Giller & Malmqvist 1998).

The diversity, abundance and biomass overall were sufficient to support sustainable salmonid populations.

4.3 *Biological Indices*

Biological Indices scores (BMWP, ASPT, Water Chemistry Status [Water Class] & Index of Acidity) are shown in Tables 1 and 2. Scoring taxa present in samples for BMWP, Water Chemistry Status and Index of Acidity are found respectively in Appendices 3-5.

<u>BMWP and ASPT scores</u>
BMWP scores indicated 12 sites with fair (B) water quality and 18 sites with poor (C) water quality. However sites of low invertebrate diversity produce low BMWP scores and in Shetland the scores may not truly reflect water quality. ASPT scores are more reliable and

they indicated 22 sites with good (A2) water quality and 8 with fair (B) water quality. The sites with fair water quality all had ASPT scores of 4.8 or 4.9 at the top end of the fair water quality band. SEPA have found the monitoring results of RIVPACS unreliable in Shetland because of low diversity (David Okill, pers comm.).

The ASPT scores showed mainly good water quality and it is probable that the scores are reduced by the low diversity present. It is therefore likely that the water quality will sustain salmonid fish populations.

<u>Water Chemistry Status</u>
Note that the scores recorded in Table 2 are generated from the combined invertebrates present in all three Surber samples at each site.

Eleven sites scored Class 1 (mean pH ≥ 6.0), 18 sites scored Class 2 (mean pH >5.6) and one site, Burn of Quoys BQ2, scored Class 3 suggesting the possibility of acidification. However the other Burn of Quoys site recorded Class 1.

These results showed that burns were not significantly acidified.

<u>Index of Acidity</u>
Note that the scores recorded in Table 2 are generated from the combined invertebrates present in all three Surber samples at each site.

Acidity Index scores were Class II at 12 sites showing intermediate conditions and Class III at 18 sites indicating acid conditions. Unlike the Water Chemistry scores the Index of Acidity indices are generated by the presence/absence of a wide range of species. If diversity is reduced by factors other than acidification then this scoring system may be unreliable.

Morris (1987) found there was little evidence of acidification of Shetland streams and the water chemistry results and pH records of this survey support this.

<u>pH</u>
The pH records are shown in Table 3.

The pH records varied from 6.35 in the Gossawater Burn to 8.01 in the Burn of Weisdale. The mean pH for all sites was 7.50. The only two sites recording <pH 7.0 were both sampled on the one day when water levels were significantly elevated from recent rainfall.

4.4 Survey Limitations

This survey was conducted in the autumn only. Because of the variation in phenology of freshwater benthic invertebrates it is recommended to sample twice in the year, both spring and autumn, and systems like RIVPACS are based on this. BMWP scores may therefore be lower than if two sampling periods were used.

The survey was based on a single habitat and comments on diversity, abundance and biomass reflect the species present in this habitat. However this habitat is used for the collection of invertebrate samples for water quality and is a much studied habitat in lotic waters. Invertebrates may also occupy different habitats at times of the year, for example *Ecdyonurus* spp. were found in greater concentrations in pools than riffles in April but the reverse was so in September (Egglishaw & Mackay 1967).

5 Conclusion

5.1 Current status

The invertebrate communities present in the watercourses consisted mainly of common and widespread species and no rarities were found. Diversity was low probably as a result of Shetland's isolation. In general communities were typical of those found in moderately clean and well-oxygenated water. The relative proportions of invertebrate groups indicated no significant organic enrichment. Where enrichment was indicated it is likely to be the result of natural allochthonous inputs. Abundance and biomass of invertebrates appeared to be low to moderate in all watercourses.

ASPT scores indicated that the water quality of the watercourses was fair or good. Water Chemistry Status Scores indicated that the watercourses were either slightly acidic or circum-neutral

Overall the water quality, invertebrate communities and productivity should support sustainable salmonid populations if other environmental factors are suitable.

5.2 Monitoring

The study has produced adequate baseline data to inform the design of any future monitoring programme. If the current design proposal is accepted then a minimum of three control burns will be selected for monitoring, one in each area of Delting, Nesting and Kergord. Most sites produced sufficient abundance and diversity of invertebrates for monitoring changes from impacts. The low diversity of species in Shetland burns may have contributed to lower water quality scores but as the principal purpose of monitoring is to detect change this will not invalidate monitoring results. The Index of Acidity should not be used in future monitoring however. pH values were only ascertained for low flows in most cases and if data is not available pH should be recorded for spate flows also.

The minimum monitoring programme recommended is a pre-construction year baseline followed by post construction monitoring immediately after completion of works and again three years later.

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Figure 1 *Invertebrate Sampling Sites: Delting*

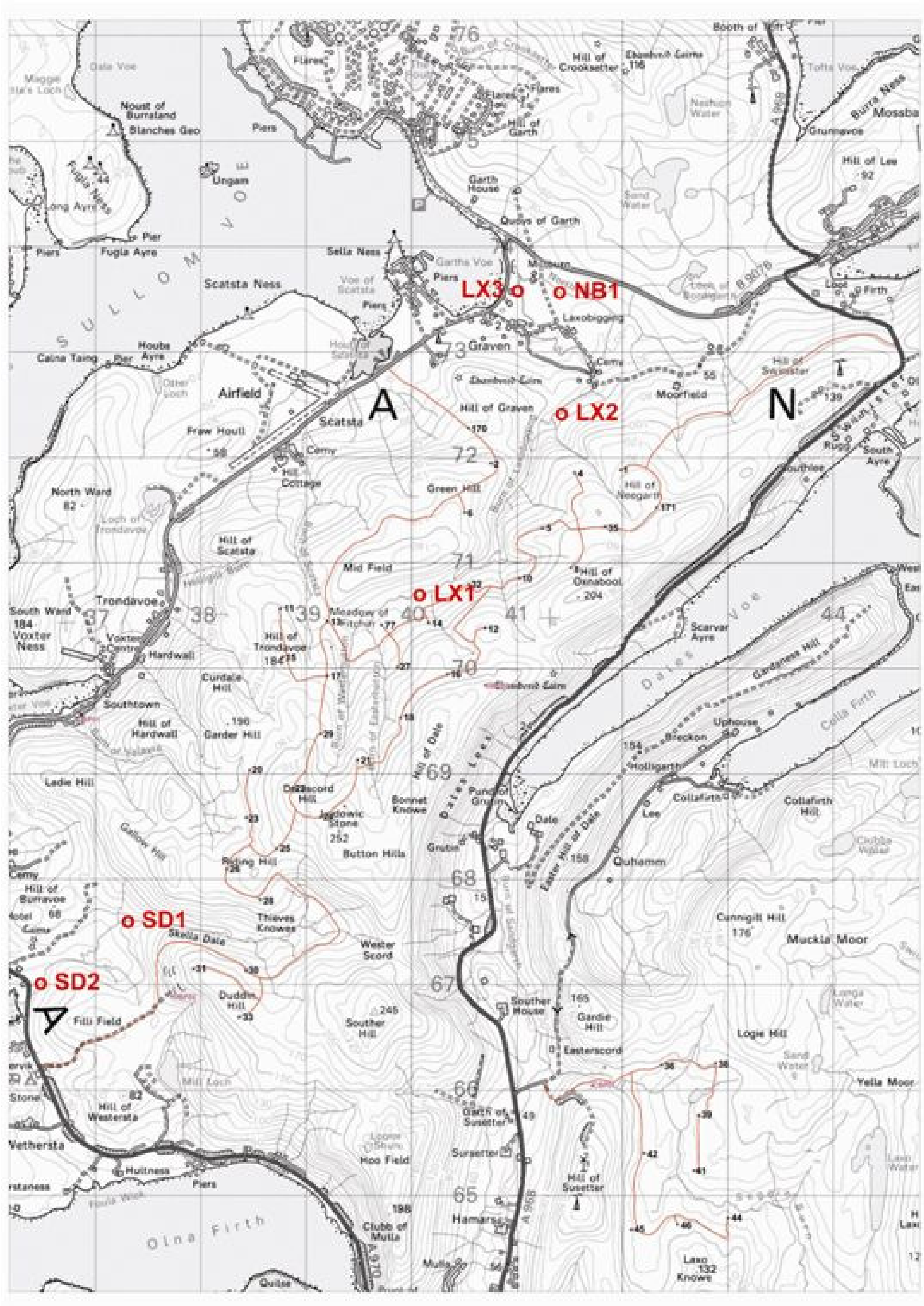

Figure 1 contd. *Invertebrate Sampling Sites: Nesting*

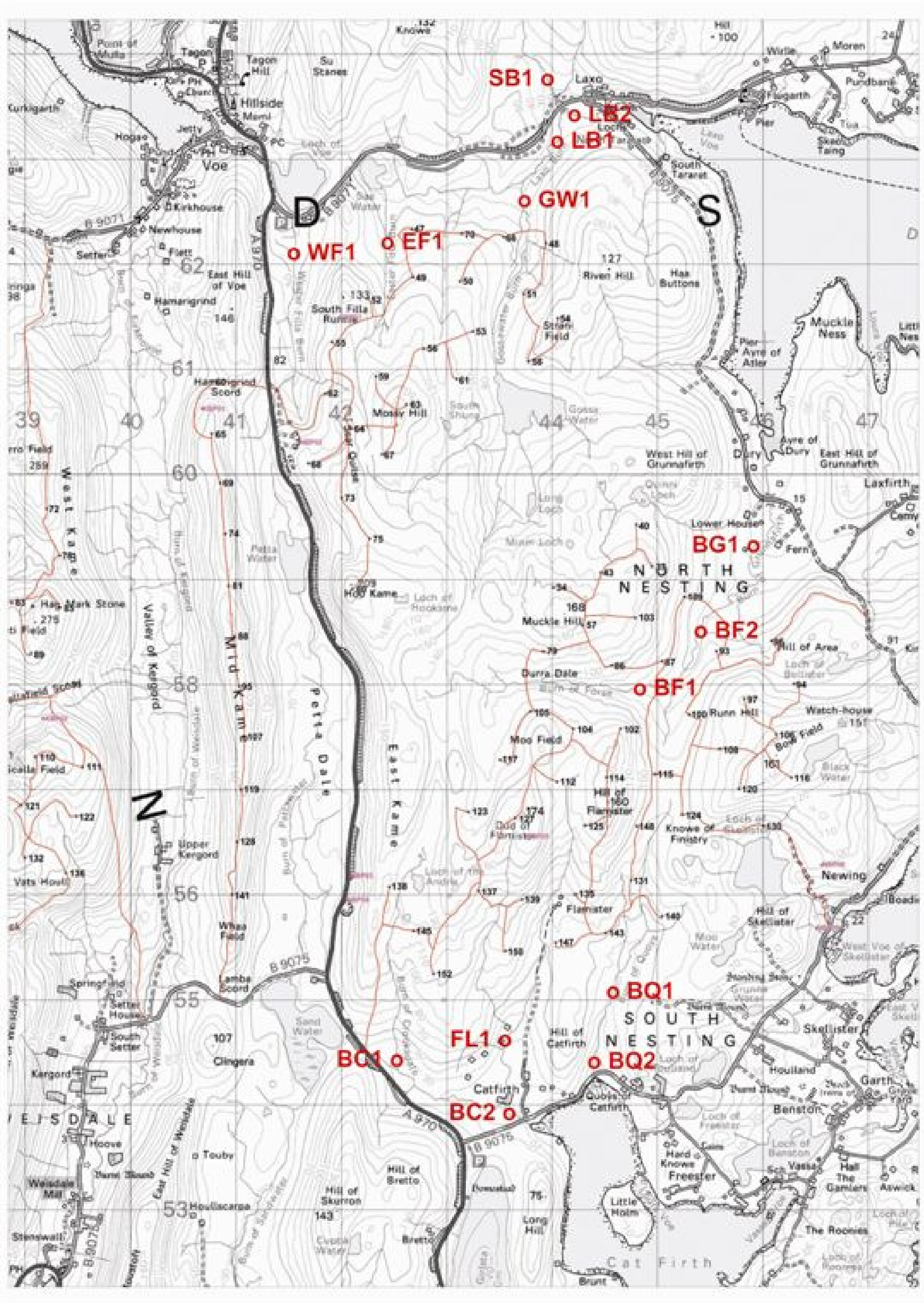

Figure 1 contd. *Invertebrate Sampling Sites: Nesting*

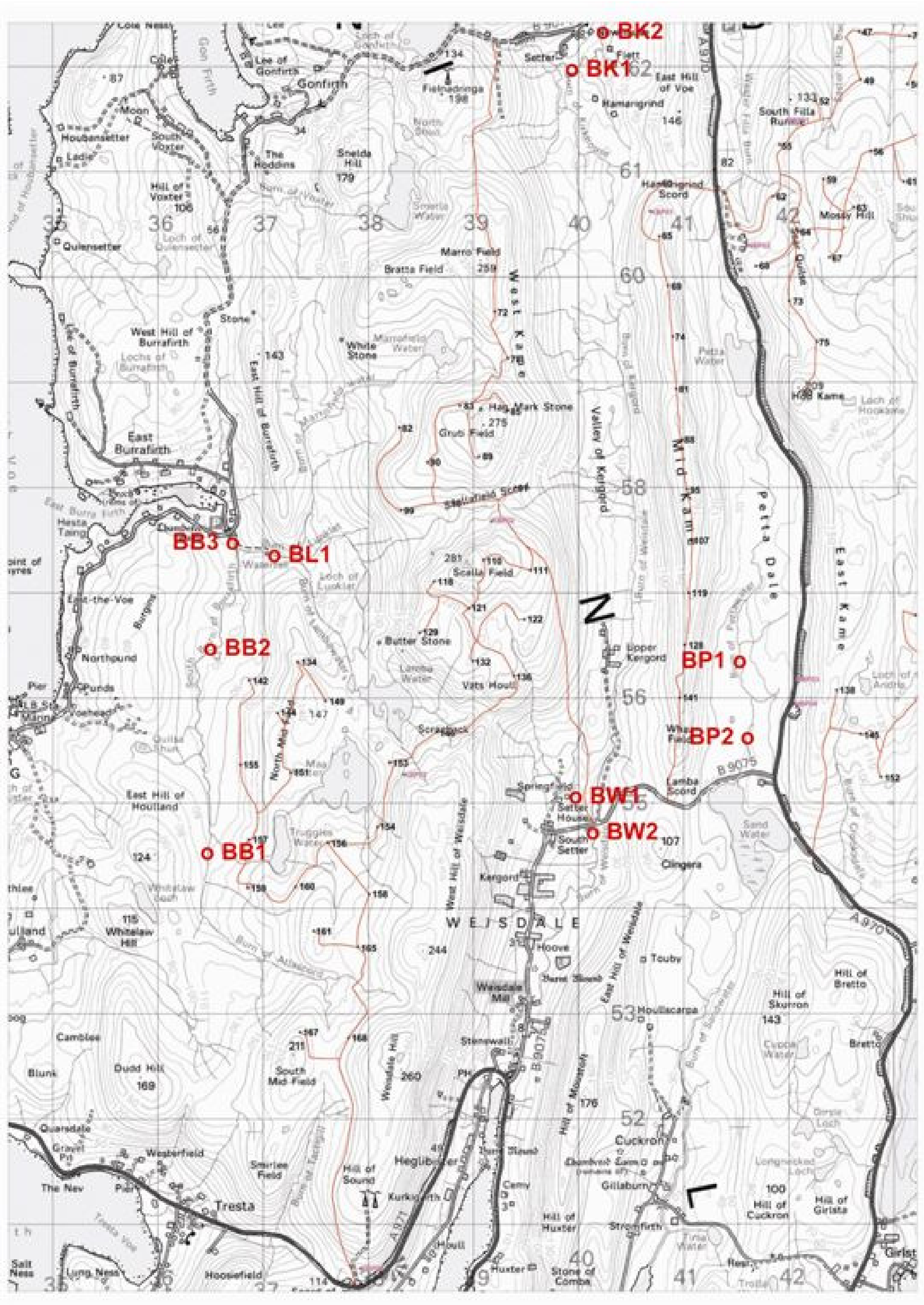

Figure 2 *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

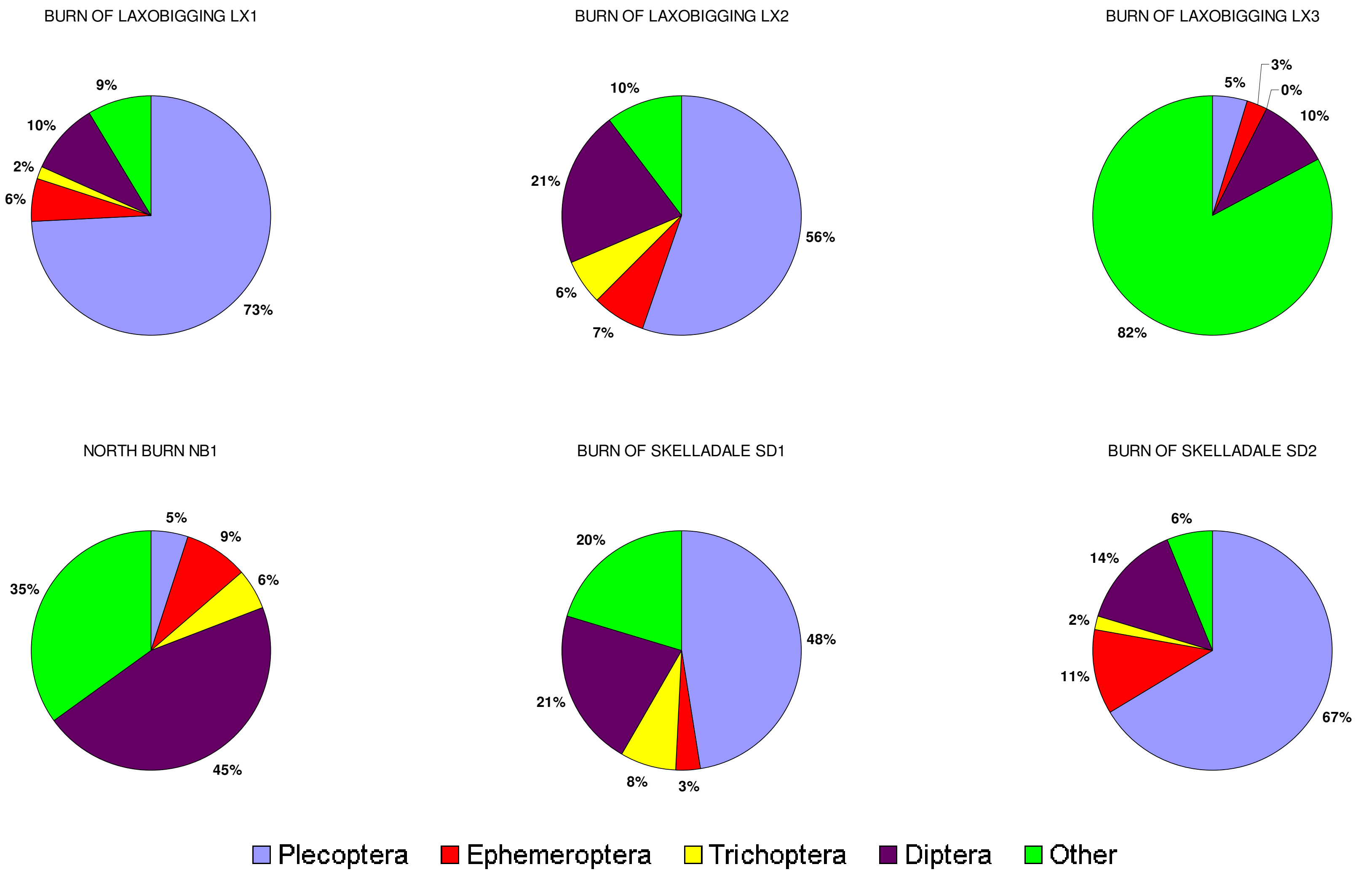

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

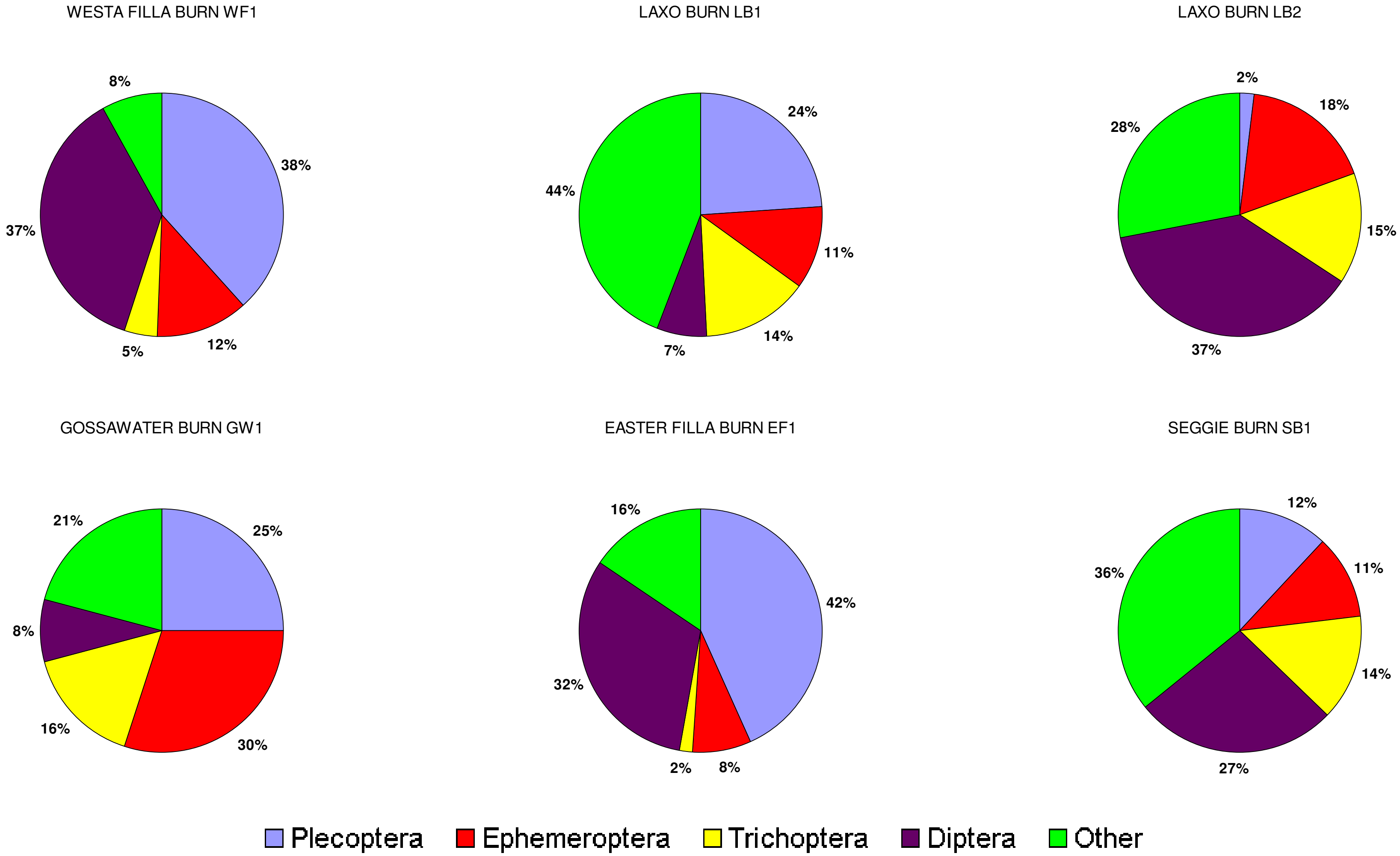

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

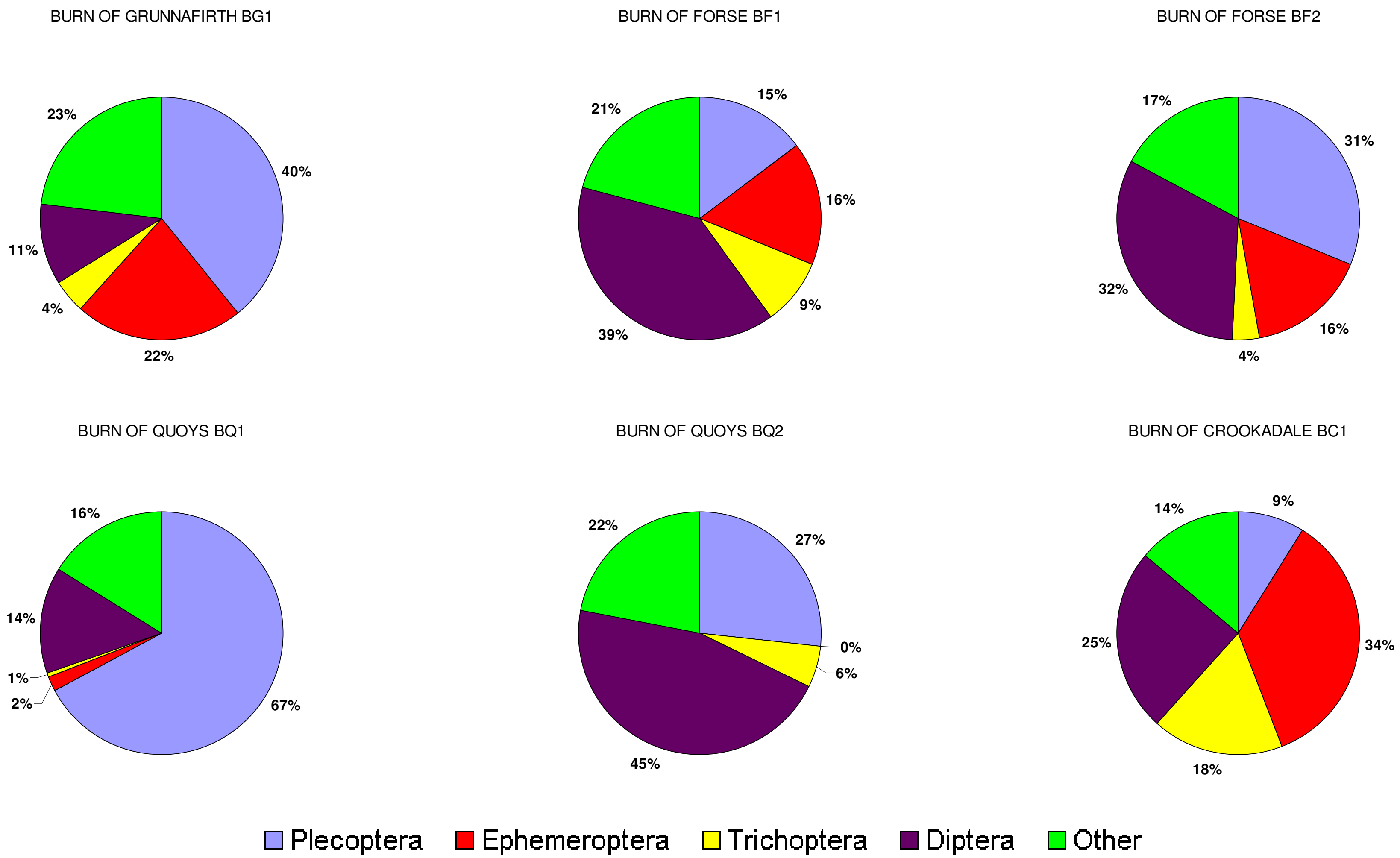

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

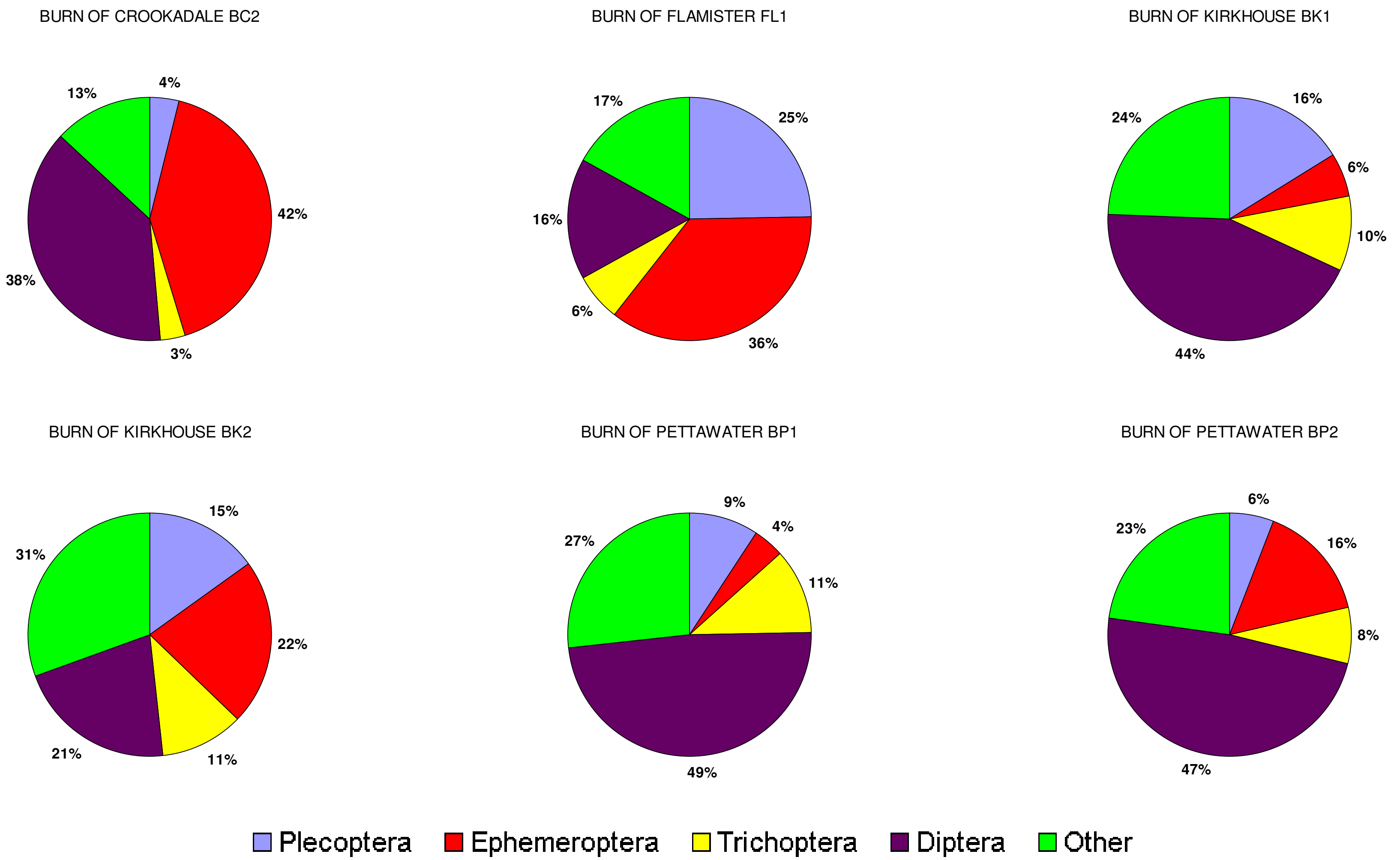

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

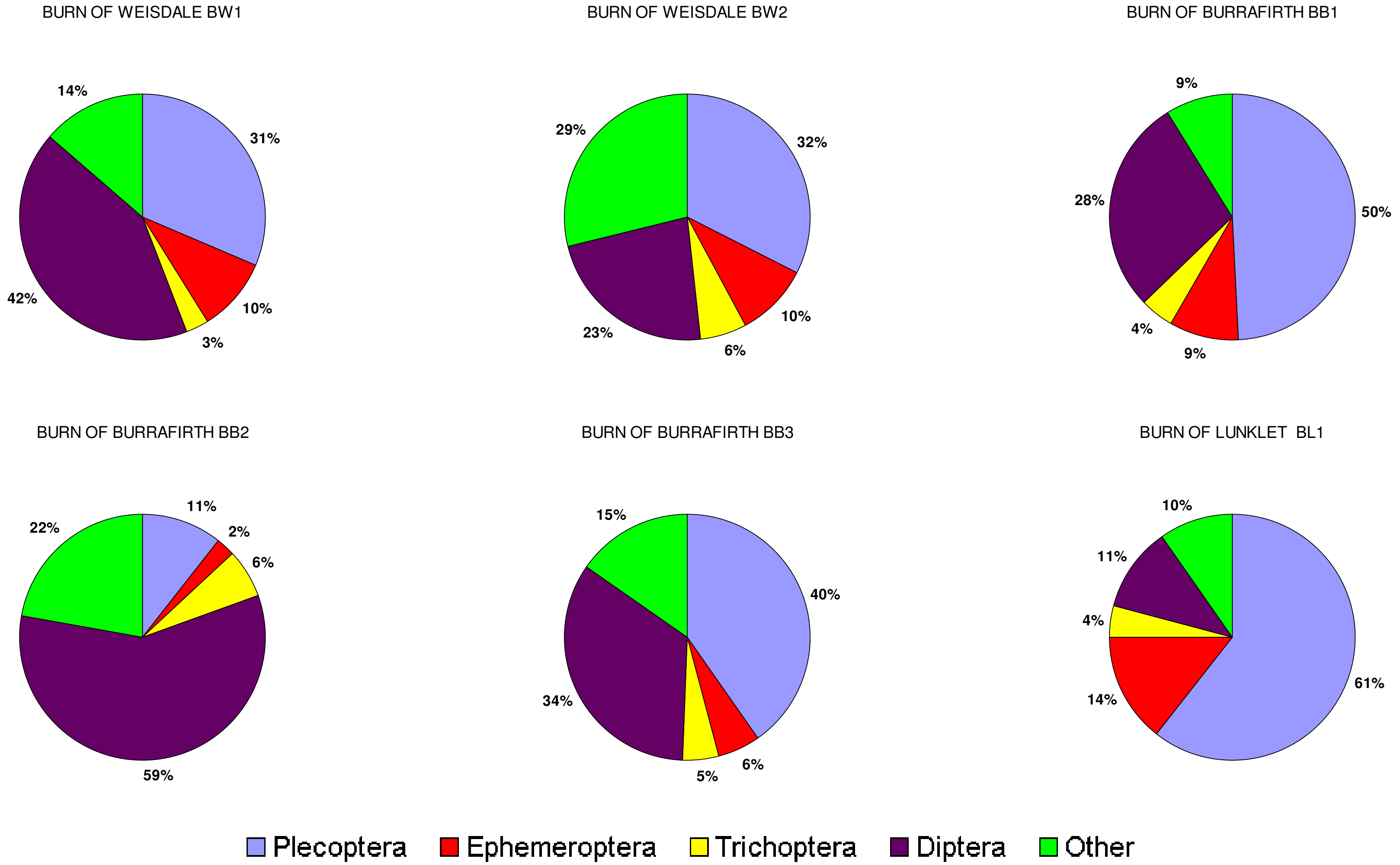

__Figure 3__ Mean density (number/m²) of invertebrates in Surber samples (three per site)

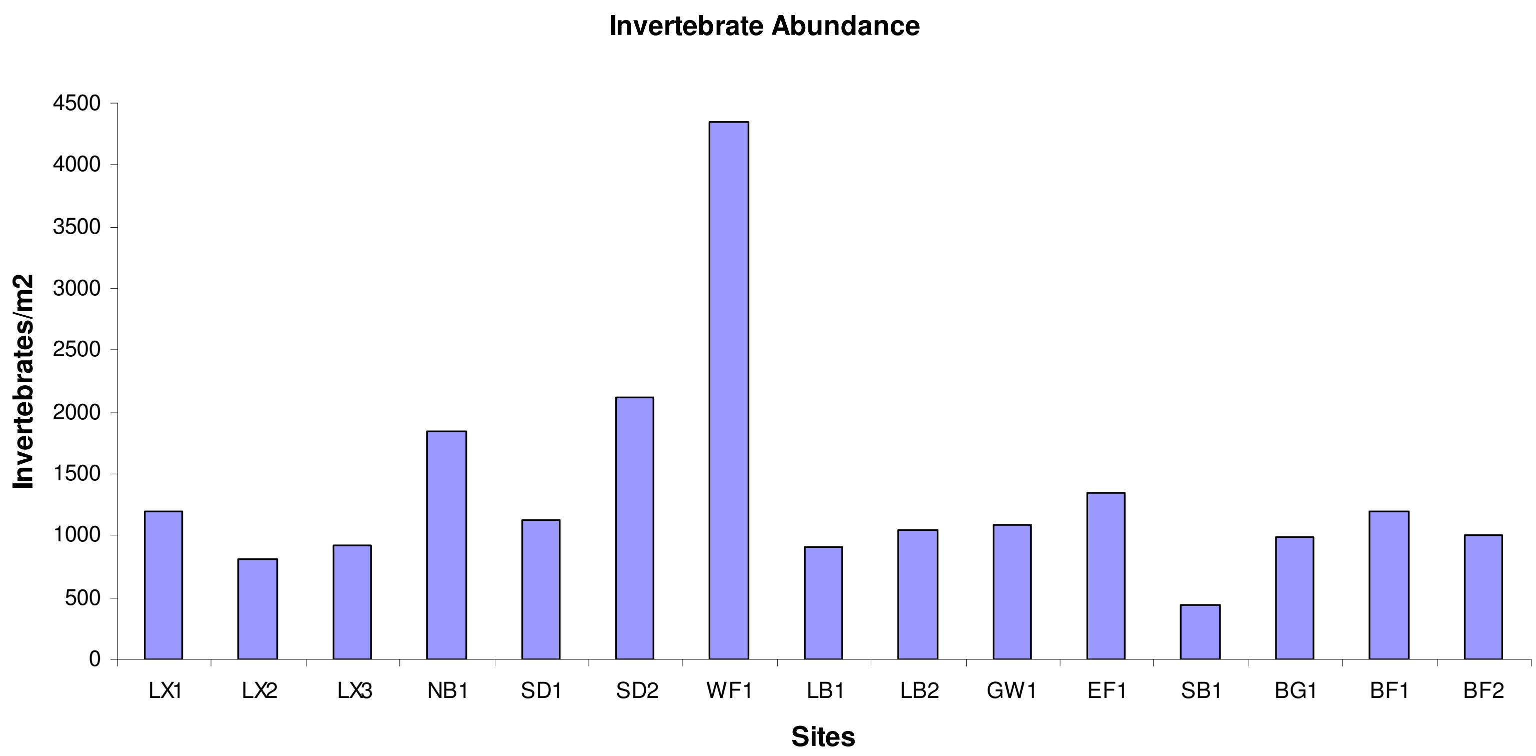

Figure 3 contd. *Mean density (number/m²) of invertebrates in Surber samples (three per site)*

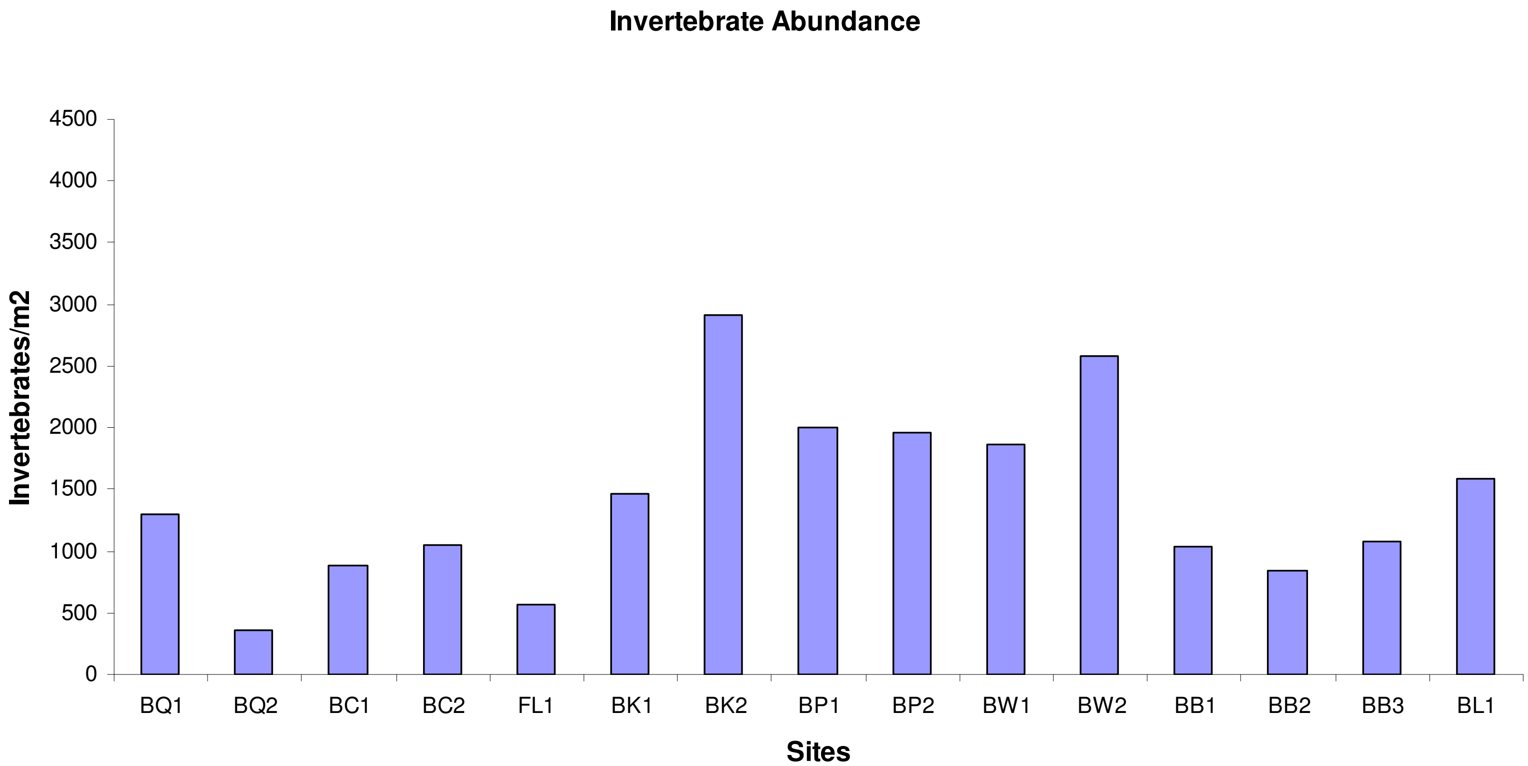

Figure 4 *Mean biomass (dry weight gm/m²) of invertebrates in Surber samples (three per site)*

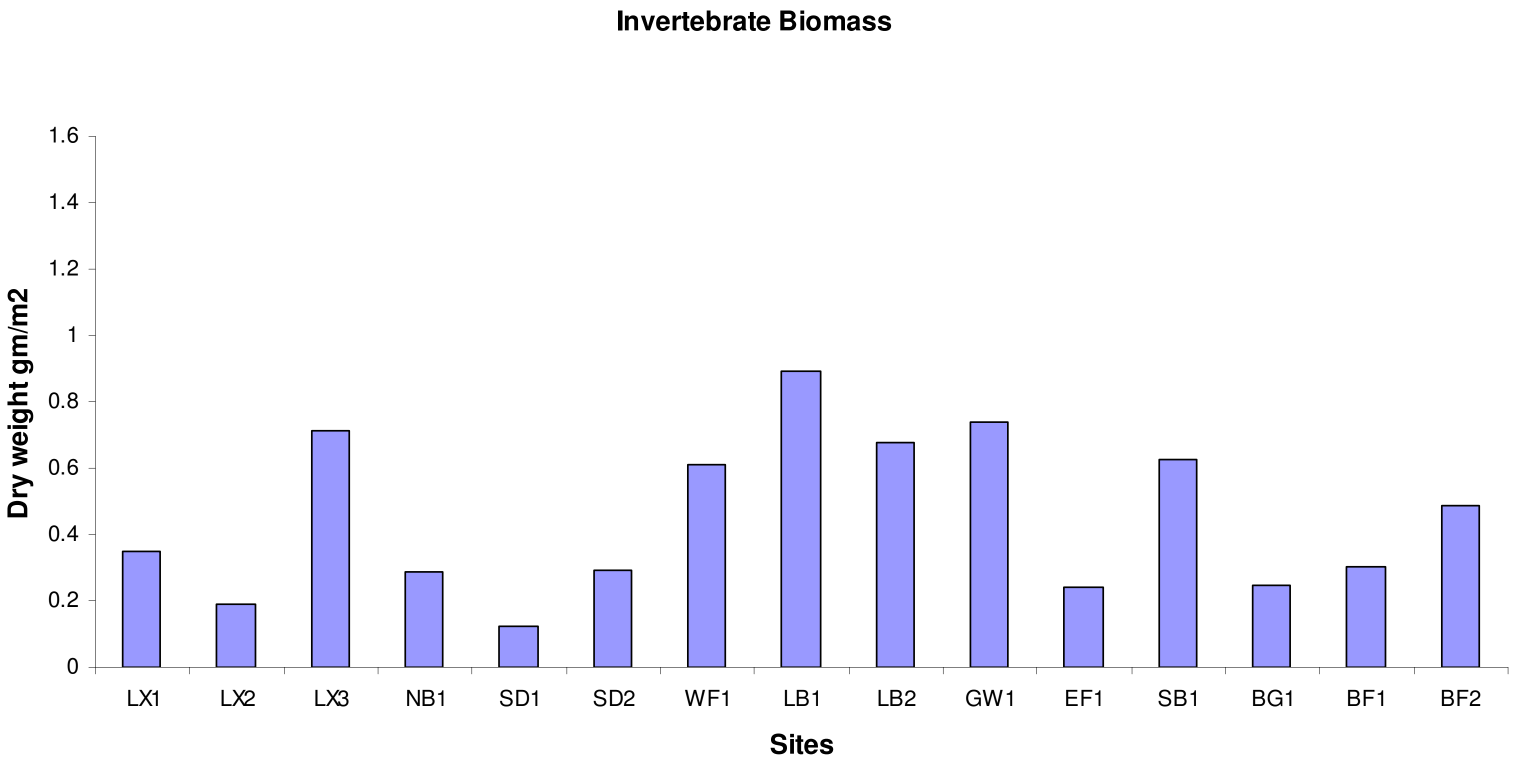

Figure 4 contd. *Mean biomass (dry weight gm/m²) of invertebrates in Surber samples (three per site)*

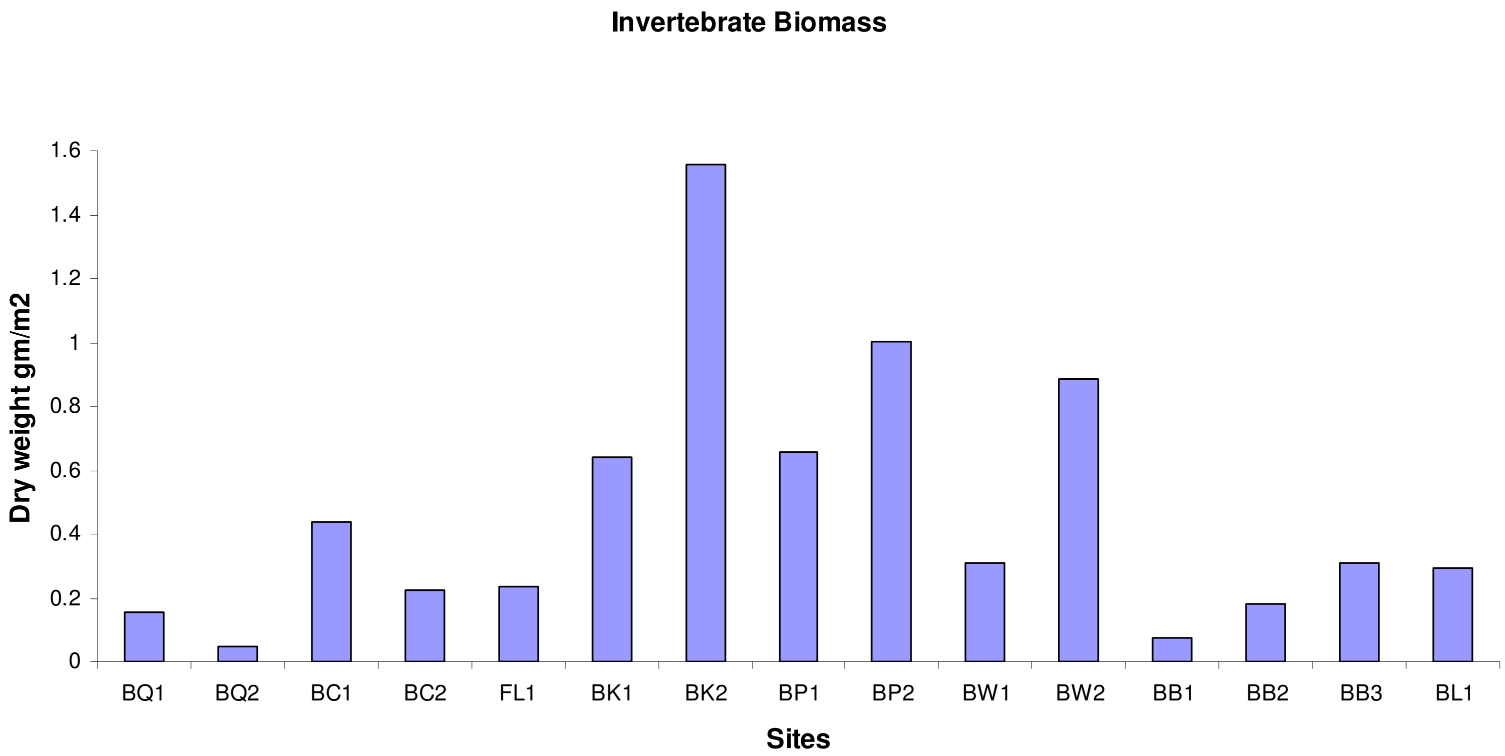

***Table 1** Kick Samples: Monitoring Scores*

Watercourse	Sample Codes	Grid Reference			Sampling Date	BMWP score	Number of scoring taxa (n)	ASPT Score
		Square	East	North				
Delting								
Laxobigging								
Laxobigging	LX1	HU	40084	70665	27/08/2008	39	7	5.6
Laxobigging	LX2	HU	41384	72397	27/08/2008	52	10	5.2
Laxobigging	LX3	HU	40982	73595	27/08/2008	47	9	5.2
North Burn	NB1	HU	41326	73600	27/08/2008	62	11	5.6
Skelladale								
Skelladale	SD1	HU	37252	67575	27/08/2008	49	9	5.4
Skelladale	SD2	HU	36484	67002	27/08/2008	43	8	5.4
Nesting								
Wester Filla								
Wester Filla Burn	WF1	HU	41547	62104	25/08/2008	59	12	4.9
Laxo								
Laxo Burn	LB1	HU	44051	63172	25/08/2008	53	11	4.8
Laxo Burn	LB2	HU	44187	63422	25/08/2008	39	8	4.9
Burn of Gossawater	GW1	HU	43732	62549		39	8	4.9
Easter Filla	EF1	HU	42411	62251	25/08/2008	48	9	5.3
Seggie Burn	SB1	HU	43961	63789	25/08/2008	62	12	5.2
Grunnafirth								
Burn of Grunnafirth	BG1	HU	45908	59296	28/08/2008	46	9	5.1
Burn of Forse	BF1	HU	44830	57917	28/08/2008	62	11	5.6
Burn of Forse	BF2	HU	45386	58492	28/08/2008	51	9	5.7
Quoys								
Burn of Quoys	BQ1	HU	44568	55033	24/08/2008	46	8	5.8
Burn of Quoys	BQ2	HU	44393	54376	24/08/2008	39	8	4.9
Crookadale								
Burn of Crookadale	BC1	HU	42502	54354	23/08/2008	46	9	5.1
Burn of Crookadale	BC2	HU	43608	53888	23/08/2008	49	9	5.4
Burn of Flamister	FL1	HU	43641	54440	24/08/2008	42	8	5.3
Kergord								
Kirkhouse								
Burn of Kirkhouse	BK1	HU	39955	61950	26/08/2008	39	8	4.9
Burn of Kirkhouse	BK2	HU	40247	62364	26/08/2008	59	12	4.9
Pettawater								
Burn of Pettawater	BP1	HU	41500	56312	24/08/2008	51	10	5.1
Burn of Pettawater	BP2	HU	41588	55564	24/08/2008	41	8	5.1
Weisdale								
Burn of Weisdale	BW1	HU	39972	55004	28/08/2008	57	11	5.2
Burn of Weisdale	BW2	HU	40080	54734	24/08/2008	57	11	5.2
Burrafirth								
Burn of Burrafirth	BB1	HU	36457	54567	26/08/2008	31	6	5.2
Burn of Burrafirth	BB2	HU	36472	56432	26/08/2008	44	9	4.9
Burn of Burrafirth	BB3	HU	36713	57461	26/08/2008	41	8	5.1
Burn of Lunklet	BL1	HU	37063	57342	26/08/2008	54	10	5.4

Table 2 *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Delting								
Laxobigging								
Burn of Laxobigging	LX1-1	85	9	III	2	1203	0.0081	0.348
Burn of Laxobigging	LX1-2	66	12	-	-		0.0399	
Burn of Laxobigging	LX1-3	210	11	-	-		0.0565	
Burn of Laxobigging	LX2-1	132	15	II	2	810	0.0280	0.188
Burn of Laxobigging	LX2-2	66	13	-	-		0.0201	
Burn of Laxobigging	LX2-3	45	10	-	-		0.0082	
Burn of Laxobigging	LX3-1	145	12	III	2	927	0.1363	0.711
Burn of Laxobigging	LX3-2	40	6	-	-		0.0283	
Burn of Laxobigging	LX3-3	93	6	-	-		0.0486	
North Burn	NB1-1	161	13	III	2	1847	0.0177	0.289
North Burn	NB1-2	84	14	-			0.0207	
North Burn	NB1-3	309	18	-			0.0482	
Skelladale								
Burn of Skelladale	SD1-1	97	13	III	2	1130	0.0086	0.125
Burn of Skelladale	SD1-2	122	14	-	-		0.0134	
Burn of Skelladale	SD1-3	120	13	-	-		0.0154	
Burn of Skelladale	SD2-1	444	16	III	2	2120	0.0491	0.293
Burn of Skelladale	SD2-2	138	15	-	-		0.0292	
Burn of Skelladale	SD2-3	54	8	-	-		0.0096	
Nesting								
Wester Filla								
Wester Filla Burn	WF1-1	264	15	II	1	4347	0.0389	0.611
Wester Filla Burn	WF1-2	455	16	-	-		0.0639	
Wester Filla burn	WF1-3	585	17	-	-		0.0804	
Laxo								
Laxo Burn	LB1-1	50	13	II	1	903	0.0790	0.892
Laxo Burn	LB1-2	102	14	-	-		0.0964	
Laxo Burn	LB1-3	119	20	-	-		0.0922	
Laxo Burn	LB2-1	75	14	II	1	1043	0.0203	0.676
Laxo Burn	LB2-2	89	18	-	-		0.0746	
Laxo Burn	LB2-3	149	19	-	-		0.1078	
Gossawater Burn	GW1-1	87	15	III	2	1090	0.0400	0.737
Gossawater Burn	GW1-2	118	13	-	-		0.0560	
Gossawater Burn	GW1-3	122	14	-	-		0.1252	

Table 2 contd. *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Easter Filla Burn	EF1-1	111	14	III	2	1353	0.0237	0.240
Easter Filla Burn	EF1-2	121	11	-	-		0.0260	
Easter Filla Burn	EF1-3	174	11	-	-		0.0222	
Seggie Burn	SB1-1	75	11	III	2	447	0.0816	0.626
Seggie Burn	SB1-2	40	12	-	-		0.0841	
Seggie Burn	SB1-3	19	8	-	-		0.0221	
Grunnafirth								
Burn of Grunnafirth	BG1-1	119	11	III	2	993	0.0255	0.246
Burn of Grunnafirth	BG1-2	92	15	-	-		0.0362	
Burn of Grunnafirth	BG1-3	87	9	-	-		0.0121	
Burn of Forse	BF1-1	82	13	III	2	1193	0.0080	0.305
Burn of Forse	BF1-2	187	14	-	-		0.0462	
Burn of Forse	BF1-3	89	15	-	-		0.0373	
Burn of Forse	BF2-1	89	11	III	2	1010	0.0691	0.485
Burn of Forse	BF2-2	114	11	-	-		0.0451	
Burn of Forse	BF2-3	100	15	-	-		0.0313	
Quoys								
Burn of Quoys	BQ1-1	134	11	II	1	1300	0.0243	0.155
Burn of Quoys	BQ1-2	113	10	-	-		0.0171	
Burn of Quoys	BQ1-3	143	9	-	-		0.0051	
Burn of Quoys	BQ2-1	16	4	III	3	363	0.0097	0.047
Burn of Quoys	BQ2-2	53	11	-	-		0.0028	
Burn of Quoys	BQ2-3	40	7	-	-		0.0017	
Crookadale								
Burn of Crookadale	BC1-1	127	13	III	2	883	0.0481	0.437
Burn of Crookadale	BC1-2	128	12	-	-		0.0778	
Burn of Crookadale	BC1-3	10	6	-	-		0.0051	
Burn of Crookadale	BC2-1	109	10	III	2	1043	0.0118	0.224
Burn of Crookadale	BC2-2	109	12	-	-		0.0211	
Burn of Crookadale	BC2-3	95	13	-	-		0.0343	
Burn of Flamister	FL1-1	78	11	III	2	567	0.0508	0.237
Burn of Flamister	FL1-2	46	4	-	-		0.0026	
Burn of Flamister	FL1-3	46	8	-	-		0.0177	

Table 2 contd. *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Kergord								
Kirkhouse								
Burn of Kirkhouse	BK1-1	119	11	II	1	1457	0.0189	0.641
Burn of Kirkhouse	BK1-2	213	14	-	-		0.1192	
Burn of Kirkhouse	BK1-3	105	15	-	-		0.0543	
Burn of Kirkhouse	BK2-1	336	22	II	1	2907	0.1733	1.558
Burn of Kirkhouse	BK2-2	305	22	-	-		0.1794	
Burn of Kirkhouse	BK2-3	231	21	-	-		0.1146	
Pettawater								
Burn of Pettawater	BP1-1	188	15	II	1	2007	0.0507	0.658
Burn of Pettawater	BP1-2	107	16	-	-		0.0812	
Burn of Pettawater	BP1-3	307	17	-	-		0.0655	
Burn of Pettawater	BP2-1	194	18	II	1	1957	0.0967	1.005
Burn of Pettawater	BP2-2	228	16	-	-		0.1751	
Burn of Pettawater	BP2-3	165	14	-	-		0.0298	
Weisdale								
Burn of Weisdale	BW1-1	278	22	II	1	1867	0.0187	0.307
Burn of Weisdale	BW1-2	150	14	-	-		0.0280	
Burn of Weisdale	BW1-3	132	17	-	-		0.0455	
Burn of Weisdale	BW2-1	293	15	II	1	2587	0.1502	0.884
Burn of Weisdale	BW2-2	198	15	-	-		0.0560	
Burn of Weisdale	BW2-3	285	17	-	-		0.0589	
Burrafirth								
Burn of Burrafirth	BB1-1	188	12	III	2	1040	0.0193	0.077
Burn of Burrafirth	BB1-2	103	8	-	-		0.0024	
Burn of Burrafirth	BB1-3	21	8	-	-		0.0014	
Burn of Burrafirth	BB2-1	135	12	II	1	843	0.0092	0.181
Burn of Burrafirth	BB2-2	50	14	-	-		0.0176	
Burn of Burrafirth	BB2-3	68	15	-	-		0.0276	
Burn of Burrafirth	BB3-1	142	14	III	2	1073	0.0358	0.310
Burn of Burrafirth	BB3-2	74	9	-	-		0.0308	
Burn of Burrafirth	BB3-3	106	16	-	-		0.0263	
Burn of Lunklet	BL1-1	265	13	III	2	1590	0.0239	0.294
Burn of Lunklet	BL1-2	69	12	-	-		0.0450	
Burn of Lunklet	BL1-3	143	14	-	-		0.0193	

Table 3 Environmental factors: Kick Samples

Sample Code	Depth (cm) 1/4	1/2	3/4	Bed Width (m)	Wet Width (m)	Macrophyte % cover	Clarity	Flow (ms-1)	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)	pH	˚C	Canopy Cover %
Delting																			
Laxobigging																			
Laxobigging LX1	5	15	11	1.6	1.6	10	clear brown	0.3	0	0	0	10	25	64	1	0	7.17	13.7	0
Laxobigging LX2	18	15	11	2.9	2.9	17	clear brown	0.7	0	0	0	5	15	65	15	0	7.40	13.7	0
Laxobigging LX3	8	12	10	3.4	3.4	15	clear brown	0.7	0	0	0	10	25	60	5	0	7.61	15.4	0
North Burn NB1	14	18	19	0.9	0.9	45	clear brown	0.7	10	0	0	9	30	50	1	0	7.35	13.9	0
Skelladale																			
Burn of Skelladale SD1	16	14	5	3.9	3.3	10	clear brown	0.4	0	0	0	10	20	50	20	0	7.53	12.8	0
Burn of Skelladale SD2	9	8	8	4.4	3.4	5	clear brown	0.5	0	0	0	5	15	60	20	0	7.55	13.7	0
Nesting																			
Wester Filla																			
Wester Filla Burn WF1	6	4	3	2.7	1.7	41	clear brown	0.3	0	0	0	10	30	60	0	0	7.82	13.2	0
Laxo																			
Laxo Burn LB1	11	15	20	7.0	7.0	40	clear brown	0.5	0	0	5	15	20	50	10	0	6.74	14.0	0
Laxo Burn LB2	13	27	23	8.5	8.5	25	clear brown	0.4	0	0	0	10	20	60	10	0	7.18	13.7	0
Gossawater Burn GW1	20	12	6	2.3	2.3	10	clear brown	0.7	0	0	0	10	15	65	10	0	6.35	14.4	0
Easter Filla Burn EF1	8	10	8	2.1	2.1	40	clear brown	0.7	0	0	0	0	10	80	10	0	7.54	12.5	0
Seggie Burn SB1	40	30	10	6.1	5.9	20	clear brown	0.4	0	0	5	5	10	60	20	0	7.53	13.0	0
Grunnafirth																			
Burn of Grunnafirth BG1	12	10	3	3.2	2.6	10	clear brown	0.3	0	0	5	5	20	60	10	0	7.71	13.7	0
Burn of Forse BF1	4	6	7	5.5	3.4	25	clear brown	0.3	0	0	0	5	15	70	10	0	7.57	11.9	0
Burn of Forse BF2	8	6	5	5.0	5.0	5	clear brown	0.2	0	0	0	5	25	60	10	0	7.69	12.6	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 3 contd. *Environmental factors: Kick Samples*

Sample Code	Depth (cm) 1/4	1/2	3/4	Bed Width (m0	Wet Width (m)	Macrophyte % cover	Clarity	Flow (ms-1)	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)	pH	˚C	Canopy Cover %
Quoys																			
Burn of Quoys BQ1	2	4	2	3.0	1.7	10	clear brown	0.25	0	0	0	10	20	50	10	10	7.55	13.4	0
Burn of Quoys BQ2	7	7	5	4.8	3.6	4	clear brown	0.25	0	0	0	10	15	70	5	0	7.8	14.7	0
Crookadale																			
Burn of Crookadale BC1	3	3	5	1.1	1.1	20	clear brown	0.25	0	10	5	15	30	40	0	0	7.31	12.7	0
Burn of Crookadale BC2	7	10	12	2.1	2.1	55	clear brown	0.4	0	0	0	10	20	60	10	0	7.35	13.3	0
Burn of Flamister FL1	2	2	3	1.6	1.6	2	clear brown	0.2	0	0	0	15	25	60	0	0	7.77	15.9	0
Kergord																			
Kirkhouse																			
Burn of Kirkhouse BK1	10	10	9	1.7	1.7	40	clear brown	0.5	0	0	0	10	15	60	5	10	7.56	13.3	0
Burn of Kirkhouse BK2	10	11	10	1.8	1.8	31	clear brown	0.5	0	0	5	10	24	60	1	0	7.45	11.9	0
Pettawater																			
Burn of Pettawater BP1	14	11	3	1.9	1.9	60	clear brown	0.4	0	0	5	5	80	10	0	0	7.8	16.1	0
Burn of Pettawater BP2	18	11	7	2.7	2.7	60	clear brown	0.2	0	0	10	20	40	20	10	0	7.95	16.1	0
Weisdale																			
Burn of Weisdale BW1	10	15	4	1.6	1.2	55	clear brown	0.3	0	0	0	5	20	70	5	0	7.81	13.9	0
Burn of Weisdale BW2	7	3	5	3.4	3.4	65	clear brown	0.4	0	0	0	5	40	55	0	0	8.01	18.5	0
Burrafirth																			
Burn of Burrafirth BB1	14	5	8	2.5	2.0	11	clear brown	0.2	0	0	0	10	25	55	10	0	7.46	16.8	0
Burn of Burrafirth BB2	4	7	9	4.5	4.5	30	clear brown	0.2	0	0	0	5	20	70	5	0	7.37	18.7	0
Burn of Burrafirth BB3	16	15	7	6.0	6.0	10	clear brown	0.4	0	0	0	5	5	60	20	10	7.49	16.4	0
Burn of Lunklet BL1	15	9	13	4.6	4.2	2	clear brown	0.3	0	0	5	10	20	45	20	0	7.45	14.8	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
Delting											
Laxobigging	14	0	riffle	0	0	0	0	10	90	0	0
LX1-1	12	5	riffle	0	0	0	0	20	80	0	0
LX1-2	6	10	riffle	0	0	0	5	25	70	0	0
LX1-3	12	5	riffle	0	0	0	0	0	100	0	0
LX2-1	10	5	riffle	0	0	0	0	10	90	0	0
LX2-2	12	0	riffle	0	0	0	0	30	70	0	0
LX2-3	10	0	riffle	0	0	0	5	15	80	0	0
LX3-1	12	0	riffle	0	0	0	10	20	70	0	0
LX3-2	12	0	riffle	0	0	0	5	15	80	0	0
LX3-3	22	55	riffle	0	0	0	5	15	80	0	0
NB1-1	20	42	riffle	0	0	0	20	30	50	0	0
NB1-2	18	41	riffle	0	0	0	20	20	60	0	0
NB1-3											
Skelladale	10	40	riffle	0	0	0	5	15	80	0	0
SD1-1	5	0	riffle	0	0	0	10	20	70	0	0
SD1-2	14	0	riffle	0	0	0	5	15	80	0	0
SD1-3	8	0	riffle	0	0	0	0	70	30	0	0
SD2-1	14	10	riffle	0	0	0	0	20	80	0	0
SD2-2	12	30	riffle	0	0	0	0	10	90	0	0
SD2-3	14	0	riffle	0	0	0	0	10	90	0	0
Nesting											
Wester Filla											
WF1-1	9	30	riffle	0	0	0	10	20	70	0	0
WF1-2	4	60	riffle	0	0	0	0	30	70	0	0
WF1-3	4	30	riffle	0	0	0	10	40	50	0	0
Laxo											
LB1-1	16	10	riffle	0	0	0	20	20	60	0	0
LB1-2	18	0	riffle	0	0	0	10	20	70	0	0
LB1-3	12	5	riffle	0	0	0	20	20	60	0	0
LB2-1	18	45	riffle	0	0	0	0	10	90	0	0
LB2-2	16	30	riffle	0	0	0	5	15	80	0	0
LB2-3	20	30	riffle	0	0	0	5	5	90	0	0
GW1-1	16	20	riffle	0	0	0	5	15	80	0	0
GW1-2	12	10	riffle	0	0	0	5	15	80	0	0
GW1-3	16	3	riffle	0	0	0	10	20	70	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 contd. *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
EF1-1	12	30	riffle	0	0	0	0	10	90	0	0
EF1-2	12	30	riffle	0	0	0	0	10	90	0	0
EF1-3	8	31	riffle	0	0	0	0	20	80	0	0
SB1-1	20	10	riffle	0	0	5	5	10	80	0	0
SB1-2	18	1	riffle	0	0	5	5	10	80	0	0
SB1-3	18	40	riffle	0	0	5	5	20	70	0	0
Grunnafirth											
BG1-1	8	5	riffle	0	0	0	0	20	80	0	0
BG1-2	5	5	riffle	0	0	0	0	20	80	0	0
BG1-3	12	5	riffle	0	0	0	0	20	80	0	0
BF1-1	8	10	riffle	0	0	0	5	25	70	0	0
BF1-2	12	15	riffle	0	0	0	0	10	90	0	0
BF1-3	5	5	riffle	0	0	0	0	10	90	0	0
BF2-1	8	5	riffle	0	0	0	5	25	70	0	0
BF2-2	8	10	riffle	0	0	0	5	25	70	0	0
BF2-3	11	5	riffle	0	0	0	5	25	70	0	0
Quoys											
BQ1-1	5	11	riffle	0	0	10	10	40	40	0	0
BQ1-2	5	1	riffle	0	0	0	10	10	80	0	0
BQ1-3	5	15	riffle	0	0	0	5	15	80	0	0
BQ2-1	7	0	riffle	0	0	0	5	15	80	0	0
BQ2-2	4	2	riffle	0	0	0	5	15	80	0	0
BQ2-3	5	10	riffle	0	0	0	5	15	80	0	0
Crookadale											
BC1-1	10	5	riffle	0	0	0	20	20	60	0	0
BC1-2	6	0	riffle	0	0	0	20	60	20	0	0
BC1-3	3	1	riffle	0	0	10	20	20	50	0	0
BC2-1	8	20	riffle	0	0	5	15	20	60	0	0
BC2-2	10	20	riffle	0	0	0	20	20	60	0	0
BC2-3	10	10	riffle	0	0	0	10	10	80	0	0
FL1-1	4	0	riffle	0	0	0	10	20	70	0	0
FL1-2	4	0	riffle	0	0	0	5	25	70	0	0
FL1-3	4	1	riffle	0	0	0	5	20	75	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 contd. *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
Kergord											
Kirkhouse											
BK1-1	14	30	glide	0	0	0	0	10	90	0	0
BK1-2	12	40	riffle	0	0	0	5	15	80	0	0
BK1-3	14	30	riffle	0	0	0	0	20	70	0	10
BK2-1	12	40	riffle	0	0	5	5	20	70	0	0
BK2-2	10	20	riffle	0	0	5	10	15	70	0	0
BK2-3	10	30	riffle	0	0	5	15	20	60	0	0
Pettawater											
BP1-1	14	5	glide	0	10	15	20	60	5	0	0
BP1-2	14	30	glide	0	0	10	20	70	0	0	0
BP1-3	12	90	glide	0	50	0	10	30	10	0	0
BP2-1	14	30	riffle	0	0	10	20	30	40	0	0
BP2-2	14	80	riffle	0	0	10	20	30	40	0	0
BP2-3	14	80	riffle	0	0	20	30	50	0	0	0
Weisdale											
BW1-1	10	50	riffle	0	0	0	0	15	85	0	0
BW1-2	10	50	riffle	0	0	0	0	15	85	0	0
BW1-3	7	50	riffle	0	0	0	0	15	85	0	0
BW2-1	11	20	riffle	0	0	0	5	35	60	0	0
BW2-2	9	40	riffle	0	0	0	0	30	70	0	0
BW2-3	7	50	riffle	0	0	0	10	30	60	0	0
Burrafirth											
BB1-1	9	0	riffle	0	0	0	0	20	80	0	0
BB1-2	5	20	riffle	0	0	0	0	20	80	0	0
BB1-3	9	0	riffle	0	0	0	10	20	70	0	0
BB2-1	6	60	riffle	0	0	0	20	30	50	0	0
BB2-2	9	49	riffle	0	0	0	10	20	70	0	0
BB2-3	6	41	riffle	0	0	0	20	30	50	0	0
BB3-1	14	5	riffle	0	0	0	0	20	80	0	0
BB3-2	14	5	riffle	0	0	0	0	5	95	0	0
BB3-3	14	10	riffle	0	0	0	0	5	95	0	0
BL1-1	12	5	riffle	0	0	0	5	20	75	0	0
BL1-2	9	5	riffle	0	0	0	0	10	90	0	0
BL1-3	12	2	riffle	0	0	0	0	10	90	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Appendix 1 *BMWP Scoring System*

Common Name	Family	BMWP Score
Flatworms	Planariidae	5
	Dendrocoelidae	5
Snails	Neritidae	6
	Viviparidae	6
	Valvatidae	3
	Hydrobiidae	3
	Lymnaeidae	3
	Physidae	3
	Planorbidae	3
Limpets and Mussels	Ancylidae	6
	Unionidae	6
	Sphaeriidae	3
Worms	Oligochaeta	1
Leeches	Piscicolidae	4
	Glossiphoniidae	3
	Hirudididae	3
	Erpobdellidae	3
Crustaceans	Asellidae	3
	Corophiidae	6
	Gammaridae	6
	Astacidae	8
Mayflies	Siphlonuridae	10
	Baetidae	4
	Heptageniidae	10
	Leptophlebiidae	10
	Ephemerellidae	10
	Potamanthidae	10
	Ephemeridae	10
	Caenidae	7
Stoneflies	Taeniopterygidae	10
	Nemouridae	7
	Leuctridae	10
	Capniidae	10
	Perlodidae	10
	Perlidae	10
	Chloroperlidae	10
Damselflies	Platycnemidae	6
	Coenagriidae	6
	Lestidae	8
	Calopterygidae	8
Dragonflies	Gomphidae	8
	Cordulegasteridae	8
	Aeshnidae	8
	Corduliidae	8
	Libellulidae	8
Bugs	Mesoveliidae *	5
	Hydrometridae	5
	Gerridae	5
	Nepidae	5
	Naucoridae	5
	Aphelocheiridae	10
	Notonectidae	5
	Pleidae	5
	Corixidae	5
Beetles	Haliplidae	5
	Hygrobiidae	5
	Dytiscidae	5
	Gyrinidae	5
	Hydrophilidae	5
	Clambidae	5
	Scirtidae	5
	Dryopidae	5
	Elmidae	5
	Chrysomelidae	5
	Curculionidae	5
Alderflies	Sialidae	4
Caddisflies	Rhyacophilidae	7
	Philopotamidae	8
	Polycentropidae	7
	Psychomyiidae	8
	Hydropsychidae	5
	Hydroptilidae	6
	Phryganeidae	10
	Limnephilidae	7
	Molannidae	10
	Beraeidae	10
	Odontoceridae	10
	Leptoceridae	10
	Goeridae	10
	Lepidostomatidae	10
	Brachycentridae	10
	Sericostomatidae	10
True flies	Tipulidae	5
	Chironomidae	2
	Simuliidae	5

Appendix 2 *Acid intolerant indicators: Water Chemistry Status Groups and Index of Acidity Lists*

Water Chemistry

Species	**Normal Minimum pH**
Group 1	
Gammarus pulex	≥ 6.0
Glossosoma & Agapetus spp.	6.0
Ancylus fluviatilis	6.0
Lymnaea peregra	6.0
Asellus aquaticus	6.0
Group 2	
Hydropsyche	5.5 - 6.0
Baetis sp.	5.5 Occasionally 5.2
Heptageniidae	5.5 Occasionally 5.2

Index of Acidity

List A taxa (absent at pH <6.0)	**List B taxa (absent at pH <5.5)**
Gammarus pulex	*Baetis rhodani*
Lymnaea peregra	*Rhithrogena semicolorata*
Ancylus fluviatilis	*Ecdyonurus spp.*
Potamopyrgus jenkinsi	*Heptagenia lateralis*
Baetis scambus	*Perlodes microcephala*
Baetis muticus	*Chloroperla bipunctata*
Caenis rivulorum	*Hydreana gracilis*
Ephemerella ignita	*Hydropsyche pellucidula*
Perla bipunctata	
Dinocras cephalotes	
Esolus parallelipipidus	
Glossosoma spp.	
Agapetus spp.	
Hydropsyche instabilis	
Silo pallipes	
Odontocerum albicorne	
Philopotamus montanus	
Wormaldia sp.	
Sericostoma personatum	

Appendix 3 *BMWP and ASPT Scoring Taxa present in Kick Samples*

Site Code	**LX1**	**LX2**	**LX3**	**NB1**	**SD1**	**SD2**	**WF1**	**LB1**	**LB2**	**GW1**	**EF1**	**SB1**	**BG1**	**BF1**	**BF2**
Invertebrates															
Plecoptera															
Chloroperlidae	✓			✓	✓									✓	✓
Leuctridae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ephemeroptera															
Baetidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trichoptera															
Hydropsychidae							✓	✓		✓		✓			
Hydroptilidae		✓						✓				✓			
Limnephilidae			✓	✓							✓	✓			
Polycentropodidae		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhyacophilidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diptera															
Chironomidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Simulidae	✓	✓	✓	✓		✓	✓		✓				✓		✓
Tipuloidea		✓	✓			✓	✓	✓			✓	✓	✓	✓	✓
Coleoptera															
Hydraenidae					✓		✓					✓	✓	✓	
Scirtidae		✓					✓				✓				
Crustacea															
Gammaridae			✓	✓										✓	
Mollusca															
Lymnaeidae					✓	✓		✓	✓			✓			
Sphaeriidae				✓			✓	✓		✓				✓	
Oligochaeta	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

Appendix 3. contd. *BMWP and ASPT Scoring Taxa present in Kick Samples*

Site Code	BQ1	BQ2	BC1	BC2	FL1	BK1	BK2	BP1	BP2	BW1	BW2	BB1	BB2	BB3	BL1
Invertebrates															
Plecoptera															
Chloroperlidae	✓									✓	✓				✓
Leuctridae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ephemeroptera															
Baetidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trichoptera															
Hydropsychidae		✓	✓				✓						✓	✓	
Hydroptilidae															
Limnephilidae				✓											
Polycentropodidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhyacophilidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diptera															
Chironomidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Simulidae	✓		✓	✓	✓		✓	✓			✓				✓
Tipuloidea						✓	✓	✓	✓	✓			✓	✓	
Coleoptera															
Hydraenidae							✓	✓		✓	✓				
Scirtidae							✓	✓	✓						✓
Crustacea															
Gammaridae				✓	✓										
Mollusca															
Lymnaeidae		✓				✓	✓			✓	✓		✓		
Sphaeriidae			✓							✓	✓				✓
Oligochaeta	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Appendix 4 *Water Chemistry Status: Indicator Taxa Present in Surber Samples*

Sample Code	**LX1-1**	**LX1-2**	**LX1-3**	**LX2-1**	**LX2-2**	**LX2-3**	**LX3-1**	**LX3-2**	**LX3-3**	**NB1-1**	**NB1-2**	**NB1-3**	**SD1-1**	**SD1-2**	**SD1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra															
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Hydropsyche siltalai.															

Sample Code	**SD2-1**	**SD2-2**	**SD2-3**	**WF1-1**	**WF1-2**	**WF1-3**	**LB1-1**	**LB1-2**	**LB1-3**	**LB2-1**	**LB2-2**	**LB2-3**	**GW1-1**	**GW1-2**	**GW1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra					✓	✓	✓	✓	✓	✓	✓	✓			
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai					✓	✓		✓	✓		✓		✓	✓	✓

Sample Code	**EF1-1**	**EF1-2**	**EF1-3**	**SB1-1**	**SB1-2**	**SB1-3**	**BG1-1**	**BG1-2**	**BG1-3**	**BF1-1**	**BF1-2**	**BF1-3**	**BF2-1**	**BF2-2**	**BF2-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra				✓		✓									
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai															✓

Appendix 4 *Water Chemistry Status: Indicator Taxa Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra	✓														
Group 2															
Baetis rhodani	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai							✓	✓							

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai		✓		✓	✓	✓									

Sample Code	**BW2-1**	**BW2-2**	**BW2-3**	**BB1-1**	**BB1-2**	**BB1-3**	**BB2-1**	**BB2-2**	**BB2-3**	**BB3-1**	**BB3-2**	**BB3-3**	**BL1-1**	**BL1-2**	**BL1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra		✓	✓					✓	✓						
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai	✓							✓		✓	✓	✓	✓		

Appendix 5 *Index of Acidity: Indicator Taxa Present in Surber Samples*

Sample Code	LX1-1	LX1-2	LX1-3	LX2-1	LX2-2	LX2-3	LX3-1	LX3-2	LX3-3	NB1-1	NB1-2	NB1-3	SD1-1	SD1-2	SD1-3
Index of Acidity															
List A															
Lymnaea peregra															
Potamopyrgus jenkinsi															
Philopotamus montanus				✓											
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Hydraena gracilis		✓													

Sample Code	SD2-1	SD2-2	SD2-3	WF1-1	WF1-2	WF1-3	LB1-1	LB1-2	LB1-3	LB2-1	LB2-2	LB2-3	GW1-1	GW1-2	GW1-3
Index of Acidity															
List A															
Lymnaea peregra					✓	✓	✓	✓	✓	✓	✓	✓			
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis	✓			✓		✓									

Sample Code	EF1-1	EF1-2	EF1-3	SB1-1	SB1-2	SB1-3	BG1-1	BG1-2	BG1-3	BF1-1	BF1-2	BF1-3	BF2-1	BF2-2	BF2-3
Index of Acidity															
List A															
Lymnaea peregra				✓		✓									
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis		✓			✓										

Appendix 5 contd. *Index of Acidity: Indicator Taxa Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Index of Acidity															
List A															
Lymnaea peregra	✓														
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis								✓							

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Index of Acidity															
List A															
Lymnaea peregra		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Potamopyrgus jenkinsi				✓	✓					✓	✓	✓			
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis				✓	✓	✓									

Sample Code	**BW2-1**	**BW2-2**	**BW2-3**	**BB1-1**	**BB1-2**	**BB1-3**	**BB2-1**	**BB2-2**	**BB2-3**	**BB3-1**	**BB3-2**	**BB3-3**	**BL1-1**	**BL1-2**	**BL1-3**
Index of Acidity															
List A															
Lymnaea peregra		✓	✓					✓	✓						
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis	✓	✓	✓	✓											

Appendix 6 *Invertebrate Numbers Present in Surber Samples*

Sample Code	**LX1-1**	**LX1-2**	**LX1-3**	**LX2-1**	**LX2-2**	**LX2-3**	**LX3-1**	**LX3-2**	**LX3-3**	**NB1-1**	**NB1-2**	**NB1-3**	**SD1-1**	**SD1-2**	**SD1-3**
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	1		15	4	5	1	3		1		1	4	6	19	6
Leuctridae															
Early nymphs	54	36	162	68	36	20	9			1	5	16	25	44	61
Ephemeroptera															
Baetidae															
Baetis rhodani	8	7	6	12	4	2	8			12	4	32	4	5	2
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai															
Hydroptilidae															
Oxyethira sp														1	
Limnephilidae															
Early instars										4	2	1			
Potamophylax sp										1	1				
Philopotamidae															
Philopotamus montanus				2											
Polycentropidae															
Plectronemia conspersa					1							1			
Polycentropus flavomaculatus	1	1		4	1	2				5	2	6	7	4	11
Rhyacophilidae															
Rhyacophila dorsalis	2	2		3	1	1				1		7	1		2
Diptera															
Ceratopogonidae							1					1	1		
Chironomidae	13	9	5	24	8	13	18	3	2	68	33	146	16	25	27
Empididae		1		1										1	
Limoniidae															
Dicronota sp							1								
Eloeophila sp												1			
Muscidae															
Limnophora sp				1											
Simulidae	1	1	5	2	2		2			1	2	2			
Tipulidae															
Tipula sp														1	1

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	LX1-1	LX1-2	LX1-3	LX2-1	LX2-2	LX2-3	LX3-1	LX3-2	LX3-3	NB1-1	NB1-2	NB1-3	SD1-1	SD1-2	SD1-3
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis		1													
Scirtidae															
Elodes sp.			3	3			3								
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra															
Sphaeriidae															
Pisidium sp.										3	1	2			
Crustacea															
Gammaridae															
Gammarus zaddachi							89	32	77						
Ostracoda			1	2	1		1			55	26	76			2
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	3	1	7	2	2	1	9	1	1	1	2	3	2	4	2
Lumbricidae		2	3	3	3	3					2	2			1
Lumbriculidae	2	3	1			1					1	3	2	1	2
Naididae		2			1		1	2	10				20	6	1
Tubificidae										1			1	1	
Nematoda								1				3	2	4	
Hydracarina			2	1	1	1		1	2	8	2	3	10	6	2

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**SD2-1**	**SD2-2**	**SD2-3**	**WF1-1**	**WF1-2**	**WF1-3**	**LB1-1**	**LB1-2**	**LB1-3**	**LB2-1**	**LB2-2**	**LB2-3**	**GW1-1**	**GW1-2**	**GW1-3**
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	19	12	2	4	2	14	1		2					3	4
Leuctridae															
Early nymphs	300	68	22	41	116	324	1	19	42	1	2	3	18	32	25
Ephemeroptera															
Baetidae															
Baetis rhodani	40	18	14	7	60	90	4	22	4	17	19	19	23	38	37
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai					2	17		4	7		5		3	3	14
Hydroptilidae															
Oxyethira sp							2		1	2	1	2			
Limnephilidae															
Early instars															1
Potamophylax sp									1			2			
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa									1						
Polycentropus flavomaculatus	3	4	2	9	20	4	4	6	2	5	5	17	4	9	4
Rhyacophilidae															
Rhyacophila dorsalis	1	1	1	2	5	1	2	6	2	1	4	2	2	5	7
Diptera															
Ceratopogonidae		1													
Chironomidae	60	14	9	162	218	70	4	6	6	35	16	50	7	10	8
Empididae	1					1					1	1			
Limoniidae															
Dicronota sp	1					3									1
Eloeophila sp															
Muscidae															
Limnophora sp										1	2				
Simulidae	3	1		2	5	20	1				10	1	1		
Tipulidae															
Tipula sp		1							1		1				

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**SD2-1**	**SD2-2**	**SD2-3**	**WF1-1**	**WF1-2**	**WF1-3**	**LB1-1**	**LB1-2**	**LB1-3**	**LB2-1**	**LB2-2**	**LB2-3**	**GW1-1**	**GW1-2**	**GW1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis													1		
Illybius sp															
Dropteridae															
Dryops sp									3						
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis	1			2		2									
Scirtidae															
Elodes sp.	1			2	2	5									
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra					1	1	16	6	1	2	4	12			
Sphaeriidae															
Pisidium sp.							8	7	9		1	5	3		2
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	5	2			3		2	1	2	3	9	10	1	1	
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	1	8	2	3	5	2			7	3	3	3	1	1	1
Lumbricidae	1	2	2	9	2	14	4	14	21	2	4	3	4	4	13
Lumbriculidae		2						2	4	1		4	10	5	4
Naididae	6	1		1		8						2			
Tubificidae				1	1			3		1	1	1	8	6	1
Nematoda				1	1		1	3	1	1		1		1	
Hydracarina	1	3		18	12	9		3	2		1	11	1		

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	EF1-1	EF1-2	EF1-3	SB1-1	SB1-2	SB1-3	BG1-1	BG1-2	BG1-3	BF1-1	BF1-2	BF1-3	BF2-1	BF2-2	BF2-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium				5	2		13	17	1	1	6	1	3		4
Leuctridae															
Early nymphs	17	50	109	7	1	1	40	20	26	8	28	9	21	23	43
Ephemeroptera															
Baetidae															
Baetis rhodani	6	11	14	9	5	1	31	9	27	6	41	11	10	22	17
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai															1
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars															
Potamophylax sp	2	3	1	1								1			
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa											1	1			
Polycentropus flavomaculatus				11	5	2	3	3	4	6	16	4	3	6	1
Rhyacophilidae															
Rhyacophila dorsalis			1				2	1			2	1			
Diptera															
Ceratopogonidae	1									1					
Chironomidae	39	44	31	17	8	8	8	8	9	37	68	28	31	45	16
Empididae	3	1	2	1				2		1				1	
Limoniidae															
Dicronota sp			2		1					1	2				2
Eloeophila sp														1	
Muscidae															
Limnophora sp															
Simulidae			3				1		3						1
Tipulidae															
Tipula sp	2	1			1			1			2				

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	EF1-1	EF1-2	EF1-3	SB1-1	SB1-2	SB1-3	BG1-1	BG1-2	BG1-3	BF1-1	BF1-2	BF1-3	BF2-1	BF2-2	BF2-3
Coleoptera															
Dytiscidae															
Agabus guttatus		1													
Agabus sp	2														
Hydroporus tristis															
Illybius sp	2		1												
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis		1			1										
Scirtidae															
Elodes sp.	2														
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra				5		2									
Sphaeriidae															
Pisidium sp.															
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda						1		1			1	2	1		1
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	18	6	7	4	2	3	8	7		7	2	12	8	3	6
Lumbricidae	1	2	3	12	11	1	3	10		1	4	6	1	3	1
Lumbriculidae	1			3	2		8	4	6	2		1		3	2
Naididae										3		1	4		1
Tubificidae	15				1			6	10					2	2
Nematoda								1			1	3	1		
Hydracarina		1					2	2	1	8	13	8	6	5	2

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	4	4													
Leuctridae															
Early nymphs	65	72	117	2	20	7	3	21	1	4	2	6	16	25	1
Ephemeroptera															
Baetidae															
Baetis rhodani	4	1	3				55	40	4	26	63	41	39	11	11
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai							2	7							
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars					2		1								
Potamophylax sp															
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa					1		11				1	1	2		
Polycentropus flavomaculatus		1				2	6	1		4			4		5
Rhyacophilidae															
Rhyacophila dorsalis		1			1			5			3	1			
Diptera															
Ceratopogonidae															
Chironomidae	30	11	11	11	16	22	29	30	1	62	24	21	6	8	13
Empididae	1		1		1					1					
Limoniidae															
Dicronota sp								1			1	1			
Eloeophila sp															
Muscidae															
Limnophora sp															
Simulidae			1				2	5	1		4	6			
Tipulidae															
Tipula sp															

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	BQ1-1	BQ1-2	BQ1-3	BQ2-1	BQ2-2	BQ2-3	BC1-1	BC1-2	BC1-3	BC2-1	BC2-2	BC2-3	FL1-1	FL1-2	FL1-3
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis								2							
Scirtidae															
Elodes sp.															
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra	2														
Sphaeriidae															
Pisidium sp.							1	2			1				
Crustacea															
Gammaridae															
Gammarus zaddachi										4	4	2	1		1
Ostracoda	4		1			2	1								
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	6	12	4		3	4				2		1	1		
Lumbricidae	7	7		2	2		1	2	1	1	1	1	6		1
Lumbriculidae	1										2	5	1	2	3
Naididae		1		1	3										
Tubificidae						2	13	12	2	2	3	7			11
Nematoda			1		1								1		
Hydracarina	10	3	4		3	1	2			3		2	1		

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	BK1-1	BK1-2	BK1-3	BK2-1	BK2-2	BK2-3	BP1-1	BP1-2	BP1-3	BP2-1	BP2-2	BP2-3	BW1-1	BW1-2	BW1-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	1	23	6	6	11	8	3	5		3			4	4	8
Leuctridae															
Early nymphs	2	36	3	26	22	57	25	7	16	5	24	2	120	22	17
Ephemeroptera															
Baetidae															
Baetis rhodani	4	16	5	83	60	51		1	16	14	38	39	32	13	10
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai		1		13	8	25									
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars													1		
Potamophylax sp						1									
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa			1												
Polycentropus flavomaculatus	12	14	10	22	19	2	12	18	30	10	9	7	2	3	3
Rhyacophilidae															
Rhyacophila dorsalis	2	2	1	5	1	2	1	3	5	7	10	2	1	6	1
Diptera															
Ceratopogonidae	1			1	2	1							1		1
Chironomidae	88	48	53	90	46	36	67	30	182	94	85	82	77	73	69
Empididae			1	1	1		1		1	5	2		4	4	2
Limoniidae															
Dicronota sp							1	3	2	1	2		1		
Eloeophila sp						1							2		
Muscidae															
Limnophora sp															
Simulidae				1	1	2	1	4	4	2	5	5	1		1
Tipulidae															
Tipula sp							1								

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp														1	
Haliplidae															
Haliplus lineaticollis					1										
Hydraenidae															
Hydraena gracilis				1	1	1									
Scirtidae															
Elodes sp.				1		1		1	1				1		
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii				3	1					1	1	1			
Lymnaeidae															
Lymnaea peregra		3	4	10	3	1	3	6	2			2	1	1	2
Sphaeriidae															
Pisidium sp.									1						
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	2	16	3	4	4	3	1	1	3	10	4	2	3	6	1
Hirudinea															
Glossiphonia complanata			1									1			
Helobdella stagnalis					1										
Oligochaeta															
Enchytraeidae		1	2	1	10	3	50	5	12	3	7		3		3
Lumbricidae		25	4	23	19	19	3	10	6	10	19		2	6	4
Lumbriculidae	5	6	2	1	4	2	4	1		1		1	1		1
Naididae				25	6				1	12	3	7	11	1	3
Tubificidae	1	4		5	73	10				3	15	6	3	1	2
Nematoda	1			2		1		1	1	2	1		1		
Hydracarina		18	9	12	11	4	15	11	24	11	3	8	6	9	4

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	BW2-1	BW2-2	BW2-3	BB1-1	BB1-2	BB1-3	BB2-1	BB2-2	BB2-3	BB3-1	BB3-2	BB3-3	BL1-1	BL1-2	BL1-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	6	6	13	11		2	5		4	18	6	12	62	17	25
Leuctridae															
Early nymphs	141	25	61	88	50	2	12	3	3	50	14	30	115	28	42
Ephemeroptera															
Baetidae															
Baetis rhodani	41	18	16	16	13			2	4	7	8	3	40	1	28
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai	2							3		2	1	1	2		
Hydroptilidae															
Oxyethira sp					1				1						
Limnephilidae															
Early instars															
Potamophylax sp															
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa				1		1						1			1
Polycentropus flavomaculatus	1	31	5	10			2	2		2	1	1	5	2	5
Rhyacophilidae															
Rhyacophila dorsalis	2		6			1	2	1	5	3	1	2	1	1	2
Diptera															
Ceratopogonidae	1		1												
Chironomidae	38	73	56	45	21	11	77	18	27	43	34	30	20	11	19
Empididae	1		1				2	2	3						
Limoniidae															
Dicronota sp										1					
Eloeophila sp															
Muscidae															
Limnophora sp															
Simulidae	1	3	2	3	8		14	1	3	1		1	4		
Tipulidae															
Tipula sp									1						

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BW2-1**	**BW2-2**	**BW2-3**	**BB1-1**	**BB1-2**	**BB1-3**	**BB2-1**	**BB2-2**	**BB2-3**	**BB3-1**	**BB3-2**	**BB3-3**	**BL1-1**	**BL1-2**	**BL1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp									1						
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis	11	1	1	2											
Scirtidae															
Elodes sp.					1								3		
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra		1	1					1	3						
Sphaeriidae															
Pisidium sp.														1	1
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	3	11	3	1			11	9	7	3		7		3	1
Hirudinea															
Glossiphonia complanata		1	1												
Helobdella stagnalis		1													
Oligochaeta															
Enchytraeidae		3	2	5	8	1	2	3	3	3		4	5	1	7
Lumbricidae	20	2	2	1			1	1	2	3	7	5	2	1	2
Lumbriculidae						1						2		2	2
Naididae										3		1	3		
Tubificidae	20	1	107												
Nematoda							1	2	1			2			1
Hydracarina	5	21	7	5	1	2	6	2		3	2	4	3	1	7

Appendix 7 *Standard Fieldsheet*

Waterbody: **Date:** **Code:**

KICK SAMPLE

E **N:** **Altitude:**

wet width (m): **bed width (m):** **depth: ¼: ½: ¾:**

substrate

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Instream veg (%): **Clarity (cm):** **Flow**:glide/run/rifflle/ torrent
speed (m.s^{-1}): **canopy cover (%):** **Photographs:**

Other (pollution, erosion etc) **pH** **Temperature**

☐ **Stone search competed**

SURBER SAMPLES

1.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

2.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

3.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

Appendix 8 *Site Photographs*


Burn of Laxobigging LX1


Burn of Laxobigging LX2


Burn of Laxobigging LX3


North Burn NB1


Burn of Skelladale SD1


Burn of Skelladale SD2

Appendix 8 contd. *Site Photographs*


Wester Filla Burn WF1


Laxo Burn LB1


Laxo Burn LB2


Burn of Gossawater GW1


Easter Filla Burn EF1


Seggie Burn SB1

Appendix 8 contd. *Site Photographs*


Burn of Grunnafirth BG1


Burn of Forse BF1


Burn of Forse BF2


Burn of Quoys BQ1


Burn of Quoys BQ2


Burn of Crookadale BC1

Appendix 8 contd. *Site Photographs*


Burn of Crookadale BC2


Burn of Flamister FL1


Burn of Kirkhouse BK1


Burn of Kirkhouse BK2


Burn of Pettawater BP1


Burn of Pettawater BP2

Appendix 8 contd. *Site Photographs*


Burn of Weisdale BW1


Burn of Weisdale BW2


Burn of Burrafirth BB1


Burn of Burrafirth BB2


Burn of Burrafirth BB3


Burn of Lunklet BL1