Biological and Water Quality Monitoring

Autumn 2008

prepared for City of Ryde

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Executive Summary

This report has been developed by Sydney Water in response to engagement under of the City of Ryde Tender Number COR-EOC-05/07. This report contributes to the City of Ryde Council's implementation of its Biological and Chemical Water Quality Monitoring Strategy using macroinvertebrates and water chemistry in the main creek systems within its area. This report starts the fifth year of the strategy with collection of samples from Archers, Shrimptons, Buffalo, Porters and Terrys creeks in Autumn 2008. Autumn 2008 sampling was conducted on 3rd-5th March 2008 and on the 2nd-4th April 2008.

A total of 1,811 macroinvertebrates were collected and examined from the Autumn 2008 sampling period which saw visits to Archers, Shrimptons, Buffalo, Porters and Terrys creeks, with 51 taxa recorded. A total of 73 taxa have been recorded from all creeks in the Spring 2004 to Autumn 2008 period from the edge habitat.

Macroinvertebrate results of Autumn 2008 indicate Archers, Shrimptons, Buffalo, Porters and Terrys creeks have impaired macroinvertebrate communities with similar results recorded in Spring 2004 to Spring 2007. The third poorest SIGNAL-SF result of the program was recorded for Shrimptons Creek, with the two lower results recorded in 2005 for this creek. In Autumn 2008 few sensitive EPT taxa were collected and were slightly less abundant than in Spring 2007. Only one EPT indicator taxa defined by AUSRIVAS predicted model output, was recorded in Autumn 2008. Multivariate analysis of macroinvertebrate data indicated slight changes in community composition between sampled seasons for each creek with Shrimptons Creek showing the most variability in community structure over the 2005 to 2008 period. Terrys Creek has had the most stable community structure closely followed by Buffalo and Porters creeks. Archers Creek displays the second most variable community structure over this time period.

Indicative water quality results of Autumn 2008 indicate Archers, Shrimptons, Buffalo, Porters and Terrys creeks did not meet, on all or virtually all sampling occasions, ANZECC (2000) guidelines for the protection of aquatic ecosystems for Total Oxidised Nitrogen, Total Nitrogen, and Dissolved Oxygen, although levels varied between creeks. In Archers, Buffalo and Porters creeks Ammonium (NH4) did not meet ANZECC (2000) guidelines. ANZECC (2000) criteria was also exceeded for Total Phosphorus in Shrimptons Creek. In March 2008 pH exceeded 0.1 above the upper ANZECC (2000) limit for the protection of aquatic ecosystems in Buffalo Creek. These water quality results of Autumn 2008 suggest that whilst some similarity exists, influences on water chemistry in each creek are not the same across the City of Ryde. The impaired macroinvertebrate communities recorded in each of the five study streams reflect water quality failures highlighted in the comparison of water quality results to ANZECC (2000) guidelines and probably other unmeasured parameters.

Multivariate analysis of extrinsic water quality parameters highlighted rainfall and a surrogate measure of storm water catchment drainage (length of storm water pipe) as contributors to influencing community structure. An example of efficient delivery via the storm water system was observed in Porters Creek during Autumn 2008.

Updated comments have been made on progress of Biological and Chemical Water Quality Monitoring Strategy aims.

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1 Introduction

Sydney Water Corporation (Sydney Water) has developed this report in response to engagement under the City of Ryde Council Tender Number COR-EOC-05/07.

This report contributes to the City of Ryde Council's implementation of its Biological and Chemical Water Quality Monitoring Strategy using macroinvertebrates and water chemistry in the main creek systems within its area. This strategy was originally planned as a seven year program of which the first two years of the program saw all five creeks monitored. The intention of the broad program for the remaining five years was to target two of the five creeks each year on a rotational basis. However, discussions arising out of presentation of the Spring 2006 report lead to inclusion of all five sites in Autumn 2007 report to better encompass natural variation from drier and wetter hydrological conditions that may prevail through the program. The Autumn 2008 report begins the fifth year of the seven-year program with inclusion of all five sites for macroinvertebrates and water chemistry, which were sampled once each month in March & April of Autumn 2008. Additional water quality was conducted as per variations.

Monitoring macroinvertebrates and water chemistry enables the City of Ryde Council to:

- Evaluate chemical and biological water quality monitoring both for short and long term interpretation and temporal evaluation over the duration of the strategy;
- Detail where, when and how often samples should be taken from creeks within the Ryde Local Government Area based on existing site data, catchment position, accessability and trends identified;
- Prescribe how to sample for macroinvertebrates, building on the standard protocols designed by AUSRIVAS;
- Provide for a series of options for identification of key indicator taxa to family and or morphospecies;
- Identify suitable indices such as SIGNAL SF to assess water quality, including calculation of the Observed/Expected (OE50 and OE0 SIGNAL2) ratios from the respective AUSRIVAS predictive models for autumn, spring, and combined seasons;
- Provide the basis for an appraisal of the capacity of a standard monitoring strategy to be intergrated into a community monitoring program eg. Streamwatch.
- Provide the foundation to augment the Streamwatch capacity within the City of Ryde including options for improved education awareness of water quality issues within schools and community groups.
- Provide information and direction on potential infrastructural works to complement water quality monitoring and improve overall creek health.

2 Study Area

2.1 Site locations

The five designated sites (Figure 1) of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy are:

- Site 1 – Terrys Creek near M2 motorway at the end of Somerset Road, North Epping
- Site 2 – Shrimptons Creek at Wilga Park
- Site 3 – Porters Creek, accessed through the Ryde City Depot, after the creek is piped under the depot
- Site 4 – Buffalo Creek, accessed through private property (52 Higginbotham Rd)
- Site 5 – Archers Creek at Maze Park

Additional water quality sites for Shrimptons, Porters, Buffalo and Archers Creeks were sampled for various analytes in Autumn 2008, refer to Table 8 for these locations.

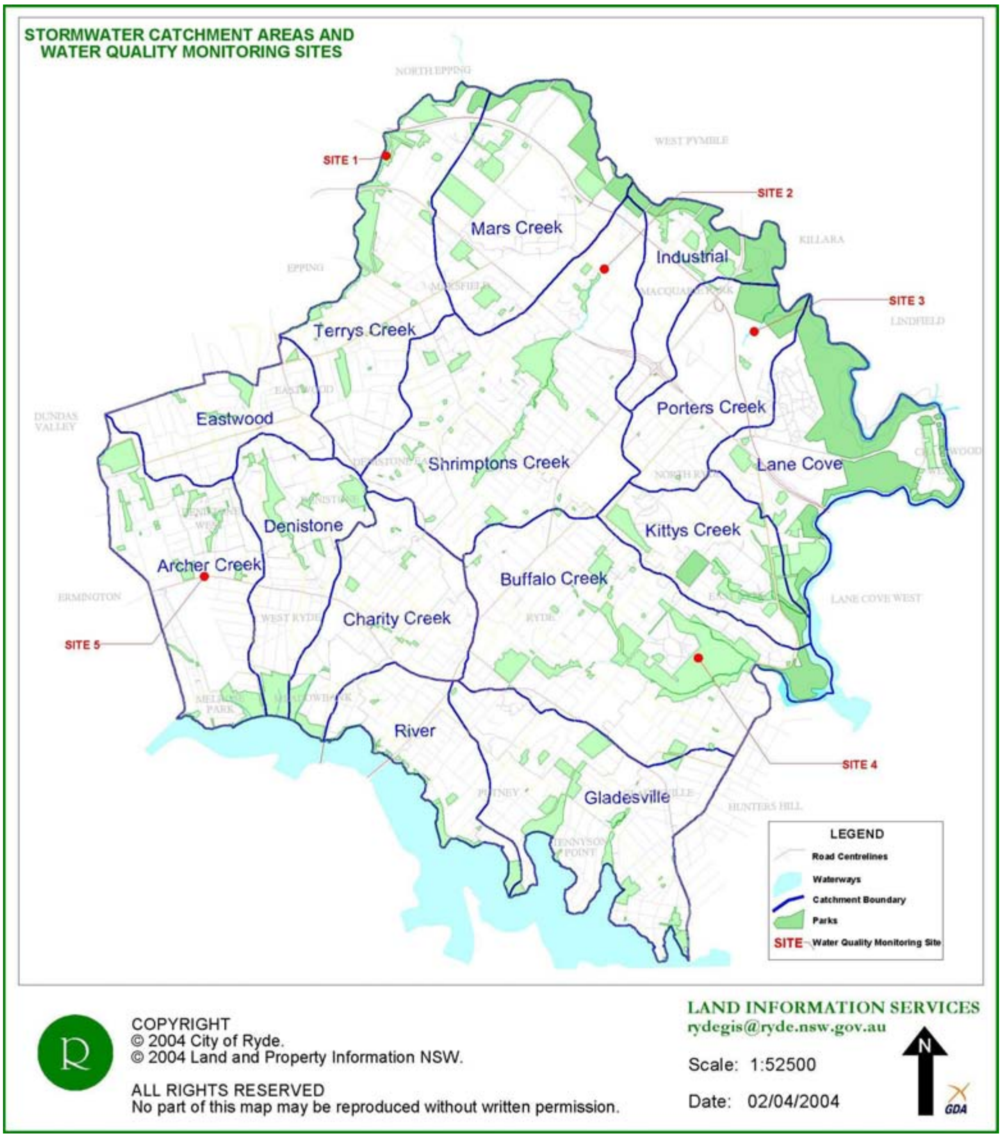

Figure 1 Site locations of the Biological and Chemical Water Quality Monitoring Strategy of the City of Ryde

2.2 Autumn 2008 sampling events

Two sampling events were conducted for Autumn 2008 for the City of Ryde Biological and Chemical Water Quality Monitoring Strategy. Sampling was conducted at all five creeks. These creeks were sampled in each of the following periods:

- 3rd to 5th March 2008
- 2nd to 4th April 2008

Figure 2 Archers Creek in Autumn 2008 showing completed rehabilitation work

3 Methodology

3.1 Macroinvertebrate sampling

Rapid assessment macroinvertebrate sampling was conducted in accordance with AUSRIVAS protocols for NSW (Turak *et al*., 2004). Sydney Water staff that conducted field sampling have met criteria of the in-house test method for macroinvertebrate identification and enumeration. Use of experienced staff addresses issues identified by Metzeling *et al.* (2003).

Three edge habitat samples were collected from each site within a pre-selected area in March and April within the season of Autumn 2008 as specified in the City of Ryde Biological and Chemical Water Quality Monitoring tender document COR-EOC-05/07. The 'edge' habitat, is defined as areas with little or no current. These areas were sampled with a hand-held dip net with 320 mm by 250 mm opening and 0.25 mm (250 µm) mesh that conformed to ISO 7828-1985 (E). The net was swept from open water towards the shore, working over a bank length of about 10 m moving in an upstream direction. In the process, deposits of silt and detritus on the stream bottom were stirred up so that benthic animals were suspended and then caught in the net.

The net contents were then emptied into a large white sorting tray with a small amount of water to allow live macroinvertebrate specimens to be picked out with fine forceps and pipettes for a period of 40 minutes. If new taxa are collected between 30 and 40 minutes, sorting will continue for a further 10 minutes. If no new taxa are found after 10 minutes the picking ceases. If new taxa are found, the 10 minute processing cycle is continued up to a maximum total sorting time of 1 hour. There is no set minimum number of animals collected using the NSW protocols (Turak, *et al.,* 2004).

All specimens collected will be preserved in small glass specimen jars containing 70% ethanol with a clear label indicating site code, creek name, date, habitat and name of Sydney Water staff sampler. Sampling equipment will be washed thoroughly between samples to prevent the cross contamination of animals.

3.2 Macroinvertebrate sample processing

Macroinvertebrates were identified and enumerated to the family taxonomic level, except for: non-biting midges (Chironomids) to sub-family; aquatic worms to Class Oligochaeta; and aquatic mites to Order Acarina. The method used, SSWI433 *In-house test method macroinvertebrate cataloguing, identification and counting,* is in compliance with the requirements of AS ISO/IEC 17025 *General Requirements for the Competence of Testing and Calibration Laboratories* under technical accreditation number 610 issued by National Association of Testing Authorities (NATA) and has been employed since 1997. In particular, macroinvertebrate identification was performed using appropriate published keys listed in Hawking (2000), internal keys to the Sydney water macroinvertebrate reference collection, unpublished descriptions and voucher specimens.

Quality assurance was conducted as per *SSWI434 In-house test method quality control of macroinvertebrate identification, counting and archiving of collections* in compliance with the requirements of AS ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories under technical accreditation number 610. Quality assurance was conducted on 5% of samples collected for this study. Quality assurance is further described in Appendix A.

3.3 Water quality sampling

Water chemistry was sampled once each month within Autumn 2008 (March and April) at the time of macroinvertebrate sampling.

Samples were taken by filling the sample bottles directly from the surface of the stream. Temperature, pH and dissolved oxygen were measured on site as per methods summarised in Table 1.

Table 1 Water chemistry parameters, method of analysis in field

ANALYTE	METHOD
pH, temperature	Yeokal 611 WTW meter
Dissolved Oxygen (mg/L)	HACH meter

Samples for the analysis of turbidity, conductivity, total dissolved solids (TDS), faecal coliforms, total phosphorus, total nitrogen (as a measure of total oxidised nitrogen and total Kjeldahl nitrogen), total alkalinity, ammonia, metals and speciated petrohydrocarbons were returned to the laboratory and analysed by the methods summarised in Table 2 within 12 hrs of sampling.

Table 2 Water chemistry parameters, method of analysis in laboratory

ANALYTE	DETECTION LIMIT	METHOD
Turbidity	0.10 NTU	APHA 2130B
Total Dissolved Solids	10 mg/L	APHA 2450 C
Faecal Coliforms	1 cfu/100mL	APHA 9222-D
Total Phosphorus	0.002 mg/L	APHA4500P- H
Alkalinity ($CaCO_3$/L)	0.5 mg/L	APHA 2320 B
Oxidised Nitrogen	0.01 mg/L	APHA 4500-NO3 I
Total Kjeldahl Nitrogen	0.1 mg/L	Calculation
Ammoniacal Nitrogen	0.01 mg/L	APHA 4500-NH3 H
Conductivity	0.1 mS/m	APHA 2510 B
Mercury		TM01TUL
Chromium		TM56TML
Iron		TM56TML
Copper		TM56TML
Zinc		TM56TML
Arsenic		TM56TML

Cadmium		TM56TML
Lead		TM56TML
TPH C6-C9		TC008WHL
TPH C10-C14		TC008WHL
TPH C15-C28		TC008WHL
TPH C29-C36		TC008WHL

Additional water quality sample collection and measurements in Autumn 2008 on Archers, Shrimptons, Buffalo and Porters creeks allowed spatial comparisons of collected variables on each creek in an attempt to investigate potential dry weather point sources.

Water quality sampling, while not to the frequency suggested by ANZECC (2000), the water quality results did allow characterisation of water quality of each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary).

3.4 Rainfall Data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 are presented where records were recorded. For the few missing records from station 066156, data were substituted from Sydney Water Meteorology Station number 566040 at West Epping.

3.5 Comparison with historical data

The City of Ryde Council Tender Number COR-EOC-05/07 requested compilation and analysis of all historic raw data (where comparable) back to 2004 and, where data was available back to 2001, for assessment with Autumn 2008 study data to provide a temporal evaluation of ecological health of the five creeks under study. Ecowise supplied raw macroinvertebrate and water chemistry data (Spring 2004 to Autumn 2006) and together with Spring 2006, Autumn 2007, Spring 2007 and Autumn 2008 data allowed the compilation of data points as summarised in Table 3. Previous data were unavailable in a suitable format for this purpose or had comparability issues such as the location sampled on Porters and Buffalo creeks in spring 2004.

Table 3 Summary of when, each variable was sampled, between Spring 2004 and Autumn 2008

	Sampling period																																							
	Spring 2004					Autumn 2005					Spring 2005					Autumn 2006					Spring 2006					Autumn 2007					Spring 2007					Autumn 2008				
	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck
Macroinvertebrates	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Alkalinity (Total)	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ammonia NH3-N						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Conductivity (mS/m)						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DO (mg/L)	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Faecal Coliform	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Oxidised Nitrogen NOx-N						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
pH	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Temp	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TN						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Dissolved Solids	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Kjeldahl Nitrogen						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Phosphorus	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Turbidity	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

3.6 Data analyses

After identification and enumeration of macroinvertebrates the data were analysed with univariate and multivariate analysis techniques.

Univariate methods

Data analyses were performed using a number of biological indices and predictive models. These included:

- Diversity index EPT (mayfly, stonefly, caddis fly) richness
- Biotic index SIGNAL-SF
- Output from AUSRIVAS predictive models (Eastern Edge Autumn; Eastern Edge Spring; Combined Edge)
  - AUSRIVAS OE50
  - AUSRIVAS OE0 SIGNAL2

The range of each measure has been plotted in this report with +/-1 standard deviation of the mean for basing ecological decisions (ANZECC, 2000). Presenting data in this way attempts to take account of variation at study sites and provide a basis in future years to enable management tracking and or as a basis for making management decisions.

EPT richness

The biotic index EPT (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera - caddisfly families) richness is based upon the sensitivity of these taxa to respond to changes in water quality condition (Lenat 1988). Generally the number of these taxa found at a site can be used as an indicator of stream biological health, although some EPT taxa are more tolerant.

Some caution must be given when interpreting patterns based on EPT taxa as many of these macroinvertebrates are also sensitive to natural changes in streams, such as altitude. In general, EPT taxa favour higher altitude streams to low altitude streams. However Sydney Water has observed a diverse range of these taxa at altitudes as low as 10 metres in undisturbed waterways in the greater Sydney region and in the Clyde River. The absence of these taxa in streams may be attributable to human disturbances within urban catchments and or decline in flow over recent years from lack of rainfall.

SIGNAL-SF

The original version of the Stream Invertebrate Grade Number Average Level (SIGNAL) biotic index (Chessman, 1995-Sydney Water data) has been refined by testing that included the response of SIGNAL to natural and human influenced (anthropogenic) environmental factors (Growns *et al*. 1995), variations in sampling and sample processing methods (Growns *et al*. 1997; Metzeling *et al*. 2003) and setting sensitivity grades of the taxa objectively (Chessman *et al*. 1997; Chessman *et al*. 2002). “F” indicates taxonomy is at the family level and “S” indicates Sydney region version. SIGNAL-SF has been derived from macroinvertebrate data of the greater Sydney region (Chessman *et al.*, 2007). Water quality status of clean water has been established in the index using data from near pristine reference sites in the bushland fringes of Sydney by using the 10th percentile of the average score of these reference sites. SIGNAL-SF allows a direct measure of test site condition and incorporates abundance information from the rapid assessment sampling.

The first step in calculating a SIGNAL-SF score is applying predetermined sensitivity grade numbers (from 1, tolerant to 10, highly sensitive) to family counts that occur within a location habitat sample. Then multiply the square root transformed count of each family by the sensitivity grade number for that family, summing the products, and dividing by the total square root transformed number of individuals in all graded families. Families that were present in the samples but with no grade numbers available (relatively few, only 4 with infrequent occurrence) were removed from the calculation of the SIGNAL-SF score for the sample. This procedure was repeated for each sample. Calculation then occurs of a location specific average and a measure of variation (plus and minus one standard deviation of the average score) through time as recommended by Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (2000) was made to allow stream health comparisons between sampling occasions for each creek and between creeks. Comparisons in this manner allow ranking of stream health as a guide to management decisions.

As aquatic mites (Order Acarina) and aquatic worms (Class Oligochaeta) are left at higher taxonomic levels in the AUSRIVAS protocol, the respective SIGNAL-SF grades of the families of aquatic mites and worms were averaged and used in the calculation of SIGNAL-SF scores for this report.

Arbitrary pollution categories can be assigned (Table 4). Sydney Water has successfully demonstrated the application of this index in stream monitoring of management changes to the sewerage system and subsequent organic pollution responses in creeks from these decisions (Besley & Chessman, 2008).

Table 4 Interpretation of SIGNAL-SF scores (Chessman et al., 2007)

SIGNAL-F score	Water quality status
> 6.5	Clean water
5.2-6.5	Possible mild organic pollution
3.8-5.2	Probable moderate organic pollution
< 3.8	Probable severe organic pollution

AUSRIVAS predictive models OE50 output

AUSRIVAS (AUStralian RIVers Assessment System) predictive model is based on the British bioassessment system RIVPACS (River Invertebrate Prediction and Classification System; Wright 1995). The RIVPACS model was modified to suit the environmental conditions present only in Australia (Turak *et al.* 2004). The AUSRIVAS model is an interactive software package, which uses the macroinvertebrate and environmental data collected from numerous reference river sites across the state of NSW. It is a tool that can quickly assess the ecological health of any river or creek site. Collected macroinvertebrate data are transformed into presence absence (1 or 0) form, which is also referred to as binary data. The predictor environmental variables required to run for each model vary as outlined in Tables 5 and 6 but generally include altitude, location (latitude and longitude), stream size characteristics, substratum composition, river alkalinity and rainfall (Turak 2001). These environmental variables allow the software to compare test sites, in this case City of Ryde creek samples, to comparable reference site groups with similar environmental characteristics.

AUSRIVAS models can incorporate data taken from pool edge or riffle habitats. The paucity of riffle habitats at the sites under study by the City of Ryde in sampling conducted for the program to date preclude use of the riffle models. Only four riffle samples were collected by Ecowise between Spring 2004 and Autumn 2006. Hence in comparison of Autumn 2007 data with historical data the respective edge models have been employed.

The applicable AUSRIVAS models for comparison of the City of Ryde test creek sites are: the eastern edge Autumn model; eastern edge Spring model; and Combined Season eastern edge model. However, Ecowise (Spring 2005) suggested the later model does not allow changes in condition between seasonal sampling events for the City of Ryde strategy. The later model has been included here for completeness as Ransom *et al.* (2004) describes this model as preferable as it maximizes the family list for the test site being examined.

The respective model uses the test site information and comparable reference site group information to calculate a score called the "OE50 ratio" (observed/expected number of macroinvertebrate families with greater than 50% probability of occurring at a test site) (Coysh *et al*. (2000). The OE50 ratio provides a measure of impairment at a test site (Ransom *et al.*, 2004). The OE50 ratio of each test site sample also corresponds to a band that assists in interpretation and aids management decisions (Coysh *et al.*, 2000). That is, the band helps to categorise each test site showing how it compares with reference sites from rivers of the same type. Interpretation of the five possible bands of river condition is detailed in Table 5 (Coysh *et al.*, 2000). Thresholds that correspond to these bands of each respective model are detailed in Table 6.

Table 5 Interpretation of bands associated with AUSRIVAS OE50 model output (Coysh et al., 2000)

Band	Description	O/E taxa	O/E taxa interpretations
X	More biologically diverse than reference	▪ O/E greater than 90th percentile of reference sites used to create the model	▪ More families found than expected ▪ Potential biodiversity 'hot spot' or mild organic enrichment ▪ Continuous irrigation flow in a normally intermittent stream
A	Similar to reference	▪ O/E within range of central 80% of reference sites used to create the model	▪ Expected number of families within the range found at 80% of the reference sites
B	Significantly impaired	▪ O/E below 10th percentile of reference sites used to create the model. ▪ Same width as band A	▪ Fewer families than expected ▪ Potential impact either on water and/or habitat quality resulting in a loss of families
C	Severely impaired	▪ O/E below band B ▪ Same width as band A	▪ Many fewer families than expected ▪ Loss of families from substantial impairment of expected biota caused by water and/or habitat quality
D	Extremely impaired	▪ O/E below band C down to zero	▪ Few of the expected families and only the hardy, pollution tolerant families remain ▪ Severe impairment

Table 6 Upper thresholds for bands of impairment (OE50 taxa) for AUSRIVAS models developed for NSW (Turak and Waddell, 2001)

Model	**Threshold**			
	A	B	C	D
Combined edge (East)	1.17	0.82	0.48	0.14
Autumn edge	1.17	0.81	0.46	0.11
Spring edge	1.16	0.83	0.51	0.19

Indicator taxa from the AUSRIVAS predictive models output

AUSRIVAS output identifies taxa that were expected from the respective reference site group to which a test site is being compared. As part of this output missing taxa are listed with greater than 50% probability of occurrence. To provide consistency in this report the definition used by Ecowise (2004, 2005a, 2005b, 2006) has been used in this report. That is, indicator taxa are defined as taxa within the EPT (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera – caddisfly) orders with SIGNAL2 scores of greater than 6.

AUSRIVAS predictive models OE0 SIGNAL-2 output

Together with OE50 output each AUSRIVAS model also generates AUSRIVAS OE50-SIGNAL2 values and AUSRIVAS OE0-SIGNAL2 values. This output incorporates SIGNAL2 (Chessman 2003a) tolerance grades derived from reference sites across NSW sampled to create the AUSRIVAS models in NSW. Please note SIGNAL2 tolerance grades are different to the greater Sydney region tolerance grades of SIGNAL-SF as the later has been derived from sites of the Sydney region and not from broadly across NSW.

An example calculation of AUSRIVAS OE50-SIGNAL2 values is provided in previous Ecowise reports, which sourced this example from Chessman (2003a). In the Spring 2006 report AUSRIVAS OE50 SIGNAL2 values were found to be quite variable and for this reason were not recommended for use in future temporal comparisons. That is, the large variation recorded in this measure provided little ability to detect future changes in community structure from future management decisions.

In contrast AUSRIVAS OE0-SIGNAL2 values were found to have less variance and were recommended to be calculated in Autumn 2007 and beyond. The lesser variation of AUSRIVAS OE0-SIGNAL2 is attributed to the inclusion of taxa with 50% probability of occurrence or more used to calculate AUSRIVAS OE50-SIGNAL2 and additional taxa with less than 50% probability of occurrence.

No bands have been developed for SIGNAL2 (Coysh *et al.* 2000), however, values of around 1 would be similar to reference condition (Chessman pers comm.). Using AUSRIVAS calculated values are recommended by Chessman (2003a) as a way to overcome natural variation, which is an issue for calculation of SIGNAL2 as described in Chessman (2003b).

Multivariate methods

Data analyses were performed using the PRIMER software package (Clark and Warwick 2001). Analysis techniques included:

- Classification and ordination,
- SIMPER
- BIOENV

These analysis techniques complement univariate analyses by exploring patterns of macroinvertebrate community structure. Macroinvertebrate community structure at a site can also be referred to as the biological signature. Prior to analysis the data from the field survey was square root transformed and rare taxa observed in only one sample were removed.

Autumn 2008 macroinvertebrate samples were compared in an ordination with 2005, 2006, 2007 and Autumn 2008 data for all creeks of the monitoring program to look at context of community composition. Please note Spring 2004 data were not included in these comparisons as comparable sites in Buffalo and Porters creeks were not sampled in Spring 2004 and also not sampled in Spring 2004 were all water quality variables at Archers Shrimptons and Terrys creeks (Table 3).

Macroinvertebrate data of each creek were also explored by a comparison of data from the seasons, Autumn 2005, Spring 2005, Autumn 2006, Spring 2006, Autumn 2007, Spring 2007 and Autumn 2008.

Classification and Ordination

The group average classification technique was used to place the sampling sites into groups, each of which had a characteristic macroinvertebrate community based on relative similarity of their attributes. Similarities (distances) between the fauna of each pair of sites were calculated using the Bray-Curtis measure, which is not sensitive to rough approximations in the estimation of taxa abundances (Faith *et al.* 1987), as is the case with rapid assessment sampling. The group average classification technique initially forms pairs of samples with the most similar taxa and gradually fuses the pairs into larger and larger groups (clusters) with increasing internal variability.

Classification techniques will form groups even if the data set actually forms a continuum. In order to determine whether the groups were 'real' the samples were ordinated using the non-metric multidimensional scaling (MDS) technique. Ordination produces a plot of sites on two or three axes such that sites with a similar taxa lie close together and sites with a differing taxon composition lie farther apart. Output from classification is then checked against ordination groupings to assist with interpretation.

Any ordination procedure inevitably introduces distortion when trying to simultaneously represent the similarities between large numbers of samples in only two or three dimensions. The success of the procedure is measured by a stress value, which indicates the degree of distortion imposed. In the PRIMER software package a stress value of below 0.2 indicates an acceptable representation of the original data although lower values are desirable.

To achieve suitable mutlivariate representations of data in 2 or 3 dimensions with greater data collection, an analysis strategy to minimize stress (and achieve a better measure of fit) is to pool up macroinvertebrate data of the same season for each creek to produce one data point per season per creek as demonstrated in the Spring 2007 report for all five creeks. This analysis strategy has been adopted for the ordination plot of all creeks in this report.

SIMPER

The SIMPER routine was employed to investigate community structure between and within groups of sites as detailed above. This routine employs Bray Curtis similarities to examine the contribution of individual taxa to the average similarity between groups and also within groups.

BIOENV

The extrinsic physical and chemical characteristics of the creeks were compared with the intrinsic macroinvertebrate community structure using the BIOENV routine. The underlying similarity matrix was constructed with the normalised Euclidean Distance association measure option. This option enabled a comparison of water quality variables without undue weight being assigned by differing unit scales. Log10 transformations were applied to: Faecal Coliforms; Ammonia; Oxidised Nitrogen; Total Phosphorus; Total Kjeldahl Nitrogen; Total Nitrogen; Turbidity; Conductivity; and Total Dissolved Solids. All other physical and chemical variables listed in Table 2 were untransformed in the BIOENV analysis.

4 Results

4.1 Water quality & site observations

The field and laboratory results for water quality parameters measured at Archers, Shrimptons, Buffalo, Porters and Terrys creeks in Autumn 2008 are presented in Table 7, while not to the frequency suggested by ANZECC (2000), did allow characterisation of water quality for each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary).

The dissolved oxygen saturation levels from Archers, Buffalo and Terrys creeks during Autumn 2008 were well below the 85% recommended level within ANZECC (2000) for the protection of aquatic ecosystems. Shrimptons Creek recorded its highest level of dissolved oxygen in March 2008 at 86.4% saturation, just above the lower ANZECC (2000) limit for the protection of aquatic ecosystems. However, this site still has the lowest overall historical average between Spring 2004 and Spring 2007 of 46% saturation. Porters Creek was the only other site to record a dissolved oxygen level within the ANZECC (2000) recommended guidelines in the April sampling session during Autumn 2008. Porters Creek is also the creek with the highest overall historical average dissolved oxygen levels (90.5%, Table 7) in the period Spring 2004 to Spring 2007.

Additional water quality sample collection and measurements on Archers, Shrimptons, Buffalo and Porters creeks allowed spatial comparisons of collected variables on each creek in an attempt to investigate potential dry weather point sources.

This spatial comparison of Dissolved Oxygen with upstream sites on Porters, Shrimptons and Archers Creeks shows no apparent decline or improvement with increasing distance upstream from the downstream core site (Table 8). However on Buffalo Creek the two upstream Burrows Park sites had a lower Dissolved Oxygen result than for the core downstream Buffalo Creek site (Site 4) during March 2008. The opposite trend was recorded during April 2008 where both Burrows Park sites record a higher dissolved oxygen result than the downstream core site (Site 4).

Bacteriological results were compared with ANZECC (2000) guidelines for secondary contact (recreation). Since water bodies sampled for City of Ryde were unlikely to be used for primary contact purposes such as swimming, it was considered that application of the secondary contact guidelines were appropriate. However, it must be noted that comparisons with these guidelines do not infer a measure of compliance with the guidelines, as samples have not been collected under an appropriate regime for compliance monitoring (five samples in a 30 day period). The comparisons are indicative only to provide a degree of context to bacteriological results obtained. All samples taken from the five core COR sites during Autumn 2008 were below the ANZECC (2000) limit of 1000 CFU/100mL indicating all creeks were within safe levels for secondary contact.

During the March sampling period the two additional sites in the upper Buffalo Creek catchment at Burrows Park upstream of the core site (Site 4) recorded elevated non-compliant levels of faecal coliforms compared to ANZECC (2000) (4500 and 10,000 CFU/100mL, Table 8). The elevated levels of faecal coliforms at Burrows Park on Buffalo Creek are either diluted or levels have decayed by the time they travel down to the core site (Site 4) as CFU levels, although 600% higher in March than April, (620 to 120 CFU/100mL respectively, Table 7), conformed to ANZECC (2000) recommended levels of 1000CFU/100mL.

The most upstream site on Shrimptons Creek at Santa Rosa Park, during April 2008 was the only other additional site to have elevated faecal coliform levels above the recommended ANZECC (2000) guidelines (4200CFU/100mL, Table 8). As with Buffalo Creek, the downstream core site (Site 2) had lower faecal coliforms for April 2008 of 700 CFU/100mL (Table 7). In contrast faecal coliform levels in Porters Creek during March and April 2008 varied between sites and sample dates.

Turbidity levels were within acceptable ANZECC (2000) ranges for all core site samples taken from Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Autumn 2008. Turbidity levels at the additional upstream sites during Autumn 2008 were notably higher at two locations (Table 8). The first being Buffalo creek at the two sites at Burrows Park. These were found to be 72.2 and 87.3 NTU in March 2008 (turbidity readings were not taken in April 2008). The second additional site to have an elevated turbidity level was upstream of the core Porters Creek site (Site 3) at the storm water Junction Pit. This was at a level over 12 times the recommended ANZECC (2000) limit of 50 NTU (625 NTU). Visual changes from mild to extreme turbidity occurred during the actual sampling day in April 2008.

Total Oxidised Nitrogen as a measure of nutrient levels were elevated above ANZECC (2000) guidelines for the protection of aquatic ecosystems for all samples at Terrys, Porters, Buffalo and Archers Creeks in Autumn 2008. Shrimptons Creek had the lowest recorded levels of Total Oxidised Nitrogen for the combined sampling period for Autumn 2008 compared to the historical results from Spring 2004 (Appendix 2). In the last two sampling seasons (Spring 2007 and Autumn 2008) Shrimptons Creek has not exceeded ANZECC (2000) guidelines for Total Oxidised Nitrogen. At Shrimptons Creek in Autumn 2008, unlike Total Oxidised Nitrogen, Total Phosphorus levels were elevated above ANZECC (2000). All other creeks had Total Phosphorous levels within the recommended guidelines (ANZECC, 2000). Total Phosphorous levels in Archers Creek dropped to well below ANZECC (2000) and the historical average in both March and April of Autumn 2008 (20 and 22µg/L respectively). Similar results were last seen at Archers Creek in Spring 2005 (Appendix 2). Shrimptons and Porters Creek had the highest Total Nitrogen levels in Autumn 2008 (Table 7), which are well over the acceptable ANZECC (2000) guideline of 500 µg/L for the protection of aquatic ecosystems

Ammonia levels exceeded ANZECC (2000) recommended levels of 20 µg/L at Archers, Buffalo and Porters Creeks on both sampling occasions in Autumn 2008 and for all historical averages between Spring 2004 and Spring 2007 indicating potentially toxic pollution events may have occurred in these streams. Shrimptons and Terrys Creeks both complied with recommended Ammonia levels for March and April sampling sessions in Autumn 2008, which reflects similar results in Spring 2007 at these two sites (Sydney Water 2007b, Table 7).

Conductivity (as a measure of salinity) was within ANZECC (2000) recommendations for all samples at all five creeks in Autumn 2008 and with the exception of Porters Creek this was the case for historical averages from the other four creeks between Spring 2004 and Spring 2007 (Table 7). The level of conductivity in Porters Creek on average was 3080 µs/cm (Table 7), which is well above the upper ANZECC (2000) limit of 2200 µs/cm for the protection of aquatic ecosystems, indicating that the stream health may be affected in Porters Creek.

The pH was within acceptable ranges (ANZECC, 2000) for most samples within Autumn 2008 at Archers, Shrimptons, Buffalo, Porters and Terrys creeks with the exception of March 2008 at Buffalo Creek where a pH level of 8.1 was recorded which was a minimal 0.1 above the upper ANZECC (2000) guideline for the protection of aquatic ecosystems.

Additional Metal & Petrochemical Analysis at Buffalo Ck

Of the eight metals analysed at Buffalo Creek only three exceeded the maximum levels recommended by ANZECC (2000), these include cadmium, copper and zinc (Table 9).

Zinc levels in Buffalo Creek were elevated to 57 µg/L (Table 9), which is over seven times the recommended ANZECC (2000) limit of 8 µg/L.

Cadmium levels in Buffalo Creek were elevated to 1 µg/L (Table 9), which is five times the recommended ANZECC (2000) limit of 0.2 µg/L.

Copper levels in Buffalo Creek were elevated to 19 µg/L (Table 9), which is thirteen times the recommended ANZECC (2000) limit of 1.4 µg/L.

Speciated petroleum hydrocarbons can be present in stream sediments as a result of spills, leakages and the combustion of fossil fuels. Results in Buffalo Creek were below detection limits and as such do not appear to pose a problem to aquatic life (Table 9).

Water quality results for comparable samples are consolidated in Appendix 2.

Table 7 ***Water quality results for Autumn 2008 in relation to the ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary)***

Parameter Units		**Faecal Coliform CFU/100mL**	**NH^{4+} µg/L**	**NOx µg/L**	**TP µg/L**	**TKN µg/L**	**TN µg/L**	**Alkilinity mg CaCO$_3$/L**	**Turb NTU**	**Cond-uctivity µS/cm**	*TDS* **mg/L**	**pH**	**DO % Sat**	**Temp-erature ^{0}C**
ANZECC (2000)	***Aquatic Ecosystems***	*-*	*20*	*40*	*50*	N/A	*500*	*N/A*	*50*	*125-2200*	*N/A*	*6.8-8.0*	*85-110*	*-*
	Secondary Contact	*1000*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
ARCHERS CK	March	170	30	370	20	290	660	77.5	2.18	513	310	7.3	63	19.8
	April	160	40	110	22	230	340	83	1.48	470	253	7.28	73	16.7
	Historical*	**778**	**39**	**123**	**55**	**350**	**472**	**71**	**4.95**	**418**	**247**	**7.1**	**63.2**	**17.7**
SHRIMPTONS CK	March	200	10	10	53	670	680	74	3.17	358	214	7.4	86.4	17.3
	April	700	10	10	92	620	620	73	6.17	291	130	7.16	39.5	16.8
	Historical*	**687**	**42**	**193**	**58**	**460**	**630**	**63**	**10.69**	**360**	**218**	**6.9**	**46.0**	**16.81**
BUFFALO CK	March	620	40	450	35	370	820	91	37.2	885	552	8.1	75.3	21
	April	120	50	220	33	260	480	77	4.69	654	389	7.3	81	15.8
	Historical*	**826**	**76**	**276**	**41**	**352**	**590**	**79**	**8.76**	**653**	**368**	**7.2**	**64.5**	**17.0**
PORTERS CK	March	530	250	430	38	1100	1530	81	15.2	650	444	7.6	69.5	19.3
	April	370	750	300	27	1100	4100	100	3.96	505	290	7.56	95.4	16.9
	Historical*	**3244**	**627**	**995**	**26**	**1062**	**2051**	**59**	**4.82**	**3080**	**1934**	**7.5**	**90.5**	**18.5**
TERRYS CK	March	150	10	270	24	310	580	71.5	3.21	474	284	8	76.1	21.9
	April	250	10	120	25	200	320	64	3.1	351	160	7.32	84.3	15.7
	Historical*	**369**	**114**	**133**	**43**	**397**	**531**	**56**	**4.76**	**359**	**214**	**7.0**	**60.5**	**15.31**

Historical* = Average of historical water quality data for samples taken from Spring 2004 – Spring 2007.

Table 8 ***Water quality results at additional COR sites for Autumn 2008 in relation to the ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary)***

Parameter Units		Faecal Col CFU/ 100mL	NH^{4+} µg/L	NOx µg/L	TP µg/L	TKN µg/L	TN µg/L	Alkilinity mg $CaCO_3$/L	Turb NTU	Cond-uctivity µS/cm	*TDS* mg/L	pH	DO % Sat	Temp-erature ^{0}C
ANZECC (2000)	***Aquatic Ecosystem***	-	*20*	*40*	*50*	N/A	*500*	*N/A*	*50*	*125-2200*	*N/A*	*6.8-8.0*	*85-110*	-
	Secondary Contact	*1000*	-	-	-	-	-	-	-	-	-	-	-	-
ARCHERS CREEK	**Historical***												**63.2**	
Archers Ck Warrawong St	March												61.6	
Archers Ck Jayne St	March												50.4	
Archers Ck Denman St	March												81	
SHRIMPTONS CREEK	**Historical***	**687**	**42**	**193**	**58**	**460**	**630**	**63**	**10.69**	**360**	**218**	**6.9**	**46.0**	**16.81**
Shrimptons Ck Beswick Rd	March												56.2	
Shrimptons Ck Kent Rd	March	650	30	40	41	330	370	37.5	6.02	291	170	6.8	22.3	19
	April	25	10	20	34	230	250	37	2.58	184	86	7.23	62.7	16.3
Shrimptons Ck Lucinda Rd	March												58.4	
Shrimptons Ck Bridge St	March												86.7	
Shrimptons Ck Santa Rosa Pk	March	490	20	970	40	420	1390	101	7	889	548	7.7	60.4	22.2
	April	4200	10	30	20	330	360	134	3.5	903	487	7.22	68	18.1

Historical* = Average of historical water quality data for samples taken from Spring 2004 – Spring 2007.

Table 8 ***Water quality results at additional COR sites for Autumn 2008 in relation to the ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary)*** (Continued)

Parameter Units		**Faecal Col CFU/ 100mL**	**NH^{4+} µg/L**	**NOx µg/L**	**TP µg/L**	**TKN µg/L**	**TN µg/L**	**Alkilinity mg $CaCO_3$/L**	**Turb NTU**	**Cond-uctivity µS/cm**	*TDS* **mg/L**	**pH**	**DO % Sat**	**Temp-erature ^{0}C**
BUFFALO CREEK	**Historical***	**826**	**76**	**276**	**41**	**352**	**590**	**79**	**8.76**	**653**	**368**	**7.2**	**64.5**	**17.0**
Buffalo Ck d/s Burrows Pk	March	4500	10	540	45	410	950	84	72.2	2173	1320	7.3	71.3	21.8
	April	860										7.06	94.1	17.7
Buffalo Ck us Burrows Pk	March	10000	20	890	71	520	1410	88	87.3	763	468	7.5	70.1	21.7
	April	600										7.71	109.4	17
PORTERS CREEK	**Historical***	**3244**	**627**	**995**	**26**	**1062**	**2051**	**59**	**4.82**	**3080**	**1934**	**7.5**	**90.5**	**18.5**
Porters Ck Spur Branch	March	410	110	260	49	540	800	106	8.63	474	302	7.8	81	21.4
	April	920	100	220	1530	960	1180	68	625	318	172	7.56	120.2	17.6
Porters Ck Main Branch Channel (COR staff site)	March	210	110	120	43	370	490	55.5	19.5	152	92	7.1	84.2	23
	April	62	70	80	37	420	500	60	2.88	154	70	6.95	69.3	17.2
Porters Ck Main Branch Wicks Rd	March	540	10	110	32	630	740	74	20.7	661	454	8.5	76	22.6
	April	120	70	1150	51	520	1670	54	31.6	713	385	9.05	114.5	19.5

Historical = Average of historical water quality data for samples taken from Spring 2004 – Spring 2007.*

Table 9 ***Metal and Speciated Petrohydrocarbon concentrations at Buffalo Creek for Autumn 2008 in relation to the ANZECC (2000) guidelines for protection of 95% of species***

	ANZECC (2000) Protection 95% species	**BUFFALO CK March 08**
METAL ug/L		
Total Mercury	0.6	<0.1
Total Chromium	1	<1
Total Iron	ID	173
Total Copper	1.4	19
Total Zinc	8	57
Total Arsenic	37	<1
Total Cadmium	0.2	1
Total Lead	3.4	2
SPECIATED PETRO HYDROCARBONS mg/L		
C6-C9	ID	<0.05
C10-C14	ID	<0.1
C15-C28	ID	<0.1
C20-C36	ID	<0.2

Note: ID= indeterminate

Figure 3 ***Buffalo's Creek d/s Burrows Park in Autumn 2008***

4.2 Rainfall Data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 presented below displays the Autumn 2008 sampling period and preceding five months (Figure 4). In the five months preceding the March 2008 sampling event 729 mm of rainfall occurred within a range of 50 – 150 mm per month with the exception of 275 mm falling in February 2008. The annual rainfall for 2007 was 1430 mm. This is the first year since 2003 with 1262mm to record above average results (Table 10).

Table 10 Total rainfall by year

Year	Rainfall (mm)
2003	1262
2004	905
2005	788
2006	730
2007	1430

The rainfall in early to mid 2007 was characterised by infrequent, short but heavy rainfall periods between relatively longer dry periods with the exception of June 2007 (Appendix 3). This pattern changed in late 2007 to early 2008 to longer, lighter rain periods in between shorter dry periods.

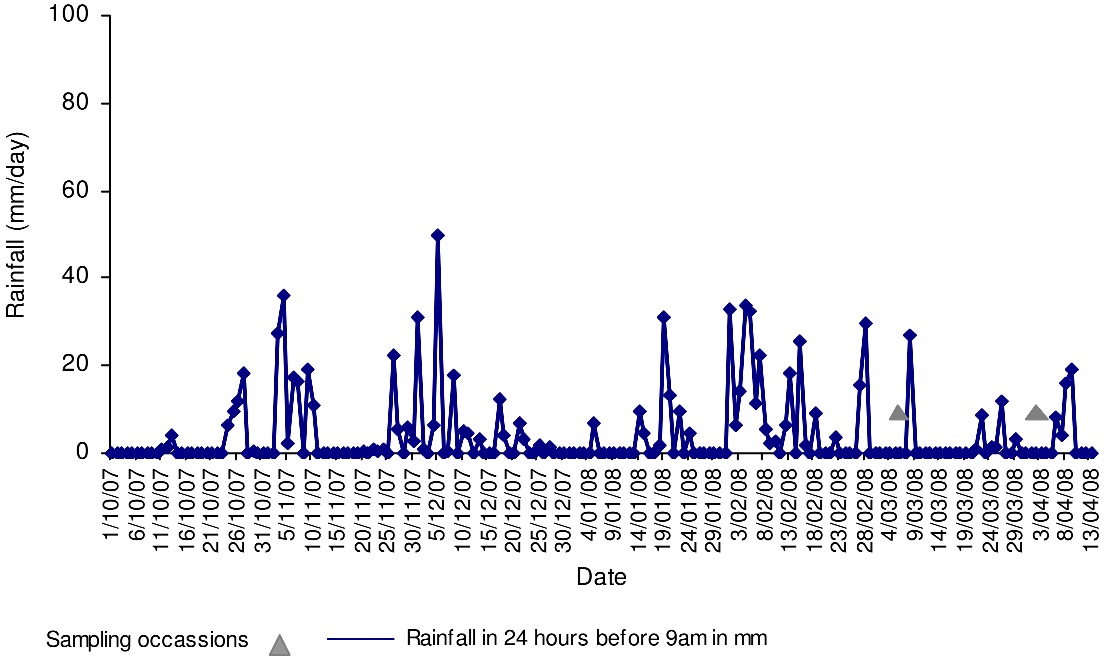

Figure 4 Daily rainfall data 1st October 2007 to 30th April 2008 with sampling occasions indicated

4.3 Macroinvertebrate Results

General Characteristics of Aquatic Macroinvertebrate Assemblages

A total of 1 811 macroinvertebrates were collected and examined from the five core sites in the Autumn sampling period which saw visits to Archers, Shrimptons, Buffalo, Porters and Terrys creeks, with 51 taxa recorded. A total of 73 taxa have been recorded from all creeks in the Spring 2004 to Autumn 2008 period from the edge habitat. This compares with 157 taxa of the SIGNAL-SF index of the greater Sydney region, although that total not only includes taxa from the pool edge habitat but other stream habitats.

Comparison of taxa collected in each creek between varying sampling periods such as Spring 2004 to Spring 2007 and Spring 2004 to Autumn 2008 indicates additional taxa have been collected in Autumn 2008 for each creek (Table 11). With additional seasonal sampling planned under the strategy it is likely further additional taxa will be recorded, particularly if average or above average rainfall continues.

Table 11 Number of taxa recorded in each creek in below specified sample periods

Sampling Seasons	Archers	Shrimptons	Buffalo	Porters	Terrys
Spring 04- Spring 07	48	45	46	45	51
Spring 04- Autumn 08	50	46	47	48	53

Neither larvae of the Sydney Hawk Dragonfly *Austrocordulia leonardi* (listed as endangered under the *FM Act*) or the Adams Emerald Dragonfly *Archaeophya adamsi* (listed as vulnerable under the *FM Act 1994*) were observed in Autumn 2008 samples and are not listed in historical data supplied.

Macroinvertebrate results for comparable samples (Table 3) are consolidated in Appendix 4.

EPT richness

The average EPT taxa richness for each sampled creek was summarized for all sampled seasons in Figure 5. This summary indicated that EPT taxa are rarely collected from the five sampled creeks with Buffalo and Porters Creeks having the highest average, yet neither of these two creeks averaged a single EPT taxa per sampling period (Figure 6). Autumn 2008 saw a slight rise in EPT taxa richness for Buffalo Ck, but all other creeks saw EPT taxa richness drop compared to Spring 2007 with Shrimptons and Terrys Creeks not recording a single EPT taxa (Figure 6).

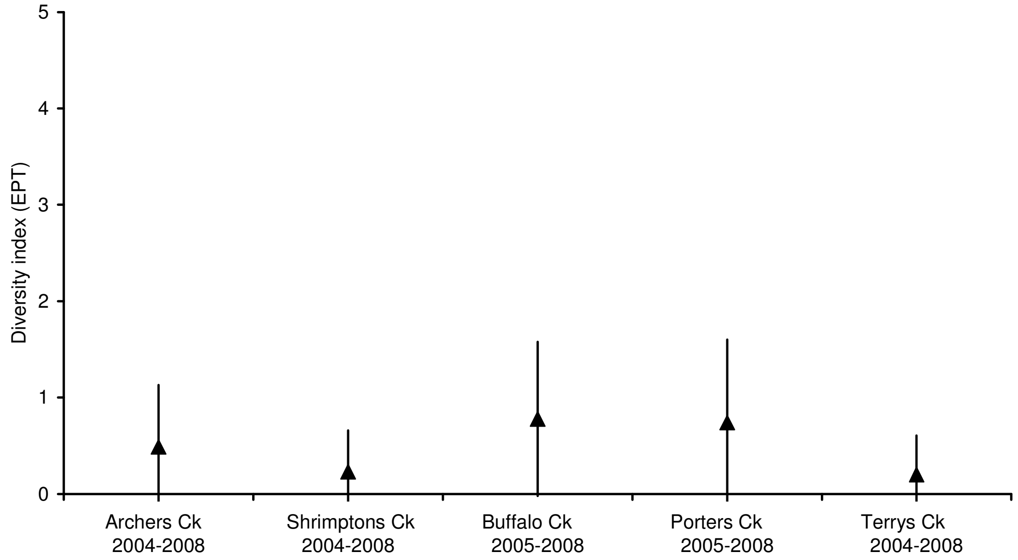

Figure 5 EPT richness of all creeks of monitoring program

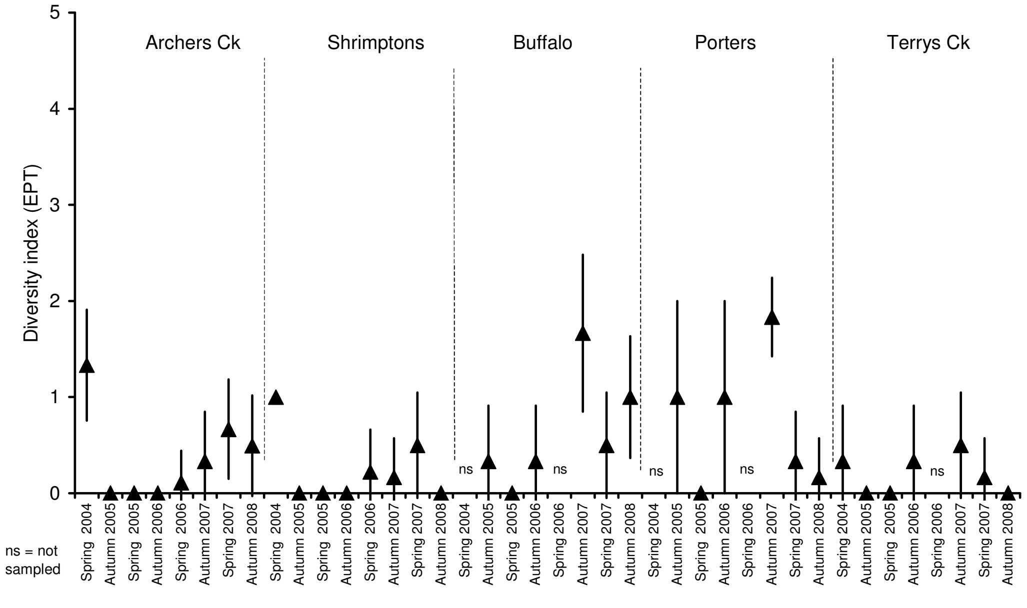

Figure 6 EPT richness by season

SIGNAL-SF

Stream health as described by the SIGNAL-SF biotic index results indicate impaired macroinvertebrate communities, this is most likely due to polluted water quality inputs via efficient stormwater delivery systems and other urban disturbances within catchments of all study creeks (Figure 7 and Figure 8).

Average stream health slightly increased in Autumn 2008 for Archers, Buffalo and Porters Creeks compared to Spring 2007, however average stream health for Shrimptons Creek decreased, while average stream health in Terrys was slightly lower (Figure 7).

Average scores, of these five creeks for all seasons combined (Spring 2004 to Autumn 2008)), occur in the probable moderate organic pollution category (Figure 8, Table 4). The Autumn/Spring 2005 and Autumn 2008 data points of Shrimptons Creek (Figure 7) were the only periods to occur in the probable severe organic pollution category (Table 4).

Shrimpton's Creek stream health had been steadily improving each sampling period since Autumn 2005, however stream health has dropped in Spring 2007 and again in Autumn 2008. This has resulted in it returning to the probable severe organic pollution category (Table 4).

Archers Creek continued its trend of average stream health being higher in autumn seasons and lower in spring seasons. Autumn 2008 saw Archers Creek record it's highest score since sampling began in Spring 2004 (Figure 7).

The range of stream health recorded for Buffalo, Porters and Terrys creeks is relatively narrow and average stream health of Autumn 2008 is within the range previously recorded (Figure 7 & 8).

Archers Creek narrowly had the highest average stream health when assessed with SIGNAL-SF from macroinvertebrate sampling between 2004 and 2008 (Figure 8). Although when all five creeks are compared in terms of ANZECC (2000) guidelines (+/-1 standard deviation of the average), the overlapping ranges of stream health, indicate no difference was exhibited between the creeks (Figure 8). The larger range recorded for Shrimptons Creek reflects the temporal change in stream health recorded in Figure 7.

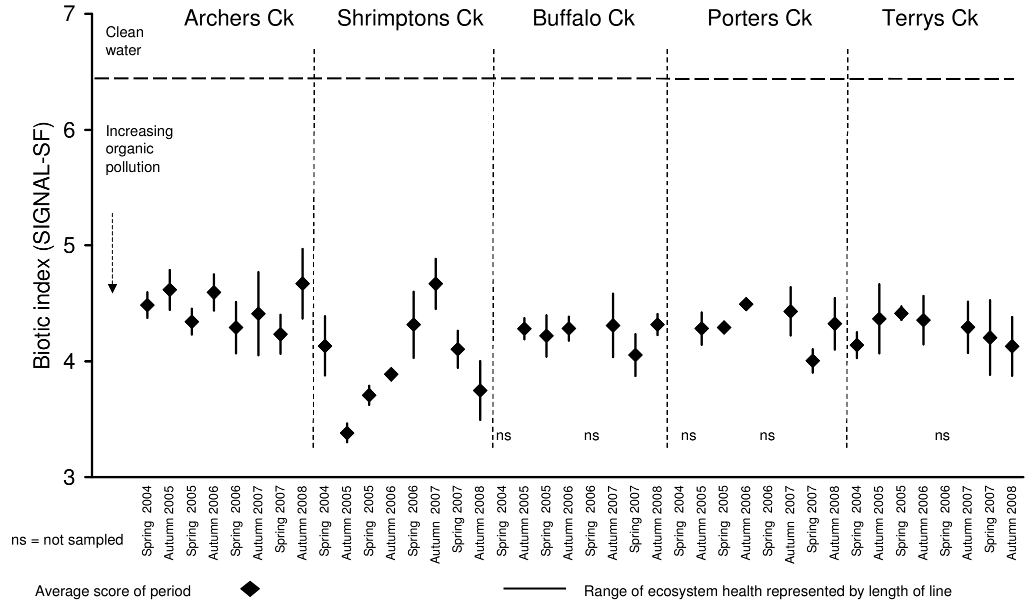

Figure 7. SIGNAL-SF by season

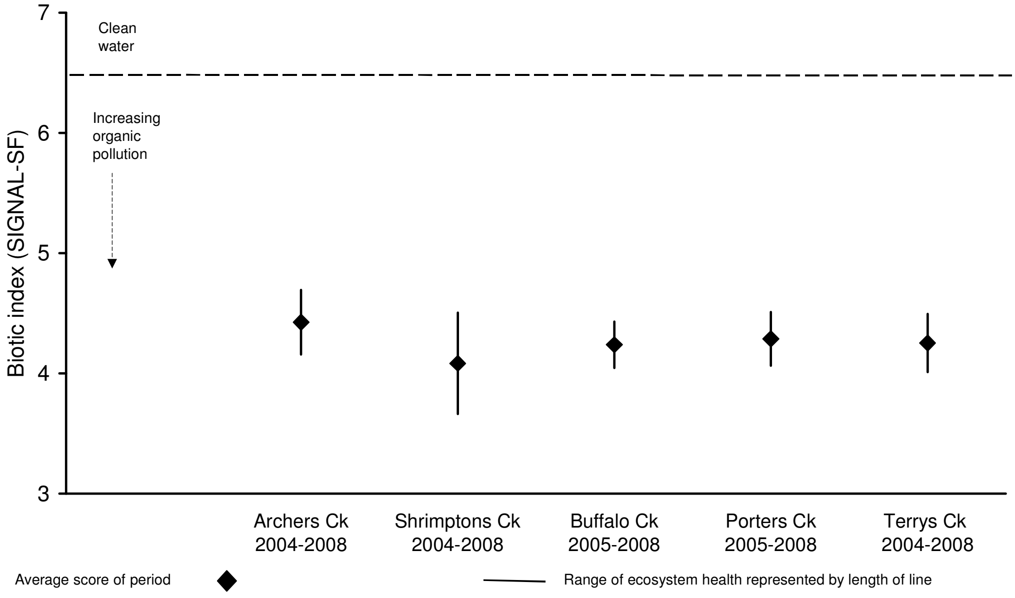

Figure 8. SIGNAL-SF of all creeks of monitoring program

AUSRIVAS OE50

The Autumn edge model for 2008 does not include an average score for OE50 for Archers Creek. The output for the model stated that it was *outside the experience of the model*, this didn't affect the Combined Season model, which does have a result for Archers Creek for 2007/08.

With the addition of Autumn 2008 data to the Autumn edge model AUSRIVAS OE50 the average value of stream health dropped from significantly impaired in 2007 to severely impaired in 2008 for Shrimptons, Buffalo, Porters Creeks and Terrys creeks. Shrimptons, Buffalo and Porters Creeks had a considerable decline in stream health (range of health did not overlap that of the previous season), whereas Terrys Creek only just fell into the severely impaired band (with its range of health overlapping that of the previous season) (Figure 10, Table 5 & 6).

The Combined Season edge model AUSRIVAS OE50 showed an increase in average stream health from 2006/07 to 2007/08 for Archers and Shrimptons Creeks. Stream health in Archers Creek went from the severely impaired band in 2006/07 to the significantly impaired band in 2007/08. Archers Creek improvement is in contrast to previous years were it has steadily declined since 2004/05. Average stream health in Shrimptons Creek has continued to improve since 2005/06 where it was recorded in the extremely impaired band (Figure 11, Table 5 & 6). Stream health in Porters and Terrys Creeks decreased from 2005/06 to 2007/08 moving from the significantly impaired band to the severely impaired band. Buffalo Creek showed the same trend, however, both combined years are plotted very close together on the threshold of the two bands, hence no real change was observed in stream health categories (Figure 11, Table 5 & 6).

Output of the Autumn edge model AUSRIVAS OE50 are generally a category higher (significantly impaired) compared to that of the Spring edge model (severely impaired) for all creeks, with Shrimptons Creek being the only possible exception (Figure 9 & 10). This trend is generally reflected in the pooled average scores of all sampled years (Figure 12 & 13).

The addition of more data points to the Combined season edge model comparing the five creeks with all samples pooled (Figure 14) saw increased variability in the range of stream health. This range of variability was similar for the pooled data of the Spring and Autumn models (Figure 12 & 13).

The Spring eastern edge, Autumn eastern edge and Combined Season edge AUSRIVAS OE50 model output comparing the five streams with all sampling periods pooled (Figure 12, 13 and 14), indicated the range of stream health of all creeks were similar, apart from model differences highlighted above, which aligns with the SIGNAL-SF results (Figure 8). Although the OE50 range of stream health is relatively larger than that of SIGNAL-SF.

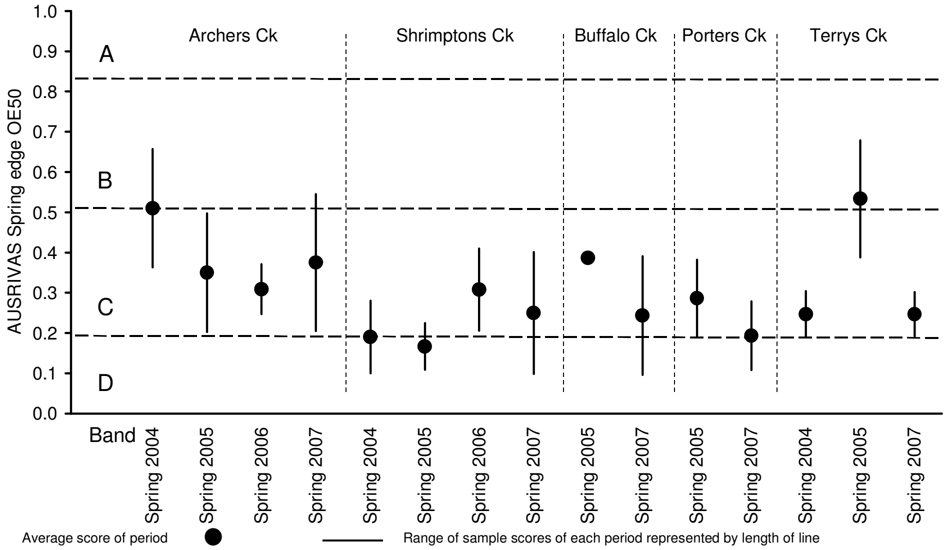

Figure 9. AUSRIVAS OE50 of all creeks from Spring edge model

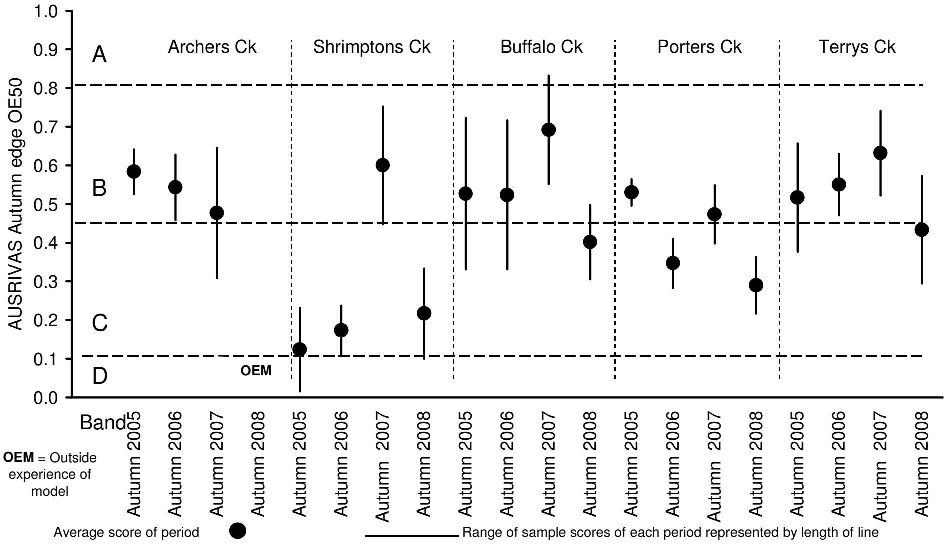

Figure 10. AUSRIVAS OE50 of all creeks from Autumn edge model

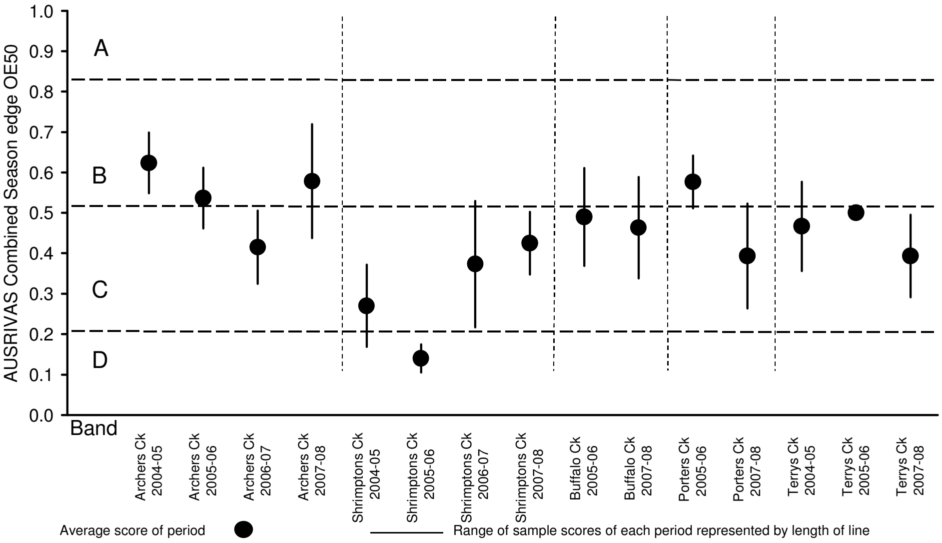

Figure 11. ***AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)***

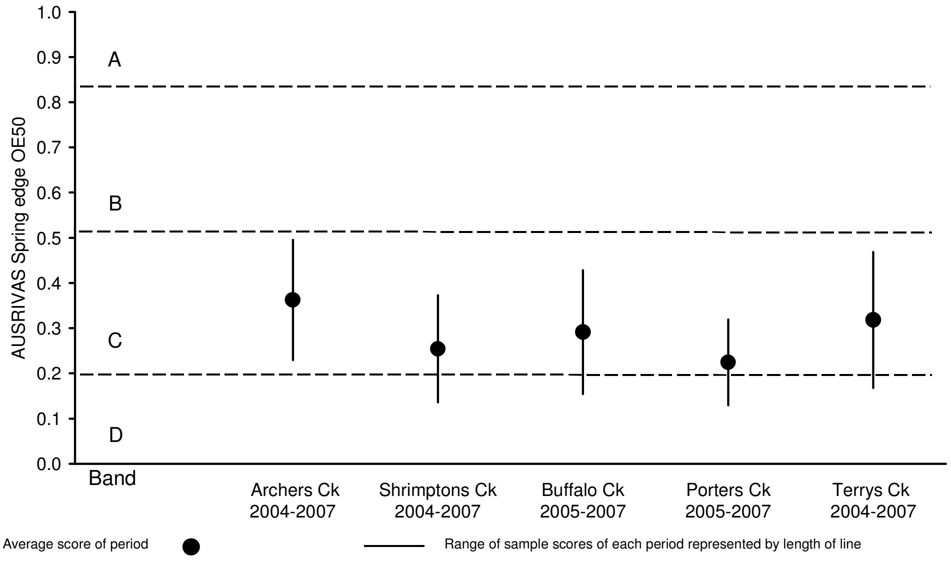

Figure 12. ***AUSRIVAS OE50 summary of all creeks from Spring edge model***

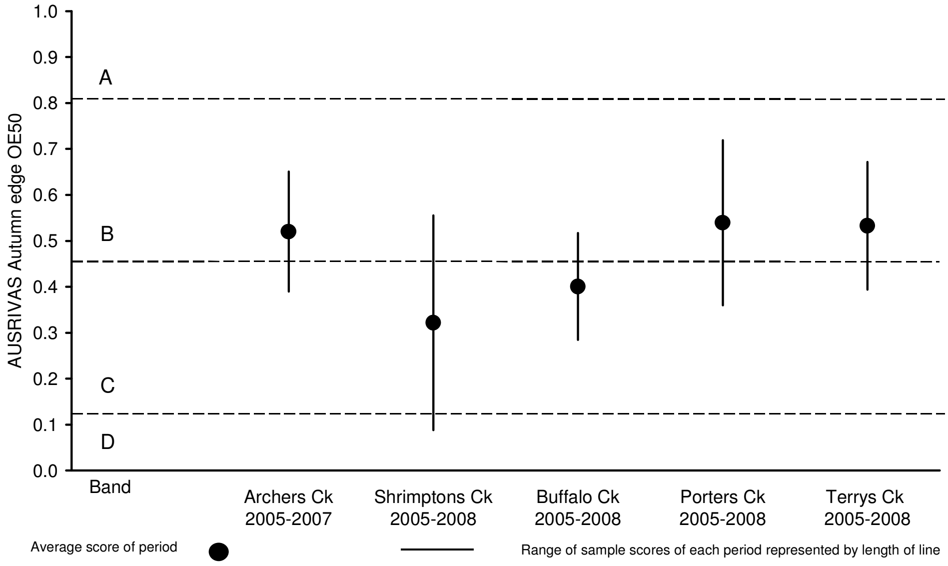

Figure 13. ***AUSRIVAS OE50 summary of all creeks from Autumn edge model***

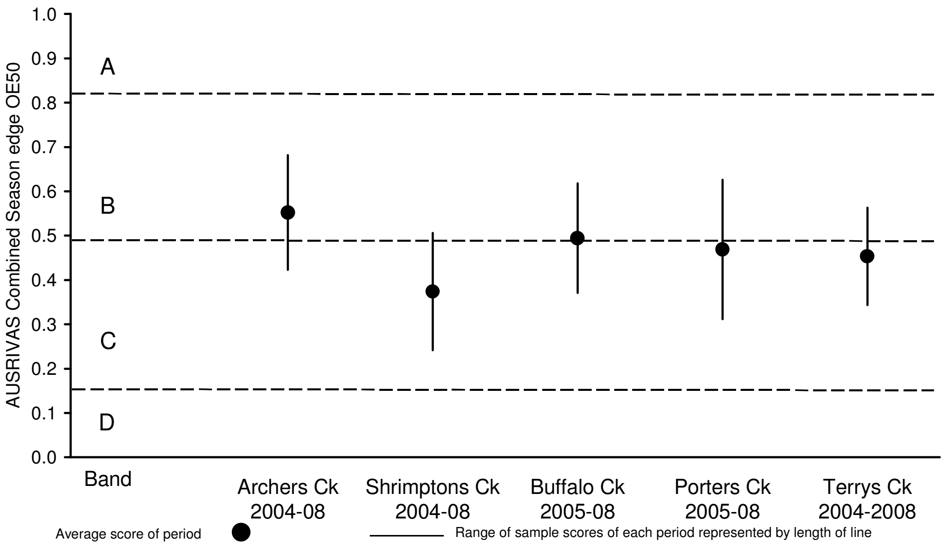

Figure 14 ***AUSRIVAS OE50 summary of all creeks from combined season edge model (with financial year data combined)***

EPT Indicator taxa from AUSRIVAS predictive model output

AUSRIVAS output identifies taxa that were expected from the respective reference site group to which a test site was compared. As part of this output missing taxa are listed with greater than 50% probability of occurrence. To provide consistency in this report the definition used by Ecowise (2004, 2005a, 2005b, 2006) has been used in this report. That is, indicator taxa are defined as taxa within the EPT (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera – caddisfly) orders with SIGNAL2 scores of greater than 6.

Across the five creeks of the monitoring program missing EPT indicator taxa identified by AUSRIVAS Autumn edge model output listed 16 taxa as missing with three mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera). There were also 18 EPT taxa missing from the AUSRIVAS Spring edge model output with two mayfly larvae (Ephemeroptera), three stonefly larvae (Plecoptera) and 13 caddisfly larvae (Trichoptera). The AUSRIVAS Combined season edge model output listed 16 EPT taxa as missing comprising three mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera).

The Trichopteran, Antipodoecidae was the only AUSRIVAS predicted EPT indicator taxa with a SIGNAL2 score greater than 6 that was sampled in Autumn 2008, and this was just a single specimen in Porters Creek. There were other EPT taxa present in Autumn 2008 samples such as Hydroptilidaes (Trichoptera) and Baetidaes (Ephemeroptera) yet they have SIGNAL2 scores of less than 7.

AUSRIVAS OE0 SIGNAL2

The Autumn edge model for 2008 does not include an average score for OE0 SIGNAL2 for Archers Creek. The output for the model stated that it was *outside the experience of the model*, this didn't affect the Combined Season model, which does have a result for Archers Creek for 2007/08 (Figure 17).

The Autumn OE0 SIGNAL2 output for 2008 indicated a minor drop in average stream health compared to Autumn 2007 for Shrimptons, Buffalo and Terry's Creeks. Porters Creek indicated a minor improvement (Figure 16). The Autumn OE0 SIGNAL2 output is similar through time to that of the Spring OE0 SIGNAL2 output (Figure 15 & 16). This is in contrast to the respective OE50 outputs that shows Autumn being healthier than Spring (Figure 9 & 10).

The combined seasons AUSRIVAS OE0 SIGNAL2 output showed little variability between sampling seasons compared to the Spring and Autumn AUSRIVAS OE0 SIGNAL2 outputs (Figures 15 to 17).

Comparison of the five streams with all sampling periods pooled from output of the Autumn eastern edge model, Spring eastern edge model, and Combined season edge model of AUSRIVAS OE0 SIGNAL2 indicated that stream health was similar for all five creeks (Figure 18 to Figure 20). This trend is the same as that found in the respective OE50 models (Figures 12 to 14) and SIGNAL-SF (Figure 8), however the creeks are closer aligned and show less variability in the range of stream health similar to that of SIGNAL-SF.

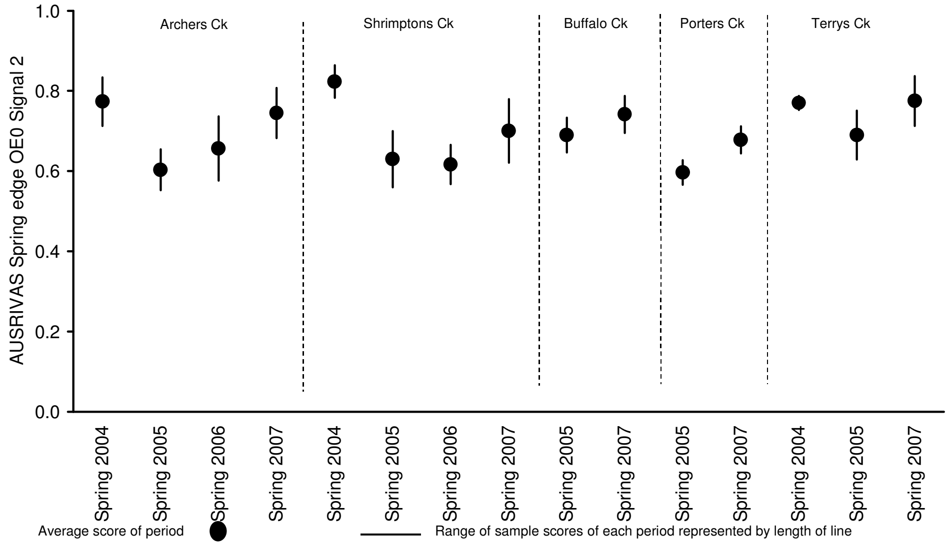

Figure 15 AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model

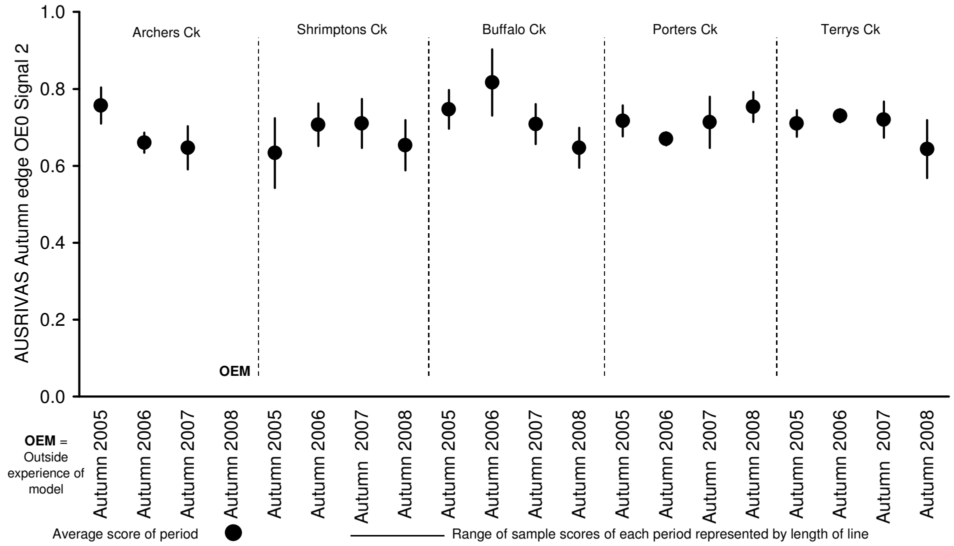

Figure 16 AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model

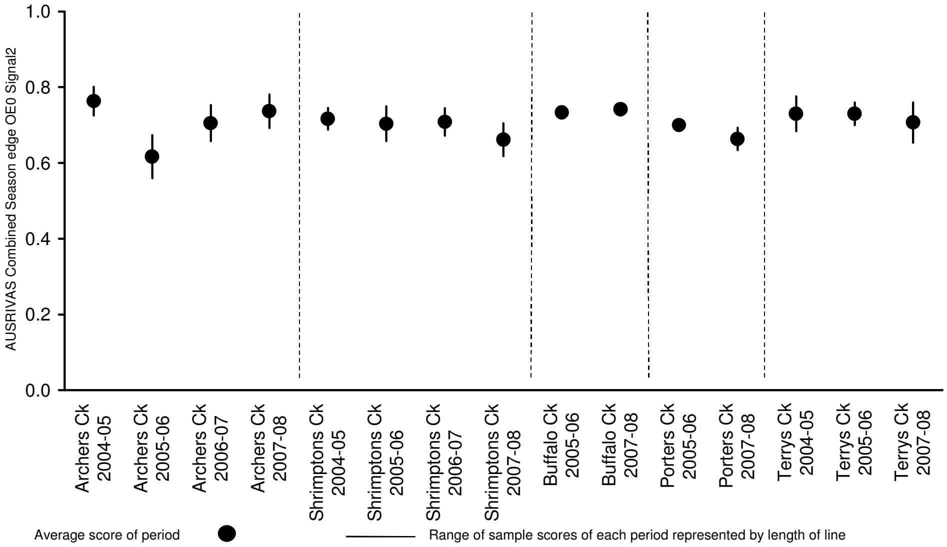

Figure 17 ***AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (with financial year data combined)***

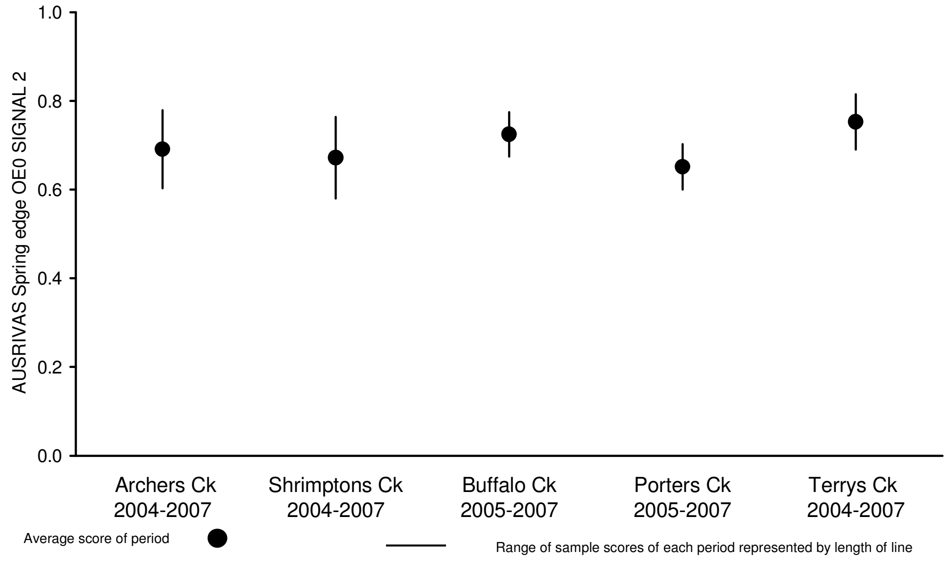

Figure 18 ***AUSRIVAS OE0 SIGNAL2 summary of all creeks from Spring edge model***

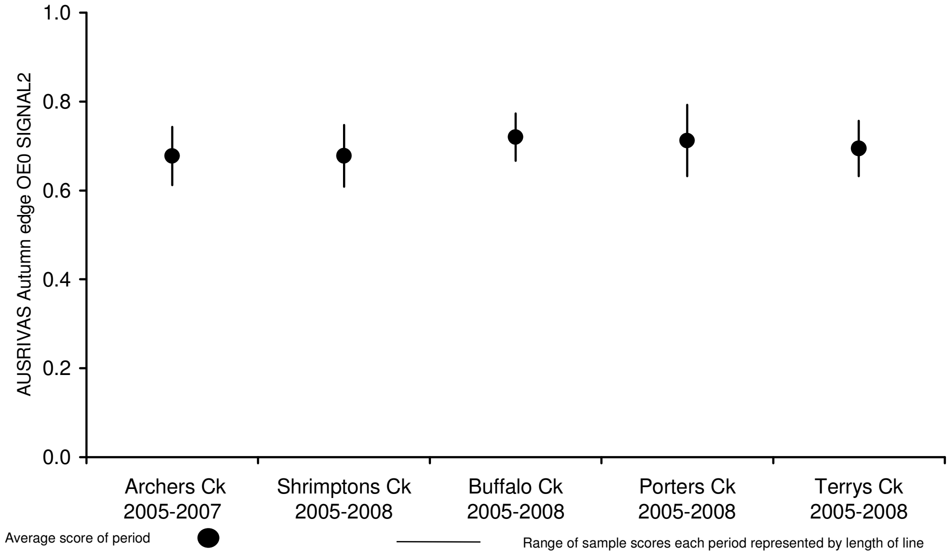

Figure 19 ***AUSRIVAS OE0 SIGNAL2 summary of all creeks from Autumn edge model***

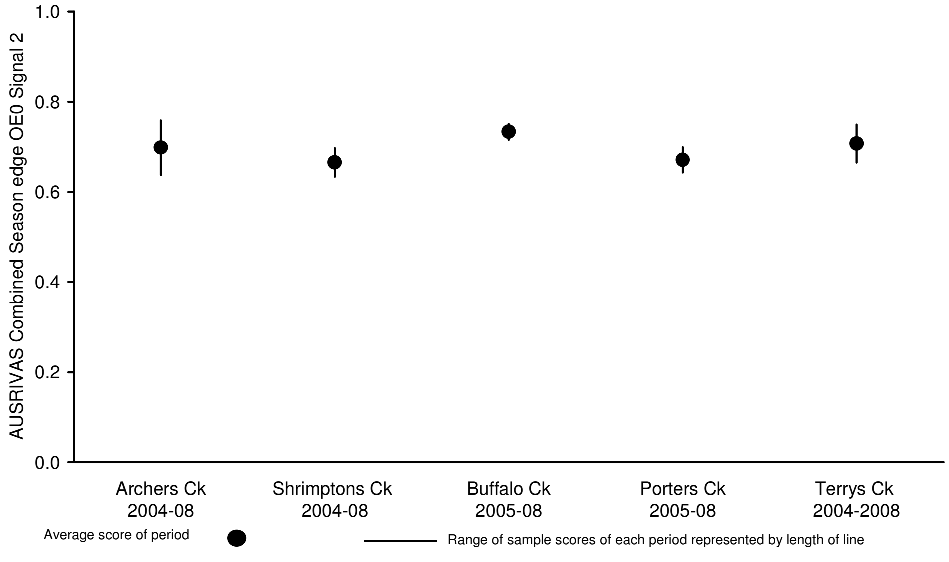

Figure 20 ***AUSRIVAS OE0 SIGNAL2 summary of all creeks from combined season edge model (with financial year data combined)***

Multivariate Analyses

Classification and Ordination

To achieve suitable mutlivariate representations of data in 2 or 3 dimensions with greater data collection, an analysis strategy to minimize stress and achieve a better measure of fit) is to pool up macroinvertebrate data of the same season for each creek to produce one data point per season per creek as demonstrated in the Spring 2007 report for all five creeks. This analysis strategy has been adopted for the ordination plot of all creeks (Figure 21). This summary can be thought of as reducing noise of the replicate data from the somewhat patchy occurrence of macroinvertebrates at a stream site. A better measure of fit (lower stress value 0.14) was achieved compared with all replicates shown (stress = 0.19, figure not presented).

The between season variability in community structure of Shrimptons Creek is displayed in Figure 21 with the latest sampling period of Autumn 2008 having a similar structure to that of Spring 2005, Autumn 2005, and Autumn 2006 whilst showing a distinct change to that of Spring 2007.

Archers Creek had the next most variable community structure over time. Buffalo and Porters Creeks show less variability through time while Terrys Creek showed the least variability in community structure. The community structure of Autumn 2008 for Buffalo, Porters and Terrys creeks has generally fallen within that previously observed for these three creeks.

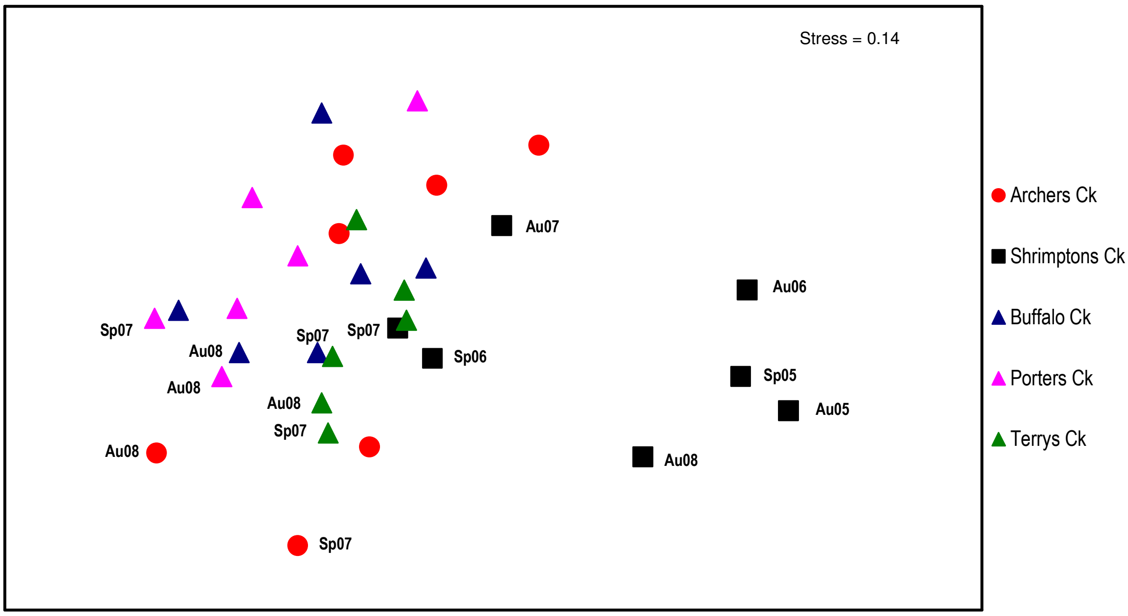

Figure 21 Plot of non-metric multidimensional scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of all creeks with each point representing samples from the same season of the same creek

Exploration of the similarity of Archers Creek macroinvertebrate community structure for 2005, 2006 and 2007 samples from the same season were relatively similar (Figure 22).

The first division of the classification analysis split all Spring 2005, Autumn 2005, Autumn 2006 and four Autumn 2007 samples from all other samples and the second classification split two Autumn 2007 samples and all Autumn 2008 samples from all other samples.

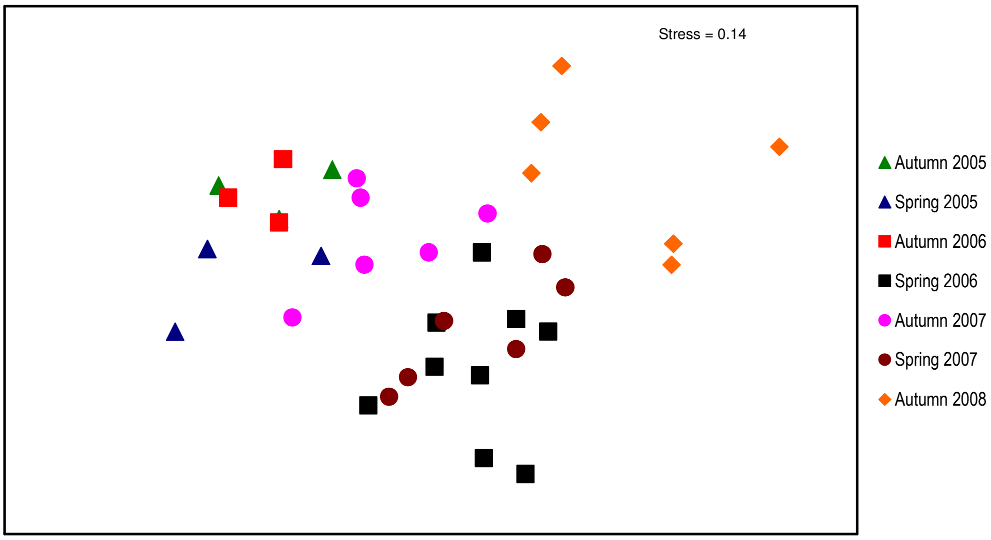

Figure 22 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of Archers Creek***

The first division in the classification of macroinvertebrate samples from Shrimptons Creek separated one sample from Autumn 2008. The second division separated samples from Autumn and Spring 2005, Autumn 2006, and the remaining five samples from Autumn 2008 from all other samples (Figure 23).

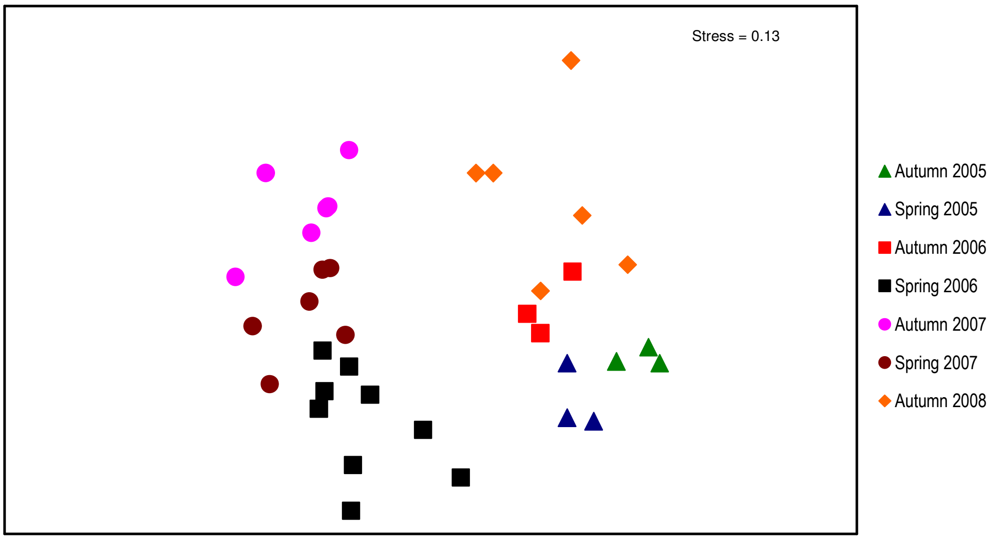

Figure 23 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of Shrimptons Creek.***

The addition of Autumn 2008 data to the ordination plot for Buffalo Creek increased the stress from 0.10 in Spring 2007 to 0.13 in Autumn 2008. This jump in stress was influenced by one sample collected in Autumn 2008 that was separated by the first classification division, which separates more in the third dimension than other samples for the ordination. The second classification division split Autumn 2005, Spring 2005, and Autumn 2006 samples from all other samples (Figure 24).

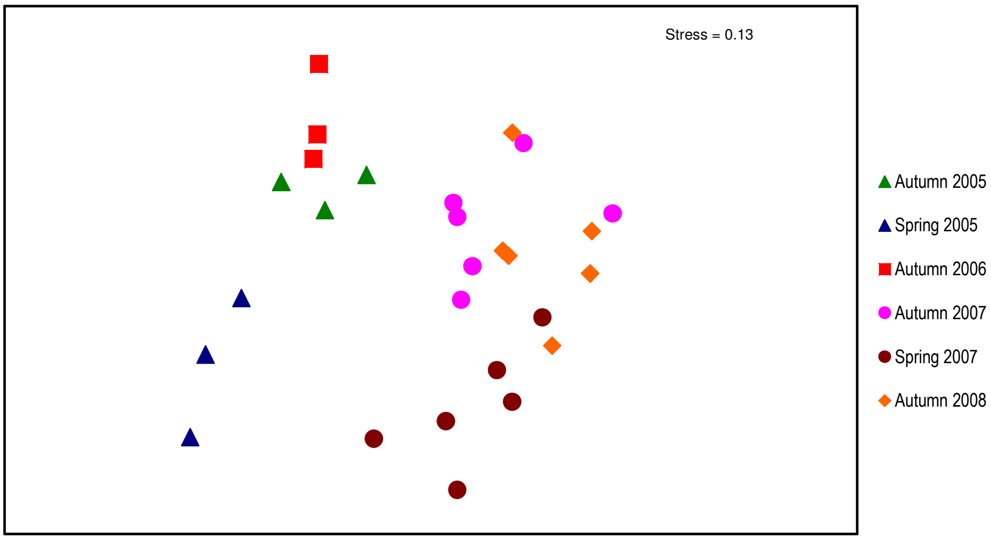

Figure 24 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of Buffalo Creek***

For Porters Creek the first division of the classification separated Autumn 2008 and Spring 2007 samples from all other samples (Figure 25).

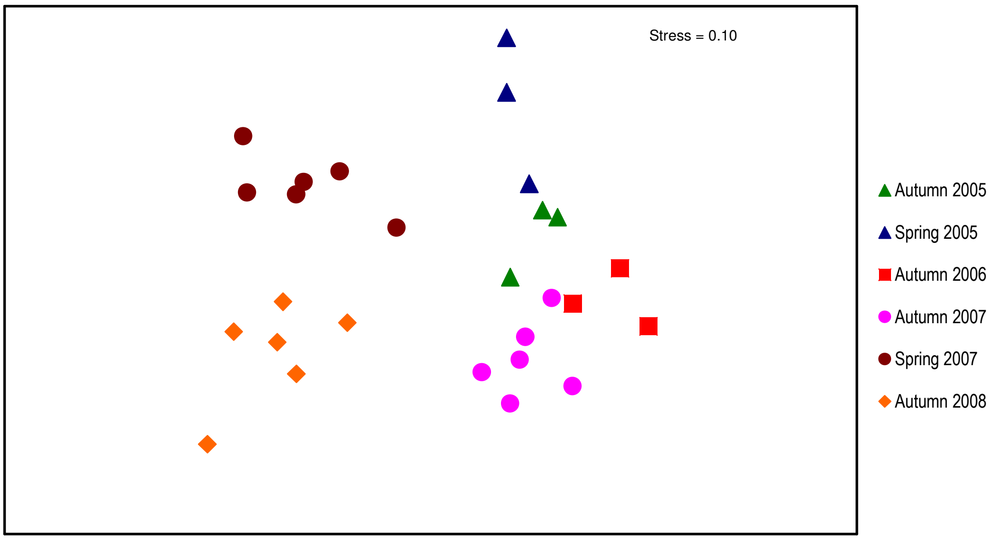

Figure 25 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of Porters Creek***

Four of the six Autumn 2008 samples were the most dissimilar to those collected in other sampling seasons for Terrys Creek (Figure 26). However the difference in community structure of these four samples from all other samples is minimal as the first division in the classification analysis is at 54% similarity.

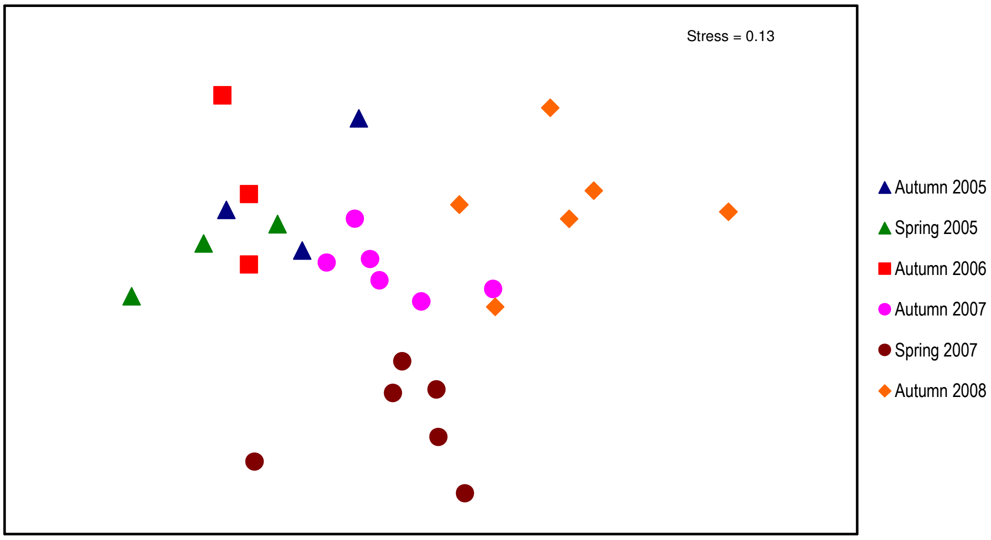

Figure 26 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 and 2008 macroinvertebrate data of Terrys Creek***

SIMPER

A change has been made to the SIMPER output to improve non-specialist reading of this report. In the output, common name (following Hawking & Smith, 1997) has been used instead of formal taxonomic Order name.

SIMPER when performed on all five creeks was based on merged replicates from the same season for each creek in as per the combined creek ordination (Figure 21) and classification analysis. SIMPER results indicate Shrimptons and Archers Creeks had the lowest average similarity (56%), with increasing similarity for other creeks, Buffalo and Porters Creeks (60%) and Terrys Creek (68%) (Appendix 5).

Comparison of macroinvertebrate samples from each creek with each other creek was also provided by SIMPER output by average dissimilarity. These values are presented in Table 12 and indicate samples from Buffalo, Porters and Terrys creeks are more similar and reflect the closer yet separate position in the five creeks MDS plot (Figure 21).

Table 12 Average dissimilarity between samples of creek comparisons

	Archers %	Shrimptons %	Buffalo %	Porters %
Shrimptons	51			
Buffalo	45	50		
Porters	47	54	41	
Terrys	44	48	37	41

SIMPER was then performed on each creek for samples shown in Figure 22 to Figure 26. Average similarity ranged from 57% to 77% (Table 13, Appendix 5).

From the SIMPER analysis a change in community composition is evident for Shrimptons Creek from the beginning of sampling in Autumn 2005 to the most recent sampling in Autumn 2008. This does not appear to be influenced by season. Community structure in Shrimptons Creek has gone from being dominated by tolerant non-insects to being dominated by tolerant insects, and then recently gone back to again being dominated by tolerant non-insects. In the Autumn 2005, Spring 2005, Autumn 2006 and Autumn 2008 seasons the community structure was dominated by tolerant non-insects with 5-6 taxa contributed 90% of the community structure compared with Autumn and Spring 2007 where 10 taxa contributed 90% of the community structure. Common non-insect community members included the introduced snail *Physa acuta* (Physidae), flatworms (Dugesiidae) and worms (Oligochaeta). The tolerant insects that were found were native non-biting midges (Chironominae), dragonflies (Megapodagrionidae, Coenagionidae, Isostictidae, Hemicorduliidae) and back swimmers (Notonectidae).

SIMPER analysis indicated in Autumn seasons Buffalo, Porters and Terrys creeks had a more consistent insect dominated community structure, although tolerant of pollution. The percentage contribution to community structure of insects was generally greater than 60% in each of these creeks with the exception of Autumn 2008 for Terrys Creek that had less dominat taxa, 6 compared with 13 to 14 for previous Autumn seasons. Each creek had consistent members of the respective communities through time with abundance differences evident between seasons of Autumn 2005 to Autumn 2008 (Appendix 5). In Spring the list of taxa that contribute to community structure is reduced and higher contributions from non-insects such as *Physa acuta* (Physidae), flatworms (Dugesiidae), worms (Oligochaeta) have been observed.

Community structure in Archers Creek in each Autumn season was dominated by tolerant insects with greater than 60% contribution. In Spring 2006 and Spring 2007 this contribution was below 50% while in Spring 2005 this contribution was closer to 60%.

Table 13 Average similarity of the same season samples for each creek

	Archers %	Shrimptons %	Buffalo %	Porters %	Terrys %
Autumn 2005	68	76	76	77	70
Spring 2005	59	77	67	73	65
Autumn 2006	72	77	75	72	73
Spring 2006	60	62	ns	ns	ns
Autumn 2007	57	60	70	71	66
Spring 2007	61	63	66	68	65
Autumn 2008	61	58	64	60	67

ns = not sampled

BIOENV

The output of BIOENV routine is presented in Appendix 6. The correlation of extrinsic water quality and physical variables including catchment storm water delivery characteristics (Table 14) with intrinsic macroinvertebrate sample data of all five creeks for 2005 to 2008 was mild at 0.394. This was an improvement of 0.164 above Spring 2007 BIOENV that did not include the catchment storm water delivery characteristics. Investigation into the extrinsic variables identified in the best result correlation included Oxidized Nitrogen, Rainfall, Cobbles and Total Length of Pipe. The BIOENV routine was then run on two subsequent subsets of the variables listed in Appendix 6 for all five creeks. The first of these was for all variables excluding catchment storm water delivery characteristics and the second included only the catchment storm water delivery characteristics. Correlations were marginally weaker at 0.345 and 0.305 respectively.

BIOENV analysis of each individual creek for 2005, 2006, 2007 and 2008 produced mild correlations of 0.486, 0.409, 0.498 and 0.477 for Archers, Shrimptons, Buffalo and Terrys creeks respectively. While the combination of variables varied for these creeks rainfall was consistently highlighted by BIOENV analysis (Appendix 6) and these correlations were marginally higher than recorded in the Spring 2007 report. Of the individual creeks, Porters Creek had the highest, but still moderate correlation of 0.617 with two variables highlighted, Total Dissolved Solids and rainfall (Appendix 6). Previously for

Porters Creek, rainfall had not appeared in the best results of the BIOENV output. Suggesting that further average rainfall or better than average rainfall may strengthen this trend in all five creeks.

As the correlations of these extrinsic variables are weak to moderate, this suggests that the respective macroinvertebrate community structures of each creek are not predominantly influenced by these water quality variables. This suggests physico-chemical measurements collected to date under the strategy do not appear to be all of the drivers for the shifts recorded in macroinvertebrate community structure. As such efforts to improve water quality should not be solely concentrated on variables measured to date.

Table 14 Catchment storm water delivery characteristics for each creek

Creek	Total Length of Pipe (TLP) (m)	Total Number of pipe Outlets (NO)	Catchment Area (CA) (hectares)	Ratio TLP/CA	Ratio NO/CA
Archers	19,310	65	286	67.5	22.7
Shrimptons	41,797	74	555	75.3	13.3
Buffalo	33,336	62	546	61.1	11.3
Porters	15,797	16	225	70.2	7.1
Terrys	17,158	28	1012	16.9	2.8

5 Discussion

5.1 Water quality

Water quality sampling results, while not to the frequency suggested by ANZECC (2000), did allow for characterisation of water quality at each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary). The results of the Autumn 2008 water quality sampling regime for Shrimptons, Porters, Buffalo, Terrys and Archers creeks of the Biological and Chemical Water Quality Monitoring Strategy of the City of Ryde indicate that urban pollution transport is having a moderate impact on instream water quality. This impact is notable by records of low levels of dissolved oxygen and the high levels of nutrients, especially nitrogen. This trend has also been observed in previous sampling events in 2004, 2005, 2006 and 2007 (Ecowise 2004, 2005a 2005b 2006, Sydney Water 2006, 2007a, 2007b). The additional water quality sampling did not indicate a clear point source.

Weather conditions, in the four months preceding Autumn 2008 sample collection, were characterised by relatively longer, lighter rain periods in between shorter dry periods in contrast to early to mid 2007 that was characterized by infrequent, short but heavy rainfall periods between relatively longer dry periods.

Dissolved oxygen concentrations are the single most important water quality indicator for the survival of aquatic organisms and the control of many important physico-chemical processes. The oxygen balance in waters is dependant upon physical, chemical and biochemical conditions in the water body. Oxygen input results from diffusion from the atmosphere and photosynthesis by algae and other aquatic plants. Dissolved oxygen removal is due to respiration by aquatic organisms, decomposition of organic matter, oxidation of chemically reduced compounds and loss to the atmosphere. The solubility of oxygen in water decreases with increasing temperature but the respiratory rate of aquatic organisms increases with temperature (Connell, 1993). Aquatic ecosystems are thus acutely sensitive to any reduction in dissolved oxygen levels.

Dissolved oxygen concentrations are often subject to large diurnal and seasonal fluctuations as a result of changes in temperature and photosynthetic rates. Therefore, a dissolved oxygen measurement taken at one time of the day may not truly represent the oxygen regime in the water body.

Nevertheless, the slight overall increase in levels of dissolved oxygen in the water at each of Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Autumn 2008 (Table 7) compared to the Spring 2007 results (Sydney Water, 2007b) may be attributed to the change in rainfall pattern between the end of 2007 and beginning of 2008. Slightly higher dissolved oxygen levels may be maintained with continued rainfall at average or above average levels.

The low dissolved oxygen levels in the two upper Buffalo Creek sites at Buffalo Park in March 2008 may be attributed to storm water runoff associated with relatively prolonged rainfall in February 2008. A reversal of this trend was recorded in the April 2008 results with higher dissolved oxygen levels. April 2008 sampling was preceded by lighter and less frequent rainfall (Figure 3 and Table 8).

This spatial comparison of dissolved oxygen with upstream sites on Porters, Shrimptons and Archers Creeks shows no apparent decline or improvement with increasing distance upstream from the respective downstream core sites. This suggests these creeks are influenced by urban inputs along there entire lengths.

The indicator species used for faecal coliforms are naturally occurring and harmless inhabitants of the digestive tract of all warm-blooded animals (Boey, 1993). The occurrence of large numbers of these bacteria signifies the presence of faecal pollution, and therefore the possible presence of those pathogenic organisms that occur in faeces. A variety of factors can influence faecal contamination of streams including urban runoff, presence of waterfowl and other wildlife, waste depots and illegal dumping of waste.

Recorded levels of faecal coliform concentrations at the five core sites were similar in the Autumn 2008 sampling period to that observed in the Spring 2007 sampling period and were compliant with ANZECC (2000).

During the March sampling period the two additional sites in the upper Buffalo Creek catchment at Burrows Park upstream of the core site (Site 4) recorded elevated non-compliant levels of faecal coliforms compared to ANZECC (2000) (4500 and 10,000 CFU/100mL, Table 8).

The slightly elevated levels of faecal coliforms at Burrows Park on Buffalo Creek were either diluted or decayed by the time they travel down to the core site (Site 4). As the March 2008 levels were higher than the April 2008 levels and the March 2008 samples followed higher rainfall this may reflect a higher volume of rainfall needed to see this parameter increase. Faecal coliforms units of 15000 – 20000 are not uncommon in storm water runoff during significant wet weather events, which can include run-off from: private sewer leaks; fertilizer; and animal faeces, such as dogs. Much higher faecal coliforms would be expected if the results were from a sewer overflow event.

Shrimptons Creek at Santa Rosa Park during April 2008 was the only other additional upstream site to have elevated faecal coliform levels above the recommended ANZECC (2000) guidelines (4200CFU/100mL, Table 8). As with Buffalo Creek, the decay or dilution with downstream movement has resulted in a lower faecal coliform result at the core site (Site 2) for April 2008 of 700 CFU/100mL. While higher than the March 2008 sample of 200 CFU/100mL the faecal coliform indicator is somewhat variable compared to other water quality variables and the two numbers are probably effectively similar.

An example of dry weather drainage runoff that influences stream health in the City of Ryde occurred during the April 2008 water quality sampling of Porters Creek on the Spur Branch. Initially the site appeared no more turbid, relative to previous sampling occasions, but within minutes of being at the site we observed a huge load of turbid water, which entered the site and influenced the turbidity reading. The April 2008 results for Porters Creek of 625 NTU were over six times greater than the previously highest recorded NTU reading which was from Shrimptons Creek in Spring 2006 of 97 NTU from an apparent bank collapse. This turbidity reading provides an example of efficient delivery via the storm water system. This example highlights the difficult task of interpreting potential water quality influences when readings are taken from a very small period of time while aquatic life is subject to peak pollution spikes that may not be captured between sampling events or are not measured amongst the variables collected under the strategy.

Nitrogen and phosphorus are essential elements for life. They are found naturally in the earth's crusts (phosphorus) and atmosphere (nitrogen) but are not directly available to most living organisms. As a result, lack of these elements is often the factor limiting growth of algae, bacteria and other plants. Increasing the readily available phosphorus and nitrogen loads in streams can lead to algal blooms and excessive plant growth. The elevated nitrogen levels as measured by Total Nitrogen and Total Oxidised Nitrogen found in Archers, Shrimptons, Buffalo, Porters and Terrys creeks during Autumn 2008 were most likely from urban runoff from eroded catchments, decomposing organic matter and low dissolved oxygen levels, which is known to be a significant factor in increasing the amounts of readily available nutrients from sediments via chemical synthesis. Total Nitrogen and Total Oxidised Nitrogen levels at the additional sites upstream of Shrimptons, Buffalo and Porters Creeks exceeded the historical average and/or the current Autumn 2008 result for the downstream core site (Sites 2, 3 & 4) on at least one occasion.

The reduction in the number of Total Phosphorus samples exceeding ANZECC (2000) guidelines from being at least half of all samples historically to only two samples at Shrimptons Creek in Autumn 2008 (one fifth of all samples) indicates that there has been a reduction of phosphorous loads into the City of Ryde catchment which may be linked to the overall slightly higher dissolved oxygen results for each creek.

Ammoniacal nitrogen is often present in sewage effluent, because of the decomposition of nitrogen containing compounds in the treated waste. The un-dissociated form, ammonia (NH3) is far more toxic to aquatic life than the ionic form, ammonium (NH4+). During low pH and temperature NH3 dissociates to the less toxic form NH4+. This is then reversed during periods of high pH and temperature.

Laboratory methods for ammonia record the nitrogen content from the ammonium (associated ionic form) ions NH4+. This ion forms compounds with other particles dissolved within the water column. It is harmless to plants and animals within the specified concentration, pH and temp range. ANZECC (2000) has determined this to be 20µg/L for the protection of aquatic life in lowland streams with a pH of 8 and temp of 20OC. Ammonia (NH3) is a toxic by product of NH4+ that exists as a gas of which the N content is not measured during the routine laboratory analysis. With increasing temp and pH the % of NH3 against NH4+ increases exponentially and it is this compound that is detrimental to aquatic life. ANZECC (2000) does not at all measure this or provide guidelines on this form - but it does determine the NH4+ concentrations that are dangerously high and most likely to produce the toxic NH3 compound and provides guidelines on this.

The 95% trigger value for freshwater according to ANZECC (2000) is 0.9µg/L - this is set as generally the worst-case benchmark. A more tailored level of 20µg/L for Freshwater Lowland Streams in SE Australia (ANZECC 2000) is applied for the City of Ryde water quality monitoring.

Porters Creek had the highest levels of ammonia, exceeding ANZECC (2000) guidelines on average more than 25 times the recommended levels during Autumn 2008. This is reflected in the historical data with Porters Creek continually exceeding ANZECC (2000) by at least 20 times the recommended levels during 2005, 2006 and 2007. The elevated levels of ammonium in this creek indicate under favorable conditions the ammonium (NH4+) ion will be converted to the potentially toxic ammonia (NH3) compound and compromise the health of the aquatic ecosystem.

Total Dissolved Solids refers to the total amount of organic and inorganic substances – including minerals, salts, metals, cations or anions that are dispersed among a volume of water. By definition the solids must be small enough to be filtered through a 2 micrometer sieve. Sources for TDS include agricultural and urban run-off, industrial wastewater, sewage and natural sources such as leaves, silt, plankton and rocks. Piping or plumbing may also release metals into the water. The US EPA recommends the threshold of acceptable criteria for human drinking of TDS concentrations to not exceed 500mg/L (500 ppm). In some cases further testing may be warranted as water with a high TDS concentration may indicate elevated levels of ions that pose a health concern such as aluminium, arsenic, copper, lead, nitrate and others. Striped Bass fish species have shown reduced spawning in concentrations as low as 350 mg/L and concentrations below 200 mg/L promoted healthier spawning conditions (Kaisser, 1969).

Total Dissolved Solids in Buffalo Creek were above 500 mg/L during March 2008. They were over three times the US EPA limit (1330 mg/L). This correlates with the metal results sampled at the site situated downstream of core Site 4, which exceed ANZECC (2000) guidelines for 3 of the 8 metals analysed including copper, zinc and cadmium. No other sites were analysed for metals but the historical results for Porters Creek (TDS 1934 mg/L) indicates that contaminants associated with TDS may be impacting on aquatic stream life.

Zinc occurs in almost all minerals in the earth's crust and is important as a trace element in all living organisms. Zinc and zinc compounds are used in galvanizing iron and steel and in all chemicals, paints and a host of other manufactured materials. Toxicity of zinc is generally low in humans but can constitute a hazard to aquatic life, especially when zinc acts synergistically with metals such as cadmium, copper and lead (Ohnesorge and Wilhelm 1991).

Cadmium is a relatively scarce element that occurs naturally with zinc. Cadmium and its compounds are used in batteries, for anticorrosive coatings of metals, in pigments and stabilizers for plastics, and can be liberated through the burning of coal. Cadmium can cause toxic effects in humans and aquatic life.

Copper is ubiquitous in bedrock at moderate concentrations. It is one of the trace metals essential to life despite being as inherently toxic as non-essential heavy metals such as lead and mercury.

5.2 Macroinvertebrates

Results of the Autumn 2008 macroinvertebrate sample collection of the Biological and Chemical Water Quality Monitoring Strategy of Ryde City Council Tender Number COR-EOC-05/07 indicate Archers, Shrimptons, Buffalo, Porters and Terrys creeks have impaired macroinvertebrate communities with similar results recorded in Spring 2004 to Spring 2007.

ANZECC (2000) indicates adequate base line data is required to establish an acceptable level of change before informed management judgments can be made that take account of natural variability in an indicator. ANZECC (2000) suggests three to five years of data be gathered from control or reference locations. Natural variability of each site with comparable data are being gathered under the Biological and Chemical Water Quality Monitoring Strategy. To this end, for the macroinvertebrate indicator, use of the Sydney specific SIGNAL-SF index and NSW AUSRIVAS predictive models provides this data by the statistically defined 10th percentile of mean reference condition values. The range of each measure of stream health has been plotted in this report with +/-1 standard deviation of the mean for basing ecological decisions (ANZECC, 2000). Presenting data in this way attempts to take account of variation at study sites and provide a basis in future years to enable management tracking and or as a basis for making management decisions. To date there are six seasons of comparable data for all five creeks since sampling began in Spring 2004, and with inclusion of data from seasons in years with rainfall that is average or above will provide a good baseline for management decisions.

The period between Spring 2004 to Autumn 2007 has been characterised by below average rainfall. Spring 2007 saw a return to average rainfall, with consistent falls through late 2007 and early 2008 leading up to the Autumn 2008 sampling period. In the Autumn 2008 samples a total of 1811 macroinverterbates were collected in Autumn 2008, which is a considerable drop compared to Spring 2007, which had 2490 animals, and the previous Autumn 2007 sampling session saw 2635 animals collected. Total taxa collected did not go down, hence the abundance of the animals was lower than in the past. A closer look reveals that compared to Spring 2007 the Chironiminae abundance dropped dramatically (742 to 253) as well as some of the non-insects (worms and gastropods), which would be expected based on past trends. Compared to the previous Autumn 2007 sampling abundance of all dragonfly taxa went down sharply as did the Atyidae (Fairy Shrimp) and again the Chironiminae (443-253). This an average of 20 less macroinvertebrate animals collected per sample in Autumn 2008. Sampling in Autumn 2007 and 2008 had been conducted in relatively the same periods and as such the reduced numbers in 2008 may reflect environmental cues that influence development of macroinvertebrate taxa with either the aquatic life stage not being present in the water at the time of sampling or the cohort (age class) being too small to be retained by 0.25 mm mesh of the net. A 0.25 mm mesh is used to collect macroinvertebrates that are of a suitable size to allow identification with taxonomic keys as keying characters are generally written for relatively mature (late instar) specimens.

Sensitive taxa as measured by EPT richness were virtually absent and a number of the EPT indicator taxa from AUSRIVAS predicted model output were not observed. EPT taxa were not present in Autumn 2008 in Shrimptons and Terrys Creeks despite being present in the previous three sampling seasons. Archers and Buffalo Creeks continued to have a low but consistent presence of EPT taxa in Autumn 2008 largely due to the Caddis fly larvae (Trichoptera) Hydroptilidae. The Mayfly (Ephemeroptera) Baetidae was also present in Archers Creek in the second round (April 2008) of sampling effectively replacing the Hydroptilids observed in the first round of sampling (March 2008). Porters Creek had only one individual EPT taxa present in one replicate, the Caddis fly larvae (Trichoptera) Antipodoecidae. The Caddisfly (Trichoptera) Antipodoecidae was the only EPT indicator taxa (as per criteria of section 3.6) sampled in Autumn 2008. The only other EPT indicator taxa found since sampling begun in 2004 was the Stonefly (Plecoptera) Eustheniidae in Autumn 2006.

Due to the status of EPT taxa in City of Ryde study creeks, EPT richness as a measure is limited in being able to infer information of any future negative impacts on stream health. In the previous report of Spring 2007 it was suggested the return to average or above average rainfall conditions may influence the presence of EPT taxa, given average conditions have returned, it may take prolonged conditions to see an improvement. However it may be able to indicate positive community structure changes. Hence reference to EPT indicator taxa from AUSRIVAS predicted model output (as per criteria of section 3.6) status should be made in assessing positive changes in this measure, before attributing positive changes to management activities.

As mentioned in the results section AUSRIVAS predictive model OE50 and OE0 SIGNAL 2 output did not include a result for Archers Creek for Autumn 2008. The output described it as being outside the experience of the model. This means that the combination of the physical and biological data was not typical of reference material used by the AUSRIVAS Autumn eastern edge model. Recent changes to the stream channel combined with few AUSRIVAS reference sites situated in the Sydney region may explain the returned result. A result was returned for the AUSRIVAS combined season eastern edge model.

Direct measurement of stream health using SIGNAL-SF and measurement via AUSRIVAS predictive model OE50 and OE0 SIGNAL2 outcomes both reflected impaired stream health of Archers, Shrimptons, Buffalo, Porters and Terrys creeks. A marginal increase in average SIGNAL-SF scores occurred in Autumn 2008 for Archers, Buffalo and Porters creeks while Terrys Creek was virtually the same and a slight declined occurred for Shrimptons Creek. For all five creeks the range of stream health in Autumn 2008 overlapped that recorded in the previous season of Spring 2007 and also overlapped with all other seasons except for Shrimptons Creek. The range of stream health in Shrimptons Creek for the last two seasons was clearly lower than that observed in Autumn 2007 with the Autumn 2008 result returned to the SIGNAL-SF probable severe organic pollution category, last seen in 2005. AUSRIVAS predictive model OE50 output from Autumn 2008 indicated average stream health dropped in all creeks that returned results compared with the Autumn 2007 model output. The AUSRIVAS range of stream health of Autumn 2008 did not overlap the range of stream health from Autumn 2007 for Shrimptons Buffalo and Porters creeks.

Autumn and combined season model AUSRIVAS OE0 SIGNAL2 results were similar to SIGNAL-SF than AUSRIVAS OE50 output except the Autumn 2008 range of stream health overlapped that of Autumn 2007.

The slight differences in patterns presented by SIGNAL-SF, AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2 measures partially relate to the abundance and tolerance component involved in the calculation of SIGNAL-SF scores, versus presence absence component used in the calculation of AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2. Another source of the slight differences between these two analysis tools may be from direct measurement and measurement via comparison to reference site groups of the AUSRIVAS predictive models. Despite these slight differences and together with the EPT richness index results impaired stream health is identified in the five creeks studied under the Biological and Chemical Water Quality Monitoring Strategy.

A limitation with AUSRIVAS models is the difference in band threshold values for Autumn, Spring, and combined Autumn Spring models. Although the threshold (10th percentile) for band A (similar to reference) is virtually the same for these three models, mixing Autumn and Spring output should not occur as Coysh et al. (2000) indicates mixing assessments based on different season models should be discouraged. Hence, Autumn, Spring and Combined Autumn Spring model results were presented separately for AUSRIVAS output. SIGNAL-SF (Chessman et al., 2007) does not have this seasonal limitation, and perhaps trends are more easily identified from this tool.

The abovementioned univariate analysis tools, EPT richness, SIGNAL-SF, AUSRIVAS OE50, AUSRIVAS OE0SIGNAL2 all indicated impaired ecosystem health. The multivariate analysis tools complement univariate analyses by exploring patterns of macroinvertebrate communities by looking at the chosen array of samples and all taxa recorded.

Multivariate analyses indicate biological signature or community (assemblage) structure of Archers and Shrimptons creeks has been more variable through time than community structure of Buffalo, Porters or Terrys creeks. Exploration of multivariate SIMPER results indicates Archers Creek has generally had a community structure that resembled the structure of Buffalo, Porters and Terrys creeks occurring at the fringes whereas the community structure of Shrimptons Creek has at times been quite different with tolerant non-insect taxa dominating collected samples.

Chessman et al. (2006) determined twice as many taxa appeared to favour sites in good geomorphic condition as favoured poor sites. Chessman et al. (2006) also indicated many taxa associated with sites in poor condition are introduced taxa. In the City of Ryde macroinvertebrate data the dominant aquatic snail was the introduced Physa acuta and aquatic worms counts had numerous specimens of the introduced Lumbriculus variegatus. Chessman et al. (2006) suggests rehabilitation of geomorphic condition can assist in the rehabilitation of native riverine biota.

Native riverine macroinvertebrate community structure in bushland streams around Sydney, that have no urban water quality disturbances, typically have main contributions from insects such as MayFlies, Caddisflies, Beetles, and

Aquatic Mites. The sensitive taxa of the Sydney region have higher SIGNAL grades as recorded in Chessman et al. (2007).

In previous reports (SWC 2006, 2007a, 2007b) exploration of stormwater drainage connection was recommended. Due to cost, the calculation of the percentage of effective imperviousness in each of the five catchments was not made. Rather possible surrogates of this measure included: total length of pipe; total number of outlets; catchment area; ratio of total length of pipe to catchment area; and ratio of total number of pipe outlets to catchment area were calculated by the City of Ryde. Calculated values were included in the BIOENV routine for all five creeks.

The attempt to link water quality patterns with macroinvertebrate patterns using the multivariate BIOENV routine produced at best one moderate correlation. This suggests physico-chemical measurements collected to date under the strategy do not appear to be all of the drivers for the shifts recorded in macroinvertebarte community structure. As such efforts to improve water quality should not be solely concentrated on variables measured to date. The variable rainfall was highlighted in all BIOENV results, and with further average rainfall or better than average rainfall this trend may strengthen in all five creeks. In the combined analysis of all five creeks together with rainfall the catchment storm water delivery characteristic total length of pipe was also highlighted. This probably suggests rainfall and efficient catchment pollution transport to the stream are influencing in-stream macroinvertebrate community structure.

Conclusions of research conducted in the greater Melbourne area that looked at water quality, epilithic diatoms, benthic algae and macroinvertebrate indicators suggested minimisation of directly piped stormwater drainage connection of impervious surfaces to be beneficial in mitigation of urban impacts on receiving streams (Hatt et al., 2004; Walsh, 2004; Taylor et al. 2004; Newall & Walsh, in press). The primary degrading process to urban steams is suggested to be effective imperviousness (the proportion of a catchment covered by impervious surfaces directly connected to the stream by stormwater pipes) (Walsh et al., 2005a) provided sewer overflows, sewage treatment plant discharges, or long-lived pollutants from earlier land uses are not operable as these can obscure stormwater impacts (Walsh et al., 2005b). Walsh (2004) determined community composition was strongly explained by the gradient of urban density and that most sensitive taxa were absent from urban sites with greater than 20% connection of impervious surfaces to streams by pipes. The virtual lack of recorded sensitive EPT indicator taxa in the monitoring conducted to date may suggest there is greater than 20% connection of impervious surfaces to Archers, Shrimptons, Buffalo, Porters and Terrys creeks. Inclusion of data from a number of above average rainfall periods is required before comments can be made with regard to disturbance influence of average or above average rainfall conditions.

The direct connection of impervious surfaces to a stream allows small rainfall events to produce surface runoff that cause frequent disturbance to the stream through regular delivery of water and pollutants (Walsh et al., 2005). In catchments with existing drainage networks such as those under study in this program, policies that facilitate infiltration, evaporation, transpiration or storage for later in-house use will gradually benefit stream health in the longer term based on outcomes of research conducted in Melbourne.

The impaired macroinvertebrate communities described above for Archers, Shrimptons, Buffalo, Porters and Terrys creeks in the City of Ryde may be due to stormwater connectivity with regular delivery of pollutants and altered geomorphic conditions due to this connectivity. Further data collection under average rainfall or better than average rainfall may strengthen the extrinsic rainfall trend defined by the BIOENV routine and assist in clarifying the broad driver of stream health being investigated in the Biological and Chemical Water Quality Monitoring Strategy.

6

Discussion of question from the Water Quality Monitoring Steering Committee

Question 1 *Are there any distinct dry weather point sources in Porters Creek? An investigation based upon water quality measurements was discussed with sites to be defined subsequent to the steering committee meeting of December 2007.*

The Spur and Main branches of Porters Creek were investigated on Porters Creek above core site 3, with three sites as listed in Table 8.

Autumn 2008 water quality results highlight Ammonia (NH_4^+) and Total Kjeldahl Nitrogen (TKN) were elevated at core Site 3 on both sampling occasions while Total Nitrogen (TN) was elevated on one sampling occasion. For all other water quality parameters tested, one or more upstream sites investigated in Autumn 2008 on Porters Creek had similar or greater results (Table 7 and Table 8).

At the site situated on the Spur Branch of Porters Creek, some results of different water quality parameters were the highest recorded for the Autumn 2008 sampling occasions. While the upper most site on the Main Branch at Wicks Road also recorded the highest results for other water quality variables (Table 8).

On field visits different pipe outlets have been observed to flow. Placing this information together with the turbidity observation for core Site 3 mentioned in the water quality discussion, suggests a complex network of storm water/drainage pipes exist that deliver urban runoff to Porters Creek from potentially different sources. As such it remains difficult to conclude the influence if any of the depot on water quality at the core Site 3.

It is recommended that additional water quality sampling be considered for Porters Creek in Spring 2008 to further clarify this question.

Figure 27 Porters Creek at Wicks Road in Autumn 2008 showing drainage inputs

7 Comments on progress of strategy aims

The section places the current knowledge of sampling data consolidated in this report within the context of the aims detailed in the City of Ryde's request for the engagement of consultants No COR-EOC-05/07.

- Evaluate chemical and biological water quality monitoring both for short and long term interpretation and temporal evaluation over the duration of the strategy;

Consolidation of available comparable data was conducted in the Spring 2006 report. If further historical data become available then these will be added into future reports. Analysis in the Autumn and Spring 2007 and Autumn 2008 reports has also incorporated available comparable historical data. Additional sampling across all five streams has allowed statistical analysis to identify temporal shifts in community structure across seasons and under varying weather conditions. Investigation of the data in this way will continue in subsequent reports to provide a better understanding of variation between Autumn and Spring seasons and between weather conditions which will provide better base line data to assess changes in community structure that may result from future City of Ryde management actions.

- Detail where, when and how often samples should be taken from creeks within the Ryde Local Government Area based on existing site data, catchment position, accessability and trends identified;

Recommendations made in Spring 2006 report to sample all creeks in each sample session have been implemented and allow capture of variation through time and under different weather conditions that influence the five study streams. Benefits of sampling all five creeks are detailed above and in the last paragraph of this section.

- Prescribe how to sample for macroinvertebrates, building on the standard protocols designed by AUSRIVAS;

Adoption of a standard methodology under the strategy allows for collection of comparable data and in turn statistical analysis of comparable measures which facilitiates interpretation of collected data.

- Provide for a series of options for identification of key indicator taxa to family and or morphospecies;

This is facilititated by EPT indicator taxa from AUSRIVAS predicted model output. SIGNAL-SF grades could also be used to assess key indicator taxa. With currently only two EPT taxa recorded to date no advantage is afforded by SIGNAL-SF at this stage.

- Identify a standard suite of analyses to determine status and trends in water quality including calculation of the AUSRIVAS index;

Suitable indices such as SIGNAL SF to assess water quality status, including calculation of the Observed/Expected (OE50 and OE0 SIGNAL2) ratios from the respective AUSRIVAS predictive models for autumn, spring, and combined seasons were evaluated in Spring 2006 with subsequent recommendation made and these have been implemented in Autumn and Spring 2007 and Autumn 2008 reports. Multivariate statistical analysis techniques have also been incorporated into Spring 2006, Autumn 2007 and Spring 2007 reports. A change was made to the routine used to assess water quality and macroinvertebartes linkages in Spring 2006 with the BIOENV routine employed instead of the BVSTEP routine which conducts a less thorough search. This change was made given the relatively small amount of water quality variables and suitable computing power was available to conduct a full search of the data with BIOENV.

- Provide the basis for an appraisal of the capacity of a standard monitoring strategy to be intergrated into a community monitoring program eg. Streamwatch.

Suggestions were put forward in the Spring 2006 and Autumn 2007 reports for use of SIGNAL2 in a format that could be calculated by community groups without access to the AUSRIVAS predictive models. In the 2007 report, calibration was made for boundary points of water quality status so community groups could use this analysis in the City of Ryde area. Standard collection methods would need to be used and suitable quality control of data would need to be implemented to provide comparability of data through time.

- Provide the foundation to augment the Streamwatch capacity within the City of Ryde including options for improved education awareness of water quality issues within schools and community groups.

As above.

- Provide information and direction on potential infrastructural works to complement water quality monitoring and improve overall creek health.

The consolidation of available comparable data that has occurred and additional sampling will allow capture of variation through time and under different weather conditions in each of the five study streams. Continued average rainfall conditions or better would be advantageous to allow capture of variation in community structure and water quality under wetter conditions. Understanding variation between Autumn and Spring and under different weather conditions will provide better base line data to assess changes in community structure that may result from future City of Ryde management actions.

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Appendix 1 Quality assurance

Sydney Water Analytical Services is a quality business organisation, certified to AS/NZS ISO 9001:2000 Quality management systems - requirements certification number 2764, issued by Benchmark 31st November 2004 for the Monitoring Process Management System. All investigations performed for the production of this report, and all business operations of the organisation, have been conducted to the requirements of this standard including project management, macroinvertebrate sampling, water quality sampling and interpretive reporting.

Macroinvertebrates have been identified and enumerated to the genus or species taxonomic level, (as appropriate for the study) by the Aquatic Ecology team. The method used SSWI433 In-house test method macroinvertebrate cataloguing, identification and counting is in compliance with the requirements of AS ISO/IEC 17025:1999 General Requirements for the Competence of Testing and Calibration Laboratories was added under technical accreditation number 610 issued by National Association of Testing Authorities (NATA) in 1997. In particular macroinvertebrate identification was performed with appropriate published keys listed in Hawking (2000), internal keys to the macroinvertebrate collection, unpublished descriptions and voucher specimens. Where a specimen could not be keyed to a formally described species, a morphospecies number has been assigned as per in-house test method SSWI433. Terrestrial macroinvertebrate morphospecies have been shown to produce similar patterns to those obtained using formally described species (Oliver and Beattie, 1996).

Quality assurance was conducted as per SSWI434 In-house test method quality control of macroinvertebrate identification, counting and archiving of collections in compliance with the requirements of AS ISO/IEC 17025:1999 General Requirements for the Competence of Testing and Calibration Laboratories was added under technical accreditation number 610 in 1997. Quality assurance was conducted on at least 5% of samples collected for this study, and identification and counting errors on average are less than 10% for the study.

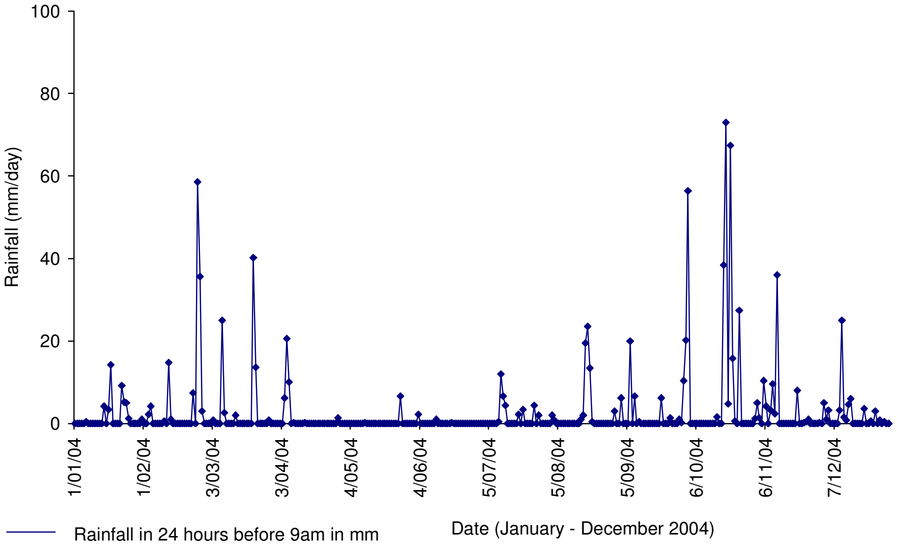
Appendix 2 Water quality results

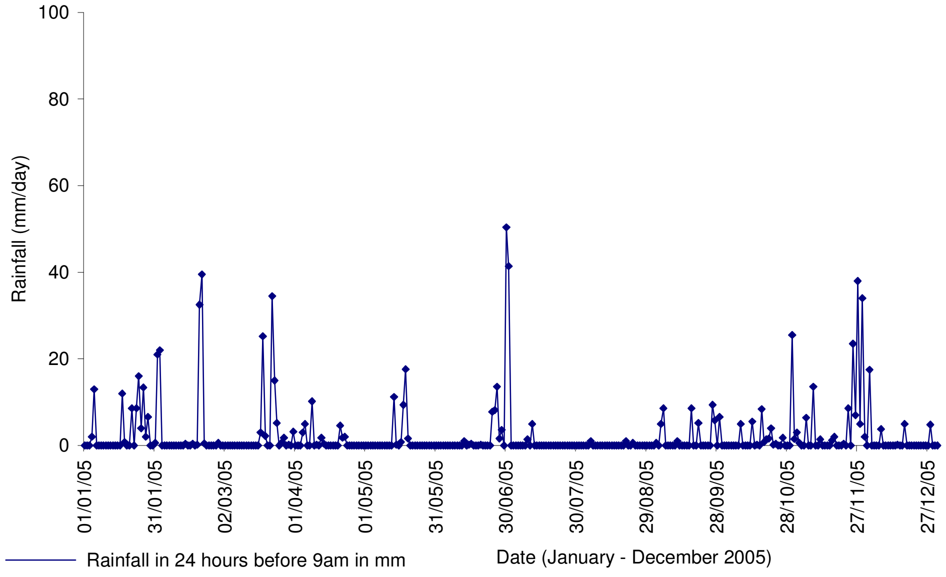
Stream	Site code	Season	Sample date	Faecal Coliforms	Ammonia	Oxidised Nitrogen NOx	Total Phosphorus TP	Total Kjeldahl Nitrogen TKN	Total Nitrogen TN	Alkalinity	Turbidity	Conductivity	Total Dissolved Solids	pH	Dissolved Oxygen DO
				CFU/100mL	µg/L	µg/L	µg/L	µg/L	µg/L	mg CaCO3/L	NTU	µS/cm	mg/L		mg/L
Terrys Ck	Site 1	autumn 2008	3/5/08	150	10	**270**	24	310	**580**	72	3.21	474	284	8.0	8.40
Shrimptons Ck	Site 2	autumn 2008	3/5/08	200	10	10	**53**	670	**680**	74	3.17	358	214	7.4	5.80
Porters Ck	Site 3	autumn 2008	3/5/08	530	**250**	**430**	38	1100	**1530**	81	15.2	650	444	7.6	6.70
Buffalo Ck	Site 4	autumn 2008	3/5/08	620	**40**	**450**	35	370	**820**	91	37.2	885	552	**8.1**	6.80
Archers Ck	Site 5	autumn 2008	3/5/08	170	**30**	**370**	20	290	**660**	78	2.18	513	310	7.3	6.50
Terrys Ck	Site 1	autumn 2008	4/3/08	250	10	**120**	25	200	320	64	3.1	351	160	7.3	8.30
Shrimptons Ck	Site 2	autumn 2008	4/3/08	700	10	10	**92**	620	**620**	73	6.17	291	130	7.2	3.80
Porters Ck	Site 3	autumn 2008	4/3/08	370	**750**	**300**	27	1100	**4100**	100	3.96	505	290	7.6	9.30
Buffalo Ck	Site 4	autumn 2008	4/3/08	120	**50**	**220**	33	260	480	77	4.69	654	389	7.3	8.00
Archers Ck	Site 5	autumn 2008	4/3/08	160	**40**	**110**	22	230	340	83	1.48	470	253	7.3	7.10

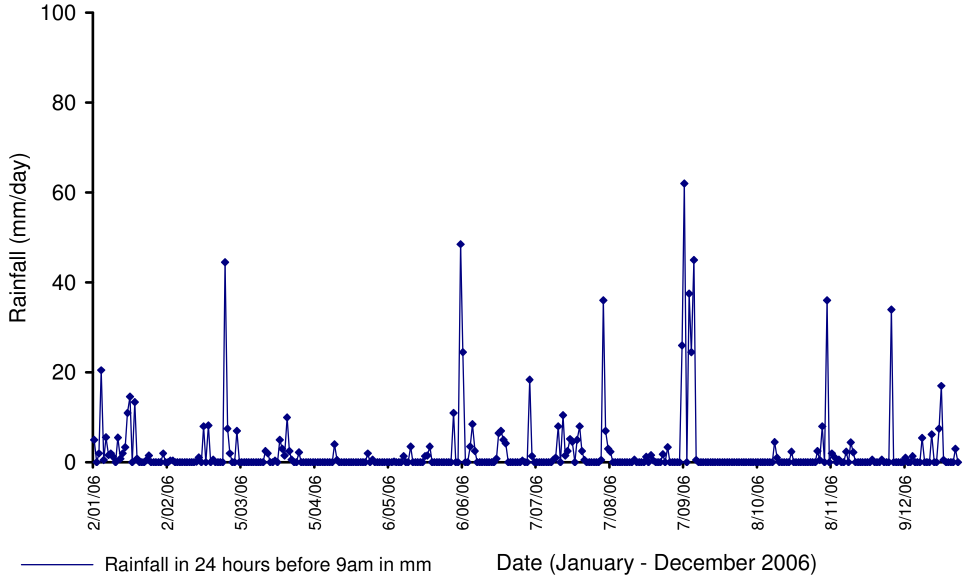
Stream	Site code	Season	Sample date	Faecal Coliforms	Ammonia	Oxidised Nitrogen NOx	Total Phosphorus TP	Total Kjeldahl Nitrogen TKN	Total Nitrogen TN	Alkalinity	Turbidity	Conductivity	Total Dissolved Solids	pH	Dissolved Oxygen DO
				CFU/100mL	µg/L	µg/L	µg/L	µg/L	µg/L	mg CaCO3/L	NTU	µS/cm	mg/L		mg/L
Terrys Ck	Site 1	spring 2007	27/09/07	87	20	**190**	21	290	480	67	2	503	276	7.3	6.00
Shrimptons Ck	Site 2	spring 2007	26/09/07	300	**160**	30	**54**	650	**680**	72	2.6	403	232	7.1	2.35
Porters Ck	Site 3	spring 2007	27/09/07	**1000**	**2600**	**3200**	**60**	3110	**6310**	122	6.7	671	372	7.8	6.50
Buffalo Ck	Site 4	spring 2007	27/09/07	54	**40**	**170**	37	440	**610**	90	7.3	960	484	7.3	5.70
Archers Ck	Site 5	spring 2007	26/09/07	270	20	**480**	26	680	**1160**	59	3.2	527	304	7.5	6.30
Terrys Ck	Site 1	spring 2007	23/10/07	6	**40**	**80**	35	730	**810**	88	1.6	712	437	7.0	4.00
Shrimptons Ck	Site 2	spring 2007	22/10/07	150	<10	<10	**111**	1000	**1000**	77	11.9	519	350	**6.7**	2.90
Porters Ck	Site 3	spring 2007	23/10/07	160	**1020**	**2600**	**68**	1580	**4180**	90	8.2	505	326	7.7	7.30
Buffalo Ck	Site 4	spring 2007	23/10/07	140	**110**	**60**	**73**	790	**850**	108	7.7	1001	621	7.2	6.95
Archers Ck	Site 5	spring 2007	22/10/07	90	**150**	**50**	**57**	480	**530**	74	7.1	378	220	**6.7**	3.90
Terrys Ck	Site 1	autumn 2007	14-15/03/07	300	<10	**370**	30	280	**650**	64	1.6	472	358	7.2	5.07
Shrimptons Ck	Site 2	autumn 2007	14-15/03/07	600	<10	**550**	**58**	330	**880**	64	2.9	362	276	7.1	3.2
Porters Ck	Site 3	autumn 2007	14-15/03/07	600	**580**	**1310**	**51**	1040	**2350**	97	1.3	**3030**	2010	7.9	8.42
Buffalo Ck	Site 4	autumn 2007	14-15/03/07	68	**90**	**120**	48	440	**560**	75	2.1	646	442	7.3	5.09
Archers Ck	Site 5	autumn 2007	14-15/03/07	290	<10	**170**	**89**	270	440	64	0.9	397	300	7.2	4.60
Terrys Ck	Site 1	autumn 2007	17-18/04/07	900	**110**	**200**	**53**	530	**730**	57	2.7	438	.	7.1	5.30
Shrimptons Ck	Site 2	autumn 2007	17-18/04/07	550	**30**	**160**	45	490	**650**	81	8.4	397	.	6.9	3.75
Porters Ck	Site 3	autumn 2007	17-18/04/07	**10000**	**710**	**1590**	20	1200	**2790**	98	3.2	3130	.	7.8	7.70
Buffalo Ck	Site 4	autumn 2007	17-18/04/07	740	**130**	**120**	48	540	**660**	81	8.6	912	.	6.7	3.83
Archers Ck	Site 5	autumn 2007	17-18/04/07	210	**30**	**50**	**58**	520	**570**	70	4.2	322	.	7.2	4.10
Shrimptons Ck	Site 2	spring 2006	28/09/06	69	**130**	**140**	**64**	580	**720**	94	7.8	717	420	7.1	4.33
Archers Ck	Site 5	spring 2006	28/09/06	160	5	5	**104**	520	**520**	83	2.0	509	293	7.4	6.53
Shrimptons Ck	Site 2	spring 2006	18/10/06	560	10	20	**136**	1180	**1200**	66	6.3	481	311	**6.5**	2.21
Archers Ck	Site 5	spring 2006	18/10/06	340	5	10	**90**	500	**510**	70	2.3	448	295	6.9	3.94
Shrimptons Ck	Site 2	spring 2006	10/11/06	880	**70**	**1200**	**68**	800	**2000**	58	**96.7**	384	265	7.4	4.16
Archers Ck	Site 5	spring 2006	10/11/06	**1700**	**20**	**40**	**50**	360	400	84	1.8	502	310	7.2	7.19
Terrys Ck	Site 1	autumn 2006	9-10/03/06	160	<10	**60**	30	310	370	50	2.3	381	180	6.8	4.99
Shrimptons Ck	Site 2	autumn 2006	9-10/03/06	330	**40**	<10	**50**	380	390	85	4.6	435	230	**6.7**	2.13
Porters Ck	Site 3	autumn 2006	9-10/03/06	**9800**	**820**	**760**	20	1500	**2300**	48	1.9	**3712**	2200	7.4	7.41
Buffalo Ck	Site 4	autumn 2006	9-10/03/06	220	**130**	**470**	**70**	500	**1000**	90	8.0	738	390	7.2	4.36
Archers Ck	Site 5	autumn 2006	9-10/03/06	140	**90**	**80**	**100**	520	**600**	95	2.5	1482	830	7.0	4.09
Terrys Ck	Site 1	autumn 2006	19-20/04/06	560	**450**	**90**	**100**	1100	**1200**	45	3.2	306	180	7.0	2.40
Shrimptons Ck	Site 2	autumn 2006	19-20/04/06	860	**30**	30	**80**	480	**510**	40	5.0	281	160	**6.7**	4.61
Porters Ck	Site 3	autumn 2006	19-20/04/06	290	**350**	**630**	20	700	**1300**	45	2.3	**3792**	2100	7.6	8.30
Buffalo Ck	Site 4	autumn 2006	19-20/04/06	170	**90**	**450**	**60**	470	**920**	70	5.1	749	400	7.2	4.64
Archers Ck	Site 5	autumn 2006	19-20/04/06	240	**90**	**470**	**70**	390	**860**	45	4.1	259	150	7.1	4.38
Terrys Ck	Site 1	autumn 2006	9-10/05/06	66	**70**	**240**	**50**	380	**620**	60	2.4	358	220	7.1	3.98
Shrimptons Ck	Site 2	autumn 2006	9-10/05/06	750	20	**40**	**80**	340	380	35	7.7	264	140	6.8	5.04
Porters Ck	Site 3	autumn 2006	9-10/05/06	40	**400**	**650**	10	800	**1400**	1	1.2	**2916**	1700	7.3	8.33
Buffalo Ck	Site 4	autumn 2006	9-10/05/06	110	**60**	**480**	**60**	240	**720**	90	4.4	667	400	7.3	4.72
Archers Ck	Site 5	autumn 2006	9-10/05/06	28	**50**	**370**	40	300	**670**	55	5.1	245	120	7.2	6.31

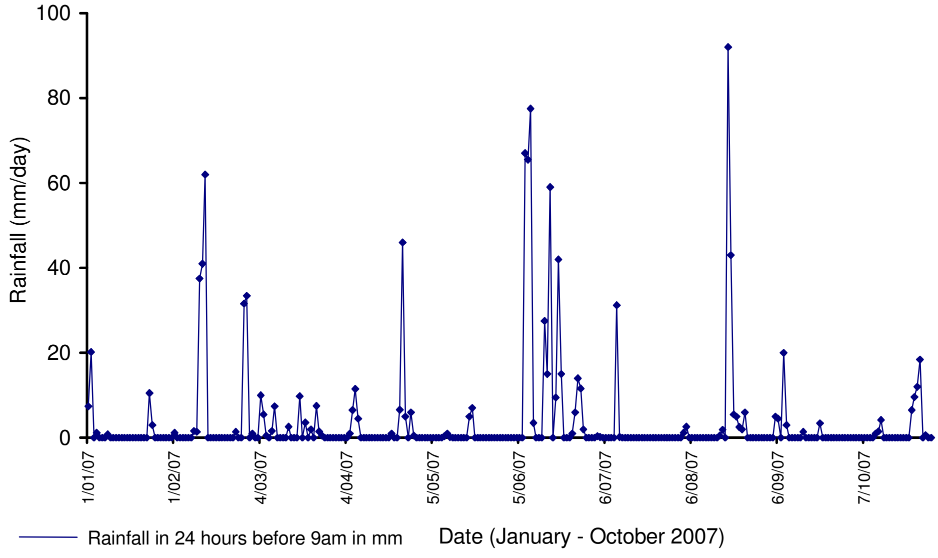
Stream	Site code	Season	Sample date	Faecal Coliforms	Ammonia	Oxidised Nitrogen NOx	Total Phosphorus TP	Total Kjeldahl Nitrogen TKN	Total Nitrogen TN	Alkalinity	Turbidity	Conductivity	Total Dissolved Solids	pH	Dissolved Oxygen DO
				CFU/100mL	µg/L	µg/L	µg/L	µg/L	µg/L	mg CaCO3/L	NTU	µS/cm	mg/L		mg/L
Terrys Ck	Site 1	spring 2005	6-7/09/05	300	**59**	**48**	10	90	140	43	6.5	187	140	**6.7**	8.10
Shrimptons Ck	Site 2	spring 2005	6-7/09/05	90	5	37	4	28	65	42	7	164	140	**6.7**	4.31
Porters Ck	Site 3	spring 2005	6-7/09/05	500	**110**	**58**	2	240	300	37	3	**6141**	4000	7.0	8.72
Buffalo Ck	Site 4	spring 2005	6-7/09/05	16	10	**50**	8	27	77	79	5.5	620	380	7.0	6.19
Archers Ck	Site 5	spring 2005	6-7/09/05	**2000**	17	26	11	56	82	56	10	245	160	6.8	5.56
Terrys Ck	Site 1	spring 2005	11-12/10/05	**2000**	10	33	10	52	85	47	2.2	245	180	7.1	4.49
Shrimptons Ck	Site 2	spring 2005	11-12/10/05	**32000**	16	36	10	54	90	43	3.9	246	150	7.2	3.26
Porters Ck	Site 3	spring 2005	11-12/10/05	**16000**	**54**	**51**	5	130	180	31	4.5	**3965**	2600	7.6	8.67
Buffalo Ck	Site 4	spring 2005	11-12/10/05	**6500**	**26**	**63**	20	70	130	44	29	472	210	7.6	9.16
Archers Ck	Site 5	spring 2005	11-12/10/05	**3800**	6	**54**	10	50	100	30	5.1	206	100	7.3	4.56
Terrys Ck	Site 1	spring 2005	2/11/05	380	<1	2	4	37	39	37	1	159	110	**6.5**	5.40
Shrimptons Ck	Site 2	spring 2005	2/11/05	500	6	19	6	45	64	50	6.1	226	150	**6.6**	5.24
Porters Ck	Site 3	spring 2005	2/11/05	260	**83**	**42**	<1	210	250	30	6.4	**5633**	3500	7.1	7.89
Buffalo Ck	Site 4	spring 2005	2/11/05	**2000**	5	28	5	35	63	60	4.1	299	200	7.0	5.65
Archers Ck	Site 5	spring 2005	2/11/05	640	6	18	4	56	74	79	12.6	350	210	6.9	5.58
Terrys Ck	Site 1	autumn 2005	30-31/03/05	**60000**	**590**	**170**	**100**	800	**970**	40	42	315	130	7.2	8.44
Shrimptons Ck	Site 2	autumn 2005	30-31/03/05	**3400**	20	**240**	40	280	**520**	52	9	305	170	**6.7**	4.46
Porters Ck	Site 3	autumn 2005	30-31/03/05	**1000**	**670**	**820**	40	1100	**1900**	99	18.9	1719	1100	7.3	7.61
Buffalo Ck	Site 4	autumn 2005	30-31/03/05	36	**130**	**290**	30	370	**660**	59	17.4	241	140	7.6	8.37
Archers Ck	Site 5	autumn 2005	30-31/03/05	360	20	**50**	60	350	400	68	22.2	183	180	7.1	7.49
Terrys Ck	Site 1	autumn 2005	26-27/04/05	90	**70**	**140**	40	300	440	62	1.7	264	180	**6.6**	6.60
Shrimptons Ck	Site 2	autumn 2005	26-27/04/05	940	**40**	**100**	30	270	370	65	3.2	236	160	**6.4**	5.73
Porters Ck	Site 3	autumn 2005	26-27/04/05	220	**400**	**590**	20	1100	**1700**	35	3.6	**2520**	1800	7.2	8.77
Buffalo Ck	Site 4	autumn 2005	26-27/04/05	520	**80**	**940**	40	.	**770**	95	7.6	548	390	**6.7**	5.4
Archers Ck	Site 5	autumn 2005	26-27/04/05	300	**40**	20	10	240	260	78	1.4	261	160	6.8	5.80
Terrys Ck	Site 1	autumn 2005	26-27/05/05	130	**40**	**110**	30	260	370	61	1.8	325	180	7.3	8.34
Shrimptons Ck	Site 2	autumn 2005	26-27/05/05	400	**40**	**290**	30	.	**560**	65	4.9	333	180	7.2	5.65
Porters Ck	Site 3	autumn 2005	26-27/05/05	59	**350**	**640**	20	1100	**1700**	30	1.5	**2305**	1500	7.8	10.02
Buffalo Ck	Site 4	autumn 2005	26-27/05/05	170	**90**	**350**	40	300	**650**	92	7.1	641	360	7.5	7.39
Archers Ck	Site 5	autumn 2005	26-27/05/05	360	**60**	**70**	20	310	380	99	3.3	376	200	7.4	8.14
Terrys Ck	Site 1	spring 2004	14-15/09/04	80	.	.	**110**	.	.	50	2.4	.	150	6.8	5.08
Shrimptons Ck	Site 2	spring 2004	14-15/09/04	880	.	.	**90**	.	.	58	3.1	.	140	6.8	2.20
Archers Ck	Site 5	spring 2004	14-15/09/04	650	.	.	**150**	.	.	70	0.6	.	110	7.0	6.53
Terrys Ck	Site 1	spring 2004	11-12/10/04	44	.	.	30	.	.	64	0.3	.	310	7.6	5.01
Shrimptons Ck	Site 2	spring 2004	11-12/10/04	110	.	.	**60**	.	.	76	0.5	.	260	7.4	5.69
Archers Ck	Site 5	spring 2004	11-12/10/04	**1500**	.	.	**50**	.	.	82	0.8	.	230	7.5	4.27
Terrys Ck	Site 1	spring 2004	23-24/11/04	150	.	.	40	.	.	56	2.6	.	180	**6.7**	6.90
Shrimptons Ck	Site 2	spring 2004	23-24/11/04	**1000**	.	.	**90**	.	.	75	11.5	.	190	**6.4**	2.93
Archers Ck	Site 5	spring 2004	23-24/11/04	**1700**	.	.	40	.	.	84	4.7	.	270	**6.6**	8.02

Appendix 3 Rainfall 2004 – 2007






100
80
60
40
20
0
Rainfall (mm/day)
2/01/06
2/02/06
5/03/06
5/04/06
6/05/06
6/06/06
7/07/06
7/08/06
7/09/06
8/10/06
8/11/06
9/12/06
Rainfall in 24 hours before 9am in mm
Date (January - December 2006)


100
80
60
40
20
0
Rainfall (mm/day)
1/01/07
1/02/07
4/03/07
4/04/07
5/05/07
5/06/07
6/07/07
6/08/07
6/09/07
7/10/07
Rainfall in 24 hours before 9am in mm
Date (January - October 2007)

Appendix 4 Macroinvertebrate results

			S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2006 Archers Ck	S5 autumn 2006 Archers Ck	S5 autumn 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck
Aquatic mites	Acarina	Acarina	1	3	1			1	3	3					1	3	1		4			1										3	9		1					
Beetles	Coleoptera	Dytiscidae		3		2		1	1	1																								1					1	
Beetles	Coleoptera	Elmidae																													2									
Beetles	Coleoptera	Hydraenidae													1						1																			
Beetles	Coleoptera	Hydrophilidae																				1																		
Beetles	Coleoptera	Psephenidae																																						
Beetles	Coleoptera	Scirtidae																																	1					
Caddisfly larvae	Trichoptera	Antipodoecidae																																						
Caddisfly larvae	Trichoptera	Hydroptilidae	2		3																1								12	3	9				8	2	6		2	
Caddisfly larvae	Trichoptera	Leptoceridae		1																																	1			
Dobsonfly larvae	Megaloptera	Corydalidae																																						
Dragonfly larvae	Odonata	Aeshnidae	1	1		5	5		2		14		11	8												3	2	1	1									1	2	
Dragonfly larvae	Odonata	Coenagrionidae	7	5	5	21	7	4	6	3	29	1	7	6		1					5			1			2	1	1									2	4	3
Dragonfly larvae	Odonata	Gomphidae																																						
Dragonfly larvae	Odonata	Hemicorduliidae	2	6	1	25			4	3	18	1	7	5				1			2	10	1			3	4		9	1	1	2	9							
Dragonfly larvae	Odonata	Isostictidae																																						
Dragonfly larvae	Odonata	Lestidae			3											1	1		2			3																		
Dragonfly larvae	Odonata	Libellulidae	2	4	5	1	15	14	3	9	8	7	2	4		1		1						6		2	2	4	2	1	2	2	1					4	3	1
Dragonfly larvae	Odonata	Megapodagrionidae		2		6		1	15	22	5	2	7	5	1			1			1	6		1	2	7		1		2				1				1	1	
Dragonfly larvae	Odonata	Synthemistidae															1										1													
Dragonfly larvae	Odonata	Telephlebiidae																																						
Fairy shrimps	Decapoda	Atyidae		1					6	11	17	5	1													11	1					2	1							
Flatworms	Turbellaria	Dugesiidae	2	3	1		1	2	3	15	7	1	4	4	9	7	3	10	16	11	9	2	2	5		10	8	1	17	3		18	12	7	2			3	3	
Lacewing	Neuroptera	Osmylidae																																						
Leeches	Arhynchobdellida	Erpobdellidae																																						
Leeches	Arhynchobdellida	Hirudinidae																																						
Leeches	Rhynchobdellida	Glossiphoniidae		1	4					1		6	6	2							1	1		1	3	1	1											2	1	2
Mayfly larvae	Ephemeroptera	Baetidae			1																			3		2							2					6	7	6
Moth Larvae	Lepidoptera	Pyralidae																												2										1
Mussels	Bivalvia	Corbiculidae		1	1		3	3			1																													
Mussels	Bivalvia	Sphaeriidae		3																	1								12		1	9	13	1						
Proboscis Worms	Nemertea	Nemertea																																1						
Round Worms	Nematoda	Nematoda		1	1																									2										
Sand hoppers	Amphipoda	Ceinidae				2																													1					
Sand hoppers	Amphipoda	Talitridae																																						
Slatters	Isopoda	Oniscidae				7		1				3			1	4			1																		1			

			S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2006 Archers Ck	S5 autumn 2006 Archers Ck	S5 autumn 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 spring 2006 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 autumn 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 spring 2007 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck
Snails	Gastropoda	Ancylidae																													1			1				
Snails	Gastropoda	Hydrobiidae	1	3	2										2	4	1	1	3		7	11	10	5	1				13	12	7	1	11	8	8	13	7	5	8	1
Snails	Gastropoda	Lymnaeidae				1							1									1		1											1					
Snails	Gastropoda	Physidae	3	5	10	9	5	13	4	4	1	1	5		8	4	12	15	3	7	8	7	11	7	2	9	13	1	18	10	11	15	12	21	11	5		9	7	1
Snails	Gastropoda	Planorbidae																																						
Stonefly larvae	Plecoptera	Eustheniidae																																						
True bugs	Hemiptera	Belostomatidae																																						
True bugs	Hemiptera	Corixidae						1		1	10																						1	1						
True bugs	Hemiptera	Gelastocoridae													1				1																					
True bugs	Hemiptera	Gerridae						1				1		1																										
True bugs	Hemiptera	Hebridae																																						
True bugs	Hemiptera	Mesoveliidae																																						
True bugs	Hemiptera	Naucoridae																																						
True bugs	Hemiptera	Nepidae																																						
True bugs	Hemiptera	Notonectidae			2						11	2	1	4												2					1	7	12		2	1	9		2	11
True bugs	Hemiptera	Pleidae																																						
True bugs	Hemiptera	Saldidae																															1							
True bugs	Hemiptera	Veliidae	3	1				3	6	5	3	2	2	1	1		1		2	2	1		2		7	15	3			1					3	2	8	1	3	1
True Fly larvae	Diptera	Bibionidae																			2																			
True Fly larvae	Diptera	Cecidomyiidae																																						
True Fly larvae	Diptera	Ceratopogonidae																																	4		3	2	3	
True Fly larvae	Diptera	Culicidae				17	1					1		1		1			11	6		14										4	3							
True Fly larvae	Diptera	Dixidae																																						
True Fly larvae	Diptera	Dolichopodidae																												1										
True Fly larvae	Diptera	Ephydridae																																						
True Fly larvae	Diptera	Muscidae																			1											1					1			
True Fly larvae	Diptera	Psychodidae																			1										1						1			
True Fly larvae	Diptera	s-f Chironominae	9	10	11	69	94	38	9	5	22	71	72	##	22	15	19	27	6	8	34	32	18	13	34	25	35	23	33	18	40	33	42	24	8	16	9	10	9	17
True Fly larvae	Diptera	s-f Orthocladiinae	1		10				1						7	1		1	2	1	6				3	1	1		3	9	5			1	20	23	22	10	32	14
True Fly larvae	Diptera	s-f Tanypodinae	1	6	3	7			1	1	1		3	10	2	1		1	1	1	2	2	2	1	1	2	3	1	10	5	1	1	2	5				2		
True Fly larvae	Diptera	Simuliidae													1										1					2	1					1		3		
True Fly larvae	Diptera	Stratiomyidae	3	1		1			1	2	6	1		1		1	4		2	6			1	1							5		2	1	1	1	1	1		
True Fly larvae	Diptera	Syrphidae																				1																		
True Fly larvae	Diptera	Tipulidae	1	1										1				2					2								2			2	1	2		1	1	
Worms	Oligochaeta	Oligochaeta	4	6	12	24	19	11	4	16	15	8	13	14	12	9	8	11	3	1	4	8	3	8	11		10	3	16	23	6	2	8	5	4	5	2	1	3	3
Yabbies	Decapoda	Parastacidae																																						
Yabbie cleaner	Temnocephala	Temnocephalidae																																						

			S2 spring 2004 Shrimptons Ck	S2 spring 2004 Shrimptons Ck	S2 spring 2004 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck
Aquatic mites	Acarina	Acarina	1		3	1			1		2	4	5	4		1		2	1	1	4	7	1	1	11	2	4	9	2		1		2	1		6		2		1	1
Beetles	Coleoptera	Dytiscidae																				1																			
Beetles	Coleoptera	Elmidae																																							
Beetles	Coleoptera	Hydraenidae																																							
Beetles	Coleoptera	Hydrophilidae																																					1	
Beetles	Coleoptera	Psephenidae																																							
Beetles	Coleoptera	Scirtidae																																							
Caddisfly larvae	Trichoptera	Antipodoecidae																																							
Caddisfly larvae	Trichoptera	Hydroptilidae	2	3																										2	5	3									
Caddisfly larvae	Trichoptera	Leptoceridae			1																																				
Dobsonfly larvae	Megaloptera	Corydalidae																																							
Dragonfly larvae	Odonata	Aeshnidae																								2	4	1	2		1										
Dragonfly larvae	Odonata	Coenagrionidae	3	6		1		2	3			3	1			1		3			1			3	4	1	7	6	1	7	1	13	2	4	2	1	1	1	1		
Dragonfly larvae	Odonata	Gomphidae	1																																						
Dragonfly larvae	Odonata	Hemicorduliidae	1	4	2		1					7	4	1		5	2	2	4		1	4			7	1	9	6	14	2		5	2	2	1	2		2	1		
Dragonfly larvae	Odonata	Isostictidae														1								1	3	3	1	5	7	4	1	8	6	4	1						
Dragonfly larvae	Odonata	Lestidae			1												1			8		2	3																		
Dragonfly larvae	Odonata	Libellulidae		3						2	4	1		1												1	1	2			2					1				4	
Dragonfly larvae	Odonata	Megapodagrionidae		2																		1	1	3	2	8	7	4	4	6	13	8	8			3	2	2		3	
Dragonfly larvae	Odonata	Synthemistidae																																							
Dragonfly larvae	Odonata	Telephlebiidae																								1															
Fairy shrimps	Decapoda	Atyidae																																							
Flatworms	Turbellaria	Dugesiidae	2	4	9	14	19	11	14	12	10	7	8	9	4	1		2		8	3	2	2	4	4	4	7	11	1	7	9	13	5	1	1	8	13	17	13	9	17
Lacewing	Neuroptera	Osmylidae																														1									
Leeches	Arhynchobdellida	Erpobdellidae						9																																	
Leeches	Arhynchobdellida	Hirudinidae																																							
Leeches	Rhynchobdellida	Glossiphoniidae				15	5	9	7	9	12	1	1										1	1												10	2	1			3
Mayfly larvae	Ephemeroptera	Baetidae																		1			1		1																
Moth Larvae	Lepidoptera	Pyralidae																																							
Mussels	Bivalvia	Corbiculidae		4		9	3	10	6	4	12	9	6	3																											
Mussels	Bivalvia	Sphaeriidae	2	3	10										1																	1		1		3					1
Proboscis Worms	Nemertea	Nemertea																																							
Round Worms	Nematoda	Nematoda	1																																						
Sand hoppers	Amphipoda	Ceinidae																																							
Sand hoppers	Amphipoda	Talitridae																																							
Slatters	Isopoda	Oniscidae							2																1							1									

			S2 spring 2004 Shrimptons Ck	S2 spring 2004 Shrimptons Ck	S2 spring 2004 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 autumn 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 spring 2005 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 autumn 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 spring 2006 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 autumn 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 spring 2007 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck
Snails	Gastropoda	Ancylidae	1	1	1												1	1							1		1			3	2	2	2	5							
Snails	Gastropoda	Hydrobiidae		1							3					1		2					1									1		1							
Snails	Gastropoda	Lymnaeidae							1			1				1						1						1			1	1	1		1			1			
Snails	Gastropoda	Physidae	6	7	10	17	17	12	14	20	15	5	11	11	13	16	8	13	10	10	13	9	14		1	15	16	8	4	17	17	29	17	9	4	14	8	4	8	6	13
Snails	Gastropoda	Planorbidae	2	3	10	11	2	6	4	11	11	2			3	1	6	1	2											2				3			1				
Stonefly larvae	Plecoptera	Eustheniidae																																							
True bugs	Hemiptera	Belostomatidae																																							
True bugs	Hemiptera	Corixidae		3	2				2																1		1	1		1	4		5	2	1		1				
True bugs	Hemiptera	Gelastocoridae						1	1	2											1																				
True bugs	Hemiptera	Gerridae																							1	1			1							1					
True bugs	Hemiptera	Hebridae																																							
True bugs	Hemiptera	Mesoveliidae																								1															
True bugs	Hemiptera	Naucoridae																																							
True bugs	Hemiptera	Nepidae																									1					1									
True bugs	Hemiptera	Notonectidae															2	2	1	4	2	1	1	2	5	1		2		1			1	1	1	5		3			
True bugs	Hemiptera	Pleidae										1																													
True bugs	Hemiptera	Saldidae																																							
True bugs	Hemiptera	Veliidae																		1					1	11	4							2							
True Fly larvae	Diptera	Bibionidae																																							
True Fly larvae	Diptera	Cecidomyiidae																																							
True Fly larvae	Diptera	Ceratopogonidae	1												1																								1		
True Fly larvae	Diptera	Culicidae														2					8													1							
True Fly larvae	Diptera	Dixidae																																							
True Fly larvae	Diptera	Dolichopodidae																																							
True Fly larvae	Diptera	Ephydridae																																							
True Fly larvae	Diptera	Muscidae																																4							
True Fly larvae	Diptera	Psychodidae																																							
True Fly larvae	Diptera	s-f Chironominae	12	11	10		1		5	10	15		2	3	21	25	21	20	32	18	18	26	12	8	4	5	17	2	26	30	27	50	7	12	11				1		
True Fly larvae	Diptera	s-f Orthocladiinae					1									1							1												1		1				1
True Fly larvae	Diptera	s-f Tanypodinae														1		1			2		1			1		1			1	1	2	5			1				
True Fly larvae	Diptera	Simuliidae																																							
True Fly larvae	Diptera	Stratiomyidae		1		1		4	1							1	1			1			1										1								
True Fly larvae	Diptera	Syrphidae																																							
True Fly larvae	Diptera	Tipulidae																																							
Worms	Oligochaeta	Oligochaeta	7	6	12	10	9	17	16	13	17	13	11	17	10	4	8	1	8	10	3	3		7	5	4	1		6	12	2	5	5	5	3	3	5	2	4		3
Yabbies	Decapoda	Parastacidae										1			2								1			2	1	3				1					1				
Yabbie cleaner	Temnocephala	Temnocephalidae																								1															

			S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck
Aquatic mites	Acarina	Acarina	1					1		1				1		1													
Beetles	Coleoptera	Dytiscidae				1	1	2							2	1								2	1	4			
Beetles	Coleoptera	Elmidae																											
Beetles	Coleoptera	Hydraenidae																											
Beetles	Coleoptera	Hydrophilidae													3											1			
Beetles	Coleoptera	Psephenidae							1																				
Beetles	Coleoptera	Scirtidae			1										1							1							
Caddisfly larvae	Trichoptera	Antipodoecidae										1														1			
Caddisfly larvae	Trichoptera	Hydroptilidae										3	3	7	4	5	1			1			1						
Caddisfly larvae	Trichoptera	Leptoceridae	1		1				1	1			3	4		3	1												
Dobsonfly larvae	Megaloptera	Corydalidae																											
Dragonfly larvae	Odonata	Aeshnidae	2	2	2	1			3	5	7		2																
Dragonfly larvae	Odonata	Coenagrionidae	3	10	13	9		2	15	7	12	8	12	2	10	5	7	1	3	1		1		1				2	2
Dragonfly larvae	Odonata	Gomphidae				1																							
Dragonfly larvae	Odonata	Hemicorduliidae	9	8	8	11			5	5	13	10	6	2	9	3	6		2								2		2
Dragonfly larvae	Odonata	Isostictidae	21	19	13	9	5	7	18	7	7	8	6	2	13	13	8	1	8	3	3	2						2	2
Dragonfly larvae	Odonata	Lestidae																											
Dragonfly larvae	Odonata	Libellulidae	1	3	4	2	5	9	5	1	3	5	9	4	6	5	1		1				1	1			1		
Dragonfly larvae	Odonata	Megapodagrionidae	6	14	8	4		2	10	7	26	8	7	2	5	11	5	4	13	10	1	4	8	2	5	3	12	2	10
Dragonfly larvae	Odonata	Synthemistidae																											
Dragonfly larvae	Odonata	Telephlebiidae																											
Fairy shrimps	Decapoda	Atyidae	5				2		5	5	14	10	8	3	1	10	1									1			
Flatworms	Turbellaria	Dugesiidae	5	3		2						3	2	2					2			1		5	2	1			5
Lacewing	Neuroptera	Osmylidae																											
Leeches	Arhynchobdellida	Erpobdellidae				2	2	1						2															
Leeches	Arhynchobdellida	Hirudinidae																										1	
Leeches	Rhynchobdellida	Glossiphoniidae	2	7	5	3	4	5	8	16	3	2	3		1		2											1	1
Mayfly larvae	Ephemeroptera	Baetidae	1																										
Moth Larvae	Lepidoptera	Pyralidae																											
Mussels	Bivalvia	Corbiculidae		4	2																								
Mussels	Bivalvia	Sphaeriidae														1													1
Proboscis Worms	Nemertea	Nemertea											1																
Round Worms	Nematoda	Nematoda																											
Sand hoppers	Amphipoda	Ceinidae				3	1																						
Sand hoppers	Amphipoda	Talitridae									1																	1	
Slatters	Isopoda	Oniscidae				1																4							

			S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck
Snails	Gastropoda	Ancylidae	1										1			1				3	1		7		1			1	
Snails	Gastropoda	Hydrobiidae	30	22	13	23	13	34	23	10	18	15	33	15	26	18	30	9	18	21	4	28	11	10	8	8	12	7	14
Snails	Gastropoda	Lymnaeidae																1				1							
Snails	Gastropoda	Physidae	12	10	7	4	8	7	2	7	3	10	8	6	5	4	9	3	10	14	11	6	6	3	5	5			1
Snails	Gastropoda	Planorbidae	4	6	6		2	2		2	2				2				1		1	1	3		1	1	1		
Stonefly larvae	Plecoptera	Eustheniidae							1																				
True bugs	Hemiptera	Belostomatidae																											
True bugs	Hemiptera	Corixidae				1	2	9																		1	1		
True bugs	Hemiptera	Gelastocoridae																											
True bugs	Hemiptera	Gerridae								1						1													
True bugs	Hemiptera	Hebridae																											
True bugs	Hemiptera	Mesoveliidae																											
True bugs	Hemiptera	Naucoridae																											
True bugs	Hemiptera	Nepidae				1																							
True bugs	Hemiptera	Notonectidae	2		2	1			4	8		7	8	4	4	9	11				1	2		4	7	10	2	1	1
True bugs	Hemiptera	Pleidae																											
True bugs	Hemiptera	Saldidae																											
True bugs	Hemiptera	Veliidae		3							2																		
True Fly larvae	Diptera	Bibionidae																											
True Fly larvae	Diptera	Cecidomyiidae																										1	
True Fly larvae	Diptera	Ceratopogonidae																											
True Fly larvae	Diptera	Culicidae				1						1			2											1		1	
True Fly larvae	Diptera	Dixidae																											
True Fly larvae	Diptera	Dolichopodidae																											
True Fly larvae	Diptera	Ephydridae																											
True Fly larvae	Diptera	Muscidae																											
True Fly larvae	Diptera	Psychodidae													1										1			1	
True Fly larvae	Diptera	s-f Chironominae	34	48	46	77	132	100		10	7	3	14	6	4	17	7	22	22	18	27	20	25	10	13	14	15	16	18
True Fly larvae	Diptera	s-f Orthocladiinae	7	1					1			6	7	5	1	4								6	19	13	1	2	1
True Fly larvae	Diptera	s-f Tanypodinae	4	2	14					18	11	3	4	5		4		1			1		2			1			1
True Fly larvae	Diptera	Simuliidae																						1					
True Fly larvae	Diptera	Stratiomyidae		2		1							1		1	1	1	1	3				1	1	4	3		5	3
True Fly larvae	Diptera	Syrphidae																											
True Fly larvae	Diptera	Tipulidae																1	1			1		1		1			
Worms	Oligochaeta	Oligochaeta	3	6	10	10	5	7	6	6	8		3	7	7			8	17	15	2	3	5	2	4	7			4
Yabbies	Decapoda	Parastacidae																											
Yabbie cleaner	Temnocephala	Temnocephalidae																											

			S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck
Aquatic mites	Acarina	Acarina	2	2	1	6	1	1											1					1					
Beetles	Coleoptera	Dytiscidae					2																						
Beetles	Coleoptera	Elmidae																											
Beetles	Coleoptera	Hydraenidae																											
Beetles	Coleoptera	Hydrophilidae	1		1					1										1					1				
Beetles	Coleoptera	Psephenidae																											
Beetles	Coleoptera	Scirtidae		1																									
Caddisfly larvae	Trichoptera	Antipodoecidae																											
Caddisfly larvae	Trichoptera	Hydroptilidae			3							8	3	6	2	3	2		2	2		1			2	7	12	9	11
Caddisfly larvae	Trichoptera	Leptoceridae										1																	
Dobsonfly larvae	Megaloptera	Corydalidae																											
Dragonfly larvae	Odonata	Aeshnidae	3	1	1			1	3	6	3		2	6	5	4	3							2	3	1	2		
Dragonfly larvae	Odonata	Coenagrionidae	5	8	15				5	6	12	1		4	9	2	4	2	2	5	1				3			1	2
Dragonfly larvae	Odonata	Gomphidae																											
Dragonfly larvae	Odonata	Hemicorduliidae	1	16	19	7			13	4	2	1	5	10	6	8	10			2	1	1	4	1	1	1			1
Dragonfly larvae	Odonata	Isostictidae		1	2	1			2		2	1	1	2	3	6	5	3		8	5		5		2	1		2	
Dragonfly larvae	Odonata	Lestidae																											
Dragonfly larvae	Odonata	Libellulidae		5	2	2	1	13	13	10	4	2		7	3	7		2							2		1		1
Dragonfly larvae	Odonata	Megapodagrionidae	9	21	19	20		3	9	2	8	2	3	5	5	9	3	1	1	9	10	2	5	8	9	7	9	3	3
Dragonfly larvae	Odonata	Synthemistidae		1																									
Dragonfly larvae	Odonata	Telephlebiidae											1																
Fairy shrimps	Decapoda	Atyidae																											
Flatworms	Turbellaria	Dugesiidae	4	6	5	3	2	6	3	4	3			3	8	4	4				2	4		5	5	4	6	2	5
Lacewing	Neuroptera	Osmylidae																											
Leeches	Arhynchobdellida	Erpobdellidae			1																								
Leeches	Arhynchobdellida	Hirudinidae																											
Leeches	Rhynchobdellida	Glossiphoniidae	2	1	2				4	9		1			2														
Mayfly larvae	Ephemeroptera	Baetidae								4		14	8	13												1			
Moth Larvae	Lepidoptera	Pyralidae																											
Mussels	Bivalvia	Corbiculidae	3	8	7	5	1	11	4	6	7																		
Mussels	Bivalvia	Sphaeriidae										1		1		3	9				1		2						1
Proboscis Worms	Nemertea	Nemertea																											
Round Worms	Nematoda	Nematoda													1														
Sand hoppers	Amphipoda	Ceinidae		1	2	2	8																						
Sand hoppers	Amphipoda	Talitridae								1																			
Slatters	Isopoda	Oniscidae				3	4	2	1																1				

			S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck
Snails	Gastropoda	Ancylidae																					1						
Snails	Gastropoda	Hydrobiidae	6	4	18	11	13	7	2			9	12	4	4	2	10	7	10	6	3	5	9		7	10	14	17	4
Snails	Gastropoda	Lymnaeidae							1		1	1	1	4	3	6	2			4	2				1	3	1		
Snails	Gastropoda	Physidae	4	1	6	7	12	24	8	7	5	14	1	7	15	18	15	12	12	18	14	18	19	7	18	26	2	2	15
Snails	Gastropoda	Planorbidae	2	2	3			1				3			4	8	2	1	1	6		2		5	9	3			1
Stonefly larvae	Plecoptera	Eustheniidae																											
True bugs	Hemiptera	Belostomatidae																											
True bugs	Hemiptera	Corixidae	1				1								1														
True bugs	Hemiptera	Gelastocoridae												1							1	1			1				
True bugs	Hemiptera	Gerridae							1	1		1			1		1							1		3			
True bugs	Hemiptera	Hebridae																							1				
True bugs	Hemiptera	Mesoveliidae								1				1															
True bugs	Hemiptera	Naucoridae																											
True bugs	Hemiptera	Nepidae																											
True bugs	Hemiptera	Notonectidae	11	10	10	4	4	1	14	10	14	10	10	11	7	13	12	4	1	2	1	3	2	13	5	14	9	12	7
True bugs	Hemiptera	Pleidae																					1						
True bugs	Hemiptera	Saldidae																											
True bugs	Hemiptera	Veliidae												1					1			1			2	2	1		
True Fly larvae	Diptera	Bibionidae																											
True Fly larvae	Diptera	Cecidomyiidae																											
True Fly larvae	Diptera	Ceratopogonidae			1						2	1								1									
True Fly larvae	Diptera	Culicidae		1			5			1	2								2										
True Fly larvae	Diptera	Dixidae																											
True Fly larvae	Diptera	Dolichopodidae																											
True Fly larvae	Diptera	Ephydridae																											
True Fly larvae	Diptera	Muscidae																											
True Fly larvae	Diptera	Psychodidae																											
True Fly larvae	Diptera	s-f Chironominae	9	13	36	26	31	74	78	46	56	14	29	16	20	10	23	51	28	19	9	19	13	8	10	18	17	7	23
True Fly larvae	Diptera	s-f Orthocladiinae	2						2	4	2	2			1										4	5	15	4	18
True Fly larvae	Diptera	s-f Tanypodinae	2	2	7	2					4	1	6	3	5	2	2		1	4		2	2				3	3	
True Fly larvae	Diptera	Simuliidae					1																						
True Fly larvae	Diptera	Stratiomyidae	2	1	3	1			1	1	5	3		1	2	1	1			1						1	1	2	
True Fly larvae	Diptera	Syrphidae	1																										
True Fly larvae	Diptera	Tipulidae	1																										
Worms	Oligochaeta	Oligochaeta	11	11	9	32	17	18	8	3	10		2		2	9	3	4	1	1	4	2	7		3		4	1	1
Yabbies	Decapoda	Parastacidae																											
Yabbie cleaner	Temnocephala	Temnocephalidae																											

			S1 spring 2004 Terrys Ck	S1 spring 2004 Terrys Ck	S1 spring 2004 Terrys Ck	S1 spring 2005 Terrys Ck	S1 spring 2005 Terrys Ck	S1 spring 2005 Terrys Ck	S1 autumn 2005 Terrys Ck	S1 autumn 2005 Terrys Ck	S1 autumn 2005 Terrys Ck	S1 autumn 2006 Terrys Ck	S1 autumn 2006 Terrys Ck	S1 autumn 2006 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 autumn 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 spring 2007 Terrys Ck	S1 Autumn 2008 Terrys Ck	S1 Autumn 2008 Terrys Ck	S1 Autumn 2008 Terrys Ck	S1 Autumn 2008 Terrys Ck	S1 Autumn 2008 Terrys Ck	S1 Autumn 2008 Terrys Ck
Aquatic mites	Acarina	Acarina				1	7	4	2		1	2	3	2	1	2		2		1			2		5							
Beetles	Coleoptera	Dytiscidae					1																								1	
Beetles	Coleoptera	Elmidae	1		3			3	6	1		4	1			4				2			1		1		2		1			
Beetles	Coleoptera	Hydraenidae																1									1					
Beetles	Coleoptera	Hydrophilidae																														
Beetles	Coleoptera	Psephenidae																														
Beetles	Coleoptera	Scirtidae	1								1							1		1												
Caddisfly larvae	Trichoptera	Antipodoecidae																														
Caddisfly larvae	Trichoptera	Hydroptilidae		1								1			1										4							
Caddisfly larvae	Trichoptera	Leptoceridae																														
Dobsonfly larvae	Megaloptera	Corydalidae										1																				
Dragonfly larvae	Odonata	Aeshnidae						1	1			1				1			2													
Dragonfly larvae	Odonata	Coenagrionidae	1	1	3			7		3	4	7	5	2	5	1		3		2	1	1	1						1			
Dragonfly larvae	Odonata	Gomphidae	1																													
Dragonfly larvae	Odonata	Hemicorduliidae	2	4	7	21			2	6	20	17	16	26	3	2		5	5	6	3	1		1	10	5						2
Dragonfly larvae	Odonata	Isostictidae			2	8	5	7	6	8	6	4	2	4	3	2	1	10		1					2	5			6	1	1	5
Dragonfly larvae	Odonata	Lestidae				6																										
Dragonfly larvae	Odonata	Libellulidae					14	13				2	1	4	1		2		2	4					1	1	1		1			
Dragonfly larvae	Odonata	Megapodagrionidae	6	10	12	11	8	7	16	26	14	42	17	18	18	11	6	8	16	16	16	9	3	8	8	12	12	7	10	8	13	6
Dragonfly larvae	Odonata	Synthemistidae																												1		
Dragonfly larvae	Odonata	Telephlebiidae																												1		
Fairy shrimps	Decapoda	Atyidae			1																											
Flatworms	Turbellaria	Dugesiidae	1	3	3	2	2	3	6	14	4	10	2	11	3	2	10	9	8	12	10	14	1	8	2	6	5	2	3	2	3	2
Lacewing	Neuroptera	Osmylidae																														
Leeches	Arhynchobdellida	Erpobdellidae																														
Leeches	Arhynchobdellida	Hirudinidae														1																
Leeches	Rhynchobdellida	Glossiphoniidae					1	1	3	2	1	2	2		1	1			1											1		1
Mayfly larvae	Ephemeroptera	Baetidae														1	1															
Moth Larvae	Lepidoptera	Pyralidae																			1											
Mussels	Bivalvia	Corbiculidae		5	1	2	9	3	3	5	10	9		8																		
Mussels	Bivalvia	Sphaeriidae	4	1	3											4		2	4				4	1	3	4	4					
Proboscis Worms	Nemertea	Nemertea															1															
Round Worms	Nematoda	Nematoda																														
Sand hoppers	Amphipoda	Ceinidae				1	3		3		1																					
Sand hoppers	Amphipoda	Talitridae											1	2		1				1					1					1	1	
Slatters	Isopoda	Oniscidae				1																										

			spring 2004 Terrys Ck S1	spring 2004 Terrys Ck S1	spring 2004 Terrys Ck S1	spring 2005 Terrys Ck S1	spring 2005 Terrys Ck S1	spring 2005 Terrys Ck S1	autumn 2005 Terrys Ck S1	autumn 2005 Terrys Ck S1	autumn 2005 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1
Snails	Gastropoda	Ancylidae			1																				1							
Snails	Gastropoda	Hydrobiidae	4	7	6		14	11	11	10	13	25	4	14	26	8	10	18	34	12	15	21	17	7	6	13	9	11	8	13	17	17
Snails	Gastropoda	Lymnaeidae	1			5	3					1					1															
Snails	Gastropoda	Physidae	4	4	6	12	11	7	3	8	8	1	9	9	6	1	4	13	10	11	8	6	2	12	7	7	7	4	8	2	9	5
Snails	Gastropoda	Planorbidae		1	5	1		4	2	4	4	2			1			1	1	5		1		1	3	2	1		1			
Stonefly larvae	Plecoptera	Eustheniidae																														
True bugs	Hemiptera	Belostomatidae	1																													
True bugs	Hemiptera	Corixidae						5																								
True bugs	Hemiptera	Gelastocoridae									1				1							1										
True bugs	Hemiptera	Gerridae		1			1	2			2	3	3	3				4	2										1			1
True bugs	Hemiptera	Hebridae																														
True bugs	Hemiptera	Mesoveliidae																														
True bugs	Hemiptera	Naucoridae			1					1																						
True bugs	Hemiptera	Nepidae																1														
True bugs	Hemiptera	Notonectidae			3	4	1	2	11	2	7	5	6	4	3	4	7	11	3	3							4	4	7	6	7	4
True bugs	Hemiptera	Pleidae																														
True bugs	Hemiptera	Saldidae																														
True bugs	Hemiptera	Veliidae						1			3	4	1			1	2				1			5							2	1
True Fly larvae	Diptera	Bibionidae																														
True Fly larvae	Diptera	Cecidomyiidae																														
True Fly larvae	Diptera	Ceratopogonidae					2				1																					1
True Fly larvae	Diptera	Culicidae					3						1											9	4							
True Fly larvae	Diptera	Dixidae																							1							
True Fly larvae	Diptera	Dolichopodidae																														
True Fly larvae	Diptera	Ephydridae																							1							
True Fly larvae	Diptera	Muscidae																														
True Fly larvae	Diptera	Psychodidae																														
True Fly larvae	Diptera	s-f Chironominae	8	11	11	33	32	30	3	17	28	2	19	5	8	15	13	9	13	5	41	16	33	17	18	17	5		2	1	3	3
True Fly larvae	Diptera	s-f Orthocladiinae	2		2				2		1		1		7	5	2			2	1				2		1		1			
True Fly larvae	Diptera	s-f Tanypodinae		2	1	11	6	1	3	4	21	1	9	11	14	1	5	8	1	3	1	4	1		1	1	5		2	1		
True Fly larvae	Diptera	Simuliidae				1		1								3		3			1		1									
True Fly larvae	Diptera	Stratiomyidae	1				1		1	2		5				1		3	1	1			1					1	2		1	
True Fly larvae	Diptera	Syrphidae																														
True Fly larvae	Diptera	Tipulidae							4															1	1				1			
Worms	Oligochaeta	Oligochaeta	7	10	7	9	15	7	4	15	8	18	14	17	4	8	4	4	1	3	8	8	4	4		2	4	1	3	3	3	
Yabbies	Decapoda	Parastacidae																														
Yabbie cleaner	Temnocephala	Temnocephalidae																														

Appendix 5 SIMPER output

SIMPER all five creeks reps merged 2005, 2006, 2007, and 2008

```
Data worksheet
Name: All five cks reps merged sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Creek
S5       Archers Ck
S4       Buffalo Ck
S3       Porters Ck
S2       Shrimptons Ck
S1       Terrys Ck

Group Archers Ck
Average similarity: 56.00

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 9.29      8.28     2.28      14.79    14.79
Worms Oligochaeta                                5.79      6.18     2.35      11.03    25.83
Snails Physidae                                  5.79      5.32     2.72       9.51    35.33
Flatworms Dugesiidae                             4.35      3.47     2.28       6.19    41.53
Dragonfly larvae Coenagrionidae                  3.49      3.19     1.70       5.69    47.22
Dragonfly larvae Hemicorduliidae                 3.40      3.07     1.25       5.49    52.71
Dragonfly larvae Megapodagrionidae               3.19      2.94     2.43       5.26    57.97
True Fly larvae s-f Tanypodinae                  2.97      2.90     2.81       5.18    63.15
True bugs Veliidae                               3.14      2.71     2.16       4.84    67.99
Dragonfly larvae Libellulidae                    2.56      2.46     2.69       4.40    72.39
True Fly larvae Stratiomyidae                    2.28      2.13     3.21       3.81    76.20
Dragonfly larvae Aeshnidae                       2.16      1.55     1.01       2.77    78.97
Snails Hydrobiidae                               3.20      1.40     0.56       2.49    81.46
True Fly larvae Culicidae                        2.34      1.39     0.83       2.48    83.94
True Fly larvae s-f Orthocladiinae               3.25      1.28     0.76       2.28    86.22
True bugs Notonectidae                           1.97      1.13     0.82       2.01    88.23
Leeches Glossiphoniidae                          1.63      0.94     0.79       1.68    89.91
Fairy shrimps Atyidae                            1.95      0.87     0.57       1.55    91.46

Group Buffalo Ck
Average similarity: 60.82

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 9.13      9.33     2.81      15.35    15.35
Dragonfly larvae Megapodagrionidae               5.48      6.15    10.15      10.12    25.46
Worms Oligochaeta                                4.95      4.97     4.28       8.17    33.63
True bugs Notonectidae                           4.79      4.37     3.02       7.18    40.82
Snails Hydrobiidae                               4.65      3.96     1.74       6.51    47.33
Snails Physidae                                  4.37      3.28     1.77       5.39    52.72
Dragonfly larvae Hemicorduliidae                 3.31      3.05     3.26       5.01    57.73
Flatworms Dugesiidae                             3.37      3.03     2.23       4.98    62.71
Dragonfly larvae Libellulidae                    3.27      2.95     2.32       4.86    67.57
True Fly larvae s-f Tanypodinae                  2.76      2.64     3.77       4.33    71.90
Dragonfly larvae Isostictidae                    2.63      2.22     2.25       3.65    75.55
True Fly larvae Stratiomyidae                    1.99      1.86     2.52       3.06    78.61
Dragonfly larvae Coenagrionidae                  2.49      1.48     0.91       2.43    81.04
Snails Planorbidae                               2.17      1.30     0.97       2.14    83.19
Dragonfly larvae Aeshnidae                       1.82      1.28     1.10       2.10    85.28
Caddisfly larvae Hydroptilidae                   2.55      1.15     0.69       1.89    87.17
Mussels Corbiculidae                             2.08      1.08     0.48       1.78    88.95
Snails Lymnaeidae                                1.70      0.93     0.76       1.53    90.48
```

```
Group Porters Ck
Average similarity: 60.19

Species                                Av.Abund    Av.Sim    Sim/SD    Contrib%    Cum.%
True Fly larvae s-f Chironominae           8.28      8.46      2.70       14.06    14.06
Snails Hydrobiidae                         7.80      7.71      2.50       12.81    26.87
Dragonfly larvae Megapodagrionidae         4.72      4.47      2.46        7.43    34.30
Snails Physidae                            4.28      4.31      4.41        7.16    41.46
Dragonfly larvae Isostictidae              4.31      4.14      2.05        6.88    48.34
Dragonfly larvae Coenagrionidae            4.26      4.01      3.18        6.66    55.00
Worms Oligochaeta                          3.49      3.51      2.34        5.83    60.83
Dragonfly larvae Hemicorduliidae           3.75      3.34      2.29        5.55    66.39
True bugs Notonectidae                     3.29      2.50      2.07        4.16    70.54
Snails Planorbidae                         2.27      2.35      3.54        3.91    74.45
Dragonfly larvae Libellulidae              2.40      2.33      2.66        3.87    78.32
Leeches Glossiphoniidae                    2.77      2.07      1.11        3.44    81.76
Flatworms Dugesiidae                       2.04      1.60      1.29        2.66    84.42
True Fly larvae s-f Tanypodinae            2.37      1.48      1.14        2.46    86.88
Fairy shrimps Atyidae                      2.55      1.42      0.97        2.35    89.23
True Fly larvae Stratiomyidae              1.78      1.24      1.20        2.06    91.29

Group Shrimptons Ck
Average similarity: 55.90

Species                                Av.Abund    Av.Sim    Sim/SD    Contrib%    Cum.%
Snails Physidae                            6.65      9.77      3.41       17.47    17.47
Flatworms Dugesiidae                       6.08      9.21      4.31       16.48    33.95
Worms Oligochaeta                          5.80      8.98      3.72       16.07    50.02
True Fly larvae s-f Chironominae           5.63      3.76      1.07        6.72    56.75
Dragonfly larvae Coenagrionidae            2.83      3.39      4.44        6.07    62.81
Aquatic mites Acarina                      2.69      2.81      1.86        5.02    67.83
Dragonfly larvae Hemicorduliidae           2.93      2.73      1.21        4.88    72.71
Leeches Glossiphoniidae                    2.58      2.48      0.81        4.43    77.15
Snails Planorbidae                         2.53      2.43      1.05        4.34    81.49
Mussels Corbiculidae                       1.95      1.39      0.40        2.48    83.97
Dragonfly larvae Libellulidae              1.36      1.34      0.87        2.39    86.36
Snails Lymnaeidae                          1.06      1.21      1.47        2.17    88.53
Yabbies Parastacidae                       1.03      0.81      0.89        1.45    89.98
Dragonfly larvae Megapodagrionidae         1.95      0.72      0.47        1.28    91.26

Group Terrys Ck
Average similarity: 68.23

Species                                Av.Abund    Av.Sim    Sim/SD    Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae         7.50      8.09      5.18       11.85    11.85
True Fly larvae s-f Chironominae           7.56      6.74      3.24        9.87    21.73
Snails Hydrobiidae                         6.53      6.49      3.51        9.51    31.23
Worms Oligochaeta                          5.25      5.52      7.86        8.09    39.32
Flatworms Dugesiidae                       4.92      4.78      3.74        7.01    46.33
Snails Physidae                            4.93      4.58      2.28        6.71    53.04
True Fly larvae s-f Tanypodinae            4.24      4.16      4.45        6.10    59.14
Dragonfly larvae Hemicorduliidae           4.16      3.20      1.69        4.70    63.83
Dragonfly larvae Coenagrionidae            2.51      2.23      2.61        3.26    67.10
True bugs Notonectidae                     3.19      2.13      1.05        3.11    70.21
Beetles Elmidae                            2.03      2.08      5.61        3.04    73.26
Dragonfly larvae Isostictidae              2.37      1.89      2.09        2.78    76.03
True bugs Veliidae                         1.81      1.82      3.66        2.67    78.70
Snails Planorbidae                         1.92      1.73      3.27        2.54    81.24
Aquatic mites Acarina                      2.16      1.70      1.31        2.50    83.74
True Fly larvae Stratiomyidae              1.74      1.63      2.88        2.38    86.12
Dragonfly larvae Libellulidae              2.28      1.41      1.22        2.06    88.18
True bugs Gerridae                         1.67      1.25      1.33        1.83    90.02
```

Groups Archers Ck & Buffalo Ck

```
Average dissimilarity = 44.86

                                   Group Archers Ck  Group Buffalo Ck
Species                            Av.Abund          Av.Abund          Av.Diss   Diss/SD   Contrib%     Cum.%
True Fly larvae s-f Chironominae       9.29              9.13            2.77      1.51       6.18       6.18
Snails Hydrobiidae                     3.20              4.65            2.16      1.38       4.83      11.00
Snails Physidae                        5.79              4.37            2.06      1.44       4.60      15.60
True Fly larvae s-f Orthocladiinae     3.25              2.13            2.01      1.09       4.48      20.08
True bugs Notonectidae                 1.97              4.79            1.99      1.51       4.43      24.51
Dragonfly larvae Isostictidae          0.00              2.63            1.67      1.93       3.73      28.23
Dragonfly larvae Megapodagrionidae     3.19              5.48            1.62      2.15       3.62      31.86
Caddisfly larvae Hydroptilidae         1.45              2.55            1.60      1.18       3.57      35.43
True bugs Veliidae                     3.14              0.78            1.57      1.46       3.50      38.93
Dragonfly larvae Coenagrionidae        3.49              2.49            1.50      1.32       3.35      42.28
Flatworms Dugesiidae                   4.35              3.37            1.50      1.40       3.34      45.62
Worms Oligochaeta                      5.79              4.95            1.39      1.66       3.09      48.71
Mussels Corbiculidae                   0.49              2.08            1.35      1.16       3.01      51.71
Snails Planorbidae                     0.00              2.17            1.33      1.35       2.96      54.68
Fairy shrimps Atyidae                  1.95              0.00            1.27      0.92       2.83      57.51
True Fly larvae Culicidae              2.34              1.06            1.22      1.31       2.72      60.23
Dragonfly larvae Hemicorduliidae       3.40              3.31            1.22      1.66       2.71      62.95
Mayfly larvae Baetidae                 1.14              1.49            1.13      1.00       2.51      65.46
Dragonfly larvae Aeshnidae             2.16              1.82            1.04      1.34       2.31      67.77
Leeches Glossiphoniidae                1.63              1.26            1.01      1.22       2.25      70.02
Mussels Sphaeriidae                    1.00              1.08            0.99      0.88       2.21      72.23
Dragonfly larvae Libellulidae          2.56              3.27            0.96      1.33       2.13      74.36
Snails Lymnaeidae                      0.71              1.70            0.91      1.47       2.03      76.39
Slatters Oniscidae                     1.14              0.83            0.79      1.15       1.76      78.15
Aquatic mites Acarina                  1.27              1.18            0.78      1.21       1.73      79.88
True Fly larvae s-f Tanypodinae        2.97              2.76            0.74      1.42       1.66      81.54
True Fly larvae Ceratopogonidae        0.49              0.74            0.64      1.17       1.42      82.97
True Fly larvae Stratiomyidae          2.28              1.99            0.62      1.34       1.37      84.34
True Fly larvae Tipulidae              1.03              0.17            0.61      1.13       1.35      85.69
True bugs Corixidae                    0.82              0.50            0.57      0.89       1.28      86.97
True bugs Gerridae                     0.34              0.86            0.54      1.12       1.20      88.18
Beetles Dytiscidae                     0.74              0.24            0.49      1.05       1.08      89.26
True Fly larvae Simuliidae             0.82              0.17            0.48      1.08       1.07      90.33
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Groups Archers Ck & Porters Ck

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Average dissimilarity = 46.78

                                   Group Archers Ck  Group Porters Ck
Species                                    Av.Abund          Av.Abund  Av.Diss   Diss/SD   Contrib%     Cum.%
Snails Hydrobiidae                             3.20              7.80     3.43      1.45       7.33       7.33
Dragonfly larvae Isostictidae                  0.00              4.31     2.84      2.27       6.07      13.40
True Fly larvae s-f Chironominae               9.29              8.28     2.83      1.40       6.05      19.45
True Fly larvae s-f Orthocladiinae             3.25              2.52     2.10      1.12       4.49      23.94
Worms Oligochaeta                              5.79              3.49     1.80      1.52       3.84      27.79
True bugs Veliidae                             3.14              0.52     1.74      1.54       3.72      31.50
Flatworms Dugesiidae                           4.35              2.04     1.70      1.18       3.64      35.14
Snails Physidae                                5.79              4.28     1.64      1.42       3.50      38.65
Fairy shrimps Atyidae                          1.95              2.55     1.53      1.31       3.27      41.92
Dragonfly larvae Megapodagrionidae             3.19              4.72     1.51      1.60       3.23      45.15
Snails Planorbidae                             0.00              2.27     1.48      2.67       3.17      48.32
True bugs Notonectidae                         1.97              3.29     1.46      1.43       3.11      51.44
True Fly larvae Culicidae                      2.34              0.69     1.34      1.21       2.87      54.31
Leeches Glossiphoniidae                        1.63              2.77     1.30      1.31       2.79      57.10
Dragonfly larvae Coenagrionidae                3.49              4.26     1.28      1.37       2.74      59.84
Dragonfly larvae Hemicorduliidae               3.40              3.75     1.25      1.34       2.66      62.50
True Fly larvae s-f Tanypodinae                2.97              2.37     1.21      1.48       2.58      65.08
Dragonfly larvae Aeshnidae                     2.16              1.46     1.16      1.24       2.49      67.57
Caddisfly larvae Hydroptilidae                 1.45              1.04     1.11      0.92       2.38      69.94
True Fly larvae Stratiomyidae                  2.28              1.78     0.84      1.37       1.80      71.74
True bugs Corixidae                            0.82              0.81     0.80      0.89       1.70      73.45
Slatters Oniscidae                             1.14              0.50     0.75      1.12       1.61      75.05
Snails Ancylidae                               0.29              1.19     0.74      0.93       1.58      76.63
Dragonfly larvae Libellulidae                  2.56              2.40     0.73      1.19       1.55      78.18
Mayfly larvae Baetidae                         1.14              0.17     0.73      0.79       1.55      79.74
Beetles Dytiscidae                             0.74              1.06     0.69      1.27       1.48      81.22
Mussels Sphaeriidae                            1.00              0.33     0.69      0.59       1.48      82.70
Aquatic mites Acarina                          1.27              0.74     0.66      1.04       1.40      84.10
True Fly larvae Tipulidae                      1.03              0.52     0.64      1.19       1.37      85.47
Caddisfly larvae Leptoceridae                  0.14              1.02     0.60      0.93       1.29      86.76
Mussels Corbiculidae                           0.49              0.41     0.50      0.70       1.07      87.82
True Fly larvae Simuliidae                     0.82              0.17     0.49      1.06       1.05      88.87
Snails Lymnaeidae                              0.71              0.24     0.47      1.52       1.00      89.87
Leeches Erpobdellidae                          0.00              0.61     0.40      0.64       0.85      90.72
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Groups Buffalo Ck & Porters Ck
Average dissimilarity = 41.13

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                                      Group Buffalo Ck  Group Porters Ck
Species                                       Av.Abund          Av.Abund   Av.Diss     Diss/SD   Contrib%  Cum.%
Snails Hydrobiidae                                4.65              7.80      2.52        1.47       6.13   6.13
True Fly larvae s-f Chironominae                  9.13              8.28      2.02        1.25       4.92  11.05
Snails Physidae                                   4.37              4.28      1.68        1.26       4.08  15.13
True Fly larvae s-f Orthocladiinae                2.13              2.52      1.68        1.18       4.08  19.21
True bugs Notonectidae                            4.79              3.29      1.65        1.42       4.02  23.23
Dragonfly larvae Coenagrionidae                   2.49              4.26      1.63        1.52       3.97  27.21
Caddisfly larvae Hydroptilidae                    2.55              1.04      1.57        1.14       3.81  31.02
Fairy shrimps Atyidae                             0.00              2.55      1.55        1.26       3.76  34.78
Dragonfly larvae Isostictidae                     2.63              4.31      1.45        1.29       3.52  38.30
Leeches Glossiphoniidae                           1.26              2.77      1.41        1.33       3.42  41.72
Mussels Corbiculidae                              2.08              0.41      1.37        1.04       3.32  45.04
Worms Oligochaeta                                 4.95              3.49      1.23        1.02       3.00  48.04
Flatworms Dugesiidae                              3.37              2.04      1.19        1.44       2.89  50.93
Dragonfly larvae Megapodagrionidae                5.48              4.72      1.17        1.22       2.84  53.77
Dragonfly larvae Hemicorduliidae                  3.31              3.75      1.16        1.51       2.82  56.59
True Fly larvae s-f Tanypodinae                   2.76              2.37      1.12        1.46       2.72  59.30
Snails Lymnaeidae                                 1.70              0.24      1.02        1.24       2.47  61.78
Snails Planorbidae                                2.17              2.27      1.02        1.71       2.47  64.25
Dragonfly larvae Libellulidae                     3.27              2.40      0.98        1.31       2.39  66.64
Dragonfly larvae Aeshnidae                        1.82              1.46      0.98        1.30       2.39  69.03
Mayfly larvae Baetidae                            1.49              0.17      0.90        0.75       2.20  71.23
True Fly larvae Stratiomyidae                     1.99              1.78      0.77        1.37       1.87  73.09
Snails Ancylidae                                  0.17              1.19      0.75        0.95       1.82  74.91
Beetles Dytiscidae                                0.24              1.06      0.68        1.02       1.65  76.55
Mussels Sphaeriidae                               1.08              0.33      0.67        0.90       1.62  78.18
True bugs Corixidae                               0.50              0.81      0.66        0.86       1.60  79.77
Aquatic mites Acarina                             1.18              0.74      0.63        1.13       1.54  81.32
Slatters Oniscidae                                0.83              0.50      0.63        0.96       1.53  82.85
True Fly larvae Culicidae                         1.06              0.69      0.60        1.20       1.46  84.31
Caddisfly larvae Leptoceridae                     0.17              1.02      0.60        0.94       1.46  85.77
True bugs Veliidae                                0.78              0.52      0.55        1.05       1.33  87.10
True bugs Gerridae                                0.86              0.33      0.54        1.13       1.32  88.42
True Fly larvae Ceratopogonidae                   0.74              0.00      0.47        1.29       1.15  89.57
Beetles Hydrophilidae                             0.74              0.46      0.46        1.30       1.13  90.70
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Groups Archers Ck & Shrimptons Ck
Average dissimilarity = 51.44

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                                      Group Archers Ck    Group Shrimptons Ck
Species                               Av.Abund            Av.Abund              Av.Diss Diss/SD  Contrib%     Cum.%
True Fly larvae s-f Chironominae          9.29                5.63                 4.84    1.41      9.40      9.40
Flatworms Dugesiidae                      4.35                6.08                 2.19    1.55      4.26     13.66
Snails Hydrobiidae                        3.20                0.74                 2.13    1.17      4.13     17.79
True Fly larvae s-f Orthocladiinae        3.25                0.69                 2.06    0.91      4.01     21.80
Dragonfly larvae Megapodagrionidae        3.19                1.95                 2.05    1.56      3.98     25.78
True bugs Veliidae                        3.14                0.92                 1.95    1.48      3.80     29.57
Snails Planorbidae                        0.00                2.53                 1.90    1.36      3.69     33.26
Snails Physidae                           5.79                6.65                 1.84    1.52      3.58     36.84
True Fly larvae Culicidae                 2.34                0.29                 1.65    1.18      3.21     40.05
Leeches Glossiphoniidae                   1.63                2.58                 1.64    1.24      3.18     43.23
Mussels Corbiculidae                      0.49                1.95                 1.61    1.02      3.13     46.36
Dragonfly larvae Hemicorduliidae          3.40                2.93                 1.60    1.35      3.12     49.48
True Fly larvae s-f Tanypodinae           2.97                1.09                 1.57    1.48      3.06     52.53
Dragonfly larvae Aeshnidae                2.16                0.57                 1.51    1.24      2.94     55.48
Fairy shrimps Atyidae                     1.95                0.00                 1.48    0.91      2.87     58.35
Dragonfly larvae Coenagrionidae           3.49                2.83                 1.44    1.23      2.81     61.16
Aquatic mites Acarina                     1.27                2.69                 1.39    1.30      2.70     63.86
True bugs Notonectidae                    1.97                1.35                 1.32    1.24      2.57     66.43
Worms Oligochaeta                         5.79                5.80                 1.15    1.36      2.23     68.66
True Fly larvae Stratiomyidae             2.28                0.89                 1.14    1.52      2.21     70.87
Dragonfly larvae Libellulidae             2.56                1.36                 1.08    1.30      2.11     72.98
Caddisfly larvae Hydroptilidae            1.45                0.14                 0.99    0.74      1.93     74.90
Mussels Sphaeriidae                       1.00                0.63                 0.92    0.73      1.79     76.70
True bugs Corixidae                       0.82                1.11                 0.89    1.08      1.73     78.43
Mayfly larvae Baetidae                    1.14                0.34                 0.84    0.84      1.63     80.06
Slatters Oniscidae                        1.14                0.49                 0.83    1.06      1.62     81.68
Yabbies Parastacidae                      0.00                1.03                 0.72    1.29      1.40     83.08
True Fly larvae Tipulidae                 1.03                0.00                 0.71    1.07      1.37     84.45
Dragonfly larvae Lestidae                 0.63                0.53                 0.67    0.73      1.31     85.76
Dragonfly larvae Isostictidae             0.00                1.04                 0.65    0.64      1.27     87.03
Snails Ancylidae                          0.29                0.94                 0.64    0.86      1.24     88.27
True Fly larvae Simuliidae                0.82                0.00                 0.56    1.03      1.09     89.36
Beetles Dytiscidae                        0.74                0.14                 0.55    1.00      1.07     90.43
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Groups Buffalo Ck & Shrimptons Ck
Average dissimilarity = 50.01

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                                     Group Buffalo Ck  Group Shrimptons Ck
Species                              Av.Abund          Av.Abund              Av.Diss   Diss/SD   Contrib%  Cum.%
True Fly larvae s-f Chironominae         9.13              5.63                 4.40      1.54       8.81   8.81
Dragonfly larvae Megapodagrionidae       5.48              1.95                 2.90      1.67       5.80  14.61
Snails Hydrobiidae                       4.65              0.74                 2.85      1.69       5.70  20.31
True bugs Notonectidae                   4.79              1.35                 2.59      1.56       5.18  25.49
Snails Physidae                          4.37              6.65                 2.49      1.79       4.98  30.47
Flatworms Dugesiidae                     3.37              6.08                 2.09      1.36       4.19  34.66
Caddisfly larvae Hydroptilidae           2.55              0.14                 1.75      1.05       3.51  38.16
Leeches Glossiphoniidae                  1.26              2.58                 1.73      1.25       3.47  41.63
Dragonfly larvae Isostictidae            2.63              1.04                 1.67      1.51       3.34  44.97
Mussels Corbiculidae                     2.08              1.95                 1.65      1.05       3.30  48.27
Dragonfly larvae Libellulidae            3.27              1.36                 1.50      1.36       3.01  51.28
Snails Planorbidae                       2.17              2.53                 1.43      1.27       2.86  54.14
Dragonfly larvae Hemicorduliidae         3.31              2.93                 1.43      1.38       2.86  57.00
Dragonfly larvae Coenagrionidae          2.49              2.83                 1.42      1.41       2.84  59.84
True Fly larvae s-f Tanypodinae          2.76              1.09                 1.39      1.51       2.78  62.62
True Fly larvae s-f Orthocladiinae       2.13              0.69                 1.38      0.91       2.77  65.39
Aquatic mites Acarina                    1.18              2.69                 1.37      1.36       2.74  68.13
Worms Oligochaeta                        4.95              5.80                 1.31      1.61       2.63  70.76
Dragonfly larvae Aeshnidae               1.82              0.57                 1.23      1.34       2.45  73.21
Mayfly larvae Baetidae                   1.49              0.34                 1.03      0.79       2.06  75.27
Snails Lymnaeidae                        1.70              1.06                 0.98      1.48       1.97  77.24
True Fly larvae Stratiomyidae            1.99              0.89                 0.96      1.44       1.93  79.17
Mussels Sphaeriidae                      1.08              0.63                 0.82      1.02       1.63  80.80
True bugs Veliidae                       0.78              0.92                 0.81      1.00       1.61  82.41
True Fly larvae Culicidae                1.06              0.29                 0.75      1.16       1.49  83.90
Yabbies Parastacidae                     0.00              1.03                 0.71      1.30       1.42  85.32
True bugs Corixidae                      0.50              1.11                 0.70      1.09       1.41  86.73
Slatters Oniscidae                       0.83              0.49                 0.66      0.89       1.31  88.04
True bugs Gerridae                       0.86              0.39                 0.63      1.08       1.25  89.29
Snails Ancylidae                         0.17              0.94                 0.62      0.82       1.24  90.54
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Groups Porters Ck & Shrimptons Ck
Average dissimilarity = 54.08

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                                     Group Porters Ck  Group Shrimptons Ck
Species                              v.Abund           Av.Abund            Av.Diss    Diss/SD  Contrib%   Cum.%
Snails Hydrobiidae                      7.80               0.74                5.19       2.36      9.60    9.60
True Fly larvae s-f Chironominae        8.28               5.63                4.28       1.56      7.91   17.51
Flatworms Dugesiidae                    2.04               6.08                3.11       1.93      5.75   23.26
Dragonfly larvae Isostictidae           4.31               1.04                2.79       1.65      5.16   28.42
Dragonfly larvae Megapodagrionidae      4.72               1.95                2.61       1.56      4.83   33.25
Snails Physidae                         4.28               6.65                2.01       1.45      3.71   36.96
Worms Oligochaeta                       3.49               5.80                1.81       1.43      3.34   40.30
True bugs Notonectidae                  3.29               1.35                1.80       1.42      3.33   43.64
Fairy shrimps Atyidae                   2.55               0.00                1.78       1.26      3.29   46.93
Leeches Glossiphoniidae                 2.77               2.58                1.67       1.34      3.10   50.02
True Fly larvae s-f Orthocladiinae      2.52               0.69                1.63       1.09      3.02   53.05
Mussels Corbiculidae                    0.41               1.95                1.63       0.92      3.01   56.06
Dragonfly larvae Hemicorduliidae        3.75               2.93                1.61       1.46      2.97   59.03
Dragonfly larvae Coenagrionidae         4.26               2.83                1.54       1.40      2.85   61.88
Aquatic mites Acarina                   0.74               2.69                1.46       1.22      2.71   64.59
True Fly larvae s-f Tanypodinae         2.37               1.09                1.43       1.17      2.65   67.24
Snails Planorbidae                      2.27               2.53                1.23       1.49      2.27   69.51
Dragonfly larvae Aeshnidae              1.46               0.57                1.08       1.06      1.99   71.50
Dragonfly larvae Libellulidae           2.40               1.36                1.03       1.20      1.90   73.40
True Fly larvae Stratiomyidae           1.78               0.89                1.03       1.18      1.90   75.30
Snails Ancylidae                        1.19               0.94                0.97       1.00      1.80   77.10
True bugs Corixidae                     0.81               1.11                0.97       1.02      1.79   78.89
Beetles Dytiscidae                      1.06               0.14                0.78       0.98      1.45   80.33
True bugs Veliidae                      0.52               0.92                0.74       0.87      1.37   81.70
Yabbies Parastacidae                    0.00               1.03                0.73       1.29      1.35   83.05
Caddisfly larvae Hydroptilidae          1.04               0.14                0.72       0.67      1.33   84.38
Snails Lymnaeidae                       0.24               1.06                0.69       1.84      1.28   85.66
Caddisfly larvae Leptoceridae           1.02               0.00                0.68       0.88      1.25   86.91
Leeches Erpobdellidae                   0.61               0.43                0.67       0.73      1.23   88.14
Slatters Oniscidae                      0.50               0.49                0.53       0.91      0.98   89.13
Mussels Sphaeriidae                     0.33               0.63                0.49       0.91      0.92   90.04
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Groups Archers Ck & Terrys Ck
Average dissimilarity = 43.89

	Group Archers Ck	Group Terrys Ck				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.29	7.56	2.75	1.34	6.27	6.27
Dragonfly larvae Megapodagrionidae	3.19	7.50	2.67	2.51	6.09	12.37
Snails Hydrobiidae	3.20	6.53	2.66	1.35	6.06	18.42
True Fly larvae s-f Orthocladiinae	3.25	1.65	1.70	1.00	3.88	22.30
Flatworms Dugesiidae	4.35	4.92	1.53	1.72	3.48	25.79
Snails Physidae	5.79	4.93	1.53	1.49	3.48	29.27
True bugs Notonectidae	1.97	3.19	1.49	1.37	3.39	32.66
Dragonfly larvae Isostictidae	0.00	2.37	1.46	1.99	3.34	35.99
Dragonfly larvae Hemicorduliidae	3.40	4.16	1.43	1.31	3.26	39.25
True Fly larvae Culicidae	2.34	1.06	1.30	1.28	2.97	42.22
Mussels Corbiculidae	0.49	2.02	1.26	1.16	2.87	45.09
Fairy shrimps Atyidae	1.95	0.00	1.24	0.92	2.82	47.91
Snails Planorbidae	0.00	1.92	1.18	2.99	2.68	50.59
Beetles Elmidae	0.20	2.03	1.14	2.64	2.61	53.20
Dragonfly larvae Coenagrionidae	3.49	2.51	1.11	1.14	2.53	55.73
Worms Oligochaeta	5.79	5.25	1.09	1.60	2.48	58.22
Dragonfly larvae Aeshnidae	2.16	0.79	1.06	1.15	2.42	60.64
True Fly larvae s-f Tanypodinae	2.97	4.24	1.02	1.50	2.33	62.97
True bugs Veliidae	3.14	1.81	1.00	1.18	2.27	65.23
Mussels Sphaeriidae	1.00	1.08	0.99	0.90	2.26	67.49
Dragonfly larvae Libellulidae	2.56	2.28	0.98	1.30	2.22	69.71
Aquatic mites Acarina	1.27	2.16	0.96	1.54	2.19	71.90
Caddisfly larvae Hydroptilidae	1.45	0.67	0.94	0.97	2.15	74.05
True bugs Gerridae	0.34	1.67	0.87	1.60	1.98	76.03
Leeches Glossiphoniidae	1.63	1.50	0.81	1.41	1.84	77.87
Slatters Oniscidae	1.14	0.17	0.71	1.01	1.62	79.49
Mayfly larvae Baetidae	1.14	0.24	0.70	0.80	1.59	81.09
True bugs Corixidae	0.82	0.37	0.61	0.84	1.40	82.49
True Fly larvae Tipulidae	1.03	0.74	0.61	1.24	1.38	83.87
True Fly larvae Simuliidae	0.82	0.88	0.59	1.24	1.33	85.20
True Fly larvae Stratiomyidae	2.28	1.74	0.58	1.39	1.32	86.53
Sand hoppers Talitridae	0.00	0.93	0.57	1.31	1.30	87.82
True Fly larvae Ceratopogonidae	0.49	0.57	0.56	0.94	1.27	89.09
Snails Lymnaeidae	0.71	0.80	0.51	1.05	1.15	90.24

Groups Buffalo Ck & Terrys Ck
Average dissimilarity = 37.25

Group Buffalo Ck	Group Terrys Ck					
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.13	7.56	2.12	1.35	5.68	5.68
Snails Physidae	4.37	4.93	1.78	1.55	4.78	10.46
Snails Hydrobiidae	4.65	6.53	1.71	1.22	4.60	15.06
True bugs Notonectidae	4.79	3.19	1.59	1.38	4.26	19.32
Dragonfly larvae Hemicorduliidae	3.31	4.16	1.41	1.52	3.80	23.12
Caddisfly larvae Hydroptilidae	2.55	0.67	1.40	1.11	3.76	26.88
Dragonfly larvae Megapodagrionidae	5.48	7.50	1.35	1.78	3.63	30.51
Mussels Corbiculidae	2.08	2.02	1.29	1.02	3.46	33.97
Beetles Elmidae	0.00	2.03	1.25	4.53	3.35	37.32
Flatworms Dugesiidae	3.37	4.92	1.24	1.36	3.32	40.64
True Fly larvae s-f Orthocladiinae	2.13	1.65	1.19	1.08	3.20	43.84
Dragonfly larvae Libellulidae	3.27	2.28	1.18	1.32	3.18	47.02
Dragonfly larvae Coenagrionidae	2.49	2.51	1.14	1.59	3.07	50.09
True Fly larvae s-f Tanypodinae	2.76	4.24	1.06	1.48	2.86	52.95
Worms Oligochaeta	4.95	5.25	0.97	1.32	2.59	55.54
Snails Lymnaeidae	1.70	0.80	0.95	1.31	2.55	58.09
Snails Planorbidae	2.17	1.92	0.92	1.61	2.47	60.55
Aquatic mites Acarina	1.18	2.16	0.92	1.48	2.46	63.02
Dragonfly larvae Isostictidae	2.63	2.37	0.89	1.37	2.40	65.41
Mayfly larvae Baetidae	1.49	0.24	0.88	0.77	2.35	67.77
Dragonfly larvae Aeshnidae	1.82	0.79	0.85	1.30	2.27	70.04
Mussels Sphaeriidae	1.08	1.08	0.84	1.10	2.25	72.29
Leeches Glossiphoniidae	1.26	1.50	0.84	1.44	2.24	74.53
True Fly larvae Culicidae	1.06	1.06	0.75	1.25	2.02	76.56
True bugs Veliidae	0.78	1.81	0.75	1.58	2.02	78.57
True bugs Gerridae	0.86	1.67	0.74	1.31	1.99	80.56
Sand hoppers Talitridae	0.17	0.93	0.53	1.31	1.42	81.98
Slatters Oniscidae	0.83	0.17	0.53	0.80	1.42	83.40
True Fly larvae Simuliidae	0.17	0.88	0.52	1.03	1.39	84.80
Sand hoppers Ceinidae	0.46	0.67	0.51	0.95	1.36	86.16
True Fly larvae Stratiomyidae	1.99	1.74	0.48	1.37	1.28	87.44
True Fly larvae Tipulidae	0.17	0.74	0.47	0.97	1.25	88.69
Beetles Hydrophilidae	0.74	0.00	0.46	1.36	1.22	89.91
True bugs Corixidae	0.50	0.37	0.43	0.99	1.15	91.06

```
Groups Porters Ck  &  Terrys Ck
Average dissimilarity = 40.89

                                    Group Porters Ck    Group Terrys Ck
Species                                     Av.Abund           Av.Abund  Av.Diss Diss/SD Contrib%         Cum.%
True Fly larvae s-f Chironominae                8.28               7.56     2.05    1.32     5.00          5.00
Dragonfly larvae Megapodagrionidae              4.72               7.50     1.93    1.39     4.73          9.73
Flatworms Dugesiidae                            2.04               4.92     1.85    1.71     4.53         14.26
Snails Hydrobiidae                              7.80               6.53     1.81    1.58     4.43         18.69
True Fly larvae s-f Tanypodinae                 2.37               4.24     1.53    1.54     3.73         22.42
Fairy shrimps Atyidae                           2.55               0.00     1.51    1.26     3.68         26.11
Dragonfly larvae Isostictidae                   4.31               2.37     1.50    1.42     3.68         29.78
True bugs Notonectidae                          3.29               3.19     1.46    1.46     3.57         33.36
True Fly larvae s-f Orthocladiinae              2.52               1.65     1.41    1.36     3.44         36.80
Dragonfly larvae Hemicorduliidae                3.75               4.16     1.41    1.29     3.44         40.24
Mussels Corbiculidae                            0.41               2.02     1.27    1.04     3.11         43.35
Beetles Elmidae                                 0.00               2.03     1.27    4.26     3.11         46.46
Dragonfly larvae Coenagrionidae                 4.26               2.51     1.27    1.40     3.11         49.57
Worms Oligochaeta                               3.49               5.25     1.20    1.29     2.94         52.51
Leeches Glossiphoniidae                         2.77               1.50     1.19    1.49     2.91         55.41
Snails Physidae                                 4.28               4.93     1.19    1.41     2.90         58.31
Aquatic mites Acarina                           0.74               2.16     1.04    1.83     2.55         60.86
Dragonfly larvae Libellulidae                   2.40               2.28     0.95    1.22     2.33         63.20
True bugs Gerridae                              0.33               1.67     0.90    1.58     2.21         65.41
True bugs Veliidae                              0.52               1.81     0.86    1.66     2.09         67.50
Dragonfly larvae Aeshnidae                      1.46               0.79     0.78    1.11     1.91         69.41
Caddisfly larvae Hydroptilidae                  1.04               0.67     0.75    0.94     1.83         71.24
Snails Ancylidae                                1.19               0.17     0.73    0.95     1.78         73.02
True Fly larvae Culicidae                       0.69               1.06     0.70    1.02     1.70         74.72
Mussels Sphaeriidae                             0.33               1.08     0.68    0.90     1.67         76.39
True Fly larvae Stratiomyidae                   1.78               1.74     0.67    1.25     1.63         78.03
Beetles Dytiscidae                              1.06               0.33     0.66    1.16     1.62         79.64
True bugs Corixidae                             0.81               0.37     0.65    0.74     1.58         81.22
Caddisfly larvae Leptoceridae                   1.02               0.00     0.58    0.88     1.41         82.64
Snails Planorbidae                              2.27               1.92     0.56    1.31     1.36         83.99
Snails Lymnaeidae                               0.24               0.80     0.53    0.88     1.29         85.29
True Fly larvae Simuliidae                      0.17               0.88     0.53    1.01     1.29         86.58
True Fly larvae Tipulidae                       0.52               0.74     0.52    1.08     1.28         87.86
Sand hoppers Talitridae                         0.33               0.93     0.51    1.27     1.24         89.10
Sand hoppers Ceinidae                           0.33               0.67     0.50    0.78     1.22         90.33

Groups Shrimptons Ck  &  Terrys Ck
Average dissimilarity = 48.04

                                    Group Shrimptons Ck   Group Terrys Ck
Species                                        Av.Abund          Av.Abund   Av.Diss   Diss/SD   Contrib%  Cum.%
Snails Hydrobiidae                                 0.74              6.53      4.19      2.41       8.73   8.73
Dragonfly larvae Megapodagrionidae                 1.95              7.50      4.10      1.95       8.54  17.27
True Fly larvae s-f Chironominae                   5.63              7.56      3.80      1.69       7.91  25.18
True Fly larvae s-f Tanypodinae                    1.09              4.24      2.29      1.90       4.76  29.94
Dragonfly larvae Hemicorduliidae                   2.93              4.16      1.85      1.38       3.86  33.80
True bugs Notonectidae                             1.35              3.19      1.83      1.32       3.80  37.61
Mussels Corbiculidae                               1.95              2.02      1.60      1.06       3.32  40.93
Snails Physidae                                    6.65              4.93      1.56      1.27       3.25  44.18
Dragonfly larvae Isostictidae                      1.04              2.37      1.48      1.56       3.07  47.25
Leeches Glossiphoniidae                            2.58              1.50      1.45      1.25       3.01  50.26
Beetles Elmidae                                    0.00              2.03      1.43      4.14       2.99  53.25
Flatworms Dugesiidae                               6.08              4.92      1.23      1.13       2.56  55.81
Snails Planorbidae                                 2.53              1.92      1.17      1.37       2.43  58.24
Aquatic mites Acarina                              2.69              2.16      1.17      1.44       2.43  60.67
Dragonfly larvae Libellulidae                      1.36              2.28      1.12      1.18       2.34  63.01
True bugs Veliidae                                 0.92              1.81      1.12      2.00       2.33  65.34
True bugs Gerridae                                 0.39              1.67      1.01      1.54       2.09  67.43
Dragonfly larvae Coenagrionidae                    2.83              2.51      0.95      1.51       1.98  69.41
Worms Oligochaeta                                  5.80              5.25      0.89      1.42       1.85  71.26
True Fly larvae s-f Orthocladiinae                 0.69              1.65      0.84      1.14       1.75  73.02
Mussels Sphaeriidae                                0.63              1.08      0.82      0.99       1.70  74.72
True Fly larvae Stratiomyidae                      0.89              1.74      0.79      1.38       1.65  76.36
True bugs Corixidae                                1.11              0.37      0.78      1.07       1.63  77.99
True Fly larvae Culicidae                          0.29              1.06      0.74      0.85       1.55  79.54
Yabbies Parastacidae                               1.03              0.00      0.69      1.30       1.44  80.97
Snails Lymnaeidae                                  1.06              0.80      0.66      1.28       1.38  82.35
Sand hoppers Talitridae                            0.00              0.93      0.65      1.30       1.35  83.70
Dragonfly larvae Aeshnidae                         0.57              0.79      0.65      1.20       1.34  85.05
Snails Ancylidae                                   0.94              0.17      0.60      0.81       1.25  86.29
True Fly larvae Simuliidae                         0.00              0.88      0.59      0.94       1.22  87.52
Dragonfly larvae Lestidae                          0.53              0.41      0.55      0.60       1.15  88.67
True Fly larvae Tipulidae                          0.00              0.74      0.54      0.91       1.13  89.80
Sand hoppers Ceinidae                              0.00              0.67      0.48      0.69       1.00  90.80
```

SIMPER Archers Creek 2005, 2006, 2007, and 2008

```
Data worksheet
Name: Archers sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Season Year
S5       Autumn 2005
S5       Spring 2005
S5       Autumn 2006
S5       Spring 2006
S5       Autumn 2007
S5       Spring 2007
S5       Autumn 2008

Group Autumn 2005
Average similarity: 68.02

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae               3.60      7.56     2.16      11.11    11.11
Fairy shrimps Atyidae                            3.30      7.18     8.38      10.56    21.67
Worms Oligochaeta                                3.29      6.80     3.09       9.99    31.67
True Fly larvae s-f Chironominae                 3.31      6.58     5.68       9.67    41.33
Dragonfly larvae Libellulidae                    2.52      5.47     4.54       8.04    49.37
Flatworms Dugesiidae                             2.75      5.32     5.50       7.82    57.19
Dragonfly larvae Coenagrionidae                  3.19      5.20     4.94       7.65    64.83
True bugs Veliidae                               2.14      5.09     3.65       7.49    72.32
Dragonfly larvae Hemicorduliidae                 2.66      4.82     8.37       7.08    79.40
Snails Physidae                                  1.67      3.65     1.80       5.36    84.77
True Fly larvae Stratiomyidae                    1.62      2.98     7.13       4.38    89.15
True Fly larvae s-f Tanypodinae                  1.00      2.65     8.58       3.90    93.04


Group Spring 2005
Average similarity: 58.85

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae              8.06     19.91     6.33      33.83    33.83
Worms Oligochaeta                             4.19     10.61     6.70      18.04    51.87
Snails Physidae                               2.95      7.20     6.86      12.24    64.11
Dragonfly larvae Coenagrionidae               3.08      6.42     6.60      10.90    75.01
Dragonfly larvae Libellulidae                 2.87      6.04     1.03      10.27    85.28
Dragonfly larvae Aeshnidae                    1.49      2.00     0.58       3.40    88.68
Mussels Corbiculidae                          1.15      1.97     0.58       3.36    92.04

Group Autumn 2006
Average similarity: 72.35

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 9.12     23.36    19.19      32.29    32.29
Worms Oligochaeta                                3.39      8.50    11.35      11.74    44.04
Leeches Glossiphoniidae                          2.10      4.91     2.60       6.79    50.82
Dragonfly larvae Megapodagrionidae               2.10      4.62     4.53       6.39    57.21
Dragonfly larvae Libellulidae                    2.02      4.46     4.33       6.17    63.38
Dragonfly larvae Coenagrionidae                  2.03      4.02     1.99       5.56    68.94
Dragonfly larvae Hemicorduliidae                 1.96      3.84     2.25       5.30    74.24
Flatworms Dugesiidae                             1.67      3.63     2.69       5.02    79.26
True bugs Veliidae                               1.28      3.17     3.92       4.38    83.63
True bugs Notonectidae                           1.47      3.16     4.33       4.36    88.00
Dragonfly larvae Aeshnidae                       2.05      2.45     0.58       3.38    91.38
```

Group Spring 2006

```
Average similarity: 60.44

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 4.35     14.99     4.12      24.80    24.80
Snails Physidae                                  2.81     10.08     3.57      16.67    41.48
Flatworms Dugesiidae                             2.63      8.68     2.77      14.37    55.84
Worms Oligochaeta                                2.43      7.90     2.82      13.07    68.92
Snails Hydrobiidae                               1.81      4.53     1.47       7.49    76.41
True Fly larvae s-f Tanypodinae                  1.07      3.40     1.76       5.62    82.03
True bugs Veliidae                               0.80      1.96     0.79       3.24    85.28
True Fly larvae s-f Orthocladiinae               1.06      1.92     0.79       3.17    88.45
True Fly larvae Stratiomyidae                    0.87      1.55     0.57       2.57    91.02
```

Group Autumn 2007

```
Average similarity: 57.33

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 5.02     17.66     4.21      30.81    30.81
Worms Oligochaeta                                2.53      6.59     1.30      11.49    42.30
Snails Physidae                                  2.35      6.46     3.17      11.27    53.57
Flatworms Dugesiidae                             2.20      4.54     1.22       7.93    61.50
True Fly larvae s-f Tanypodinae                  1.19      4.00     5.04       6.99    68.48
Dragonfly larvae Libellulidae                    1.50      3.89     1.21       6.79    75.27
True bugs Veliidae                               1.93      3.06     0.75       5.35    80.62
Leeches Glossiphoniidae                          1.08      2.51     1.28       4.38    85.00
Dragonfly larvae Megapodagrionidae               1.01      1.90     0.77       3.31    88.31
Dragonfly larvae Aeshnidae                       0.98      1.76     0.78       3.07    91.38
```

Group Spring 2007

```
Average similarity: 60.74

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 5.57     14.85     7.21      24.44    24.44
Snails Physidae                                  3.77     10.13     6.96      16.67    41.11
Snails Hydrobiidae                               2.81      6.64     2.44      10.93    52.04
Worms Oligochaeta                                2.95      6.42     3.39      10.56    62.60
Flatworms Dugesiidae                             2.70      4.94     1.22       8.14    70.74
True Fly larvae s-f Tanypodinae                  1.84      3.92     2.54       6.45    77.20
Mussels Sphaeriidae                              2.01      3.08     1.02       5.08    82.27
Dragonfly larvae Hemicorduliidae                 1.57      2.35     1.15       3.87    86.15
Dragonfly larvae Libellulidae                    1.04      2.12     1.28       3.49    89.64
True Fly larvae s-f Orthocladiinae               1.33      1.76     0.73       2.90    92.54
```

Group Autumn 2008

```
Average similarity: 61.14

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Orthocladiinae               4.42     13.68     5.42      22.37    22.37
True Fly larvae s-f Chironominae                 3.35     10.70     5.74      17.51    39.88
Snails Hydrobiidae                               2.52      6.99     2.75      11.43    51.31
Worms Oligochaeta                                1.69      5.02     3.59       8.21    59.52
True bugs Veliidae                               1.62      4.29     4.33       7.02    66.54
Snails Physidae                                  2.03      4.28     1.16       7.00    73.54
True bugs Notonectidae                           1.69      3.38     1.06       5.54    79.07
Caddisfly larvae Hydroptilidae                   1.35      2.18     0.74       3.57    82.65
True Fly larvae Ceratopogonidae                  1.15      2.05     0.78       3.35    86.00
Mayfly larvae Baetidae                           1.26      1.64     0.48       2.68    88.68
True Fly larvae Stratiomyidae                    0.67      1.42     0.79       2.32    91.00
```

SIMPER Shrimptons Creek 2005, 2006, 2007 and 2008

```
Data worksheet
Name: Shrimptons sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Season Year
S2       Autumn 2005
S2       Spring 2005
S2       Autumn 2006
S2       Spring 2006
S2       Autumn 2007
S2       Spring 2007
S2       Autumn 2008

Group Autumn 2005
Average similarity: 75.89

Species                        Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Snails Physidae                    3.90     16.31     7.41      21.49    21.49
Flatworms Dugesiidae               3.81     15.30     9.53      20.16    41.65
Worms Oligochaeta                  3.43     13.48    44.44      17.77    59.41
Leeches Glossiphoniidae            3.04     10.94     8.30      14.42    73.83
Mussels Corbiculidae               2.63      9.41     3.56      12.40    86.23
Snails Planorbidae                 2.39      7.68     3.56      10.12    96.35

Group Spring 2005
Average similarity: 76.54

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Snails Physidae                               4.03     13.28    19.85      17.35    17.35
Worms Oligochaeta                             3.91     13.08    46.28      17.09    34.44
Flatworms Dugesiidae                          3.46     11.45    11.43      14.97    49.41
Leeches Glossiphoniidae                       3.04      9.70    10.63      12.67    62.08
True Fly larvae s-f Chironominae              3.09      8.94     4.43      11.68    73.76
Snails Planorbidae                            2.88      8.57     3.06      11.20    84.96
Mussels Corbiculidae                          2.64      7.51    12.72       9.82    94.78

Group Autumn 2006
Average similarity: 76.70

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Worms Oligochaeta                             3.68     16.90    13.74      22.03    22.03
Flatworms Dugesiidae                          2.82     13.43     9.18      17.51    39.55
Snails Physidae                               2.96     13.00     3.19      16.95    56.50
Aquatic mites Acarina                         2.08      9.91    14.34      12.92    69.42
Mussels Corbiculidae                          2.39      9.70     6.21      12.64    82.06
Dragonfly larvae Hemicorduliidae              1.88      6.51     2.65       8.49    90.55

Group Spring 2006
Average similarity: 62.17

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae              4.59     20.77     7.14      33.41    33.41
Snails Physidae                               3.41     15.57    10.74      25.04    58.46
Worms Oligochaeta                             2.05      7.05     1.41      11.35    69.80
Flatworms Dugesiidae                          1.31      3.75     1.10       6.03    75.83
True bugs Notonectidae                        1.03      3.23     1.14       5.19    81.03
Aquatic mites Acarina                         1.12      3.02     1.10       4.86    85.89
Dragonfly larvae Hemicorduliidae              1.12      2.85     0.79       4.58    90.47
```

```
Group Autumn 2007
Average similarity: 60.39

Species                                      Av.Abund    Av.Sim   Sim/SD    Contrib%   Cum.%
True Fly larvae s-f Chironominae                 2.95      8.39     2.58       13.89   13.89
Dragonfly larvae Megapodagrionidae               2.10      6.97     5.43       11.55   25.44
Flatworms Dugesiidae                             2.16      6.71     3.12       11.10   36.54
Aquatic mites Acarina                            2.02      5.61     3.42        9.28   45.83
Dragonfly larvae Coenagrionidae                  1.80      5.41     2.78        8.96   54.79
Dragonfly larvae Isostictidae                    1.72      5.19     3.30        8.59   63.38
Dragonfly larvae Hemicorduliidae                 2.14      4.74     1.11        7.85   71.23
Worms Oligochaeta                                1.72      4.72     1.08        7.81   79.04
Snails Physidae                                  2.28      4.63     1.08        7.67   86.71
True bugs Notonectidae                           1.01      2.01     0.75        3.33   90.04

Group Spring 2007
Average similarity: 63.13

Species                                      Av.Abund    Av.Sim   Sim/SD    Contrib%   Cum.%
True Fly larvae s-f Chironominae                 4.53     12.18     4.26       19.29   19.29
Snails Physidae                                  3.79     10.55     5.00       16.72   36.01
Worms Oligochaeta                                2.22      6.38     4.93       10.10   46.12
Flatworms Dugesiidae                             2.25      5.37     2.58        8.51   54.62
Dragonfly larvae Coenagrionidae                  2.01      4.99     3.48        7.90   62.53
Dragonfly larvae Isostictidae                    1.88      4.87     3.27        7.71   70.23
Dragonfly larvae Megapodagrionidae               1.95      3.26     0.78        5.17   75.41
Snails Ancylidae                                 1.37      3.05     1.34        4.83   80.24
True bugs Corixidae                              1.28      2.94     1.28        4.65   84.89
Dragonfly larvae Hemicorduliidae                 1.25      2.90     1.35        4.59   89.48
True bugs Notonectidae                           0.67      1.56     0.78        2.48   91.96

Group Autumn 2008
Average similarity: 58.25

Species                                      Av.Abund    Av.Sim   Sim/SD    Contrib%   Cum.%
Flatworms Dugesiidae                             3.55     21.11     4.30       36.24   36.24
Snails Physidae                                  2.91     16.22     4.55       27.84   64.07
Worms Oligochaeta                                1.52      6.57     1.29       11.27   75.34
Dragonfly larvae Megapodagrionidae               1.05      3.54     0.77        6.07   81.41
Leeches Glossiphoniidae                          1.22      2.81     0.76        4.82   86.23
Aquatic mites Acarina                            0.98      2.68     0.77        4.61   90.84
```

SIMPER Buffalo Creek 2005, 2006, 2007 and 2008

```
Data worksheet
Name: Buffalo sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Season Year
S4       Autumn 2005
S4       Spring 2005
S4       Autumn 2006
S4       Autumn 2007
S4       Spring 2007
S4       Autumn 2008

Group Autumn 2005
Average similarity: 76.18

Species                                       Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae                3.98      7.79     6.42      10.23    10.23
True Fly larvae s-f Chironominae                  4.20      7.27    13.67       9.54    19.77
True bugs Notonectidae                            3.21      7.22     9.55       9.48    29.25
Worms Oligochaeta                                 3.21      7.12     6.08       9.34    38.59
Dragonfly larvae Coenagrionidae                   2.98      5.52    11.31       7.24    45.83
Snails Hydrobiidae                                2.90      4.90     7.43       6.43    52.26
Flatworms Dugesiidae                              2.23      4.73    14.18       6.21    58.47
Mussels Corbiculidae                              2.40      4.59     5.43       6.02    64.49
Dragonfly larvae Hemicorduliidae                  3.12      4.36     1.27       5.73    70.22
True Fly larvae s-f Tanypodinae                   1.82      3.23     9.55       4.24    74.46
Snails Planorbidae                                1.52      3.23     9.55       4.24    78.70
Snails Physidae                                   1.82      3.02     2.42       3.97    82.67
Aquatic mites Acarina                             1.28      2.63     3.13       3.46    86.12
True Fly larvae Stratiomyidae                     1.38      2.59     4.88       3.40    89.52
Leeches Glossiphoniidae                           1.28      2.59     4.88       3.40    92.92

Group Spring 2005
Average similarity: 66.97

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae               6.42     14.61     9.20      21.82    21.82
Worms Oligochaeta                              4.67     11.55    20.99      17.24    39.06
Snails Physidae                                3.67      8.14     4.59      12.16    51.22
Snails Hydrobiidae                             3.19      7.97     6.51      11.90    63.12
Slatters Oniscidae                             1.72      4.22     7.11       6.30    69.42
Flatworms Dugesiidae                           1.87      4.20    15.55       6.27    75.69
Mussels Corbiculidae                           2.18      3.84     2.27       5.74    81.43
True bugs Notonectidae                         1.67      3.71     2.25       5.54    86.97
Dragonfly larvae Libellulidae                  2.01      3.13     6.71       4.68    91.65

Group Autumn 2006
Average similarity: 75.41

Species                                       Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                  7.70     15.95    22.99      21.15    21.15
True bugs Notonectidae                            3.55      7.62    12.00      10.11    31.25
Dragonfly larvae Libellulidae                     2.92      5.42     3.65       7.19    38.44
Snails Physidae                                   2.57      5.39    10.50       7.15    45.60
Dragonfly larvae Coenagrionidae                   2.72      5.25    12.79       6.96    52.56
Mussels Corbiculidae                              2.37      4.90     6.84       6.50    59.06
Worms Oligochaeta                                 2.57      4.75     3.53       6.30    65.36
Dragonfly larvae Megapodagrionidae                2.41      4.27     2.42       5.66    71.02
Flatworms Dugesiidae                              1.82      3.94    40.60       5.22    76.24
Dragonfly larvae Aeshnidae                        1.97      3.94    40.60       5.22    81.47
Dragonfly larvae Hemicorduliidae                  2.34      3.66     4.91       4.85    86.31
True Fly larvae s-f Orthocladiinae                1.61      3.22    40.60       4.27    90.58
```

```
Group Autumn 2007
Average similarity: 69.52

Species                                       Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                  4.26      9.71     5.15      13.97    13.97
True bugs Notonectidae                            3.23      7.79     6.96      11.21    25.18
Snails Physidae                                   3.23      6.36     2.24       9.14    34.32
Snails Hydrobiidae                                2.51      5.25     2.69       7.55    41.88
Dragonfly larvae Hemicorduliidae                  2.47      5.09     2.72       7.33    49.20
Dragonfly larvae Megapodagrionidae                2.06      4.40     6.84       6.33    55.54
Caddisfly larvae Hydroptilidae                    1.93      4.09     4.75       5.88    61.42
True Fly larvae s-f Tanypodinae                   1.71      3.53     3.54       5.07    66.49
Dragonfly larvae Isostictidae                     1.64      3.19     4.05       4.59    71.08
Snails Lymnaeidae                                 1.60      3.15     4.78       4.53    75.61
Dragonfly larvae Aeshnidae                        1.64      2.85     1.35       4.10    79.71
Dragonfly larvae Coenagrionidae                   1.57      2.28     1.24       3.28    83.00
Flatworms Dugesiidae                              1.43      1.76     0.79       2.53    85.53
Mayfly larvae Baetidae                            1.70      1.71     0.48       2.46    87.99
True Fly larvae Stratiomyidae                     1.02      1.68     1.33       2.42    90.41

Group Spring 2007
Average similarity: 65.62

Species                                       Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                  4.63     14.86     4.90      22.64    22.64
Snails Physidae                                   3.92     14.48    10.77      22.07    44.71
Snails Hydrobiidae                                2.54      8.75     4.89      13.33    58.05
Dragonfly larvae Megapodagrionidae                1.97      5.37     2.51       8.18    66.22
Worms Oligochaeta                                 1.68      5.13     2.72       7.82    74.05
True bugs Notonectidae                            1.43      4.67     4.74       7.12    81.16
Dragonfly larvae Isostictidae                     1.51      3.02     0.78       4.60    85.76
Dragonfly larvae Coenagrionidae                   1.01      1.86     0.77       2.83    88.59
True Fly larvae s-f Tanypodinae                   0.97      1.83     0.77       2.79    91.39

Group Autumn 2008
Average similarity: 63.54

Species                                       Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                  3.63      9.91     6.68      15.60    15.60
True bugs Notonectidae                            3.12      9.02     3.62      14.19    29.79
Snails Physidae                                   3.11      6.90     2.31      10.86    40.65
Dragonfly larvae Megapodagrionidae                2.49      6.89     3.97      10.85    51.50
Flatworms Dugesiidae                              2.10      6.11     4.67       9.62    61.12
Snails Hydrobiidae                                2.61      5.21     1.25       8.20    69.32
Caddisfly larvae Hydroptilidae                    2.31      4.66     1.15       7.34    76.66
True Fly larvae s-f Orthocladiinae                2.39      4.48     1.24       7.04    83.70
Snails Planorbidae                                1.33      1.85     0.71       2.91    86.61
Dragonfly larvae Aeshnidae                        0.93      1.51     0.75       2.38    88.99
Worms Oligochaeta                                 0.96      1.37     0.77       2.16    91.14
```

SIMPER Porters Creek 2005, 2006, 2007 and 2008

```
Data worksheet
Name: Porters sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Season Year
S3       Autumn 2005
S3       Spring 2005
S3       Autumn 2006
S3       Autumn 2007
S3       Spring 2007
S3       Autumn 2008

Group Autumn 2005
Average similarity: 77.34

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 6.51     12.97    10.80      16.77    16.77
Snails Hydrobiidae                               4.59      8.36     7.06      10.81    27.58
Dragonfly larvae Isostictidae                    4.18      8.13    10.32      10.51    38.09
Dragonfly larvae Hemicorduliidae                 2.89      5.97    60.48       7.72    45.80
Snails Physidae                                  3.09      5.94    11.11       7.68    53.48
Dragonfly larvae Megapodagrionidae               3.01      5.44    11.33       7.03    60.51
Dragonfly larvae Coenagrionidae                  2.83      4.66     2.66       6.03    66.54
Snails Planorbidae                               2.30      4.54     8.09       5.87    72.40
Worms Oligochaeta                                2.45      4.16     4.70       5.38    77.78
Leeches Glossiphoniidae                          2.10      3.56     3.53       4.61    82.39
True Fly larvae s-f Tanypodinae                  2.39      3.40     4.45       4.40    86.79
Dragonfly larvae Aeshnidae                       1.41      2.98    60.48       3.86    90.65

Group Spring 2005
Average similarity: 72.69

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae             10.09     23.35     7.12      32.12    32.12
Snails Hydrobiidae                            4.74     10.08     8.73      13.86    45.98
Dragonfly larvae Isostictidae                 2.63      5.99    19.38       8.24    54.22
Worms Oligochaeta                             2.68      5.99    19.38       8.24    62.46
Snails Physidae                               2.49      5.65     4.31       7.77    70.24
Leeches Glossiphoniidae                       1.99      4.63     6.74       6.37    76.61
Dragonfly larvae Libellulidae                 2.22      4.33     2.89       5.95    82.56
True bugs Corixidae                           1.80      2.91     3.64       4.00    86.56
Leeches Erpobdellidae                         1.28      2.88     4.62       3.97    90.53

Group Autumn 2006
Average similarity: 71.92

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Snails Hydrobiidae                               4.07      8.77     4.85      12.20    12.20
Dragonfly larvae Coenagrionidae                  3.33      7.27     5.23      10.10    22.30
Dragonfly larvae Megapodagrionidae               3.64      7.01     7.28       9.75    32.05
Dragonfly larvae Isostictidae                    3.18      6.57    18.65       9.14    41.19
Worms Oligochaeta                                2.58      6.08    18.65       8.46    49.65
Dragonfly larvae Hemicorduliidae                 2.69      5.55    18.65       7.72    57.37
Fairy shrimps Atyidae                            2.74      5.55    18.65       7.72    65.09
Leeches Glossiphoniidae                          2.85      5.24     2.96       7.29    72.38
Dragonfly larvae Aeshnidae                       2.20      4.69    10.46       6.53    78.91
Snails Physidae                                  1.93      3.76    15.62       5.23    84.14
Dragonfly larvae Libellulidae                    1.66      3.11     2.72       4.32    88.46
True Fly larvae s-f Tanypodinae                  2.52      2.58     0.58       3.58    92.04
```

```
Group Autumn 2007
Average similarity: 71.28

Species                                      Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Hydrobiidae                               4.72     10.58      6.69      14.84    14.84
Snails Physidae                                  2.61      5.88      5.12       8.24    23.09
True bugs Notonectidae                           2.63      5.79      5.28       8.12    31.21
Dragonfly larvae Isostictidae                    2.79      5.76      3.27       8.08    39.29
True Fly larvae s-f Chironominae                 2.78      5.51      4.23       7.73    47.02
Dragonfly larvae Coenagrionidae                  2.63      5.44      3.69       7.64    54.66
Dragonfly larvae Megapodagrionidae               2.45      5.12      4.50       7.18    61.84
Dragonfly larvae Hemicorduliidae                 2.37      4.88      3.60       6.85    68.68
Dragonfly larvae Libellulidae                    2.15      4.36      3.65       6.11    74.80
Caddisfly larvae Hydroptilidae                   1.89      3.85      4.08       5.41    80.20
Fairy shrimps Atyidae                            2.15      3.77      2.18       5.29    85.49
True Fly larvae s-f Orthocladiinae               1.72      2.70      1.17       3.79    89.28
True Fly larvae s-f Tanypodinae                  1.33      1.79      0.78       2.51    91.80

Group Spring 2007
Average similarity: 67.64

Species                                      Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 4.72     18.60      7.09      27.50    27.50
Snails Hydrobiidae                               3.74     12.08      4.54      17.86    45.36
Snails Physidae                                  2.81      9.67      4.32      14.29    59.65
Worms Oligochaeta                                2.70      8.17      3.30      12.08    71.73
Dragonfly larvae Megapodagrionidae               2.43      7.43      3.03      10.98    82.71
Dragonfly larvae Isostictidae                    1.45      3.67      1.28       5.42    88.13
Snails Planorbidae                               0.79      1.59      0.78       2.35    90.48

Group Autumn 2008
Average similarity: 60.24

Species                                      Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 3.77     14.57      6.12      24.18    24.18
Snails Hydrobiidae                               3.11     11.74      5.98      19.48    43.67
Dragonfly larvae Megapodagrionidae               2.24      7.00      3.00      11.61    55.28
True Fly larvae s-f Orthocladiinae               2.30      5.76      2.29       9.57    64.85
True bugs Notonectidae                           1.87      5.35      3.11       8.87    73.72
True Fly larvae Stratiomyidae                    1.45      3.74      1.24       6.21    79.93
Worms Oligochaeta                                1.34      2.46      0.78       4.09    84.02
Snails Physidae                                  1.20      2.10      0.73       3.49    87.51
Flatworms Dugesiidae                             1.15      2.00      0.70       3.31    90.82
```

SIMPER Terrys Creek 2005, 2006, 2007 and 2008

```
Data worksheet
Name: Terrys sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups
Sample   Season Year
S1       Autumn 2005
S1       Spring 2005
S1       Autumn 2006
S1       Autumn 2007
S1       Spring 2007
S1       Autumn 2008

Group Autumn 2005
Average similarity: 69.53

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae               4.28      8.68     8.63      12.48    12.48
Snails Hydrobiidae                               3.36      7.27    14.80      10.45    22.93
True Fly larvae s-f Chironominae                 3.72      5.63     2.01       8.10    31.03
Dragonfly larvae Isostictidae                    2.58      5.54    13.25       7.97    39.00
Worms Oligochaeta                                2.90      5.12     5.83       7.36    46.36
Flatworms Dugesiidae                             2.73      4.89     5.00       7.04    53.39
Snails Physidae                                  2.46      4.70     3.87       6.76    60.16
Mussels Corbiculidae                             2.38      4.28     8.30       6.15    66.31
True Fly larvae s-f Tanypodinae                  2.77      4.11    14.09       5.91    72.22
True bugs Notonectidae                           2.46      4.09     2.80       5.89    78.11
Dragonfly larvae Hemicorduliidae                 2.78      3.94     3.39       5.67    83.78
Snails Planorbidae                               1.80      3.62     5.83       5.20    88.98
Leeches Glossiphoniidae                          1.38      2.60     3.43       3.74    92.72

Group Spring 2005
Average similarity: 65.48

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae                 5.63     13.16    17.22      20.10    20.10
Snails Physidae                                  3.14      6.82     6.79      10.42    30.51
Worms Oligochaeta                                3.17      6.57    10.72      10.03    40.54
Dragonfly larvae Megapodagrionidae               2.93      6.43    14.73       9.82    50.37
Dragonfly larvae Isostictidae                    2.57      5.66     6.67       8.64    59.00
Mussels Corbiculidae                             2.05      3.60    13.79       5.50    64.50
True Fly larvae s-f Tanypodinae                  2.26      3.53     1.76       5.39    69.89
Flatworms Dugesiidae                             1.52      3.36    18.39       5.13    75.02
Aquatic mites Acarina                            1.88      3.12     2.65       4.77    79.79
True bugs Notonectidae                           1.47      2.72     3.84       4.16    83.95
Dragonfly larvae Libellulidae                    2.45      2.70     0.58       4.12    88.07
Snails Hydrobiidae                               2.35      2.48     0.58       3.79    91.85

Group Autumn 2006
Average similarity: 72.76

Species                                      Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae               4.95      8.98    18.42      12.34    12.34
Dragonfly larvae Hemicorduliidae                 4.41      8.71    18.55      11.98    24.31
Worms Oligochaeta                                4.04      8.33    18.95      11.45    35.77
Snails Hydrobiidae                               3.58      5.51     2.85       7.58    43.34
True bugs Notonectidae                           2.23      4.48    14.83       6.16    49.50
Flatworms Dugesiidae                             2.63      4.25     2.15       5.85    55.35
True bugs Gerridae                               1.73      3.74    15.97       5.14    60.48
Snails Physidae                                  2.33      3.70     1.32       5.08    65.57
True Fly larvae s-f Tanypodinae                  2.44      3.70     1.32       5.08    70.65
True Fly larvae s-f Chironominae                 2.67      3.68     2.86       5.06    75.71
Dragonfly larvae Coenagrionidae                  2.10      3.62     3.89       4.98    80.69
Dragonfly larvae Isostictidae                    1.80      3.45     5.69       4.75    85.44
Aquatic mites Acarina                            1.52      3.05    15.97       4.19    89.63
Dragonfly larvae Libellulidae                    1.47      2.44     5.69       3.36    92.99
```

Group Autumn 2007

```
Average similarity: 65.81

Species                                      Av.Abund    Av.Sim    Sim/SD    Contrib%     Cum.%
Snails Hydrobiidae                               4.10      9.26      5.36       14.08     14.08
Dragonfly larvae Megapodagrionidae               3.47      8.29      5.44       12.60     26.68
True Fly larvae s-f Chironominae                 3.19      7.79      4.33       11.84     38.52
Flatworms Dugesiidae                             2.60      5.83      2.72        8.85     47.37
Snails Physidae                                  2.59      5.46      2.48        8.29     55.66
True bugs Notonectidae                           2.19      5.03      6.23        7.64     63.30
Worms Oligochaeta                                1.93      4.37      3.50        6.64     69.94
True Fly larvae s-f Tanypodinae                  2.09      3.92      2.41        5.96     75.90
Dragonfly larvae Hemicorduliidae                 1.68      3.07      1.30        4.66     80.56
Dragonfly larvae Isostictidae                    1.38      2.07      1.31        3.15     83.71
True Fly larvae s-f Orthocladiinae               1.29      1.75      0.77        2.66     86.36
Dragonfly larvae Libellulidae                    0.97      1.40      0.76        2.13     88.50
Dragonfly larvae Coenagrionidae                  1.06      1.28      0.76        1.95     90.45
```

Group Spring 2007

```
Average similarity: 65.16

Species                                      Av.Abund    Av.Sim    Sim/SD    Contrib%     Cum.%
True Fly larvae s-f Chironominae                 4.77     14.94      7.62       22.92     22.92
Snails Hydrobiidae                               3.55     10.86      3.83       16.67     39.59
Dragonfly larvae Megapodagrionidae               2.98      8.90      4.56       13.66     53.25
Snails Physidae                                  2.57      7.71      4.20       11.83     65.08
Flatworms Dugesiidae                             2.43      6.34      2.17        9.74     74.81
Worms Oligochaeta                                1.85      4.55      1.27        6.98     81.79
Dragonfly larvae Hemicorduliidae                 1.52      2.89      1.21        4.43     86.22
True Fly larvae s-f Tanypodinae                  1.00      2.35      1.36        3.60     89.83
Mussels Sphaeriidae                              1.12      2.00      0.73        3.07     92.89
```

Group Autumn 2008

```
Average similarity: 66.65

Species                                      Av.Abund    Av.Sim    Sim/SD    Contrib%     Cum.%
Snails Hydrobiidae                               3.50     14.68      4.25       22.02     22.02
Dragonfly larvae Megapodagrionidae               3.03     12.52      7.16       18.78     40.81
True bugs Notonectidae                           2.29      9.65      6.24       14.48     55.29
Snails Physidae                                  2.35      8.98      5.21       13.48     68.77
Flatworms Dugesiidae                             1.66      6.76      7.68       10.14     78.90
Worms Oligochaeta                                1.37      4.27      1.31        6.40     85.30
True Fly larvae s-f Chironominae                 1.35      3.72      1.29        5.59     90.89
```

Appendix 6 BIOENV output

BIOENV of all five creeks with replicates merged for 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: All five cks reps merged sqrt(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 Dissolved Oxygen
 11 Temperature
 12 Rainfall
 13 Altitude
 14 Bedrock
 15 Boulder
 16 Cobble
 17 Total Length Pipe
 18 No. Outlets
 19 Ratio TLP/CA
 20 Ratio NO/CA
 21 Catchment Area

Best results
No.Vars    Corr. Selections
      4    0.394 3,12,16,17
      5    0.393 3,4,12,16,17
      5    0.393 3,4,12,17,20
      5    0.392 3,9,12,16,17
      5    0.389 3,12,16,17,20
      5    0.389 3,6,12,16,17
      5    0.387 3,4,9,12,17
      4    0.387 3,12,17,20
      5    0.387 4,9,12,16,17
      3    0.386 3,12,17
```

BIOENV of Archers Creek 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Archers(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 Dissolved Oxygen
 11 Temperature
 12 Rainfall

Best results
No.Vars    Corr. Selections
      1    0.486 12
      2    0.470 4,12
      3    0.451 4,5,12
      2    0.446 5,12
      3    0.430 3,4,12
      4    0.429 3-5,12
      2    0.415 3,12
      3    0.413 4,11,12
      4    0.411 4,5,11,12
      3    0.409 3,5,12
```

BIOENV of Shrimptons Creek 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Shrimptons(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 Dissolved Oxygen
 11 Temperature
 12 Rainfall

Best results
No.Vars    Corr. Selections
      1    0.409 8
      2    0.363 8,12
      2    0.351 8,10
      2    0.350 5,8
      3    0.342 8,10,12
      3    0.342 5,8,10
      3    0.327 5,8,12
      3    0.325 8,10,11
      4    0.323 5,8,10,12
      4    0.323 3,8,10,12
```

BIOENV of Buffalo Creek 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Buffalo(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 Dissolved Oxygen
 11 Temperature
 12 Rainfall

Best results
No.Vars    Corr. Selections
      3    0.498 3,5,12
      3    0.493 3,6,12
      3    0.491 2,3,12
      5    0.491 3,5-7,12
      2    0.490 3,12
      3    0.489 3,4,12
      4    0.489 2,3,5,12
      4    0.486 3,4,6,12
      4    0.486 3,5,7,12
      4    0.485 3,5,6,12
```

BIOENV of Porters Creek 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Porters(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      2    0.617 8,12
      4    0.582 3,7,8,12
      3    0.581 3,8,12
      3    0.579 2,8,12
      3    0.576 7,8,12
      4    0.572 2,7,8,12
      3    0.570 5,8,12
      4    0.569 5,7,8,12
      5    0.549 2,7,8,10,12
      5    0.549 2,3,7,8,12
```

BIOENV of Terrys Creek 2005, 2006, 2007, 2008

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Terrys(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      2    0.477 6,12
      1    0.442 12
      3    0.429 6,9,12
      3    0.426 6,11,12
      3    0.418 6,10,12
      3    0.405 6,8,12
      2    0.405 8,12
      3    0.405 6,7,12
      2    0.403 1,12
      3    0.402 3,6,12
```