Biological and Water Quality Monitoring

Spring 2007

prepared for City of Ryde

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Executive Summary

This report has been developed by Sydney Water Corporation 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 fourth year of the strategy with collection of samples from Archers, Shrimptons, Buffalo, Porters and Terrys creeks in Spring 2007. Spring 2007 sampling was conducted on 26-27th September 2007 and on the 22-23rd October 2007.

A total of 2,490 macroinvertebrates were collected and examined from the Spring 2007 sampling period which saw visits to Archers, Shrimptons, Buffalo, Porters and Terrys creeks, with 48 taxa recorded. A total of 71 taxa have been recorded from all creeks in the Spring 2004 to Autumn 2007 period from the edge habitat. The dominant taxon in all five creeks for Spring 2007 was the non-biting midge, sub-family Chironiminae. The second most dominant taxa in Archers, Buffalo and Shrimptons creeks was the snail Physiidae, the second most dominant taxa in Terrys and Porters creeks was the snail Hydrobiidae.

Macroinvertebrate results of Spring 2007 indicate Archers, Shrimptons, Buffalo, Porters and Terrys creeks have impaired macroinvertebrate communities with similar results recorded in Spring 2004 to Autumn 2007 although a slight decline in stream health was recorded for all five study creeks. In Spring 2007 few sensitive EPT taxa were recorded being virtually absent in Shrimptons and Terrys creeks and a slight decline recorded in Buffalo and Porters creeks. Only one EPT taxa a Caddisfly larvae (Hydroptilidae) was recorded in Spring 2007 with the most consistent numbers of this taxon recorded in Archers Creek. No EPT indicator taxa defined by AUSRIVAS predicted model output, were recorded in Spring 2007 in any of the study streams. 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 2007 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 Spring 2007 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, Ammonium (NH^4), and Dissolved Oxygen, although levels varied between creeks. This was similar to Autumn 2007. Some exceedances of ANZECC (2000) criteria also occurred for Total Phosphorus in the study creeks. In October 2007 pH fell 0.1 below the lower ANZECC (2000) limit for the protection of aquatic ecosystems in Archers and Shrimptons creeks. These water quality results of Spring 2007 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.

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

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1 Introduction

Sydney Water Limited (SWC) 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 Spring 2007 report begins the fourth year of the seven year program with inclusion of all five sites for macroinvertebrates and water chemistry which were sampled once each month in September & October of Spring 2007.

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

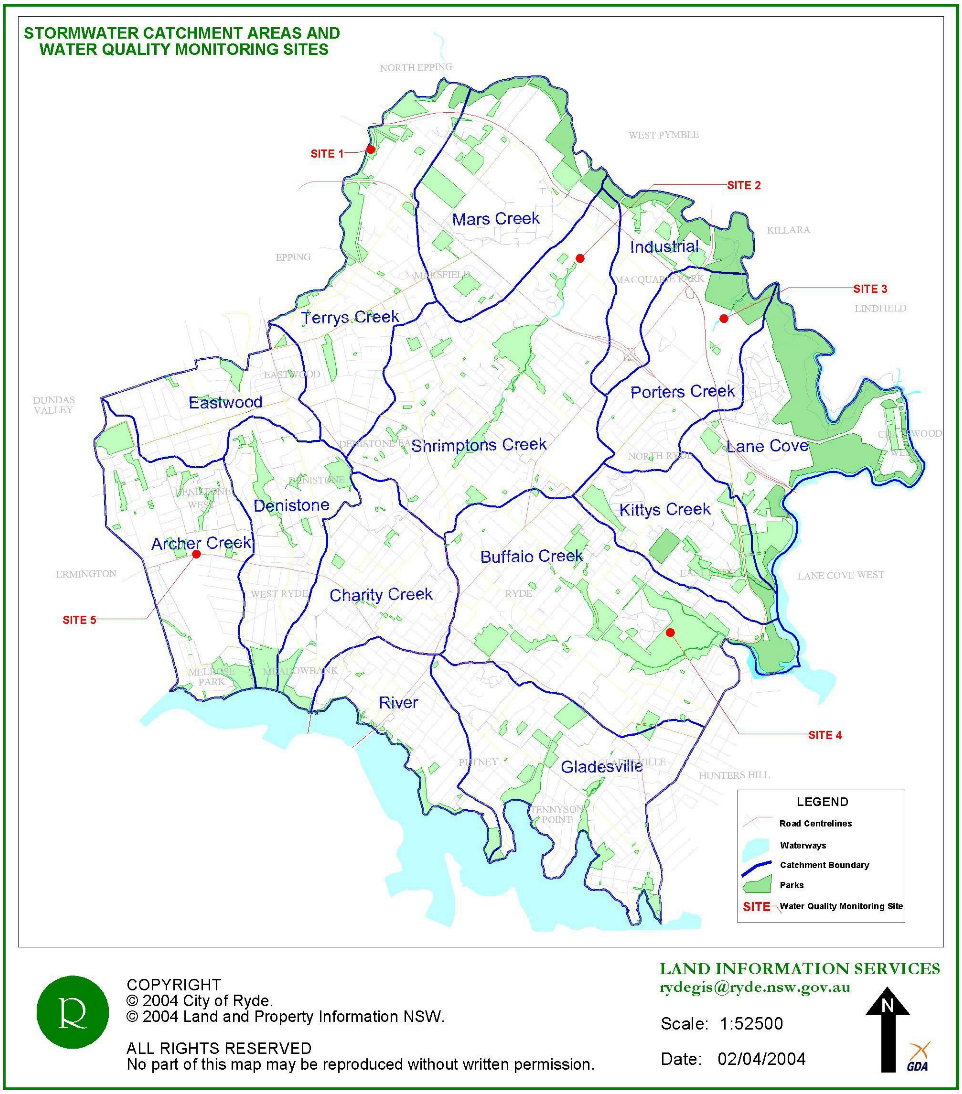
- Evaluate chemical and biological water quality monitoring both for short and long trem interpretation and temporal evaluation over the duration of the strategy;
- Detail where, when and how often samples should be taken from creeks within the Ryde Local Government Area based on existing site data, 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 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



1.

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

2.2 Spring 2007 sampling events

Two sampling events were conducted for Spring 2007 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:

- 26-27th September 2007
- 22-23rd October 2007

Buffalo Ck in Spring 2007

Terrys Creek in Spring 2007

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 samples were collected from each site within a pre-selected area each month within the season of Autumn 2007 as specified in the City of Ryde Biological and Chemical Water Quality Monitoring tender document COR-EOC-05/07. Edge, 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 SWC 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 Spring 2007 (September & October) 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 and ammonia 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

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 Spring 2006 study data to provide a temporal evaluation of ecological health of Archers and Shrimptons Creeks. Ecowise supplied raw macroinvertebrate and water chemistry data (Spring 2004 to Autumn 2006) and together with Spring 2006, Autumn 2007 and Spring 2007 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 2007

	Sampling period																																		
	Spring 2004					Autumn 2005					Spring 2005					Autumn 2006					Spring 2006					Autumn 2007					Spring 2007				
	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, a diverse range of these taxa has been observed by Sydney Water, at altitudes as low as 10 meters in undisturbed waterways in Sydney 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-SWC 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 (Beslye & Chessman, In Press).

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 4 and 5 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.

Spring 2007 macroinvertebrate samples were compared in an ordination with 2005, 2006 and Autumn 2007 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 and Spring 2007.

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 a large number of sites 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.

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 physical and chemical characteristics of the creeks were compared with 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 3 were untransformed in the BIOENV analysis. Before running the BIOENV analysis Draftsman Plots were examined and indicated Log10 Conductivity and Log10 Total Dissoled Solids were highly correlated, as were Log10 Total Kjeldahl and Log10 Total Nitrogen. As such Log10 Conductivity and Log10 Total Nitrogen were omitted from the BIOENV analysis as either variable of each highly correlated pair can substitute for each other without effective loss of information 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 Spring 2007 (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, Shrimptons, Buffalo and Terrys creeks during Spring 2007 were well below the 85% recommended level within ANZECC (2000) for the protection of aquatic ecosystems. In September 2007 dissolved oxygen levels fell as low as 27% saturation within Shrimptons Creek. Overall this site showed the lowest dissolved oxygen saturation levels for both sampling periods and the lowest historical average of dissolved oxygen between Spring 2004 and Autumn 2007 (47%). Porters Creek recorded the best levels of dissolved oxygen with 80% saturation in the October 2007 sample however this still failed to comply with the lower ANZECC (2000) guideline limit of 85% saturation for the protection of aquatic ecosytems. Historically, Porters Creek is the only creek to comply with ANZECC (2000) guidelines for dissolved oxygen with an average of 93% saturation between Spring 2004 and Autumn 2007.

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. The September 2007 sample from Porters Creek was the only sample to have Faecal Coliforms (1000 CFU) equal to the limit of the recommended secondary contact level (ANZECC, 2000) of 1,000/100mL. Historically Porters Creek has regularly exceeded these guidelines with an average of 3871 CFU/100mL between Spring 2004 and Autumn 2007. All other samples from Terrys, Shrimptons, Buffalo and Archers creeks were within safe levels for secondary contact.

Turbidity levels were within acceptable ANZECC (2000) ranges for all samples taken from Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Spring 2007.

Total Oxidised Nitrogen and Total Nitrogen as measures 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 Spring 2007. Porters Creek had the highest Total Nitrogen levels in Spring 2007 (3200 µg/L and 2600 µg/L respectively), which are well over the acceptable ANZECC (2000) guideline of 40 µg/L for the protection of aquatic ecosystems. Shrimptons Creek was the only site to comply with the ANZECC (2000) guidelines for Total Oxidised Nitrogen for both samples in Spring 2007.

Historically, all sites on average between Spring 2004 and Autumn 2007 fail to comply with ANZECC (2000) guidelines for Total Oxidised Nitrogen and Total Nitrogen concentrations. Porters Creek had the worst averages of 649 µg/L for Total Oxidised Nitrogen and 1470 µg/L for Total Nitrogen, which are more than double the averages of the next non-complying creek (Buffalo Creek, Table 7).

Ammonia levels exceeded ANZECC (2000) recommended levels of 20 µg/L at all five sites on at least one sampling occasion in Spring 2007, and for all historical averages between Spring 2004 and Autumn 2007 indicating potentially toxic pollution events may have occurred in all streams.

Total Phosphorus results historically vary between seasons and sites but overall comply with ANZECC (2000) recommendations of 50 µg/L on average between Spring 2004 and Autumn 2007 at Archers, Buffalo, Porters and Terrys Creeks. Shrimptons Creek did not comply with the guidelines in Spring 2007, 64 µg/L and 111 µg/L, or historically with an average of 65 µg/L. Porters Creek also did not comply for both samples in Spring 2007 showing elevated levels of 60 µg/L and 68 µg/L respectively.

Conductivity (as a measure of salinity) was within ANZECC (2000) recommendations for all samples at all five creeks in Spring 2007 and with the exception of Porters Creek this was the case for historical averages from the other four creeks between Spring 2004 and Autumn 2007. The level of conductivity in Porters Creek on average was 3533 µs/cm, 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 Spring 2007 at Archers, Shrimptons, Buffalo, Porters and Terrys creeks with the exception of October 2007 at Archers and Shrimptons Creeks where pH levels of 6.7 were recorded which was 0.1 below the lower ANZECC (2000) guideline for the protection of aquatic ecosystems.

Water quality results for comparable samples (Table 3) are consolidated in Appendix 2.

Table 7. Water quality results for Spring 2007 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**	**Alkalinity mg CaCO$_3$/L**	**Turb NTU**	**Conductivit y µS/cm**	**TDS mg/L**	**pH**	**DO % Sat**	**Temperature ^{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	September	270	20	480	26	680	1160	59	3.23	527	304	7.5	64.5	15.1
	October	90	150	50	57	480	530	74	7.06	378	220	6.7	45.3	17.3
	Historical*	***977***	***42***	***129***	***47***	***252***	***381***	***70.1***	***6.04***	***401***	***227***	***7.05***	***62.5***	***17.38***
SHRIMPTONS CK	September	300	160	30	54	650	680	72	2.65	403	232	7.11	27.0	16.9
	October	150	10	10	111	1000	1000	77	11.9	519	350	6.7	36.8	19.8
	Historical*	***728***	***33***	***205***	***55***	***404***	***600***	***61.8***	***11.10***	***345***	***209***	***6.86***	***47.2***	***16.81***
BUFFALO CK	September	54	40	170	37	440	610	90.5	7.3	960	484	7.28	64.8	19.0
	October	140	110	60	73	790	850	108	7.74	1001	621	7.2	82.1	20.4
	Historical*	***1038***	***76***	***306***	***39***	***299***	***565***	***75.9***	***8.99***	***594***	***331***	***7.20***	***65.0***	***16.99***
PORTERS CK	September	1000	2600	3200	60	3110	6310	122	6.74	671	372	7.78	66.8	15.0
	October	160	1020	2600	68	1580	4180	90.5	8.21	505	326	7.7	80.5	19.3
	Historical*	***3871***	***412***	***649***	***21***	***829***	***1470***	***50.0***	***4.34***	***3533***	***2251***	***7.46***	***93.0***	***18.54***
TERRYS CK	September	87	20	190	21	290	480	67	1.99	503	276	7.32	60.3	14.0
	October	6	40	80	35	730	810	87.5	1.61	712	437	7	41.5	15.6
	Historical*	***462***	***129***	***133***	***46***	***376***	***510***	***52.6***	***5.19***	***314***	***192***	***6.98***	***62.5***	***15.31***

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

4.2 Rainfall Data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 presented below displays the Spring 2007 sampling period and preceding four months (Figure 2). In the four months preceding the September 2007 sampling event 624 mm of rainfall occurred with 416 mm of this falling in June 2007 and 163mm falling in August 2007. A total of 1111 mm has fallen to date for 2007.

Rainfall in the three years prior to 2007 (2004 - 905 mm; 2005 - 788 mm and 2006 – 814 mm) was below average. The most recent year with about average rainfall was 2003 with 1262 mm. Rainfall in 2007 approaches average rainfall but is characterised by short rainfall periods between relatively longer dry periods with the exception of June 2007.

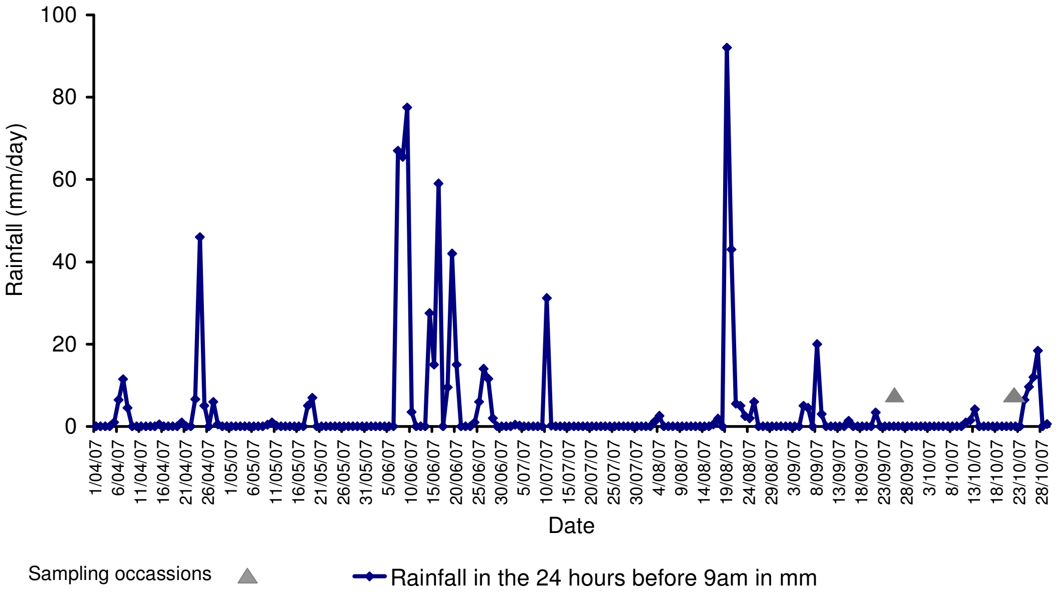


Figure 2. Daily rainfall data 1st April 2007 to 31st October 2007 with sampling occasions indicated

4.3 Macroinvertebrate Results

General Characteristics of Aquatic Macroinvertebrate Assemblages

A total of 2,490 macroinvertebrates were collected and examined from the Spring 2007 sampling period which saw visits to Archers, Shrimptons, Buffalo, Porters and Terrys creeks, with 48 taxa recorded. A total of 71 taxa have been recorded from all creeks in the Spring 2004 to Autumn 2007 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 Autumn 2007 and Spring 2004 to Spring 2007 indicates additional taxa have been collected in Spring 2007 for each creek (Table 8). With additional seasonal sampling planned under the strategy it is likely further additional taxa will be recorded, particularly if above average rainfall conditions return.

Table 8. Numer of taxa recorded in each creek in below specified sample periods

	Archers	Shrimptons	Buffalo	Porters	Terrys
Spring 04 - Autumn 07	42	43	44	43	48
Spring 04- Spring 07	48	45	46	45	51

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 Spring 2007 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 4. 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 3). Spring 2007 however saw EPT richness drop in Buffalo and Porters Creeks, but richness rose slightly in both Archers and Shrimptons Creeks resulting in all creeks being of a similar richness for this sampled season (Figure 4).

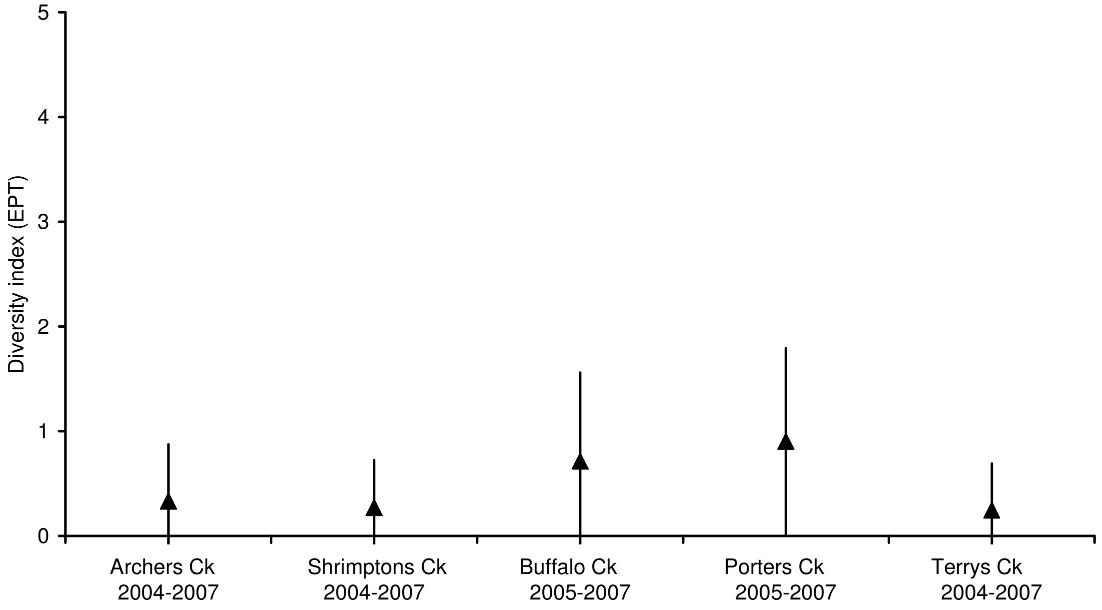


Figure 3. EPT richness of all creeks of monitoring program

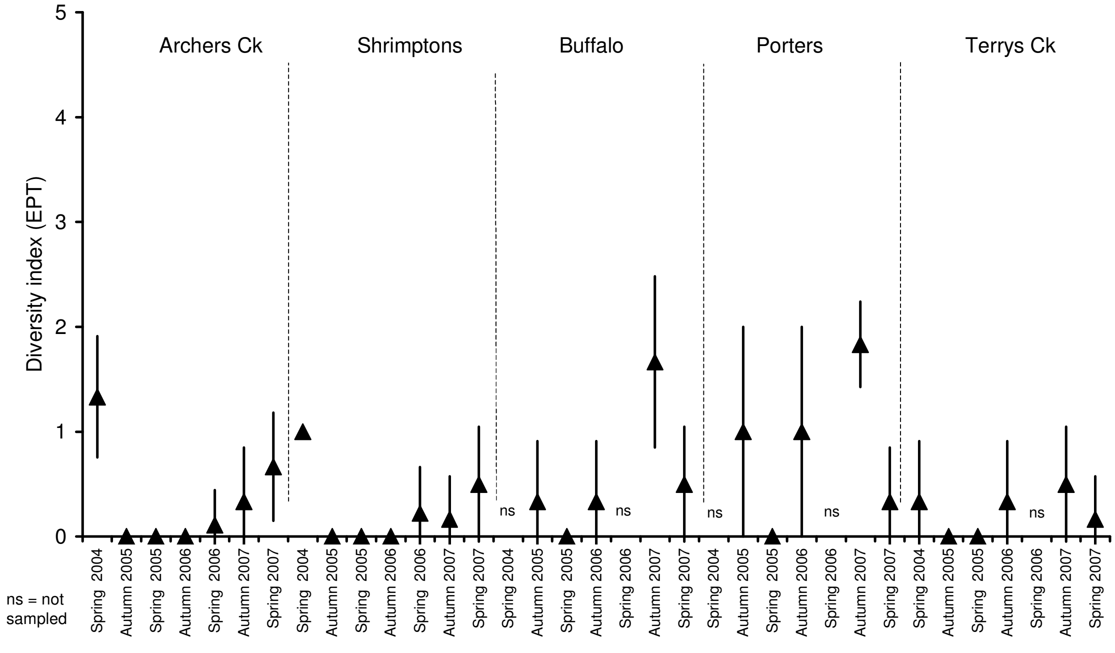


Figure 4. EPT richness by season

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 5).

Average stream health dropped in Sring 2007 for all five creeks compared to the previous Autumn 2007 sampling period (Figure 5), which may reflect the June 2007 rainfall event. SIMPER results indicate increased abundance of tolerant non-insects such as *Physa acuta* (Physidae), flatworms (Dugesiidae), worms (Oligochaeta) that have relatively lower SIGNAL-SF grades are the main reason for this decline in SIGNAL-SF scores.

Average scores, of these five creeks for all seasons combined (Spring 2004 to Spring 2007), occur in the probable moderate organic pollution category (Figure 6, Table 4). The Autumn and Spring 2005 data points of Shrimptons Creek (Figure 5) 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 but Spring 2007 saw it drop noticeably.

Archers Creek continued its trend of stream health being lower in Spring seasons than that recorded in Autumn seasons (Figure 5).

The range of stream health recorded for Buffalo, Porters and Terrys creeks is relatively narrow although it has very slightly broadened due to the drop in average stream health in Spring 2007 for these creeks (Figure 5 & 6).

Archers Creek narrowly had the highest average stream health when assessed with SIGNAL-SF from macroinvertebrate sampling between 2004 and 2007. 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 6). The larger range recorded for Shrimptons Creek reflects the temporal change in stream health recorded in Figure 5.

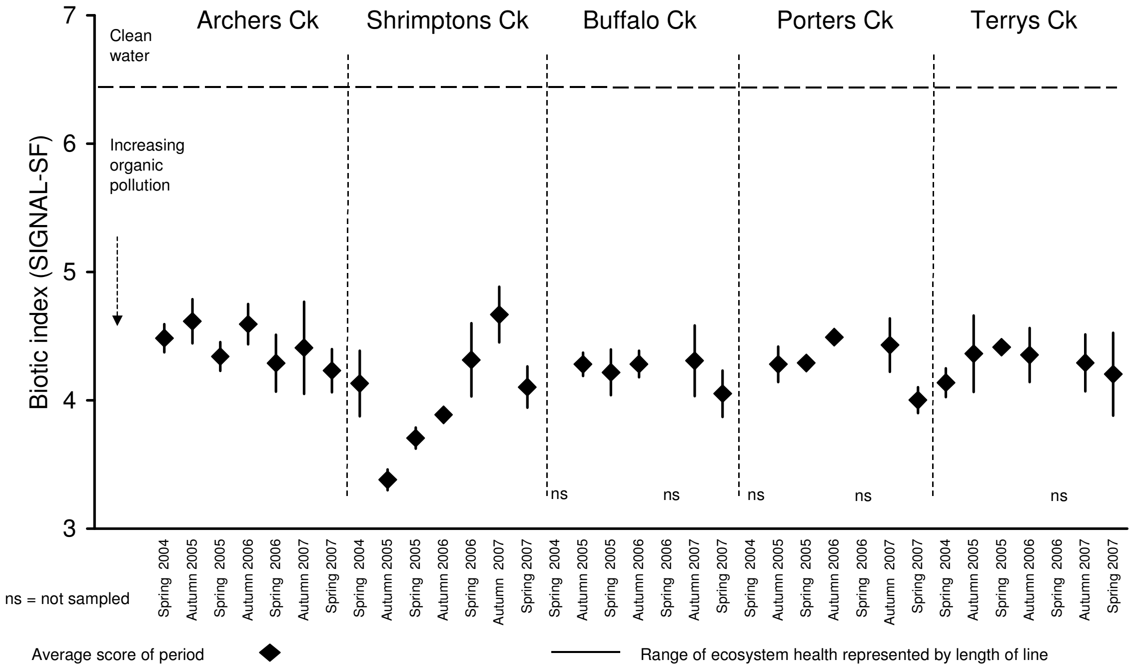


Figure 5. SIGNAL-SF by season

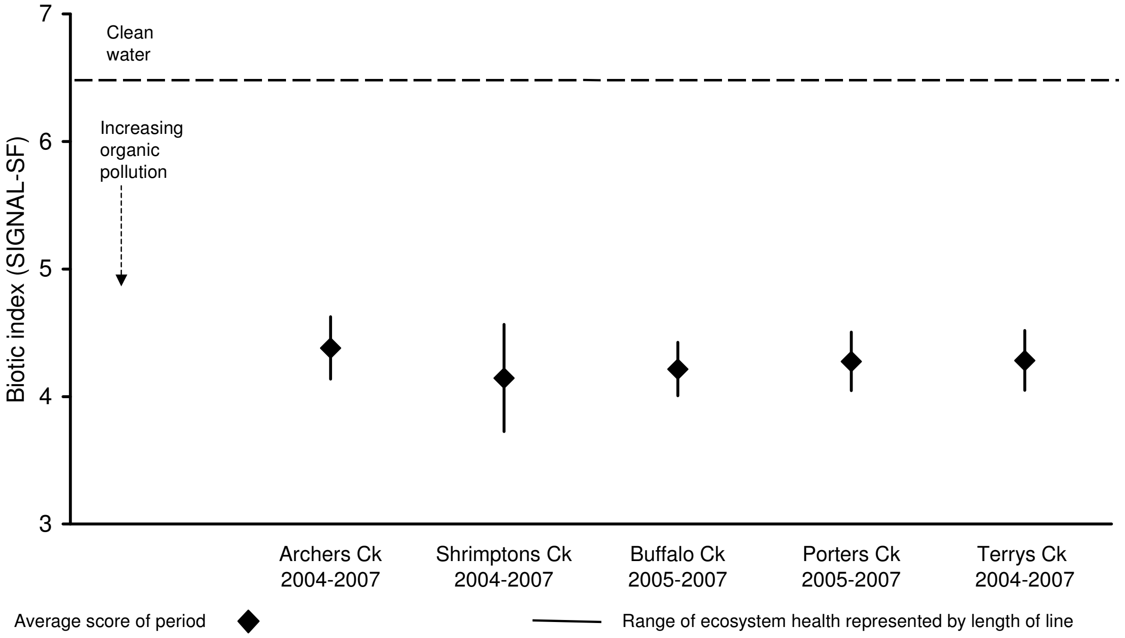


Figure 6. SIGNAL-SF of all creeks of monitoring program

AUSRIVAS OE50

With the addition of Spring 2007 data AUSRIVAS OE50 to the Spring edge model the average value of stream health is similar to previous spring seasons (significantly impaired) for all five creeks with the exception of stream health of Terrys Creek that dropped considerably from the significantly impaired category to the severely impaired category (Figure 7, Tables 5 & 6).

As the Combined Season OE50 model calculation has been based on a financial year. No data were added to this model for this report. Results for the Combined Season model and Autumn model will be updated after collection of Autumn 2008 data. Desciption of Autumn model and Combined Season model output up to Autumn 2007 is provided below for completeness.

The Autumn model AUSRIVAS OE50 results, from 2005 to 2007, indicated macroinvertebrate communities of the five creeks were generally a category healthier, rated as significantly impaired, compared with Spring model AUSRIVAS OE50 results that indicated macroinvertebrate communities were generally severely impaired (Figures 7 & 8).

Combined Season OE50 results from financial year pooled data reflects general trends of Autumn and Spring models. Trends in this plot will better develop with increased data collection.

The Combined season edge model AUSRIVAS OE50 output comparing the five streams with all sampling periods pooled (Figure 12) exhibited less variability in the range of stream health than was exhibited in the comparably pooled data for Spring eastern edge and Autumn eastern edge AUSRIVAS OE50 model outputs (Figure 10 and Figure 11) from the data points available in the 2004 to 2007 period.

The Spring eastern edge and Autumn eastern edge AUSRIVAS OE50 model output comparing the five streams with all sampling periods pooled (Figure 10 and Figure 11) indicated stream health of all creeks was similar which aligned with the SIGNAL-SF results (Figure 6). Whereas the comparably pooled data for the Combined Season edge model AUSRIVAS OE50 output indicated stream health of Shrimptons Creek was poorer than the other four creeks with the exception of Buffalo Creek on a few occasions (Figure 12).

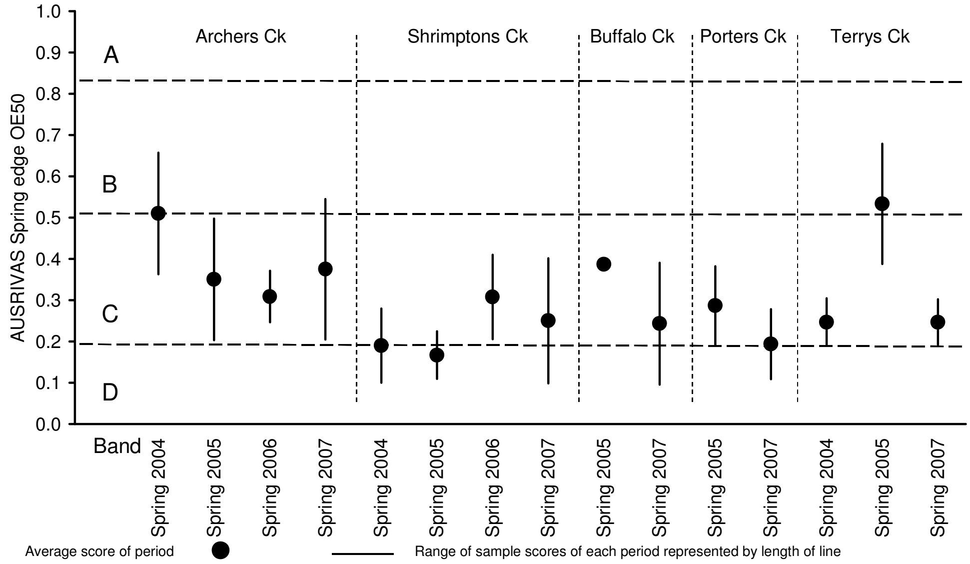


Figure 7. AUSRIVAS OE50 of all creeks from Spring edge model

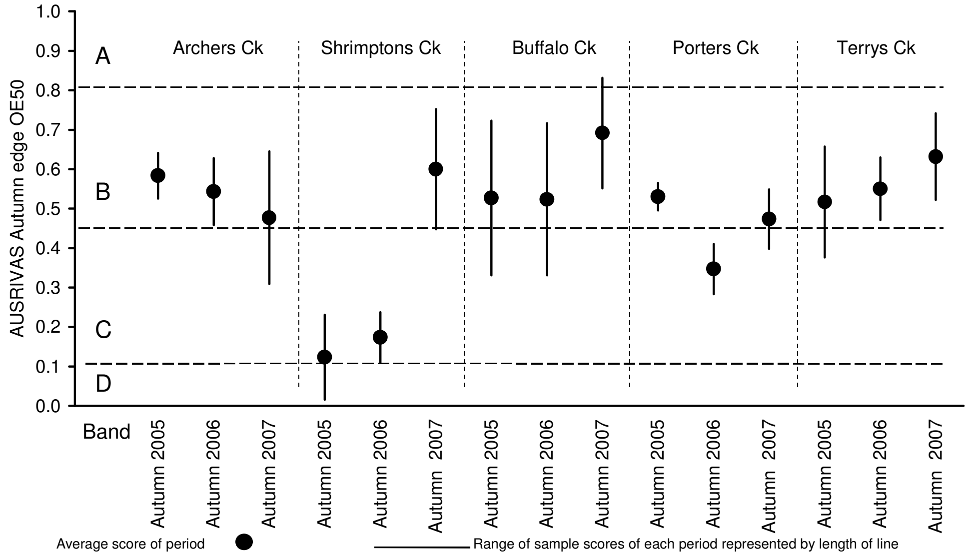


Figure 8. AUSRIVAS OE50 of all creeks from Autumn edge model

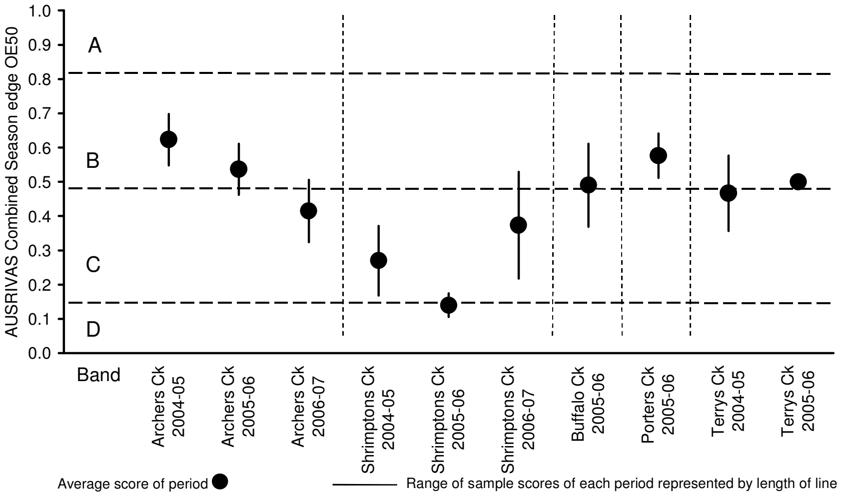


Figure 9. AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)

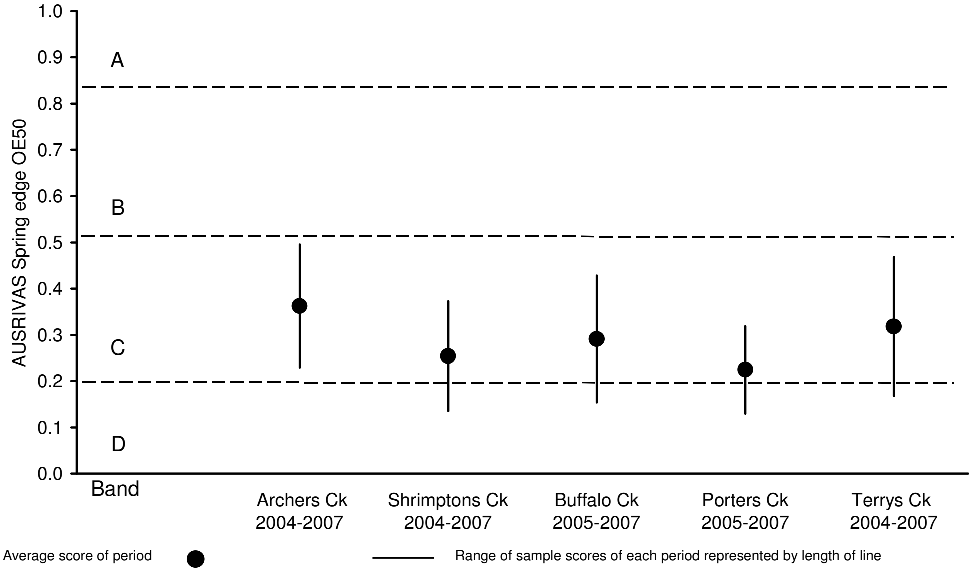


Figure 10. AUSRIVAS OE50 of all creeks from Spring edge model

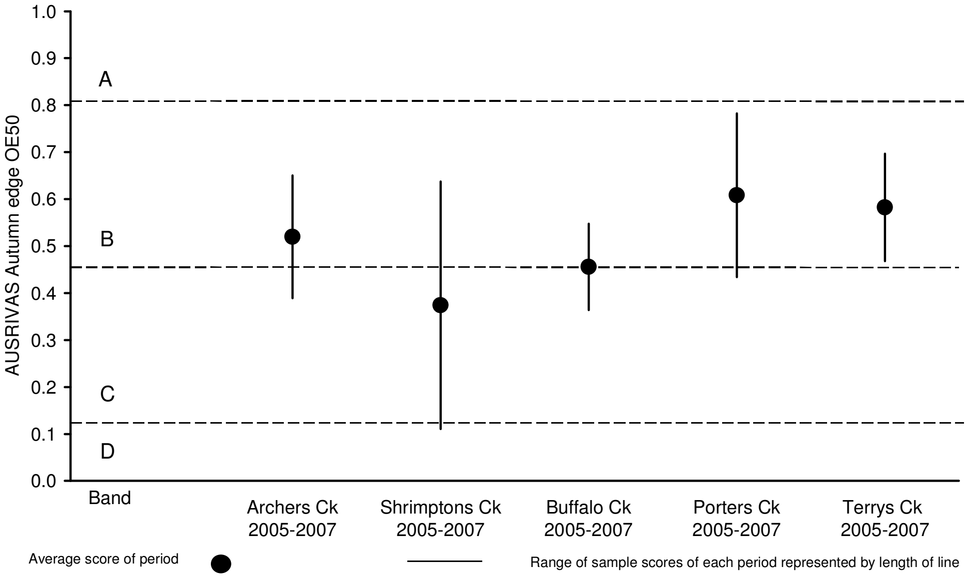


Figure 11. AUSRIVAS OE50 of all creeks from Autumn edge model

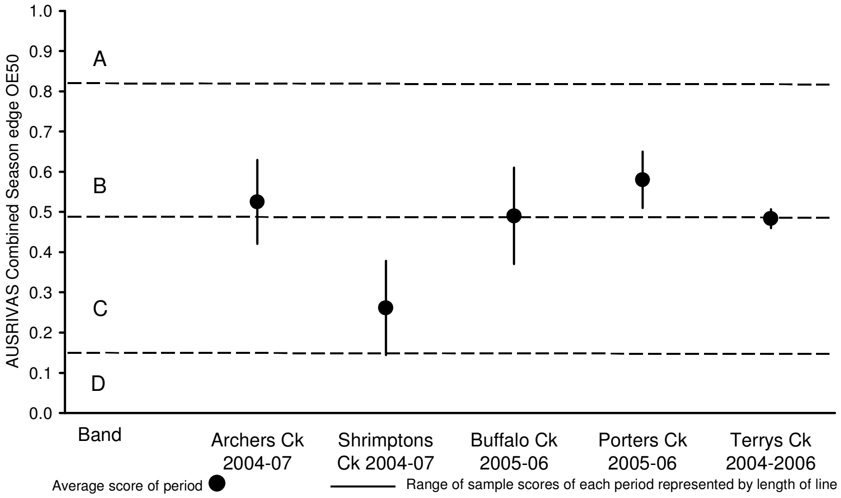


Figure 12. AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)

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 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.

Across the five creeks of the monitoring program missing EPT indicator taxa identified by AUSRIVAS Spring edge model output listed 18 taxa as missing with two mayfly larvae (Ephemeroptera), three stonefly larvae (Plecoptera) and 13 caddisfly larvae (Trichoptera). There were also 16 EPT taxa missing from the AUSRIVAS Autumn edge model output with three mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera). The AUSRIVAS Combined season edge model output listed 18 EPT taxa as missing comprising three mayfly larvae (Ephemeroptera), three stonefly larvae (Plecoptera) and 12 caddisfly larvae (Trichoptera).

AUSRIVAS OE0 SIGNAL2

AUSRIVAS OE0 SIGNAL2 scores from output of the Spring eastern edge model, Autumn eastern edge model, and Combined season edge model are presented in Figure 13 to Figure 18.

The Spring eastern edge model has been updated with data from the Spring 2007 sampling season. As the Combined Season OE0 SIGNAL2 model calculation has been based on a financial year. No data were added to this model for this report. Results for the Combined Season model and Autumn model will be updated after collection of Autumn 2008 data. Desciption of Autumn model and Combined Season model output up to Autumn 2007 is provided below for completeness.

The OE0 SIGNAL2 plot for Spring edge 2007 model output indicated a minor improvement in average stream health for all five creeks (Figure 13). This is in contrast to the OE50 and SIGNAL-SF models, which generally indicated a slight drop in average stream health for Spring 2007 (Figures 5 & 10).

Spring model AUSRIVAS OE0 SIGNAL2 output was more variable between sampling seasons than OE0 SIGNAL2 output from the Autumn model and Combined Seasons model (Figures 16 to 18).

Comparison of the five streams with all sampling periods pooled from output of the Spring eastern edge model, Autumn eastern edge model, and Combined season edge model of AUSRIVAS OE0 SIGNAL2 indicated similar stream health levels in each creek (Figure 16 to Figure 18).

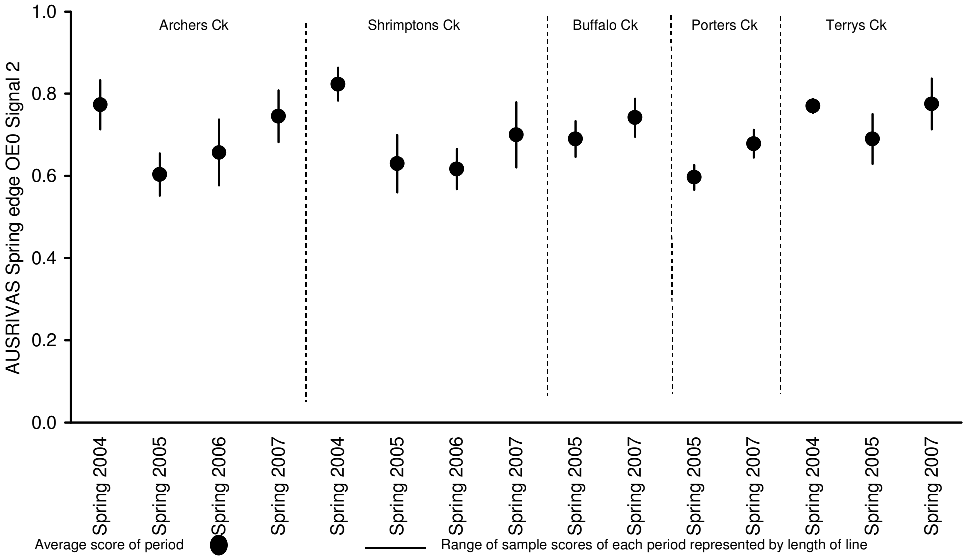


Figure 13. AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model

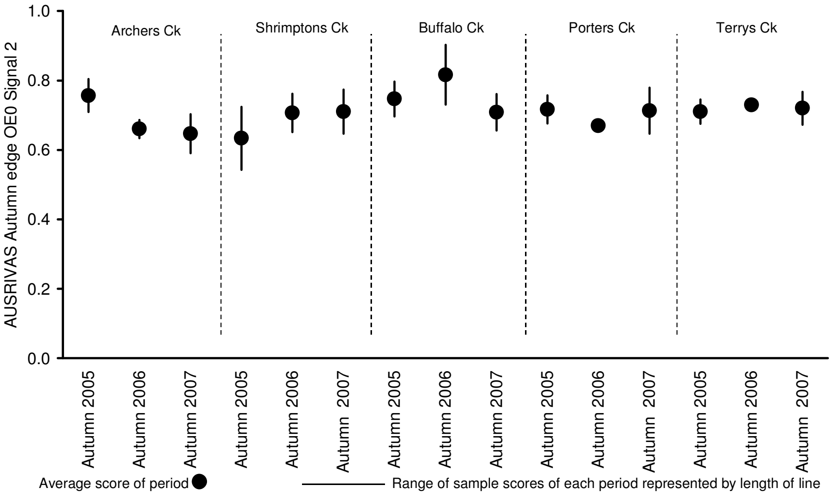


Figure 14. AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model

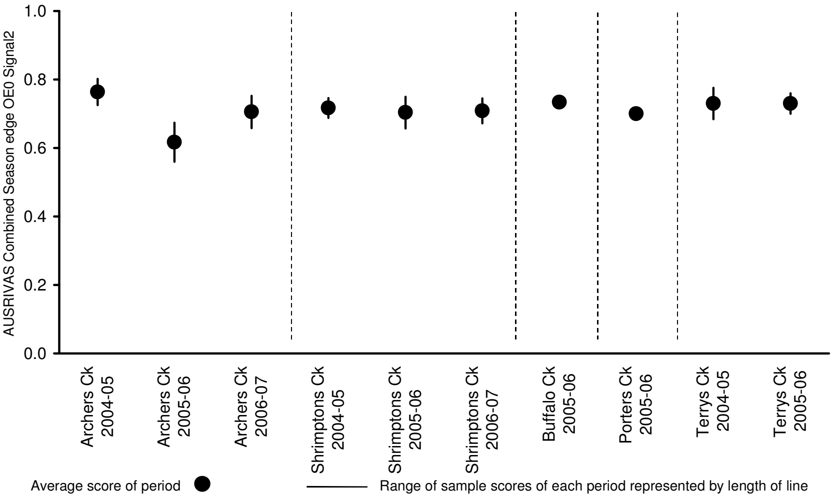


Figure 15. AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (with financial year data combined)

Figure 16. AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model

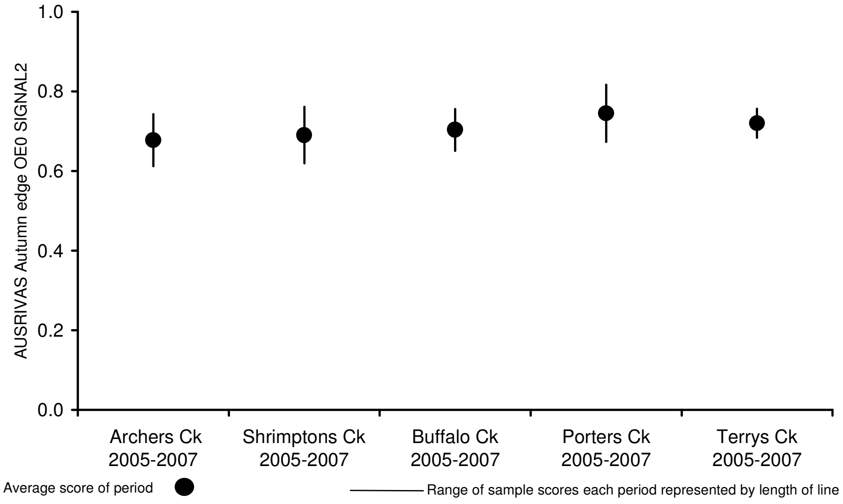


Figure 17. AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model

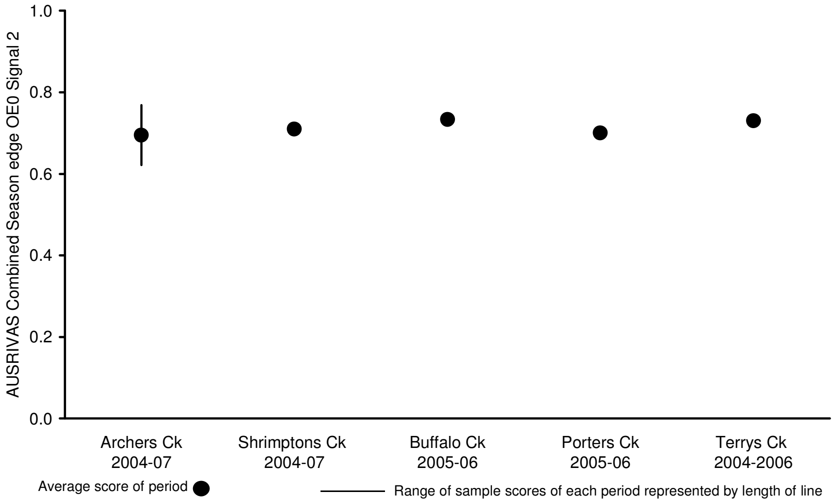


Figure 18. AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (with financial year data combined)

Multivariate Analyses

Classification and Ordination

Results of ordination of macroinvertebrate data of 2005 and 2006 from all five creeks indicated Buffalo, Porters and Terrys creeks had the most similar community composition. While community composition of Shrimptons Creek was most dissimilar, with Archers Creek community composition being intermediate. The community composition from Archers and Shrimptons creeks was equally variable but in different directions (Figure 19). The addition of Autumn and Spring 2007 data have in filled some of the previous separation recorded in Spring 2006 report (SWC, 2006) and greater variation in community structure has been recorded for Buffalo, Porters and Terrys creeks (Figure 20).

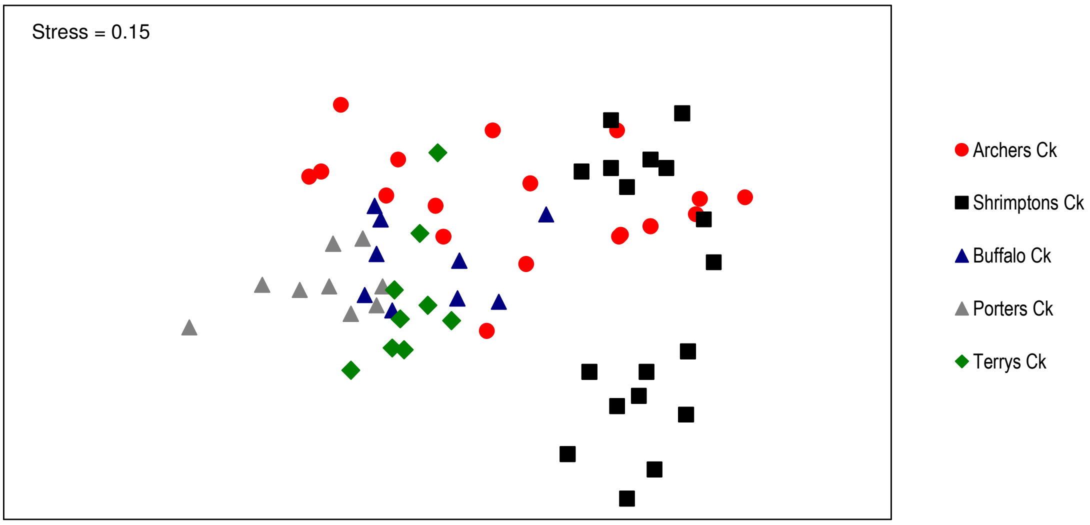


Figure 19. Plot of non-metric multidimensional scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005 and 2006 macroinvertebrate data of all creeks

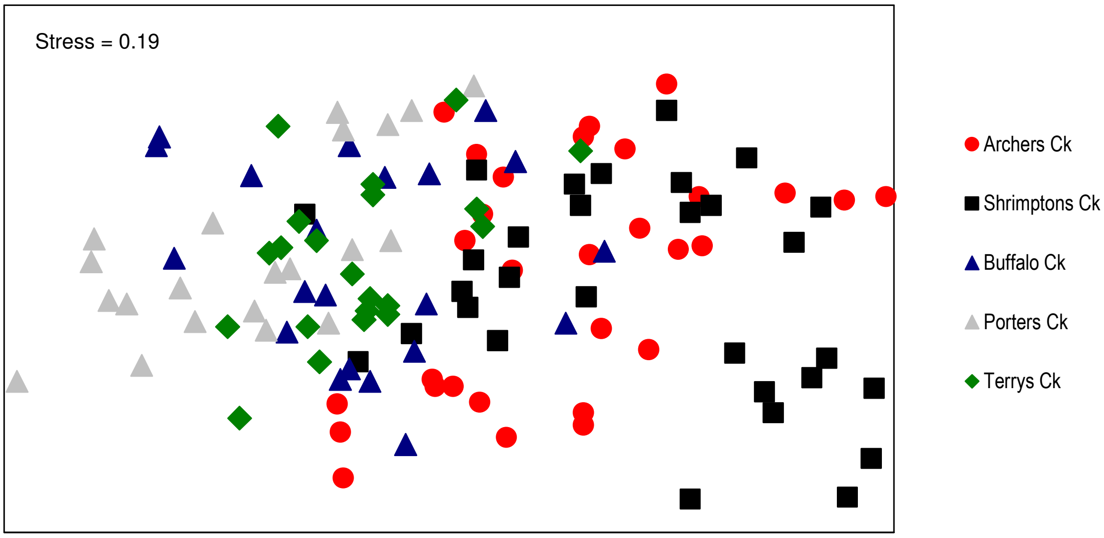


Figure 20. Plot of non-metric multidimensional scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of all creeks

In Figure 20 the general trends from the Spring 2006 report remain. That is Buffalo, Porters and Terrys creeks had the most similar community composition. While community composition of Shrimptons Creek was most dissimilar, with Archers Creek community composition being intermediate.

Pooling up macroinvertebrate data of the same season for each creek to produce one data point per season per creek provides a summary in Figure 21 of the above plot (Figure 20). This summary can be thought of as reducing noise of the replicate data from the somewhat patchy occurance of macroinvertebrates at a stream site. Variability in community structure through time (between sampling seasons) is evident for all sites (Figure 21). Community structure has been most stable at Terrys and Buffalo creeks followed by Porters, Archers creeks with most variability in community structure being recorded for Shrimptons Creek (Figure 21). The non-insect dominated community that was present in Shrimptons Creek in Autumn and Spring 2005 and Autumn 2006 is separated from predominantly tolerant insect dominated communities recorded from other streams and other periods from Shrimptons Creek (Figure 21). The pooling of replicate data reduced the influence of additional sampling of Archers and Shrimptons Creeks in Spring 2006. A better measure of fit (lower stress value 0.12 of Figure 21) was achieved for the community structure of the different sample periods from the five study streams from pooling of data compared with the unpooled data presented in Figure 20 (stress value of 0.19).

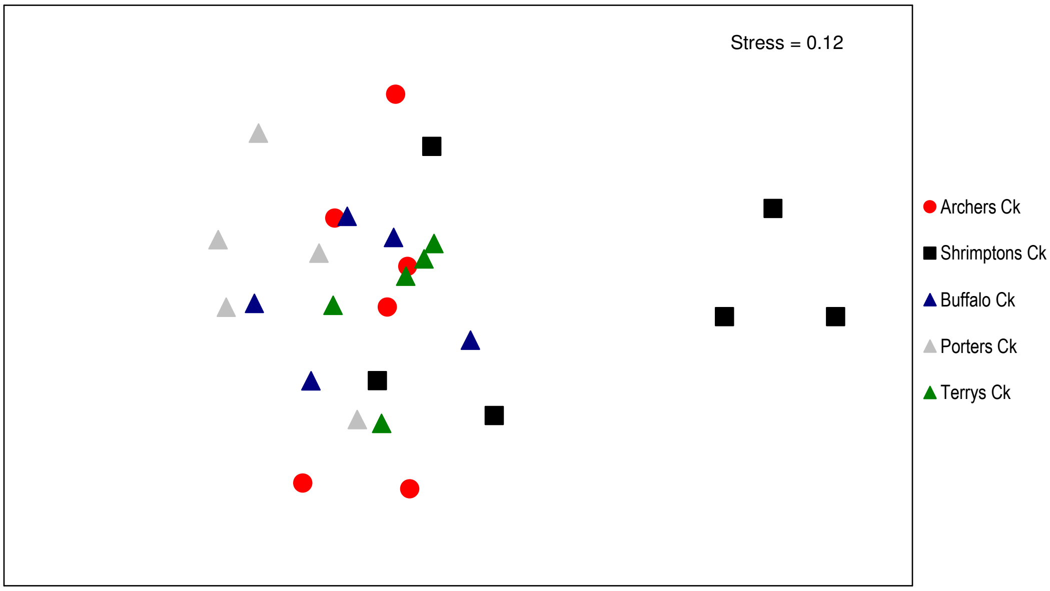


Figure 21. ***Plot of non-metric multidimensional scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of all creeks with each point representing samples from the same season of the same creek combined***

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 2006 and Spring 2007 samples and three of the six Autumn 2007 samples from all other samples. This split reflects shifts in community structure have occurred through time although addition of Spring 2007 samples did not increase overall variability in community structure as much as addition of Spring 2006 data (Figure 22).

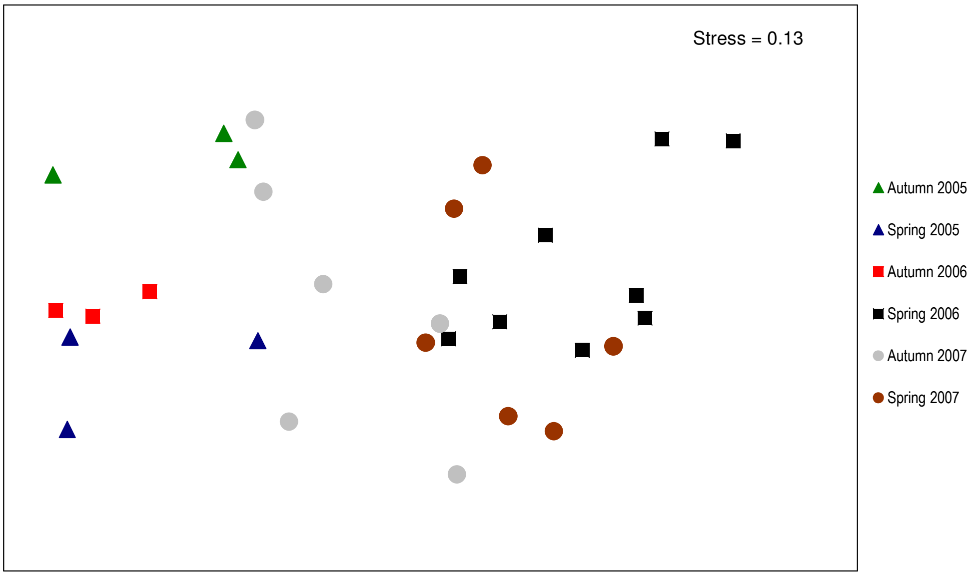


Figure 22. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of Archers Creek

The first division in the classification of macroinvertebrate samples from Shrimptons Creek separated samples from Autumn and Spring 2005 and Autumn 2006 from all other samples addition of Spring 2007 data in filled some of the previous separation recorded between Spring 2006 and Autumn 2007 samples (Figure 23).

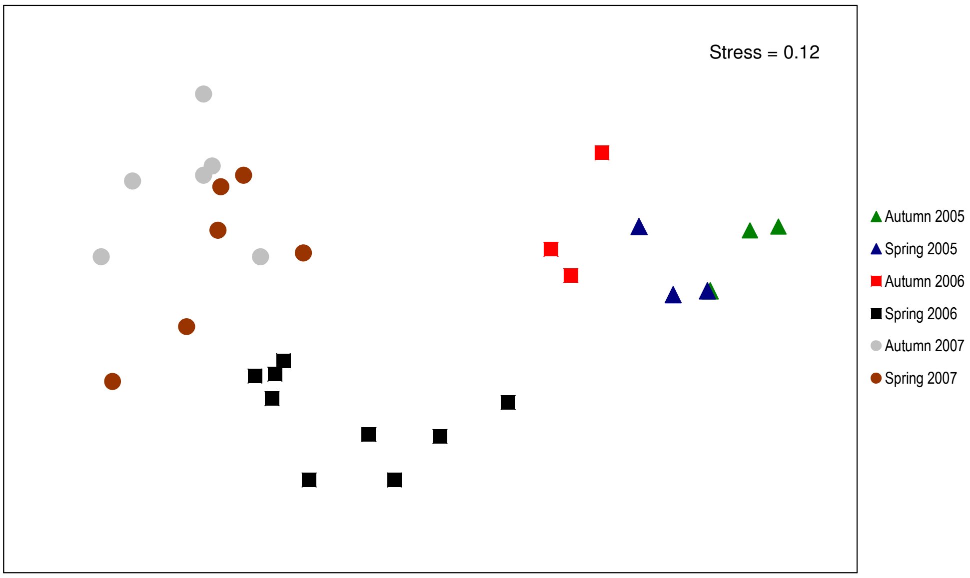


Figure 23. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of Shrimptons Creek

Addition of Spring 2007 samples increased variability in community structure a shift away from that recorded in Autumn 2007. This shift and variation variation in community structure is reflected in the first two divisions from classification analysis of macroinvertebrate samples from Buffalo Creek with these groups generally reflected in the corresponding ordination plot (Figure 24). Samples from Autumn 2005 and Autumn 2006 and one sample from Spring 2005 formed one group of samples while Autumn 2007 samples together with one Spring 2007 sample formed another separate group of samples, with the third group of samples comprised of the remaining five Spring 2007 and two Spring 2005 samples.

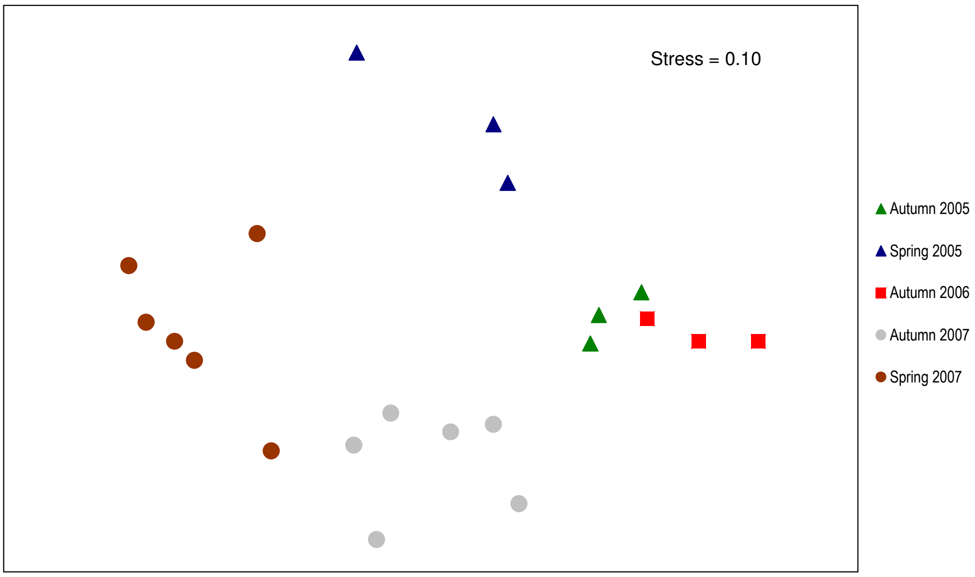


Figure 24. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of Buffalo Creek

The first division of the classification analysis of Porters Creek separated Spring 2007 samples from all other samples and the second division separated Spring 2005 samples from Autumn 2005, Autumn 2006 and Autumn 2007 samples (Figure 25). Addition of Spring 2007 samples increased variability in community structure with a shift away from that recorded in Autumn 2007 (Figure 25).

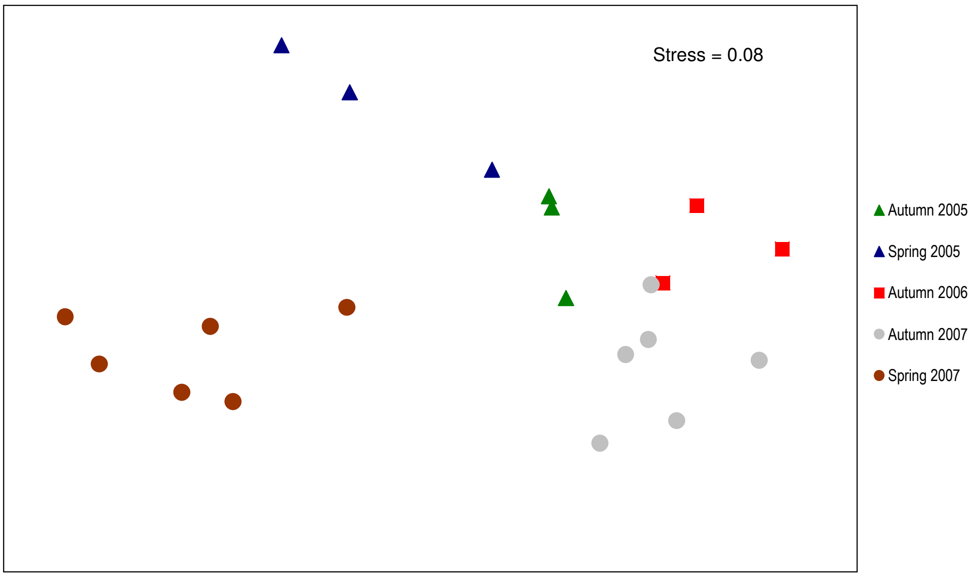


Figure 25. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of Porters Creek

Addition of Spring 2007 samples increased variability in community structure with a shift away from that recorded previously (Figure 26). Previous classification analysis of macroinvertebrate samples from Terrys Creek indicated relatively similar community structure occurred in samples across seasons for Terrys Creek. The first two divisions in classification analysis included Spring 2007 data together with three of the six Autumn 2007 samples from all other samples with this reflected in the corresponding ordination plot (Figure 26).

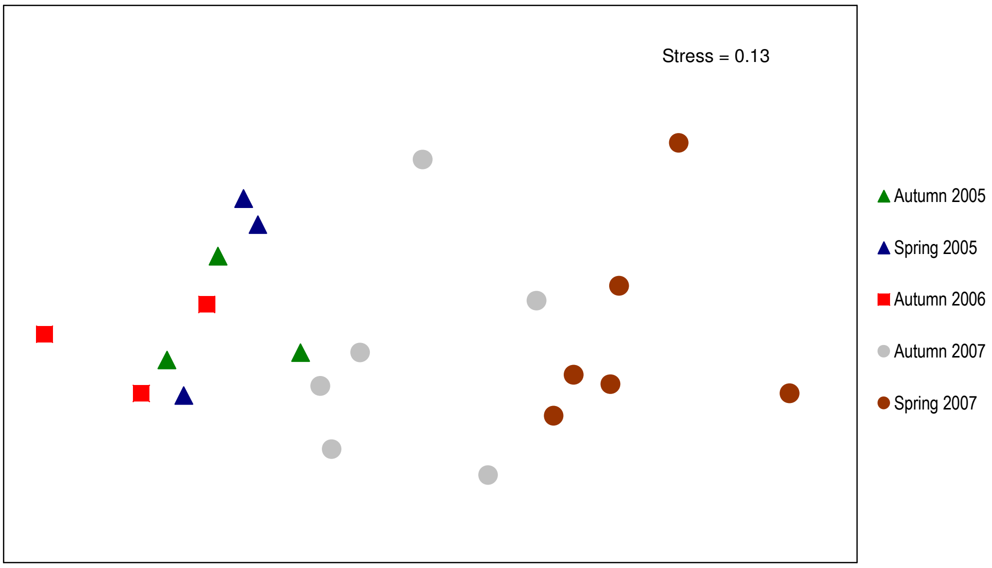


Figure 26. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006 and 2007 macroinvertebrate data of Terrys Creek

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 the macroinvertebrate samples from all five creeks (for the samples shown in MDS plot Figure 20, indicated Shrimptons Creek had the lowest average similarity (51%), with increasing similarity for other creeks, Archers Creek (52%), Buffalo Creek (57%), Porters Creek (58%) and Terrys Creek (60%) (Appendix 5). The lower average similarity of Shrimptons and Archers creek samples may be partly influenced by the additional sample collection period of Spring 2006 for these creeks and by Buffalo and Porters creeks not being sampled in Spring 2004. The addition of Spring 2007 data did see a slight decrease in similarity for Buffalo, Porters and Terrys creeks. With future sample collection from all five creeks in each sample session this possible partial influence should further diminish.

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 9 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 20.

Table 9. Average dissimilarity between samples of creek comparisons

	Archers %	Shrimptons %	Buffalo %	Porters %
Shrimptons	54			
Buffalo	51	53		
Porters	55	58	46	
Terrys	51	53	44	46

SIMPER was then performed on each creek for samples shown in Figure 22 to Figure 26. Average similarity generally ranged from 57% to 77% (Table 10, Appendix 5).

In Shrimptons Creek a change in community composition was evident from SIMPER analysis of Autumn 2005 to Autumn 2007 samples. In Autumn 2005, Spring 2005 and Autumn 2006 periods the community structure was dominated by tolerant non-insects with greater than 80% contribution in these seasons. Common community members in this period included the introduced snail *Physa acuta* (Physidae), flatworms (Dugesiidae), worms (Oligochaeta). In Spring 2006, the dominance by tolerant non-insects began to diminish. By Autumn 2007, over half the structure comprised tolerant insects such as non-biting midges (Chironominae), dragonflies (Megapodagrionidae, Coenagionidae, Isostictidae, Hemicorduliidae) and back swimmers (Notonectidae). In Spring 2007 the contribution of tolerant non-insects such as *Physa acuta* (Physidae), flatworms (Dugesiidae) and worms (Oligochaeta) increased to 40% of the community structure compared with 26% in Autumn 2007 (Appendix 5).

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. Each creek had consistent members of the respective communities through time with abundance differences evident between seasons of Autumn 2005 to Autumn 2007 (Appendix 5). In Spring the list of taxa that contribute to community structure is reduced and higher contributions from non-isects such as *Physa acuta* (Physidae), flatworms (Dugesiidae), worms (Oligochaeta) have been observed. In Spring 2007 non-insect contributions have been 42%, 46% and 49% from Buffalo, Porters and Terrys creeks respectively compared with 47%, 34% and 40% in Spring 2005.

Community structure in Archers Creek in Spring 2005, Spring 2006 and Autumn 2007 was dominated by tolerant non-insects with greater than 60% contribution in these seasons. In Autumn 2005 and Autumn 2006 this contribution was below 50%. In Spring 2007 the contribution of tolerant non-insects increased to about 50%.

Table 10. Average similarity of the same season samples for each creek.

	Archers %	Shrimptons %	Buffalo %	Porters %	Terrys %
Autumn 2005	68	76	76	77	71
Spring 2005	60	77	67	73	66
Autumn 2006	72	77	75	72	73
Spring 2006	61	63	ns	ns	ns
Autumn 2007	57	61	70	73	66
Spring 2007	62	63	66	69	64

ns = not sampled

BIOENV

The output of BIOENV routine is presented in Appendix 6. The correlation of the water quality and physical variables with macroinvertebrate sample data of all five creeks for 2005 to 2007 was quite weak at 0.23. Investigation of individual creek records of water quality and physical variables with macroinvertebrate sample data for 2005, 2006 and 2007 produced mild correlations of 0.34, 0.41, 0.43 and 0.53 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). Does this reflect Walshes work on stream connectivity; see further comments in the discussion section on this topic.

Results for Porters creeks produced a moderate correlation of 0.65. For Porters Creek, Oxidised Nitrogen and Total Dissolved Solids were indicated by BIOENV as best explaining sample separation (Appendix 6).

To further examine if the water quality pattern was similar to the macroinvertebrate pattern an ordination plot was raised based on BIOENV selection of variables with the highest correlation listed above for Porters Creek. The ordination plot of these water quality variables (Figure 27) did not match the pattern observed for the macroinvertebrate data (Figure 25) of Porters Creek from the same sampling periods. This indicates macroinvertebrate community structure is not predominantly influenced by these water quality variables (or other variables that they may be highly correlated but have not been measured). 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. This also suggests efforts to improve water quality should not be solely concentrated on variables measured to date.

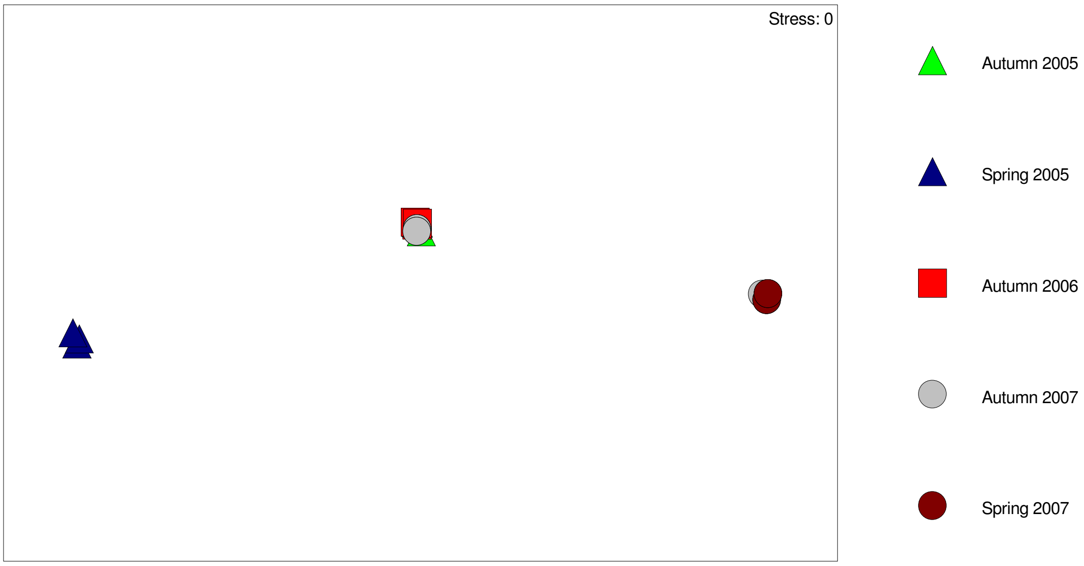


Figure 27. Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 2-dimension analysis for 2005, 2006 and 2007 water quality data of Porters Creek based on Euclidean Distance association measure for Log10 transformed Oxidised Nitrogen and Total Dissolved Solids variables identified by BIOENV analysis.

5 Discussion

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 Spring 2007 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, 2007).

Weather conditions, in the four months preceding Spring 2007 sample collection, were characterised by short rainfall periods with relatively long dry periods with the exception of June 2007 which had more days of rain than without. Despite the June 2007 rain and the 90mm event in August 2007 water levels were lower than observed in Autumn 2007 in the five streams under study in the Biological and Chemical Water Quality Monitoring Strategy of the City of Ryde.

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 poor levels of dissolved oxygen in the water and non-conformance to the ANZECC (2000) guidelines for all samples at Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Spring 2007 can be attributed to the low flows being experienced in southeastern New South Wales during the current drought. Furthermore, the accumulation of organic matter in the form of plant debris during this period of low flow increases the decomposition load within the relatively small streams and respiration of the decomposers increases. This leads to further reductions in dissolved oxygen levels. Historically, Archers, Shrimptons, Buffalo and Terrys creeks have performed consistently with the current data with very few past sampling events producing a dissolved oxygen level within the acceptable range of 85% - 110% saturation levels. This suggests the creeks have been influenced by urban pollution for a long period of time. Interestingly the average dissolved oxygen levels for Spring 2007 fell below the historical average for Archers, Shrimptons, Porters and Terrys Creeks possibly due to the fairly consistent rain fall during June (total of 416mm) which may have transported large loads of plant debris into the streams. Shrimptons Creek was also further influenced by construction work in the upstream reaches during which flow was diverted to enable a complete bed and bank reconstruction.

Spring 2007 was the first time Dissolved Oxygen levels in Porters Creek failed to meet ANZECC (2000) recommended levels. This may be again related to rainfall during the preceeding months depositing organic debris into the stream followed by reduced flows. The stormwater storage tank and associated accumulated debris in the sediment pit from the adjoining Ryde City Depot are cleaned out weekly during rain events not every 2 years as miss-indicated in the last report. Therefore it would appear that the Ryde City Depot is not affecting dissolved oxygen levels in Porters Creek.

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 were considerably lower in the Spring 2007 sampling period in comparison with the historical average for all five creeks. This may indicate that the August 2007 rainfall may have contained reduced bacteria loads with sampling in September and October 2007. Spring 2007 sampling may have also been too long after the extended rainfall period in June 2007 to record higher bacteria loads in the City of Ryde catchments.

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 and phosphorus levels as measured by Total Nitrogen, Total Phosphorus and Total Oxidised Nitrogen found in Archers, Shrimptons, Buffalo, Porters and Terrys creeks during Spring 2007 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.

Ammoniacal nitrogen is often present in sewage effluent, because of the decomposition of nitrogen containing compounds in the treated waste. The undissociated form, ammonia (NH_3) is far more toxic to aquatic life than the ionic form, ammonium (NH_4^+). During low pH and temperature NH_3 dissociates to the less toxic form NH_4^+. This is then reversed during periods of high pH and temperature.

The highest pH was found at Porters Creek during Spring 2007. This site also had the highest levels of ammonia, exceeding ANZECC (2000) guidelines on average more than 90 times the recommended levels during Spring 2007. This is reflected in the historical data with Porters Creek continually exceeding ANZECC (2000) by at least 20 times the recommended levels during Autumn 2005 and 2006. The elevated levels of ammonium in all five creeks indicate the potential that under favourable conditions the ammonium ion will be converted to the potentially toxic ammonia (NH^3) compound and compromise the health of the aquatic ecosystem.

Aquatic ecosystems are influenced by pH because of its effects on chemical speciation. As previously discussed the toxicity of ammoniacal nitrogen is extremely pH dependant. Most natural water bodies are slightly alkaline but acidic conditions can arise because of the breakdown of organic matter. The pH in Archers, Shrimptons, Porters, Buffalo and Terrys creeks did not exceed the ANZECC (2000) guidelines during Spring 2007. However, over half of the historical samples for Shrimptons Creek did fall below the ANZECC (2000) recommended guideline. This may be attributed to high organic loads from urban runoff and the overall size of the catchment and stream.

Salts occur naturally in all stream waters yet are usually found in such low concentrations in freshwater that they are measured in units of conductivity (µs/cm). Conductivity is a measure of the ability of a water sample to conduct electricity and is dependant on the total concentration of dissolved ionic substances in the water. Salts are generally derived from sources within the natural environment including rocks and soil, which set it apart from other pollutants, and are temperature dependant. Historically Porters Creek is the only site to have conductivity levels on average well above ANZECC (2000) guidelines for the protection of aquatic ecosystems. Conductivity levels in Porters Creek dropped substantially during the Spring 2007 sampling to levels well within the lower ANZECC (2000) limit. These levels were last seen in Autumn 2005 in Porters Creek. Reduced runoff and stream flow may have reduced the presence of dissolved salts at this site. The other four creeks including Archers, Shrimptons, Buffalo and Terrys remained relatively unchanged during Spring 2007 to historical averages indicating that conductivity is stable at these sites.

Turbidity levels returned to acceptable limits at Shrimptons Creek during Spring 2007 indicating that no further bank collapses have occurred together with suitable rainfall to transport large inputs of suspended matter into the stream.

Macroinvertebrates

Results of the Spring 2007 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 Autumn 2007. Despite this impairment, sampling in each Autumn and Spring has resulted in collection between two to five additional taxa being recorded in each of the five study streams in 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. 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. Natural variability of each site with comparable data are being gathered under the Biological and Chemical Water Quality Monitoring Strategy.

To period between Spring 2004 to Autumn 2007 has been characterised by below average rainfall. Rainfall in June 2007 has tended towards average levels although overall 2007 has been characterised by relatively long dry periods between short periods of rain with the exception of June 2007. 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.

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. Weather conditions influenced a slight decline in average SIGNAL-SF scores in Spring 2007 for all creeks. Water quality measurements in September and October 2007 represent conditions at that time after settling of the August and particularly June 2007 rainfall events. As such values recorded in Spring 2007 would represent base flow conditions rather than storm maximums with perhaps the exception of dissolved oxygen, that is probably at its lowest at the end of drier periods when flow is reduced. AUSRIVAS predictive model OE50 output from Spring 2007 indicated average stream health slightly dropped in all creeks except Archers Creek. Results from AUSRIVAS predictive model OE0 SIGNAL2 output from Spring 2007 are contradictory and indicated average stream health slightly increased in all creeks.

Differences between sampling periods were more evident in the SIGNAL-SF measure than AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2 measures. The abundance component involved in the calculation of SIGNAL-SF scores may be partly responsible for the slight difference between recorded SIGNAL-SF and AUSRIVAS OE0 SIGNAL2 patterns, as both AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2 are based on presence absence data. 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.

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. Spring 2007 saw EPT taxa drop in Buffalo and Porters Creeks from above an average of one EPT taxa in Autumn 2007 to below one. This drop can be explained by the loss of Baetidaes and Leptoceridaes from each site respectively. Futher sample collection will determine if this is a seasonal pattern where EPT diversity is lower in Spring. Archers and Shrimptons Creek had a minimal increase in average EPT taxa, which is due to the arrival of Hydroptilidaes. No EPT indicator taxa defined by AUSRIVAS predicted model output (as per criteria of section 3.6) were recorded in Spring 2007 from all five streams.

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. However it may be able to indicate positive community structure changes, although return to average or above average rainfall conditions may influence the presence of EPT taxa. 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.

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. Fewer dominant taxa occurred in Archers Creek than in the other four creeks that are monitored. The dominant taxa of Archers Creek also occur in the other creeks.

Multivariate SIMPER results indicated shifts in community structure occurred again in Spring 2007. Archers Creek had a less extensive list of dominant taxa than the other creeks and had fluctuating abundances of these dominants between seasons. Buffalo, Porters and Terrys Creeks had a range of tolerant insect and non-insect taxa whose abundances also varied between seasons, although tolerant insect taxa have contributed at least half of the assemblage. Autumn and Spring 2007 samples from Shrimptons Creek indicate a shift in community structure to look more like the other four creeks compared with previous seasons of Autumn 2005 to Spring 2006.

The change in abundances of these tolerant taxa between sampling periods influenced the observed multivariate patterns. This change in abundance would have also contributed to recorded SIGNAL-SF variation of different sampling periods. As AUSRIVAS models use binary data (presence/absence) no contribution to these measures is provided by recorded abundances, rather they rely on diversity of the collected sample to compare against modelled taxa groups of pre established reference site groups.

The attempt to link water quality patterns with macroinvertebrate patterns using the multivariate BIOENV routine produced at best one moderate correlation. The ordination plot of BIOENV identified water quality variables did not match the pattern observed for the macroinvertebrate data of Porters Creek from the same sampling periods. This indicates macroinvertebrate community structure is not predominantly influenced by BIOENV identified 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 macroinvertebarte community structure. This also suggests efforts to improve water quality should not be solely concentrated on variables measured to date.

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.

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).

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 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.

Suggested Exploration of Stormwater Drainage Connection

If the City of Ryde can find resources in the future, it is recommended that calculation of the percentage of effective imperviousness in each of the five catchments under the Biological and Chemical Water Quality Monitoring Strategy be made. A surrogate of this measure that could be tried is length of pipes and or number of connections per stream catchment as this is available in a City of Ryde GIS layer. This calculation would then allow ranking of streams by this measure. This ranking could be used to guide allocation of resources to yield ecological benefit via: enhancement of in-stream habitat; restoration of riparian zones; or pollution load reductions via stormwater treatment or reuse. The values for length of pipes and or number of connections per stream catchment for the five catchments can also be used in the BIOENV routine at next calculation. Identification of rainfall by the BIOEVN routine suggests this may be a suitable environmental variable to investigate.

6 Discussion of questions from the Water Quality Monitoring Steering Committee

Question 1. During the presentation to Ryde City Council Water Quality Monitoring Steering Committee in June 2007 the question was posed whether there was a relationship between the macroinvertebrate communities and fish populations within the Ryde LGA.

A literature search was conducted to answer this question. To begin, macroinvertebrates are very important to fish populations as they are an important food-source for many fish species (Wallace *et al*. 1996), adversely small fish can also be prey to some of the larger aquatic invertebrates. The Ryde Flora and Fauna Study 2006 (BEC, 2006) lists the known fish species found in the Ryde LGA:

- Firetail Gudgeon
- Striped Gudgeon
- Dwarf flathead Gudgeon
- Freshwater Mullet
- Mosquitofish (Gambusia)
- Short-finned Eel

All of the fish species found in the Ryde LGA are known to predate on aquatic macroinvertebrates, for the three native Gudgeons and the introduced Gambusia they are a major food source (Allen *et al*., 2002; McDowell 1996). This causes a problem, as the native fish have to compete with the Gambusia for food and habitat, and due to their high reproduction rate and aggressive behaviour (McDowall, 1996) the Gambusia may have an advantage over native fishes.

Gambusia was introduced into many Australian catchments as a control agent for mosquito larvae, however it is suggested they don’t consume mosquito larvae in any greater numbers than native fish species (McDowall 1996). In fact a study by Arthington (1989) found that native Chironomidae (nonbiting midge) larvae was the dominant aquatic food source for Gambusia. This issue is then exacerbated as the Gambusia has a voracious appetite for the natural macroinverterbates that prey on mosquito larvae (Allen et al., 2002). There are numerous macroinvertebrates that will prey on mosquito larvae and Andersen *et al* (2004) comments that Hemipterans (true bugs) in relative abundance undoubtedly play a role in controlling mosquito numbers.

There are however natural predators of Gambusia within the Ryde LGA, mature Striped Gudgeon are known to actively prey on Gambusia (Allen *et al*., 2002; McDowell 1996). Large macroinvertebrates are also known to feed on small fish, Gooderham *et al* (2002) describes the Belostomatidae (true bug) as often being top of the food chain that readily hunts small fish, the Nepidae (true bug) is another hemipteran that hunts small fish. As Gambusia is a dominant small fish in the five creeks it would be expected that they are a source of food for the aforementioned macroinvertebrates. The common yabby (Parastacidae) is another invertebrate that will feed on small fish, a study by Beatty (2006) found that *Cherax destructor* had a high proportion of Gambusia in their diet.

Our conclusion is habitat rehabilitation and improvements in water quality would result in a greater diversity of macroinvertebrates and greater abundances. This could result in higher numbers of animals that predate on Gambusia and mosquito larvae.

Question 2. During the presentation to Ryde City Council Water Quality Monitoring Steering Committee in June 2007 the question was posed whether there is a relationship between macroinvertebrate communities and gross pollutant traps.

Unfortunately after a thorough literature search no research or current information was found that related to a direct link between the two.

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 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.

- *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 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 o f available comparable data that has occurred and additional sampling will allow capture of variation through time and under different werather conditions in each of the five study streams. Return to average rainfall conditions would also 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.

Archers Creek in Spring 2007 showing rehabilitation work in progress.

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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).

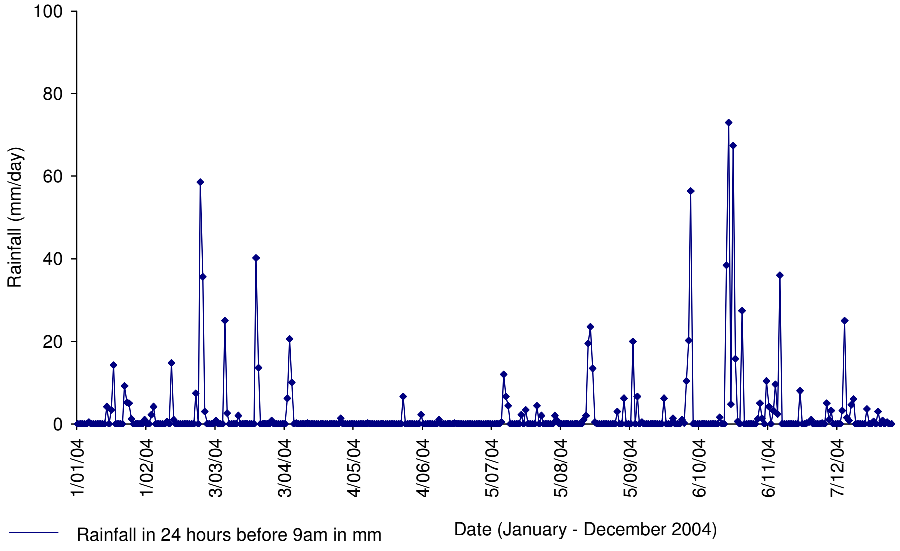
Quality assurance was conducted as per SSWI434 In-house test method quality control of macroinvertebrate identification, counting and archiving of collections in compliance with the requirements of AS ISO/IEC 17025:1999 General Requirements for the Competence of Testing and Calibration Laboratories was 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.

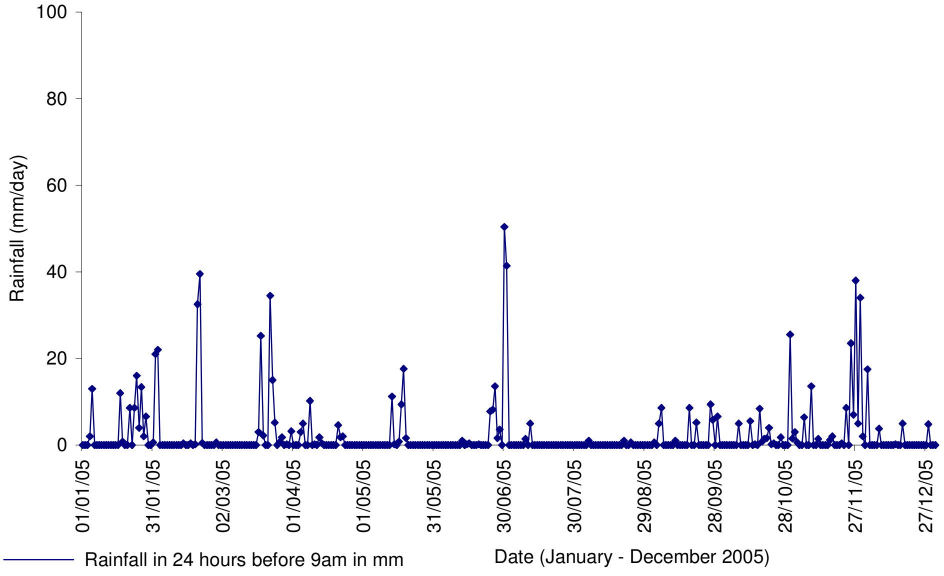
Appendix 2 Water quality results

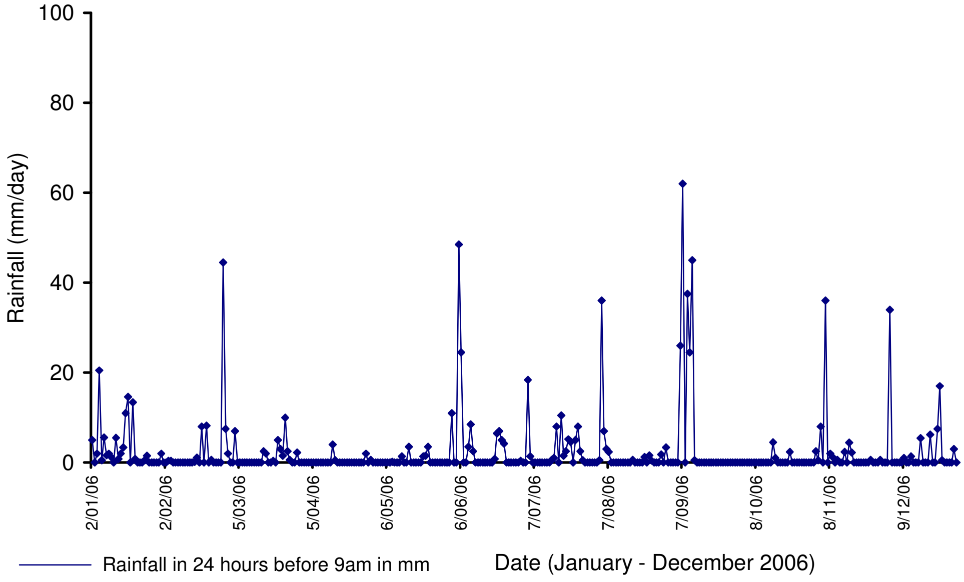
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L
Terrys 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

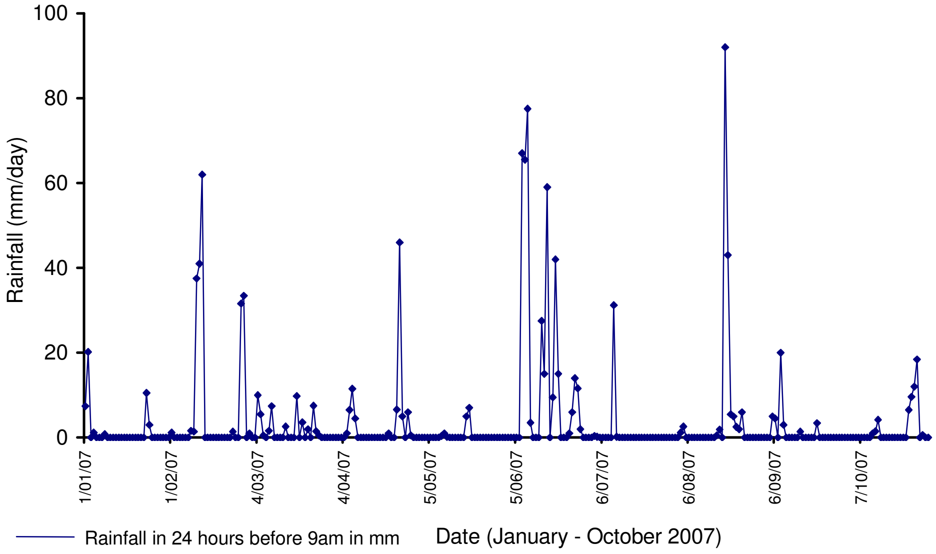
Stream	Site code	Season	Sample date	Faecal Coliforms	Ammonia	Oxidised Nitrogen NOx	Total Phosphorus TP	Total Kjeldahl Nitrogen TKN	Total Nitrogen TN	Alkalinity	Turbidity	Conductivity	Total Dissolved Solids	pH	Dissolved Oxygen DO
				CFU/100mL	µg/L	µg/L	µg/L	µg/L	µg/L	mg CaCO3/L	NTU	µS/cm	mg/L		mg/L
Terrys 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)
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

			Archers Ck spring 2004 S5	Archers Ck spring 2004 S5	Archers Ck spring 2004 S5	Archers Ck spring 2005 S5	Archers Ck spring 2005 S5	Archers Ck spring 2005 S5	Archers Ck autumn 2005 S5	Archers Ck autumn 2005 S5	Archers Ck autumn 2005 S5	Archers Ck autumn 2006 S5	Archers Ck autumn 2006 S5	Archers Ck autumn 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck spring 2006 S5	Archers Ck autumn 2007 S5	Archers Ck autumn 2007 S5	Archers Ck autumn 2007 S5	Archers Ck autumn 2007 S5	Archers Ck autumn 2007 S5	Archers Ck autumn 2007 S5	Archers Ck spring 2007 S5	Archers Ck spring 2007 S5	Archers Ck spring 2007 S5	Archers Ck spring 2007 S5	Archers Ck spring 2007 S5	Archers Ck spring 2007 S5
Aquatic mites	Acarina	Acarina	1	3	1			1	3	3					1	3	1		4			1											3	9	
Beetles	Coleoptera	Dytiscidae		3		2		1	1	1																									1
Beetles	Coleoptera	Elmidae																														2			
Beetles	Coleoptera	Hydraenidae													1						1														
Beetles	Coleoptera	Hydrophilidae																				1													
Beetles	Coleoptera	Psephenidae																																	
Beetles	Coleoptera	Scirtidae																																	
Caddisfly larvae	Trichoptera	Antipodoecidae																																	
Caddisfly larvae	Trichoptera	Hydroptilidae	2		3																1									12	3	9			
Caddisfly larvae	Trichoptera	Leptoceridae		1																															
Dobsonfly larvae	Megaloptera	Corydalidae																																	
Dragonfly larvae	Odonata	Aeshnidae	1	1		5	5		2		14		11	8												3	2	3	1	1					
Dragonfly larvae	Odonata	Coenagrionidae	7	5	5	21	7	4	6	3	29	1	7	6		1					5			1			2	2	1	1					
Dragonfly larvae	Odonata	Gomphidae																																	
Dragonfly larvae	Odonata	Hemicorduliidae	2	6	1	25			4	3	18	1	7	5				1			2	10	1			3	4	23		9	1	1	2	9	
Dragonfly larvae	Odonata	Isostictidae																																	
Dragonfly larvae	Odonata	Lestidae			3											1	1		2			3						3							
Dragonfly larvae	Odonata	Libellulidae	2	4	5	1	15	14	3	9	8	7	2	4		1		1						6		2	2	3	4	2	1	2	2	1	
Dragonfly larvae	Odonata	Megapodagrionidae		2		6		1	15	22	5	2	7	5	1			1			1	6		1	2	7			1		2				1
Dragonfly larvae	Odonata	Synthemistidae															1										1								
Dragonfly larvae	Odonata	Telephlebiidae																																	
Fairy shrimps	Decapoda	Atyidae		1					6	11	17	5	1													11	1	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	16	1	17	3		18	12	7
Lacewing	Neuroptera	Osmylidae																																	
Leeches	Arhynchobdellida	Erpobdellidae																																	
Leeches	Arhynchobdellida	Hirudinidae																																	
Leeches	Rhynchobdellida	Glossiphoniidae		1	4					1		6	6	2							1	1		1	3	1	1	3							
Mayfly larvae	Ephemeroptera	Baetidae			1																			3		2								2	
Moth Larvae	Lepidoptera	Pyralidae																													2				
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																													
Sand hoppers	Amphipoda	Talitridae																																	

			Archers Ck 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 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
Slatters	Isopoda	Oniscidae				7		1				3			1	4			1																
Snails	Gastropoda	Ancylidae																																1	
Snails	Gastropoda	Hydrobiidae	1	3	2										2	4	1	1	3		7	11	10	5	1					13	12	7	1	11	8
Snails	Gastropoda	Lymnaeidae				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	6	1	18	10	11	15	12	21
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	Mesoveliidae																																	
True bugs	Hemiptera	Naucoridae																																	
True bugs	Hemiptera	Nepidae																																	
True bugs	Hemiptera	Notonectidae			2						11	2	1	4												2						1	7	12	
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	11			1				
True Fly larvae	Diptera	Bibionidae																			2														
True Fly larvae	Diptera	Ceratopogonidae																																	
True Fly larvae	Diptera	Culicidae				17	1					1		1		1			11	6		14						6					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		
True Fly larvae	Diptera	Psychodidae																			1											1			
True Fly larvae	Diptera	s-f Chironominae	9	10	11	69	94	38	9	5	22	71	72	109	22	15	19	27	6	8	34	32	18	13	34	25	35	25	23	33	18	40	33	42	24
True Fly larvae	Diptera	s-f Orthocladiinae	1		10				1						7	1		1	2	1	6				3	1	1			3	9	5			1
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	1	10	5	1	1	2	5
True Fly larvae	Diptera	Simuliidae													1										1						2	1			
True Fly larvae	Diptera	Stratiomyidae	3	1		1			1	2	6	1		1		1	4		2	6			1	1				3				5		2	1
True Fly larvae	Diptera	Syrphidae																				1													
True Fly larvae	Diptera	Tipulidae	1	1										1				2					2									2			2
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	17	3	16	23	6	2	8	5
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
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	
Beetles	Coleoptera	Dytiscidae																				1													
Beetles	Coleoptera	Elmidae																																	
Beetles	Coleoptera	Hydraenidae																																	
Beetles	Coleoptera	Hydrophilidae																																	
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
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
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				
Dragonfly larvae	Odonata	Megapodagrionidae		2																		1	1	3	2	8	7	4	4	6	13	8	8		
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
Lacewing	Neuroptera	Osmylidae																														1			
Leeches	Arhynchobdellida	Erpobdellidae						9																											
Leeches	Arhynchobdellida	Hirudinidae																																	
Leeches	Rhynchobdellida	Glossiphoniidae				15	5	9	7	9	12	1	1										1	1											
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	
Proboscis Worms	Nemertea	Nemertea																																	
Round Worms	Nematoda	Nematoda	1																																
Sand hoppers	Amphipoda	Ceinidae																																	
Sand hoppers	Amphipoda	Talitridae																																	

			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
Slatters	Isopoda	Oniscidae							2																1							1			
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
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
Snails	Gastropoda	Planorbidae	2	3	10	11	2	6	4	11	11	2			3	1	6	1	2											2				3	
Stonefly larvae	Plecoptera	Eustheniidae																																	
True bugs	Hemiptera	Belostomatidae																																	
True bugs	Hemiptera	Corixidae		3	2				2																1		1	1		1	4		5	2	1
True bugs	Hemiptera	Gelastocoridae						1	1	2											1														
True bugs	Hemiptera	Gerridae																							1	1			1						
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
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	Ceratopogonidae	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
True Fly larvae	Diptera	s-f Orthocladiinae					1									1							1												1
True Fly larvae	Diptera	s-f Tanypodinae														1		1			2		1			1		1			1	1	2	5	
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
Yabbies	Decapoda	Parastacidae										1			2								1			2	1	3				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
Aquatic mites	Acarina	Acarina	1					1		1				1		1							
Beetles	Coleoptera	Dytiscidae				1	1	2							2	1							
Beetles	Coleoptera	Elmidae																					
Beetles	Coleoptera	Hydraenidae																					
Beetles	Coleoptera	Hydrophilidae													3								
Beetles	Coleoptera	Psephenidae							1														
Beetles	Coleoptera	Scirtidae			1										1							1	
Caddisfly larvae	Trichoptera	Antipodoecidae										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	
Dragonfly larvae	Odonata	Gomphidae				1																	
Dragonfly larvae	Odonata	Hemicorduliidae	9	8	8	11			5	5	13	10	6	2	9	3	6		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	
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
Dragonfly larvae	Odonata	Megapodagrionidae	6	14	8	4		2	10	7	26	8	7	2	5	11	5	4	13	10	1	4	8
Dragonfly larvae	Odonata	Synthemistidae																					
Dragonfly larvae	Odonata	Telephlebiidae																					
Fairy shrimps	Decapoda	Atyidae	5				2		5	5	14	10	8	3	1	10	1						
Flatworms	Turbellaria	Dugesiidae	5	3		2						3	2	2					2			1	
Lacewing	Neuroptera	Osmylidae																					
Leeches	Arhynchobdellida	Erpobdellidae				2	2	1						2									
Leeches	Arhynchobdellida	Hirudinidae																					
Leeches	Rhynchobdellida	Glossiphoniidae	2	7	5	3	4	5	8	16	3	2	3		1		2						
Mayfly larvae	Ephemeroptera	Baetidae	1																				
Moth Larvae	Lepidoptera	Pyralidae																					
Mussels	Bivalvia	Corbiculidae		4	2																		
Mussels	Bivalvia	Sphaeriidae														1							
Proboscis Worms	Nemertea	Nemertea											1										
Round Worms	Nematoda	Nematoda																					
Sand hoppers	Amphipoda	Ceinidae				3	1																
Sand hoppers	Amphipoda	Talitridae									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
Slatters	Isopoda	Oniscidae				1																4	
Snails	Gastropoda	Ancylidae	1										1			1				3	1		7
Snails	Gastropoda	Hydrobiidae	30	22	13	23	13	34	23	10	18	15	33	15	26	18	30	9	18	21	4	28	11
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
Snails	Gastropoda	Planorbidae	4	6	6		2	2		2	2				2				1		1	1	3
Stonefly larvae	Plecoptera	Eustheniidae							1														
True bugs	Hemiptera	Belostomatidae																					
True bugs	Hemiptera	Corixidae				1	2	9															
True bugs	Hemiptera	Gelastocoridae																					
True bugs	Hemiptera	Gerridae								1						1							
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	
True bugs	Hemiptera	Pleidae																					
True bugs	Hemiptera	Saldidae																					
True bugs	Hemiptera	Veliidae		3							2												
True Fly larvae	Diptera	Bibionidae																					
True Fly larvae	Diptera	Ceratopogonidae																					
True Fly larvae	Diptera	Culicidae				1						1			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													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
True Fly larvae	Diptera	s-f Orthocladiinae	7	1					1			6	7	5	1	4							
True Fly larvae	Diptera	s-f Tanypodinae	4	2	14					18	11	3	4	5		4		1			1		2
True Fly larvae	Diptera	Simuliidae																					
True Fly larvae	Diptera	Stratiomyidae		2		1							1		1	1	1	1	3				1
True Fly larvae	Diptera	Syrphidae																					
True Fly larvae	Diptera	Tipulidae																1	1			1	
Worms	Oligochaeta	Oligochaeta	3	6	10	10	5	7	6	6	8		3	7	7			8	17	15	2	3	5
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
Aquatic mites	Acarina	Acarina	2	2	1	6	1	1											1				
Beetles	Coleoptera	Dytiscidae					2																
Beetles	Coleoptera	Elmidae																					
Beetles	Coleoptera	Hydraenidae																					
Beetles	Coleoptera	Hydrophilidae	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	
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						
Dragonfly larvae	Odonata	Coenagrionidae	5	8	15				5	6	12	1		4	9	2	4	2	2	5	1		
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
Dragonfly larvae	Odonata	Isostictidae		1	2	1			2		2	1	1	2	3	6	5	3		8	5		5
Dragonfly larvae	Odonata	Lestidae																					
Dragonfly larvae	Odonata	Libellulidae		5	2	2	1	13	13	10	4	2		7	3	7		2					
Dragonfly larvae	Odonata	Megapodagrionidae	9	21	19	20		3	9	2	8	2	3	5	5	9	3	1	1	9	10	2	5
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	
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									
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
Proboscis Worms	Nemertea	Nemertea																					
Round Worms	Nematoda	Nematoda													1								
Sand hoppers	Amphipoda	Ceinidae		1	2	2	8																
Sand hoppers	Amphipoda	Talitridae								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
Slatters	Isopoda	Oniscidae				3	4	2	1														
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
Snails	Gastropoda	Lymnaeidae							1		1	1	1	4	3	6	2			4	2		
Snails	Gastropoda	Physidae	4	1	6	7	12	24	8	7	5	14	1	7	15	18	15	12	12	18	14	18	19
Snails	Gastropoda	Planorbidae	2	2	3			1				3			4	8	2	1	1	6		2	
Stonefly larvae	Plecoptera	Eustheniidae																					
True bugs	Hemiptera	Belostomatidae																					
True bugs	Hemiptera	Corixidae	1				1								1								
True bugs	Hemiptera	Gelastocoridae												1							1	1	
True bugs	Hemiptera	Gerridae							1	1		1			1		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
True bugs	Hemiptera	Pleidae																					1
True bugs	Hemiptera	Saldidae																					
True bugs	Hemiptera	Veliidae												1					1			1	
True Fly larvae	Diptera	Bibionidae																					
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
True Fly larvae	Diptera	s-f Orthocladiinae	2						2	4	2	2			1								
True Fly larvae	Diptera	s-f Tanypodinae	2	2	7	2					4	1	6	3	5	2	2		1	4		2	2
True Fly larvae	Diptera	Simuliidae					1																
True Fly larvae	Diptera	Stratiomyidae	2	1	3	1			1	1	5	3		1	2	1	1			1			
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
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
Aquatic mites	Acarina	Acarina				1	7	4	2		1	2	3	2	1	2		2		1			2		5	
Beetles	Coleoptera	Dytiscidae					1																			
Beetles	Coleoptera	Elmidae	1		3			3	6	1		4	1			4				2			1		1	
Beetles	Coleoptera	Hydraenidae																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			
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
Dragonfly larvae	Odonata	Isostictidae			2	8	5	7	6	8	6	4	2	4	3	2	1	10		1					2	5
Dragonfly larvae	Odonata	Lestidae				6																				
Dragonfly larvae	Odonata	Libellulidae					14	13				2	1	4	1		2		2	4					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
Dragonfly larvae	Odonata	Synthemistidae																								
Dragonfly larvae	Odonata	Telephlebiidae																								
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
Lacewing	Neuroptera	Osmylidae																								
Leeches	Arhynchobdellida	Erpobdellidae																								
Leeches	Arhynchobdellida	Hirudinidae														1										
Leeches	Rhynchobdellida	Glossiphoniidae					1	1	3	2	1	2	2		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
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	

			spring 2004 Terrys Ck	spring 2004 Terrys Ck	spring 2004 Terrys Ck	spring 2005 Terrys Ck	spring 2005 Terrys Ck	spring 2005 Terrys Ck	autumn 2005 Terrys Ck	autumn 2005 Terrys Ck	autumn 2005 Terrys Ck	autumn 2006 Terrys Ck	autumn 2006 Terrys Ck	autumn 2006 Terrys Ck	autumn 2007 Terrys Ck	autumn 2007 Terrys Ck	autumn 2007 Terrys Ck	autumn 2007 Terrys Ck	autumn 2007 Terrys Ck	autumn 2007 Terrys Ck	spring 2007 Terrys Ck	spring 2007 Terrys Ck	spring 2007 Terrys Ck	spring 2007 Terrys Ck	spring 2007 Terrys Ck	spring 2007 Terrys Ck
			S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Slatters	Isopoda	Oniscidae				1																				
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
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
Snails	Gastropoda	Planorbidae		1	5	1		4	2	4	4	2			1			1	1	5		1		1	3	2
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							
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						
True bugs	Hemiptera	Pleidae																								
True bugs	Hemiptera	Saldidae																								
True bugs	Hemiptera	Veliidae						1			3	4	1			1	2				1			5		
True Fly larvae	Diptera	Bibionidae																								
True Fly larvae	Diptera	Ceratopogonidae					2				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
True Fly larvae	Diptera	s-f Orthocladiinae	2		2				2		1		1		7	5	2			2	1				2	
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
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			
True Fly larvae	Diptera	Syrphidae																								
True Fly larvae	Diptera	Tipulidae							4															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
Yabbies	Decapoda	Parastacidae																								
Yabbie cleaner	Temnocephala	Temnocephalidae																								

Appendix 5 SIMPER output

SIMPER all five creeks 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\All five cks.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Creek

Factor groups
Terrys Ck
Shrimptons Ck
Porters Ck
Buffalo Ck
Archers Ck

Group Terrys Ck

Average similarity: 60.34

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       17.81    8.63    2.38     14.31  14.31
Dragonfly larvae Megapodagrionidae     13.81    7.96    4.70     13.19  27.50
Snails Hydrobiidae                     13.76    7.66    2.35     12.70  40.20
Snails Physidae                         7.38    5.81    2.78      9.63  49.82
Flatworms Dugesiidae                    6.62    5.10    2.35      8.45  58.27
Worms Oligochaeta                       7.48    4.99    2.26      8.28  66.55
True Fly larvae s-f Tanypodinae         5.10    3.33    1.81      5.52  72.07
Dragonfly larvae Hemicorduliidae        7.10    3.13    1.15      5.19  77.26
Dragonfly larvae Isostictidae           3.52    2.29    1.05      3.80  81.05
True bugs Notonectidae                  3.48    2.08    0.93      3.44  84.49
Snails Planorbidae                      1.52    1.32    0.83      2.19  86.68
Aquatic mites Acarina                   1.67    1.30    0.83      2.16  88.84
Dragonfly larvae Coenagrionidae         2.00    1.23    0.74      2.03  90.87

Group Shrimptons Ck

Average similarity: 50.91

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Physidae                        12.17   11.27    2.51     22.15  22.15
True Fly larvae s-f Chironominae       14.27    9.44    1.40     18.54  40.69
Worms Oligochaeta                       7.50    7.82    1.72     15.37  56.06
Flatworms Dugesiidae                    6.43    6.56    1.74     12.89  68.95
Aquatic mites Acarina                   2.23    2.69    0.95      5.28  74.23
Dragonfly larvae Hemicorduliidae        2.67    2.53    0.80      4.96  79.19
Dragonfly larvae Coenagrionidae         2.20    2.16    0.82      4.24  83.43
Snails Planorbidae                      2.17    1.31    0.48      2.57  86.00
True bugs Notonectidae                  0.90    1.16    0.54      2.28  88.28
Dragonfly larvae Megapodagrionidae      2.17    0.94    0.40      1.84  90.12

Group Porters Ck

Average similarity: 58.22

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Hydrobiidae                     19.71   10.25    4.58     17.61  17.61
True Fly larvae s-f Chironominae       30.43    9.10    1.69     15.64  33.25
Snails Physidae                         7.24    6.35    3.22     10.90  44.15
Dragonfly larvae Megapodagrionidae      7.38    5.21    2.16      8.95  53.10
Dragonfly larvae Isostictidae           8.24    5.19    2.32      8.91  62.01
Worms Oligochaeta                       6.10    4.43    1.44      7.61  69.62
Dragonfly larvae Coenagrionidae         5.76    3.37    1.35      5.78  75.40
Dragonfly larvae Libellulidae           3.10    2.32    1.18      3.99  79.39
Dragonfly larvae Hemicorduliidae        4.62    2.21    0.83      3.80  83.19
True bugs Notonectidae                  3.00    1.54    0.70      2.64  85.83
Leeches Glossiphoniidae                 2.90    1.41    0.73      2.43  88.25
True Fly larvae s-f Tanypodinae         3.29    1.28    0.64      2.20  90.46
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```
Group Buffalo Ck

Average similarity: 57.41

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       29.52   11.52    3.42     20.07  20.07
Snails Physidae                        11.29    7.33    2.12     12.78  32.85
True bugs Notonectidae                  7.33    5.25    2.81      9.14  41.99
Snails Hydrobiidae                      6.76    5.09    1.64      8.87  50.86
Dragonfly larvae Megapodagrionidae      6.95    4.49    2.03      7.83  58.68
Worms Oligochaeta                       7.33    4.19    1.57      7.29  65.97
Dragonfly larvae Hemicorduliidae        5.24    2.76    1.14      4.80  70.78
Flatworms Dugesiidae                    2.90    2.23    0.97      3.88  74.65
Dragonfly larvae Coenagrionidae         3.86    2.13    0.93      3.72  78.37
True Fly larvae s-f Tanypodinae         2.14    1.86    0.95      3.24  81.60
Dragonfly larvae Isostictidae           2.24    1.80    0.87      3.14  84.74
Dragonfly larvae Libellulidae           3.38    1.50    0.71      2.62  87.36
Snails Planorbidae                      1.67    1.10    0.65      1.92  89.28
Dragonfly larvae Aeshnidae              1.81    1.05    0.64      1.83  91.11

Group Archers Ck

Average similarity: 51.99

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       33.83   14.48    3.33     27.86  27.86
Worms Oligochaeta                       9.73    7.46    2.41     14.34  42.20
Snails Physidae                         8.07    6.88    2.03     13.22  55.42
Flatworms Dugesiidae                    6.77    5.23    1.49     10.07  65.49
True Fly larvae s-f Tanypodinae         2.27    2.80    1.54      5.38  70.86
Dragonfly larvae Libellulidae           3.00    2.10    0.84      4.05  74.91
Dragonfly larvae Hemicorduliidae        4.30    1.73    0.73      3.33  78.24
Snails Hydrobiidae                      3.23    1.61    0.56      3.10  81.35
True bugs Veliidae                      2.27    1.56    0.68      2.99  84.34
Dragonfly larvae Megapodagrionidae      2.87    1.48    0.68      2.85  87.19
Dragonfly larvae Coenagrionidae         3.23    1.19    0.57      2.30  89.49
True Fly larvae Stratiomyidae           1.27    1.04    0.57      2.01  91.49

Groups Terrys Ck  &  Shrimptons Ck

Average dissimilarity = 53.41

                                   Group Terrys Ck  Group Shrimptons Ck
Species                                   Av.Abund             Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Snails Hydrobiidae                           13.76                 0.30     5.42     2.37     10.15  10.15
Dragonfly larvae Megapodagrionidae           13.81                 2.17     4.47     1.94      8.38  18.52
True Fly larvae s-f Chironominae             17.81                14.27     3.07     1.32      5.74  24.26
Dragonfly larvae Hemicorduliidae              7.10                 2.67     2.61     1.36      4.89  29.16
True Fly larvae s-f Tanypodinae               5.10                 0.53     2.60     1.48      4.87  34.02
Dragonfly larvae Isostictidae                 3.52                 1.50     2.10     1.38      3.93  37.96
True bugs Notonectidae                        3.48                 0.90     1.99     1.39      3.73  41.69
Worms Oligochaeta                             7.48                 7.50     1.97     1.33      3.69  45.37
Snails Physidae                               7.38                12.17     1.92     1.34      3.59  48.97
Flatworms Dugesiidae                          6.62                 6.43     1.89     1.25      3.54  52.51
Mussels Corbiculidae                          2.33                 2.07     1.85     0.94      3.46  55.96
Snails Planorbidae                            1.52                 2.17     1.74     1.25      3.26  59.22
Dragonfly larvae Coenagrionidae               2.00                 2.20     1.69     1.31      3.17  62.39
Aquatic mites Acarina                         1.67                 2.23     1.60     1.19      2.99  65.38
Leeches Glossiphoniidae                       0.71                 2.03     1.51     0.92      2.83  68.21
Dragonfly larvae Libellulidae                 2.14                 0.47     1.48     0.95      2.77  70.98
True Fly larvae s-f Orthocladiinae            1.10                 0.13     1.08     0.84      2.02  73.00
True bugs Veliidae                            0.86                 0.63     1.08     0.79      2.02  75.01
Mussels Sphaeriidae                           1.05                 0.10     1.06     0.72      1.99  77.01
Beetles Elmidae                               1.10                 0.00     1.00     0.79      1.88  78.89
True Fly larvae Stratiomyidae                 0.76                 0.37     0.95     0.94      1.78  80.66
True bugs Gerridae                            0.95                 0.10     0.91     0.82      1.70  82.36
True Fly larvae Culicidae                     0.81                 0.37     0.82     0.51      1.54  83.90
Snails Lymnaeidae                             0.48                 0.30     0.73     0.75      1.37  85.27
True bugs Corixidae                           0.24                 0.60     0.72     0.64      1.34  86.62
Snails Ancylidae                              0.05                 0.60     0.65     0.65      1.21  87.83
Dragonfly larvae Aeshnidae                    0.29                 0.33     0.62     0.68      1.16  88.99
True Fly larvae Simuliidae                    0.48                 0.00     0.58     0.60      1.09  90.07
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Groups Terrys Ck & Porters Ck

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Average dissimilarity = 45.59

                                    Group Terrys Ck  Group Porters Ck
Species                                    Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae              17.81             30.43     3.20     1.19      7.02   7.02
Flatworms Dugesiidae                           6.62              0.95     2.66     1.58      5.82  12.84
Dragonfly larvae Hemicorduliidae               7.10              4.62     2.30     1.32      5.04  17.88
Dragonfly larvae Isostictidae                  3.52              8.24     2.07     1.31      4.53  22.42
True Fly larvae s-f Tanypodinae                5.10              3.29     2.04     1.42      4.48  26.90
Dragonfly larvae Coenagrionidae                2.00              5.76     2.02     1.45      4.43  31.33
Dragonfly larvae Megapodagrionidae            13.81              7.38     1.92     1.27      4.21  35.54
Snails Hydrobiidae                            13.76             19.71     1.85     1.26      4.06  39.60
True bugs Notonectidae                         3.48              3.00     1.78     1.27      3.90  43.50
Dragonfly larvae Libellulidae                  2.14              3.10     1.70     1.38      3.72  47.22
Worms Oligochaeta                              7.48              6.10     1.66     1.27      3.64  50.86
Fairy shrimps Atyidae                          0.00              3.05     1.49     0.92      3.27  54.13
Leeches Glossiphoniidae                        0.71              2.90     1.49     1.17      3.27  57.40
True Fly larvae s-f Orthocladiinae             1.10              1.52     1.24     1.02      2.72  60.12
Aquatic mites Acarina                          1.67              0.24     1.22     1.19      2.68  62.80
Snails Planorbidae                             1.52              1.52     1.22     1.28      2.67  65.47
Mussels Corbiculidae                           2.33              0.29     1.17     0.80      2.57  68.04
Snails Physidae                                7.38              7.24     1.05     1.25      2.31  70.35
Caddisfly larvae Hydroptilidae                 0.29              1.19     0.93     0.80      2.04  72.40
Dragonfly larvae Aeshnidae                     0.29              1.14     0.88     0.87      1.93  74.33
Mussels Sphaeriidae                            1.05              0.05     0.86     0.69      1.90  76.23
True Fly larvae Stratiomyidae                  0.76              0.57     0.86     1.02      1.88  78.11
Beetles Elmidae                                1.10              0.00     0.85     0.79      1.86  79.97
True bugs Veliidae                             0.86              0.24     0.80     0.76      1.76  81.73
True bugs Gerridae                             0.95              0.10     0.77     0.81      1.69  83.42
True Fly larvae Culicidae                      0.81              0.19     0.65     0.54      1.42  84.84
Caddisfly larvae Leptoceridae                  0.00              0.71     0.63     0.72      1.39  86.22
Snails Ancylidae                               0.05              0.67     0.62     0.55      1.35  87.58
True Fly larvae Simuliidae                     0.48              0.00     0.49     0.60      1.07  88.64
Snails Lymnaeidae                              0.48              0.10     0.47     0.55      1.02  89.67
True bugs Corixidae                            0.24              0.57     0.44     0.43      0.97  90.64
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Groups Shrimptons Ck & Porters Ck

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Average dissimilarity = 58.28

                                  Group Shrimptons Ck  Group Porters Ck
Species                                      Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Snails Hydrobiidae                               0.30             19.71     6.76     3.51     11.60  11.60
True Fly larvae s-f Chironominae                14.27             30.43     4.48     1.17      7.68  19.28
Dragonfly larvae Isostictidae                    1.50              8.24     3.33     1.76      5.72  25.00
Dragonfly larvae Megapodagrionidae               2.17              7.38     3.22     1.58      5.53  30.53
Flatworms Dugesiidae                             6.43              0.95     3.11     1.51      5.34  35.87
Dragonfly larvae Coenagrionidae                  2.20              5.76     2.43     1.46      4.17  40.04
Dragonfly larvae Hemicorduliidae                 2.67              4.62     2.35     1.37      4.04  44.07
Leeches Glossiphoniidae                          2.03              2.90     2.16     1.16      3.70  47.77
Worms Oligochaeta                                7.50              6.10     2.11     1.23      3.62  51.40
Dragonfly larvae Libellulidae                    0.47              3.10     2.09     1.47      3.58  54.98
Snails Physidae                                 12.17              7.24     1.92     1.40      3.29  58.26
True Fly larvae s-f Tanypodinae                  0.53              3.29     1.91     1.07      3.28  61.54
True bugs Notonectidae                           0.90              3.00     1.91     1.25      3.27  64.81
Aquatic mites Acarina                            2.23              0.24     1.80     1.15      3.09  67.90
Fairy shrimps Atyidae                            0.00              3.05     1.80     0.93      3.08  70.99
Snails Planorbidae                               2.17              1.52     1.79     1.17      3.08  74.06
Mussels Corbiculidae                             2.07              0.29     1.37     0.68      2.35  76.41
True Fly larvae s-f Orthocladiinae               0.13              1.52     1.14     0.80      1.96  78.37
Caddisfly larvae Hydroptilidae                   0.33              1.19     1.14     0.80      1.95  80.32
Dragonfly larvae Aeshnidae                       0.33              1.14     1.06     0.82      1.81  82.14
Snails Ancylidae                                 0.60              0.67     1.05     0.75      1.81  83.95
True Fly larvae Stratiomyidae                    0.37              0.57     0.92     0.91      1.58  85.53
True bugs Corixidae                              0.60              0.57     0.89     0.68      1.53  87.05
Caddisfly larvae Leptoceridae                    0.00              0.71     0.76     0.72      1.31  88.36
True bugs Veliidae                               0.63              0.24     0.60     0.50      1.04  89.40
Snails Lymnaeidae                                0.30              0.10     0.57     0.69      0.98  90.38
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Groups Terrys Ck & Buffalo Ck

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Average dissimilarity = 44.11

                                    Group Terrys Ck  Group Buffalo Ck
Species                                    Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae              17.81             29.52     2.58     1.29      5.86   5.86
Dragonfly larvae Hemicorduliidae               7.10              5.24     2.22     1.37      5.04  10.89
Dragonfly larvae Megapodagrionidae            13.81              6.95     2.17     1.38      4.93  15.82
Snails Hydrobiidae                            13.76              6.76     2.07     1.32      4.70  20.52
True bugs Notonectidae                         3.48              7.33     2.01     1.36      4.56  25.08
Flatworms Dugesiidae                           6.62              2.90     1.89     1.21      4.28  29.36
Worms Oligochaeta                              7.48              7.33     1.87     1.35      4.24  33.60
Dragonfly larvae Libellulidae                  2.14              3.38     1.77     1.21      4.00  37.61
True Fly larvae s-f Tanypodinae                5.10              2.14     1.71     1.31      3.87  41.47
Dragonfly larvae Coenagrionidae                2.00              3.86     1.70     1.36      3.85  45.32
Mussels Corbiculidae                           2.33              2.48     1.62     1.04      3.67  48.99
Snails Physidae                                7.38             11.29     1.60     1.32      3.62  52.61
Dragonfly larvae Isostictidae                  3.52              2.24     1.57     1.28      3.56  56.17
Snails Planorbidae                             1.52              1.67     1.26     1.27      2.85  59.02
Aquatic mites Acarina                          1.67              0.67     1.24     1.21      2.80  61.83
Dragonfly larvae Aeshnidae                     0.29              1.81     1.22     1.11      2.76  64.58
Caddisfly larvae Hydroptilidae                 0.29              1.52     1.13     0.94      2.57  67.15
Mussels Sphaeriidae                            1.05              0.81     1.08     0.88      2.45  69.60
Snails Lymnaeidae                              0.48              1.19     1.03     0.95      2.35  71.94
True Fly larvae s-f Orthocladiinae             1.10              0.62     1.01     0.92      2.29  74.23
True Fly larvae Stratiomyidae                  0.76              1.10     1.00     1.15      2.26  76.49
Leeches Glossiphoniidae                        0.71              1.00     0.97     1.00      2.19  78.68
Mayfly larvae Baetidae                         0.10              1.86     0.86     0.53      1.94  80.63
Beetles Elmidae                                1.10              0.00     0.85     0.79      1.92  82.55
True bugs Gerridae                             0.95              0.24     0.82     0.91      1.87  84.41
True Fly larvae Culicidae                      0.81              0.52     0.82     0.65      1.86  86.27
True bugs Veliidae                             0.86              0.14     0.78     0.79      1.77  88.05
Sand hoppers Ceinidae                          0.38              0.62     0.63     0.61      1.43  89.48
True Fly larvae Simuliidae                     0.48              0.05     0.51     0.64      1.17  90.65
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Groups Shrimptons Ck & Buffalo Ck

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Average dissimilarity = 53.46

                                    Group Shrimptons Ck  Group Buffalo Ck
Species                                        Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae                  14.27             29.52     4.01     1.27      7.49   7.49
Snails Hydrobiidae                                 0.30              6.76     3.73     1.90      6.98  14.47
True bugs Notonectidae                             0.90              7.33     3.08     1.92      5.75  20.22
Dragonfly larvae Megapodagrionidae                 2.17              6.95     3.07     1.58      5.74  25.96
Worms Oligochaeta                                  7.50              7.33     2.37     1.34      4.44  30.40
Flatworms Dugesiidae                               6.43              2.90     2.35     1.24      4.40  34.80
Dragonfly larvae Hemicorduliidae                   2.67              5.24     2.34     1.40      4.37  39.17
Dragonfly larvae Coenagrionidae                    2.20              3.86     2.07     1.40      3.87  43.05
Dragonfly larvae Libellulidae                      0.47              3.38     2.01     1.13      3.75  46.80
Mussels Corbiculidae                               2.07              2.48     1.97     0.97      3.68  50.48
Snails Physidae                                   12.17             11.29     1.91     1.14      3.57  54.05
Dragonfly larvae Isostictidae                      1.50              2.24     1.86     1.23      3.49  57.54
Snails Planorbidae                                 2.17              1.67     1.83     1.17      3.42  60.96
Aquatic mites Acarina                              2.23              0.67     1.77     1.19      3.31  64.27
True Fly larvae s-f Tanypodinae                    0.53              2.14     1.72     1.32      3.22  67.49
Leeches Glossiphoniidae                            2.03              1.00     1.57     0.83      2.93  70.43
Dragonfly larvae Aeshnidae                         0.33              1.81     1.49     1.09      2.79  73.22
Caddisfly larvae Hydroptilidae                     0.33              1.52     1.39     0.92      2.60  75.81
Snails Lymnaeidae                                  0.30              1.19     1.19     0.99      2.22  78.04
True Fly larvae Stratiomyidae                      0.37              1.10     1.17     1.13      2.19  80.22
Mayfly larvae Baetidae                             0.10              1.86     1.05     0.54      1.96  82.18
Mussels Sphaeriidae                                0.10              0.81     0.79     0.63      1.48  83.66
True Fly larvae Culicidae                          0.37              0.52     0.76     0.58      1.43  85.09
True Fly larvae s-f Orthocladiinae                 0.13              0.62     0.74     0.73      1.38  86.47
True bugs Corixidae                                0.60              0.14     0.73     0.71      1.36  87.83
Snails Ancylidae                                   0.60              0.05     0.67     0.66      1.25  89.09
True bugs Veliidae                                 0.63              0.14     0.63     0.54      1.18  90.27
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Groups Porters Ck & Buffalo Ck

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Average dissimilarity = 46.31

                                    Group Porters Ck  Group Buffalo Ck
Species                                     Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae               30.43             29.52     3.48     1.27      7.51   7.51
Snails Hydrobiidae                             19.71              6.76     2.76     1.67      5.96  13.47
Dragonfly larvae Isostictidae                   8.24              2.24     2.28     1.51      4.92  18.40
True bugs Notonectidae                          3.00              7.33     2.26     1.47      4.88  23.28
Dragonfly larvae Hemicorduliidae                4.62              5.24     2.11     1.35      4.56  27.84
Dragonfly larvae Coenagrionidae                 5.76              3.86     2.02     1.39      4.36  32.20
Worms Oligochaeta                               6.10              7.33     1.96     1.30      4.23  36.43
Dragonfly larvae Libellulidae                   3.10              3.38     1.79     1.33      3.86  40.29
Dragonfly larvae Megapodagrionidae              7.38              6.95     1.76     1.30      3.80  44.09
True Fly larvae s-f Tanypodinae                 3.29              2.14     1.68     1.30      3.63  47.72
Flatworms Dugesiidae                            0.95              2.90     1.63     1.31      3.51  51.24
Leeches Glossiphoniidae                         2.90              1.00     1.61     1.13      3.48  54.72
Snails Physidae                                 7.24             11.29     1.58     1.39      3.41  58.12
Fairy shrimps Atyidae                           3.05              0.00     1.52     0.92      3.29  61.41
Dragonfly larvae Aeshnidae                      1.14              1.81     1.34     1.13      2.89  64.31
Mussels Corbiculidae                            0.29              2.48     1.32     0.85      2.84  67.15
Snails Planorbidae                              1.52              1.67     1.31     1.23      2.84  69.98
Caddisfly larvae Hydroptilidae                  1.19              1.52     1.31     1.08      2.83  72.81
True Fly larvae s-f Orthocladiinae              1.52              0.62     1.10     0.91      2.38  75.20
Snails Lymnaeidae                               0.10              1.19     0.98     0.91      2.12  77.32
True Fly larvae Stratiomyidae                   0.57              1.10     0.97     1.12      2.10  79.41
Mayfly larvae Baetidae                          0.05              1.86     0.82     0.49      1.78  81.19
Aquatic mites Acarina                           0.24              0.67     0.70     0.79      1.52  82.71
Caddisfly larvae Leptoceridae                   0.71              0.05     0.66     0.74      1.43  84.15
Snails Ancylidae                                0.67              0.05     0.64     0.55      1.37  85.52
Mussels Sphaeriidae                             0.05              0.81     0.63     0.59      1.37  86.88
True Fly larvae Culicidae                       0.19              0.52     0.59     0.62      1.27  88.15
Slatters Oniscidae                              0.24              0.48     0.54     0.54      1.17  89.32
Sand hoppers Ceinidae                           0.19              0.62     0.53     0.51      1.15  90.47
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Groups Terrys Ck & Archers Ck

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Average dissimilarity = 51.07

                                    Group Terrys Ck  Group Archers Ck
Species                                    Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Dragonfly larvae Megapodagrionidae            13.81              2.87     3.81     1.89      7.46   7.46
Snails Hydrobiidae                            13.76              3.23     3.73     1.59      7.30  14.76
True Fly larvae s-f Chironominae              17.81             33.83     3.12     1.29      6.10  20.86
Dragonfly larvae Hemicorduliidae               7.10              4.30     2.63     1.34      5.16  26.02
Dragonfly larvae Isostictidae                  3.52              0.00     2.19     1.49      4.30  30.32
True bugs Notonectidae                         3.48              1.33     2.06     1.32      4.03  34.35
Worms Oligochaeta                              7.48              9.73     1.86     1.35      3.65  38.00
Dragonfly larvae Libellulidae                  2.14              3.00     1.85     1.17      3.62  41.63
Flatworms Dugesiidae                           6.62              6.77     1.83     1.32      3.58  45.21
Dragonfly larvae Coenagrionidae                2.00              3.23     1.78     1.20      3.49  48.70
True Fly larvae s-f Tanypodinae                5.10              2.27     1.70     1.20      3.32  52.02
True bugs Veliidae                             0.86              2.27     1.54     1.08      3.02  55.04
Snails Physidae                                7.38              8.07     1.52     1.28      2.98  58.02
Aquatic mites Acarina                          1.67              0.97     1.41     1.24      2.77  60.79
Snails Planorbidae                             1.52              0.00     1.40     1.25      2.74  63.52
True Fly larvae Culicidae                      0.81              2.17     1.40     0.76      2.73  66.26
True Fly larvae s-f Orthocladiinae             1.10              1.40     1.34     1.05      2.63  68.89
Mussels Corbiculidae                           2.33              0.23     1.27     0.81      2.48  71.37
Mussels Sphaeriidae                            1.05              1.23     1.25     0.81      2.45  73.82
True Fly larvae Stratiomyidae                  0.76              1.27     1.19     1.06      2.33  76.15
Dragonfly larvae Aeshnidae                     0.29              1.83     1.14     0.83      2.24  78.39
Leeches Glossiphoniidae                        0.71              0.87     1.03     1.01      2.03  80.41
Fairy shrimps Atyidae                          0.00              1.87     0.95     0.59      1.86  82.27
Beetles Elmidae                                1.10              0.07     0.94     0.81      1.84  84.11
True bugs Gerridae                             0.95              0.10     0.84     0.82      1.64  85.75
True Fly larvae Simuliidae                     0.48              0.17     0.63     0.71      1.24  86.99
Caddisfly larvae Hydroptilidae                 0.29              0.83     0.63     0.50      1.23  88.22
True Fly larvae Tipulidae                      0.29              0.30     0.55     0.59      1.08  89.30
Slatters Oniscidae                             0.10              0.57     0.54     0.55      1.05  90.35
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Groups Shrimptons Ck & Archers Ck

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Average dissimilarity = 54.38

                                    Group Shrimptons Ck  Group Archers Ck
Species                                        Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae                  14.27             33.83     4.85     1.31      8.92   8.92
Dragonfly larvae Hemicorduliidae                   2.67              4.30     2.55     1.27      4.69  13.61
Flatworms Dugesiidae                               6.43              6.77     2.50     1.30      4.59  18.20
Snails Physidae                                   12.17              8.07     2.40     1.27      4.41  22.61
Worms Oligochaeta                                  7.50              9.73     2.36     1.32      4.35  26.96
Dragonfly larvae Megapodagrionidae                 2.17              2.87     2.32     1.15      4.27  31.23
Dragonfly larvae Coenagrionidae                    2.20              3.23     2.25     1.24      4.13  35.36
Snails Hydrobiidae                                 0.30              3.23     2.24     0.99      4.12  39.48
Dragonfly larvae Libellulidae                      0.47              3.00     2.22     1.11      4.08  43.56
Aquatic mites Acarina                              2.23              0.97     2.03     1.23      3.73  47.29
True bugs Veliidae                                 0.63              2.27     2.01     1.03      3.69  50.98
True Fly larvae s-f Tanypodinae                    0.53              2.27     1.92     1.38      3.54  54.52
Leeches Glossiphoniidae                            2.03              0.87     1.75     0.86      3.22  57.74
Snails Planorbidae                                 2.17              0.00     1.73     0.81      3.17  60.91
True bugs Notonectidae                             0.90              1.33     1.57     1.02      2.89  63.80
True Fly larvae Culicidae                          0.37              2.17     1.56     0.70      2.86  66.66
Mussels Corbiculidae                               2.07              0.23     1.52     0.69      2.80  69.46
True Fly larvae Stratiomyidae                      0.37              1.27     1.44     0.97      2.65  72.11
True Fly larvae s-f Orthocladiinae                 0.13              1.40     1.41     0.86      2.60  74.71
Dragonfly larvae Aeshnidae                         0.33              1.83     1.40     0.80      2.58  77.28
Dragonfly larvae Isostictidae                      1.50              0.00     1.31     0.78      2.40  79.69
Fairy shrimps Atyidae                              0.00              1.87     1.16     0.60      2.13  81.82
True bugs Corixidae                                0.60              0.47     0.91     0.71      1.67  83.49
Mussels Sphaeriidae                                0.10              1.23     0.83     0.51      1.52  85.01
Dragonfly larvae Lestidae                          0.47              0.33     0.78     0.56      1.44  86.45
Caddisfly larvae Hydroptilidae                     0.33              0.83     0.74     0.47      1.36  87.81
Snails Ancylidae                                   0.60              0.03     0.72     0.64      1.32  89.13
Slatters Oniscidae                                 0.13              0.57     0.68     0.56      1.25  90.38
```

Groups Porters Ck & Archers Ck

```
Average dissimilarity = 54.81

                                      Group Porters Ck  Group Archers Ck
Species                                       Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
Snails Hydrobiidae                               19.71              3.23     4.75     1.98      8.66   8.66
True Fly larvae s-f Chironominae                 30.43             33.83     4.00     1.28      7.31  15.97
Dragonfly larvae Isostictidae                     8.24              0.00     3.85     2.58      7.02  22.99
Flatworms Dugesiidae                              0.95              6.77     2.90     1.46      5.29  28.28
Dragonfly larvae Megapodagrionidae                7.38              2.87     2.73     1.53      4.97  33.26
Dragonfly larvae Coenagrionidae                   5.76              3.23     2.51     1.49      4.59  37.85
Dragonfly larvae Hemicorduliidae                  4.62              4.30     2.38     1.34      4.34  42.19
Worms Oligochaeta                                 6.10              9.73     2.05     1.29      3.74  45.93
True bugs Notonectidae                            3.00              1.33     1.92     1.15      3.51  49.44
Fairy shrimps Atyidae                             3.05              1.87     1.90     1.06      3.47  52.91
Dragonfly larvae Libellulidae                     3.10              3.00     1.84     1.24      3.35  56.26
True Fly larvae s-f Tanypodinae                   3.29              2.27     1.82     1.39      3.32  59.58
Leeches Glossiphoniidae                           2.90              0.87     1.73     1.16      3.16  62.74
True bugs Veliidae                                0.24              2.27     1.60     0.99      2.92  65.66
Snails Physidae                                   7.24              8.07     1.49     1.27      2.72  68.38
True Fly larvae s-f Orthocladiinae                1.52              1.40     1.47     1.03      2.68  71.06
Dragonfly larvae Aeshnidae                        1.14              1.83     1.40     0.95      2.55  73.61
Snails Planorbidae                                1.52              0.00     1.32     1.07      2.41  76.02
True Fly larvae Culicidae                         0.19              2.17     1.24     0.70      2.26  78.28
True Fly larvae Stratiomyidae                     0.57              1.27     1.18     1.03      2.15  80.43
Caddisfly larvae Hydroptilidae                    1.19              0.83     1.17     0.80      2.14  82.57
Aquatic mites Acarina                             0.24              0.97     0.91     0.79      1.66  84.23
Caddisfly larvae Leptoceridae                     0.71              0.00     0.70     0.72      1.28  85.51
Snails Ancylidae                                  0.67              0.03     0.69     0.53      1.25  86.77
Mussels Sphaeriidae                               0.05              1.23     0.64     0.46      1.17  87.94
Slatters Oniscidae                                0.24              0.57     0.62     0.54      1.14  89.08
True bugs Corixidae                               0.57              0.47     0.62     0.52      1.13  90.21
```

```
Groups Buffalo Ck  &  Archers Ck

Average dissimilarity = 51.47

                                    Group Buffalo Ck  Group Archers Ck
Species                                     Av.Abund          Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
True bugs Notonectidae                          7.33              1.33     3.25     2.02      6.31   6.31
True Fly larvae s-f Chironominae               29.52             33.83     3.10     1.29      6.03  12.34
Snails Hydrobiidae                              6.76              3.23     2.62     1.49      5.08  17.43
Dragonfly larvae Megapodagrionidae              6.95              2.87     2.59     1.47      5.03  22.45
Dragonfly larvae Hemicorduliidae                5.24              4.30     2.40     1.38      4.67  27.12
Worms Oligochaeta                               7.33              9.73     2.27     1.39      4.41  31.53
Flatworms Dugesiidae                            2.90              6.77     2.25     1.26      4.36  35.89
Dragonfly larvae Coenagrionidae                 3.86              3.23     2.15     1.34      4.19  40.08
Dragonfly larvae Libellulidae                   3.38              3.00     2.02     1.22      3.93  44.00
Snails Physidae                                11.29              8.07     1.95     1.26      3.80  47.80
Dragonfly larvae Isostictidae                   2.24              0.00     1.82     1.22      3.53  51.33
Dragonfly larvae Aeshnidae                      1.81              1.83     1.61     1.15      3.13  54.46
True bugs Veliidae                              0.14              2.27     1.56     1.01      3.03  57.49
Mussels Corbiculidae                            2.48              0.23     1.43     0.86      2.77  60.26
True Fly larvae s-f Tanypodinae                 2.14              2.27     1.39     1.31      2.70  62.96
Caddisfly larvae Hydroptilidae                  1.52              0.83     1.39     0.94      2.70  65.66
Snails Planorbidae                              1.67              0.00     1.38     1.03      2.68  68.34
True Fly larvae Culicidae                       0.52              2.17     1.36     0.79      2.64  70.98
True Fly larvae s-f Orthocladiinae              0.62              1.40     1.26     0.95      2.45  73.43
True Fly larvae Stratiomyidae                   1.10              1.27     1.25     1.10      2.43  75.86
Leeches Glossiphoniidae                         1.00              0.87     1.12     0.90      2.17  78.03
Aquatic mites Acarina                           0.67              0.97     1.07     0.90      2.08  80.11
Snails Lymnaeidae                               1.19              0.13     1.07     0.91      2.08  82.19
Mussels Sphaeriidae                             0.81              1.23     1.06     0.70      2.06  84.25
Mayfly larvae Baetidae                          1.86              0.23     1.00     0.55      1.95  86.19
Fairy shrimps Atyidae                           0.00              1.87     0.97     0.59      1.88  88.07
Slatters Oniscidae                              0.48              0.57     0.76     0.65      1.47  89.54
Sand hoppers Ceinidae                           0.62              0.07     0.49     0.45      0.96  90.50
```

SIMPER Archers Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Archers.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Season

Factor groups
Autumn 2005
Spring 2005
Autumn 2006
Spring 2006
Autumn 2007
Spring 2007

Group Autumn 2005

Average similarity: 68.02

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Dragonfly larvae Megapodagrionidae     14.00    7.56    2.16     11.11  11.11
Fairy shrimps Atyidae                  11.33    7.18    8.38     10.56  21.67
Worms Oligochaeta                      11.67    6.80    3.09      9.99  31.67
True Fly larvae s-f Chironominae       12.00    6.58    5.68      9.67  41.33
Dragonfly larvae Libellulidae           6.67    5.47    4.54      8.04  49.37
Flatworms Dugesiidae                    8.33    5.32    5.50      7.82  57.19
Dragonfly larvae Coenagrionidae        12.67    5.20    4.94      7.65  64.83
True bugs Veliidae                      4.67    5.09    3.65      7.49  72.32
Dragonfly larvae Hemicorduliidae        8.33    4.82    8.37      7.08  79.40
Snails Physidae                         3.00    3.65    1.80      5.36  84.77
True Fly larvae Stratiomyidae           3.00    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: 59.54

Species                           Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae     67.00   20.16    6.42     33.86  33.86
Worms Oligochaeta                    18.00   10.74    6.84     18.05  51.91
Snails Physidae                       9.00    7.29    7.01     12.25  64.15
Dragonfly larvae Coenagrionidae      10.67    6.49    6.73     10.91  75.06
Dragonfly larvae Libellulidae        10.00    6.08    1.04     10.21  85.27
Dragonfly larvae Aeshnidae            3.33    2.04    0.58      3.43  88.70
Mussels Corbiculidae                  2.00    1.97    0.58      3.32  92.01

Group Autumn 2006

Average similarity: 72.35

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       84.00   23.36   19.19     32.29  32.29
Worms Oligochaeta                      11.67    8.50   11.35     11.74  44.04
Leeches Glossiphoniidae                 4.67    4.91    2.60      6.79  50.82
Dragonfly larvae Megapodagrionidae      4.67    4.62    4.53      6.39  57.21
Dragonfly larvae Libellulidae           4.33    4.46    4.33      6.17  63.38
Dragonfly larvae Coenagrionidae         4.67    4.02    1.99      5.56  68.94
Dragonfly larvae Hemicorduliidae        4.33    3.84    2.25      5.30  74.24
Flatworms Dugesiidae                    3.00    3.63    2.69      5.02  79.26
True bugs Veliidae                      1.67    3.17    3.92      4.38  83.63
True bugs Notonectidae                  2.33    3.16    4.33      4.36  88.00
Dragonfly larvae Aeshnidae              6.33    2.45    0.58      3.38  91.38
```

```
Group Spring 2006

Average similarity: 61.45

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       20.11   15.25    4.10     24.82  24.82
Snails Physidae                         8.33   10.24    3.64     16.66  41.49
Flatworms Dugesiidae                    7.67    8.84    2.77     14.38  55.86
Worms Oligochaeta                       6.56    8.01    2.91     13.04  68.91
Snails Hydrobiidae                      4.33    4.62    1.46      7.52  76.43
True Fly larvae s-f Tanypodinae         1.33    3.46    1.76      5.64  82.07
True bugs Veliidae                      1.00    2.00    0.80      3.26  85.32
True Fly larvae s-f Orthocladiinae      2.00    1.97    0.79      3.20  88.53
True Fly larvae Stratiomyidae           1.56    1.55    0.57      2.53  91.06

Group Autumn 2007

Average similarity: 57.33

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       25.83   17.66    4.21     30.81  30.81
Worms Oligochaeta                       8.17    6.59    1.30     11.49  42.30
Snails Physidae                         6.33    6.46    3.17     11.27  53.57
Flatworms Dugesiidae                    6.67    4.54    1.22      7.93  61.50
True Fly larvae s-f Tanypodinae         1.50    4.00    5.04      6.99  68.48
Dragonfly larvae Libellulidae           2.83    3.89    1.21      6.79  75.27
True bugs Veliidae                      6.00    3.06    0.75      5.35  80.62
Leeches Glossiphoniidae                 1.50    2.51    1.28      4.38  85.00
Dragonfly larvae Megapodagrionidae      1.83    1.90    0.77      3.31  88.31
Dragonfly larvae Aeshnidae              1.50    1.76    0.78      3.07  91.38

Group Spring 2007

Average similarity: 62.49

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       31.67   15.27    7.64     24.43  24.43
Snails Physidae                        14.50   10.42    7.37     16.67  41.11
Snails Hydrobiidae                      8.67    6.84    2.43     10.94  52.04
Worms Oligochaeta                      10.00    6.61    3.33     10.58  62.63
Flatworms Dugesiidae                    9.50    5.07    1.23      8.11  70.74
True Fly larvae s-f Tanypodinae         4.00    4.04    2.53      6.46  77.19
Mussels Sphaeriidae                     6.00    3.14    1.02      5.02  82.21
Dragonfly larvae Hemicorduliidae        3.67    2.43    1.16      3.88  86.10
Dragonfly larvae Libellulidae           1.33    2.19    1.29      3.51  89.61
True Fly larvae s-f Orthocladiinae      3.00    1.82    0.73      2.92  92.53
```

SIMPER Shrimptons Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Shrimptons.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Season

Factor groups
Autumn 2005
Spring2005
Autumn 2006
Spring 2006
Autumn 2007
Spring 2007

Group Autumn 2005

Average similarity: 75.89

Species                  Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Physidae             15.33   16.31    7.41     21.49  21.49
Flatworms Dugesiidae        14.67   15.30    9.53     20.16  41.65
Worms Oligochaeta           12.00   13.48   44.44     17.77  59.41
Leeches Glossiphoniidae      9.67   10.94    8.30     14.42  73.83
Mussels Corbiculidae         7.33    9.41    3.56     12.40  86.23
Snails Planorbidae           6.33    7.68    3.56     10.12  96.35

Group Spring2005

Average similarity: 76.54

Species                           Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Physidae                      16.33   13.28   19.85     17.35  17.35
Worms Oligochaeta                    15.33   13.08   46.28     17.09  34.44
Flatworms Dugesiidae                 12.00   11.45   11.43     14.97  49.41
Leeches Glossiphoniidae               9.33    9.70   10.63     12.67  62.08
True Fly larvae s-f Chironominae     10.00    8.94    4.43     11.68  73.76
Snails Planorbidae                    8.67    8.57    3.06     11.20  84.96
Mussels Corbiculidae                  7.33    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                    13.67   16.90   13.74     22.03  22.03
Flatworms Dugesiidae                  8.00   13.43    9.18     17.51  39.55
Snails Physidae                       9.00   13.00    3.19     16.95  56.50
Aquatic mites Acarina                 4.33    9.91   14.34     12.92  69.42
Mussels Corbiculidae                  6.00    9.70    6.21     12.64  82.06
Dragonfly larvae Hemicorduliidae      4.00    6.51    2.65      8.49  90.55

Group Spring 2006

Average similarity: 62.88

Species                           Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae     21.44   21.04    6.75     33.46  33.46
Snails Physidae                      11.78   15.77    9.32     25.08  58.55
Worms Oligochaeta                     5.22    7.17    1.40     11.41  69.96
Flatworms Dugesiidae                  2.44    3.81    1.09      6.07  76.02
True bugs Notonectidae                1.44    3.23    1.14      5.14  81.16
Aquatic mites Acarina                 1.89    3.02    1.10      4.81  85.97
Dragonfly larvae Hemicorduliidae      2.00    2.85    0.79      4.53  90.49
```

Group Autumn 2007

```
Average similarity: 60.77

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       10.33    8.45    2.56     13.90  13.90
Dragonfly larvae Megapodagrionidae      4.67    7.02    5.43     11.54  25.44
Flatworms Dugesiidae                    5.17    6.75    3.12     11.10  36.55
Aquatic mites Acarina                   4.83    5.64    3.43      9.28  45.83
Dragonfly larvae Coenagrionidae         3.67    5.45    2.77      8.97  54.79
Dragonfly larvae Isostictidae           3.33    5.21    3.36      8.57  63.37
Dragonfly larvae Hemicorduliidae        6.17    4.78    1.11      7.86  71.23
Worms Oligochaeta                       3.83    4.74    1.09      7.79  79.02
Snails Physidae                         7.33    4.67    1.08      7.68  86.71
True bugs Notonectidae                  1.67    2.01    0.75      3.31  90.02
```

Group Spring 2007

```
Average similarity: 63.44

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       22.83   12.24    4.27     19.30  19.30
Snails Physidae                        15.50   10.61    5.03     16.72  36.02
Worms Oligochaeta                       5.33    6.41    4.98     10.10  46.12
Flatworms Dugesiidae                    6.00    5.40    2.58      8.51  54.63
Dragonfly larvae Coenagrionidae         4.83    5.02    3.47      7.91  62.53
Dragonfly larvae Isostictidae           4.00    4.89    3.27      7.71  70.24
Dragonfly larvae Megapodagrionidae      5.83    3.29    0.78      5.18  75.42
Snails Ancylidae                        2.33    3.07    1.34      4.84  80.26
True bugs Corixidae                     2.17    2.94    1.28      4.63  84.89
Dragonfly larvae Hemicorduliidae        2.00    2.92    1.35      4.60  89.48
True bugs Notonectidae                  0.67    1.56    0.78      2.47  91.95
```

SIMPER Buffalo Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Buffalo.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Season

Factor groups
Autumn 2005
Spring 2005
Autumn 2006
Autumn 2007
Spring 2007

Group Autumn 2005

Average similarity: 76.18

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Dragonfly larvae Megapodagrionidae     16.33    7.79    6.42     10.23  10.23
True Fly larvae s-f Chironominae       19.33    7.27   13.67      9.54  19.77
True bugs Notonectidae                 10.33    7.22    9.55      9.48  29.25
Worms Oligochaeta                      10.33    7.12    6.08      9.34  38.59
Dragonfly larvae Coenagrionidae         9.33    5.52   11.31      7.24  45.83
Snails Hydrobiidae                      9.33    4.90    7.43      6.43  52.26
Flatworms Dugesiidae                    5.00    4.73   14.18      6.21  58.47
Mussels Corbiculidae                    6.00    4.59    5.43      6.02  64.49
Dragonfly larvae Hemicorduliidae       12.00    4.36    1.27      5.73  70.22
Snails Planorbidae                      2.33    3.23    9.55      4.24  74.46
True Fly larvae s-f Tanypodinae         3.67    3.23    9.55      4.24  78.70
Snails Physidae                         3.67    3.02    2.42      3.97  82.67
Aquatic mites Acarina                   1.67    2.63    3.13      3.46  86.12
True Fly larvae Stratiomyidae           2.00    2.59    4.88      3.40  89.52
Leeches Glossiphoniidae                 1.67    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     43.67   14.61    9.20     21.82  21.82
Worms Oligochaeta                    22.33   11.55   20.99     17.24  39.06
Snails Physidae                      14.33    8.14    4.59     12.16  51.22
Snails Hydrobiidae                   10.33    7.97    6.51     11.90  63.12
Slatters Oniscidae                    3.00    4.22    7.11      6.30  69.42
Flatworms Dugesiidae                  3.67    4.20   15.55      6.27  75.69
Mussels Corbiculidae                  5.67    3.84    2.27      5.74  81.43
True bugs Notonectidae                3.00    3.71    2.25      5.54  86.97
Dragonfly larvae Libellulidae         5.33    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       60.00   15.95   22.99     21.15  21.15
True bugs Notonectidae                 12.67    7.62   12.00     10.11  31.25
Dragonfly larvae Libellulidae           9.00    5.42    3.65      7.19  38.44
Snails Physidae                         6.67    5.39   10.50      7.15  45.60
Dragonfly larvae Coenagrionidae         7.67    5.25   12.79      6.96  52.56
Mussels Corbiculidae                    5.67    4.90    6.84      6.50  59.06
Worms Oligochaeta                       7.00    4.75    3.53      6.30  65.36
Dragonfly larvae Megapodagrionidae      6.33    4.27    2.42      5.66  71.02
Dragonfly larvae Aeshnidae              4.00    3.94   40.60      5.22  76.24
Flatworms Dugesiidae                    3.33    3.94   40.60      5.22  81.47
Dragonfly larvae Hemicorduliidae        6.33    3.66    4.91      4.85  86.31
True Fly larvae s-f Orthocladiinae      2.67    3.22   40.60      4.27  90.58
```

```
Group Autumn 2007

Average similarity: 70.12

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       18.67    9.79    5.19     13.96  13.96
True bugs Notonectidae                 10.50    7.86    6.95     11.21  25.17
Snails Physidae                        11.67    6.40    2.26      9.13  34.31
Snails Hydrobiidae                      6.83    5.29    2.73      7.55  41.85
Dragonfly larvae Hemicorduliidae        6.67    5.14    2.70      7.33  49.18
Dragonfly larvae Megapodagrionidae      4.50    4.44    6.69      6.33  55.52
Caddisfly larvae Hydroptilidae          4.00    4.13    4.64      5.89  61.40
True Fly larvae s-f Tanypodinae         3.17    3.56    3.53      5.07  66.48
Dragonfly larvae Isostictidae           3.00    3.21    4.10      4.58  71.06
Snails Lymnaeidae                       2.83    3.18    4.65      4.53  75.59
Dragonfly larvae Aeshnidae              3.33    2.88    1.35      4.11  79.71
Dragonfly larvae Coenagrionidae         3.33    2.31    1.23      3.29  83.00
Flatworms Dugesiidae                    3.17    1.78    0.79      2.54  85.54
Mayfly larvae Baetidae                  5.83    1.74    0.48      2.48  88.02
True Fly larvae Stratiomyidae           1.33    1.70    1.33      2.42  90.44

Group Spring 2007

Average similarity: 65.62

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       23.17   14.86    4.90     22.64  22.64
Snails Physidae                        15.50   14.48   10.77     22.07  44.71
Snails Hydrobiidae                      6.67    8.75    4.89     13.33  58.05
Dragonfly larvae Megapodagrionidae      4.67    5.37    2.51      8.18  66.22
Worms Oligochaeta                       3.17    5.13    2.72      7.82  74.05
True bugs Notonectidae                  2.17    4.67    4.74      7.12  81.16
Dragonfly larvae Isostictidae           3.50    3.02    0.78      4.60  85.76
Dragonfly larvae Coenagrionidae         1.67    1.86    0.77      2.83  88.59
True Fly larvae s-f Tanypodinae         1.50    1.83    0.77      2.79  91.39
```

SIMPER Porters Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Porters.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Season

Factor groups
Autumn 2005
Spring 2005
Autumn 2006
Autumn 2007
Spring 2007

Group Autumn 2005

Average similarity: 77.34

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       42.67   12.97   10.80     16.77  16.77
Snails Hydrobiidae                     21.67    8.36    7.06     10.81  27.58
Dragonfly larvae Isostictidae          17.67    8.13   10.32     10.51  38.09
Dragonfly larvae Hemicorduliidae        8.33    5.97   60.48      7.72  45.80
Snails Physidae                         9.67    5.94   11.11      7.68  53.48
Dragonfly larvae Megapodagrionidae      9.33    5.44   11.33      7.03  60.51
Dragonfly larvae Coenagrionidae         8.67    4.66    2.66      6.03  66.54
Snails Planorbidae                      5.33    4.54    8.09      5.87  72.40
Worms Oligochaeta                       6.33    4.16    4.70      5.38  77.78
Leeches Glossiphoniidae                 4.67    3.56    3.53      4.61  82.39
True Fly larvae s-f Tanypodinae         6.67    3.40    4.45      4.40  86.79
Dragonfly larvae Aeshnidae              2.00    2.98   60.48      3.86  90.65

Group Spring 2005

Average similarity: 73.26

Species                           Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae    103.00   23.52    7.50     32.11  32.11
Snails Hydrobiidae                   23.33   10.16    8.58     13.87  45.98
Worms Oligochaeta                     7.33    6.04   19.70      8.24  54.23
Dragonfly larvae Isostictidae         7.00    6.04   19.70      8.24  62.47
Snails Physidae                       6.33    5.69    4.45      7.77  70.24
Leeches Glossiphoniidae               4.00    4.67    7.09      6.37  76.61
Dragonfly larvae Libellulidae         5.33    4.35    2.96      5.94  82.55
True bugs Corixidae                   4.00    2.93    3.75      4.00  86.55
Leeches Erpobdellidae                 1.67    2.91    4.56      3.97  90.52

Group Autumn 2006

Average similarity: 72.51

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Hydrobiidae                     17.00    8.85    4.77     12.20  12.20
Dragonfly larvae Coenagrionidae        11.33    7.33    5.14     10.11  22.31
Dragonfly larvae Megapodagrionidae     14.33    7.07    7.15      9.75  32.06
Dragonfly larvae Isostictidae          10.67    6.63   19.81      9.14  41.20
Worms Oligochaeta                       6.67    6.13   19.81      8.46  49.66
Dragonfly larvae Hemicorduliidae        7.67    5.60   19.81      7.72  57.38
Fairy shrimps Atyidae                   8.00    5.60   19.81      7.72  65.10
Leeches Glossiphoniidae                 9.00    5.28    3.03      7.28  72.38
Dragonfly larvae Aeshnidae              5.00    4.73   10.12      6.53  78.91
Snails Physidae                         4.00    3.79   14.91      5.23  84.13
Dragonfly larvae Libellulidae           3.00    3.13    2.69      4.32  88.46
True Fly larvae s-f Tanypodinae         9.67    2.61    0.58      3.60  92.05
```

```
Group Autumn 2007

Average similarity: 72.68

Species                            Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Hydrobiidae                    22.83   10.79    6.71     14.85  14.85
Snails Physidae                        7.00    5.99    5.31      8.24  23.08
True bugs Notonectidae                 7.17    5.89    5.48      8.11  31.19
Dragonfly larvae Isostictidae          8.33    5.89    3.19      8.10  39.29
True Fly larvae s-f Chironominae       8.50    5.61    4.40      7.72  47.02
Dragonfly larvae Coenagrionidae        7.33    5.56    3.63      7.65  54.66
Dragonfly larvae Megapodagrionidae     6.33    5.22    4.45      7.19  61.85
Dragonfly larvae Hemicorduliidae       6.00    4.98    3.52      6.86  68.71
Dragonfly larvae Libellulidae          5.00    4.45    3.57      6.12  74.83
Caddisfly larvae Hydroptilidae         3.83    3.93    4.00      5.41  80.25
Fairy shrimps Atyidae                  5.50    3.84    2.20      5.28  85.53
True Fly larvae s-f Orthocladiinae     3.83    2.75    1.18      3.79  89.32
True Fly larvae s-f Tanypodinae        2.67    1.81    0.78      2.49  91.81

Group Spring 2007

Average similarity: 69.03

Species                            Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae      22.33   18.97    7.39     27.48  27.48
Snails Hydrobiidae                    15.17   12.36    4.30     17.90  45.39
Snails Physidae                        8.33    9.86    4.44     14.28  59.67
Worms Oligochaeta                      8.33    8.31    3.47     12.04  71.70
Dragonfly larvae Megapodagrionidae     6.67    7.57    3.08     10.97  82.67
Dragonfly larvae Isostictidae          2.83    3.75    1.28      5.44  88.11
Snails Planorbidae                     1.00    1.64    0.78      2.37  90.48
```

SIMPER Terrys Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\terrys.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: Square root
Cut off for low contributions: 90.00%
Factor name: Season

Factor groups
Autumn 2005
Spring 2005
Autumn 2006
Autumn 2007
Spring 2007

Group Autumn 2005

Average similarity: 70.61

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Dragonfly larvae Megapodagrionidae     18.67    8.82    7.99     12.49  12.49
Snails Hydrobiidae                     11.33    7.38   12.57     10.46  22.95
True Fly larvae s-f Chironominae       16.00    5.69    2.07      8.07  31.01
Dragonfly larvae Isostictidae           6.67    5.63   11.74      7.98  38.99
Worms Oligochaeta                       9.00    5.19    6.32      7.35  46.34
Flatworms Dugesiidae                    8.00    4.98    4.78      7.05  53.39
Snails Physidae                         6.33    4.77    4.10      6.75  60.14
Mussels Corbiculidae                    6.00    4.34    9.17      6.15  66.29
True Fly larvae s-f Tanypodinae         9.33    4.17   15.15      5.91  72.20
True bugs Notonectidae                  6.67    4.17    2.74      5.90  78.10
Dragonfly larvae Hemicorduliidae        9.33    3.99    3.57      5.66  83.76
Snails Planorbidae                      3.33    3.67    6.32      5.20  88.96
Leeches Glossiphoniidae                 2.00    2.65    3.33      3.75  92.71

Group Spring 2005

Average similarity: 66.01

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae       31.67   13.26   18.31     20.09  20.09
Snails Physidae                        10.00    6.88    6.69     10.42  30.50
Worms Oligochaeta                      10.33    6.62   10.66     10.03  40.53
Dragonfly larvae Megapodagrionidae      8.67    6.48   15.08      9.82  50.35
Dragonfly larvae Isostictidae           6.67    5.70    7.00      8.63  58.98
Mussels Corbiculidae                    4.67    3.63   13.50      5.49  64.48
True Fly larvae s-f Tanypodinae         6.00    3.56    1.74      5.39  69.87
Flatworms Dugesiidae                    2.33    3.39   20.38      5.13  75.00
Aquatic mites Acarina                   4.00    3.15    2.62      4.77  79.77
True bugs Notonectidae                  2.33    2.74    3.95      4.15  83.92
Dragonfly larvae Libellulidae           9.00    2.73    0.58      4.13  88.05
Snails Hydrobiidae                      8.33    2.51    0.58      3.80  91.85

Group Autumn 2006

Average similarity: 72.76

Species                             Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Dragonfly larvae Megapodagrionidae     25.67    8.98   18.42     12.34  12.34
Dragonfly larvae Hemicorduliidae       19.67    8.71   18.55     11.98  24.31
Worms Oligochaeta                      16.33    8.33   18.95     11.45  35.77
Snails Hydrobiidae                     14.33    5.51    2.85      7.58  43.34
True bugs Notonectidae                  5.00    4.48   14.83      6.16  49.50
Flatworms Dugesiidae                    7.67    4.25    2.15      5.85  55.35
True bugs Gerridae                      3.00    3.74   15.97      5.14  60.48
Snails Physidae                         6.33    3.70    1.32      5.08  65.57
True Fly larvae s-f Tanypodinae         7.00    3.70    1.32      5.08  70.65
True Fly larvae s-f Chironominae        8.67    3.68    2.86      5.06  75.71
Dragonfly larvae Coenagrionidae         4.67    3.62    3.89      4.98  80.69
Dragonfly larvae Isostictidae           3.33    3.45    5.69      4.75  85.44
Aquatic mites Acarina                   2.33    3.05   15.97      4.19  89.63
Dragonfly larvae Libellulidae           2.33    2.44    5.69      3.36  92.99
```

```
Group Autumn 2007

Average similarity: 66.10

Species                              Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
Snails Hydrobiidae                      18.00    9.30    5.38     14.07  14.07
Dragonfly larvae Megapodagrionidae      12.50    8.32    5.56     12.59  26.67
True Fly larvae s-f Chironominae        10.50    7.82    4.37     11.84  38.50
Flatworms Dugesiidae                     7.33    5.85    2.71      8.86  47.36
Snails Physidae                          7.50    5.48    2.48      8.29  55.65
True bugs Notonectidae                   5.17    5.05    6.17      7.64  63.29
Worms Oligochaeta                        4.00    4.39    3.50      6.64  69.93
True Fly larvae s-f Tanypodinae          5.33    3.94    2.40      5.96  75.90
Dragonfly larvae Hemicorduliidae         3.50    3.08    1.29      4.66  80.56
Dragonfly larvae Isostictidae            2.83    2.09    1.31      3.16  83.71
True Fly larvae s-f Orthocladiinae       2.67    1.75    0.77      2.64  86.36
Dragonfly larvae Libellulidae            1.50    1.40    0.76      2.12  88.48
Dragonfly larvae Coenagrionidae          1.83    1.29    0.76      1.96  90.44

Group Spring 2007

Average similarity: 64.46

Species                              Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
True Fly larvae s-f Chironominae        23.67   14.78    7.53     22.92  22.92
Snails Hydrobiidae                      13.17   10.75    3.77     16.68  39.60
Dragonfly larvae Megapodagrionidae       9.33    8.80    4.56     13.65  53.26
Snails Physidae                          7.00    7.62    4.22     11.82  65.08
Flatworms Dugesiidae                     6.83    6.28    2.16      9.74  74.82
Worms Oligochaeta                        4.33    4.51    1.27      7.00  81.82
Dragonfly larvae Hemicorduliidae         3.33    2.85    1.21      4.42  86.24
True Fly larvae s-f Tanypodinae          1.33    2.32    1.35      3.60  89.84
Mussels Sphaeriidae                      2.00    1.98    0.73      3.08  92.91
```

Appendix 6 BIOENV output

BIOENV of all five creeks of 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\All five cks
wq Log 10.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File:  G:\PROJECTS\0-1\PM000067\City  of  Ryde\Spring  2007\macroinvertebrate\mv\All  five
cks.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 6

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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
 13 Altitude
 14 Bedrock
 15 Boulder
 16 Cobble

Best results

No. Vars    Corr. Selections
       6    0.232 1,3,7,8,12,16
       6    0.231 1,7-9,12,16
       6    0.229 1,4,7,9,11,12
       6    0.229 3,7,8,11,12,16
       6    0.229 7-9,11,12,16
       6    0.229 1,4,7,9,12,16
       6    0.229 1,7,9,11,12,16
       6    0.228 1,3,4,7,12,16
       6    0.227 1,7-9,11,12
       6    0.227 3,4,7,8,12,16
       6    0.226 1,3,4,7,9,12
       6    0.226 1,3,4,7,11,12
       6    0.226 1,3,7,8,11,12
       6    0.226 1,3,7,9,11,12
       6    0.225 1,3,8,11,12,16
```

BIOENV of Archers Creek 2005, 2006, 2007

```
Worksheet

File:  G:\PROJECTS\0-1\PM000067\City  of  Ryde\Spring  2007\macroinvertebrate\mv\Archers
wq.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Archers.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 8

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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    0.344 5,12
       4    0.340 1,5,11,12
       3    0.337 5,11,12
       8    0.332 1,4-7,10-12
       7    0.332 1,4-7,11,12
       5    0.330 1,4,5,11,12
       3    0.328 1,5,12
       6    0.328 1,4-7,12
       3    0.327 1,5,11
       3    0.327 4,5,12
       7    0.327 1,5-7,9,11,12
       6    0.327 1,4,5,7,11,12
       6    0.327 1,4,6,7,11,12
       4    0.326 1,4,5,12
       6    0.326 1,5-7,9,12
```

BIOENV of Shrimptons Creek 2005, 2006, 2007

```
Worksheet

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Shrimptons
wq.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring
2007\macroinvertebrate\mv\Shrimptons.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 8

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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
       4    0.410 7,8,10,12
       5    0.409 5,7,8,10,12
       4    0.404 5,7,8,10
       6    0.400 3,5,7,8,10,12
       5    0.399 5,7,8,10,11
       6    0.394 5,7,8,10-12
       5    0.394 7,8,10-12
       5    0.393 3,7,8,10,12
       3    0.392 7,8,12
       5    0.392 6-8,10,12
       6    0.390 3,7,8,10-12
       3    0.389 7,8,10
       4    0.389 7,8,10,11
       6    0.388 5,7-10,12
                       7    0.386 5,7-12
```

BIOENV of Buffalo Creek 2005, 2006, 2007

```
Worksheet

File:  G:\PROJECTS\0-1\PM000067\City  of  Ryde\Spring  2007\macroinvertebrate\mv\Buffalo
wq.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Buffalo.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 8

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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
       5    0.532 2,3,6,7,12
       5    0.526 3,5-7,12
       6    0.524 2,3,5-7,12
       7    0.522 2-7,12
       5    0.521 3,4,6,7,12
       5    0.518 2,3,5,7,12
       6    0.517 2-4,6,7,12
       4    0.517 2,3,7,12
       4    0.515 2,3,6,12
       6    0.514 3-7,12
       5    0.508 2-4,7,12
       3    0.507 3,6,12
       6    0.507 2-5,7,12
       4    0.505 3,6,7,12
       4    0.505 3,5,7,12
```

BIOENV of Porters Creek 2005, 2006, 2007

```
Worksheet

File:  G:\PROJECTS\0-1\PM000067\City  of  Ryde\Spring  2007\macroinvertebrate\mv\porters
wq.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Porters.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 8

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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    0.649 3,8
       2    0.642 2,8
       4    0.624 3-5,8
       4    0.623 2-4,8
       2    0.623 5,8
       3    0.619 3,4,8
       3    0.619 2,3,8
       3    0.615 2,4,8
       3    0.612 4,5,8
       3    0.610 2,5,8
       5    0.610 2-5,8
       3    0.608 3,5,8
       4    0.603 2,4,5,8
       4    0.599 2,3,5,8
       4    0.599 2,5,6,8
```

BIOENV of Terrys Creek 2005, 2006, 2007

```
Worksheet

File:  G:\PROJECTS\0-1\PM000067\City  of  Ryde\Spring  2007\macroinvertebrate\mv\terrys
wq.pri
Sample selection: All
Variable selection: All

Similarity Matrix

File: G:\PROJECTS\0-1\PM000067\City of Ryde\Spring 2007\macroinvertebrate\mv\Terrys.sid
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Maximum number of variables: 8

Similarity Matrix Parameters for sample data worksheet:
Analyse between: Samples
Similarity measure: Normalised Euclidean distance
Standardise: No
Transform: None

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    0.429 6,12
       1    0.400 6
       3    0.399 1,6,12
       3    0.388 6,11,12
       4    0.379 1,6,11,12
       3    0.370 3,6,12
       2    0.368 3,6
       3    0.368 6,8,12
       2    0.367 5,6
       2    0.366 6,11
       4    0.364 1,6,9,12
       3    0.362 5,6,12
       3    0.358 3,6,11
       4    0.357 6,8,11,12
       4    0.355 1,5,6,12
```